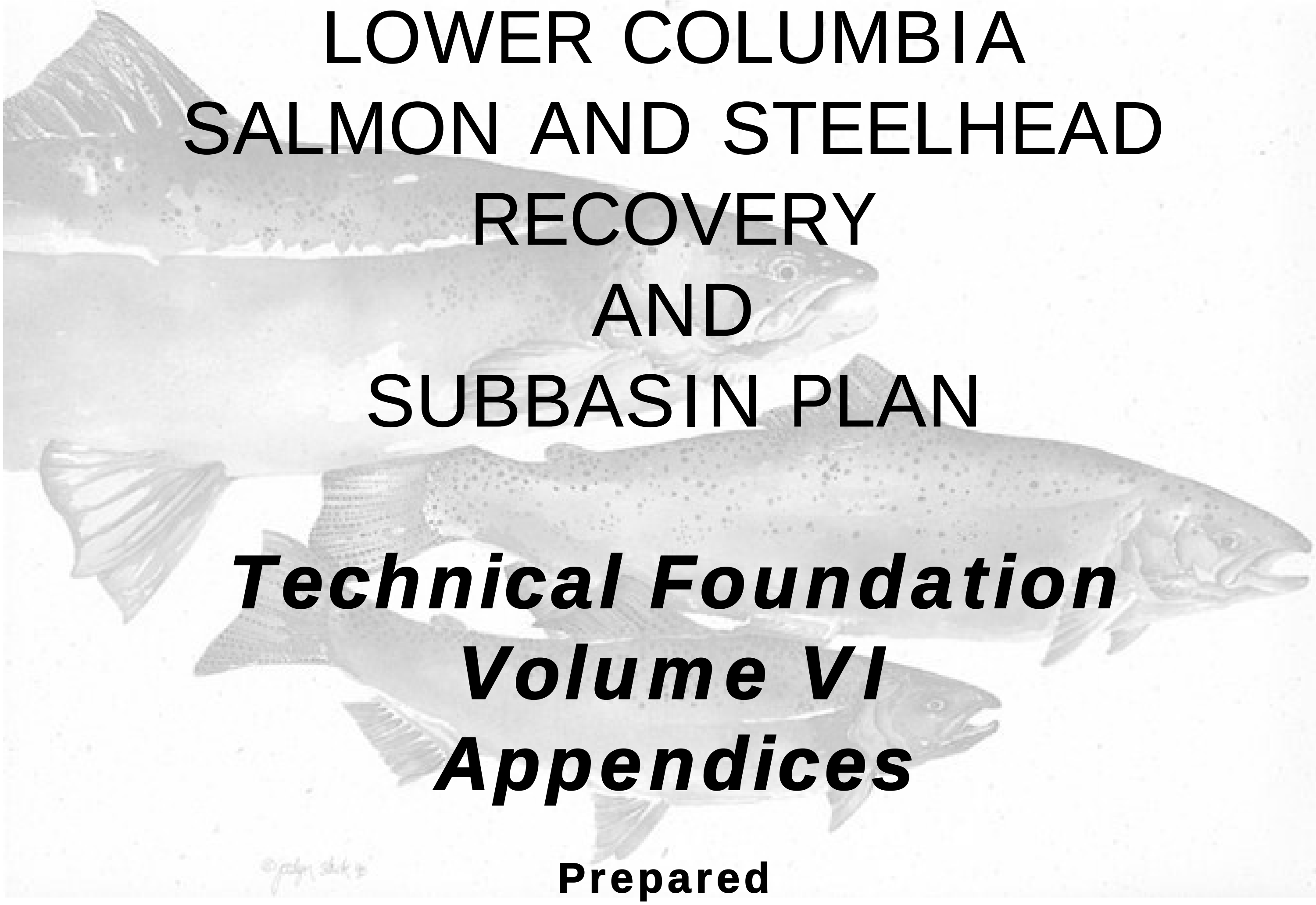

LOWER COLUMBIA SALMON AND STEELHEAD RECOVERY AND SUBBASIN PLAN

Technical Foundation Volume VI Appendices

Prepared For Northwest Power And Conservation Council

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DRAFT

Prepared By:
Lower Columbia Fish Recovery Board

Preface

This is number six of six volumes of a Technical Foundation for Recovery and Subbasin Planning prepared under direction of the *Washington Lower Columbia River Fish Recovery Board*. This information provides a basis for an integrated Salmon Recovery and Subbasin Plan prepared by the *Fish Recovery Board*. The Technical Foundation is an encyclopedia of information relating to focal and other species addressed by the plan, environmental conditions, ecological relationships, limiting factors, existing programs, and economic considerations. The Technical Foundation summarizes existing information and new assessments completed as part of the planning process. A separate Executive Summary document provides an overview of the entire Technical Foundation.

Technical Foundation volumes include:

Vol. I	Focal Fish Species	*Species overviews, limiting factors, recovery standards, and status assessments for lower Columbia River chinook salmon, coho salmon, chum salmon, steelhead, bull trout, and cutthroat trout*
Vol. II	Subbasins	*Fish populations and habitat conditions in each of 11 Washington lower Columbia River subbasins*
Vol. III	Other Species	*Descriptions, status, and limiting factors of other fish and wildlife species of interest to recovery and subbasin planning*
Vol. IV	Existing Programs	*Descriptions of Federal, State, Local, Tribal, and non governmental programs and projects that affect or are affected by recovery and subbasin planning*
Vol. V	Economic Assessment	*Potential costs and economic considerations for recovery and subbasin planning*
Vol. VI	Appendices	*Methods and detailed discussions of assessments completed as part of this planning process*

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1.0 Population Ranking

1.1 Population Persistence

Table 1-1. Population Persistence Score Definitions

Category	Description	Application
0	Either extinct or very high risk of extinction	0-40% probability of persistence for 100 years
1	Relatively high risk of extinction	40-75% probability of persistence for 100 years
2	Moderate risk of extinction	75-95% probability of persistence for 100 years
3	Low (negligible) risk of extinction	95-99% probability of persistence for 100 years
4	Very low risk of extinction	>99% probability of persistence for 100 years

Table 1-2. Chum Salmon Population Persistence

			Population Persistence			
Strata	State	Population	score	data	criteria	comments
Coast	WA	Grays/Chinook	2.2		75-95% probability of persistence for 100 years	Grays River peak spawner counts from 1945-2000 averaged 1,149 fish; peak counts represent 80% of total return under optimal conditions. Survey results indicate a small, but stable population. NMFS status assessment indicates 0.38 risk of 90% decline in 50 years.
	WA	Elochoman/Skamokawa	1.2		40-75% probability of persistence for 100 years	A small remnant run has persisted in the basin; population is small and expected to be relatively unstable.
	WA	Mill/Abernathy/Germany	1.0		40-75% probability of persistence for 100 years	A small remnant run has persisted in the basin; population is small and expected to be relatively unstable.
	OR	Youngs				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
			1.4		40-75% probability of persistence for 100 years	
Cascade	WA	Cowlitz Chum	1.0		40-75% probability of persistence for 100 years	A small remnant run has persisted in the basin; population is small and expected to be relatively unstable. Typically, less than 20 adults are collected annually at the Cowlitz Salmon Hatchery.
	WA	Kalama Chum	1.0		40-75% probability of persistence for 100 years	A small remnant run has persisted in the basin; population is small and expected to be relatively unstable.
	WA	Lewis Chum	1.0		40-75% probability of persistence for 100 years	A small remnant run has persisted in the basin; population is small and expected to be relatively unstable. Chum are occasionally observed during fall chinook surveys; 3-4 adult chum are collected annually at the Merwin fish trap.
	WA	Salmon Chum	0.4		0-40% probability of persistence for 100 years	Chum salmon not known to utilize Salmon Creek; historic chum run likely extirpated.
	WA	Washougal Chum	1.7		40-75% probability of persistence for 100 years	A small remnant run has persisted in the basin; population is small and expected to be somewhat unstable.
	OR	Clackamas				
	OR	Sandy				
			1.0		40-75% probability of persistence for 100 years	

Gorge	WA	Lower Gorge	2.9	75-95% probability of persistence for 100 years	After Grays River, these tributaries support the most productive wild chum salmon population in the lower Columbia. NMFS status assessment indicated 0.01 risk of 90% decline in 50 years for Hardy Creek and 0.86 risk of 90% decline in 50 years for Hamilton Creek.
	WA	Upper Gorge	0.9	0-40% probability of persistence for 100 years	Chum salmon not known to utilize the Wind or Little White Salmon Rivers; historic chum run likely extirpated.
			1.9	40-75% probability of persistence for 100 years	

Table 1-3. Chinook Population Persistence

Population Persistence

Strata	State	Population	score	data	criteria	comments
Coast Fall						
	WA	Grays	1.5		40-75% probability of persistence for 100 years	Wild fish contribution to the annual escapement is expected to be small; first generation hatchery fish comprise most of the annual escapement. NMFS status assessment indicated the risk of extinction in 50 years was 0.58.
	WA	Elochoman	1.5		40-75% probability of persistence for 100 years	Wild fish contribution to the annual escapement is expected to be small; first generation hatchery fish comprise most of the annual escapement. NMFS status assessment indicated the risk of extinction in 50 years was 0.03.
	WA	Mill/Abernathy/Germany	1.8		40-75% probability of persistence for 100 years	Fall chinook may not be native to Mill, Germany, or Abernathy Creek; first generation hatchery fish comprise most of the annual escapement. However, the fall chinook hatchery program was discontinued in 1995 and the 2001 escapement for Germany and Abernathy Creeks was each over 1,500 fish. NMFS status assessment indicated the risk of extinction in 50 years for Mill Creek was 0.4; the risk of 90% decline in 50 years was 0.17 and 0.15 for Abernathy Creek and Germany Creek, respectively.
	OR	Youngs Bay				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
			1.6		40-75% probability of persistence for 100 years	
Cascade Fall						
	WA	Lower Cowlitz	1.7		40-75% probability of persistence for 100 years	Historic abundance of natural fall chinook escapement was estimated to be over 100,000 fish; recent escapements have been less that 2,000. Currently, hatchery production accounts for most fish returning to the basin. NMFS status assessment indicated a 0.33 risk of 90% decline in 50 years.
	WA	Coweeman	2.2		75-95% probability of persistence for 100 years	Run is considered wild production with minimal hatchery influence. Historic escapement was about 5,000 fall chinook; recent escapements have fluctuated near 500 fish. NMFS status assessment indicated zero risk of 90% decline in 25 years, 90% decline in 50 years, or extinction in 50 years.

WA	Toutle	1.6	40-75% probability of persistence for 100 years	Historic abundance of natural fall chinook escapement was estimated to be over 6,000 fish. Currently, hatchery production accounts for most fish returning to the basin. Fall chinook populations in the basin are recovering from the 1980 Mt. St. Helens eruption.
WA	Upper Cowlitz	1.2	40-75% probability of persistence for 100 years	Historically, the Cispus River was the major area of production for fall chinook salmon, with an annual escapement over 8,000 fish.
WA	Kalama	1.8	40-75% probability of persistence for 100 years	Fall chinook were historically abundant in the Kalama (at least 20,000 fish), however, estimates of wild run size are difficult as hatchery operations began in the basin in 1895. In recent decades, spawning escapement has fluctuated around 5,000 fish; first generation hatchery fish account for most natural spawners. NMFS status assessment indicated a 0.03 risk of extinction in 50 years.
WA	Lewis/Salmon	2.2	75-95% probability of persistence for 100 years	Lewis River fall chinook are a native stock of wild production. Escapement to the NF Lewis represent about 85% of the lower Columbia wild fall chinook natural production; the remaining 15% comes from the EF Lewis and Sandy Rivers. NMFS status assessment of NF Lewis fall chinook indicated a 0.19 risk of 90% decline in 50 years and zero risk of extinction in 50 years. NMFS status assessment of EF Lewis fall chinook indicated a 0.06 risk of 90% decline in 50 years and zero risk of extinction in 50 years.
WA	Washougal	1.7	40-75% probability of persistence for 100 years	In the early 1950s, fall chinook spawner escapement was estimated at 3,000 fish. By the late 1960s, escapement had declined to hundreds of fish. Since 1970, spawner escapement has steadily increased to current levels that fluctuate near 3,000 fish. NMFS status assessment indicated a 0.0 risk of 90% decline or extinction in 50 years. A significant portion of natural spawners are first generation hatchery fish.
OR	Sandy			
OR	Clackamas			
		1.7	40-75% probability of persistence for 100 years	

Gorge Fall					
	WA	Lower Gorge	1.8	40-75% probability of persistence for 100 years	Bonneville upriver bright fall chinook stock was discovered in 1994; stock origin is unknown, but is likely from hatchery strays. The current population remains low but stable.
	WA	Upper Gorge	1.8	40-75% probability of persistence for 100 years	Average return of fall chinook to the Wind River in the 1950s was estimated at 1,500 fish; annual spawner escapement has been less than 250 fall chinook since 1989. NMFS status assessment for the Wind River indicated a 0.74 risk of extinction in 50 years. The current fall chinook run in the Wind is a derivative of Spring Creek NFH stock. Fall chinook were thought to be historically abundant in the Little White Salmon River, based on egg take records at the Little White Salmon NFH starting in 1897. Recent natural escapement estimates are not available but are expected to be low.
	WA	Big White Salmon	1.7	40-75% probability of persistence for 100 years	
	OR	Hood			
			1.8	40-75% probability of persistence for 100 years	
Cascade late fall					
	WA	Lewis NF	3.1	95-99% probability of persistence for 100 years	
	OR	Sandy			
			3.1	95-99% probability of persistence for 100 years	
Cascade spring					
	WA	Upper Cowlitz	1.7	40-75% probability of persistence for 100 years	Escapement estimates in the mid 1900s indicate approximately 10,000 spring chinook spawned above the Mayfield Dam site. The highest recorded spring chinook return to the upper Cowlitz was 20,761 fish in 1965. Current production is maintained from hatchery plants and a trap and haul program. NMFS status assessment for the Cowlitz River indicated a 0.25 risk of 90% decline in 50 years.
	WA	Cispus	1.7	40-75% probability of persistence for 100 years	

	WA	Tilton	0.0	0-40% probability of persistence for 100 years	In the early 1950s, spawning escapement to the Tilton was about 200 spring chinook. Spring chinook have not been observed in the Tilton since that time.
	WA	Toutle	0.7	0-40% probability of persistence for 100 years	Toutle River spring chinook are not considered a separate stock by WDFW. Annual escapement in the early 1950s was estimated at 400 fish and 1990s annual escapement was about 150 fish.
	WA	Kalama	1.2	40-75% probability of persistence for 100 years	Spring chinook were not believed to be historically abundant in the Kalama River; by the 1950s, only a remnant (<100) wild population remained. NMFS status assessment indicated a 0.82 risk of 90% decline in 50 years. Current spawning escapement is primarily first generation hatchery fish.
	WA	Lewis NF	0.2	0-40% probability of persistence for 100 years	Pre-Merwin Dam (1931) escapement of spring chinook was at least 3,000 fish; by the 1950s, only a remnant (<100) population remained. The native component of the run may have been extirpated and replaced with a hybridized hatchery stock, although more research is necessary to confirm this. NMFS status assessment indicated the risk of extinction in 50 years was 0.2. Current spawning escapement is primarily first generation hatchery fish.
	OR	Sandy			
			0.9	0-40% probability of persistence for 100 years	
Gorge spring					
	WA	Big White Salmon	0.0	0-40% probability of persistence for 100 years	
	OR	Hood			
			0.0	0-40% probability of persistence for 100 years	

Table 1-4. Steelhead Population Persistence

Population Persistence

Strata	State	Population	Score	Data	Criteria	Comments
Coast winter						
	WA	Grays	1.9		40-75% probability of persistence for 100 years	Historical abundance of Grays winter steelhead was about 2,000 fish (1920s to 1930s). Today, a small bu persistent run exists (estimated 400-600 fish escapement). The annual return is composed primarily of hatchery fish.
	WA	Elochoman/Skamokawa	1.7		40-75% probability of persistence for 100 years	Historic abundance data for Elochoman steelhead are limited; 1960s annual spawning escapement was estimated near 5,200 fish. Recent escapements have been below 400 fish. The annual return is composed primarily of hatchery fish.
	WA	Mill/Abernathy/Gemany	2.2		75-95% probability of persistence for 100 years	Historic steelhead abundance data for these basins are limited, although steelhead runs were expected to be relatively small. Recent escapements have been below 300 fish. The annual return is composed primarily of hatchery fish.
			1.9		40-75% probability of persistence for 100 years	
Cascade winter						
	WA	Lower Cowlitz	1.3		40-75% probability of persistence for 100 years	Winter steelhead were historically abundant throughout the Cowlitz River. Average annual escapement from 1983 to 1995 was 16,240 winter steelhead; the run is composed primarily of first generation hatchery fish.
	WA	Upper Cowlitz	1.6		40-75% probability of persistence for 100 years	Winter steelhead were historically abundant throughout the Cowlitz River. During the 1960s, an average of 11,081 adult steelhead were collected annually at the Mayfield Dam facility. Escapement to the upper basin is composed primarily of first generation hatchery fish transported around the hydro projects.
	WA	Cispus	1.6		40-75% probability of persistence for 100 years	
	WA	Tilton	1.4		40-75% probability of persistence for 100 years	

WA	Coweeman	1.9	40-75% probability of persistence for 100 years	Historic production levels are not known for this stock. Wild winter steelhead escapement in recent years has fluctuated near 200. Most adult winter steelhead returning to the Coweeman are hatchery fish.
WA	N.F. Toutle	2.0	40-75% probability of persistence for 100 years	Historic production levels are not known for this stock. Wild winter steelhead escapement in recent years has fluctuated near 300. Most adult winter steelhead returning to the North Toutle are from natural production. NMFS status assessment indicated that the risk of extinction in 50 years for Green River winter steelhead was 0.73.
WA	S.F. Toutle	2.2	75-95% probability of persistence for 100 years	Historic abundance estimates for this stock are not available. Wild fish escapement in the 1980s was around 2,000; current day escapements have fluctuated near 400 fish. NMFS status assessment indicated a 1.0 risk of 90% decline in 25 and 50 years.
WA	Kalama	3.0	95-99% probability of persistence for 100 years	Historically, winter steelhead were moderately abundant in the Kalama River. Wild winter steelhead escapement has fluctuated around 1,000 fish since the mid 1980s. NMFS status assessment indicated a 0.0 risk of extinction in 50 years.
WA	E.F. Lewis	2.1	75-95% probability of persistence for 100 years	Historic annual wild winter steelhead escapement estimates for the Lewis River ranged from 1,000 to 11,000 fish. East Fork wild winter steelhead redd index escapements from 1991-1996 averaged 76. An estimated 51% of annual spawners are of hatchery origin. NMFS status assessment for the East Fork winter steelhead indicated a 1.0 risk of 90% decline in both 25 and 50 years.
WA	N.F. Lewis	1.8	40-75% probability of persistence for 100 years	Historic annual wild winter steelhead escapement estimates for the Lewis River ranged from 1,000 to 11,000 fish. North Fork wild winter steelhead redd index escapements from 1991-1996 averaged 70. An estimated 93% of annual spawners are of hatchery origin.

	WA	Salmon	1.5	40-75% probability of persistence for 100 years	Historic abundance estimates for this stock are not available. Wild fish escapement in 1989 was around 80; current day escapement data are not available. The annual return is likely composed of mostly hatchery fish.
	WA	Washougal	1.9	40-75% probability of persistence for 100 years	Historic abundance estimates are scarce; 539 steelhead were documented during 1936 escapement surveys. Wild winter steelhead redd index escapement counts since 1991 have averaged 237. Hatchery winter steelhead are thought to account for most of the annual escapement.
	OR	Clackamas			
	OR	Sandy			
			1.8	40-75% probability of persistence for 100 years	
Gorge winter					
	WA	Lower Gorge Tribs	1.9	40-75% probability of persistence for 100 years	Historic and current abundance estimates for Hamilton Creek wild winter steelhead are not available.
	WA	Upper Gorge Tribs	1.9	40-75% probability of persistence for 100 years	Historic run size has been estimated at 2,500 fish (contribution of summer and winter steelhead to this run size is not clear). Wild winter steelhead escapement estimates in recent years are not available. The winter steelhead run is expected to be small and sustained primarily by wild fish.
	OR	Hood			
			1.9	40-75% probability of persistence for 100 years	
Cascade summer					
	WA	Kalama	2.3	75-95% probability of persistence for 100 years	Historically, summer steelhead were moderately abundant in the Kalama River. Run size estimate in the 1950s was about 1,500 fish. Wild summer steelhead escapement has fluctuated around 1,000 fish from the mid 1970s to the mid 1990s; recent year escapements have been below 500 fish. NMFS status assessment indicated a 0.01 risk of extinction in 50 years.

	WA	N.F. Lewis	0.3	0-40% probability of persistence for 100 years	From 1925 to 1933, annual escapement of wild summer steelhead to the Lewis River was estimated at 4,000 fish. In 1984, North Fork Lewis wild summer steelhead escapement was estimated to be less than 50 fish. Recent year escapement estimates of wild summer steelhead are not available; the current return is thought to be primarily hatchery fish.
	WA	E.F. Lewis	2.1	75-95% probability of persistence for 100 years	From 1925 to 1933, annual escapement of wild summer steelhead to the Lewis River was estimated at 4,000 fish. In 1984, East Fork Lewis wild summer steelhead escapement was estimated to be 600 fish. 1990s escapement estimates of wild summer steelhead averaged 851. Wild summer steelhead comprise about 30% of the annual return.
	WA	Washougal	2.0	75-95% probability of persistence for 100 years	From 1925 to 1933, annual escapement of wild summer steelhead to the Washougal River was estimated at 2,500 fish. 539 steelhead were documented during 1936 escapement surveys; most of these were expected to be summer steelhead. Recent wild winter steelhead redd index escapement counts have fluctuated near 100. Hatchery winter steelhead are thought to account for most of the annual escapement. NMFS status assessment estimated a 1.0 risk of 90% decline in 50 years.
			1.7	40-75% probability of persistence for 100 years	
Gorge summer					
	WA	Wind	2.8	75-95% probability of persistence for 100 years	Historic run size has been estimated at 2,500 fish (contribution of summer and winter steelhead to this run size is not clear). Recent snorkel index escapement counts of wild summer steelhead have been below 100 fish. The summer steelhead run is expected to be small and sustained primarily by wild fish. The NMFS status assessment estimated a 0.0 risk of extinction in 50 years.
	OR	Hood			
			2.8		

1.2 Adult Abundance and Productivity

Table 1-5. Adult Abundance and Productivity Score Despriptions

Category	Description	Application
0	Numbers & productivity consistent with either functional extinction or very high risk of extinction	Risk analysis (PCC) estimates 0-40% persistence probability.
1	Numbers & productivity consistent with relatively high risk of extinction	Risk analysis (PCC) estimates 40-75% persistence probability.
2	Numbers & productivity consistent with moderate risk of extinction	Risk analysis (PCC) estimates 75-95% persistence probability.
3	Numbers and productivity consistent with low (negligible) risk of extinction	Risk analysis (PCC) estimates 95-99% persistence probability.
4	Numbers & productivity consistent with very low risk of extinction	Risk analysis (PCC) estimates >99% persistence probability.

Table 1-6. Chum Adult Abundance and Productivity

Adult Abundance and Productivity

Strata	State	Population	Score	Data	Criteria	Comments
Coast	WA	Grays/Chinook	2	2.5	Risk analysis (PCC) estimates 75-95% persistence probability.	Since 1987, peak counts of live and dead fish have been performed in the mainstem, West Fork, Crazy Johnson Creek, and Gorley Creek. The recent average (1987-2000) peak count for the basin was 1,078 chum. Peak counts represent 80% of total return under optimal conditions. Survey results indicate a small, but stable population. NMFS status assessment indicates 0.38 risk of 90% decline in 50 years.
	WA	Elochoman/Skamokawa	1	2.5	Risk analysis (PCC) estimates 40-75% persistence probability.	Annual spawning surveys are not conducted in the basin; adult adundance and production is expected to be low.
	WA	Mill/Abernathy/Germany	0.5	2.5	Risk analysis (PCC) estimates 0-40% persistence probability.	Annual spawning surveys are not conducted in the basin; adult adundance and production is expected to be extremely low.
	OR	Youngs				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
Cascade						
	WA	Cowlitz Chum	0.5	2.5	Risk analysis (PCC) estimates 0-40% persistence probability.	Annual spawning surveys are not conducted in the basin. Typically, less than 20 adults are collected annually at the Cowlitz Salmon Hatchery. Production is expected to be extremely low.
	WA	Kalama Chum	0.5	2.5	Risk analysis (PCC) estimates 0-40% persistence probability.	Annual spawning surveys are not conducted in the basin; adult adundance and production is expected to be extremely low.

	WA	Lewis Chum	0.5	2.5	Risk analysis (PCC) estimates 0-40% persistence probability.	Annual spawning surveys are not conducted in the basin; chum are occasionally observed during fall chinook surveys. 3-4 adult chum are collected annually at the Merwin fish trap. Historically, the most dense spawning aggregation was observed in the lower East Fork (up to rm 6). 4 adult carcasses found in Cedar Creek in 1998. Production is expected to be extremely low.
	WA	Salmon Chum	0	1	Risk analysis (PCC) estimates 0-40% persistence probability.	Chum salmon not known to utilize Salmon Creek; historic chum run likely extirpated.
	WA	Washougal Chum	1.5	2.5	Risk analysis (PCC) estimates 40-75% persistence probability.	Annual spawning surveys are not conducted in the basin; adult adundance and production is expected to be low. In 1998, one chum was found in the mainstem Washougal during spawning surveys. In 2000 non-index surveys, one chum was observed in Lacamas Creek (lower tributary at rm 0.8).
	OR	Clackamas				
	OR	Sandy				
Gorge						
	WA	Lower Gorge	3	3	Risk analysis (PCC) estimates 95-99% persistence probability.	Peak live and dead fish/mile index escapement counts for Bonneville chum ranged from 20 to 849 from 1986-2001. After Grays River, these tributaries support the most productive wild chum salmon population in the lower Columbia.
	WA	Upper Gorge	1	4	Risk analysis (PCC) estimates 40-75% persistence probability.	From 1938-1954, Bonneville Dam chum counts ranged from 788-3,636. Since 1971, chum counts at Bonneville Dam have ranged from 1 to 147; subsequent migration to the Wind or Little White Salmon has not been documented. Chum runs to these basins are believed to be extirpated.

Table 1-7. Chinook Adult Abundance and Productivity

Adult Abundance and Productivity

Strata	State	Population	Score	Data	Criteria	Comments
Coast Fall						
		Grays	0.5		Risk analysis (PCC) estimates 0-40% persistence probability.	Spawning escapement from 1964-2001 ranged from 4 to 2,685 (average 523). Natural escapement was over 1,000 chinook in the late 1980s, but has been below 400 since 1990. The 1987-2000 average escapement was 310 adults. Evidence suggests few natural fall chinook juveniles are produced annually.
		Elochoman	1		Risk analysis (PCC) estimates 40-75% persistence probability.	Spawning escapement in the Elochoman River from 1964-2001 ranged from 53 to 2,392 (average 624). The 1987-2000 average escapement was 636 adults. Spawning escapement in Skamokawa Creek from 1964-2001 ranged from 25 to 5,596 (average 1,056). Skamokawa fall chinook escapement has been below 1,000 fish since 1990. Natural escapement is dominated by hatchery strays and fall chinook juvenile production is presumed to be low.
		Mill/Abernathy/Germany	1		Risk analysis (PCC) estimates 40-75% persistence probability.	Mill Creek spawning escapement during 1984-2001 ranged from 2 to 1,867 (average 316). Abernathy Creek spawning escapement during 1981-2001 ranged from 200 to 3,807 (average 1,094). Germany Creek spawning escapement during 1981-2001 ranged from 15 to 2,158 (average 340). Natural escapement was assumed to be dominated by hatchery strays and fall chinook juvenile production was presumed to be low, however, the 2001 fall chinook escapement to Germany and Abernathy Creeks was each over 1,500 fish and the hatchery program was discontinued in 1995.
		Youngs Bay				
		Big Creek				
		Clatskanie				
		Scappoose				
Cascade Fall						
	WA	Lower Cowlitz	1		Risk analysis (PCC) estimates 40-75% persistence probability.	Cowlitz River spawning escapement from 1964-2001 ranged from 1,045 to 23,345 (average 5,522); however, annual escapement since the early 1990s has been about 2,500 fish. Natural escapement is dominated by hatchery strays and fall chinook juvenile production is presumed to be low.

WA	Coweeman	2	Risk analysis (PCC) estimates 75-95% persistence probability.	Historic escapement was about 5,000 fall chinook. Spawning escapement from 1964-2001 ranged from 40 to 2,148 (average 302). The run is sustained completely by natural production.
WA	Toutle	1.5	Risk analysis (PCC) estimates 40-75% persistence probability.	Historic abundance of natural fall chinook escapement was estimated to be over 6,000 fish. From 1964-1979, average annual escapement to the Toutle basin was 10,756 fall chinook. South Fork Toutle spawning escapement from 1964-2001 ranged from 0 to 578 (average 177). Green River spawning escapement from 1964-2001 ranged from 10 to 6,654 (average 1,900). Currently, hatchery production accounts for most fish returning to the basin, as chinook continue to re-establish a population after the 1980 Mt. St. Helens eruption.
WA	Upper Cowlitz	0	Risk analysis (PCC) estimates 0-40% persistence probability.	Reliable current natural spawner escapement estimates are not available for the upper Cowlitz, although the only fall chinook found in the upper basin are those collected at Mayfield Dam and passed upstream of Cowlitz Falls Dam. Two different adult production models have estimated the upper Cowlitz production potential at 63,818 and 93,015 adults, respectively.
WA	Kalama	1	Risk analysis (PCC) estimates 40-75% persistence probability.	Spawning escapement in the mid 1900s was estimated at 20,000 fall chinook. From 1964-2001, spawning escapement ranged from 1,055 to 24,297 (average 5,514). Spawning escapement is sustained primarily by first generation hatchery fish.
WA	Lewis/Salmon	2	Risk analysis (PCC) estimates 75-95% persistence probability.	Spawning escapement in the 1950s was estimated at 5,000 and 4,000 fall chinook for the NF and EF Lewis respectively. From 1964-2001, NF Lewis spawning escapement ranged from 3,184 to 21,726 (average 11,232). From 1986-2001, EF Lewis spawning escapement ranged from 52 to 591 (average 279). Natural spawning escapement is sustained primarily by wild fish, with little hatchery influence.
WA	Washougal	1	Risk analysis (PCC) estimates 40-75% persistence probability.	In the early 1950s, fall chinook spawner escapement was estimated at 3,000 fish. By the late 1960s, escapement had declined to hundreds of fish. Spawning escapement from 1964-2001 ranged from 70 to 4,669 (average 2,000). Since 1970, spawner escapement has steadily increased to current levels that fluctuate near 3,000 fish. Spawning escapement is sustained primarily by first generation hatchery fish.
OR	Sandy			

	OR	Clackamas			
Gorge Fall					
	WA	Lower Gorge	1	Risk analysis (PCC) estimates 40-75% persistence probability.	Hamilton Creek spawning escapement from 1995-2001 ranged from 47 to 300 (average 144). Bonneville area spawning escapement from 1995-2001 ranged from 477 to 5,151 (average 2,143).
	WA	Upper Gorge	1.5	Risk analysis (PCC) estimates 40-75% persistence probability.	Average return of fall chinook to the Wind River in the 1950s was estimated at 1,500 fish. Spawner escapement from 1964-2001 ranged from 0 to 1,845 (average 416). Since the late 1970s, fall chinook natural escapement in the Wind River has been a result of natural production or strays from other basins; the run is thought to be a derivative of Spring Creek NFH stock. Natural escapement estimates are not available for Little White Salmon fall chinook, although natural production is expected to be low.
	WA	Big White Salmon	1.5	Risk analysis (PCC) estimates 40-75% persistence probability.	
	OR	Hood			
Cascade late falls					
	WA	Lewis NF	3	Risk analysis (PCC) estimates 95-99% persistence probability.	
	OR	Sandy			
Cascade spring					
	WA	Upper Cowlitz	0.5	Risk analysis (PCC) estimates 0-40% persistence probability.	The highest recorded spring chinook return to the upper Cowlitz was 20,761 fish in 1965. From 1962-1966, an average of 9,928 spring chinook were counted annually at Mayfield Dam. From 1978-1985 (excluding 1984), an average of 3,894 spring chinook were counted annually at Mayfield Dam. Current production in the upper basin is maintained from juvenile hatchery plants and an adult trap and haul program.
	WA	Cispus	0.5	Risk analysis (PCC) estimates 0-40% persistence probability.	

	WA	Tilton	0	Risk analysis (PCC) estimates 0-40% persistence probability.	Spawning escapement has not been observed in the Tilton River since the early 1950s; natural production in the basin is expected to be non-existent.
	WA	Toutle	0	Risk analysis (PCC) estimates 0-40% persistence probability.	Annual escapement in the early 1950s was estimated at 400 fish and 1990s annual escapement was about 150 fish. Natural production is presumed to be low; most fish are harvested in the sport fishery.
	WA	Kalama	0.5	Risk analysis (PCC) estimates 0-40% persistence probability.	Spring chinook were not believed to be historically abundant in the Kalama River; by the 1950s, only a remnant (<100) wild population remained. Spawning escapement from 1980-2001 ranged from 0 to 2,892 (average 444); spawning escapement is primarily first generation hatchery fish.
	WA	Lewis NF	0.5	Risk analysis (PCC) estimates 0-40% persistence probability.	Pre-Merwin Dam (1931) escapement of spring chinook was at least 3,000 fish; by the 1950s, only a remnant (<100) population remained. Spawning escapement from 1980-2001 ranged from 213 to 6,939, but generally fluctuated near 1,000 fish. Current spawning escapement is primarily first generation hatchery fish.
	OR	Sandy			
Gorge spring					
	WA	Big White Salmon	0	Risk analysis (PCC) estimates 0-40% persistence probability.	
	OR	Hood			

Table 1-8. Steelhead Adult Abundance and Productivity

Adult Abundance and Productivity

Strata	State	Population	Score	Data	Criteria	Comments
Coast winter						
	WA	Grays	1.5		Risk analysis (PCC) estimates 40-75% persistence probability.	Historical abundance of Grays winter steelhead was about 2,000 fish (1920s to 1930s). Escapement counts from 1991 to 2000 ranged from 158 to 1,224 (average 658). Natural production is expected to be low.
	WA	Elochoman/Skamokawa	1		Risk analysis (PCC) estimates 40-75% persistence probability.	Annual spawning escapement from 1963 to 1967 was estimated at 5,200 fish. Recent escapement counts for the Elochoman from 1991 to 2001 have ranged from 52 to 402 (average 197). Recent escapement counts for the Skamokawa from 1991 to 2001 have ranged from 92 to 304 (average 202). Natural production is expected to be low.
	WA	Mill/Abernathy/Gemany	1.5		Risk analysis (PCC) estimates 40-75% persistence probability.	Recent escapement counts for Abernathy Creek from 1991 to 2001 have ranged from 16 to 280 (average 130). Recent escapement counts for Germany Creek from 1993 to 2001 have ranged from 40 to 252 (average 119). Natural production is expected to be low.
Cascade winter						
	WA	Lower Cowlitz	1		Risk analysis (PCC) estimates 40-75% persistence probability.	Winter steelhead were historically abundant throughout the Cowlitz River. Wild winter steelhead average run size during the late 1970s and 1980s was estimated at 309 fish. Annual escapement from 1983 to 1995 ranged from 4,067 to 30,200 (average 16,240); this production was primarily hatchery returns. Wild steelhead production is likely minimal, however, key production areas still exist in the lower river tributaries.
	WA	Upper Cowlitz	1		Risk analysis (PCC) estimates 40-75% persistence probability.	Winter steelhead were historically abundant throughout the Cowlitz River. From 1961 to 1965, adult steelhead collected annually at the Mayfield Dam facility ranged from 8,821 to 13,155 (average 11,081). Current escapement to the upper basin is composed primarily of first generation hatchery fish transported around the hydro projects (274 in 2000-01). Spawning has been observed in the mainstem Cowlitz and Cispus Rivers; juvenile steelhead/rainbow trout have been found in many tributaries.

WA	Cispus	1		Risk analysis (PCC) estimates 40-75% persistence probability.	
WA	Tilton	0.5		Risk analysis (PCC) estimates 0-40% persistence probability.	
WA	Coweeman	1.5		Risk analysis (PCC) estimates 40-75% persistence probability.	Total escapement counts of wild winter steelhead from 1987-2001 have ranged from 44 to 1,008 (average 393). Hatchery returns from 1986-1990 ranged from 1,795 to 2,427. Hatchery fish contribute little to natural production; wild fish production is expected to be low.
WA	N.F. Toutle	2		Risk analysis (PCC) estimates 75-95% persistence probability.	Total escapement counts of wild winter steelhead in the North Toutle River from 1989-2001 have ranged from 18 to 322 (average 157). Total escapement counts of wild winter steelhead in the Green River from 1985-2001 have ranged from 44 to 775 (average 193). Hatchery releases have not occurred in recent years; escapement is expected to be completely from natural production.
WA	S.F. Toutle	2		Risk analysis (PCC) estimates 75-95% persistence probability.	Total escapement counts of wild winter steelhead in the South Toutle River from 1981-2001 have ranged from 51 to 2,222 (average 857). Hatchery releases have been minimal; escapement is expected to be completely from natural production.
WA	Kalama	3	3.5	Risk analysis (PCC) estimates 95-99% persistence probability.	Total escapement counts of wild winter steelhead in the Kalama River from 1977-2001 have ranged from 371 to 2,322. Annual escapement is expected to be a mixture of natural and hatchery production. From 1991-1996, annual winter steelhead escapement was estimated to be 31% hatchery spawners.
WA	E.F. Lewis	1.5		Risk analysis (PCC) estimates 40-75% persistence probability.	Redd index escapement counts from 1986-2001 ranged from 53 to 282 (average 157); a new index was instituted in 1997 and the relationship to the previous index is unknown. Annual escapement is expected to be a mixture of natural and hatchery production. From 1991-1996, annual winter steelhead escapement was estimated to be 51% hatchery spawners.
WA	N.F. Lewis	1.5		Risk analysis (PCC) estimates 40-75% persistence probability.	Redd index escapement counts from 1991-1996 averaged 70. Annual escapement is expected to be primarily hatchery production. From 1991-1996, annual winter steelhead escapement was estimated to be 93% hatchery spawners.

	WA	Salmon	1		Risk analysis (PCC) estimates 40-75% persistence probability.	Wild fish escapement in 1989 was around 80; current day escapement data are not available. Natural production is expected to be low; the annual return is likely composed of mostly hatchery fish.
	WA	Washougal	1.5		Risk analysis (PCC) estimates 40-75% persistence probability.	Wild winter steelhead redd index escapement counts from 1991-2001 ranged from 92 to 839 (average 237). Natural production is expected to be low; hatchery fish comprise most of the annual escapement.
	OR	Clackamas				
	OR	Sandy				
Gorge winter						
	WA	Lower Gorge Tribs	1.5		Risk analysis (PCC) estimates 40-75% persistence probability.	Historic and current abundance estimates for Hamilton Creek wild winter steelhead are not available. Natural production is expected to be low.
	WA	Upper Gorge Tribs	1.5		Risk analysis (PCC) estimates 40-75% persistence probability.	Wild steelhead escapement to Trout Creek was estimated at 100 in the 1980s and only 30 in the 1990s. Wild winter steelhead escapement estimates in recent years are not available. The winter steelhead run is expected to be small and sustained primarily by wild fish.
	OR	Hood				
Cascade summer						
	WA	Kalama	1.5	3.5	Risk analysis (PCC) estimates 40-75% persistence probability.	Total escapement counts of wild summer steelhead in the Kalama River from 1977-2001 have ranged from 140 to 2,926. Annual escapement is expected to be a mixture of natural and hatchery production. From 1991-1996, annual winter steelhead escapement was estimated to be 64% hatchery spawners.
	WA	N.F. Lewis	0	4	Risk analysis (PCC) estimates 0-40% persistence probability.	Recent year escapement estimates of wild summer steelhead are not available; the current return is thought to be primarily hatchery fish. Hatchery rack counts of summer steelhead from 1996-2002 at the Lewis River Hatchery have ranged between 500 and 2,000 and at the Merwin Hatchery have ranged between 500 and 1,000.

	WA	E.F. Lewis	1.5	2.5	Risk analysis (PCC) estimates 40-75% persistence probability.	In 1984, East Fork Lewis wild summer steelhead escapement was estimated to be 600 fish. Escapement estimates of East Fork wild summer steelhead from 1991-1996 averaged 851. Snorkel index escapements counts from 1996-2001 fluctuated around 80. Wild summer steelhead comprise about 30% of the annual return. Natural production is expected to be moderate.
	WA	Washougal	1.5	2.5	Risk analysis (PCC) estimates 40-75% persistence probability.	Wild summer steelhead snorkel index escapement counts from 1953-2001 ranged from about 30 to 450. The 1991-1996 average annual wild steelhead escapement in the mainstem Washougal was estimated at 571. Natural production is expected to be moderate. Hatchery fish comprise the majority of the spawning escapement.
Gorge summer						
	WA	Wind	2	3	Risk analysis (PCC) estimates 75-95% persistence probability.	Wild steelhead escapement to Trout Creek was estimated at 100 in the 1980s and only 30 in the 1990s. Snorkel index escapement counts in the Wind River from 1989-2000 have steadily decreased from 274 to 26 adults. The summer steelhead run is expected to be small and sustained primarily by wild fish.
	OR	Hood				

1.3 Juvenile Outmigrants

Table 1-9. Juvenile Outmigrants Score Description

Category	Description	Application
0	Declining with high confidence in slope or extrapolated from other data sources	Includes cases where no data available
1	Stable, extrapolated from other data sources	Includes case where limited sample data indicate natural production occurs but data are insufficient to identify a trend
2	Stable or increasing, low confidence in trend or extrapolated from other data sources	Includes case where extended data time series is available but trend fit is poor
3	Stable or increasing, medium confidence in trend	Requires extended data time series
4	Stable or increasing, high confidence in trend	Requires extended data time series

Table 1-10. Chum Juvenile Out-migrants

Juvenile Out-migrants

Strata	State	Population	Score	Data	Criteria	Comments
Coast						
	WA	Grays/Chinook	2	1	Includes case where extended data time series is available but trend fit is poor	Survey results since 1999 indicate slowly increasing productivity; time series not sufficient to establish trend.
	WA	Elochoman/Skamokawa	0	1	Includes cases where no data available	No basin-specific data is available; natural production of juveniles expected to be minimal.
	WA	Mill/Abernathy/Germany	0	1	Includes cases where no data available	Natural production of juveniles expected to be minimal. 7 chum juveniles captured during seining operations in Abernathy Creek in 1995.
	OR	Youngs				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
Cascade						
	WA	Cowlitz Chum	0	1	Includes cases where no data available	No basin-specific data is available; natural production of juveniles expected to be minimal.
	WA	Kalama Chum	0	1	Includes cases where no data available	No basin-specific data is available; natural production of juveniles expected to be minimal.
	WA	Lewis Chum	0	1	Includes cases where no data available	Natural production of juveniles is expected to be minimal. In 1998, 45 juvenile chum salmon were captured during seining operations related to a hatchery smolt residualization study.
	WA	Salmon Chum	0	1	Includes cases where no data available	No basin-specific data is available; natural production of juveniles expected to be non-existent.
	WA	Washougal Chum	0	1	Includes cases where no data available	No basin-specific data is available; natural production of juveniles expected to be minimal.
	OR	Clackamas				
	OR	Sandy				
Gorge						
	WA	Lower Gorge	2	3	Includes case where extended data time series is available but trend fit is poor	Limited basin-specific data is available, but juvenile porduction is expected to be stable.
	WA	Upper Gorge	0	1	Includes cases where no data available	No basin-specific data is available; natural production of juveniles expected to be non-existent.

Table 1-11 Chinook Juvenile Out-migrants

Juvenile Out-migrants

Strata	State	Population	Score	Data	Criteria	Comments
Coast Fall						
	WA	Grays	0		Includes cases where no data available	No basin-specific juvenile data are available; natural juvenile production is expected to be low.
	WA	Elochoman	0		Includes cases where no data available	No basin-specific juvenile data are available; natural juvenile production is expected to be low.
	WA	Mill/Abernathy/Germany	1		Includes case where limited sample data indicate natural production occurs but data are insufficient to identify a trend	Natural juvenile production has been assumed to be low. In 1995, 910 fall chinook juveniles were captured in 10 seining trips to Abernathy Creek. Recent spawner escapement suggests that substantial natural production is occurring in Germany and Abernathy Creeks, or hatchery strays from other basins are utilizing these creeks.
	OR	Youngs Bay				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
Cascade Fall						
	WA	Lower Cowlitz	0		Includes cases where no data available	No basin-specific juvenile data are available. A smolt density model predicted the natural production potential for the Cowlitz River below Mayfield Dam of 2,183,000 smolts. Natural juvenile production is presumed to be low.
	WA	Coweeman	0		Includes cases where no data available	No basin-specific juvenile data are available. A smolt density model predicted the natural production potential for the Coweeman River of 602,000 smolts.
	WA	Toutle	0		Includes cases where no data available	No basin-specific juvenile data are available. A smolt density model predicted the natural production potential for the Toutle River of 2,799,000 smolts. Current natural juvenile production is presumed to be low.

	WA	Upper Cowlitz	1	Includes case where limited sample data indicate natural production occurs but data are insufficient to identify a trend	No basin-specific juvenile data are available, although naturally produced smolts, as well as hatchery smolts released in the upper basin, are collected at the Cowlitz Falls Dam and released to stress relief ponds at the Cowlitz Salmon Hatchery. A smolt density model predicted the natural production potential for the Cowlitz River above Cowlitz Falls of 4,058,000 smolts and 357,000 smolts for the Tilton River. Natural juvenile production is presumed to be low.
	WA	Kalama	0	Includes cases where no data available	A natural spawning escapement of 24,549 fall chinook in 1988 produced an estimated 522,312 to 964,439 juveniles in 1989 (estimated 43 to 79 juveniles produced per female). A smolt density model predicted natural production potential of 162,000 fingerlings above Kalama Falls and 428,670 fingerlings below Kalama Falls.
	WA	Lewis/Salmon	0	Includes cases where no data available	Estimates of annual natural juvenile fall chinook emigration from the Lewis River during 1977-1979 and 1982-1987 ranged from 1,540,000 to 4,650,000 (average 2,786,667). Substantial natural juvenile production occurs today as the Lewis River fall chinook run is maintained by natural production.
	WA	Washougal	0	Includes cases where no data available	A moderate amount of natural juvenile production is expected to occur. In 1980, WDFW estimated that 5,000,000 fall chinook juveniles emigrated from the Washougal basin.
	OR	Sandy			
	OR	Clackamas			
Gorge Fall					
	WA	Lower Gorge	1	Includes case where limited sample data indicate natural production occurs but data are insufficient to identify a trend	Productivity data are limited, but seining operations have shown consistent juvenile production from late spawning fall chinook in the mainstem Columbia near Bonneville.
	WA	Upper Gorge	1	Includes case where limited sample data indicate natural production occurs but data are insufficient to identify a trend	Naturally produced fall chinook juveniles are captured each year in the lower Wind River smolt trap, indicating some natural production is occurring. A smolt density model predicted natural smolt production potential of 206,608 fall chinook in the Wind and 73,652 fall chinook fingerlings in the Little White Salmon.

	WA	Big White Salmon	1	Includes case where limited sample data indicate natural production occurs but data are insufficient to identify a trend	
	OR	Hood			
Cascade late falls					
		Lewis NF	3	Requires extended data time series	Estimates of annual natural juvenile fall chinook emigration from the Lewis River during 1977-1979 and 1982-1987 ranged from 1,540,000 to 4,650,000 (average 2,786,667). Substantial natural juvenile production occurs today as the Lewis River fall chinook run is maintained by natural production.
		Sandy			
Cascade spring					
		Upper Cowlitz	3	Requires extended data time series	Records of natural production from juvenile trap and haul at Cowlitz Falls Project? A smolt density model predicted natural smolt production potential of 1,600,000 spring chinook in the Cowlitz above Mayfield Dam.
		Cispus	3	Requires extended data time series	
		Tilton	0	Includes cases where no data available	No basin-specific juvenile data are available; natural juvenile production is expected to be absent.
		Toutle	0	Includes cases where no data available	A smolt density model predicted natural smolt production potential of 788,400 spring chinook in the Toutle River.
		Kalama	0	Includes cases where no data available	No basin-specific juvenile data are available; natural juvenile production is expected to be low. A smolt density model predicted natural smolt production potential of 111,192 spring chinook smolts below Kalama Falls and 465,160 smolts above Kalama Falls.
		Lewis NF	0	Includes cases where no data available	No basin-specific juvenile data are available; natural juvenile production is expected to be low.
		Sandy			
Gorge spring					
		Big White Salmon	0	Includes cases where no data available	
		Hood			

Table 1-12. Steelhead Juvenile Out-migrants

Juvenile Out-migrants

Strata	State	Population	Score	Data	Criteria	Comments
Coast winter						
	WA	Grays	0		Includes cases where no data available	Basin-specific data are not available. A smolt density model predicted that the Grays could produce 45,300 winter steelhead smolts.
	WA	Elochoman/Skamokawa	0		Includes cases where no data available	A juvenile trap on Beaver Creek began operation in 1961; juvenile outmigration peaks in April and May. Annual trap counts have not been located; natural juvenile production in the basin is expected to be low.
	WA	Mill/Abernathy/Gemany	2		Includes case where extended data time series is available but trend fit is poor	Basin-specific data are not available; natural juvenile production in the basin is expected to be low.
Cascade winter						
	WA	Lower Cowlitz	0		Includes cases where no data available	Basin-specific data are not available; natural juvenile production in the basin is expected to be low. A smolt density model predicted potential production in the Cowlitz of 63,399 winter steelhead smolts.
	WA	Upper Cowlitz	2		Includes case where extended data time series is available but trend fit is poor	Moderate juvenile production has occurred from adult winter steelhead released in the upper Cowlitz. Juveniles have been collected at the Cowlitz Falls Project since 1996 and transported below the barrier dam.
	WA	Cispus	2		Includes case where extended data time series is available but trend fit is poor	
	WA	Tilton	2		Includes case where extended data time series is available but trend fit is poor	
	WA	Coweeman	0		Includes cases where no data available	Basin-specific data are not available; natural juvenile production in the basin is expected to be low. A smolt density model predicted potential production in the Coweeman of 38,229 winter steelhead smolts.

	WA	N.F. Toutle	0	0	Includes cases where no data available	Basin-specific data are not available; natural juvenile production in the basin is expected to be moderate. A smolt density model predicted potential production in the Toutle of 135,573 winter steelhead smolts.
	WA	S.F. Toutle	0	0	Includes cases where no data available	Basin-specific data are not available; natural juvenile production in the basin is expected to be moderate. A smolt density model predicted potential production in the Toutle of 135,573 winter steelhead smolts.
	WA	Kalama	2	3	Includes case where extended data time series is available but trend fit is poor	WDFW has estimated potential summer and winter steelhead smolt production in the Kalama at 34,850. The number of naturally-produced steelhead smolts migrating annually from the Kalama during 1978-1984 ranged from 11,175 to 46,659.
	WA	E.F. Lewis	1		Includes case where limited sample data indicate natural production occurs but data are insufficient to identify a trend	Basin-specific data are not available; natural juvenile production in the basin is expected to be moderate.
	WA	N.F. Lewis	2		Includes case where extended data time series is available but trend fit is poor	Basin-specific data are not available; natural juvenile production in the basin is expected to be low.
	WA	Salmon	0		Includes cases where no data available	Basin-specific data are not available; natural juvenile production in the basin is expected to be low.
	WA	Washougal	0		Includes cases where no data available	Basin-specific data are not available; natural juvenile production in the basin is expected to be low.
	OR	Clackamas				
	OR	Sandy				
Gorge winter						
	WA	Lower Gorge Tribs	0		Includes cases where no data available	Basin-specific data are not available; natural juvenile production in the basin is expected to be low.
	WA	Upper Gorge Tribs	2		Includes case where extended data time series is available but trend fit is poor	Wild steelhead smolt yield from 1995 to 1999 showed increasing production with a low of about 8,000 smolts in 1995 to a high of about 24,000 smolts in 1998 (contribution of winter and summer steelhead in these estimates is not known).
	OR	Hood				
Cascade summer						

	WA	Kalama	2	3	Includes case where extended data time series is available but trend fit is poor	WDFW has estimated potential summer and winter steelhead smolt production in the Kalama at 34,850. The number of naturally-produced steelhead smolts migrating annually from the Kalama during 1978-1984 ranged from 11,175 to 46,659.
	WA	N.F. Lewis	0	1	Includes cases where no data available	Basin-specific data are not available; natural juvenile production in the basin is expected to be low.
	WA	E.F. Lewis	1	1	Includes case where limited sample data indicate natural production occurs but data are insufficient to identify a trend	Basin-specific data are not available; natural juvenile production in the basin is expected to be moderate.
	WA	Washougal	0	0	Includes cases where no data available	Basin-specific data are not available; natural juvenile production in the basin is expected to be moderate.
Gorge summer						
	WA	Wind	2.5	3.5	Includes case where extended data time series is available but trend fit is poor	Wild steelhead smolt yield from 1995 to 1999 showed increasing production with a low of about 8,000 smolts in 1995 to a high of about 24,000 smolts in 1998 (contribution of winter and summer steelhead in these estimates is not known). A smolt density model predicted potential summer steelhead smolt production in the Wind basin at 62,273.
	OR	Hood				

1.4 Within-Population Spatial Structure

Table 1-13. Within-Population Spatial Structure Score Description

Category	Description	Application[1]
0	Spatial structure is inadequate in quantity, quality[2], and connectivity to support a population at all.	Quantity was based on whether all areas that were historically used remain accessible. Connectivity based on whether all accessible areas of historic use remain in use. Catastrophic risk based on whether key use areas are dispersed among multiple reaches or tributaries. Spatial scores of 0 were typically assigned to populations that were functionally extirpated by passage blockages.
1	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population far below viable size	The majority of the historic range is no longer accessible and fish are currently concentrated in a small portion of the accessible area.
2	Spatial structure is adequate in quantity, quality[2], and connectivity to support a population of moderate but less than viable size.	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.
3	Spatial structure is adequate in quantity, quality[2], and connectivity to support population of viable size, but subcriteria for dynamics and/or catastrophic risk are not met	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.
4	Spatial structure is adequate in quantity, quality, connectivity, dynamics, and catastrophic risk to support viable population.	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.

Table 1-14. Chum Within-Population Spatial Structure

Within-Population Spatial Structure

Strata	State	Population	Score	Data	Criteria	Comments
Coast						
	WA	Grays/Chinook	2	3	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	Spawning is concentrated in mainstem Grays River from rm 9.5-13.0, the lower 1.4 miles of the West Fork, the lower 0.5 miles of Crazy Johnson Creek, and Gorley Creek. Substantial tributary spawning occurs in years of higher flow. Lack of stable spawning habitat is considered the primary physical limitation on chum production.
	WA	Elochoman/Skamokawa	3	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Chum have access to all historical habitat; however, current spawning activity is concentrated to the lower reaches of the basin above tidal influence.
	WA	Mill/Abernathy/Germany	3	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Chum have access to all historical habitat; however, current spawning activity is concentrated in the lower 0.4 miles of Abernathy Creek and the lower reaches of other creeks above tidal influence.
	OR	Youngs				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
Cascade						

WA	Cowlitz Chum	3	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Historically, chum were thought to primarily utilize the lower Cowlitz and its tributaries below the Mayfield Dam site, although chum were also observed in the upper basin. Access to the upper watershed was blocked by the construction of Mayfield Dam in 1962. Recent observations identified chum in the headwaters of Lacamas Creek. The remaining few chum salmon are thought to be distributed throughout the lower watershed.
WA	Kalama Chum	3	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Chum have access to all historic habitat. Current chum habitat is limited to the mainstem Kalama between Modrow Bridge (rm 2.4) and lower Kalama Falls (rm 10).
WA	Lewis Chum	3	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Construction of Merwin Dam in 1932 blocked access to most of the productive habitat in the basin, however, the degree to which chum salmon historically utilized the upper basin is not clear. Chum salmon have been observed spawning in the mainstem downstream of Merwin Dam. Today, chum spawning in the East Fork occurs up to rm 10 and available habitat likely extends up to Lucia Falls (rm 21.3).
WA	Salmon Chum	1.5	1	The majority of the historic range is no longer accessible and fish are currently concentrated in a small portion of the accessible area.	Minimal work on chum salmon has been performed leading to a high degree of uncertainty in the population spatial structure. Most of the historic habitat accessible to salmonids is expected to be accessible today, although quality has been degraded.
WA	Washougal Chum	3	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all	Chum have access to all historic habitat. Spawning is believed to occur in the Little Washougal and the lower reaches of the mainstem Washougal.

					historical areas remain accessible and are used but key use areas are not broadly distributed.	
	OR	Clackamas				
	OR	Sandy				
Gorge						
	WA	Lower Gorge	3	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Chum have access to all historic habitat. Spawning occurs in the lower 1.0 mile of Hardy, Hamilton, Duncan, Greenleaf, and Indian Mary Creeks, as well as side channel habitat in the Columbia River near the I-205 Bridge and Ives and Pierce Islands. However, spawning habitat water flow is affected by Bonneville Dam operations; thus, habitat productivity varies annually.
	WA	Upper Gorge	1.5	2	The majority of the historic range is no longer accessible and fish are currently concentrated in a small portion of the accessible area.	Historic chum production occurred in the lower reaches of these basins, below impassable falls. These areas were inundated with the Bonneville Pool (1938) and are not expected to be suitable habitat. Shipherd Falls on the Wind River was laddered in 1956, providing access to the upper watershed.

Table 1-15. Chinook Within-Population Spatial Structure

Within-Population Spatial Structure						
Strata	**State**	**Population**	**Score**	**Data**	**Criteria**	**Comments**
Coast Fall						
	WA	Grays	4		All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Spawning occurs in the mainstem Grays River from tidewater (rm 8) to above the confluence with the West Fork (rm 14) and also in the lower 1.5 miles of the West Fork from the mouth to the hatchery. Historical habitat in the basin remains accessible today, however, low seasonal water flows have been a chronic problem for natural and hatchery chinook production.
	WA	Elochoman	3		Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Spawning occurs in the mainstem Elochoman River from tidewater (rm 4) to the Elokomin Salmon Hatchery (rm 9.2); the upper portions of this reach are only accessible during favorable water flows. Spawning occurs in Skamokawa Creek from Wilson Creek upstream to Standard and McDonald Creeks (~4.5 miles). Historical habitat in the basin remains accessible today.
	WA	Mill/Abernathy/Germany	4		All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	In Mill Creek, spawning occurs from the Mill Creek Bridge downstream to the mouth (2 miles). In Abernathy Creek, spawning occurs from the Abernathy NFH downstream to the mouth (3 miles). In Germany Creek, spawning occurs in the lower 3.5 miles of the basin. Historical habitat in the basin remains accessible today.
	OR	Youngs Bay				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
Cascade Fall						

WA	Lower Cowlitz	4	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Spawning occurs throughout the mainstem Cowlitz from the Cowlitz Salmon Hatchery downstream to the Kelso Bridge (~45 miles), but is concentrated in the 8-mile stretch between the Cowlitz Salmon and Trout Hatcheries. Historical habitat in the basin remains accessible today.
WA	Coweeman	4	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Spawning occurs primarily in the mainstem from Mulholland Creek (rm 18.4) downstream to the Jeep Club Bridge (~6 miles). Historical habitat in the basin remains accessible today.
WA	Toutle	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Most historic spawning occurred in the lower 5 miles of the mainstem Toutle, although spawning was observed far into the headwaters (Coldwater Creek on the North Fork ~46 miles from the mouth). Most historic spawning areas in the basin were destroyed in the 1980 Mt. St. Helens eruption. In the South Fork Toutle, spawning occurs primarily from the 4700 Bridge to the confluence with the mainstem (~2.6 miles). In the Green River, spawning occurs primarily from the North Toutle Hatchery to the river mouth (~0.5 miles).
WA	Upper Cowlitz	2	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	An estimated 46% of the total Cowlitz fall chinook run historically came from areas above Mayfield Dam; 28% of the spawning grounds were inundated by the Mayfield and Mossyrock Reservoirs. The completion of Mayfield Dam in 1962 blocked access to the upper watershed; all fish were passed over the dam from 1962-1966 and small numbers of fall chinook were hauled to the Tilton and upper Cowlitz from 1967-1980. An adult trap and haul program began in 1994; fall chinook collected at Mayfield Dam have been released in the Tilton, upper Cowlitz, and Cispus Rivers. Collection efficiency and the ability to pass juvenile production through the system varies annually and is affected by flow and operations at the Cowlitz Falls Project.

	WA	Kalama	4	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Historic fall chinook spawning occurred primarily in the mainstem Kalama between lower Kalama Falls (rm 10) and the Modrow Bridge (rm 2.4); this reach remains accessible today. Also, fall chinook surplus to hatchery broodstock needs are passed above the falls and allowed to spawn naturally in the upper river.
	WA	Lewis/Salmon	4	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	NF Lewis fall chinook historically spawned in the mainstem Lewis up to the Yale Dam site. Construction of Merwin Dam in 1931 blocked access to approximately half of the fall chinook spawning habitat in the NF Lewis. In the EF Lewis, fall chinook historically spawned from Lucia Falls (rm 21.3) downstream to below Daybreak Park near rm 6.2; this reach remains accessible today.
	WA	Washougal	4	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	A ladder was constructed at Salmon Falls (rm 14.5) in the late 1950s, providing access to Dougan Falls (rm 21.6). Fall chinook have generally spawned from Salmon Falls downstream about 4 miles; this area remains accessible today.
	OR	Sandy			
	OR	Clackamas			
Gorge Fall					
	WA	Lower Gorge	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Available habitat today is expected to be similar to habitat that existed in 1994 when the population was discovered.

	W A	Upper Gorge	2	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	Historically, fall chinook spawned in the lower 2 miles of the Wind River below Shipherd Falls. The Bonneville Pool inundated the primary fall chinook spawning area in 1938. The falls were laddered in 1956, providing access to the upper basin. Fall chinook have been observed up to the Carson NFH (rm 18), but spawning in the mainstem above Shipherd Falls is limited. Limited fall chinook spawning occurs in the lower river below Shipherd Falls. Historic fall chinook spawning in the Little White Salmon was also concentrated to the lower 2 miles of river below a barrier; this lower reach was also inundated by the Bonneville Pool (1938). Natural spawning in the Little White Salmon River is primarily from hatchery strays.
	W A	Big White Salmon	2	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	
	OR	Hood			
Cascade late falls					
	WA	Lewis NF	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Construction of Merwin Dam in 1931 blocked access to approximately half of the fall chinook spawning habitat in the NF Lewis.
	OR	Sandy			
Cascade spring					

WA	Upper Cowlitz	2	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	In the 1950s, 96% of the spring chinook production in the Cowlitz River was estimated to have occurred above Mayfield Dam; completion if the dam in 1962 blocked access to the upper Cowlitz. All fish were passed over the dam from 1962-1966; from 1974-1980, an annual average of 2,838 spring chinook were hauled to the Tilton and upper Cowlitz. A trap and haul program began at Mayfield in 1994; spring chinook are released in the upper Cowlitz and Cispus.
WA	Cispus	2	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	Historically, spring chinook spawning occurred in the Cispus between Iron and East Canyon Creeks. Access to the Cispus was blocked by the construction of Mayfield Dam in 1962.Returning spring chinook captured at Mayfield Dam have been released in the Cispus since 1994.
WA	Tilton	0	Quantity was based on whether all areas that were historically used remain accessible. Connectivity based on whether all accessible areas of historic use remain in use. Catastrophic risk based on whether key use areas are dispersed among multiple reaches or tributaries. Spatial scores of 0 were typically assigned to populations that were functionally extirpated by passage blockages.	Access to the Tilton was blocked by the construction of Mayfield Dam in 1962. Adults captured at Mayfield were released in the basin in the late 1970s, primarily for the sport fishery. The Tilton is not included in the current Mayfield trap and haul program that began in 1994.
WA	Toutle	4	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Natural spawning in the Toutle is expected to be minimal; little is known about specific spring chinook spawning areas in the Toutle. Most of the quality spawning habitat was destroyed by the 1980 Mt. St. Helens eruption; the system continues to recover through natural processes. Fish access has not been blocked by hydro projects.

	WA	Kalama	4	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Historic spring chinook spawning occurred primarily in the mainstem Kalama between lower Kalama Falls (rm 10) and the Lower Kalama Hatchery (Fallert Creek; rm 4.8); this reach remains accessible today. Also, spring chinook surplus to hatchery broodstock needs are passed above the falls and allowed to spawn naturally in the upper river; spring chinook have been observed up to upper Kalama Falls (rm 36).
	WA	Lewis NF	0	Quantity was based on whether all areas that were historically used remain accessible. Connectivity based on whether all accessible areas of historic use remain in use. Catastrophic risk based on whether key use areas are dispersed among multiple reaches or tributaries. Spatial scores of 0 were typically assigned to populations that were functionally extirpated by passage blockages.	NF Lewis fall chinook historically spawned in the mainstem Lewis upstream of the Merwin Dam site. Construction of Merwin Dam in 1931 blocked access to approximately 80% of the spring chinook spawning habitat in the NF Lewis. Currently, spawning occurs in the mainstem Lewis and tributaries between Merwin Dam and the Lewis River Hatchery (~4 miles); however, spawning is concentrated below Merwin Dam and in Cedar Creek.
	OR	Sandy			
Gorge spring					
	WA	Big White Salmon	0	Quantity was based on whether all areas that were historically used remain accessible. Connectivity based on whether all accessible areas of historic use remain in use. Catastrophic risk based on whether key use areas are dispersed among multiple reaches or tributaries. Spatial scores of 0 were typically assigned to populations that were functionally extirpated by passage blockages.	

	OR	Hood				

Table 1-16. Steelhead Within-Population Spatial Structure

Within-Population Spatial Structure

Strata	State	Population	Score	Data	Criteria	Comments
Coast winter						
	WA	Grays	4		All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Steelhead were historically distributed throughout the Grays basin. Grays River Falls (rm 13) was lowered with explosives in 1957; numerous other natural and man-made barriers above Grays Falls were cleared to improve steelhead access in the 1950s. Currently, steelhead are thought to be distributed throughout the entire basin.
	WA	Elochoman/Skamokawa	4		All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Steelhead are distributed throughout the mainstem Elochoman and Skamokawa, as well as the lower reaches of most tributaries. Areas thought to be historically used by steelhead remain accessible today.
	WA	Mill/Abernathy/Gemany	4		All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Steelhead are distributed throughout the mainstem Mill, Germany, and Abernathy Creeks, as well as many tributaries. Areas thought to be historically used by steelhead remain accessible today.
Cascade winter						
	WA	Lower Cowlitz	2		The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	Historically, the lower Cowlitz provided about 20% of the steelhead production area in the Cowlitz basin. These areas remain accessible today, although minimal steelhead production occurs in just a few key production areas.

WA	Upper Cowlitz	2	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	Historically, the upper Cowlitz provided about 80% of the steelhead production area in the Cowlitz basin. Completion of Mayfield Dam in 1962 blocked access to this production area. A trap and haul program to reintroduce salmonids to the upper basin began in 1994; winter steelhead are released in the upper Cowlitz, Cispus, and Tilton basins. Juveniles have been collected at the Cowlitz Falls Project since 1996 and transported below the barrier dam.
WA	Cispus	2	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	
WA	Tilton	2	The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	
WA	Coweeman	4	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Winter steelhead were historically distributed throughout the Coweeman basin. Historic habitat remains accessible today.
WA	N.F. Toutle	3	Areas may have been blocked or are no long used but fish continue to be broadly distributed among multiple reaches and tributaries. Also includes populations where all historical areas remain accessible and are used but key use areas are not broadly distributed.	Winter steelhead were historically distributed throughout the North Fork Toutle and Green River basins. Historic habitat remains accessible today. In the North Fork, spawning occurs in the mainstem and Alder and Deer Creeks. In the Green, spawning occurs in the mainstem and Devil, Elk, and Shultz Creek.
WA	S.F. Toutle	4	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Winter steelhead were historically distributed throughout the South Fork Toutle. Historic habitat remains accessible today. Spawning occurs in the mainstem and Studebaker, Johnson, and Bear Creeks.

	WA	Kalama	4	3	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Historically, steelhead were confined to below lower Kalama Falls; steelhead could only navigate the falls under certain water conditions. A fishway was constructed at the falls in 1936, providing easier access to the upper watershed. Historic habitat remains accessible today. Spawning occurs in the mainstem and many tributaries, including Gobar, Elk, and Fossil Creeks. Upper Kalama Falls at rm 36.8 blocks all upstream migration.
	WA	E.F. Lewis	4		All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Winter steelhead were historically distributed throughout the basin below Sunset Falls; the falls were lowered in 1982, providing access in the basin up to Lucia Falls (rm 21.3). Thus, more habitat is accessible today than was available historically. About 12% of the annual return currently spawns above Sunset Falls; spawning occurs throughout the mainstem and in many tributaries, including Rock Creek.
	WA	N.F. Lewis	2		The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	Construction of Merwin Dam in 1932 blocked access to about 80% of the North Fork's historical production area. A mill dam on Cedar Creek blocked passage until 1946 when the dam was removed. Current natural production is limited; spawning is concentrated in Cedar Creek.
	WA	Salmon	4		All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Historically, winter steelhead were believed to be distributed throughout Salmon Creek. Historic habitat remains accessible today. Spawning currently occurs throughout Salmon Creek, portions of Lake River, and the lower reaches of Gee, Whipple, and Burntbridge Creek.
	WA	Washougal	4		All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Steelhead were historically distributed throughout the Washougal basin. Historic habitat remains accessible today. Several small dams that impeded/blocked steelhead migration have been removed or bypassed, providing access in the basin up to Dougan Falls (rm 21.6). Spawning is thought to occur throughout the mainstem and in many tributaries, including the West Fork, the Little Washougal, and Stebbins and Cougar Creeks.
	OR	Clackamas				
	OR	Sandy				
Gorge						

winte r						
	WA	Lower Gorge Tribs	4		All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Winter steelhead were historically distributed throughout the lower reaches (~2 miles) of Hamilton Creek. Historic habitat remains accessible today, although spawning usage is not well documented.
	WA	Upper Gorge Tribs	2		The majority of the historic range is accessible but fish are currently concentrated in a small portion of the accessible area.	Winter steelhead were historically distributed throughout the Wind basin; Shipherd Falls (rm 2.1) was expected to be a natural barrier to most salmonids, except for steelhead. The Bonneville Pool inundated spawning and rearing habitat in the lower river below Shipherd Falls. Shipherd Falls was laddered in 1956, providing easier access to the upper watershed. Historic habitat remains accessible today. Numerous drop-offs and waterfalls exist throughout the basin; some have been modified to promote fish passage while others remain and impede migration. Winter steelhead are thought to be distributed through the lower 11 miles of the mainstem and Trout Creek.
	OR	Hood				
Cascade summer						
	WA	Kalama	4	3	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Historically, steelhead were confined to below lower Kalama Falls; steelhead could only navigate the falls under certain water conditions. A fishway was constructed at the falls in 1936, providing easier access to the upper watershed. Historic habitat remains accessible today. Spawning occurs in the mainstem and many tributaries, including the North Fork, Gobar, Elk, Fossil, and Wild Horse Creeks. Upper Kalama Falls at rm 36.8 blocks all upstream migration.
	WA	N.F. Lewis	0	4	Quantity was based on whether all areas that were historically used remain accessible. Connectivity based on whether all accessible areas of historic use remain in use. Catastrophic risk based on whether key use areas are dispersed among multiple	Construction of Merwin Dam in 1932 blocked access to about 80% of the North Fork's historical production area. A mill dam on Cedar Creek blocked passage until 1946 when the dam was removed. Current natural production is limited; spawning is concentrated in Cedar Creek and in the mainstem between rm 7 and rm 20.

					reaches or tributaries. Spatial scores of 0 were typically assigned to populations that were functionally extirpated by passage blockages.	
	WA	E.F. Lewis	4	2.5	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Summer steelhead were historically distributed throughout the basin below Sunset Falls; the falls were lowered in 1982, providing access in the basin up to Lucia Falls (rm 21.3). Thus, more habitat is accessible today than was available historically. About 12% of the annual return currently spawns above Sunset Falls; spawning occurs throughout the mainstem and in many tributaries, including Rock Creek.
	WA	Washougal	4	2.5	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Steelhead were historically distributed throughout the Washougal basin. Historic habitat remains accessible today. Several small dams that impeded/blocked steelhead migration have been removed or bypassed, providing access in the basin up to Dougan Falls (rm 21.6). Spawning is thought to occur throughout the mainstem and in many tributaries, including the West Fork, the Little Washougal, and Stebbins and Cougar Creeks.
Gorge summer						
	WA	Wind	4	2.5	All areas that were historically used remain accessible, all accessible areas remain in use, and key use areas are broadly distributed among multiple reaches or tributaries.	Summer steelhead were historically distributed throughout the Wind basin; Shipherd Falls (rm 2.1) was expected to be a natural barrier to most salmonids, except for steelhead. The Bonneville Pool inundated spawning and rearing habitat in the lower river below Shipherd Falls. Shipherd Falls was laddered in 1956, providing easier access to the upper watershed. Historic habitat remains accessible today. Numerous drop-offs and waterfalls exist throughout the basin; some have been modified to promote fish passage while others remain and impede migration. Summer steelhead are thought to be distributed through the mainstem and numerous tributaries, including the Little Wind River, Panther Creek, Bear Creek, Trout Creek, Trapper Creek, Dry Creek, and Paradise Creek.

OR	Hood	

1.5 Within Population Diversity

Table 1-17. Within-Population Diversity Score Description

Category	Description	Application[1]
0	All four diversity elements (life history diversity, gene flow and genetic diversity, utilization of diverse habitats[2], and resilience and adaptation to environmental fluctuations) are well below predicted historical levels, extirpated populations, or remnant populations of unknown lineage	Life history diversity was based on comparison of adult and juvenile migration timing and age composition. Genetic diversity was based on the occurrence of small population bottlenecks in historic spawning escapement and degree of hatchery influence especially by non local stocks. Resiliency was based on observed rebounds from periodic small escapement. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.
1	At least two diversity elements are well below historical levels. Population may not have adequate diversity to buffer the population against relatively minor environmental changes or utilize diverse habitats. Loss of major presumed life history phenotypes is evident; genetic estimates indicate major loss in genetic variation and/or small effective population size. Factors that severely limit the potential for local adaptation are present.	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.
2	At least one diversity element is well below predicted historical levels; population diversity may not be adequate to buffer strong environmental variation and/or utilize available diverse habitats. Loss of life history phenotypes, especially among important life history traits, and/or reduction in genetic variation is evident. Factors that limit the potential for local adaptation are present.	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.
3	Diversity elements are not at predicted historical levels, but are at levels able to maintain a population. Minor shifts in proportions of historical life-history variants, and/or genetic estimates, indicate some loss in variation (e.g. number of alleles and heterozygosity), and conditions for local adaptation processes are present.	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.
4	All four diversity elements are similar to predicted historical levels. A suite of life-history variants, appropriate levels of genetic variation, and conditions for local adaptation processes are present.	Stable life history patterns, minimal hatchery influence, no extended interval of critical low escapements, and rapid rebounds from periodic declines in numbers.

Table 1-18. Chum Within-Population Diversity

Within-Population Diversity

Strata	State	Population	Score	Data	Criteria	Comments
Coast						
	WA	Grays/Chinook	3	3	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.	Historic hatchery releases were intermittent and unsuccessful at establishing a hatchery run. Population has remained relatively stable over time.
	WA	Elochoman/Skamokawa	1	3	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.	Regular hatchery releases of outside stocks occurred through 1983. Although spawning surveys are not conducted, wild runs are believed to have consistently experienced very low escapements.
	WA	Mill/Abernathy/Germany	1	3	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.	Regular hatchery releases of outside stocks occurred through 1991. Although spawning surveys are not conducted, wild runs are believed to have consistently experienced very low escapements.
	OR	Youngs				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
Cascade						
	WA	Cowlitz Chum	1	3	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.	Hatchery releases of chum salmon have not occurred in the Cowlitz basin; however, the wild run is believed to have consistently experienced very low escapements.
	WA	Kalama Chum	1	3	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple	Hatchery releases of chum salmon have not occurred in the Kalama basin; however, the wild run is believed to have consistently experienced very low escapements.

					years.	
	WA	Lewis Chum	1	3	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.	Hatchery releases of chum salmon have not occurred in the Lewis basin; however, the wild run is believed to have consistently experienced very low escapements.
	WA	Salmon Chum	1	1	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.	Hatchery releases of chum salmon have not been documented in the Salmon Creek basin; however, the wild run is believed to have consistently experienced very low escapements.
	WA	Washougal Chum	2	3	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases of chum salmon have not occurred in the Washougal basin; however, the wild run is believed to have consistently experienced low escapements.
	OR	Clackamas				
	OR	Sandy				
Gorge						
	WA	Lower Gorge	4	3	Stable life history patterns, minimal hatchery influence, no extended interval of critical low escapements, and rapid rebounds from periodic declines in numbers.	Historic hatchery releases in chum salmon did not occur in these tributaries. The Washougal Hatchery is currently rearing wild Hardy Creek chum stock for enhancement efforts in Duncan Creek.
	WA	Upper Gorge	1	3	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.	Hatchery releases of chum salmon have not occurred in the Wind or Little White Salmon basins; however, the wild run is believed to have consistently experienced very low escapements.

Table 1-19. Chinook Within-Population Diversity

Within-Population Diversity

Strata	State	Population	Score	Data	Criteria	Comments
Coast Fall						
	WA	Grays	2.5		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases of fall chinook began in the basin in 1947; annual releases generally ranged between 2 to 4 million, although about 17 million smolts were released in 1980. Straying and transfer of fall chinook stock has resulted in a blended hatchery stock. The last release of fall chinook in the Grays occurred in 1997; the program was discontinued because of funding cuts.
	WA	Elochoman	2		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases of fall chinook began in the basin in 1950; annual releases generally ranged between 2 to 4 million, although about 7 million smolts were released in 1980. Straying and transfer of fall chinook stock has resulted in a blended hatchery stock. Current annual fall chinook release goal is 2 million smolts in the Elochoman River; hatchery fall chinook are not released in Skamokawa Creek.
	WA	Mill/Abernathy/Germany	2		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases of fall chinook began in Abernathy Creek in 1960. Annual releases from the Abernathy Creek NFH averaged 1 million fish from 1974-1994; the program was discontinued in 1995 because of funding cuts. Approximately 1 million fall chinook from other hatchery programs were released annually in Abernathy Creek from 1960-1977. Straying and transfer of fall chinook stock has resulted in a blended hatchery stock.
	OR	Youngs Bay				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
Cascade Fall						

WA	Lower Cowlitz	2.5	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases of fall chinook in the Cowlitz began in 1952; since the late 1960s, hatchery annual releases have generally ranged from 4 to 8 million, but have been as high as 14 million. The current Cowlitz Salmon Hatchery fall chinook annual production goal is 5 million juveniles; some juveniles are released in the upper Cowlitz to rear and others are reared to smolts in the hatchery and released in the lower Cowlitz.
WA	Coweeman	3	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.	Hatchery influence on this stock has been fairly limited; the stock is representative of indigenous fall chinook populations in the Cowlitz River basin. Hatchery releases of fall chinook in the Coweeman from out of basin stocks occurred from 1951-1979; releases were discontinued in 1980. Only one CWT hatchery stray has ever been recovered in spawning surveys.
WA	Toutle	2	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases of fall chinook in the Toutle began in 1951; since the mid 1960s, hatchery annual releases have generally ranged from 2 to 6 million. The current North Toutle Hatchery fall chinook annual production goal is 2.5 million sub-yearlings. The hatchery was destroyed in the 1980 eruption of Mt. St. Helens; rearing ponds in the basin began operation in 1985 and the hatchery resumed broodstock collection in 1990.
WA	Upper Cowlitz	2	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	The current Cowlitz Salmon Hatchery fall chinook annual production goal is 5 million juveniles; some juveniles are released in the upper Cowlitz to rear and others are reared to smolts in the hatchery and released in the lower Cowlitz.

WA	Kalama	2.5	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases of fall chinook in the Kalama began in 1895; releases since the 1960s have generally ranged from 2 to 6 million, but have been as high as 15 million annually. Current annual hatchery fall chinook production goal is 5 million smolts. Natural spawning in the basin is sustained by first generation hatchery fish.
WA	Lewis/Salmon	3	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.	Hatchery releases of fall chinook began in the NF Lewis in the early 1900s. Hatchery releases were generally under 1 million fish, however, were as high as 2.5 million annually. Hatchery releases were discontinued in 1986 to eliminate interaction with the healthy wild population. The run today is maintained by natural production with little hatchery influence. Hatchery fall chinook were not released in the EF Lewis.
WA	Washougal	2	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases of fall chinook in the Washougal began in the 1950s; releases since the 1960s have generally ranged from 1 to 6 million, but have been as high as 12 million annually. Current annual hatchery fall chinook production goal is 3.5 million. Natural spawning in the basin is sustained by first generation hatchery fish.
OR	Sandy			
OR	Clackamas			
Gorge Fall				
WA	Lower Gorge	2.5	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	The Spring Creek NFH released 50,160 fall chinook in Hamilton Creek in 1977. Origin of the existing population is not known, however, likely is from hatchery strays. Hatcheries in the area that produce the bright fall chinook stock include the Bonneville Hatchery, the Little White Salmon NFH, and the Spring Creek NFH?

WA	Upper Gorge	2.5	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery fall chinook production began in the Wind River in 1899. Fall chinook releases average 2 million fish annually from 1952-1976. Fall chinook hatchery releases in the Wind River were discontinued in 1976. The current fall chinook run in the Wind River is thought to be a derivative of Spring Creek NFH stock. Hatchery fall chinook production began in the Wind River in 1899. Hatchery production shifted from tules to upriver brights in 1988 as part of mitigation agreements; current annual release goals in the Little White Salmon are 2 million.
WA	Big White Salmon	2.5	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	
OR	Hood			
Cascade late falls				
WA	Lewis NF	3.5	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.	
OR	Sandy			
Cascade spring				
WA	Upper Cowlitz	2	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery juvenile spring chinook are released above Cowlitz Falls Dam to rear in the upper Cowlitz; outmigrating juveniles are captured at the Cowlitz Falls Project and released in the lower Cowlitz. Adults collected at Mayfield since 1994 and released in the upper Cowlitz are primarily first generation hatchery fish. Production is sustained through hatchery adults and juveniles.

WA	Cispus	2	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery juvenile spring chinook are released in the Cispus to rear; outmigrating juveniles are captured at the Cowlitz Falls Project and released in the lower Cowlitz. Adults collected at Mayfield since 1994 and released in the Cispus are primarily first generation hatchery fish. Production is sustained through hatchery adults and juveniles.
WA	Tilton	0	Life history diversity was based on comparison of adult and juvenile migration timing and age composition. Genetic diversity was based on the occurrence of small population bottlenecks in historic spawning escapement and degree of hatchery influence especially by non local stocks. Resiliency was based on observed rebounds from periodic small escapement. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.	Natural spawning escapements have not been observed in the Tilton since the 1950s; hatchery fish have not been planted in the basin since 1980. The Tilton spring chinook run has likely been extirpated.
WA	Toutle	0	Life history diversity was based on comparison of adult and juvenile migration timing and age composition. Genetic diversity was based on the occurrence of small population bottlenecks in historic spawning escapement and degree of hatchery influence especially by non local stocks. Resiliency was based on observed rebounds from periodic small escapement. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.	Natural spring chinook production in the Toutle has historically been low. Hatchery releases in the basin from the late 1960s through the present have been to provide for the sport fishery. Any production in the basin is likely from hatchery strays.
WA	Kalama	1	Natural spawning populations have been affected by large fractions of non-local hatchery stocks, substantial shifts in life history have been documented, and wild populations have experienced very low escapements over multiple years.	A spring chinook hatchery program in the Kalama began in 1959; releases since the 1960s have generally ranged from 200,000 to 500,000 smolts annually. Spring chinook releases from 1967-2001 averaged 378,280; the 2002 hatchery spring chinook release total was 332,200 smolts. Natural spawning in the basin is sustained by first generation hatchery fish.

	WA	Lewis NF	0	Life history diversity was based on comparison of adult and juvenile migration timing and age composition. Genetic diversity was based on the occurrence of small population bottlenecks in historic spawning escapement and degree of hatchery influence especially by non local stocks. Resiliency was based on observed rebounds from periodic small escapement. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.	Hatchery releases of spring chinook began in the NF Lewis in the early 1900s. Annual hatchery releases from 1972-1990 averaged 601,184; recent year releases have fluctuated near 1.2 million spring chinook. Natural spawning in the basin is sustained by first generation hatchery fish.
	OR	Sandy			
Gorge spring					
	OR	Big White Salmon	0	Life history diversity was based on comparison of adult and juvenile migration timing and age composition. Genetic diversity was based on the occurrence of small population bottlenecks in historic spawning escapement and degree of hatchery influence especially by non local stocks. Resiliency was based on observed rebounds from periodic small escapement. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.	
	OR	Hood			

Table 1-20. Steelhead Within-Population Diversity

Within-Population Diversity						
Strata	State	Population	Score	Data	Criteria	Comments
Coast winter						
	WA	Grays	2.5		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Winter steelhead hatchery fish have been planted in the basin since 1957. Releases since the early 1980s has generally fluctuated between 30,000 and 50,000; from 1990-2000, annual releases have average about 45,000.
	WA	Elochoman/Skamokawa	2		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Winter steelhead hatchery fish have been planted in the basin since 1955. Annual releases have fluctuated near 100,000 smolts since the early 1980s. The Beaver Creek Hatchery, which produced steelhead for release in the basin, closed in 1999.
	WA	Mill/Abernathy/Gemany	2		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery steelhead have rarely been planted in Mill Creek; winter steelhead have been released in Abernathy and Germany Creeks since 1961. Releases since the early 1980s have fluctuated between 5,000 and 15,000 for both Abernathy and Germany Creeks; the largest winter steelhead release was about 32,000 smolts to Germany Creek in the late 1980s.
Cascade winter						
	WA	Lower Cowlitz	2		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery winter steelhead have been planted in the basin since 1957. Hatchery releases since 1980 have generally fluctuated between 400,000 and 800,000 smolts. WDFW is currently managing for an annual smolt production of 750,000. Wild steelhead escapement has been extremely low since the 1970s.
	WA	Upper Cowlitz	2		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Wild steelhead have not had access to the upper watershed since the completion of Mayfield Dam in 1962. Hatchery adults have been released in the upper Cowlitz, Cispus, and Tilton River basins since 1994; naturally-produced juveniles are collected at the Cowlitz Falls Project and transported to the lower Cowlitz.

WA	Cispus	2	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	
WA	Tilton	2	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	
WA	Coweeman	2.5	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery winter steelhead have been planted in the Coweeman since 1957; most plants came from an out of basin brood source. Hatchery releases generally ranged from 30,000 to 50,000, but recent releases have been under 20,000. Hatchery adults comprise most of the annual return.
WA	N.F. Toutle	3	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.	Hatchery winter steelhead have been planted in the North Fork Toutle since 1953; hatchery releases generally ranged from 20,000 to 25,000. Winter steelhead hatchery plants have not occurred in recent years. Aside from small releases of winter steelhead fry in the the Green River after the 1980 Mt. St. Helens eruption, hatchery fish have not been released in the Green River. Current day returns are expected to be completely from natural production.
WA	S.F. Toutle	3	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.	Hatchery winter steelhead influence in the South Fork Toutle has been minimal. Total winter steelhead hatchery releases in the basin from 1968-1985 have been estimated at 58,079. Current returns are expected to be completely from natural production.

WA	Kalama	3.5	3.5	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.	Intermittent hatchery winter steelhead releases began in the Kalama in 1938; annual releases began in 1955. Hatchery releases since the early 1980s have fluctuated near 100,000, except for 1999 when about 300,000 hatchery winter steelhead were released. From 1991-1996, approximately 31% of the annual return was hatchery spawners.
WA	E.F. Lewis	2.5		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases in the East Fork from 1982-2002 have fluctuated near 100,000 fish. Current East Fork winter steelhead hatchery program goal is the annual release of 90,000 smolts. From 1991-1996, approximately 51% of the annual return was hatchery spawners.
WA	N.F. Lewis	2		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases in the North Fork from 1982-2002 have fluctuated near 150,000 fish. Current North Fork winter steelhead hatchery program goal is the annual release of 100,000 smolts, however, recent year releases have been around 300,000. From 1991-1996, approximately 93% of the annual return was hatchery spawners.
WA	Salmon	2		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery winter steelhead have been released in the Salmon Creek basin since 1957. Releases from 1982 to 2002 ranged between 10,000 and about 42,500. Current release goals to Salmon Creek are 25,000 Skamania winter steelhead smolts. Hatchery fish are expected to compose most of the annual return.
WA	Washougal	2.5		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery winter steelhead have been planted in the Washougal since 1957. Hatchery releases in the 1980s generally fluctuated near 150,000 smolts. Current release goals to the Washougal are 60,000 Skamania winter steelhead smolts. Hatchery fish are expected to compose most of the annual return, although interbreeding with wild fish is expected to be low because of a separation in run timing.
OR	Clackamas				
OR	Sandy				
Gorge winter					

	WA	Lower Gorge Tribs	2.5		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Intermittent releases of hatchery winter steelhead have occurred in Hamilton Creek since 1958. Hatchery releases from 1988 to 1996 ranged from about 5,000 to 10,000 smolts. Estimates of hatchery adult winter steelhead are not available.
	WA	Upper Gorge Tribs	2.5		Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery winter steelhead have been released in the Wind River intermittently since the early 1950s; releases have generally been small (<10,000 smolts). Releases of hatchery steelhead were discontinued in 1997 because of potential concerns with the remaining wild stock. Only unmarked steelhead are allowed to pass the adult trap on Trout Creek.
	OR	Hood				
Cascade summer						
	WA	Kalama	2.5	3.5	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Summer steelhead hatchery releases since the early 1980s have fluctuated near 100,000. From 1991-1996, approximately 64% of the annual return was hatchery spawners.
	WA	N.F. Lewis	0	0	Life history diversity was based on comparison of adult and juvenile migration timing and age composition. Genetic diversity was based on the occurrence of small population bottlenecks in historic spawning escapement and degree of hatchery influence especially by non local stocks. Resiliency was based on observed rebounds from periodic small escapement. Diversity scores of 0 were typically assigned to populations that were functionally extirpated or consisted primarily of stray hatchery fish.	Hatchery releases of summer steelhead in the North Fork since 1982 have ranged from 25,000 to 225,000 annually. The Merwin net pen operation has an annual production goal of 235,000 summer steelhead smolts. Also, about 50,000 Skamania summer steelhead are released in the North Fork annually. The current annual return is expected to be primarily hatchery fish.

	WA	E.F. Lewis	2.5	2	Hatchery influence has been significant and potentially detrimental or populations have experienced periods of critical low escapement.	Hatchery releases of summer steelhead in the East Fork from 1982-1991 have fluctuated near 80,000 fish. Recent year releases have fluctuated near 30,000 fish. Current East Fork summer steelhead hatchery program goal is the annual release of 25,000 Skamania smolts. From 1991-1996, approximately 71% of the annual return was hatchery spawners; snorkel escapement counts from 1996-2001 confirmed that hatchery fish comprise about 70% of the annual spawning escapement.
	WA	Washougal	3	2	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.	Hatchery summer steelhead have been planted in the Washougal since the 1950s. Hatchery releases in the 1980s generally fluctuated near 200,000 smolts, although about 550,000 were released one year. Current release goals to the Washougal are 60,000 Skamania summer steelhead smolts. Escapement estimates from 1991-1996 indicate that hatchery summer steelhead comprise 87% and 1% of the spawning escapement in the North Fork Washougal and mainstem Washougal, respectively. Hatchery fish are expected to compose most of the current annual return.
Gorge summer						
	WA	Wind	3	3	Wild stock is subject to limited hatchery influence but life history patterns are stable. Extended intervals of critical low escapements have not occurred and population rapidly rebounded from periodic declines in numbers.	Hatchery summer steelhead have been released in the Wind River most years since 1960. Releases since 1983 have generally ranged between 20,000 and 50,000 smolts. Releases of hatchery steelhead were discontinued in 1997 because of potential concerns with the remaining wild stock. Snorkel surveys in the Wind from 1989-1998 indicated that hatchery summer steelhead comprised 41-60% of the annual spawning escapement. Only unmarked steelhead are allowed to pass the adult trap on Trout Creek.
	OR	Hood				

1.6 Habitat

Table 1-21. Habitat Description

Category	Description	Application
0	Habitat is incapable of supporting fish or is likely to be incapable of supporting fish in the foreseeable future	Unsuitable habitat. Quality is not suitable for salmon production. Includes only areas that are currently accessible. Inaccessible portions of the historic range are addressed by spatial structure criteria[2].
1	Habitat exhibits a combination of impairment and likely future conditions such that population is at high risk of extinction	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.
2	Habitat exhibits a combination of current impairment and likely future condition such that the population is at moderate risk of extinction	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.
3	Habitat in unimpaired and likely future conditions will support a viable salmon population	Intact habitat. Some degradation in habitat quality has occurred but habitat is sufficient to produce significant numbers of fish. (Equivalent to low bound in abundance target planning range.)
4	Habitat conditions and likely future conditions support a population with an extinction risk lower than that defined by a viable salmon population. Habitat conditions consistent with this category are likely comparable to those that historically existed.	Favorable habitat. Quality is near or at optimums for salmon. Includes properly functioning through pristine historical conditions.

Table 1-22. Chum Habitat

Habitat Strata	State	Population	Score	Data	Criteria	Comments
Coast						
	WA	Grays/Chinook	2	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Logging and agriculture in the watershed and the resulting landslides, erosion, and channel changes have damaged salmon spawning habitat. Recent habitat improvement projects have been undertaken in the basin.
	WA	Elochoman/Skamokawa	1	3	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Logging, road construction, and agriculture in the basin has decreased habitat diversity, bank stability, and fish access while increasing sediment load.
	WA	Mill/Abernathy/Germany	1	3	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Logging, road construction, and agriculture in the basin has decreased habitat diversity, bank stability, and fish access while increasing sediment load.
	OR	Youngs				
	OR	Big Creek				
	OR	Clatskanie				
	OR	Scappoose				
Cascade						
	WA	Cowlitz Chum	1	3	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Construction of Mayfield Dam in 1962 blocked access to approximately 80% of the basin's historical production area. Grazing, agriculture, forestry, and development have substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity has been lost because of channelization and diking.

	WA	Kalama Chum	1	3	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Forestry and other human activities in the basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity has been lost because of channelization and diking.
	WA	Lewis Chum	1	3	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Construction of Merwin Dam in 1932 blocked access to over half of the North Fork's historical production area. Human activity in the North Fork basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity in the lower river has been lost because of channelization and diking. The upper East Fork basin burned repeatedly during the early part of the century; the watershed is slowly recovering from habitat degradation as a result of these fires.
	WA	Salmon Chum	0	0	Unsuitable habitat. Quality is not suitable for salmon production. Includes only areas that are currently accessible. Inaccessible portions of the historic range are addressed by spatial structure criteria2.	Basin-specific habitat data is not available.
	WA	Washougal Chum	2	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	The Yacolt Burn, forestry, dam construction (removed in 1947), and human development has negatively affected habitat diversity, floodplain connectivity, and side channel habitat while increasing fine sediment in the system.
	OR	Clackamas				
	OR	Sandy				
Gorge						
	WA	Lower Gorge	2.5	2.5	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Basin-specific data is limited but habitat has likely been degraded from human activities within the basins. Current habitat availability and quality assumes consistent future Bonneville Dam operations, with minimal flow impacts.

WA	Upper Gorge	1	1	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Historic chum habitat in the lower basins below impassable falls was inundated by the Bonneville Pool (1938). Shipherd Falls on the Wind River was laddered in 1956, providing access to the upper watershed. Suitable chum habitat does not exist in the Wind or Little White Salmon Rivers. Timber harvest and road construction in both basins has negatively affected riparian diversity, water flow, and water temperature while increasing sediment load to the system.

Table 1-23. Chinook Habitat

Habitat Strata	State	Population	Score	Data	Criteria	Comments
Coast Fall						
	WA	Grays	1.5		Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Low seasonal water flows have been a chronic problem for natural and hatchery chinook production; return timing is driven by timing of fall rains. Logging and agriculture in the watershed and the resulting landslides, erosion, and channel changes have damaged salmon spawning habitat. Recent habitat improvement projects for chum salmon production have been undertaken in the basin.
	WA	Elochoman	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Logging, road construction, and agriculture in the basin has decreased habitat diversity, bank stability, and fish access while increasing sediment load.
	WA	Mill/Abernathy/Germany	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Logging, road construction, and agriculture in the basin has decreased habitat diversity, bank stability, and fish access while increasing sediment load.
		Youngs Bay				
		Big Creek				
		Clatskanie				
		Scappoose				
Cascade Fall						
	WA	Lower Cowlitz	1.5		Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Grazing, agriculture, forestry, and development have substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity has been lost because of channelization and diking.

WA	Coweeman	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Extensive logging and high road densities have decreased habitat diversity and riparian function while increasing peak flows, sediment input, and water temperature. Diking and deposits from the 1980 Mt. St. Helens eruption in the lower river have decreased floodplain connectivity. Rearing and over-wintering habitat is limited in this lower reach.
WA	Toutle	1.75	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	The 1980 Mt. St. Helens eruption severely impacted habitat in the basin; most streams are naturally recovering from the disturbance. One exception is the North Fork Toutle where natural recovery has lagged, potentially as a result of a sediment retention structure. High road densities and other human activities have limited off-channel habitat, substrate stability, and riparian function while increasing sediment, water temperature, and peak flows.
WA	Upper Cowlitz	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Construction of Mayfield Dam in 1962 blocked access to about half of the basin's historical production area, however, various trap and haul programs have provided some access to the upper basin. Channel alterations and increased sediment inputs have created low-flow passage problems and reduced habitat quality; habitat diversity is also lacking. Any downstream migrants that enter Riffe Lake are unable to navigate the 23-mile long lake successfully. Timber harvest and road construction in the Tilton River basin has decreased riparian function, channel stability, and water quality while increasing peak flows and sediment inputs.
WA	Kalama	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Forestry and other human activities in the basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity has been lost because of channelization and diking.

WA	Lewis/Salmon	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Construction of Merwin Dam in 1932 blocked access to over half of the North Fork's historical production area. Human activity in the North Fork basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity in the lower river has been lost because of channelization and diking. The upper East Fork basin burned repeatedly during the early part of the century; the watershed is slowly recovering from habitat degradation as a result of these fires.
WA	Washougal	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	The Yacolt Burn, forestry, dam construction (removed in 1947), and human development has negatively affected habitat diversity, floodplain connectivity, and side channel habitat while increasing fine sediment in the system.
OR	Sandy			
OR	Clackamas			
Gorge Fall				
WA	Lower Gorge	2.5	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Basin-specific data is limited but habitat has likely been degraded from human activities within the basins. Current habitat availability and quality assumes consistent future Bonneville Dam operations, with minimal flow impacts.
WA	Upper Gorge	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Historic chinook habitat in the lower Wind and Little White Salmon Rivers below impassable falls was inundated by the Bonneville Pool (1938). Shipherd Falls on the Wind River was laddered in 1956, providing access to the upper watershed. Timber harvest and road construction in both basins has negatively affected riparian diversity, water flow, and water temperature while increasing sediment load to the system.

	WA	Big White Salmon	1.5	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	
	OR	Hood			
Cascade late falls					
	WA	Lewis NF	3	Intact habitat. Some degradation in habitat quality has occurred but habitat is sufficient to produce significant numbers of fish. (Equivalent to low bound in abundance target planning range.)	Construction of Merwin Dam in 1932 blocked access to over half of the North Fork's historical production area. Human activity in the North Fork basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity in the lower river has been lost because of channelization and diking.
	OR	Sandy			
Cascade spring					
	WA	Upper Cowlitz	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Construction of Mayfield Dam in 1962 blocked access to about half of the basin's historical production area, however, various trap and haul programs have provided some access to the upper basin. Channel alterations and increased sediment inputs have created low-flow passage problems and reduced habitat quality; habitat diversity is also lacking. Any downstream migrants that enter Riffe Lake are unable to navigate the 23-mile long lake successfully.
	WA	Cispus	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	See upper Cowlitz.
	WA	Tilton	0	Unsuitable habitat. Quality is not suitable for salmon production. Includes only areas that are currently accessible. Inaccessible portions of the historic range are addressed by spatial structure criteria2.	Timber harvest and road construction in the Tilton River basin has decreased riparian function, channel stability, and water quality while increasing peak flows and sediment inputs.

	WA	Toutle	0	Unsuitable habitat. Quality is not suitable for salmon production. Includes only areas that are currently accessible. Inaccessible portions of the historic range are addressed by spatial structure criteria2.	The 1980 Mt. St. Helens eruption severely impacted habitat in the basin; most streams are naturally recovering from the disturbance. One exception is the North Fork Toutle where natural recovery has lagged, potentially as a result of a sediment retention structure. High road densities and other human activities have limited off-channel habitat, substrate stability, and riparian function while increasing sediment, water temperature, and peak flows.
	WA	Kalama	1	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Forestry and other human activities in the basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity has been lost because of channelization and diking.
	WA	Lewis NF	0	Unsuitable habitat. Quality is not suitable for salmon production. Includes only areas that are currently accessible. Inaccessible portions of the historic range are addressed by spatial structure criteria2.	Construction of Merwin Dam in 1932 blocked access to over half of the North Fork's historical production area. Human activity in the North Fork basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity in the lower river has been lost because of channelization and diking.
	OR	Sandy			
Gorge spring					
	WA	Big White Salmon	0	Unsuitable habitat. Quality is not suitable for salmon production. Includes only areas that are currently accessible. Inaccessible portions of the historic range are addressed by spatial structure criteria2.	
	OR	Hood			

Table 1-24. Steelhead Habitat

Habitat Strata	State	Population	Score	Data	Criteria	Comments
Coast winter						
	WA	Grays	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Logging and agriculture in the watershed and the resulting landslides, erosion, and channel changes have damaged salmon spawning habitat. Recent habitat improvement projects for chum salmon production have been undertaken in the basin.
	WA	Elochoman/Skamokawa	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Logging, road construction, and agriculture in the basin has decreased habitat diversity, bank stability, and fish access while increasing sediment load.
	WA	Mill/Abernathy/Gemany	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Logging, road construction, and agriculture in the basin has decreased habitat diversity, bank stability, and fish access while increasing sediment load.
Cascade winter						
	WA	Lower Cowlitz	1.5		Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Grazing, agriculture, forestry, and development have substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity has been lost because of channelization and diking.
	WA	Upper Cowlitz	1.5		Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Construction of Mayfield Dam in 1962 blocked access to about 80% of the basin's historical production area, however, a recent trap and haul program has provided some access to the upper basin. Channel alterations and increased sediment inputs have created low-flow passage problems and reduced habitat quality; habitat diversity is also lacking. Any downstream migrants that enter Riffe Lake are unable to navigate the 23-mile long lake successfully.

WA	Cispus	1.5	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Construction of Mayfield Dam in 1962 blocked access to the basin, however, a recent trap and haul program has provided some access. Channel alterations and increased sediment inputs have created low-flow passage problems and reduced habitat quality; habitat diversity is also lacking.
WA	Tilton	1.5	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Construction of Mayfield Dam in 1962 blocked access to the basin, however, a recent trap and haul program has provided some access. Timber harvest and road construction in the Tilton River basin has decreased riparian function, channel stability, and water quality while increasing peak flows and sediment inputs.
WA	Coweeman	1.75	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Extensive logging and high road densities have decreased habitat diversity and riparian function while increasing peak flows, sediment input, and water temperature. Diking and deposits from the 1980 Mt. St. Helens eruption in the lower river have decreased floodplain connectivity. Rearing and over-wintering habitat is limited in this lower reach.
WA	N.F. Toutle	1.75	Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	The 1980 Mt. St. Helens eruption severely impacted habitat in the basin; most streams are naturally recovering from the disturbance. One exception is the North Fork Toutle where natural recovery has lagged, potentially as a result of a sediment retention structure. High road densities and other human activities have limited off-channel habitat, substrate stability, and riparian function while increasing sediment, water temperature, and peak flows.
WA	S.F. Toutle	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	The 1980 Mt. St. Helens eruption severely impacted habitat in the basin; most streams are naturally recovering from the disturbance. High road densities and other human activities have limited off-channel habitat, substrate stability, and riparian function while increasing sediment, water temperature, and peak flows.

WA	Kalama	2.5	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Forestry and other human activities in the basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity has been lost because of channelization and diking.
WA	E.F. Lewis	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	The upper East Fork basin burned repeatedly during the early part of the century; the watershed is slowly recovering from habitat degradation as a result of these fires. Limiting habitat conditions include low habitat diversity and structure, elevated water temperatures (especially in lower tributaries), erosion and channel stability, and low floodplain connectivity as a result of diking and development in the lower basin.
WA	N.F. Lewis	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Construction of Merwin Dam in 1932 blocked access to about 80% of the North Fork's historical production area. Human activity in the North Fork basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity in the lower river has been lost because of channelization and diking.
WA	Salmon	1		Highly impaired habitat. Quality is substantially less than needed to sustain a viable population size (e.g. low bound in target planning range). Significant natural production may occur only in favorable years.	Human activity in the upper basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity in the lower river has been lost because of channelization and diking related to development
WA	Washougal	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	The Yacolt Burn, forestry, dam construction (removed in 1947), and human development has negatively affected habitat diversity, floodplain connectivity, and side channel habitat while increasing fine sediment in the system.
OR	Clackamas				
OR	Sandy				

Gorge winter

	WA	Lower Gorge Tribs	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Basin-specific data is limited but habitat has likely been degraded from human activities within the basins. Current habitat availability and quality assumes consistent future Bonneville Dam operations, with minimal flow impacts.
	WA	Upper Gorge Tribs	2		Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Historic spawning and rearing habitat in the lower Wind River was inundated by the Bonneville Pool (1938). Shipherd Falls on the Wind River was laddered in 1956, providing easier access to the upper watershed. Timber harvest and road construction in the upper basin has negatively affected riparian diversity, water flow, and water temperature while increasing sediment load to the system.
	OR	Hood				
Cascade summer						
	WA	Kalama	2.5	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Forestry and other human activities in the basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity has been lost because of channelization and diking.
	WA	N.F. Lewis	2	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	Construction of Merwin Dam in 1932 blocked access to about 80% of the North Fork's historical production area. Human activity in the North Fork basin has substantially reduced riparian function and bank stability while adding fine sediment to the system. Habitat diversity, side channel habitat, and floodplain connectivity in the lower river has been lost because of channelization and diking.
	WA	E.F. Lewis	2	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	The upper East Fork basin burned repeatedly during the early part of the century; the watershed is slowly recovering from habitat degradation as a result of these fires. Limiting habitat conditions include low habitat diversity and structure, elevated water temperatures (especially in lower tributaries), erosion and channel stability, and low floodplain connectivity as a result of diking and

						development in the lower basin.
	WA	Washougal	2	2	Moderately impaired habitat. Significant degradation in habitat quality associated with reduced population productivity.	The Yacolt Burn, forestry, dam construction (removed in 1947), and human development has negatively affected habitat diversity, floodplain connectivity, and side channel habitat while increasing fine sediment in the system.
Gorge summer						
	WA	Wind	3	3	Intact habitat. Some degradation in habitat quality has occurred but habitat is sufficient to produce significant numbers of fish. (Equivalent to low bound in abundance target planning range.)	Historic spawning and rearing habitat in the lower Wind River was inundated by the Bonneville Pool (1938). Shipherd Falls on the Wind River was laddered in 1956, providing easier access to the upper watershed. Timber harvest and road construction in the upper basin has negatively affected riparian diversity, water flow, and water temperature while increasing sediment load to the system.
	OR	Hood				

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Run Reconstructions of Select Salmon and Steelhead Populations in Washington Tributaries of the Lower Columbia River

Run Reconstructions of Select Salmon and Steelhead Populations in Washington Tributaries of the Lower Columbia River

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Abstract

Run reconstructions were completed for select salmon and steelhead populations in Washington tributaries of the lower Columbia River: Coweeman tule fall chinook, East Fork Lewis tule fall chinook, North Fork Lewis bright fall chinook, Wind spring chinook, Little White Salmon spring chinook, Kalama winter steelhead, Kalama summer steelhead, Wind summer steelhead, and Grays chum. These populations were selected because they represent a mixture of species, origin (i.e. hatchery or wild), and basin-specific factors affecting each population. Accuracy of the run reconstructions reflect currently available data; improvements to the run reconstructions are welcome by other researchers if better quality data is known and available. Results of the run reconstructions confirm the general knowledge of low productivity years during the late 1980s and mid 1990s. For all populations investigated, productivity decreased as spawner abundance increased. The inverse relationship between spawner abundance and productivity suggests that, at the habitat capacity present over the duration of the run reconstructions, habitat limitations exist that affect spawning or rearing success and prevent productivity from increasing as spawner abundance increases. Spawner abundance was not an accurate predictor of ocean recruits.

Introduction

Time series of adult abundance data are a key component of many analyses of the status, limiting factors, management practices, and future prospects for salmon in the Columbia River. For example, salmon stock productivity can be estimated from run reconstructions which estimate numbers of spawners and recruits from each brood year (Ricker 1954 and 1975, Beverton and Holt 1957). Productivity of a salmon population for a specified time period is defined as the natural log of the ratio of recruits to spawners, in the absence of density dependent mortality (Neave 1953). Run reconstruction methods vary depending on the type of data available, but are considered similar to virtual population analysis (VPA) or cohort analysis models (see Megrey 1989, Hilborn and Walters 1992, and Haddon 2001 for discussion on these models). Analyses of spawner-recruit data provide one method for assessing the cumulative effects of harvest, hatchery production, habitat changes, and hydroelectric development on anadromous fish (Martin et al. 1987). Spawner-recruit data is especially useful for measuring density independent productivity in assessments of the effects of development. Time series of spawner and recruit data from stocks throughout the Columbia River Basin may provide an important inferential basis for investigations regarding the distribution of mortality throughout the life cycle (Barnthouse et al. 1994). Also, cohort replacement rates based on recruitment-stock ratios can identify ‘harvestable surpluses’ of salmon and steelhead stocks (Lindsay et al. 1986).

In this paper, we present run reconstructions for select salmon and steelhead populations in Washington tributaries of the lower Columbia River: Coweeman tule fall chinook, East Fork Lewis tule fall chinook, North Fork Lewis bright fall chinook, Wind spring chinook, Little White Salmon spring chinook, Kalama winter steelhead, Kalama summer steelhead, Wind summer steelhead, and Grays chum. These populations were selected because they represent a mixture of species, origin (i.e. hatchery or wild), and factors affecting population trends and abundance. Furthermore, continuous, long-term escapement, age composition, and harvest data are available for these populations, which is required for run reconstructions. The only species not represented in this analysis is coho salmon; at present, adequate tributary escapement, age composition, and harvest data are lacking for coho.

Methods

A wealth of escapement, age composition, and harvest data are available for populations in Washington tributaries of the lower Columbia; the challenge is determining which data most accurately estimates the true parameters for each population. When deciding on which data to use, we considered the length of the dataset, data availability, and peer evaluation of data quality. When possible, we utilized data that covered the entire time period of the run reconstructions to minimize any potential errors that could result from using data that were collected using different methods. Based on the availability of continuous data, each run reconstruction covers a different time period.

The general approach for these run reconstructions was to begin with tributary escapement data and back calculate to the number of ocean recruits. The primary milestones in the run reconstructions are the number of spawners, the run size at the mouth of the tributary, the run size at the mouth of the Columbia River, and the run size entering the ocean. At each step, known harvest rates were used to add individuals back into the population; baseline natural mortality was not included because it is expected to be minimal compared to harvest-related mortality. If age-specific harvest rates were available, then spawners were separated by age class and individuals were returned to the population in age-class specific groups, facilitating the assignment to brood year. If age-specific harvest rates were not available, then individuals were returned to the population based on known harvest rates for each fishery and age composition data was applied to the total run to complete the link to brood year.

After the number of ocean recruits by age and brood year was determined, the various population statistics were calculated. Of primary interest was the recruit to spawner ratio and the estimate of productivity obtained from the natural log of the ratio of recruits to spawners. If adequate data were available to apportion the total population into wild and hatchery components, population statistics for each component was calculated separately. If wild juvenile outmigration numbers were available (for wild populations) or hatchery juvenile release number were available (for hatchery populations), smolt to adult survival was calculated for those years of available data.

Coweeman Tule Fall Chinook

The Coweeman tule fall chinook population is considered to be sustained from natural production with very little hatchery influence. Tributary spawning data are available since 1964 so the run reconstruction covers this time period. Spawning escapement data for 1964-2001 were obtained from the Washington Department of Fish and Wildlife (WDFW) Salmon and Steelhead Stock Inventory (SASSI) 2002. An assumed 5% prespawn mortality was applied to the escapement to determine the number of spawners

(Petrosky 1995). Age composition for 1964-2001 was calculated from escapement by age data in the StreamNet database. The spawning population was first separated by age class because age-specific harvest rates are available for mainstem and tributary fisheries; individuals were then added back to the population within each respective age class. Fall chinook 'Big Sheets' are likely the best source of age-specific harvest data for the mainstem Columbia and tributaries. Although Coweeman tule fall chinook are considered a wild run, the lower river hatchery (LRH) stock was used as a surrogate for determining tributary and mainstem harvest because the LRH stock closely resembles Coweeman tule fall chinook migration timing and patterns. Therefore, the tributary harvest rate for 1980-1990 was calculated as the tributary harvest divided by the sum of the total run minus the mainstem harvest from the 'Big Sheets' using LRH stock data. Tributary harvest rate for 1964-1979 was the 5-yr average harvest calculated from 1980-1984 'Big Sheet' data. Since 1991, tributary harvest was set at zero because the Coweeman has been closed to fishing since 1991. The Columbia River mainstem harvest rate for 1980-2001 was calculated as the sum of mainstem harvest by area divided by the total run from the 'Big Sheets" using LRH stock data. The mainstem harvest rate for 1964-1979 was the 5-yr average harvest calculated from 1980-1984 'Big sheet' data. Ocean harvest rates for the time periods from 1964-1989 and 1990-2000 were based on analyses of tule fall chinook coded-wire tagging data from the available brood years within each period, respectively (Byrne et al. 2002). The ocean harvest rate for 2001 was estimated based on preliminary fishery information. Applying the age composition and respective harvest rate data to the annual spawners results in the ocean recruitment by age and year. The annual ocean recruits were assigned to a brood year based on age; for example, the 1964 brood year was assembled with 2-year old recruits from 1966, 3-year old recruits from 1967, etc.

East Fork Lewis Tule Fall Chinook

The East Fork Lewis tule fall chinook population is considered to be sustained from natural production with very little hatchery influence. Tributary spawning data are available from 1964-2001 so the run reconstruction covers this time period. Spawning escapement data for 1964-2001 were obtained from the WDFW SASSI report (2002). An assumed 5% prespawn mortality was applied to the escapement to determine the number of spawners (Petrosky 1995). Age composition for 1964-2001 was calculated from escapement by age data in the StreamNet database. The spawning population was first separated by age class because age-specific harvest rates are available for mainstem and tributary fisheries; individuals were then added back to the population within each respective age class. Fall chinook 'Big Sheets' are likely the best source of age-specific harvest data for the mainstem Columbia and tributaries. Although East Fork Lewis tule fall chinook are considered a wild run, the LRH stock was used as a surrogate for determining tributary and mainstem harvest because the LRH stock closely resembles East Fork Lewis tule fall chinook migration timing and patterns. 'Big Sheet' data is available from 1980-present; however, tributary harvest was closed beginning in 1977 and therefore was set to zero. Tributary harvest rate for years prior to 1977 (i.e. 1964-1976) was the 5-yr average of data from the 1980-1984 'Big Sheet'; annual harvest was calculated as the tributary harvest divided by the sum of the total run minus the mainstem harvest. The Columbia River mainstem harvest rate for 1980-2001 was calculated as the sum of mainstem harvest by area divided by the total run from the 'Big Sheets" using LRH stock data. The mainstem harvest rate for 1964-1979 was the 5-yr average harvest calculated from 1980-1984 'Big sheet' data. Ocean harvest rates for the time periods from 1964-1989 and 1990-2000 were based on analyses of tule fall chinook coded-wire tagging data from the available brood years within each period, respectively (Byrne et al. 2002). The ocean harvest rate for 2001 was estimated based on preliminary fishery information. Applying the age composition and respective harvest rate data to the annual spawners results in the ocean recruitment by age and year. The annual ocean recruits were assigned to a brood year based on age; for example, the 1964 brood year was assembled with 2-year old recruits from 1966, 3-year old recruits from 1967, etc.

North Fork Lewis Bright Fall Chinook

The North Fork Lewis bright fall chinook population is currently considered to be sustained primarily from natural production; historically, there was substantial influence on the population from hatchery production, which ceased in the mid 1980s. The North Fork Lewis bright fall chinook run reconstruction begins with the run year 1964. Spawning escapement data for 1964-2001 were obtained from the WDFW SASSI report (2002). Because of the hatchery influence in the North Fork Lewis, the proportion of hatchery natural spawners was applied to the total escapement to separate the escapement into wild and hatchery spawners. The run reconstruction was completed with the wild spawners only; all age composition and harvest data was applicable to wild bright fall chinook as opposed to hatchery fish. An assumed 5% prespawn mortality was applied to the escapement to determine the number of spawners (Petrosky 1995). Age composition for 1964-2001 (excluding 1979) was calculated from escapement by age data in the StreamNet database; data for 1979 was incomplete. Age composition for 1979 was derived from data presented in Myers et al. (2002) for naturally spawning bright fall chinook in the Lewis River; Myers et al. (2002) referenced Hymer et al. (1992) as the data source. The wild spawning population was first separated by age class because age-specific harvest rates are available for mainstem and tributary fisheries; individuals were then added back to the population within each respective age class. Fall chinook 'Big Sheets' are likely the best source of age-specific harvest data for the mainstem Columbia and tributaries. The lower river wild (LRW) stock was used as a surrogate for determining tributary and mainstem harvest because the LRW stock closely resembles North Fork Lewis bright fall chinook migration timing and patterns. Therefore, the tributary harvest rate for 1980-2001 was calculated as the tributary harvest divided by the sum of the total run minus the mainstem harvest from the 'Big Sheets' using LRW stock data. Tributary harvest rate for 1964-1979 was the 5-yr average harvest calculated from 1980-1984 'Big Sheet' data. The Columbia River mainstem harvest rate for 1980-2001 was calculated as the sum of mainstem harvest by area divided by the total run from the 'Big Sheets" using LRW stock data. The mainstem harvest rate for 1964-1979 was the 5-yr average harvest calculated from 1980-1984 'Big sheet' data. Ocean harvest rates for the time periods from 1964-1989 and 1990-2000 were based on analyses of bright fall chinook coded-wire tagging data from the available brood years within each period, respectively (Byrne et al. 2002). The ocean harvest rate for 2001 was estimated based on preliminary fishery information. Applying the age composition and respective harvest rate data to the annual spawners results in the ocean recruitment by age and year.

Juvenile outmigration data was available for most years from 1977-1987 (Hymer et al. 1992); smolt to adult survival (SAR) was calculated for those years with outmigration data. The annual ocean recruits were assigned to a brood year based on age; for example, the 1964 brood year was assembled with 2-year old recruits from 1966, 3-year old recruits from 1967, etc.

Wind Spring Chinook

Spring chinook are not native to the Wind River. The current spring chinook population is sustained through hatchery production that began in 1955; broodstock for the hatchery program was derived from a mixture of upper Columbia and Snake River spring chinook passing Bonneville Dam. The Wind River run reconstruction began with the 1963 run year. Although total annual escapement data is available through Carson National Fish Hatchery (NFH) rack counts, rack counts are not an accurate measure of the number of fish actually spawned in the hatchery that produced subsequent juvenile releases in the basin. However, data describing the number of fish spawned annually in the hatchery are not readily available. Thus, we calculated the annual effective spawning population as the starting point for the run reconstruction and for developing accurate recruit per spawner relationships. We utilized the ratio of juvenile release goals to adult broodstock collection goals based on production goals reported in the most recent (2002) Hatchery and Genetic Management Plan (HGMP) to establish a relationship between spawning adults and resultant juvenile production. The juvenile to adult ratio was applied to known annual juvenile release numbers in year *x* to determine the effective spawning population for year *x-2*; juvenile release data was obtained from the USFWS. Age composition for 1970-2001 was calculated from WDFW data on Carson NFH spring chinook escapement by age and return year; the age composition for 1963-69 is the average based on all years of available data (i.e. 1970-2001). The effective spawning population was first separated by age class because age-specific harvest rates are available for tributary fisheries; individuals were then added back to the population within each respective age class. Tributary harvest rates for 1970-2001 were calculated from WDFW data that detailed harvest and tribal distributions by age and year; sport harvest, tribal harvest, and tribal distributions were all included as part of the tributary harvest. Tributary harvest for 1963-69 was calculated as the 5-yr average based on harvest data for 1970-74. Mainstem harvest rates were calculate from the Biological Assessment Tables for spring chinook (BA Table 1); included in the mainstem harvest was commercial, sport, and miscellaneous harvest in Zones 1-5, as well as Zone 6 commercial and ceremonial and subsistence (C&S) harvest with an assumed 35% reduction factor applied because Wind River fish are not subjected to the total fishing pressure within Zone 6. The ocean harvest rate was assumed to be 1% because spring chinook harvest in ocean fisheries is minimal. Applying the age composition and respective harvest rate data to the annual spawners results in the ocean recruitment by age and year. Hatchery releases in the basin are available since 1965; annual SAR was calculated for 1965-present based on hatchery releases and ocean recruits. The annual ocean recruits were assigned to a brood year based on age; for example, the 1963 brood year was assembled with 3-year old recruits from 1966, 4-year old recruits from 1967, etc.

Little White Salmon Spring Chinook

Spring chinook are not native to the Little White Salmon River. The current spring chinook population is sustained through hatchery production; although numerous stocks have been planted in the Little White Salmon River, the current population is considered a derivative of the Carson NFH stock. The Little White Salmon River run reconstruction began with the 1965 run year. Although total annual escapement data is available through the Little White Salmon and Willard NFH rack counts, rack counts are not an accurate measure of the number of fish actually spawned in the hatchery that produced subsequent juvenile releases in the basin. However, data describing the number of fish spawned annually in the hatchery are not readily available. Thus, we calculated the annual effective spawning population as the starting point for the run reconstruction and for developing accurate recruit per spawner relationships. We utilized the ratio of juvenile release goals to adult broodstock collection goals based on production goals reported in the most recent HGMP (2002) to establish a relationship between spawning adults and resultant juvenile production. Juvenile transfers from the Little White Salmon and Willard NFH complex to the Umatilla River were included in the ratio because the current adult broodstock goal is based on the total production goal and not just releases to the Little White Salmon basin. The juvenile to adult ratio was applied to known annual juvenile release numbers in year x to determine the effective spawning population for year x-2; juvenile release data was obtained from the USFWS. Age composition for 1970-2001 was calculated from WDFW data on Little White Salmon NFH spring chinook escapement by age and return year; the age composition for 1965-69 is the average based on all years of available data (i.e. 1970-2001). The effective spawning population was first separated by age class because age-specific harvest rates are available for tributary fisheries; individuals were then added back to the population within each respective age class. Tributary harvest rates for 1970-2001 were calculated from WDFW data that detailed harvest and tribal distributions by age and year; sport harvest, tribal harvest, and tribal distributions were all included as part of the tributary harvest. Tributary harvest for 1965-69 was calculated as the 5-yr average based on harvest data for 1970-74. Mainstem harvest rates were calculate from the Biological Assessment Tables for spring chinook (BA Table 1); included in the mainstem harvest was commercial, sport, and miscellaneous harvest in Zones 1-5, as well as Zone 6 commercial and ceremonial and subsistence (C&S) harvest with an assumed 25% reduction factor applied because Little White Salmon River fish are not subjected to the total fishing pressure within Zone 6. The ocean harvest rate was assumed to be 1% because spring chinook harvest in ocean fisheries is minimal. Applying the age composition and respective harvest rate data to the annual spawners results in the ocean recruitment by age and year. Hatchery releases in the basin are available since 1967; annual SAR was calculated for 1967-present based on hatchery releases and ocean recruits. The annual ocean recruits were assigned to a brood year based on age; for example, the 1965 brood year was assembled with 3-year old recruits from 1968, 4-year old recruits from 1969, etc.

Kalama Winter Steelhead

Historically, the Kalama winter steelhead population was a mixture of hatchery and wild production; the maximum proportion of hatchery fish in the total escapement was 64% in

1986. Since 1998, the annual escapement has been composed completely of wild winter steelhead. WDFW maintains a research station solely for research of Kalama River steelhead and trout; because WDFW has generated a substantial time series of data for both wild and hatchery fish, the run reconstruction was completed for both components of the run. WDFW has recorded wild and hatchery winter steelhead escapement to the Kalama since 1977; each component of the escapement was the starting point for the run reconstruction. An assumed 5% prespawn mortality was applied to the escapement to determine the number of spawners (Petrosky 1995). Tributary harvest of wild winter steelhead (in numbers of fish) for 1977-1996 and 1998-2002 was obtained directly from WDFW. WDFW wild tributary harvest data for 1997 were incomplete; the harvest number used for 1997 was the 5-yr average harvest from 1998-2002. Tributary harvest of hatchery winter steelhead (in numbers of fish) for 1977-1996 was obtained directly from WDFW. WDFW hatchery tributary harvest data for 1997 were incomplete; the harvest number used for 1997 was the 5-yr average harvest from 1992-1996. Hatchery harvest since 1998 was zero because no hatchery fish are present in the escapement. Historically, there were not separate wild and hatchery winter steelhead harvest regulations in the mainstem Columbia River; since 1985, retention of wild winter steelhead in the Columbia River has been prohibited. Thus, wild winter steelhead harvest rates in the Columbia River are assumed to be the same as hatchery fish up to 1984; beginning in 1985, wild fish incidental harvest mortality is assumed to be 10% of the annual hatchery harvest rate. The only exception to this rule was the 2001-02 run year; harvest rate for 2001-02 was based on the 2002 Spring Chinook Tangle Net Fishery data. WDFW estimated there was a 2% immediate mortality and a 0.5% long term mortality (i.e. after releases) for steelhead encountered in the fishery. For 1976-77 to 2000-2001 run years, hatchery winter steelhead harvest rate in the Columbia River was calculated as the lower river sport catch divided by the Columbia river index total run (WDFW and ODFW 2002). Only sport harvest was considered in the mainstem harvest rate because there has been no commercial steelhead harvest in the Columbia River since 1974. The method for deriving harvest rates for hatchery winter steelhead has some limitations: 1) the lower river sport harvest data are reported as incomplete and 2) the index total run includes fish destined for areas above Bonneville Dam. Despite these limitations, these are the best available data for estimating winter steelhead harvest in the mainstem Columbia River. Ocean harvest rate of wild and hatchery steelhead is assumed to be 0.5% based on incidental mortality. Winter steelhead harvest data in each of the respective areas was not available by age class; therefore, harvest by area was added back into the population to obtain the number of ocean recruits before the age composition data was applied. Also, because winter steelhead adult return migration and spawning period spans two calendar years, researchers generally agree that an age is assigned at the time of return and not the time of spawning. Wild winter steelhead age composition data for the run years 1976-77 to 2001-02 were obtained from WDFW. Hatchery winter steelhead age composition data was obtained from a variety of sources: 1980-1983 run year age data were from Hymer et al. (1992), 1984-1993 run year age data were from Hulett et al. (1995), 1977-1979 and 1994-2001 run year age data were from the National Marine Fisheries Service (NMFS) SimSalmon database, and 2001-02 run year age composition was the average from all years of available data. The annual ocean recruits were assigned to a brood year based on age; for example, the 1977 brood year was assembled with 2-year old recruits from 1979-80, 3-year old recruits from 1980-81, etc.

Kalama Summer Steelhead

The Kalama summer steelhead population is a mixture of hatchery and wild production; the proportion of hatchery fish in the total escapement has ranged from 14% (2001) to 90% (1982). From 1977-2003, the proportion of hatchery fish in the annual escapement has average 66%. WDFW maintains a research station solely for research of Kalama River steelhead and trout; because WDFW has generated a substantial time series of data for both wild and hatchery fish, the run reconstruction was completed for both components of the run. WDFW has recorded wild and hatchery summer steelhead escapement to the Kalama since 1977; each component of the escapement was the starting point for the run reconstruction. An assumed 5% prespawn mortality was applied to the escapement to determine the number of spawners (Petrosky 1995). Tributary harvest of wild summer steelhead (in numbers of fish) for 1977-1996 and 1999-2003 was obtained directly from WDFW. WDFW wild tributary harvest data for 1997 and 1998 were incomplete; the harvest number used for 1997 and 1998 was obtained from Weinheimer et al. (2002). Tributary harvest of hatchery summer steelhead (in numbers of fish) for 1977-1996 was obtained directly from WDFW. Tributary harvest of hatchery summer steelhead for 1997-1999 was obtained from Weinheimer et al. (2002); 2000-2003 annual harvest was calculated as the most recent 5-year average harvest (1995-1999). Historically, there were not separate wild and hatchery summer steelhead harvest regulations in the mainstem Columbia River; since 1985, retention of wild summer steelhead in the Columbia River has been prohibited. Thus, wild summer steelhead harvest rates in the Columbia River are assumed to be the same as hatchery fish up to 1984; beginning in 1985, wild fish incidental harvest mortality is assumed to be 10% of the annual hatchery harvest rate. From 1977-2000, hatchery summer steelhead harvest rate in the Columbia River was calculated as the lower river sport catch divided by the lower river minimum run size (WDFW and ODFW 2002). Only sport harvest was considered in the mainstem harvest rate because there has been no commercial steelhead harvest in the Columbia River since 1974. The method for deriving harvest rates for hatchery summer steelhead has some limitations, but represents the best available data for estimating summer steelhead harvest in the mainstem Columbia River. For 2001-2003, hatchery summer steelhead harvest in the mainstem Columbia was calculated as the most recent 5-year average (1996-2000). Ocean harvest rate of wild and hatchery steelhead is assumed to be 0.5% based on incidental mortality. Summer steelhead harvest data in each of the respective areas was not available by age class; therefore, harvest by area was added back into the population to obtain the number of ocean recruits before the age composition data was applied. Wild summer steelhead age composition data for the run years 1977 to 2003 were obtained from WDFW. Hatchery summer steelhead age composition data was obtained from a variety of sources: 1984-1993 run year age data were from Hulett et al. (1995), 1977-1983 and 1994-2001 run year age data were from the NMFS SimSalmon database, and 2002-2003 run year age composition was the average from all years of available data. The annual ocean recruits were assigned to a brood year based on age; for example, the 1978 brood year was assembled with 2-year old recruits from 1980, 3-year old recruits from 1981, etc. Finally, the summer steelhead adult return migration is completed in a given year and spawning does not occur until the following year. Therefore, a one year lag was applied between the run year and brood year so accurate spawner/recruit relationships could be established.

Wind Summer Steelhead

The Wind River summer steelhead population is sustained primarily through wild production; the maximum proportion of hatchery fish in the annual escapement was 35% in 1991, however, recent escapements are almost completely wild summer steelhead. Thus, focus for the run reconstruction was wild production, but the hatchery portion of the population was reconstructed also. Spawning escapement data for run years 1985-1987 was obtained from WDF et al. (1993). For run years 1988-2002, spawning escapement numbers were obtained directly from WDFW. The total escapement was separated into wild and hatchery components based on WDFW data identifying the proportion of wild spawners annually from 1988-2002. The proportion of wild spawners from run year 1985-1987 was the 5-year average from 1988-1992. An assumed 5% prespawn mortality was applied to the escapement to determine the number of spawners (Petrosky 1995). Harvest of wild summer steelhead has been prohibited in the Wind River since 1981. The tributary harvest rate of wild summer steelhead for 1985-1987 was assumed to be 1% based on incidental mortality. The tributary harvest of wild summer steelhead (in numbers of fish) for 1988-2002 was obtained from WDFW. The tributary harvest rate of hatchery summer steelhead for 1985-1991 was based on data presented in Hymer et al. (1992); the harvest rate for 1992-2000 was the average harvest of the years of available data. Retention of wild steelhead in the mainstem Columbia River sport fisheries has been prohibited since 1985. The mainstem harvest rate of Wind wild summer steelhead from 1985-2000 was assumed to be 10% of the lower Columbia sport catch of Group A index steelhead plus the number of wild Group A index summer steelhead in the Zone 6 commercial catch (with a 35% reduction factor) divided by the total minimum Group A index summer steelhead run in the Columbia River (WDFW and ODFW 2002). Similarly, the mainstem harvest rate of hatchery summer steelhead from 1985-2000 was calculated as the lower Columbia sport catch of Group A index summer steelhead plus the number of hatchery group A index summer steelhead in the Zone 6 commercial catch (with a 35% reduction factor) divided by the total minimum run group A index summer steelhead in the Columbia River (WDFW and ODFW 2002). The mainstem harvest rate of hatchery and wild summer steelhead for 2001 and 2002 was the most recent 5-year average (1996-2000). The ocean harvest rate of wild and hatchery summer steelhead is assumed to be 0.5% based on incidental mortality. Summer steelhead harvest data in each of the respective areas was not available by age class; therefore, harvest by area was added back into the population to obtain the number of ocean recruits before the age composition data was applied. Age composition data for 1989-2001 was obtained from the NMFS SimSalmon database; the age composition for 1985-1988 and 2002 was the average based on all years of available data. The annual ocean recruits were assigned to a brood year based on age; for example, the 1986 brood year was assembled with 2-year old recruits from 1988, 3-year old recruits from 1989, etc. As previously described for summer steelhead, a one year lag was applied between the run year and brood year so accurate spawner/recruit relationships could be established.

Grays Chum
Although intermittent releases of hatchery chum salmon have occurred in the Grays River, the population is thought to be sustained through wild production. A long, continuous time series of escapement data was available for Grays River chum; the run reconstruction began with the 1959 run year. Grays River chum escapement data determined by different methods were available by major tributary from multiple sources. Escapement data for the mainstem and West Fork from 1959-2001 were based on total live fish counts; data for 1959-1985 were obtained directly from WDFW and data for 1986-2001 were presented in WDFW (2003). Tributary escapement data for Crazy Johnson, Gorley, and Fossil Creeks from 1959-1991 were expanded population estimates presented in Hymer (1993). Escapement data for Crazy Johnson, Gorley, and Fossil Creeks from 1992-2000 were peak counts of live and dead chum salmon presented in Roler et al. (2002). The proportion of hatchery and wild spawners in the annual escapement was not known, but is expected to be primarily wild spawners. Retention of chum salmon in the Grays River sport fishery has been prohibited since 1994; chum salmon retention in mainstem sport fisheries has been prohibited in Washington since 1995 and in Oregon since 1992. When retention was allowed, chum salmon were not a targeted species. Thus, tributary harvest of Grays River chum was assumed to be 1%. Mainstem harvest rate for 1959-2000 was calculated from the commercial catch in Zones 1-5 divided by the minimum Columbia River run size (WDFW and ODFW 2002). The mainstem harvest rate for 2001 was the most recent 5-year average harvest (1996-2000). Chum salmon ocean harvest was expected to be minimal and was assumed to be 1%. Chum salmon harvest data in each of the respective areas was not available by age class; therefore, harvest by area was added back into the population to obtain the number of ocean recruits before the age composition data was applied. Age composition data for 1959-1978 and 1985-2001 was obtained from the NMFS SimSalmon database. Age composition data for 1979-1984 was obtained from Hymer et al (1992). The annual ocean recruits were assigned to a brood year based on age; for example, the 1959 brood year was assembled with 3-year old recruits from 1962, 4-year old recruits from 1963, etc.

Critical Uncertainties
Accuracy of each run reconstruction is extremely sensitive to the quality of the available data. For example, inaccuracies in age composition data significantly affects the apportionment of fish throughout the run reconstruction. We attempted to utilize those data that are considered to be the best available information; there may be other unpublished or otherwise unavailable data of which we are not aware. In the absence of available data, we made professional assumptions that are expected to closely estimate the true parameters.

Results
Coweeman Tule Fall Chinook
Appendix A-1 includes the Coweeman River tule fall chinook run reconstruction table. The results cover brood years 1964-1995. Recruits per spawner were generally less than

10; average recruits per spawner was 5.748 (Figure 1). Productivity (defined as the natural log of the ratio of recruits to spawners) averaged 1.142 (consequently, this is the highest average productivity of all populations analyzed); the lowest productivity was observed in the late 1980's and mid 1990s (Figure 1). Recruits per spawner and productivity spiked in 1984. No pattern was observed in an analysis of productivity within specific decades (Figure 2). This productivity plot revealed that productivity was negative at spawner abundance greater than 500; however, the negative productivity may be an artifact of environmental conditions rather than spawner abundance. These years of negative productivity correspond with years of low ocean productivity (1988, 1989, 1994, and 1995). There is no linear relationship between spawners and recruits (r^2=0.0003, p=0.9297); therefore, the number of spawners is not an accurate predictor of recruits (Figure 3).

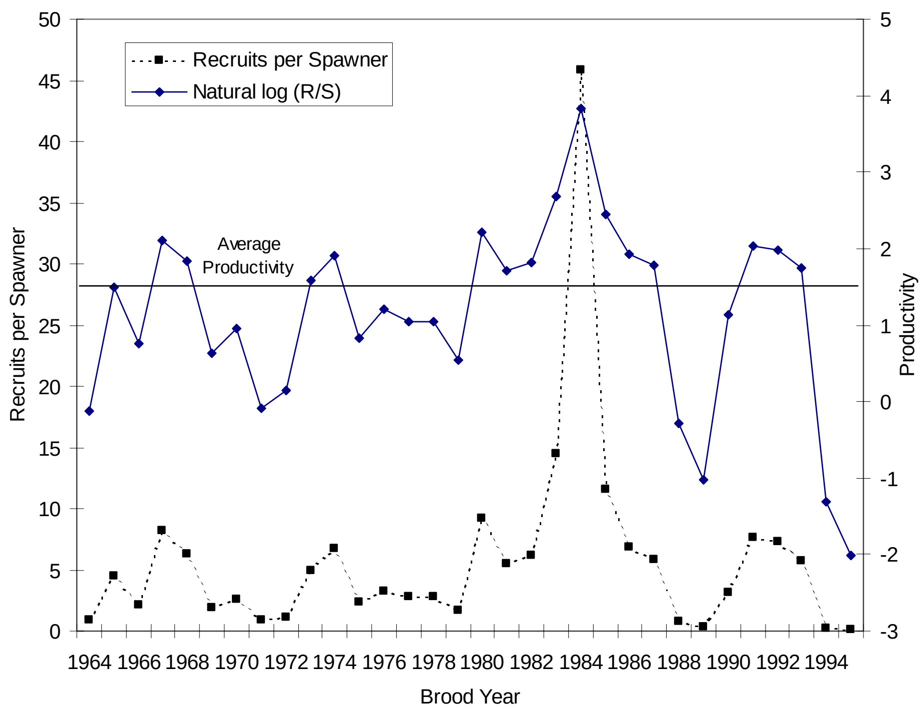

Figure 1. Coweeman tule fall chinook recruits per spawner ratio and productivity by brood year, 1964-1995.

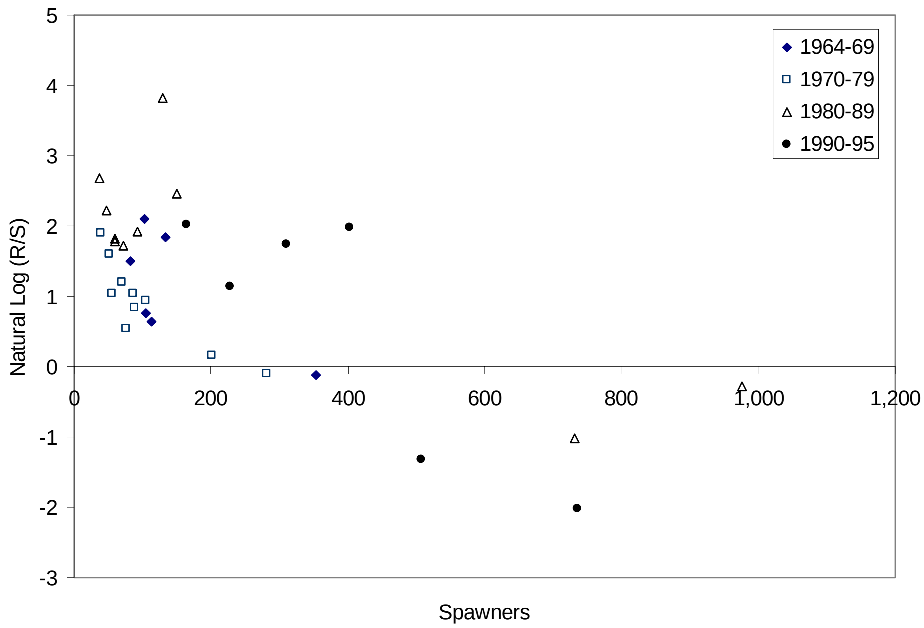

Figure 2. Scatter plot of Coweeman tule fall chinook spawners and productivity by brood year, grouped by decade.

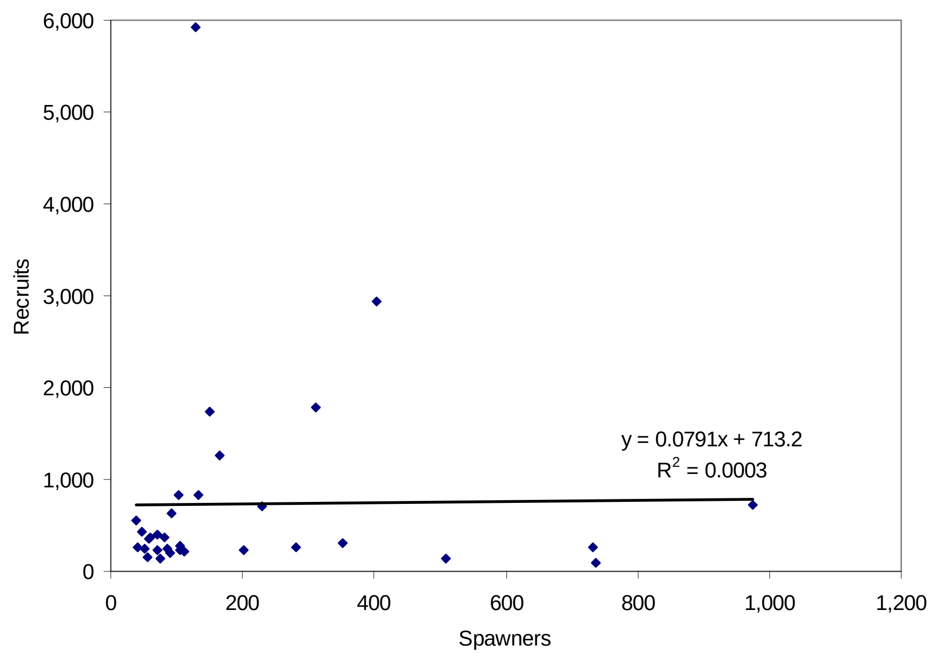

Figure 3. Scatter plot of Coweeman tule fall chinook spawners and recruits.

East Fork Lewis Tule Fall Chinook

Appendix A-2 includes the East Fork Lewis River tule fall chinook run reconstruction table. The results cover brood years 1964-1995. Recruits per spawner were generally less than 5; average recruits per spawner was 3.597 (Figure 4). A period of low recruit per spawner values was observed from 1985 to 1996; as expected, productivity was also low during this time period. Productivity averaged 0.736, with the lowest value observed in 1994 (Figure 4). Recruits per spawner and productivity spiked in the late 1960s and again in 1984. Few patterns were observed in a comparison of productivity within specific decades (Figure 5). In general, productivity in the 1990s was lower than other decades. Although the relationship appears weak, productivity may decline as spawner abundance increases. Years of negative productivity were 1988, 1989, 1991, and 1994; these years correspond with years of low ocean productivity. There is no linear relationship between spawners and recruits (r^2=0.012, p=0.5507); therefore, the number of spawners is not an accurate predictor of recruits (Figure 6).

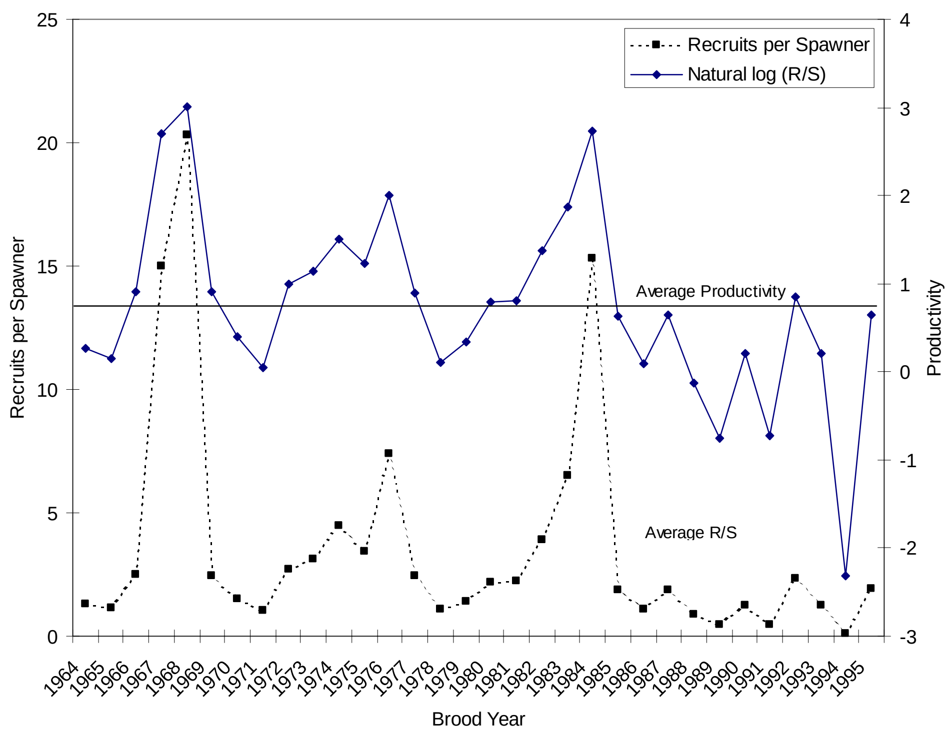

Figure 4. East Fork Lewis tule fall chinook recruits per spawner ratio and productivity by brood year, 1964-1996.

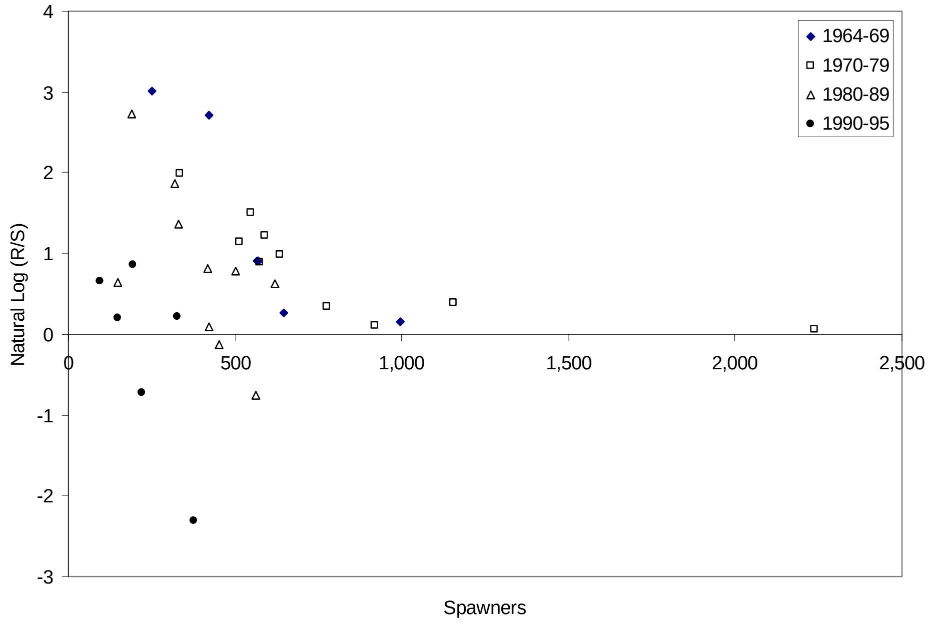

Figure 5. Scatter plot of East Fork Lewis tule fall chinook spawners and productivity by brood year, grouped by decade.

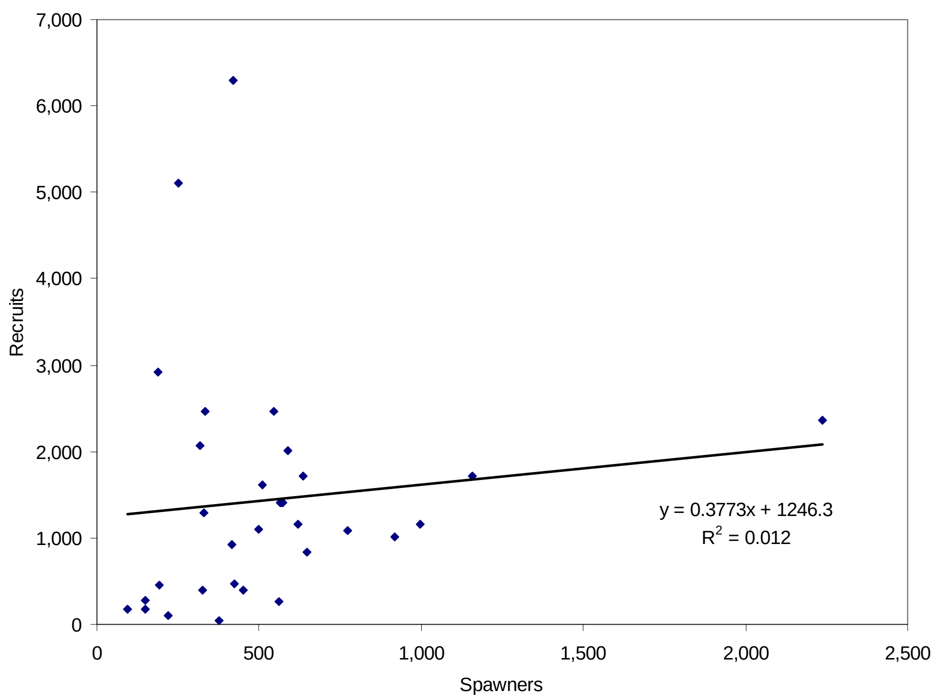

Figure 6. Scatter plot of East Fork Lewis tule fall chinook spawners and recruits.

North Fork Lewis Bright Fall Chinook

Appendix A-3 includes the North Fork Lewis River bright fall chinook run reconstruction table. The results cover brood years 1964-1995. Recruits per spawner were generally less than 4; average recruits per spawner was 2.287 (Figure 7). Productivity averaged 0.488; the lowest productivity was observed in 1994 and 1995 (Figure 7). The highest recruit per spawner and productivity values were observed in 1968, 1976, and 1984. Few patterns were observed in a comparison of productivity within specific decades (Figure 8). Productivity appears to decline as spawner abundance increases. There were nine years of negative productivity; the lowest productivity was observed in 1989, 1994, and 1995. Negative productivity was observed in at least 2 years of all decades included in the analysis. There is no linear relationship between spawners and recruits (r^2=0.0181, p=0.4631); therefore, the number of spawners is not an accurate predictor of recruits (Figure 9). Juvenile outmigration data was available from 1977-87; smolt to adult survival ranged from 0.004 in 1978 to 0.014 in 1986 (Figure 10).

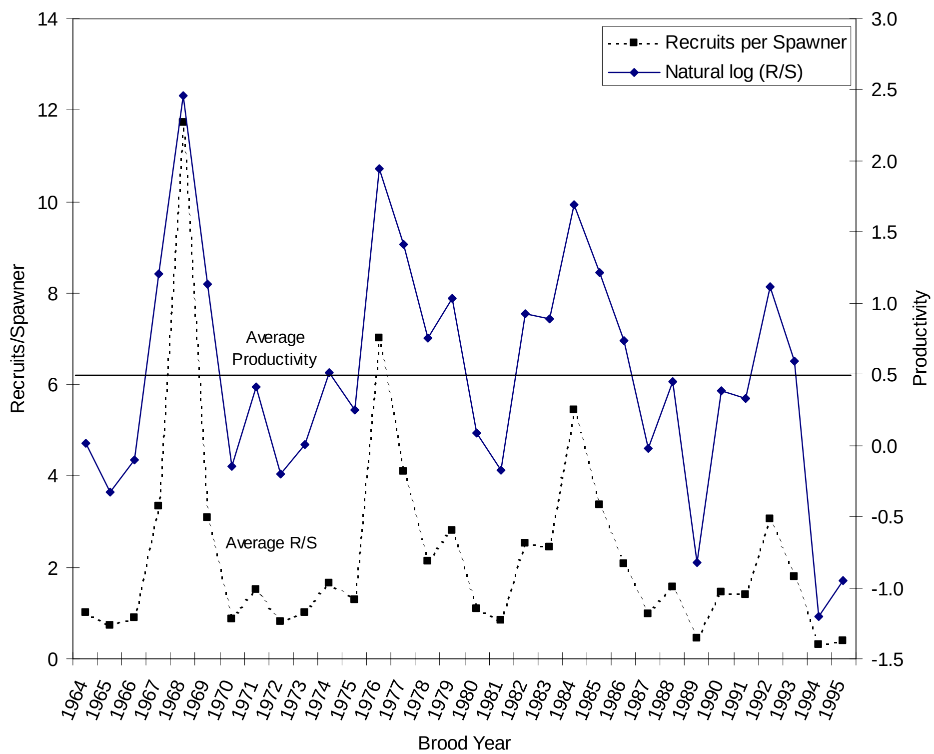

Figure 7. North Fork Lewis bright fall chinook recruits per spawner ratio and productivity by brood year, 1964-1996.

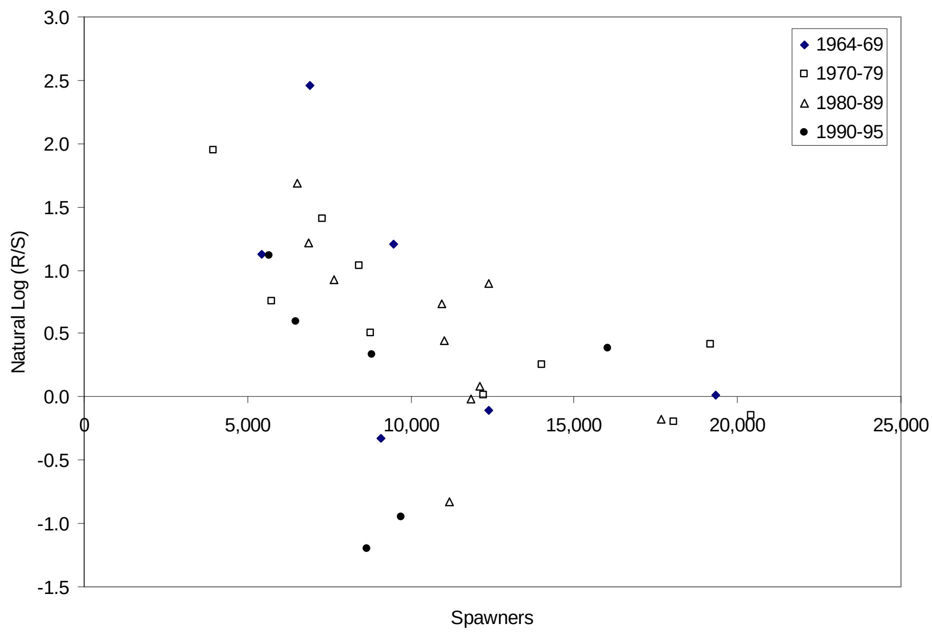

Figure 8. Scatter plot of North Fork Lewis bright fall chinook spawners and productivity by brood year, grouped by decade.

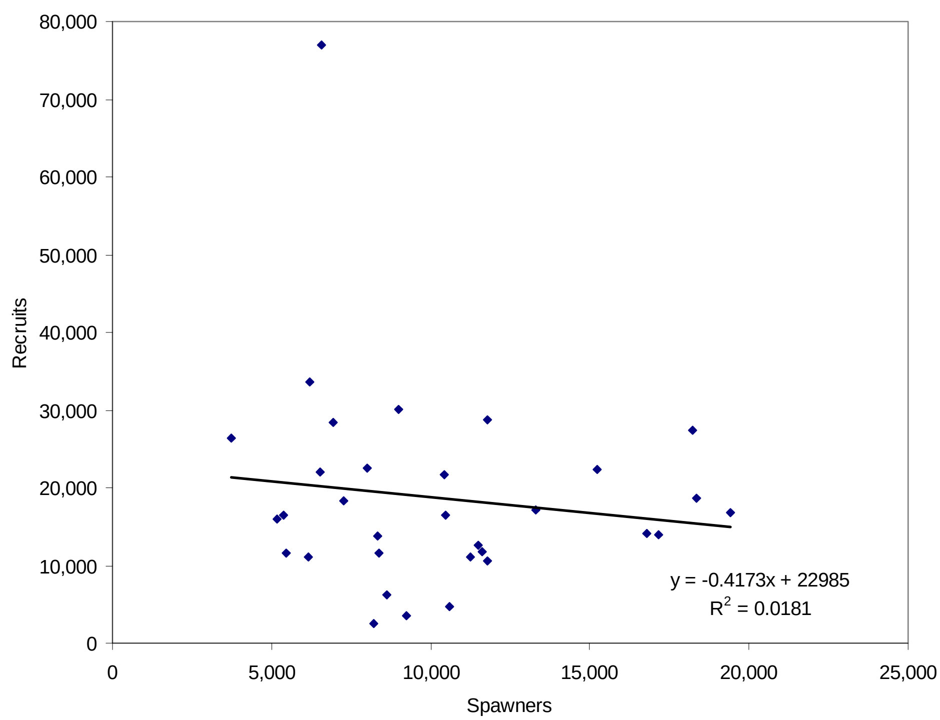

Figure 9. Scatter plot of North Fork Lewis bright fall chinook spawners and recruits.

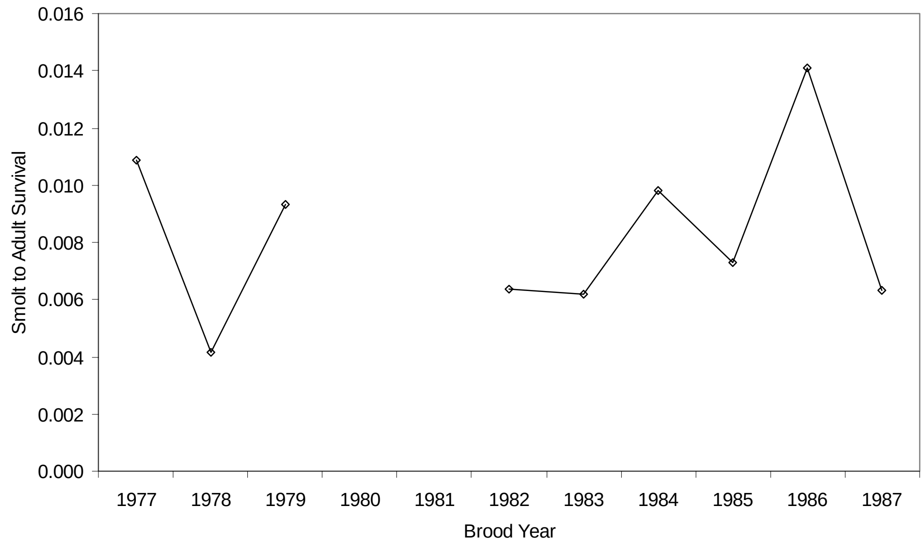

Figure 10. North Fork Lewis bright fall chinook smolt to adult survival by brood year, 1977-1987.

Wind Spring Chinook

Appendix A-4 includes the Wind River spring chinook run reconstruction table. The results cover brood years 1963-1995. Recruits per spawner were generally less than 3; average recruits per spawner was 2.275, while productivity averaged 0.432 (Figure 11). The highest recruit per spawner and productivity values were observed in 1986 and 1993. Few patterns were observed in a comparison of productivity within specific decades (Figure 12). Productivity appears to decline as spawner abundance increases. There were nine years of negative productivity; none were recorded in the 1960s. The lowest productivity was observed in 1972. Negative productivity was observed in at least 2 years of the 1970s, 1980s, and 1990s. There is weak negative linear relationship between spawners and recruits (r^2=0.048, p=0.2206); therefore, the number of spawners is not an accurate predictor of recruits (Figure 13). Hatchery release data are available from 1965 to the present; smolt to adult survival was calculated for 1965-95. Smolt to adult survival ranged from 0.0001 in 1972 to 0.007 in 1968 (Figure 14).

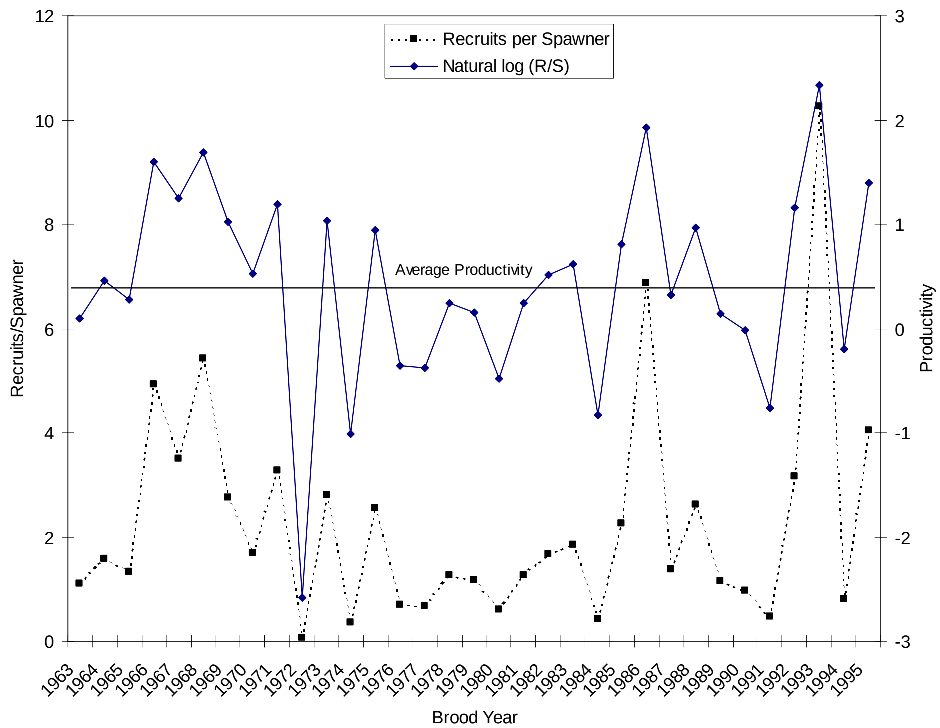

Figure 11. Wind River spring chinook recruits per spawner ratio and productivity by brood year, 1963-1995.

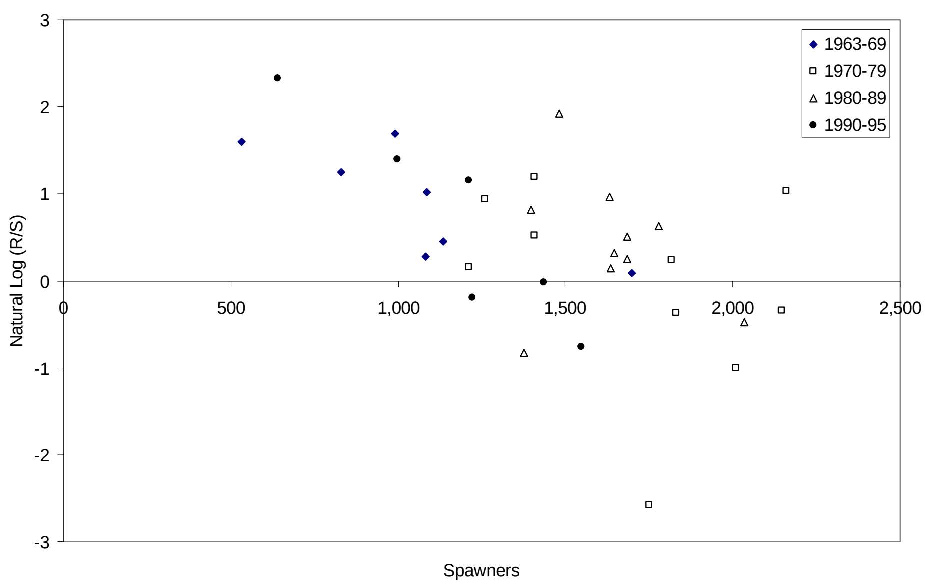

Figure 12. Scatter plot of Wind River spring chinook spawners and productivity by brood year, grouped by decade.

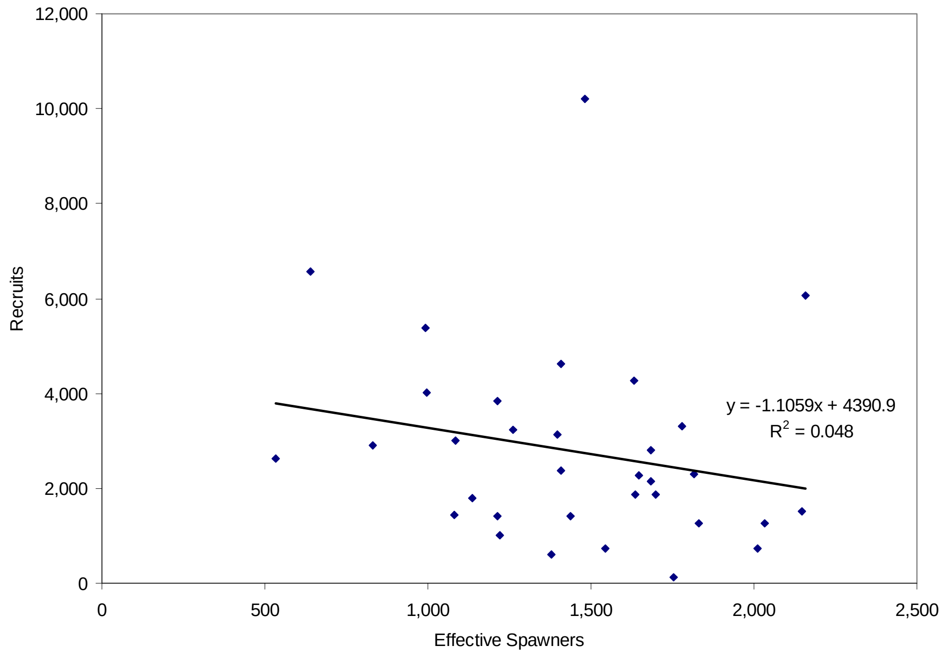

Figure 13. Scatter plot of Wind River spring chinook spawners and recruits.

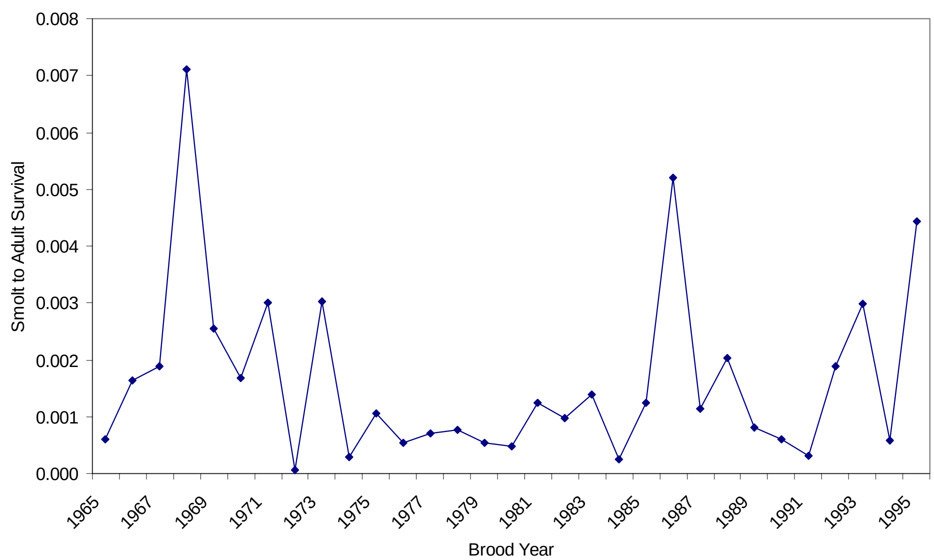

Figure 14. Wind River spring chinook smolt to adult survival by brood year, 1965-1995.

Little White Salmon Spring Chinook

Appendix A-5 includes the Little White Salmon River spring chinook run reconstruction table. The results cover brood years 1965-1995. Recruits per spawner were generally less than 5; average recruits per spawner was 3.660, while productivity averaged 0.688 (Figure 15). The highest recruit per spawner and productivity values were observed in

1965, 1981, 1982, and 1986. Few patterns were observed in a comparison of productivity within specific decades (Figure 16). There were nine years of negative productivity; six of which were recorded in the 1970s. Negative productivity occurred in all decades expect the 1960s. The lowest productivity was observed in 1976. There is weak linear relationship between spawners and recruits (r^2=0.101, p=0.0815; Figure 17); however, the y-intercept of –638.01 is not realistic. Therefore, the number of spawners is not an accurate predictor of recruits. Hatchery release data are available from 1967 to the present; smolt to adult survival was calculated for 1967-95. Smolt to adult survival ranged from 0.0002 in 1972 and 1976 to 0.025 in 1982 (Figure 18).

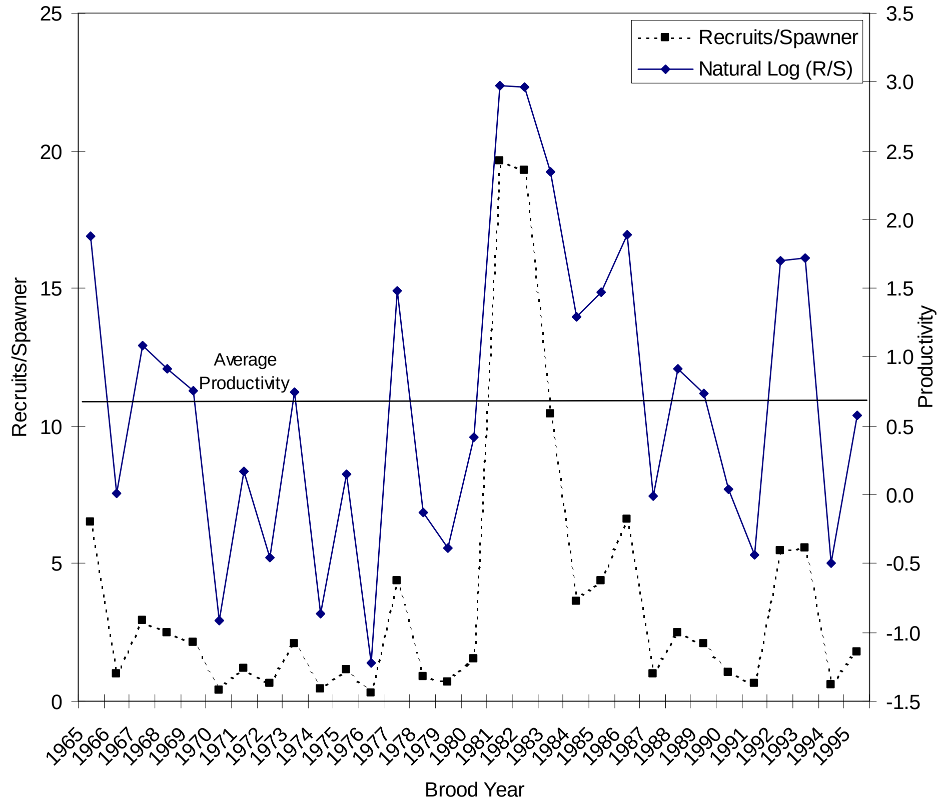

Figure 15. Little White Salmon spring chinook recruits per spawner ratio and productivity by brood year, 1963-1995.

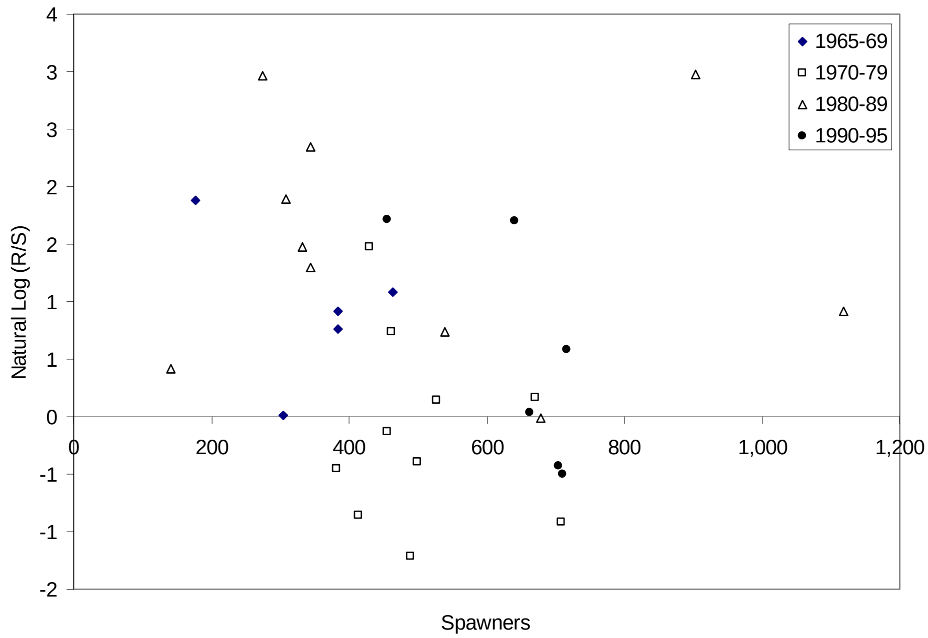

Figure 16. Scatter plot of Little White Salmon spring chinook spawners and productivity by brood year, grouped by decade.

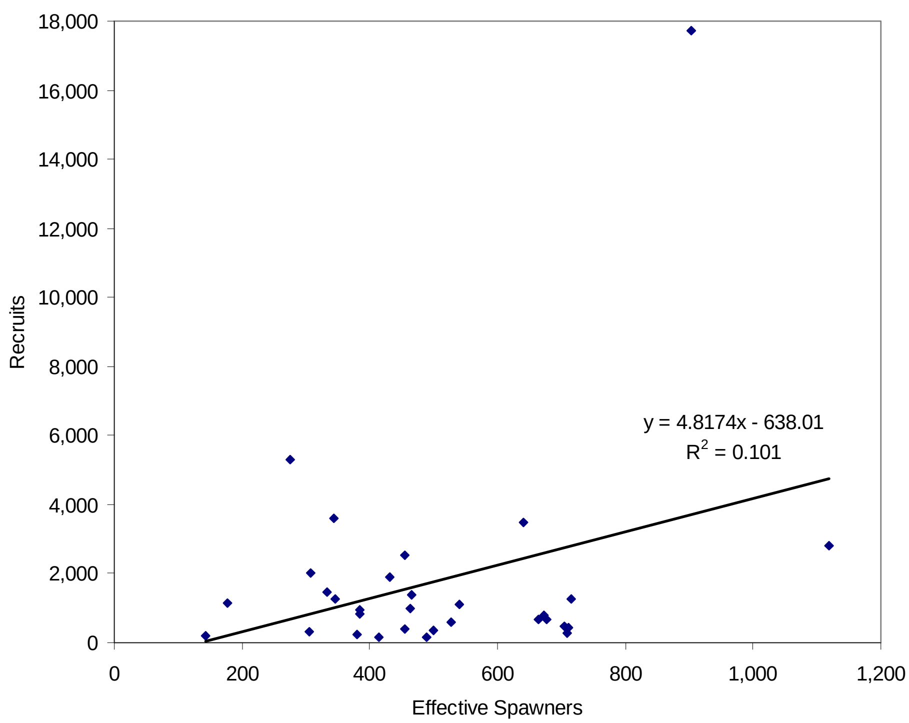

Figure 17. Scatter plot of Little White Salmon spring chinook spawners and recruits.

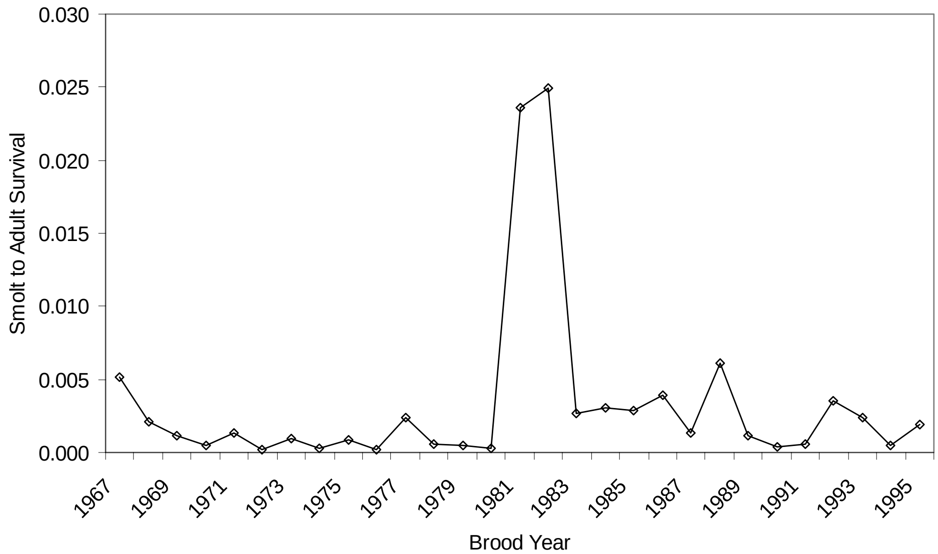

Figure 18. Little White Salmon spring chinook smolt to adult survival by brood year, 1965-1995.

Kalama Winter Steelhead

Appendix A-6 includes the Kalama River winter steelhead run reconstruction table. The results cover brood years 1977-1995. Wild and hatchery fish were analyzed separately because sufficient catch and escapement data exists that allows for the separation of these two components of the population. The total population data is also presented and generally represents an intermediary value between the wild and hatchery fish. Wild recruits per spawner were generally less than 4; average wild recruits per spawner was 1.685 (Figure 19). Generally, hatchery recruits per spawner were similar to or greater than the wild recruits per spawner for the same brood year. Average wild productivity was 0.279 (Figure 20). Generally, hatchery productivity was similar to or greater than the wild productivity for the same brood year. Maximum wild recruits per spawner and productivity occurred in 1979. Hatchery recruits per spawner and productivity spiked in 1982, 1983, and 1989; values were also high in 1979 and 1985 (Figure 20). Few patterns were observed in a comparison of productivity within specific decades (Figure 21 and Figure 22). Productivity appears to decline as spawner abundance increases (for both wild and hatchery fish). For the wild component of the population, there were seven brood years of negative productivity (two in the 1980s and five years in the 1990s; Figure 21). For the hatchery component of the population, there were two brood years of negative productivity (1977 and 1986; Figure 22); as a result of reduced hatchery operations, the hatchery component of the population began declining in the early 1990s. There is no linear relationship between wild spawners and recruits (r^2=0.0105, *p*=0.6763); therefore, the number of spawners is not an accurate predictor of recruits (Figure 23). There is no linear relationship between hatchery spawners and recruits (r^2=0.0016, *p*=0.8905); therefore, the number of spawners is not an accurate predictor of recruits (Figure 24).

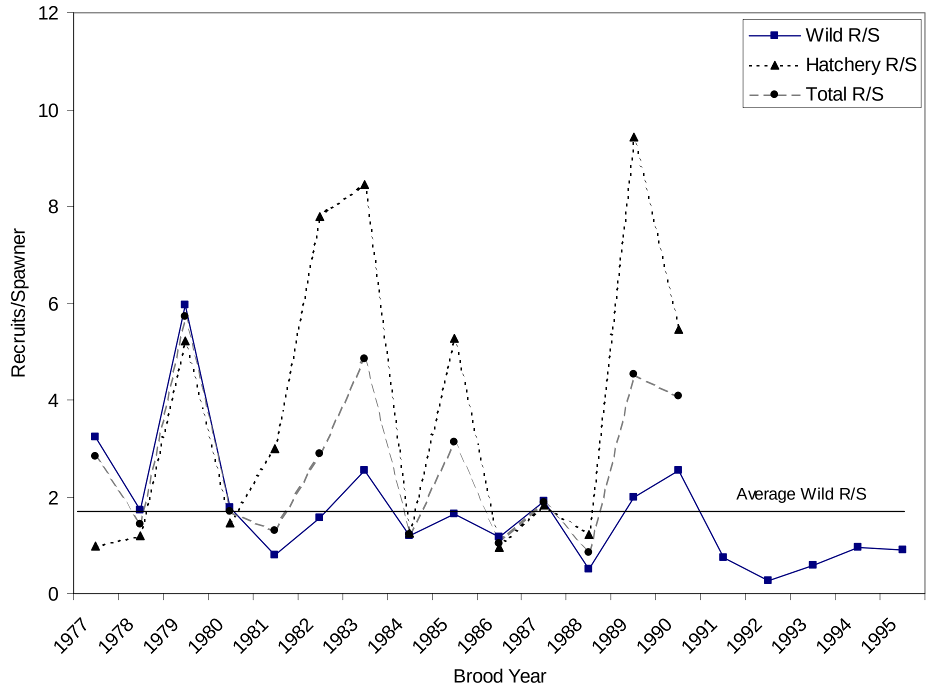

Figure 19. Kalama River winter steelhead recruits per spawner ratio by brood year for the wild and hatchery components as well as the total run, 1977-1995.

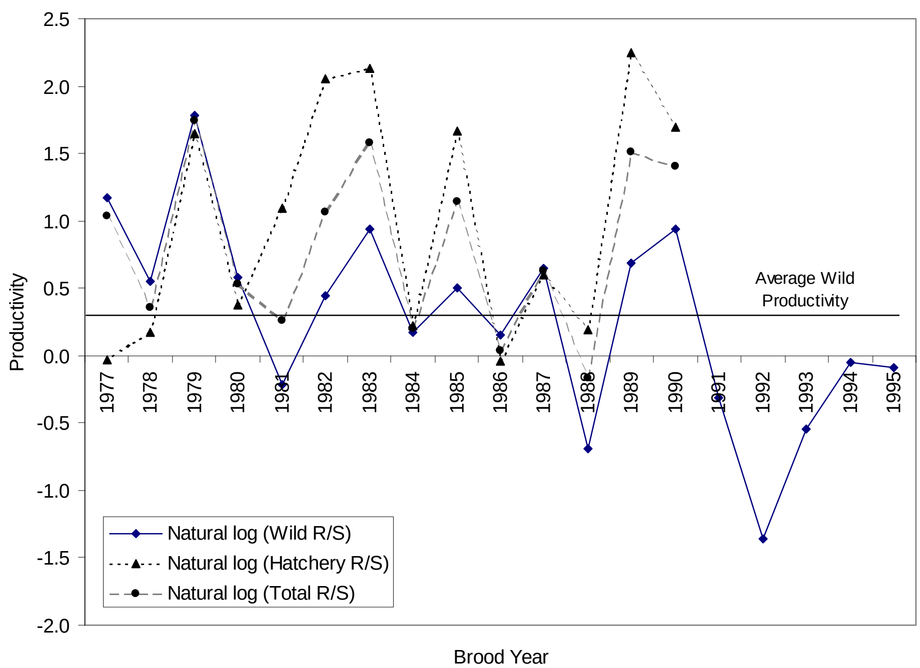

Figure 20. Kalama River winter steelhead productivity by brood year for the wild and hatchery components as well as the total run, 1977-1995.

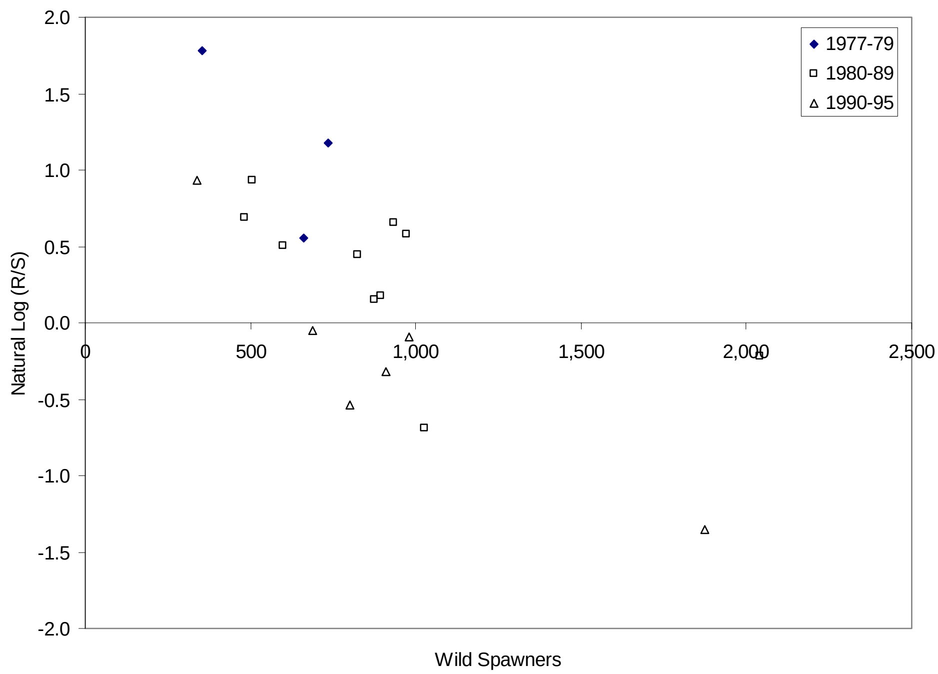

Figure 21. Scatter plot of Kalama River wild winter steelhead spawners and productivity by brood year, grouped by decade.

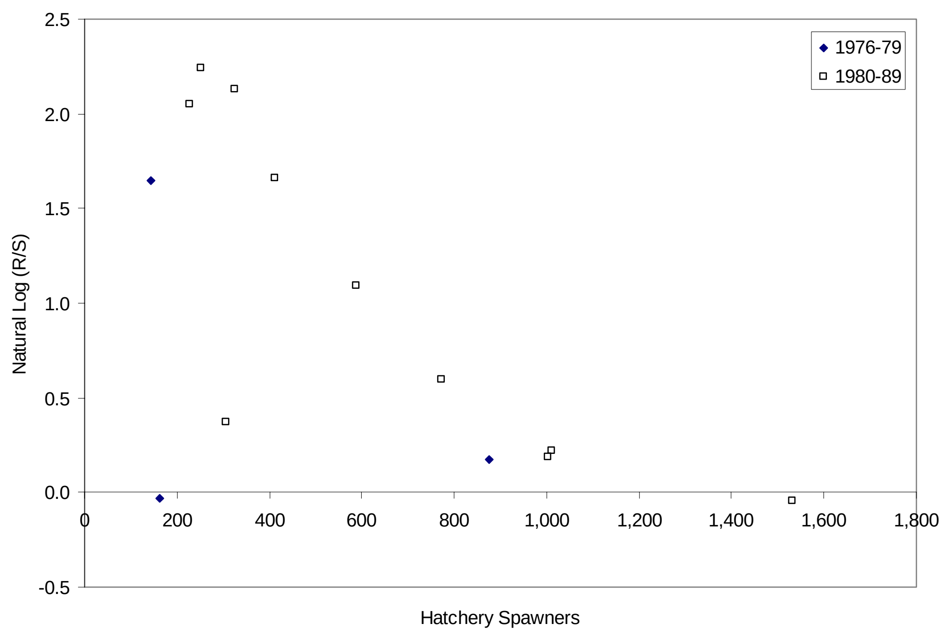

Figure 22. Scatter plot of Kalama River hatchery winter steelhead spawners and productivity by brood year, grouped by decade.

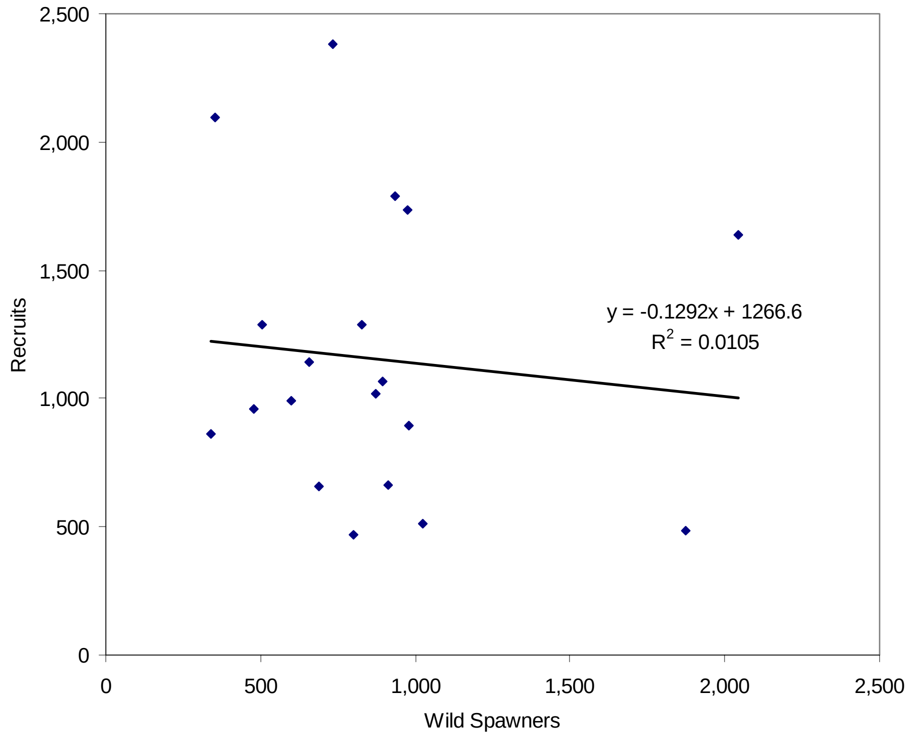

Figure 23. Scatter plot of Kalama River wild winter steelhead spawners and recruits.

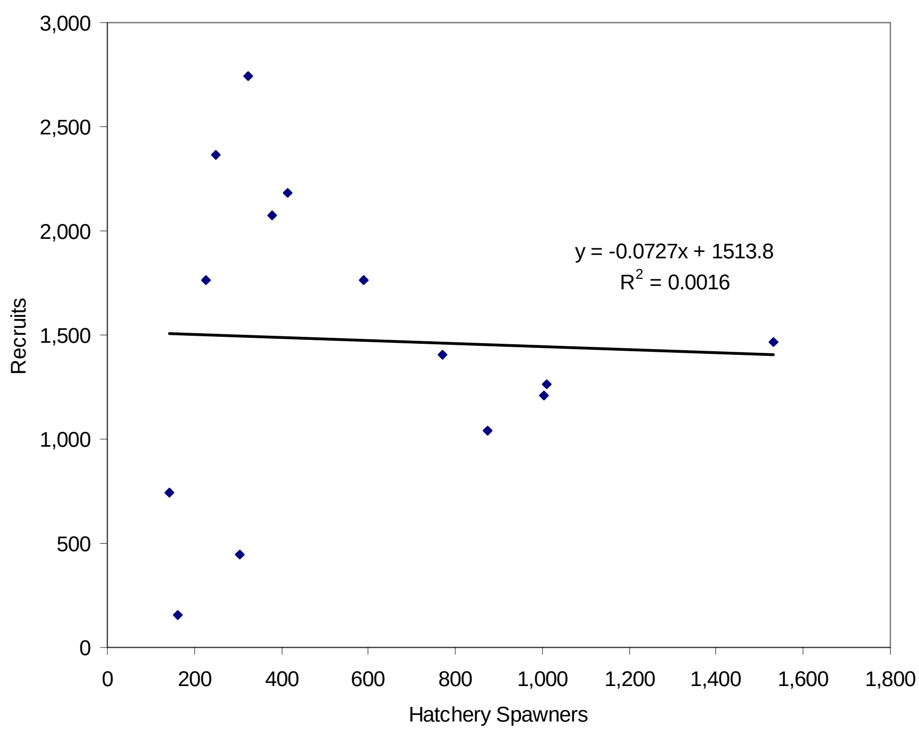

Figure 24. Scatter plot of Kalama River hatchery winter steelhead spawners and recruits.

Kalama Summer Steelhead

Appendix A-7 includes the Kalama River summer steelhead run reconstruction table. The results cover brood years 1978-1995. Wild and hatchery fish were analyzed separately because sufficient catch and escapement data exists that allows for the separation of these two components of the population. The total population data is also presented and generally represents an intermediary value between the wild and hatchery fish. Wild recruits per spawner were generally less than 3; average wild recruits per spawner was 1.863 (Figure 25). A steady decline in recruits per spawner began in 1989. Generally, hatchery recruits per spawner were similar to or greater than the wild recruits per spawner for the same brood year. Average wild productivity was 0.214 (Figure 26). Generally, hatchery productivity was similar to or greater than the wild productivity for the same brood year. The highest recruit per spawner and productivity values for both wild and hatchery fish were observed in 1978 and 1985 (Figure 25 and Figure 26). Few patterns were observed in a comparison of productivity within specific decades (Figure 27 and Figure 28). Productivity appears to decline as wild and hatchery spawner abundance increases, although the relationship for hatchery fish appears weaker than that for wild fish. For the wild component of the population, productivity in the 1990s was lower than the other decades. Of six brood years of negative productivity, four were in the 1990s and two were in the 1980s (Figure 27). For the hatchery component of the population, there were five brood years of negative productivity (three in the 1980s and two in the 1990s; Figure 28). As a result of reduced hatchery operations, the hatchery component of the population began declining in the early 1990s. There is no linear relationship between wild spawners and recruits (r^2=0.0448, p=0.3989); therefore, the number of spawners is not an accurate predictor of recruits (Figure 29). There is no linear relationship between hatchery spawners and recruits (r^2=0.0158, p=0.6081); therefore, the number of spawners is not an accurate predictor of recruits (Figure 30).

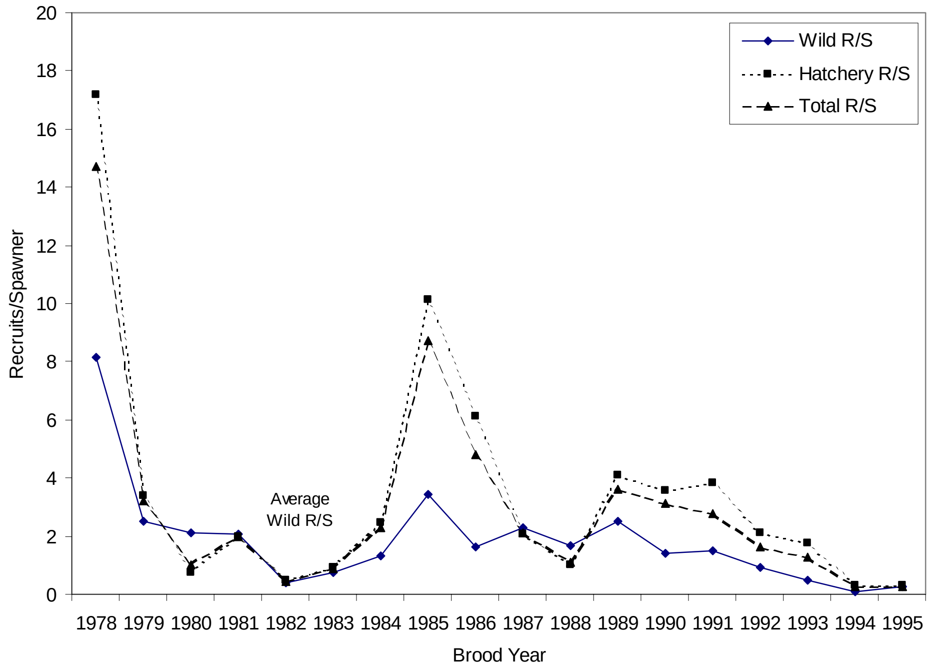

Figure 25. Kalama River summer steelhead recruits per spawner ratio by brood year for the wild and hatchery components as well as the total run, 1977-1995.

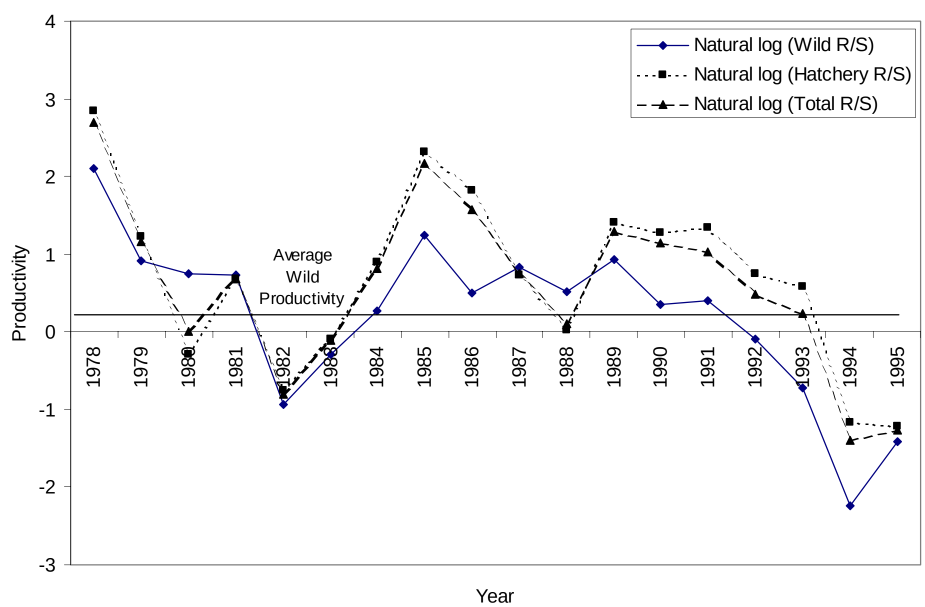

Figure 26. Kalama River summer steelhead productivity by brood year for the wild and hatchery components as well as the total run, 1977-1995.

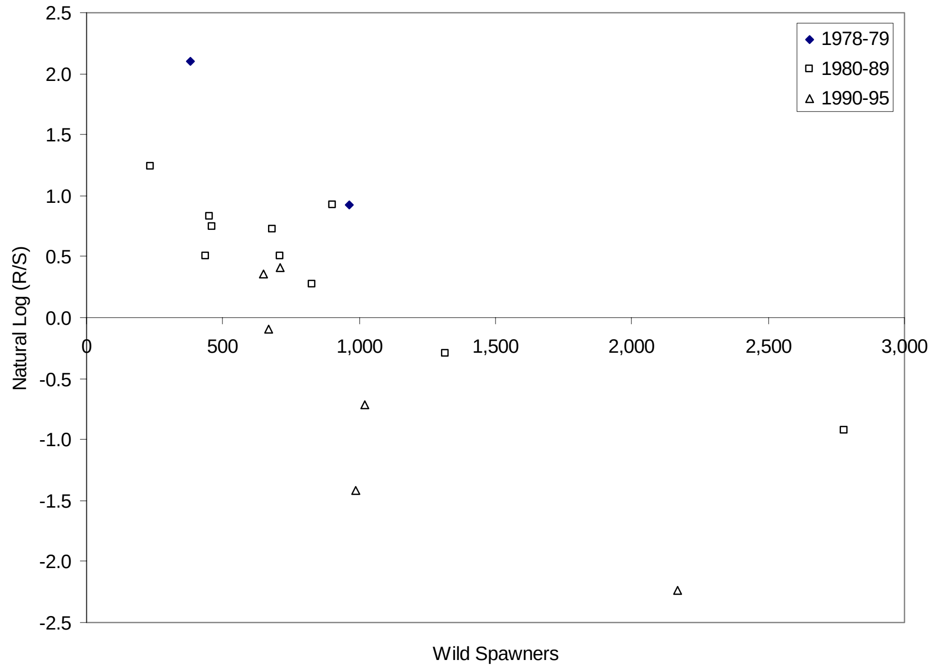

Figure 27. Scatter plot of Kalama River wild summer steelhead spawners and productivity by brood year, grouped by decade.

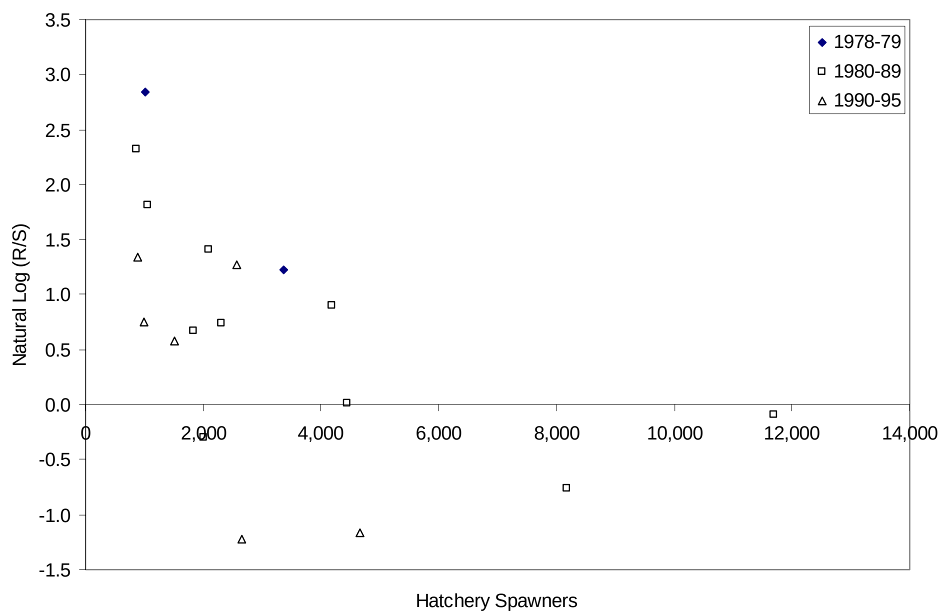

Figure 28. Scatter plot of Kalama River hatchery summer steelhead spawners and productivity by brood year, grouped by decade.

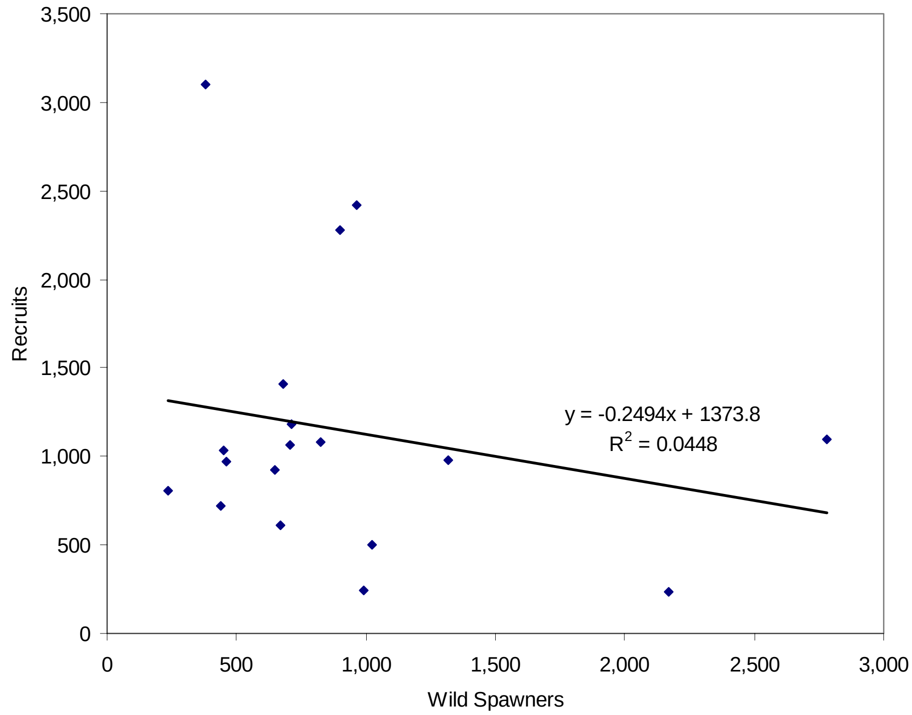

Figure 29. Scatter plot of Kalama River wild summer steelhead spawners and recruits.

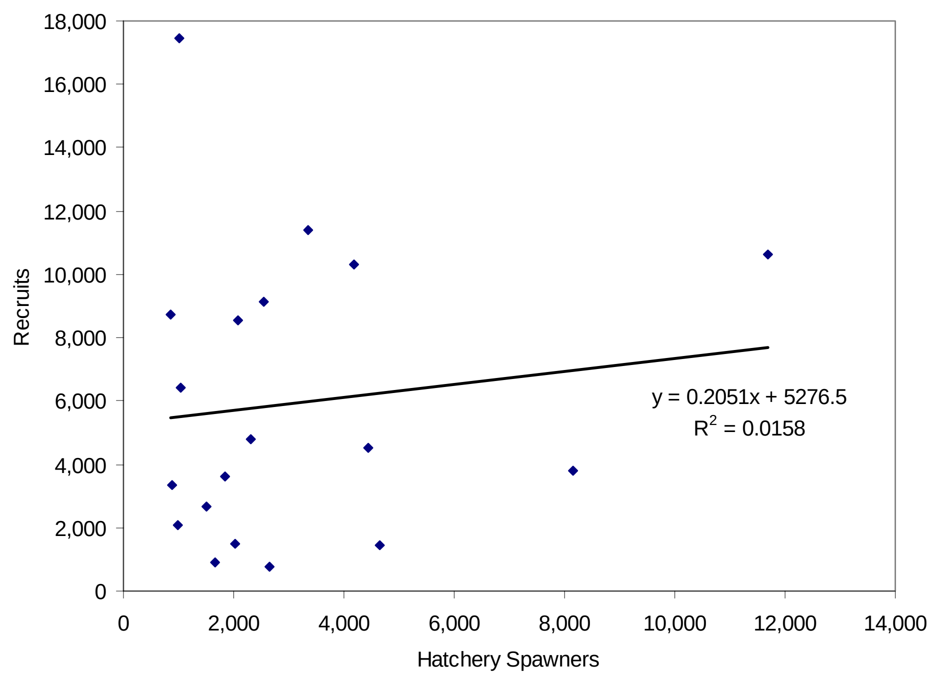

Figure 30. Scatter plot of Kalama River hatchery summer steelhead spawners and recruits.

Wind Summer Steelhead

Appendix A-8 includes the Wind River summer steelhead run reconstruction table. The results cover brood years 1986-1996; this is the shortest time period of all run reconstructions performed in this analysis. Wild and hatchery fish were analyzed separately because sufficient catch and escapement data exists that allows for the separation of these two components of the population. The total population data is also presented and generally represents an intermediary value between the wild and hatchery fish. Wild recruits per spawner were generally less than 2; average wild recruits per spawner was 1.088 (Figure 31). Generally, hatchery recruits per spawner were similar to or greater than the wild recruits per spawner for the same brood year. Average wild productivity was 0.002 (Figure 32). Generally, hatchery productivity was similar to or greater than the wild productivity for the same brood year; the only notable exception was 1995 where hatchery productivity was extremely low. The highest recruit per spawner and productivity values for hatchery fish were observed in 1986 and 1987; maximum recruit per spawner and productivity values for wild fish occurred in 1987 (Figure 31 and Figure 32). Few patterns were observed in a comparison of productivity within specific decades (Figure 33 and Figure 34). Productivity appears to decline as wild and hatchery spawner abundance increases, although the relationship for hatchery fish does not appear to be very strong. For the wild component of the population, productivity in the 1990s was lower than the other decades. Of six brood years of negative productivity, five were in the 1990s and one was in the 1980s (Figure 33). For the hatchery component of the population, there were also six brood years of negative productivity (one in the 1980s and five in the 1990s; Figure 34). As a result of reduced hatchery operations, the hatchery component of the population began declining in the late 1990s. There is no linear relationship between wild spawners and recruits (r^2=0.0151, p=0.7186); therefore, the number of spawners is not an accurate predictor of recruits (Figure 35). There is no linear relationship between hatchery spawners and recruits (r^2=0.0001, p=0.9755); therefore, the number of spawners is not an accurate predictor of recruits (Figure 36).

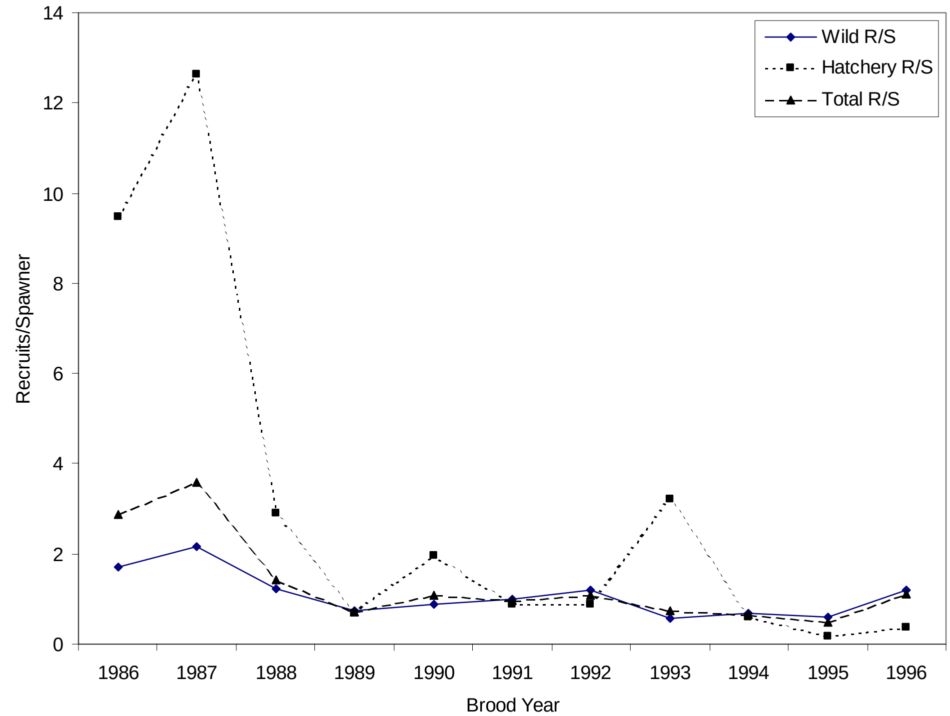

Figure 31. Wind River summer steelhead recruits per spawner ratio by brood year for the wild and hatchery components as well as the total run, 1977-1995.

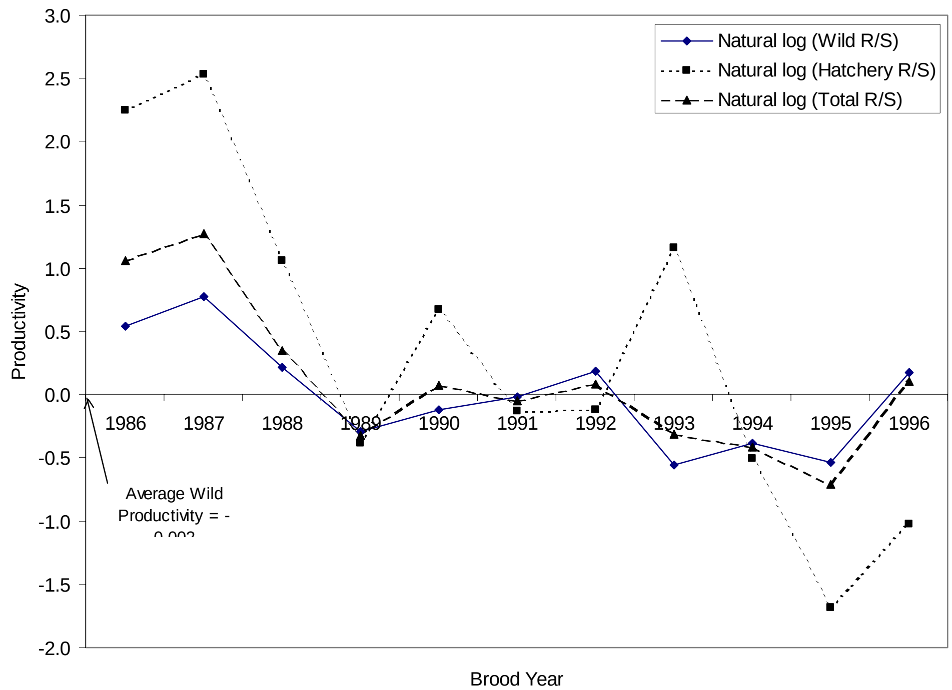

Figure 32. Wind River summer steelhead productivity by brood year for the wild and hatchery components as well as the total run, 1977-1995.

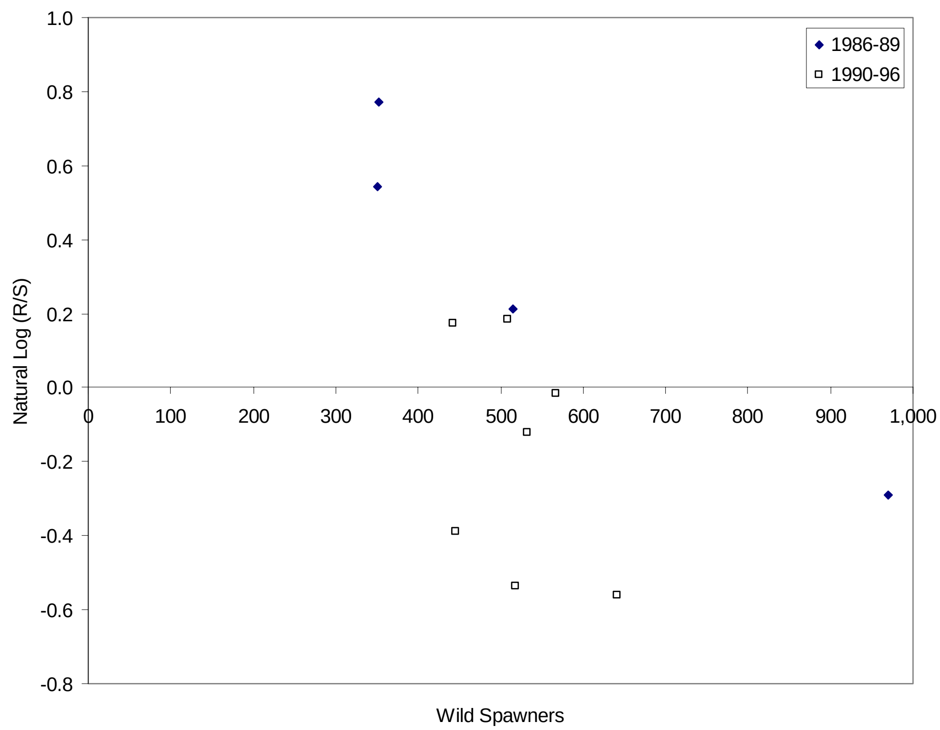

Figure 33. Scatter plot of Wind River wild summer steelhead spawners and productivity by brood year, grouped by decade.

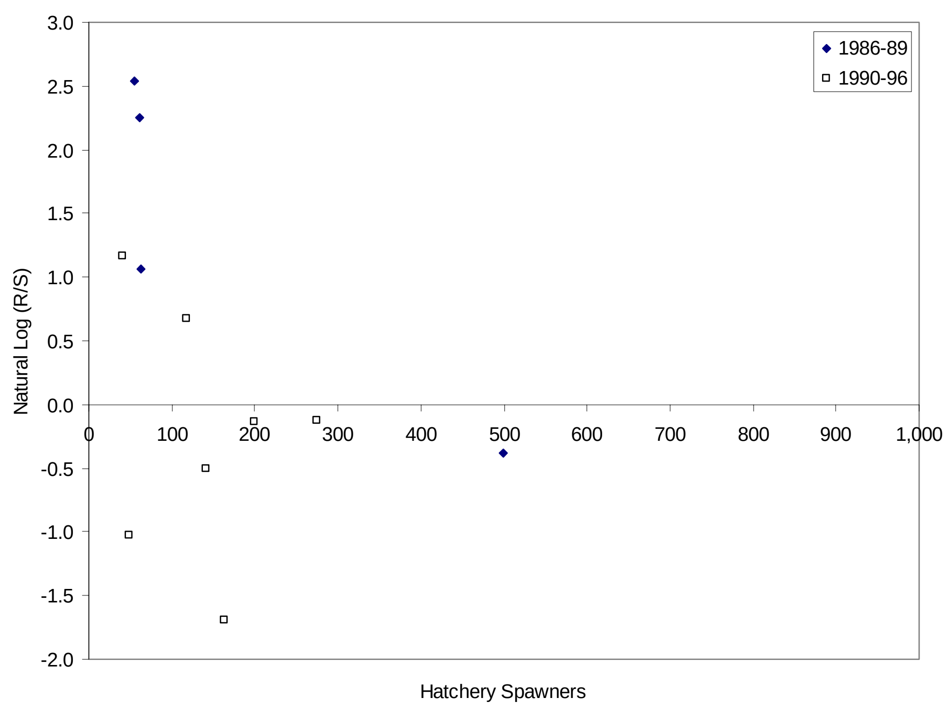

Figure 34. Scatter plot of Wind River hatchery summer steelhead spawners and productivity by brood year, grouped by decade.

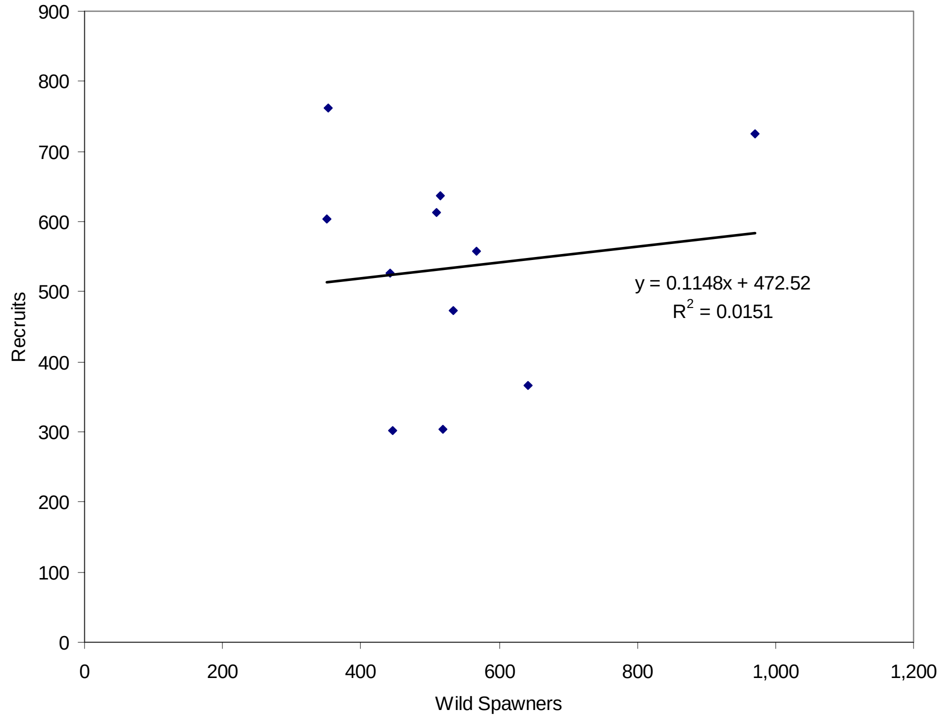

Figure 35. Scatter plot of Wind River wild summer steelhead spawners and recruits.

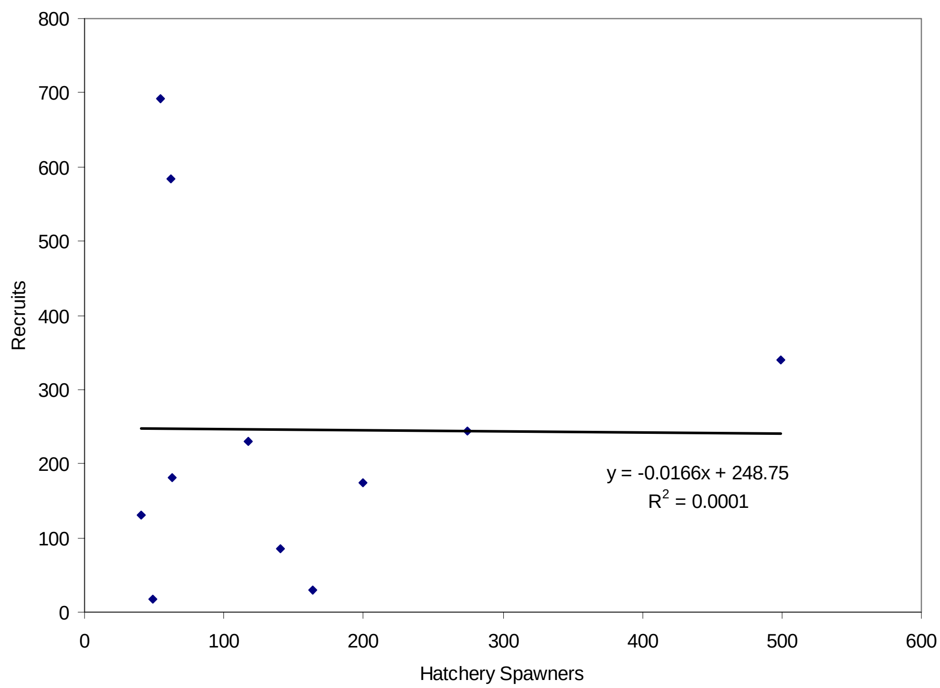

Figure 36. Scatter plot of Wind River hatchery summer steelhead spawners and recruits.

Grays Chum

Appendix A-9 includes the Grays River chum salmon run reconstruction table. The results cover brood years 1959-1996. Recruits per spawner were generally less than 10; average recruits per spawner was 6.39 (Figure 37). Productivity averaged 0.829 (Figure 37). Productivity and recruits per spawner spiked in 1981, but was also high in many other years (Figure 37). Few patterns were observed in a comparison of productivity within specific decades (Figure 38). Productivity appears to decline as spawner abundance increases. Negative productivity was observed in all decades included in the analysis; negative productivity was more prevalent in the 1960s and 1990s. There is no linear relationship between hatchery spawners and recruits (r^2=0.00004, p=0.9701); therefore, the number of spawners is not an accurate predictor of recruits (Figure 39).

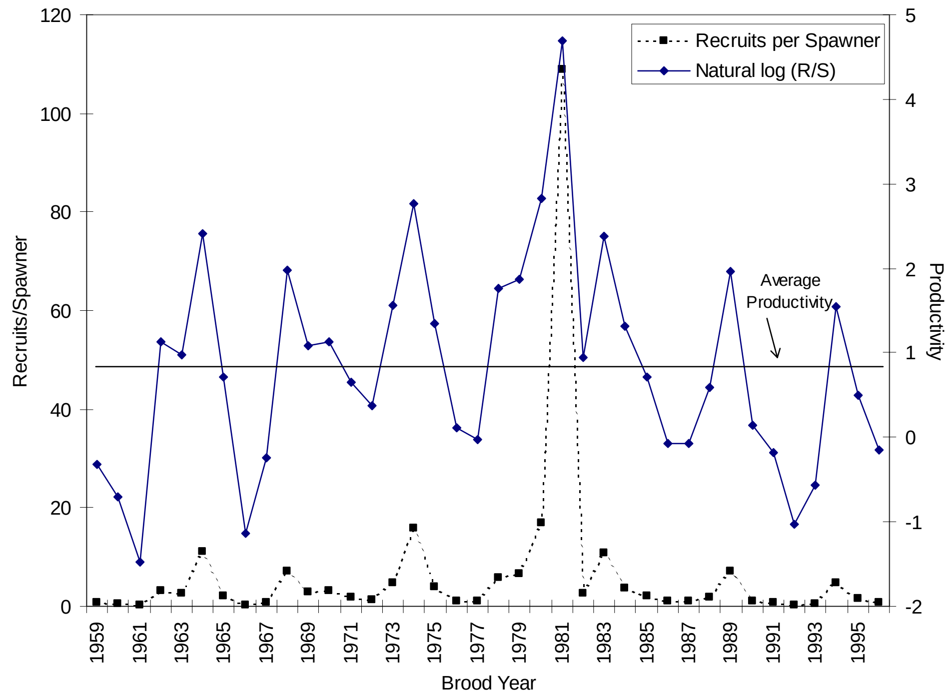

Figure 37. Grays River chum salmon recruits per spawner ratio and productivity by brood year, 1959-1996.

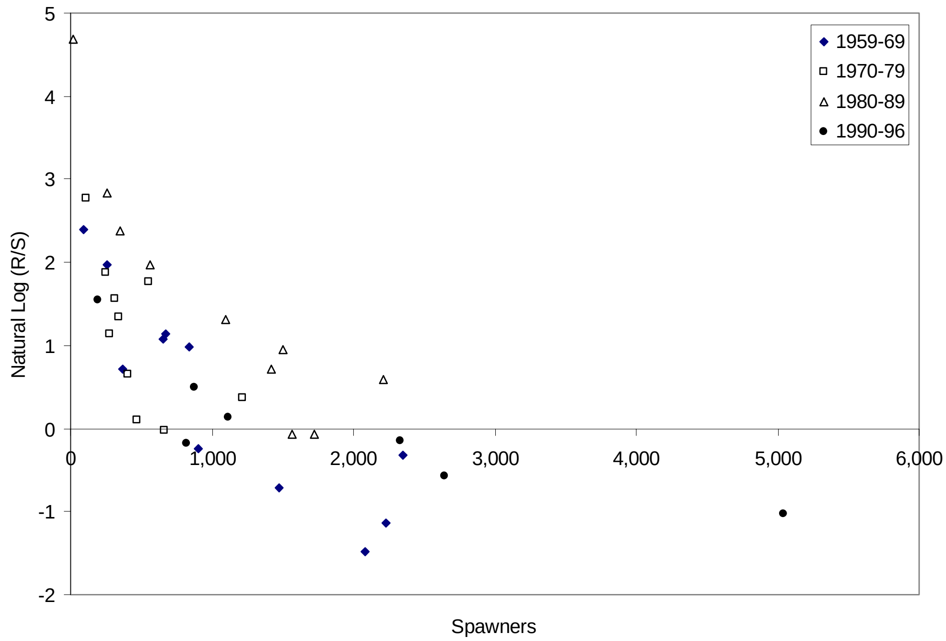

Figure 38. Scatter plot of Grays River chum salmon spawners and productivity by brood year, grouped by decade.

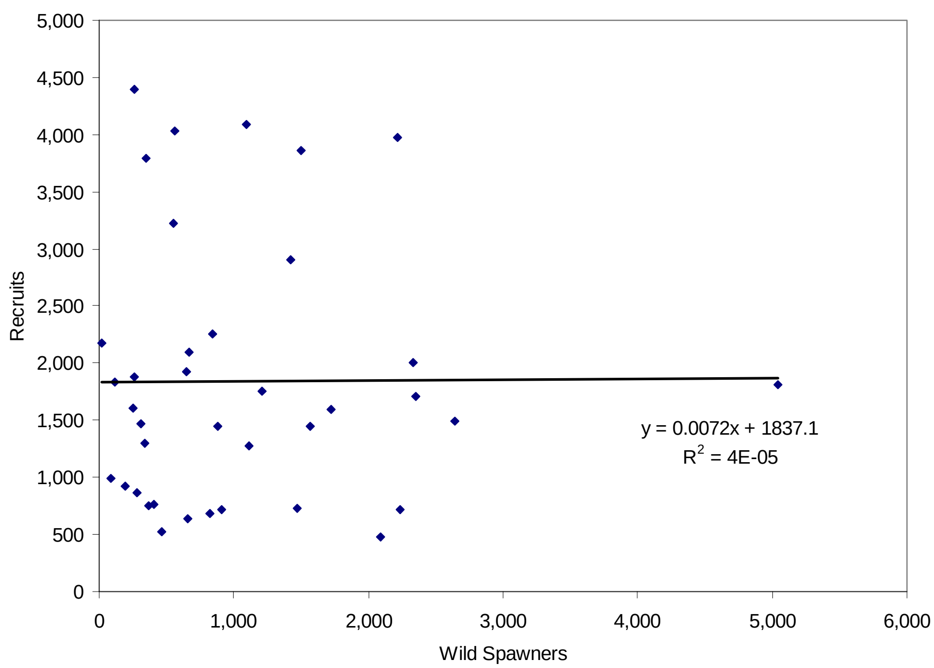

Figure 39. Scatter plot of Grays River chum salmon spawners and recruits.

Discussion

The populations chosen for these run reconstructions represent a mixture of species, origin (i.e. hatchery or wild), and basin-specific factors affecting each population, such as habitat quality and passage barriers. The results of these run reconstructions reflect the quality of data used to create them; the run reconstructions are intended to serve as a starting point for additional investigation. Improvements in methods and data quality are welcome. As unpublished data become available, new and improved data can easily be incorporated into the run reconstructions. Also, as information becomes available annually, each run reconstruction can be updated so that more recent brood year evaluations can be completed. A summary of the primary population statistics from the run reconstructions is presented in Table 1 for comparison purposes.

Table 1. Comparison of recruit to spawner ratio and productivity for each population.

Population	Average Recruits per Spawner	Average Productivity
Coweeman Tule Fall Chinook	5.748	1.142
East Fork Lewis Tule Fall Chinook	3.597	0.736
North Fork Lewis Bright Fall Chinook	2.287	0.488
Wind Spring Chinook	2.275	0.432
Little White Salmon Spring Chinook	3.660	0.688
Kalama Winter Steelhead		
Wild	1.685	0.279
Hatchery	3.816	1.001
Total	2.676	0.809
Kalama Summer Steelhead		
Wild	1.863	0.214
Hatchery	3.471	0.685
Total	3.013	0.585
Wind Summer Steelhead		
Wild	1.088	0.002
Hatchery	3.071	0.349
Total	1.337	0.103
Grays Chum	6.390	0.829

A few general patterns have developed from the run reconstruction results. Most run reconstructions indicate that productivity and the recruit to spawner ratio was low for the late 1980s and the mid 1990s (particularly, brood years 1988, 1989, 1994, and 1995). This pattern is consistent with existing knowledge of the extremely poor environmental conditions during those years; this consistency lends credibility to the results. Notable exceptions to this pattern include the Wind spring chinook 1988 and 1995 broods (Figure 11), the Kalama hatchery winter steelhead 1989 brood (Figure 19 and Figure 20), and the Grays chum 1989 and 1994 broods (Figure 37), which had better than average productivity and recruit to spawner ratio.

For all populations investigated, productivity decreased as spawner abundance increased. Although the relationship was weak for some populations, the general pattern was still evident. This observation needs to be interpreted cautiously; the observed inverse relationship between spawner abundance and productivity is not justification for maintaining low spawner numbers. The relationship simply indicates that, as spawner abundance increases, the population as a whole performs poorly; thus, each individual contributes less to the population's production. Poor population performance at high spawner abundance seems logical if some part of the life cycle is limited, but poor population performance does not make sense in a population that has unrestricted access to quality spawning and rearing habitat. Therefore, the inverse relationship between spawner abundance and productivity suggests that, at the habitat capacity present over the duration of the run reconstructions, habitat limitations exist that affect spawning or rearing success and prevent productivity from increasing as spawner abundance increases.

The number of spawners is a poor predictor of recruits. In most populations analyzed, there was no linear relationship between spawners and recruits. In one population, spring chinook in the Little White Salmon River, a weak linear relationship existed between spawners and recruits (Figure 17). However, the regression equation defining this relationship does not make sense. In particular, the y-intercept of this equation was -638.01; in reality, it is not possible to have a negative number of recruits. If the y-intercept of the regression equation is set at zero, the resulting r^2 is negative, which violates the underlying assumptions of the regression relationship; this result is true of all populations analyzed.

Each fall chinook population realized a spike in productivity and recruit to spawner ratio in the 1984 brood year (Figure 1, Figure 4, and Figure 7). The spike was more pronounced for the Coweeman and East Fork Lewis tule fall chinook populations, but was still prominent for the North Fork Lewis bright fall chinook. This increased productivity did not occur with other species; in actuality, the 1984 brood was a poor performer for many of the other populations investigated. Thus, conditions specific to these fall chinook populations are responsible for this success of the 1984 brood, although causation would be difficult to determine. Multiple factors may have had an effect, such as migration timing or pattern that exposed this brood to excellent ocean productivity, possible harvest changes that allowed for better survival, or productive rearing conditions in the Cowlitz and Lewis River basins.

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APPENDIX A. Run Reconstruction Tables

APPENDIX A-1. Coweeman River Tule Fall Chinook Run Reconstruction Table

	Escapement			Age Composition					Spawners by Age					Tributary Harvest Rate by Age				
Run Year	Total Escapement (wild)	Pre-spawn Mortality	Total Spawners (wild)	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
1964	371	0.05	352	0.019	0.561	0.334	0.086	0.000	7	198	118	30	0	0.133	0.017	0.047	0.080	0.014
1965	86	0.05	82	0.128	0.163	0.674	0.035	0.000	10	13	55	3	0	0.133	0.017	0.047	0.080	0.014
1966	110	0.05	105	0.018	0.527	0.373	0.082	0.000	2	55	39	9	0	0.133	0.017	0.047	0.080	0.014
1967	108	0.05	103	0.074	0.250	0.630	0.046	0.000	8	26	65	5	0	0.133	0.017	0.047	0.080	0.014
1968	140	0.05	133	0.057	0.371	0.436	0.136	0.000	8	49	58	18	0	0.133	0.017	0.047	0.080	0.014
1969	118	0.05	112	0.271	0.220	0.449	0.059	0.000	30	25	50	7	0	0.133	0.017	0.047	0.080	0.014
1970	111	0.05	105	0.351	0.369	0.243	0.036	0.000	37	39	26	4	0	0.133	0.017	0.047	0.080	0.014
1971	296	0.05	281	0.020	0.348	0.598	0.034	0.000	6	98	168	10	0	0.133	0.017	0.047	0.080	0.014
1972	212	0.05	201	0.179	0.179	0.580	0.061	0.000	36	36	117	12	0	0.133	0.017	0.047	0.080	0.014
1973	54	0.05	51	0.222	0.278	0.389	0.111	0.000	11	14	20	6	0	0.133	0.017	0.047	0.080	0.014
1974	42	0.05	40	0.024	0.286	0.595	0.095	0.000	1	11	24	4	0	0.133	0.017	0.047	0.080	0.014
1975	94	0.05	89	0.032	0.330	0.511	0.128	0.000	3	29	46	11	0	0.133	0.017	0.047	0.080	0.014
1976	74	0.05	70	0.081	0.365	0.446	0.108	0.000	6	26	31	8	0	0.133	0.017	0.047	0.080	0.014
1977	91	0.05	86	0.058	0.372	0.477	0.093	0.000	5	32	41	8	0	0.133	0.017	0.047	0.080	0.014
1978	58	0.05	55	0.065	0.258	0.581	0.097	0.000	4	14	32	5	0	0.133	0.017	0.047	0.080	0.014
1979	80	0.05	76	0.091	0.307	0.466	0.136	0.000	7	23	35	10	0	0.133	0.017	0.047	0.080	0.014
1980	50	0.05	48	0.107	0.321	0.500	0.071	0.000	5	15	24	3	0	0.005	0.017	0.070	0.073	0.000
1981	75	0.05	71	0.079	0.211	0.605	0.105	0.000	6	15	43	8	0	0.239	0.011	0.060	0.097	0.071
1982	63	0.05	60	0.171	0.197	0.553	0.079	0.000	10	12	33	5	0	0.166	0.031	0.048	0.116	0.000
1983	40	0.05	38	0.000	0.500	0.500	0.000	0.000	0	19	19	0	0	0.052	0.007	0.012	0.022	0.000
1984	136	0.05	129	0.171	0.104	0.659	0.067	0.000	22	13	85	9	0	0.097	0.013	0.050	0.057	0.000
1985	158	0.05	150	0.060	0.179	0.673	0.089	0.000	9	27	101	13	0	0.235	0.030	0.044	0.057	0.000
1986	97	0.05	92	0.218	0.145	0.355	0.210	0.073	20	13	33	19	7	0.087	0.070	0.024	0.051	0.000
1987	62	0.05	59	0.279	0.186	0.360	0.174	0.000	16	11	21	10	0	0.173	0.020	0.100	0.115	0.000
1988	1,027	0.05	976	0.073	0.153	0.734	0.040	0.000	71	150	716	39	0	0.113	0.041	0.036	0.048	0.080
1989	770	0.05	732	0.030	0.084	0.330	0.555	0.000	22	62	241	406	0	0.129	0.049	0.077	0.107	0.029
1990	241	0.05	229	0.101	0.257	0.373	0.228	0.041	23	59	85	52	9	0.097	0.060	0.068	0.098	0.083
1991	174	0.05	165	0.000	0.316	0.379	0.305	0.000	0	52	63	50	0	0.000	0.000	0.000	0.000	0.000
1992	424	0.05	403	0.023	0.074	0.735	0.157	0.012	9	30	296	63	5	0.000	0.000	0.000	0.000	0.000
1993	327	0.05	311	0.066	0.309	0.354	0.271	0.000	20	96	110	84	0	0.000	0.000	0.000	0.000	0.000
1994	535	0.05	508	0.056	0.315	0.556	0.074	0.000	28	160	282	37	0	0.000	0.000	0.000	0.000	0.000
1995	774	0.05	735	0.025	0.300	0.519	0.156	0.000	19	220	382	115	0	0.000	0.000	0.000	0.000	0.000
1996	2,148	0.05	2041	0.002	0.154	0.663	0.181	0.000	4	315	1,353	369	0	0.000	0.000	0.000	0.000	0.000
1997	1,328	0.05	1262	0.000	0.007	0.619	0.374	0.000	0	9	781	472	0	0.000	0.000	0.000	0.000	0.000
1998	144	0.05	137	0.014	0.082	0.493	0.411	0.000	2	11	67	56	0	0.000	0.000	0.000	0.000	0.000
1999	93	0.05	88	0.031	0.354	0.458	0.156	0.000	3	31	40	14	0	0.000	0.000	0.000	0.000	0.000
2000	126	0.05	120	0.016	0.172	0.742	0.070	0.000	2	21	89	8	0	0.000	0.000	0.000	0.000	0.000
2001	646	0.05	614	0.022	0.203	0.681	0.094	0.000	13	124	418	58	0	0.000	0.000	0.000	0.000	0.000

Run Year	Coweeman River Run Size by Age					Mainstem Harvest Rate by Age					Columbia River Run Size by Age					Ocean Harvest Rate by Age					Ocean Escapement by Age				
	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
1964	8	201	124	33	0	0.117	0.304	0.358	0.409	0.749	9	289	192	56	0	0.530	0.530	0.530	0.530	0.530	18	615	409	119	0
1965	12	14	58	3	0	0.117	0.304	0.358	0.409	0.749	14	19	90	5	0	0.530	0.530	0.530	0.530	0.530	29	41	191	11	0
1966	2	56	41	9	0	0.117	0.304	0.358	0.409	0.749	2	81	64	16	0	0.530	0.530	0.530	0.530	0.530	5	171	135	33	0
1967	9	26	68	5	0	0.117	0.304	0.358	0.409	0.749	10	37	105	9	0	0.530	0.530	0.530	0.530	0.530	21	80	224	19	0
1968	9	50	61	20	0	0.117	0.304	0.358	0.409	0.749	10	72	95	33	0	0.530	0.530	0.530	0.530	0.530	21	154	201	71	0
1969	35	25	53	7	0	0.117	0.304	0.358	0.409	0.749	40	36	82	12	0	0.530	0.530	0.530	0.530	0.530	84	77	175	26	0
1970	43	40	27	4	0	0.117	0.304	0.358	0.409	0.749	48	57	42	7	0	0.530	0.530	0.530	0.530	0.530	103	121	89	15	0
1971	7	100	176	10	0	0.117	0.304	0.358	0.409	0.749	7	143	275	17	0	0.530	0.530	0.530	0.530	0.530	16	304	584	37	0
1972	42	37	123	13	0	0.117	0.304	0.358	0.409	0.749	47	53	191	23	0	0.530	0.530	0.530	0.530	0.530	100	112	406	48	0
1973	13	14	21	6	0	0.117	0.304	0.358	0.409	0.749	15	21	33	10	0	0.530	0.530	0.530	0.530	0.530	32	44	69	22	0
1974	1	12	25	4	0	0.117	0.304	0.358	0.409	0.749	1	17	39	7	0	0.530	0.530	0.530	0.530	0.530	3	35	83	15	0
1975	3	30	48	12	0	0.117	0.304	0.358	0.409	0.749	4	43	74	21	0	0.530	0.530	0.530	0.530	0.530	8	92	158	45	0
1976	7	26	33	8	0	0.117	0.304	0.358	0.409	0.749	7	37	51	14	0	0.530	0.530	0.530	0.530	0.530	16	80	109	30	0
1977	6	33	43	9	0	0.117	0.304	0.358	0.409	0.749	7	47	67	15	0	0.530	0.530	0.530	0.530	0.530	14	100	143	31	0
1978	4	14	34	6	0	0.117	0.304	0.358	0.409	0.749	5	21	52	10	0	0.530	0.530	0.530	0.530	0.530	10	44	111	21	0
1979	8	24	37	11	0	0.117	0.304	0.358	0.409	0.749	9	34	58	19	0	0.530	0.530	0.530	0.530	0.530	19	73	123	41	0
1980	5	16	26	4	0	0.102	0.496	0.557	0.688	1.000	6	31	58	12	0	0.530	0.530	0.530	0.530	0.530	12	66	123	25	0
1981	7	15	46	8	0	0.118	0.139	0.319	0.365	0.000	8	18	67	13	0	0.530	0.530	0.530	0.530	0.530	18	37	143	28	0
1982	12	12	35	5	0	0.161	0.359	0.314	0.309	0.000	15	19	51	8	0	0.530	0.530	0.530	0.530	0.530	31	40	108	16	0
1983	0	19	19	0	0	0.045	0.196	0.166	0.121	0.000	0	24	23	0	0	0.530	0.530	0.530	0.530	0.530	0	51	49	0	0
1984	24	14	90	9	0	0.095	0.321	0.336	0.180	1.000	27	20	135	11	0	0.530	0.530	0.530	0.530	0.530	57	43	287	24	0
1985	12	28	106	14	0	0.046	0.171	0.177	0.266	0.000	12	33	128	19	0	0.530	0.530	0.530	0.530	0.530	26	71	273	41	0
1986	22	14	33	20	7	0.189	0.571	0.470	0.448	0.440	27	34	63	37	12	0.530	0.530	0.530	0.530	0.530	58	71	135	79	25
1987	20	11	24	12	0	0.314	0.566	0.675	0.771	0.940	29	26	73	51	0	0.530	0.530	0.530	0.530	0.530	62	55	154	108	0
1988	80	156	742	41	0	0.216	0.598	0.634	0.709	0.627	103	388	2,031	140	0	0.530	0.530	0.530	0.530	0.530	218	826	4,320	298	0
1989	25	65	262	455	0	0.005	0.262	0.274	0.344	0.600	26	88	360	693	0	0.530	0.530	0.530	0.530	0.530	54	187	767	1,475	0
1990	26	63	92	58	10	0.248	0.129	0.110	0.111	0.243	34	72	103	65	14	0.250	0.250	0.250	0.250	0.250	45	96	137	87	18
1991	0	52	63	50	0	0.157	0.212	0.219	0.122	0.164	0	66	80	57	0	0.250	0.250	0.250	0.250	0.250	0	88	107	76	0
1992	9	30	296	63	5	0.174	0.143	0.141	0.064	0.450	11	35	344	67	8	0.250	0.250	0.250	0.250	0.250	15	46	459	90	11
1993	20	96	110	84	0	0.112	0.177	0.127	0.183	0.000	23	116	126	103	0	0.250	0.250	0.250	0.250	0.250	31	155	168	138	0
1994	28	160	282	37	0	0.000	0.000	0.000	0.000	0.000	28	160	282	37	0	0.250	0.250	0.250	0.250	0.250	38	213	377	50	0
1995	19	220	382	115	0	0.088	0.040	0.012	0.059	0.000	20	230	386	122	0	0.250	0.250	0.250	0.250	0.250	27	306	515	163	0
1996	4	315	1,353	369	0	0.050	0.140	0.052	0.009	0.020	4	366	1,428	372	0	0.250	0.250	0.250	0.250	0.250	5	488	1,904	496	0
1997	0	9	781	472	0	0.004	0.201	0.119	0.087	1.000	0	11	886	517	0	0.250	0.250	0.250	0.250	0.250	0	14	1,182	690	0
1998	2	11	67	56	0	0.100	0.109	0.074	0.108	0.000	2	13	73	63	0	0.250	0.250	0.250	0.250	0.250	3	17	97	84	0
1999	3	31	40	14	0	0.000	0.094	0.201	0.065	0.000	3	35	51	15	0	0.250	0.250	0.250	0.250	0.250	4	46	68	20	0
2000	2	21	89	8	0	0.120	0.176	0.121	0.166	0.000	2	25	101	10	0	0.250	0.250	0.250	0.250	0.250	3	33	135	13	0
2001	13	124	418	58	0	0.067	0.114	0.061	0.195	0.000	14	141	445	72	0	0.325	0.325	0.325	0.325	0.325	21	208	659	107	0

Results								
Brood Year	2	3	4	5	6	Total Recruits	Recruits per Spawner	Natural log (R/S)
1964	5	80	201	26	0	312	0.886	-0.120
1965	21	154	175	15	0	365	4.462	1.496
1966	21	77	89	37	0	224	2.146	0.764
1967	84	121	584	48	0	838	8.170	2.100
1968	103	304	406	22	0	836	6.283	1.838
1969	16	112	69	15	0	212	1.894	0.639
1970	100	44	83	45	0	272	2.577	0.947
1971	32	35	158	30	0	255	0.908	-0.096
1972	3	92	109	31	0	235	1.165	0.153
1973	8	80	143	21	0	252	4.908	1.591
1974	16	100	111	41	0	268	6.708	1.903
1975	14	44	123	25	0	206	2.309	0.837
1976	10	73	123	28	0	233	3.313	1.198
1977	19	66	143	16	0	245	2.829	1.040
1978	12	37	108	0	0	157	2.855	1.049
1979	18	40	49	24	0	131	1.727	0.546
1980	31	51	287	41	25	435	9.164	2.215
1981	0	43	273	79	0	394	5.532	1.711
1982	57	71	135	108	0	371	6.196	1.824
1983	26	71	154	298	0	550	14.471	2.672
1984	58	55	4,320	1,475	18	5,926	45.867	3.826
1985	62	826	767	87	0	1,741	11.600	2.451
1986	218	187	137	76	11	630	6.841	1.923
1987	54	96	107	90	0	347	5.895	1.774
1988	45	88	459	138	0	731	0.749	-0.289
1989	0	46	168	50	0	264	0.361	-1.018
1990	15	155	377	163	0	710	3.099	1.131
1991	31	213	515	496	0	1,255	7.592	2.027
1992	38	306	1,904	690	0	2,938	7.293	1.987
1993	27	488	1,182	84	0	1,781	5.734	1.746
1994	5	14	97	20	0	136	0.268	-1.315
1995	0	17	68	13	0	98	0.133	-2.017
1996	3	46	135	107				
1997	4	33	659					
1998	3	208						
1999	21							
2000								
2001								

Notes:

Spawning escapement data for 1964-2001 were obtained from the Washington State salmon and steelhead stock inventory (WDF et al. 1993 and WDFW 2003).

Prespawn mortality is assumed to be 5%.

Age composition data for 1964-2001 were calculated from escapement data available in the StreamNet database.

Tributary harvest rate for 1964-1979 was the 5-yr average harvest calculated from the 1980-1984 “big sheets” using the lower river hatchery (LRH) stock: tributary harvest divided by the total run minus the mainstem harvest.

Tributary harvest rate for 1980-1990 was calculated from the “big sheets” using LRH stock: tributary harvest divided by the total run minus the mainstem harvest.

Tributary harvest has been closed since 1991.

Mainstem harvest rate for 1980-2001 was calculated from the “big sheets” using the LRH stock: sum of mainstem harvest divided by the total run.

Mainstem harvest rate for 1964-1979 was the 5-yr average calculated from the 1980-1984 “big sheets” using the LRH stock: sum of mainstem harvest divided by the total run.

Ocean harvest rate for 1964-1989 obtained from the Lewis River Subbasin Plan that summarized CWT recoveries for all available brood years.

Ocean harvest rate for 1990-2000 obtained from the Lewis River Subbasin Plan that summarized CWT recoveries for all available brood years.

Ocean harvest rate for 2001 was estimated (Guy Norman, personal communication).

APPENDIX A-2. East Fork Lewis River Tule Fall Chinook Run Reconstruction Table

	Escapement			Age Composition					Spawners by Age					Tributary Harvest Rate by Age					Lewis River Run Size by Age				
Run Year	Total Escapement (wild)	Pre-spawn Mortality	Spawning Escapement (wild)	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
1964	680	0.05	646	0.071	0.531	0.318	0.081	0.000	46	343	205	52	0	0.133	0.017	0.047	0.080	0.014	53	349	215	57	0
1965	1,048	0.05	996	0.150	0.157	0.654	0.039	0.000	149	157	651	39	0	0.133	0.017	0.047	0.080	0.014	172	159	683	42	0
1966	595	0.05	565	0.020	0.521	0.378	0.081	0.000	11	295	214	46	0	0.133	0.017	0.047	0.080	0.014	13	300	224	50	0
1967	442	0.05	420	0.070	0.251	0.631	0.048	0.000	29	105	265	20	0	0.133	0.017	0.047	0.080	0.014	34	107	278	22	0
1968	265	0.05	252	0.060	0.370	0.438	0.132	0.000	15	93	110	33	0	0.133	0.017	0.047	0.080	0.014	18	95	116	36	0
1969	599	0.05	569	0.451	0.169	0.337	0.043	0.000	257	96	192	25	0	0.133	0.017	0.047	0.080	0.014	296	98	201	27	0
1970	1,217	0.05	1,156	0.460	0.311	0.200	0.028	0.000	532	360	232	32	0	0.133	0.017	0.047	0.080	0.014	613	366	243	35	0
1971	2,354	0.05	2,236	0.090	0.324	0.556	0.030	0.000	201	725	1,244	67	0	0.133	0.017	0.047	0.080	0.014	232	738	1,304	72	0
1972	668	0.05	635	0.201	0.177	0.564	0.058	0.000	127	112	358	37	0	0.133	0.017	0.047	0.080	0.014	147	114	376	40	0
1973	538	0.05	511	0.610	0.136	0.188	0.067	0.000	312	69	96	34	0	0.133	0.017	0.047	0.080	0.014	359	71	101	37	0
1974	576	0.05	547	0.271	0.203	0.451	0.075	0.000	148	111	247	41	0	0.133	0.017	0.047	0.080	0.014	171	113	259	44	0
1975	618	0.05	587	0.060	0.320	0.494	0.126	0.000	35	188	290	74	0	0.133	0.017	0.047	0.080	0.014	41	191	304	81	0
1976	353	0.05	335	0.079	0.360	0.453	0.108	0.000	27	121	152	36	0	0.133	0.017	0.047	0.080	0.014	31	123	159	39	0
1977	604	0.05	574	0.060	0.376	0.474	0.091	0.000	34	216	272	52	0	0.000	0.000	0.000	0.000	0.000	34	216	272	52	0
1978	968	0.05	920	0.290	0.191	0.447	0.071	0.000	267	176	411	66	0	0.000	0.000	0.000	0.000	0.000	267	176	411	66	0
1979	814	0.05	773	0.120	0.297	0.450	0.133	0.000	93	230	348	103	0	0.000	0.000	0.000	0.000	0.000	93	230	348	103	0
1980	526	0.05	500	0.409	0.129	0.394	0.068	0.000	204	65	197	34	0	0.000	0.000	0.000	0.000	0.000	204	65	197	34	0
1981	438	0.05	416	0.094	0.089	0.687	0.130	0.000	39	37	286	54	0	0.000	0.000	0.000	0.000	0.000	39	37	286	54	0
1982	346	0.05	329	0.306	0.324	0.355	0.014	0.000	101	106	117	5	0	0.000	0.000	0.000	0.000	0.000	101	106	117	5	0
1983	334	0.05	317	0.087	0.105	0.704	0.105	0.000	28	33	223	33	0	0.000	0.000	0.000	0.000	0.000	28	33	223	33	0
1984	200	0.05	190	0.040	0.025	0.790	0.145	0.000	8	5	150	28	0	0.000	0.000	0.000	0.000	0.000	8	5	150	28	0
1985	653	0.05	620	0.173	0.211	0.462	0.153	0.000	107	131	287	95	0	0.000	0.000	0.000	0.000	0.000	107	131	287	95	0
1986	445	0.05	423	0.126	0.393	0.411	0.070	0.000	53	166	174	29	0	0.000	0.000	0.000	0.000	0.000	53	166	174	29	0
1987	157	0.05	149	0.140	0.242	0.446	0.172	0.000	21	36	67	26	0	0.000	0.000	0.000	0.000	0.000	21	36	67	26	0
1988	476	0.05	452	0.103	0.145	0.582	0.170	0.000	47	66	263	77	0	0.000	0.000	0.000	0.000	0.000	47	66	263	77	0
1989	591	0.05	561	0.050	0.079	0.386	0.486	0.000	28	44	217	273	0	0.000	0.000	0.000	0.000	0.000	28	44	217	273	0
1990	342	0.05	325	0.042	0.160	0.266	0.213	0.319	14	52	86	69	104	0.000	0.000	0.000	0.000	0.000	14	52	86	69	104
1991	230	0.05	219	0.080	0.320	0.320	0.240	0.040	17	70	70	52	9	0.000	0.000	0.000	0.000	0.000	17	70	70	52	9
1992	202	0.05	192	0.060	0.153	0.698	0.088	0.000	12	29	134	17	0	0.000	0.000	0.000	0.000	0.000	12	29	134	17	0
1993	156	0.05	148	0.077	0.243	0.479	0.201	0.000	11	36	71	30	0	0.000	0.000	0.000	0.000	0.000	11	36	71	30	0
1994	395	0.05	375	0.249	0.063	0.521	0.167	0.000	93	24	195	63	0	0.000	0.000	0.000	0.000	0.000	93	24	195	63	0
1995	100	0.05	95	0.103	0.161	0.265	0.471	0.000	10	15	25	45	0	0.000	0.000	0.000	0.000	0.000	10	15	25	45	0
1996	167	0.05	159	0.012	0.189	0.692	0.107	0.000	2	30	110	17	0	0.000	0.000	0.000	0.000	0.000	2	30	110	17	0
1997	184	0.05	175	0.000	0.013	0.397	0.590	0.000	0	2	69	103	0	0.000	0.000	0.000	0.000	0.000	0	2	69	103	0
1998	52	0.05	49	0.063	0.486	0.225	0.225	0.000	3	24	11	11	0	0.000	0.000	0.000	0.000	0.000	3	24	11	11	0
1999	109	0.05	104	0.027	0.448	0.426	0.099	0.000	3	46	44	10	0	0.000	0.000	0.000	0.000	0.000	3	46	44	10	0
2000	323	0.05	307	0.059	0.149	0.644	0.149	0.000	18	46	198	46	0	0.000	0.000	0.000	0.000	0.000	18	46	198	46	0
2001	530	0.05	504	0.008	0.468	0.491	0.034	0.000	4	236	247	17	0	0.000	0.000	0.000	0.000	0.000	4	236	247	17	0

	Mainstem Harvest Rate by Age					Columbia River Run Size by Age					Ocean Harvest Rate by Age					Ocean Escapement by Age				
Run Year	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
1964	0.117	0.304	0.358	0.409	0.749	60	501	335	96	0	0.530	0.530	0.530	0.530	0.530	127	1,067	713	205	0
1965	0.117	0.304	0.358	0.409	0.749	195	229	1,063	72	0	0.530	0.530	0.530	0.530	0.530	414	487	2,261	153	0
1966	0.117	0.304	0.358	0.409	0.749	15	430	349	84	0	0.530	0.530	0.530	0.530	0.530	32	916	743	179	0
1967	0.117	0.304	0.358	0.409	0.749	38	154	433	37	0	0.530	0.530	0.530	0.530	0.530	82	328	921	78	0
1968	0.117	0.304	0.358	0.409	0.749	20	136	180	61	0	0.530	0.530	0.530	0.530	0.530	42	290	383	130	0
1969	0.117	0.304	0.358	0.409	0.749	335	140	313	45	0	0.530	0.530	0.530	0.530	0.530	713	298	667	97	0
1970	0.117	0.304	0.358	0.409	0.749	695	526	379	59	0	0.530	0.530	0.530	0.530	0.530	1,478	1,120	805	127	0
1971	0.117	0.304	0.358	0.409	0.749	263	1,060	2,031	122	0	0.530	0.530	0.530	0.530	0.530	560	2,254	4,321	260	0
1972	0.117	0.304	0.358	0.409	0.749	166	164	585	68	0	0.530	0.530	0.530	0.530	0.530	354	349	1,244	145	0
1973	0.117	0.304	0.358	0.409	0.749	407	101	157	63	0	0.530	0.530	0.530	0.530	0.530	866	216	333	134	0
1974	0.117	0.304	0.358	0.409	0.749	194	162	403	75	0	0.530	0.530	0.530	0.530	0.530	412	346	858	160	0
1975	0.117	0.304	0.358	0.409	0.749	46	275	473	136	0	0.530	0.530	0.530	0.530	0.530	98	585	1,007	290	0
1976	0.117	0.304	0.358	0.409	0.749	35	176	248	66	0	0.530	0.530	0.530	0.530	0.530	74	375	528	141	0
1977	0.117	0.304	0.358	0.409	0.749	39	310	423	88	0	0.530	0.530	0.530	0.530	0.530	82	659	900	188	0
1978	0.117	0.304	0.358	0.409	0.749	302	252	640	111	0	0.530	0.530	0.530	0.530	0.530	643	537	1,363	236	0
1979	0.117	0.304	0.358	0.409	0.749	105	330	541	174	0	0.530	0.530	0.530	0.530	0.530	224	703	1,152	370	0
1980	0.102	0.496	0.557	0.688	1.000	228	128	444	110	0	0.530	0.530	0.530	0.530	0.530	484	273	945	234	0
1981	0.118	0.139	0.319	0.365	0.000	44	43	420	85	0	0.530	0.530	0.530	0.530	0.530	94	92	894	181	0
1982	0.161	0.359	0.314	0.309	0.000	120	166	170	7	0	0.530	0.530	0.530	0.530	0.530	255	353	362	15	0
1983	0.045	0.196	0.166	0.121	0.000	29	41	268	38	0	0.530	0.530	0.530	0.530	0.530	61	88	570	81	0
1984	0.095	0.321	0.336	0.180	1.000	8	7	226	34	0	0.530	0.530	0.530	0.530	0.530	18	15	481	72	0
1985	0.046	0.171	0.177	0.266	0.000	113	158	349	129	0	0.530	0.530	0.530	0.530	0.530	240	337	742	275	0
1986	0.189	0.571	0.470	0.448	0.440	66	388	328	53	0	0.530	0.530	0.530	0.530	0.530	140	825	698	114	0
1987	0.314	0.566	0.675	0.771	0.940	30	83	205	112	0	0.530	0.530	0.530	0.530	0.530	65	177	435	239	0
1988	0.216	0.598	0.634	0.709	0.627	59	163	720	265	0	0.530	0.530	0.530	0.530	0.530	126	347	1,531	563	0
1989	0.005	0.262	0.274	0.344	0.600	28	60	298	415	0	0.530	0.530	0.530	0.530	0.530	60	128	635	884	0
1990	0.248	0.129	0.110	0.111	0.243	18	60	97	78	137	0.250	0.250	0.250	0.250	0.250	24	79	129	104	183
1991	0.157	0.212	0.219	0.122	0.164	21	89	90	60	10	0.250	0.250	0.250	0.250	0.250	28	118	119	80	14
1992	0.174	0.143	0.141	0.064	0.450	14	34	156	18	0	0.250	0.250	0.250	0.250	0.250	19	46	208	24	0
1993	0.112	0.177	0.127	0.183	0.000	13	44	81	36	0	0.250	0.250	0.250	0.250	0.250	17	58	108	49	0
1994	0.000	0.000	0.000	0.000	0.000	93	24	195	63	0	0.250	0.250	0.250	0.250	0.250	125	31	261	84	0
1995	0.088	0.040	0.012	0.059	0.000	11	16	25	48	0	0.250	0.250	0.250	0.250	0.250	14	21	34	63	0
1996	0.050	0.140	0.052	0.009	0.020	2	35	116	17	0	0.250	0.250	0.250	0.250	0.250	3	47	155	23	0
1997	0.004	0.201	0.119	0.087	1.000	0	3	79	113	0	0.250	0.250	0.250	0.250	0.250	0	4	105	151	0
1998	0.100	0.109	0.074	0.108	0.000	3	27	12	12	0	0.250	0.250	0.250	0.250	0.250	5	36	16	17	0
1999	0.000	0.094	0.201	0.065	0.000	3	51	55	11	0	0.250	0.250	0.250	0.250	0.250	4	68	74	15	0
2000	0.120	0.176	0.121	0.166	0.000	21	55	225	55	0	0.250	0.250	0.250	0.250	0.250	27	74	300	73	0
2001	0.067	0.114	0.061	0.195	0.000	4	266	263	21	0	0.325	0.325	0.325	0.325	0.325	6	394	390	31	0

Results								
Brood Year	2	3	4	5	6	Total Recruits	Recruits per Spawner	Natural log (R/S)
1964	32	328	383	97	0	839	1.299	0.262
1965	82	290	667	127	0	1,165	1.170	0.157
1966	42	298	805	260	0	1,406	2.488	0.912
1967	713	1,120	4,321	145	0	6,298	15.000	2.708
1968	1,478	2,254	1,244	134	0	5,111	20.301	3.011
1969	560	349	333	160	0	1,402	2.463	0.901
1970	354	216	858	290	0	1,718	1.486	0.396
1971	866	346	1,007	141	0	2,360	1.055	0.054
1972	412	585	528	188	0	1,713	2.700	0.993
1973	98	375	900	236	0	1,609	3.148	1.147
1974	74	659	1,363	370	0	2,465	4.505	1.505
1975	82	537	1,152	234	0	2,005	3.415	1.228
1976	643	703	945	181	0	2,472	7.371	1.998
1977	224	273	894	15	0	1,405	2.449	0.896
1978	484	92	362	81	0	1,019	1.108	0.102
1979	94	353	570	72	0	1,088	1.407	0.342
1980	255	88	481	275	0	1,100	2.201	0.789
1981	61	15	742	114	0	932	2.239	0.806
1982	18	337	698	239	0	1,291	3.929	1.368
1983	240	825	435	563	0	2,063	6.503	1.872
1984	140	177	1,531	884	183	2,914	15.337	2.730
1985	65	347	635	104	14	1,164	1.877	0.630
1986	126	128	129	80	0	463	1.095	0.091
1987	60	79	119	24	0	283	1.896	0.640
1988	24	118	208	49	0	399	0.882	-0.126
1989	28	46	108	84	0	266	0.473	-0.748
1990	19	58	261	63	0	401	1.234	0.210
1991	17	31	34	23	0	105	0.481	-0.731
1992	125	21	155	151	0	451	2.350	0.854
1993	14	47	105	17	0	183	1.233	0.209
1994	3	4	16	15	0	37	0.099	-2.316
1995	0	36	74	73	0	182	1.920	0.653
1996	5	68	300	31				
1997	4	74	390					
1998	27	394						
1999	6							
2000								
2001								

Notes:
Spawning escapement data for 1964-2001 were obtained from the Washington State salmon and steelhead stock inventory (WDF et al. 1993 and WDFW 2003).
Prespawn mortality is assumed to be 5%.
Age composition data for 1964-2001 were calculated from escapement data available in the StreamNet database.
Tributary harvest rate for 1964-1976 was the 5-yr average harvest calculated from the 1980-1984 “big sheets” using the lower river hatchery (LRH) stock: tributary harvest divided by the total run minus the mainstem harvest.
Tributary harvest has been closed since 1977.
Mainstem harvest rate for 1980-2001 was calculated from the “big sheets” using the LRH stock: sum of mainstem harvest divided by the total run.
Mainstem harvest rate for 1964-1979 was the 5-yr average calculated from the 1980-1984 “big sheets” using the LRH stock: sum of mainstem harvest divided by the total run.
Ocean harvest rate for 1964-1989 obtained from the Lewis River Subbasin Plan that summarized CWT recoveries for all available brood years.
Ocean harvest rate for 1990-2000 obtained from the Lewis River Subbasin Plan that summarized CWT recoveries for all available brood years.
Ocean harvest rate for 2001 was estimated (Guy Norman, personal communication).

APPENDIX A-3. North Fork Lewis River Bright Fall Chinook Run Reconstruction Table

	Escapement					Age Composition						Spawners by Age						Tributary Harvest Rate by Age					
Run Year	Total Escapement	Hatchery Proportion of Escapement	Wild Escapement	Prespawn Mortality	Spawning Escapement (wild)	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7
1964	20,557	0.06	19,324	0.05	18,357	0.180	0.160	0.480	0.180	0.000	0.000	3,304	2,937	8,812	3,304	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1965	9,667	0.06	9,087	0.05	8,633	0.180	0.160	0.480	0.180	0.000	0.000	1,554	1,381	4,144	1,554	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1966	13,176	0.06	12,385	0.05	11,766	0.118	0.245	0.431	0.206	0.000	0.000	1,383	2,883	5,077	2,423	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1967	10,084	0.06	9,479	0.05	9,005	0.037	0.179	0.630	0.154	0.000	0.000	333	1,614	5,672	1,386	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1968	7,344	0.06	6,903	0.05	6,558	0.025	0.080	0.670	0.224	0.000	0.000	164	527	4,395	1,472	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1969	5,774	0.06	5,428	0.05	5,156	0.136	0.150	0.364	0.350	0.000	0.000	704	775	1,874	1,803	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1970	21,726	0.06	20,422	0.05	19,401	0.810	0.068	0.101	0.021	0.000	0.000	15,713	1,312	1,967	409	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1971	20,409	0.06	19,184	0.05	18,225	0.024	0.208	0.638	0.131	0.000	0.000	431	3,787	11,626	2,381	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1972	19,198	0.06	18,046	0.05	17,144	0.037	0.100	0.748	0.115	0.000	0.000	634	1,715	12,827	1,968	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1973	13,029	0.06	12,247	0.05	11,635	0.300	0.126	0.374	0.199	0.000	0.000	3,491	1,467	4,357	2,320	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1974	9,320	0.06	8,761	0.05	8,323	0.190	0.213	0.401	0.196	0.000	0.000	1,582	1,770	3,337	1,634	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1975	14,904	0.06	14,010	0.05	13,309	0.070	0.173	0.542	0.215	0.000	0.000	933	2,301	7,215	2,860	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1976	4,199	0.06	3,947	0.05	3,750	0.197	0.176	0.428	0.198	0.000	0.000	739	662	1,607	742	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1977	7,779	0.06	7,312	0.05	6,947	0.109	0.248	0.473	0.170	0.000	0.000	758	1,726	3,284	1,179	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1978	6,129	0.06	5,761	0.05	5,473	0.125	0.242	0.475	0.158	0.000	0.000	684	1,324	2,600	864	0	0	0.287	0.098	0.070	0.059	0.000	0.000
1979	8,954	0.06	8,417	0.05	7,996	0.132	0.199	0.437	0.221	0.009	0.000	1,055	1,591	3,494	1,767	72	0	0.287	0.098	0.070	0.059	0.000	0.000
1980	13,239	0.085	12,114	0.05	11,508	0.072	0.204	0.617	0.107	0.000	0.000	833	2,352	7,097	1,226	0	0	0.015	0.052	0.065	0.056	0.000	0.000
1981	19,297	0.085	17,657	0.05	16,774	0.093	0.090	0.687	0.130	0.000	0.000	1,560	1,510	11,523	2,181	0	0	0.253	0.035	0.050	0.049	0.000	0.000
1982	8,370	0.085	7,659	0.05	7,276	0.091	0.297	0.333	0.277	0.002	0.000	661	2,158	2,426	2,017	13	0	0.262	0.142	0.050	0.052	0.000	0.000
1983	13,540	0.085	12,389	0.05	11,770	0.082	0.090	0.632	0.196	0.000	0.000	970	1,054	7,442	2,304	0	0	0.339	0.151	0.078	0.050	0.000	0.000
1984	7,132	0.085	6,526	0.05	6,199	0.117	0.148	0.443	0.280	0.012	0.000	727	915	2,749	1,737	73	0	0.483	0.181	0.143	0.094	0.000	0.000
1985	7,491	0.085	6,854	0.05	6,512	0.209	0.200	0.427	0.162	0.002	0.000	1,363	1,302	2,781	1,057	11	0	0.384	0.131	0.104	0.090	0.000	0.000
1986	11,983	0.085	10,964	0.05	10,416	0.177	0.281	0.392	0.145	0.005	0.000	1,844	2,927	4,088	1,511	47	0	0.292	0.186	0.071	0.062	0.005	0.005
1987	12,935	0.085	11,836	0.05	11,244	0.243	0.203	0.405	0.148	0.001	0.000	2,729	2,284	4,557	1,664	11	0	0.136	0.059	0.043	0.040	0.000	0.000
1988	12,052	0.085	11,028	0.05	10,476	0.178	0.122	0.453	0.247	0.000	0.000	1,860	1,280	4,745	2,591	0	0	0.152	0.124	0.085	0.046	0.074	0.074
1989	12,199	0.085	11,162	0.05	10,604	0.077	0.112	0.272	0.531	0.007	0.000	821	1,185	2,889	5,635	74	0	0.209	0.086	0.139	0.082	0.000	0.000
1990	17,506	0.085	16,018	0.05	15,217	0.076	0.050	0.384	0.406	0.084	0.000	1,157	761	5,843	6,178	1,279	0	0.207	0.081	0.086	0.053	0.024	0.024
1991	9,066	0.029	8,803	0.05	8,363	0.059	0.130	0.312	0.459	0.040	0.001	493	1,087	2,608	3,836	334	5	0.238	0.208	0.132	0.095	0.022	0.022
1992	6,307	0.101	5,670	0.05	5,386	0.207	0.055	0.429	0.267	0.040	0.000	1,118	298	2,312	1,440	218	0	0.488	0.246	0.201	0.081	0.160	0.160
1993	7,025	0.078	6,477	0.05	6,153	0.083	0.280	0.159	0.438	0.040	0.000	508	1,725	977	2,694	249	0	0.485	0.266	0.230	0.141	0.000	0.000
1994	9,936	0.13	8,644	0.05	8,212	0.134	0.118	0.604	0.113	0.031	0.000	1,100	973	4,957	927	255	0	0.227	0.092	0.078	0.108	0.000	0.000
1995	9,715	0	9,715	0.05	9,229	0.031	0.084	0.247	0.636	0.002	0.000	282	775	2,281	5,871	20	0	0.467	0.344	0.268	0.162	0.000	0.000
1996	14,166	0.089	12,905	0.05	12,260	0.018	0.090	0.555	0.294	0.042	0.000	227	1,102	6,805	3,607	519	0	0.247	0.033	0.003	0.001	0.000	0.000
1997	8,670	0.058	8,167	0.05	7,759	0.007	0.025	0.490	0.473	0.005	0.000	55	193	3,803	3,666	42	0	0.000	0.017	0.028	0.010	0.000	0.000
1998	5,935	0.124	5,199	0.05	4,939	0.039	0.125	0.215	0.620	0.001	0.000	190	618	1,063	3,064	4	0	0.000	0.000	0.000	0.000	0.000	0.000
1999	3,184	0.233	2,442	0.05	2,320	0.053	0.268	0.495	0.168	0.016	0.000	122	622	1,149	390	37	0	0.000	0.000	0.000	0.000	0.000	0.000
2000	9,820	0.105	8,789	0.05	8,349	0.099	0.171	0.593	0.136	0.001	0.000	830	1,424	4,955	1,133	7	0	0.000	0.000	0.000	0.000	0.000	0.000
2001	15,000	0.06	14,100	0.05	13,395	0.074	0.191	0.540	0.193	0.001	0.000	995	2,565	7,235	2,583	17	0	0.136	0.086	0.017	0.014	0.000	0.000

Run Year	Lewis River Run Size by Age						Mainstem Harvest Rate by Age						Columbia River Run Size by Age						Ocean Harvest Rate by Age						Ocean Escapement by Age					
	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7	2	3	4	5	6	7
1964	4,631	3,255	9,471	3,512	0	0	0.272	0.220	0.217	0.323	0.185	0.185	6,366	4,175	12,099	5,186	0	0	0.260	0.260	0.260	0.260	0.260	0.260	8,602	5,642	16,349	7,008	0	0
1965	2,178	1,531	4,453	1,652	0	0	0.272	0.220	0.217	0.323	0.185	0.185	2,994	1,964	5,689	2,439	0	0	0.260	0.260	0.260	0.260	0.260	0.260	4,045	2,654	7,688	3,296	0	0
1966	1,939	3,195	5,456	2,575	0	0	0.272	0.220	0.217	0.323	0.185	0.185	2,665	4,099	6,970	3,803	0	0	0.260	0.260	0.260	0.260	0.260	0.260	3,601	5,539	9,419	5,139	0	0
1967	467	1,788	6,096	1,473	0	0	0.272	0.220	0.217	0.323	0.185	0.185	642	2,294	7,788	2,175	0	0	0.260	0.260	0.260	0.260	0.260	0.260	867	3,100	10,524	2,940	0	0
1968	230	584	4,724	1,564	0	0	0.272	0.220	0.217	0.323	0.185	0.185	317	749	6,035	2,310	0	0	0.260	0.260	0.260	0.260	0.260	0.260	428	1,012	8,155	3,121	0	0
1969	986	859	2,014	1,917	0	0	0.272	0.220	0.217	0.323	0.185	0.185	1,356	1,102	2,573	2,830	0	0	0.260	0.260	0.260	0.260	0.260	0.260	1,832	1,489	3,478	3,824	0	0
1970	22,024	1,454	2,114	435	0	0	0.272	0.220	0.217	0.323	0.185	0.185	30,273	1,865	2,701	642	0	0	0.260	0.260	0.260	0.260	0.260	0.260	40,910	2,520	3,650	867	0	0
1971	605	4,197	12,495	2,531	0	0	0.272	0.220	0.217	0.323	0.185	0.185	831	5,383	15,962	3,737	0	0	0.260	0.260	0.260	0.260	0.260	0.260	1,123	7,275	21,570	5,050	0	0
1972	889	1,900	13,786	2,092	0	0	0.272	0.220	0.217	0.323	0.185	0.185	1,222	2,437	17,611	3,089	0	0	0.260	0.260	0.260	0.260	0.260	0.260	1,651	3,293	23,798	4,174	0	0
1973	4,893	1,626	4,683	2,466	0	0	0.272	0.220	0.217	0.323	0.185	0.185	6,725	2,086	5,982	3,641	0	0	0.260	0.260	0.260	0.260	0.260	0.260	9,088	2,818	8,084	4,921	0	0
1974	2,217	1,961	3,587	1,737	0	0	0.272	0.220	0.217	0.323	0.185	0.185	3,047	2,516	4,582	2,565	0	0	0.260	0.260	0.260	0.260	0.260	0.260	4,117	3,400	6,191	3,466	0	0
1975	1,308	2,550	7,754	3,041	0	0	0.272	0.220	0.217	0.323	0.185	0.185	1,798	3,271	9,905	4,489	0	0	0.260	0.260	0.260	0.260	0.260	0.260	2,430	4,420	13,385	6,067	0	0
1976	1,036	733	1,727	789	0	0	0.272	0.220	0.217	0.323	0.185	0.185	1,425	941	2,206	1,165	0	0	0.260	0.260	0.260	0.260	0.260	0.260	1,925	1,271	2,981	1,574	0	0
1977	1,063	1,913	3,529	1,253	0	0	0.272	0.220	0.217	0.323	0.185	0.185	1,461	2,454	4,508	1,850	0	0	0.260	0.260	0.260	0.260	0.260	0.260	1,974	3,316	6,092	2,500	0	0
1978	959	1,468	2,795	919	0	0	0.272	0.220	0.217	0.323	0.185	0.185	1,318	1,882	3,570	1,357	0	0	0.260	0.260	0.260	0.260	0.260	0.260	1,781	2,544	4,825	1,833	0	0
1979	1,479	1,763	3,755	1,878	72	0	0.272	0.220	0.217	0.323	0.185	0.185	2,033	2,262	4,797	2,774	88	0	0.260	0.260	0.260	0.260	0.260	0.260	2,748	3,057	6,483	3,748	119	0
1980	846	2,481	7,593	1,298	0	0	0.414	0.357	0.439	0.711	0.000	0.000	1,443	3,856	13,539	4,498	0	0	0.260	0.260	0.260	0.260	0.260	0.260	1,950	5,211	18,297	6,079	0	0
1981	2,088	1,564	12,125	2,293	0	0	0.184	0.086	0.064	0.012	0.000	0.000	2,560	1,711	12,951	2,320	0	0	0.260	0.260	0.260	0.260	0.260	0.260	3,460	2,312	17,501	3,136	0	0
1982	896	2,514	2,555	2,127	13	0	0.448	0.142	0.101	0.045	0.620	0.620	1,623	2,930	2,843	2,227	35	0	0.260	0.260	0.260	0.260	0.260	0.260	2,194	3,959	3,842	3,009	48	0
1983	1,468	1,243	8,072	2,424	0	0	0.186	0.099	0.043	0.047	0.000	0.000	1,802	1,378	8,439	2,543	0	0	0.260	0.260	0.260	0.260	0.260	0.260	2,435	1,863	11,403	3,436	0	0
1984	1,405	1,116	3,208	1,916	73	0	0.202	0.256	0.229	0.293	0.000	0.000	1,760	1,500	4,163	2,712	73	0	0.260	0.260	0.260	0.260	0.260	0.260	2,379	2,027	5,626	3,664	99	0
1985	2,215	1,498	3,102	1,161	11	0	0.161	0.320	0.174	0.437	0.158	0.158	2,639	2,202	3,756	2,064	13	0	0.260	0.260	0.260	0.260	0.260	0.260	3,566	2,976	5,076	2,790	18	0
1986	2,605	3,593	4,399	1,611	47	0	0.207	0.409	0.442	0.515	0.020	0.020	3,287	6,082	7,888	3,319	48	0	0.260	0.260	0.260	0.260	0.260	0.260	4,442	8,219	10,659	4,485	65	0
1987	3,159	2,427	4,760	1,732	11	0	0.097	0.125	0.051	0.005	0.186	0.186	3,500	2,774	5,016	1,740	14	0	0.260	0.260	0.260	0.260	0.260	0.260	4,730	3,748	6,778	2,352	19	0
1988	2,193	1,462	5,184	2,715	0	0	0.143	0.306	0.476	0.628	0.557	0.557	2,559	2,107	9,899	7,290	0	0	0.260	0.260	0.260	0.260	0.260	0.260	3,459	2,848	13,377	9,851	0	0
1989	1,037	1,297	3,355	6,136	74	0	0.197	0.282	0.198	0.211	0.683	0.683	1,291	1,805	4,183	7,781	233	0	0.260	0.260	0.260	0.260	0.260	0.260	1,745	2,439	5,652	10,515	314	0
1990	1,458	828	6,396	6,522	1,310	0	0.002	0.265	0.161	0.050	0.000	0.000	1,460	1,127	7,619	6,866	1,310	0	0.170	0.170	0.170	0.170	0.170	0.170	1,759	1,358	9,180	8,272	1,578	0
1991	647	1,373	3,004	4,237	342	5	0.046	0.647	0.318	0.174	0.165	0.165	678	3,891	4,402	5,132	409	6	0.170	0.170	0.170	0.170	0.170	0.170	817	4,689	5,304	6,183	493	8
1992	2,181	396	2,895	1,568	259	0	0.081	0.022	0.281	0.164	0.346	0.346	2,374	405	4,028	1,876	397	0	0.170	0.170	0.170	0.170	0.170	0.170	2,860	488	4,853	2,260	478	0
1993	986	2,350	1,269	3,135	249	0	0.100	0.186	0.223	0.092	0.127	0.127	1,096	2,889	1,632	3,453	285	0	0.170	0.170	0.170	0.170	0.170	0.170	1,320	3,480	1,967	4,161	344	0
1994	1,424	1,071	5,374	1,039	255	0	0.005	0.000	0.036	0.063	0.678	0.678	1,432	1,071	5,573	1,109	791	0	0.170	0.170	0.170	0.170	0.170	0.170	1,725	1,291	6,714	1,337	953	0
1995	528	1,181	3,116	7,005	20	0	0.253	0.005	0.141	0.027	0.404	0.404	707	1,187	3,629	7,198	34	0	0.170	0.170	0.170	0.170	0.170	0.170	852	1,430	4,372	8,673	41	0
1996	301	1,139	6,827	3,611	519	0	0.000	0.000	0.026	0.053	0.050	0.050	301	1,139	7,008	3,813	547	0	0.170	0.170	0.170	0.170	0.170	0.170	362	1,373	8,443	4,594	659	0
1997	55	196	3,915	3,705	42	0	0.000	0.310	0.019	0.081	0.000	0.000	55	284	3,991	4,031	42	0	0.170	0.170	0.170	0.170	0.170	0.170	66	343	4,809	4,856	50	0
1998	190	618	1,063	3,064	4	0	0.000	0.000	0.000	0.086	0.000	0.000	190	618	1,063	3,351	4	0	0.170	0.170	0.170	0.170	0.170	0.170	229	744	1,280	4,038	5	0
1999	122	622	1,149	390	37	0	0.000	0.000	0.000	0.000	0.237	0.000	122	622	1,149	390	49	0	0.170	0.170	0.170	0.170	0.170	0.170	147	749	1,384	470	59	0
2000	830	1,424	4,955	1,133	7	0	0.182	0.166	0.023	0.000	0.000	0.000	1,015	1,707	5,074	1,133	7	0	0.170	0.170	0.170	0.170	0.170	0.170	1,223	2,057	6,113	1,365	8	0
2001	1,152	2,807	7,361	2,621	17	0	0.000	0.355	0.064	0.000	0.000	0.000	1,152	4,352	7,867	2,621	17	0	0.170	0.170	0.170	0.170	0.170	0.170	1,388	5,244	9,479	3,157	20	0

Results											
Brood Year	2	3	4	5	6	7	Total Recruits	Wild Outmigrants	Smolt to Adult Survival	Recruits per Spawner	Natural log (R/S)
1964	3,601	3,100	8,155	3,824	0	0	18,680			1.018	0.017
1965	867	1,012	3,478	867	0	0	6,224			0.721	-0.327
1966	428	1,489	3,650	5,050	0	0	10,616			0.902	-0.103
1967	1,832	2,520	21,570	4,174	0	0	30,096			3.342	1.207
1968	40,910	7,275	23,798	4,921	0	0	76,904			11.726	2.462
1969	1,123	3,293	8,084	3,466	0	0	15,966			3.097	1.130
1970	1,651	2,818	6,191	6,067	0	0	16,727			0.862	-0.148
1971	9,088	3,400	13,385	1,574	0	0	27,447			1.506	0.409
1972	4,117	4,420	2,981	2,500	0	0	14,019			0.818	-0.201
1973	2,430	1,271	6,092	1,833	119	0	11,745			1.010	0.009
1974	1,925	3,316	4,825	3,748	0	0	13,814			1.660	0.507
1975	1,974	2,544	6,483	6,079	0	0	17,079			1.283	0.249
1976	1,781	3,057	18,297	3,136	48	0	26,317			7.019	1.949
1977	2,748	5,211	17,501	3,009	0	0	28,470	2,620,000	0.011	4.098	1.411
1978	1,950	2,312	3,842	3,436	99	0	11,639	2,800,000	0.004	2.127	0.755
1979	3,460	3,959	11,403	3,664	18	0	22,504	2,410,000	0.009	2.814	1.035
1980	2,194	1,863	5,626	2,790	65	0	12,537			1.089	0.086
1981	2,435	2,027	5,076	4,485	19	0	14,041			0.837	-0.178
1982	2,379	2,976	10,659	2,352	0	0	18,365	2,880,000	0.006	2.524	0.926
1983	3,566	8,219	6,778	9,851	314	0	28,729	4,650,000	0.006	2.441	0.892
1984	4,442	3,748	13,377	10,515	1,578	8	33,668	3,430,000	0.010	5.431	1.692
1985	4,730	2,848	5,652	8,272	493	0	21,995	3,010,000	0.007	3.378	1.217
1986	3,459	2,439	9,180	6,183	478	0	21,738	1,540,000	0.014	2.087	0.736
1987	1,745	1,358	5,304	2,260	344	0	11,009	1,740,000	0.006	0.979	-0.021
1988	1,759	4,689	4,853	4,161	953	0	16,414			1.567	0.449
1989	817	488	1,967	1,337	41	0	4,649			0.438	-0.825
1990	2,860	3,480	6,714	8,673	659	0	22,386			1.471	0.386
1991	1,320	1,291	4,372	4,594	50	0	11,628			1.390	0.330
1992	1,725	1,430	8,443	4,856	5	0	16,459			3.056	1.117
1993	852	1,373	4,809	4,038	59	0	11,130			1.809	0.593
1994	362	343	1,280	470	8	0	2,463			0.300	-1.204
1995	66	744	1,384	1,365	20		3,580			0.388	-0.947
1996	229	749	6,113	3,157							
1997	147	2,057	9,479								
1998	1,223	5,244									
1999	1,388										
2000											
2001											

Notes:
Spawning escapement data for 1964-2001 were obtained from the Washington State salmon and steelhead stock inventory (WDF et al. 1993 and WDFW 2003).
Proportion of hatchery spawners for 1964-1979 and 2001 was estimated from the LCTRT escapement analysis (Myers et al. 2002).
Proportion of hatchery spawners for 1980-2000 was obtained from the NMFS SimSalmon database.
Prespawn mortality is assumed to be 5%.
Age composition data for years 1964 to 2001 (excluding 1979) were obtained from the StreamNet database.
Age composition data for 1979 is the average composition based on data in Myers et al. 2002 with reference to Hymer et al. 1992. StreamNet data for 1979 were not complete.
Tributary, mainstem, and ocean annual harvest rates for 7 year olds are assumed to equal the annual harvest rate in each area for 6 year olds.
Tributary harvest rate for 1980-2001 was calculated from the “big sheets” using lower river wild (LRW) stock: tributary harvest divided by the total run minus the mainstem harvest.
Tributary harvest rate for 1964-1979 was the 5-yr average calculated from the 1980-1984 “big sheets” using LRW stock: tributary harvest divided by the total run minus the mainstem harvest.
Mainstem harvest rate for 1980-2001 was calculated from the “big sheets” using LRW stock: sum of mainstem harvest divided by the total run.
Mainstem harvest rate for 1964-1979 was the 5-yr average calculated from the 1980-1984 “big sheets” using LRW stock: sum of mainstem harvest divided by the total run.
Ocean harvest rate for 1964-1989 was obtained from the Lewis River Subbasin Plan that summarized CWT recoveries for all available brood years.
Ocean harvest rate for 1990-2001 was obtained from the Lewis River Subbasin Plan that summarized CWT recoveries for all available brood years.
Wild outmigrant numbers were obtained from Table 17 in the Stock summary reports for Columbia River anadromous salmonids, Volume III: Washington. (Hymer et al. 1992).

APPENDIX A-4. Wind River Spring Chinook Run Reconstruction Table

	Escapement			Age Composition				Spawners by Age				Tributary Harvest Rate by Age			
Run Year	Hatchery Releases	Ratio of Hatchery Release/Esc Goals	Effective Spawners	3	4	5	6	3	4	5	6	3	4	5	6
1963			1,698	0.030	0.610	0.359	0.001	51	1,035	610	2	0.089	0.122	0.140	0.133
1964			1,136	0.030	0.610	0.359	0.001	34	693	408	1	0.089	0.122	0.140	0.133
1965	2,411,600	1,420	1,081	0.030	0.610	0.359	0.001	32	659	388	1	0.089	0.122	0.140	0.133
1966	1,613,400	1,420	533	0.030	0.610	0.359	0.001	16	325	192	1	0.089	0.122	0.140	0.133
1967	1,534,500	1,420	829	0.030	0.610	0.359	0.001	25	506	298	1	0.089	0.122	0.140	0.133
1968	757,000	1,420	993	0.030	0.610	0.359	0.001	30	605	357	1	0.089	0.122	0.140	0.133
1969	1,177,700	1,420	1,085	0.030	0.610	0.359	0.001	32	661	390	1	0.089	0.122	0.140	0.133
1970	1,409,400	1,420	1,409	0.045	0.845	0.110	0	63	1,190	156	0	0.063	0.062	0.060	0.000
1971	1,540,600	1,420	1,408	0.224	0.607	0.169	0	315	855	238	0	0.089	0.105	0.114	0.000
1972	2,001,100	1,420	1,752	0.007	0.621	0.372	0	13	1,088	651	0	0.269	0.159	0.155	0.000
1973	1,999,500	1,420	2,159	0.046	0.467	0.487	0.000	100	1,008	1,051	0	0.129	0.165	0.163	0.000
1974	2,488,000	1,420	2,011	0.246	0.579	0.167	0.008	494	1,165	336	17	0.051	0.152	0.110	0.133
1975	3,066,000	1,420	1,262	0.002	0.944	0.054	0.000	3	1,191	68	0	0.333	0.331	0.332	0.000
1976	2,856,100	1,420	2,145	0.052	0.029	0.914	0.004	112	63	1,961	9	0.030	0.030	0.030	0.040
1977	1,791,800	1,420	1,830	0.007	0.977	0.015	0.000	14	1,788	28	0	0.185	0.339	0.342	0.000
1978	3,046,400	1,420	1,816	0.004	0.201	0.793	0.002	7	365	1,441	3	0.333	0.336	0.337	0.375
1979	2,598,912	1,420	1,213	0.002	0.916	0.082	0.000	2	1,111	100	0	0.200	0.224	0.224	0.000
1980	2,578,650	1,420	2,033	0.010	0.180	0.811	0.000	19	366	1,648	0	0.000	0.000	0.000	0.000
1981	1,722,080	1,420	1,684	0.001	0.354	0.631	0.014	2	595	1,063	23	0.000	0.000	0.000	0.000
1982	2,886,560	1,420	1,685	0.013	0.655	0.332	0.000	21	1,104	560	0	0.000	0.000	0.000	0.000
1983	2,390,971	1,420	1,778	0.004	0.430	0.567	0.000	6	764	1,007	0	0.000	0.000	0.000	0.000
1984	2,392,468	1,420	1,378	0.037	0.592	0.366	0.005	51	815	505	7	0.000	0.000	0.000	0.000
1985	2,524,164	1,420	1,397	0.011	0.759	0.230	0.000	16	1,060	322	0	0.000	0.000	0.000	0.000
1986	1,956,220	1,420	1,483	0.011	0.627	0.362	0.000	17	930	536	0	0.111	0.443	0.394	0.000
1987	1,983,639	1,420	1,646	0.002	0.563	0.436	0.000	3	926	717	0	0.100	0.296	0.227	0.000
1988	2,105,281	1,420	1,631	0.034	0.119	0.846	0.000	56	195	1,380	0	0.191	0.315	0.155	0.000
1989	2,336,788	1,420	1,635	0.051	0.820	0.125	0.003	84	1,341	204	6	0.298	0.331	0.179	0.200
1990	2,315,382	1,420	1,437	0.002	0.875	0.123	0.000	3	1,258	176	0	0.805	0.790	0.770	1.000
1991	2,321,285	1,420	1,546	0.009	0.272	0.717	0.003	13	420	1,108	5	0.707	0.693	0.634	0.633
1992	2,040,568	1,420	1,213	0.002	0.738	0.258	0.002	3	895	313	2	0.800	0.656	0.546	0.444
1993	2,195,192	1,420	639	0.003	0.328	0.669	0.000	2	210	428	0	0.843	0.756	0.679	0.000
1994	1,722,621	1,420	1,221	0.008	0.588	0.402	0.002	9	718	491	3	0.000	0.352	0.430	0.333
1995	907,708	1,420	997	0.184	0.639	0.177	0.000	184	637	176	0	0.000	0.000	0.000	0.000
1996	1,734,188	1,420	1,007	0.003	0.980	0.017	0.000	3	987	17	0	0.811	0.644	0.551	0.000
1997	1,415,744	1,420	1,133	0.002	0.855	0.144	0.000	2	968	163	0	0.889	0.814	0.769	0.000
1998	1,430,022	1,420	1,021	0.015	0.433	0.552	0.000	15	442	564	0	0.000	0.474	0.421	0.000
1999	1,608,684	1,420	1,133	0.025	0.946	0.030	0.000	28	1,071	34	0	0.742	0.705	0.647	0.000
2000	1,449,400	1,420	1,021	0.009	0.957	0.035	0.000	9	977	35	0	0.938	0.866	0.831	0.000
2001	1,608,684	1,420	1,178	0.043	0.879	0.079	0.000	50	1,036	93	0	0.882	0.929	0.890	0.000
2002	1,449,361	1,420													
2003	1,673,255	1,420													

	Wind River Run Size by Age				Mainstem Harvest Rate by Age				Columbia River Run Size by Age				Ocean Harvest Rate				Ocean Escapement by Age			
Run Year	3	4	5	6	3	4	5	6	3	4	5	6	3	4	5	6	3	4	5	6
1963	56	1,178	710	2	0.576	0.576	0.576	0.576	131	2,780	1,674	6	0.01	0.01	0.01	0.01	132	2,808	1,691	6
1964	37	788	475	2	0.503	0.503	0.503	0.503	75	1,587	956	3	0.01	0.01	0.01	0.01	76	1,603	965	3
1965	35	750	451	2	0.614	0.614	0.614	0.614	92	1,942	1,169	4	0.01	0.01	0.01	0.01	93	1,962	1,181	4
1966	17	370	223	1	0.374	0.374	0.374	0.374	28	591	356	1	0.01	0.01	0.01	0.01	28	596	359	1
1967	27	576	347	1	0.509	0.509	0.509	0.509	55	1,172	706	2	0.01	0.01	0.01	0.01	56	1,184	713	2
1968	32	689	415	1	0.355	0.355	0.355	0.355	50	1,068	643	2	0.01	0.01	0.01	0.01	51	1,079	650	2
1969	36	753	453	2	0.307	0.307	0.307	0.307	51	1,086	654	2	0.01	0.01	0.01	0.01	52	1,097	660	2
1970	67	1,269	166	0	0.412	0.412	0.412	0.412	115	2,160	282	0	0.01	0.01	0.01	0.01	116	2,181	285	0
1971	346	955	269	0	0.309	0.309	0.309	0.309	501	1,383	389	0	0.01	0.01	0.01	0.01	506	1,397	393	0
1972	18	1,294	771	0	0.439	0.439	0.439	0.439	32	2,308	1,375	0	0.01	0.01	0.01	0.01	32	2,331	1,389	0
1973	114	1,208	1,256	0	0.494	0.494	0.494	0.494	226	2,388	2,483	0	0.01	0.01	0.01	0.01	228	2,412	2,508	0
1974	521	1,373	378	19	0.318	0.318	0.318	0.318	764	2,014	554	28	0.01	0.01	0.01	0.01	772	2,034	559	29
1975	4	1,782	102	0	0.002	0.002	0.002	0.002	4	1,785	102	0	0.01	0.01	0.01	0.01	4	1,803	103	0
1976	116	65	2,022	10	0.004	0.004	0.004	0.004	116	65	2,030	10	0.01	0.01	0.01	0.01	117	66	2,050	10
1977	17	2,705	43	0	0.253	0.253	0.253	0.253	22	3,622	58	0	0.01	0.01	0.01	0.01	22	3,658	58	0
1978	11	550	2,172	5	0.038	0.038	0.038	0.038	11	572	2,258	5	0.01	0.01	0.01	0.01	12	577	2,281	5
1979	2	1,431	129	0	0.030	0.030	0.030	0.030	2	1,476	132	0	0.01	0.01	0.01	0.01	2	1,491	134	0
1980	19	366	1,648	0	0.025	0.025	0.025	0.025	20	375	1,689	0	0.01	0.01	0.01	0.01	20	379	1,706	0
1981	2	595	1,063	23	0.049	0.049	0.049	0.049	2	626	1,118	24	0.01	0.01	0.01	0.01	2	633	1,130	25
1982	21	1,104	560	0	0.066	0.066	0.066	0.066	23	1,182	599	0	0.01	0.01	0.01	0.01	23	1,194	605	0
1983	6	764	1,007	0	0.079	0.079	0.079	0.079	7	830	1,094	0	0.01	0.01	0.01	0.01	7	838	1,105	0
1984	51	815	505	7	0.083	0.083	0.083	0.083	55	889	551	8	0.01	0.01	0.01	0.01	56	898	556	8
1985	16	1,060	322	0	0.062	0.062	0.062	0.062	17	1,129	343	0	0.01	0.01	0.01	0.01	17	1,141	346	0
1986	19	1,669	885	0	0.061	0.061	0.061	0.061	20	1,778	943	0	0.01	0.01	0.01	0.01	20	1,796	953	0
1987	3	1,315	927	0	0.059	0.059	0.059	0.059	4	1,398	985	0	0.01	0.01	0.01	0.01	4	1,412	995	0
1988	69	284	1,633	0	0.116	0.116	0.116	0.116	78	322	1,846	0	0.01	0.01	0.01	0.01	79	325	1,865	0
1989	120	2,003	249	7	0.078	0.078	0.078	0.078	130	2,172	270	8	0.01	0.01	0.01	0.01	131	2,194	273	8
1990	17	5,994	765	0	0.099	0.099	0.099	0.099	19	6,651	848	0	0.01	0.01	0.01	0.01	20	6,718	857	0
1991	45	1,367	3,028	13	0.084	0.084	0.084	0.084	49	1,493	3,307	14	0.01	0.01	0.01	0.01	50	1,508	3,340	14
1992	15	2,603	689	4	0.059	0.059	0.059	0.059	16	2,766	732	4	0.01	0.01	0.01	0.01	16	2,794	740	4
1993	11	860	1,335	0	0.051	0.051	0.051	0.051	11	905	1,406	0	0.01	0.01	0.01	0.01	11	915	1,420	0
1994	9	1,108	862	4	0.078	0.078	0.078	0.078	10	1,201	935	4	0.01	0.01	0.01	0.01	10	1,213	945	4
1995	184	637	176	0	0.040	0.040	0.040	0.040	191	663	184	0	0.01	0.01	0.01	0.01	193	670	186	0
1996	17	2,773	38	0	0.036	0.036	0.036	0.036	18	2,876	39	0	0.01	0.01	0.01	0.01	18	2,905	40	0
1997	18	5,209	706	0	0.048	0.048	0.048	0.048	18	5,469	742	0	0.01	0.01	0.01	0.01	19	5,524	749	0
1998	15	839	974	0	0.038	0.038	0.038	0.038	16	872	1,012	0	0.01	0.01	0.01	0.01	16	881	1,022	0
1999	109	3,627	95	0	0.034	0.034	0.034	0.034	113	3,754	98	0	0.01	0.01	0.01	0.01	114	3,792	99	0
2000	139	7,303	210	0	0.043	0.043	0.043	0.043	145	7,630	220	0	0.01	0.01	0.01	0.01	147	7,707	222	0
2001	426	14,687	843	0	0.145	0.145	0.145	0.145	498	17,186	986	0	0.01	0.01	0.01	0.01	503	17,360	996	0
2002																				
2003																				

Results								
Brood Year	3	4	5	6	Total Recruits	Smolt to Adult Survival	Recruits per Spawner	Natural log (R/S)
1963	28	1,184	650	2	1,864		1.097	0.093
1964	56	1,079	660	0	1,795		1.580	0.457
1965	51	1,097	285	0	1,433	0.001	1.326	0.282
1966	52	2,181	393	0	2,626	0.002	4.925	1.594
1967	116	1,397	1,389	0	2,902	0.002	3.499	1.252
1968	506	2,331	2,508	29	5,374	0.007	5.415	1.689
1969	32	2,412	559	0	3,003	0.003	2.768	1.018
1970	228	2,034	103	10	2,376	0.002	1.686	0.522
1971	772	1,803	2,050	0	4,625	0.003	3.284	1.189
1972	4	66	58	5	133	0.000	0.076	-2.579
1973	117	3,658	2,281	0	6,057	0.003	2.805	1.032
1974	22	577	134	0	734	0.000	0.365	-1.009
1975	12	1,491	1,706	25	3,233	0.001	2.562	0.941
1976	2	379	1,130	0	1,511	0.001	0.704	-0.350
1977	20	633	605	0	1,258	0.001	0.687	-0.375
1978	2	1,194	1,105	8	2,308	0.001	1.271	0.240
1979	23	838	556	0	1,417	0.001	1.169	0.156
1980	7	898	346	0	1,251	0.000	0.616	-0.485
1981	56	1,141	953	0	2,149	0.001	1.276	0.244
1982	17	1,796	995	0	2,808	0.001	1.667	0.511
1983	20	1,412	1,865	8	3,305	0.001	1.859	0.620
1984	4	325	273	0	601	0.000	0.436	-0.829
1985	79	2,194	857	14	3,144	0.001	2.251	0.811
1986	131	6,718	3,340	4	10,194	0.005	6.876	1.928
1987	20	1,508	740	0	2,268	0.001	1.378	0.321
1988	50	2,794	1,420	4	4,267	0.002	2.617	0.962
1989	16	915	945	0	1,875	0.001	1.147	0.137
1990	11	1,213	186	0	1,410	0.001	0.981	-0.019
1991	10	670	40	0	720	0.000	0.466	-0.764
1992	193	2,905	749	0	3,847	0.002	3.171	1.154
1993	18	5,524	1,022	0	6,565	0.003	10.270	2.329
1994	19	881	99	0	999	0.001	0.818	-0.201
1995	16	3,792	222	0	4,029	0.004	4.042	1.397
1996	114	7,707	996					
1997	147	17,360						
1998	503							
1999								
2000								
2001								

Notes:
Hatchery releases obtained from USFWS NFH database (Steve Pastor, personal communication).
Ratio of release goals to escapement goals was based on 2002 production levels reported in the most recent HGMP.
Annual effective spawners calculated by dividing annual hatchery releases by the ratio of release goals/escapement goals.
Age composition for 1970-2001 was calculated from WDFW data on Carson NFH spring chinook escapement by age and return year; age composition for 1965-69 is the average based on all years of available data (i.e. 1970-2001).
Tributary harvest rates for 1970-2001 are derived from WDFW data and were calculated as the Wind river sport harvest plus the Wind River tribal harvest plus Carson NFH tribal distributions divided by total run by age and return year; tributary harvest for 1965-69 is the 5-yr average based on harvest data for 1970-74.
Mainstem harvest rates are from the Biological Assessment Tables, Table 1; calculated as the Zone 1-5 commercial, sport, and miscellaneous harvest plus Zone 6 commercial and ceremonial and subsistence harvest with a 35% reduction (i.e. 65% of zone 6 harvest) divided by the total upriver run; these harvest rates are not age-specific.
Ocean harvest rate was assumed to be 1%.

APPENDIX A-5. Little White Salmon Spring Chinook Run Reconstruction Table

	Escapement			Age Composition				Spawners by Age				Tributary Harvest Rate by Age			
Run Year	Hatchery Releases	Ratio of Hatchery Release/Esc Goals	Effective Spawners	3	4	5	6	3	4	5	6	3	4	5	6
1965			177	0.050	0.704	0.244	0.002	9	124	43	0	0.037	0.000	0.000	0.000
1966			304	0.050	0.704	0.244	0.002	15	214	74	1	0.037	0.000	0.000	0.000
1967	265,100	1,500	465	0.050	0.704	0.244	0.002	23	327	113	1	0.037	0.000	0.000	0.000
1968	456,700	1,500	384	0.050	0.704	0.244	0.002	19	270	94	1	0.037	0.000	0.000	0.000
1969	696,900	1,500	384	0.050	0.704	0.244	0.002	19	270	94	1	0.037	0.000	0.000	0.000
1970	576,300	1,500	709	0.159	0.201	0.582	0.059	113	142	413	42	0.000	0.000	0.000	0.000
1971	575,900	1,500	672	0.119	0.851	0.030	0.000	80	572	20	0	0.020	0.000	0.000	0.000
1972	1,063,900	1,500	381	0.060	0.501	0.439	0.000	23	191	167	0	0.000	0.000	0.000	0.000
1973	1,007,400	1,500	463	0.050	0.480	0.453	0.017	23	222	209	8	0.250	0.000	0.000	0.000
1974	571,700	1,500	414	0.194	0.222	0.500	0.083	81	92	207	35	0.125	0.000	0.000	0.000
1975	694,000	1,500	527	0.019	0.820	0.152	0.009	10	432	80	4	0.000	0.000	0.000	0.000
1976	621,100	1,500	490	0.218	0.350	0.433	0.000	107	171	212	0	0.000	0.000	0.000	0.000
1977	790,400	1,500	430	0.020	0.889	0.088	0.003	9	383	38	1	0.000	0.000	0.000	0.000
1978	734,800	1,500	456	0.111	0.190	0.687	0.012	51	87	313	5	0.059	0.000	0.000	0.000
1979	645,680	1,500	500	0.023	0.842	0.125	0.010	12	421	63	5	0.000	0.125	0.088	0.000
1980	683,682	1,500	142	0.106	0.551	0.343	0.000	15	78	49	0	0.000	0.000	0.000	0.000
1981	750,262	1,500	903	0.000	0.950	0.049	0.000	0	858	45	0	0.000	0.002	0.023	0.000
1982	212,994	1,500	275	0.045	0.131	0.823	0.001	12	36	226	0	0.000	0.735	0.743	0.875
1983	1,354,959	1,500	344	0.005	0.360	0.635	0.000	2	124	218	0	0.000	0.047	0.038	0.000
1984	412,212	1,500	345	0.092	0.432	0.477	0.000	32	149	164	0	0.000	0.000	0.000	0.000
1985	516,252	1,500	333	0.045	0.873	0.081	0.000	15	291	27	0	0.044	0.385	0.403	0.000
1986	517,446	1,500	308	0.192	0.611	0.197	0.000	59	188	61	0	0.060	0.961	0.996	0.000
1987	499,796	1,500	678	0.124	0.807	0.069	0.000	84	547	47	0	0.105	0.574	0.577	0.000
1988	461,446	1,500	1,118	0.048	0.355	0.594	0.003	54	397	664	3	0.199	0.581	0.641	0.462
1989	1,016,706	1,500	539	0.040	0.900	0.060	0.000	21	485	33	0	0.265	0.546	0.452	1.000
1990	1,677,694	1,500	663	0.013	0.849	0.138	0.000	8	563	92	0	0.342	0.509	0.481	0.000
1991	809,079	1,500	705	0.037	0.377	0.586	0.000	26	266	413	0	0.120	0.260	0.350	0.000
1992	994,588	1,500	641	0.012	0.883	0.105	0.000	8	566	67	0	0.514	0.650	0.713	0.000
1993	1,057,864	1,500	455	0.005	0.343	0.648	0.004	2	156	295	2	0.500	0.737	0.687	0.467
1994	961,515	1,500	711	0.007	0.576	0.413	0.005	5	409	294	3	0.000	0.194	0.312	0.667
1995	682,623	1,500	716	0.285	0.546	0.166	0.003	204	391	119	2	0.000	0.000	0.000	0.000
1996	1,066,702	1,500	744	0.015	0.965	0.019	0.000	11	718	14	0	0.763	0.650	0.603	0.000
1997	1,074,173	1,500	678	0.011	0.553	0.436	0.000	7	375	295	0	0.231	0.814	0.719	0.000
1998	1,115,384	1,500	692	0.020	0.528	0.452	0.000	14	365	313	0	0.000	0.000	0.000	0.000
1999	1,016,574	1,500	678	0.033	0.933	0.034	0.000	22	632	23	0	0.442	0.371	0.353	0.000
2000	1,037,400	1,500	692	0.009	0.904	0.088	0.000	6	625	61	0	0.830	0.677	0.691	0.000
2001	1,016,574	1,500	675	0.013	0.935	0.052	0.000	9	631	35	0	0.858	0.697	0.753	0.000
2002	1,037,382	1,500		0.006	0.909	0.085	0.000	0	0	0	0	0.798	0.853	0.803	0.000
2003	1,012,339	1,500													

	LWS River Run Size by Age				Mainstem Harvest Rate by Age				Columbia River Run Size by Age				Ocean Harvest Rate				Ocean Escapement by Age			
Run Year	3	4	5	6	3	4	5	6	3	4	5	6	3	4	5	6	3	4	5	6
1965	9	124	43	0	0.626	0.626	0.626	0.626	25	332	115	1	0.01	0.01	0.01	0.01	25	336	117	1
1966	16	214	74	1	0.375	0.375	0.375	0.375	26	343	119	1	0.01	0.01	0.01	0.01	26	346	120	1
1967	24	327	113	1	0.517	0.517	0.517	0.517	50	677	235	2	0.01	0.01	0.01	0.01	51	684	237	2
1968	20	270	94	1	0.368	0.368	0.368	0.368	32	428	149	1	0.01	0.01	0.01	0.01	32	432	150	1
1969	20	270	94	1	0.323	0.323	0.323	0.323	30	399	139	1	0.01	0.01	0.01	0.01	30	403	140	1
1970	113	142	413	42	0.421	0.421	0.421	0.421	195	246	712	72	0.01	0.01	0.01	0.01	197	248	720	72
1971	81	572	20	0	0.318	0.318	0.318	0.318	119	838	29	0	0.01	0.01	0.01	0.01	121	846	30	0
1972	23	191	167	0	0.455	0.455	0.455	0.455	42	351	307	0	0.01	0.01	0.01	0.01	42	354	310	0
1973	31	222	209	8	0.510	0.510	0.510	0.510	63	453	427	16	0.01	0.01	0.01	0.01	64	458	431	16
1974	92	92	207	35	0.336	0.336	0.336	0.336	139	139	312	52	0.01	0.01	0.01	0.01	140	140	315	52
1975	10	432	80	4	0.002	0.002	0.002	0.002	10	433	80	5	0.01	0.01	0.01	0.01	10	437	81	5
1976	107	171	212	0	0.005	0.005	0.005	0.005	107	172	213	0	0.01	0.01	0.01	0.01	108	174	215	0
1977	9	383	38	1	0.267	0.267	0.267	0.267	12	522	52	2	0.01	0.01	0.01	0.01	12	527	52	2
1978	54	87	313	5	0.044	0.044	0.044	0.044	56	91	328	6	0.01	0.01	0.01	0.01	57	92	331	6
1979	12	481	69	5	0.034	0.034	0.034	0.034	12	498	71	5	0.01	0.01	0.01	0.01	12	503	72	5
1980	15	78	49	0	0.028	0.028	0.028	0.028	15	81	50	0	0.01	0.01	0.01	0.01	16	81	51	0
1981	0	860	46	0	0.055	0.055	0.055	0.055	0	910	48	0	0.01	0.01	0.01	0.01	0	919	49	0
1982	12	136	879	3	0.073	0.073	0.073	0.073	13	147	948	3	0.01	0.01	0.01	0.01	13	149	958	3
1983	2	130	227	0	0.083	0.083	0.083	0.083	2	142	248	0	0.01	0.01	0.01	0.01	2	143	250	0
1984	32	149	164	0	0.090	0.090	0.090	0.090	35	164	181	0	0.01	0.01	0.01	0.01	35	165	183	0
1985	16	473	45	0	0.065	0.065	0.065	0.065	17	506	49	0	0.01	0.01	0.01	0.01	17	511	49	0
1986	63	4,766	15,852	0	0.067	0.067	0.067	0.067	67	5,110	16,996	0	0.01	0.01	0.01	0.01	68	5,161	17,168	0
1987	94	1,284	111	0	0.066	0.066	0.066	0.066	101	1,375	118	0	0.01	0.01	0.01	0.01	102	1,389	120	0
1988	67	947	1,849	6	0.123	0.123	0.123	0.123	76	1,080	2,109	7	0.01	0.01	0.01	0.01	77	1,091	2,130	7
1989	29	1,069	59	0	0.086	0.086	0.086	0.086	32	1,169	65	0	0.01	0.01	0.01	0.01	32	1,181	66	0
1990	13	1,146	177	0	0.106	0.106	0.106	0.106	14	1,281	197	0	0.01	0.01	0.01	0.01	14	1,294	199	0
1991	30	359	636	0	0.091	0.091	0.091	0.091	32	395	700	0	0.01	0.01	0.01	0.01	33	399	707	0
1992	16	1,618	234	0	0.065	0.065	0.065	0.065	17	1,731	250	0	0.01	0.01	0.01	0.01	17	1,749	253	0
1993	5	593	943	3	0.057	0.057	0.057	0.057	5	629	1,000	3	0.01	0.01	0.01	0.01	5	635	1,011	3
1994	5	508	427	10	0.083	0.083	0.083	0.083	5	554	465	11	0.01	0.01	0.01	0.01	5	559	470	11
1995	204	391	119	2	0.046	0.046	0.046	0.046	214	410	124	2	0.01	0.01	0.01	0.01	216	414	126	2
1996	47	2,050	37	0	0.041	0.041	0.041	0.041	49	2,138	38	0	0.01	0.01	0.01	0.01	50	2,160	38	0
1997	10	2,021	1,051	0	0.055	0.055	0.055	0.055	10	2,138	1,112	0	0.01	0.01	0.01	0.01	10	2,160	1,124	0
1998	14	365	313	0	0.044	0.044	0.044	0.044	15	382	327	0	0.01	0.01	0.01	0.01	15	386	330	0
1999	40	1,005	36	0	0.039	0.039	0.039	0.039	41	1,045	38	0	0.01	0.01	0.01	0.01	42	1,056	38	0
2000	36	1,934	196	0	0.049	0.049	0.049	0.049	38	2,034	206	0	0.01	0.01	0.01	0.01	38	2,054	208	0
2001	61	2,084	141	0	0.159	0.159	0.159	0.159	73	2,477	168	0	0.01	0.01	0.01	0.01	73	2,502	169	0
2002	0	0	0	0	0.107	0.107	0.107	0.107	0	0	0	0	0.01	0.01	0.01	0.01	0	0	0	0
2003																				

Results								
Brood Year	3	4	5	6	Total Recruits	Smolt to Adult Survival	Recruits/Spawner	Natural Log (R/S)
1965	32	403	720	0	1,155		6.534	1.877
1966	30	248	30	0	308		1.012	0.012
1967	197	846	310	16	1,369	0.005	2.947	1.081
1968	121	354	431	52	958	0.002	2.494	0.914
1969	42	458	315	5	820	0.001	2.135	0.759
1970	64	140	81	0	285	0.000	0.402	-0.912
1971	140	437	215	2	794	0.001	1.183	0.168
1972	10	174	52	6	242	0.000	0.635	-0.454
1973	108	527	331	5	971	0.001	2.099	0.742
1974	12	92	72	0	175	0.000	0.423	-0.860
1975	57	503	51	0	611	0.001	1.159	0.147
1976	12	81	49	3	145	0.000	0.296	-1.217
1977	16	919	958	0	1,892	0.002	4.396	1.481
1978	0	149	250	0	399	0.001	0.875	-0.133
1979	13	143	183	0	339	0.001	0.678	-0.388
1980	2	165	49	0	216	0.000	1.524	0.422
1981	35	511	17,168	0	17,714	0.024	19.610	2.976
1982	17	5,161	120	7	5,305	0.025	19.306	2.960
1983	68	1,389	2,130	0	3,587	0.003	10.422	2.344
1984	102	1,091	66	0	1,258	0.003	3.648	1.294
1985	77	1,181	199	0	1,458	0.003	4.375	1.476
1986	32	1,294	707	0	2,033	0.004	6.609	1.889
1987	14	399	253	3	670	0.001	0.988	-0.012
1988	33	1,749	1,011	11	2,803	0.006	2.506	0.919
1989	17	635	470	2	1,125	0.001	2.085	0.735
1990	5	559	126	0	690	0.000	1.040	0.040
1991	5	414	38	0	458	0.001	0.649	-0.433
1992	216	2,160	1,124	0	3,500	0.004	5.460	1.697
1993	50	2,160	330	0	2,539	0.002	5.580	1.719
1994	10	386	38	0	434	0.000	0.610	-0.495
1995	15	1,056	208	0	1,279	0.002	1.786	0.580
1996	42	2,054	169	0				
1997	38	2,502	0					
1998	73	0						
1999	0							
2000								
2001								
2002								

Notes:
Hatchery releases were obtained from USFWS NFH database (Steve Pastor, personal communication).
Ratio of release goals to escapement goals were based on 2002 production levels reported in the most recent HGMP.
Annual effective spawners calculated by dividing annual hatchery releases by the ratio of release goals/escapement goals.
Age composition for 1970-2002 was calculated based on WDFW data of Little White Salmon NFH spring chinook escapement by age and return year; age composition for 1967-69 is the average of all years of available data.
Tributary harvest rates for 1970-2001 were derived from WDFW data and calculated as the Little White Salmon River sport harvest plus tribal harvest plus tribal distributions divided by the total run by age and return year.
Tributary harvest rates for 1967-69 was the 5-yr average of harvest for 1970-1974; tributary harvest for 2002 was the 5-yr average harvest for 1997-2001.
Mainstem harvest rates were calculated from the Biological Assessment Tables, Table 1; Zone 1-5 commercial, sport, and miscellaneous harvest plus Zone 6 commercial and ceremonial and subsistence harvest with a 25% reduction (i.e. 75% of zone 6 harvest) divided by the total upriver run; these harvest rates are not age-specific.
Mainstem harvest rate for 2002 was the most recent 5-yr average harvest for 1997-2001.
Ocean harvest rate was assumed to be 1%.

APPENDIX A-6. Kalama Winter Steelhead Run Reconstruction Table

	Escapement						Spawners			Tributary Harvest		Kalama River Run Size		Mainstem Harvest Rate	
Run Year	Total Escapement	Proportion Wild	Wild Escapement	Proportion Hatchery	Hatchery Escapement	Prespawn Mortality	Wild Spawners	Hatchery Spawners	Total Spawners	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
1976-77	946	0.82	774	0.18	172	0.05	735	163	899	1,229	170	1,964	333	0.007	0.007
1977-78	1,615	0.43	694	0.57	921	0.05	659	875	1,534	1,114	998	1,773	1,873	0.007	0.007
1978-79	521	0.71	371	0.29	150	0.05	352	143	495	647	161	999	304	0.018	0.018
1979-80	1,347	0.76	1,025	0.24	322	0.05	974	306	1,280	1,067	585	2,041	891	0.004	0.004
1980-81	2,770	0.78	2,150	0.22	620	0.05	2,043	589	2,632	2,162	318	4,205	907	0.010	0.010
1981-82	1,108	0.78	869	0.22	239	0.05	826	227	1,053	1,719	453	2,545	680	0.009	0.009
1982-83	874	0.61	532	0.39	342	0.05	505	325	830	1,020	298	1,525	623	0.026	0.026
1983-84	2,007	0.47	943	0.53	1,064	0.05	896	1,011	1,907	959	617	1,855	1,628	0.007	0.007
1984-85	1,067	0.59	632	0.41	435	0.05	600	413	1,014	1,487	1,126	2,087	1,539	0.006	0.006
1985-86	2,532	0.36	919	0.64	1,613	0.05	873	1,532	2,405	643	1,179	1,516	2,711	0.001	0.008
1986-87	1,794	0.55	982	0.45	812	0.05	933	771	1,704	218	647	1,151	1,418	0.002	0.021
1987-88	2,135	0.51	1,079	0.49	1,056	0.05	1,025	1,003	2,028	486	943	1,511	1,946	0.001	0.008
1988-89	770	0.66	506	0.34	264	0.05	481	251	732	571	1,447	1,052	1,698	0.002	0.017
1989-90	756	0.47	356	0.53	400	0.05	338	380	718	424	970	762	1,350	0.000	0.003
1990-91	1,288	0.74	959	0.26	329	0.05	911	313	1,224	26	871	937	1,184	0.002	0.018
1991-92	2,847	0.69	1,974	0.31	873	0.05	1,875	829	2,705	15	1,342	1,890	2,171	0.000	0.005
1992-93	1,155	0.73	843	0.27	312	0.05	801	296	1,097	75	790	876	1,086	0.001	0.009
1993-94	916	0.79	725	0.21	191	0.05	689	181	870	13	195	702	376	0.000	0.003
1994-95	1,315	0.78	1,030	0.22	285	0.05	979	271	1,249	53	270	1,032	541	0.000	0.004
1995-96	1,606	0.45	725	0.55	881	0.05	689	837	1,526	48	1,088	737	1,925	0.000	0.000
1996-97	505	0.9	456	0.1	49	0.05	433	47	480	33	74	466	120	0.000	0.004
1997-98	413	1	413	0	0	0.05	392	0	392	28	0	420	0	0.001	0.007
1998-99	478	1	478	0	0	0.05	454	0	454	46	0	500	0	0.000	0.000
1999-2000	817	1	817	0	0	0.05	776	0	776	99	0	875	0	0.001	0.008
2000-01	922	1	922	0	0	0.05	876	0	876	51	0	927	0	0.001	0.005
2001-02	1,355	1	1,355	0	0	0.05	1,287	0	1,287	59	0	1,346	0	0.025	0.025

	Columbia River Run Size		Ocean Harvest Rate		Ocean Escapement		Wild Age Composition							Hatchery Age Composition						
Run Year	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	2	3	4	5	6	7	8	1	2	3	4	5	6	7
1976-77	1,979	336	0.005	0.005	1,989	338	0.00	0.18	0.44	0.24	0.11	0.03	0.01	0	0.004	0.176	0.441	0.236	0.108	0.035
1977-78	1,786	1,886	0.005	0.005	1,795	1,896	0.00	0.12	0.48	0.36	0.03	0.00	0.00	0	0.003	0.118	0.482	0.358	0.034	0.005
1978-79	1,018	309	0.005	0.005	1,023	311	0.00	0.06	0.52	0.37	0.05	0.00	0.00	0	0.003	0.056	0.524	0.367	0.05	0
1979-80	2,050	895	0.005	0.005	2,060	899	0.00	0.06	0.64	0.26	0.03	0.00	0.00	0	0.001	0.063	0.644	0.264	0.027	0.001
1980-81	4,247	916	0.005	0.005	4,268	921	0.00	0.07	0.44	0.42	0.06	0.00	0.00	0.002	0.835	0.163	0	0		
1981-82	2,568	686	0.005	0.005	2,580	690	0.00	0.06	0.43	0.47	0.04	0.01	0.00	0	0.619	0.371	0.011	0		
1982-83	1,566	640	0.005	0.005	1,574	643	0.00	0.06	0.33	0.55	0.06	0.00	0.00	0	0.487	0.487	0.024	0		
1983-84	1,869	1,640	0.005	0.005	1,878	1,648	0.01	0.13	0.56	0.24	0.05	0.00	0.00	0.039	0.904	0.057	0	0		
1984-85	2,101	1,549	0.005	0.005	2,111	1,557	0.01	0.12	0.45	0.41	0.01	0.00	0.00	0.071	0.753	0.153	0.024	0	0	0
1985-86	1,517	2,733	0.005	0.005	1,525	2,746	0.00	0.11	0.53	0.30	0.05	0.01	0.00	0.012	0.79	0.185	0.012	0	0	0
1986-87	1,153	1,449	0.005	0.005	1,159	1,456	0.01	0.08	0.41	0.44	0.06	0.00	0.00	0.015	0.677	0.293	0.015	0	0	0
1987-88	1,512	1,961	0.005	0.005	1,520	1,971	0.00	0.02	0.56	0.39	0.03	0.00	0.00	0.07	0.79	0.123	0.018	0	0	0
1988-89	1,053	1,727	0.005	0.005	1,059	1,736	0.00	0.09	0.59	0.29	0.03	0.00	0.00	0.013	0.64	0.346	0	0	0	0
1989-90	762	1,354	0.005	0.005	766	1,361	0.00	0.01	0.46	0.48	0.06	0.00	0.00	0.005	0.836	0.158	0	0	0	0
1990-91	939	1,205	0.005	0.005	943	1,211	0.00	0.04	0.43	0.48	0.05	0.00	0.00	0.035	0.769	0.197	0	0	0	0
1991-92	1,891	2,182	0.005	0.005	1,901	2,193	0.00	0.03	0.65	0.29	0.04	0.00	0.00	0.014	0.874	0.112	0	0	0	0
1992-93	877	1,096	0.005	0.005	881	1,102	0.00	0.05	0.32	0.55	0.07	0.00	0.00	0.005	0.791	0.199	0.003	0.003	0	0
1993-94	702	377	0.005	0.005	705	379	0.00	0.04	0.72	0.20	0.04	0.00	0.00	0.004	0.836	0.141	0.019	0	0	0
1994-95	1,032	543	0.005	0.005	1,037	546	0.00	0.03	0.56	0.38	0.03	0.00	0.00	0	0	0.037	0.722	0.202	0.038	0.001
1995-96	737	1,925	0.005	0.005	740	1,935	0.00	0.03	0.62	0.33	0.02	0.00	0.00	0	0	0.027	0.562	0.375	0.035	0.001
1996-97	466	121	0.005	0.005	469	121	0.00	0.05	0.60	0.33	0.02	0.00	0.00	0	0	0.027	0.622	0.328	0.02	0.004
1997-98	421	0	0.005	0.005	423	0	0.00	0.07	0.51	0.37	0.04	0.00	0.00	0	0	0.047	0.602	0.333	0.018	0
1998-99	500	0	0.005	0.005	503	0	0.00	0.07	0.51	0.37	0.04	0.00	0.00	0	0	0.029	0.529	0.394	0.045	0.003
1999-2000	876	0	0.005	0.005	880	0	0.00	0.07	0.51	0.37	0.04	0.00	0.00	0	0	0.03	0.53	0.392	0.046	0.002
2000-01	927	0	0.005	0.005	932	0	0.00	0.07	0.51	0.37	0.04	0.00	0.00	0	0	0.029	0.529	0.393	0.046	0.002
2001-02	1,381	0	0.005	0.005	1,388	0	0.00	0.07	0.51	0.37	0.04	0.00	0.00	0.012	0.442	0.144	0.245	0.142	0.018	0.001

	Hatchery Recruits by Age						
Run Year	1	2	3	4	5	6	7
1976-77	0	1	59	149	80	36	12
1977-78	0	6	224	914	679	64	9
1978-79	0	1	17	163	114	16	0
1979-80	0	1	57	579	237	24	1
1980-81	2	769	150	0	0	0	0
1981-82	0	427	256	8	0	0	0
1982-83	0	313	313	15	0	0	0
1983-84	64	1,490	94	0	0	0	0
1984-85	111	1,172	238	37	0	0	0
1985-86	33	2,170	508	33	0	0	0
1986-87	22	986	427	22	0	0	0
1987-88	138	1,557	242	35	0	0	0
1988-89	23	1,111	601	0	0	0	0
1989-90	7	1,138	215	0	0	0	0
1990-91	42	931	239	0	0	0	0
1991-92	31	1,916	246	0	0	0	0
1992-93	6	871	219	3	3	0	0
1993-94	2	317	53	7	0	0	0
1994-95	0	0	20	394	110	21	1
1995-96	0	0	52	1,087	725	68	2
1996-97	0	0	3	75	40	2	0
1997-98	0	0	0	0	0	0	0
1998-99	0	0	0	0	0	0	0
1999-2000	0	0	0	0	0	0	0
2000-01	0	0	0	0	0	0	0
2001-02	0	0	0	0	0	0	0

	Wild Recruits by Age								Hatchery Recruits by Age									Total Recruits		Productivity		
Brood Year	2	3	4	5	6	7	Total Wild Recruits	Wild R/S	1	2	3	4	5	6	7	Total Hatchery Recruits	Hatchery R/S	Total Recruits	Total R/S	Natural log (Wild R/S)	Natural log (Hatchery R/S)	Natural log (Total R/S)
1977	2	312	1,102	871	95	0	2,383	3.241	0	1	150	8	0	0	0	159	0.970	2,541	2.828	1.176	-0.030	1.040
1978	0	145	514	458	17	9	1,144	1.735	0	769	256	15	0	0	0	1,040	1.189	2,184	1.423	0.551	0.173	0.353
1979	0	98	1,060	865	74	0	2,096	5.948	2	427	313	0	0	0	0	742	5.205	2,838	5.734	1.783	1.650	1.746
1980	0	252	957	455	71	0	1,735	1.781	0	313	94	37	0	0	0	444	1.453	2,179	1.703	0.577	0.373	0.532
1981	13	256	814	514	44	0	1,640	0.803	0	1,490	238	33	0	0	0	1,761	2.990	3,401	1.293	-0.219	1.095	0.257
1982	17	172	480	586	30	0	1,286	1.557	64	1,172	508	22	0	0	0	1,767	7.780	3,052	2.900	0.443	2.052	1.065
1983	0	88	853	303	42	0	1,286	2.545	111	2,170	427	35	0	0	0	2,742	8.440	4,028	4.852	0.934	2.133	1.579
1984	7	31	622	364	45	0	1,069	1.193	33	986	242	0	0	0	0	1,261	1.248	2,330	1.222	0.176	0.221	0.200
1985	6	99	356	457	71	2	991	1.651	22	1,557	601	0	0	0	0	2,179	5.274	3,171	3.128	0.501	1.663	1.140
1986	5	4	403	542	65	0	1,020	1.168	138	1,111	215	0	0	0	0	1,464	0.955	2,483	1.032	0.155	-0.046	0.032
1987	0	38	1,239	485	26	1	1,790	1.919	23	1,138	239	0	3	0	1	1,403	1.818	3,193	1.873	0.652	0.598	0.628
1988	0	48	286	142	36	2	514	0.501	7	931	246	3	0	21	2	1,210	1.206	1,724	0.850	-0.690	0.187	-0.163
1989	0	43	510	389	15	0	957	1.991	42	1,916	219	7	110	68	0	2,364	9.424	3,321	4.539	0.689	2.243	1.513
1990	0	26	583	242	8	1	861	2.545	31	871	53	394	725	2		2,077	5.467	2,938	4.091	0.934	1.699	1.409
1991	0	28	461	156	19	1	664	0.729	6	317	20	1,087	40							-0.316		
1992	0	20	282	156	22	2	483	0.258	2	0	52	75								-1.357		
1993	0	22	217	186	39	3	466	0.582	0	0	3									-0.541		
1994	0	29	258	326	41	4	657	0.954	0	0										-0.047		
1995	1	34	452	345	62	0	893	0.912	0											-0.092		
1996	1	59	478	513	0																	
1997	2	63	712	0																		
1998	2	94	0																			
1999	3	0																				
2000	0																					
2001																						
2002																						

Notes:
Wild and hatchery spawning escapement numbers were obtained from WDFW Kalama Research Group data.
Wild and hatchery proportions were obtained from WDFW Kalama Research Group data.
Wild tributary harvest numbers for 1977-1996 and 1998-2002 were obtained from WDFW Kalama Research Group data. Harvest for 1997 was the 5-yr average harvest from 1998-2002.
Hatchery tributary harvest numbers from 1977-1996 were obtained from WDFW Kalama Research Group data. Harvest for 1997 was the 5-yr average harvest from 1992-1996. Hatchery harvest since 1998 was zero because no hatchery fish are present in the escapement.
Columbia River wild winter steelhead harvest rates were assumed to be the same as hatchery fish up to 1984; beginning in 1985, incidental harvest mortality was assumed to be 10% of the annual hatchery harvest rate. Harvest rate for 2001-02 was based on the 2002 Spring Chinook Tangle Net Fishery data: WDFW estimated a total of 2.5% mortality: 2% immediate mortality and an assumed 0.5% long term mortality.
Columbia River hatchery winter steelhead harvest rate was calculated as the lower river sport catch (Table 20, Columbia River Status Report) divided by the Columbia river index total run (Table 64, Columbia River Status Report; WDFW and ODFW 2002). Non-indian commercial steelhead harvest has not occurred since 1974. Harvest for 2001 was the most recent 5-yr average harvest (1996-2000). Harvest rate for 2002 was based on the 2002 Spring Chinook Tangle Net Fishery data: WDFW estimated 2.5% total mortality: 2% immediate mortality and an assumed 0.5% long term mortality.
Ocean harvest rate of wild and hatchery steelhead is assumed to be 0.5%.
Wild age composition data for 1976-77 to 2001-2002 from WDFW age data.
Hatchery age composition data for 1980-1983 were obtained from Hymer et al. 1992 (Table 10).
Hatchery age composition data for 1984-1993 were obtained from Hulett et al. 1995 (Table 1.4).
Hatchery age composition data for 1977-1979 and 1994-2001 were obtained from the NMFS SimSalmon database.
Hatchery age composition data for 2001-2002 was the average from all years of available data (1977-2001).

APPENDIX A-7. Kalama River Summer Steelhead Run Reconstruction Table

Run Year	Escapement						Spawners			Tributary Harvest		Kalama River Run Size		Mainstem Harvest Rate		Columbia River Run Size	
	Total Escapement	Proportion Wild	Wild Escape.	Proportion Hatchery	Hatchery Escapement	Prespawn Mortality	Wild Spawners	Hatchery Spawners	Total Spawners	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery
1977	1,469	0.27	400	0.73	1,069	0.05	380	1,016	1,396	633	2,386	1,013	3,402	0.016	0.016	1,030	3,458
1978	4,554	0.22	1,015	0.78	3,539	0.05	964	3,362	4,326	1,079	3,722	2,043	7,084	0.024	0.024	2,093	7,256
1979	2,604	0.19	484	0.81	2,120	0.05	460	2,014	2,474	832	2,965	1,292	4,979	0.018	0.018	1,316	5,072
1980	2,647	0.27	718	0.73	1,929	0.05	682	1,833	2,515	844	1,896	1,526	3,729	0.006	0.006	1,536	3,752
1981	11,524	0.25	2,926	0.75	8,598	0.05	2,780	8,168	10,948	2,978	8,527	5,758	16,695	0.034	0.034	5,958	17,275
1982	13,686	0.1	1,385	0.9	12,301	0.05	1,316	11,686	13,002	1,075	6,993	2,391	18,679	0.037	0.037	2,482	19,390
1983	5,274	0.16	869	0.84	4,405	0.05	826	4,185	5,010	1,621	7,689	2,447	11,874	0.041	0.041	2,550	12,376
1984	1,155	0.21	247	0.79	908	0.05	235	863	1,097	738	2,096	973	2,959	0.039	0.039	1,013	3,080
1985	1,567	0.29	461	0.71	1,106	0.05	438	1,051	1,489	854	2,044	1,292	3,095	0.003	0.032	1,296	3,196
1986	2,897	0.16	473	0.84	2,424	0.05	449	2,303	2,752	799	3,702	1,248	6,005	0.003	0.033	1,253	6,212
1987	5,435	0.14	748	0.86	4,687	0.05	711	4,453	5,163	148	9,214	859	13,667	0.003	0.027	861	14,052
1988	3,149	0.3	950	0.7	2,199	0.05	903	2,089	2,992	217	5,292	1,120	7,381	0.003	0.035	1,123	7,646
1989	3,376	0.2	684	0.8	2,692	0.05	650	2,557	3,207	90	5,394	740	7,951	0.005	0.049	743	8,357
1990	1,669	0.45	745	0.55	924	0.05	708	878	1,586	74	3,609	782	4,487	0.004	0.036	785	4,652
1991	1,738	0.41	704	0.59	1,034	0.05	669	982	1,651	16	2,586	685	3,568	0.004	0.038	687	3,708
1992	2,663	0.4	1,075	0.6	1,588	0.05	1,021	1,509	2,530	5	2,612	1,026	4,121	0.003	0.025	1,029	4,226
1993	7,188	0.32	2,283	0.68	4,905	0.05	2,169	4,660	6,829	204	4,433	2,373	9,093	0.004	0.038	2,382	9,455
1994	3,838	0.27	1,041	0.73	2,797	0.05	989	2,657	3,646	72	2,775	1,061	5,432	0.003	0.025	1,064	5,574
1995	3,043	0.43	1,302	0.57	1,741	0.05	1,237	1,654	2,891	9	1,573	1,246	3,227	0.004	0.036	1,250	3,348
1996	1,764	0.35	614	0.65	1,150	0.05	583	1,093	1,676	15	501	598	1,594	0.003	0.034	600	1,650
1997	2,993	0.2	598	0.8	2,395	0.05	568	2,275	2,843	38	1,012	606	3,287	0.006	0.063	610	3,506
1998	760	0.27	205	0.73	555	0.05	195	527	722	2	946	197	1,473	0.004	0.043	198	1,539
1999	407	0.54	220	0.46	187	0.05	209	178	387	44	372	253	550	0.004	0.041	254	573
2000	170	0.82	140	0.18	30	0.05	133	29	162	36	881	169	909	0.005	0.047	170	954
2001	381	0.86	329	0.14	52	0.05	313	49	362	43	881	356	930	0.005	0.046	357	975
2002	686	0.73	502	0.27	184	0.05	477	175	652	48	881	525	1,056	0.005	0.046	527	1,106
2003	1,600	0.5	800	0.5	800	0.05	760	760	1,520	66	881	826	1,641	0.005	0.046	830	1,719

	Ocean Harvest Rate		Ocean Escapement		Wild Age Composition							Hatchery Age Composition						Wild Recruits by Age							Hatchery Recruits by Age					
Run Year	Wild	Hatchery	Wild	Hatchery	2	3	4	5	6	7	8	2	3	4	5	6	7	2	3	4	5	6	7	8	2	3	4	5	6	7
1977	0.005	0.005	1,035	3,475	0.01	0.15	0.56	0.14	0.14	0.00	0.01	0.011	0.149	0.557	0.137	0.136	0.01	11	154	576	142	141	0	10	38	518	1,936	476	473	35
1978	0.005	0.005	2,103	7,292	0.01	0.27	0.59	0.08	0.04	0.00	0.00	0.009	0.272	0.593	0.08	0.044	0.001	20	572	1,246	169	93	0	3	66	1,983	4,324	583	321	7
1979	0.005	0.005	1,322	5,097	0.03	0.24	0.54	0.12	0.05	0.02	0.01	0.026	0.238	0.539	0.125	0.045	0.027	35	315	712	165	60	26	10	133	1,213	2,747	637	229	138
1980	0.005	0.005	1,543	3,771	0.02	0.26	0.56	0.11	0.05	0.00	0.01	0.017	0.256	0.561	0.109	0.049	0.008	27	394	866	168	76	0	9	64	965	2,116	411	185	30
1981	0.005	0.005	5,988	17,362	0.00	0.17	0.57	0.22	0.03	0.00	0.00	0	0.169	0.571	0.222	0.035	0.004	0	1,010	3,418	1,331	206	22	0	0	2,934	9,914	3,854	608	69
1982	0.005	0.005	2,494	19,487	0.00	0.15	0.61	0.21	0.01	0.01	0.00	0.003	0.147	0.61	0.211	0.014	0.015	8	366	1,522	526	35	37	0	58	2,865	11,887	4,112	273	292
1983	0.005	0.005	2,563	12,439	0.00	0.09	0.68	0.20	0.02	0.01	0.00	0	0.09	0.682	0.196	0.021	0.011	0	230	1,748	502	55	28	0	0	1,119	8,483	2,438	261	137
1984	0.005	0.005	1,018	3,095	0.01	0.20	0.54	0.19	0.04	0.02	0.00	0.017	0.83	0.091	0.023	0.04	0	9	203	554	194	38	19	0	53	2,569	282	71	124	0
1985	0.005	0.005	1,303	3,212	0.01	0.17	0.68	0.09	0.05	0.00	0.00	0.054	0.641	0.288	0.011	0	0.005	10	223	882	118	70	0	0	173	2,059	925	35	0	16
1986	0.005	0.005	1,259	6,243	0.00	0.19	0.56	0.19	0.04	0.02	0.00	0.038	0.735	0.21	0.017	0	0	0	234	709	234	55	28	0	237	4,589	1,311	106	0	0
1987	0.005	0.005	865	14,122	0.00	0.11	0.62	0.14	0.10	0.01	0.02	0.025	0.546	0.405	0.024	0	0	0	96	540	122	85	7	14	353	7,711	5,720	339	0	0
1988	0.005	0.005	1,129	7,684	0.00	0.11	0.68	0.17	0.03	0.00	0.00	0.037	0.673	0.272	0.011	0.007	0	5	125	770	190	34	6	0	284	5,172	2,090	85	54	0
1989	0.005	0.005	747	8,399	0.02	0.15	0.58	0.24	0.01	0.00	0.00	0.021	0.567	0.376	0.031	0.005	0	17	111	436	179	4	0	0	176	4,762	3,158	260	42	0
1990	0.005	0.005	788	4,676	0.00	0.16	0.57	0.23	0.04	0.00	0.00	0.004	0.688	0.288	0.014	0	0	0	129	449	178	33	0	0	19	3,217	1,347	65	0	0
1991	0.005	0.005	691	3,727	0.00	0.06	0.70	0.15	0.08	0.01	0.01	0.009	0.634	0.338	0.009	0	0	0	43	480	101	58	4	4	34	2,363	1,260	34	0	0
1992	0.005	0.005	1,034	4,247	0.01	0.16	0.59	0.20	0.03	0.01	0.00	0.008	0.658	0.316	0.015	0.004	0	6	168	609	210	31	10	0	34	2,795	1,342	64	17	0
1993	0.005	0.005	2,394	9,502	0.00	0.05	0.70	0.17	0.07	0.01	0.00	0.005	0.575	0.392	0.029	0	0	0	109	1,671	418	177	19	0	48	5,464	3,725	276	0	0
1994	0.005	0.005	1,069	5,602	0.00	0.10	0.51	0.30	0.07	0.01	0.01	0	0.099	0.511	0.302	0.073	0.016	0	106	546	323	78	11	6	0	555	2,862	1,692	409	90
1995	0.005	0.005	1,257	3,365	0.00	0.08	0.62	0.17	0.09	0.03	0.01	0	0.082	0.624	0.175	0.087	0.033	0	103	784	220	109	34	7	0	276	2,099	589	293	111
1996	0.005	0.005	603	1,659	0.00	0.11	0.62	0.20	0.07	0.00	0.00	0	0.11	0.62	0.197	0.073	0	0	67	374	119	44	0	0	0	182	1,028	327	121	0
1997	0.005	0.005	613	3,524	0.00	0.09	0.62	0.19	0.09	0.00	0.01	0	0.087	0.619	0.193	0.087	0.014	0	53	380	119	53	0	8	0	307	2,181	680	307	49
1998	0.005	0.005	199	1,547	0.01	0.15	0.61	0.18	0.06	0.01	0.00	0.005	0.115	0.63	0.183	0.053	0.014	1	29	120	35	11	2	1	8	178	975	283	82	22
1999	0.005	0.005	255	576	0.01	0.15	0.61	0.18	0.06	0.01	0.00	0.004	0.114	0.635	0.183	0.053	0.011	1	37	155	45	14	2	1	2	66	366	105	31	6
2000	0.005	0.005	171	959	0.01	0.15	0.61	0.18	0.06	0.01	0.00	0.004	0.115	0.628	0.184	0.056	0.013	1	25	103	30	9	1	1	4	110	602	177	54	12
2001	0.005	0.005	359	980	0.01	0.15	0.61	0.18	0.06	0.01	0.00	0.003	0.117	0.634	0.183	0.054	0.009	2	52	217	63	20	3	1	3	115	621	179	53	9
2002	0.005	0.005	530	1,112	0.01	0.15	0.61	0.18	0.06	0.01	0.00	0.012	0.348	0.480	0.115	0.037	0.008	3	77	321	94	29	4	2	13	387	533	127	42	8
2003	0.005	0.005	834	1,728	0.01	0.15	0.61	0.18	0.06	0.01	0.00	0.012	0.348	0.480	0.115	0.037	0.008	5	121	505	147	46	7	3	21	602	829	198	65	13

	Wild Recruits by Age									Hatchery Recruits by Age								Total Recruits		Productivity		
Brood Year	2	3	4	5	6	7	8	Total Wild Recruits	Wild R/S	2	3	4	5	6	7	Total Hatchery Recruits	Hatchery R/S	Total Recruits	Total R/S	Natural log (Wild R/S)	Natural log (Hatchery R/S)	Natural log (Total R/S)
1978	27	1,010	1,522	502	38	0	0	3,099	8.155	64	2,934	11,887	2,438	124	16	17,463	17.196	20,562	14.734	2.099	2.845	2.690
1979	0	366	1,748	194	70	28	14	2,420	2.510	0	2,865	8,483	71	0	0	11,419	3.396	13,839	3.199	0.920	1.223	1.163
1980	8	230	554	118	55	7	0	971	2.113	58	1,119	282	35	0	0	1,495	0.742	2,466	0.997	0.748	-0.298	-0.003
1981	0	203	882	234	85	6	0	1,410	2.067	0	2,569	925	106	0	0	3,600	1.965	5,010	1.992	0.726	0.675	0.689
1982	9	223	709	122	34	0	0	1,097	0.395	53	2,059	1,311	339	54	0	3,815	0.467	4,913	0.449	-0.929	-0.761	-0.801
1983	10	234	540	190	4	0	4	982	0.746	173	4,589	5,720	85	42	0	10,608	0.908	11,590	0.891	-0.293	-0.097	-0.115
1984	0	96	770	179	33	4	0	1,082	1.310	237	7,711	2,090	260	0	0	10,299	2.461	11,380	2.271	0.270	0.901	0.820
1985	0	125	436	178	58	10	0	808	3.442	353	5,172	3,158	65	0	0	8,748	10.142	9,556	8.709	1.236	2.317	2.164
1986	5	111	449	101	31	19	6	722	1.648	284	4,762	1,347	34	17	0	6,444	6.133	7,166	4.813	0.500	1.814	1.571
1987	17	129	480	210	177	11	7	1,030	2.292	176	3,217	1,260	64	0	90	4,806	2.087	5,836	2.120	0.829	0.736	0.752
1988	0	43	609	418	78	34	0	1,183	1.664	19	2,363	1,342	276	409	111	4,519	1.015	5,702	1.104	0.509	0.015	0.099
1989	0	168	1,671	323	109	0	8	2,279	2.525	34	2,795	3,725	1,692	293	0	8,538	4.087	10,817	3.616	0.926	1.408	1.285
1990	6	109	546	220	44	0	1	926	1.425	34	5,464	2,862	589	121	49	9,119	3.566	10,045	3.132	0.354	1.271	1.142
1991	0	106	784	119	53	2	1	1,064	1.503	48	555	2,099	327	307	22	3,357	3.824	4,420	2.788	0.407	1.341	1.025
1992	0	103	374	119	11	2	1	609	0.910	0	276	1,028	680	82	6	2,073	2.110	2,681	1.624	-0.094	0.747	0.485
1993	0	67	380	35	14	1	1	498	0.488	0	182	2,181	283	31	12	2,690	1.783	3,188	1.260	-0.717	0.578	0.231
1994	0	53	120	45	9	3	2	233	0.107	0	307	975	105	54	9	1,449	0.311	1,682	0.246	-2.233	-1.168	-1.401
1995	0	29	155	30	20	4	3	241	0.243	0	178	366	177	53	8	782	0.294	1,022	0.280	-1.414	-1.224	-1.272
1996	1	37	103	63	29	7				8	66	602	179	42	13	910	0.550					
1997	1	25	217	94	46					2	110	621	127	65								
1998	1	52	321	147						4	115	533	198									
1999	2	77	505							3	387	829										
2000	3	121								13	602											
2001	5									21												
2002																						
2003																						
2004																						

Notes:
Wild and hatchery spawning escapement numbers were obtained from WDFW Kalama Research Group data.
Wild and hatchery proportions were obtained from WDFW Kalama Research Group data.
Wild tributary harvest numbers for 1977-1996 and 1999-2003 were obtained from WDFW Kalama Research Group data. Harvest numbers for 1997-98 were obtained from Kalama Subbasin Summary 2002, Appendix B.
Hatchery tributary harvest numbers from 1977-1996 were obtained from WDFW Kalama Research Group data. Harvest numbers for 1997-1999 were obtained from Kalama Subbasin Summary 2002, Appendix B. Harvest numbers for 2000-2003 were the most recent 5-year average harvest from 1995-1999.
Columbia River wild summer steelhead harvest rates were assumed to be the same as hatchery fish up to 1984; beginning in 1985, incidental harvest mortality was assumed to be 10% of the annual hatchery harvest rate.
Columbia River hatchery summer steelhead harvest rate was calculated as the lower river sport catch (Table 66, Columbia River Status Report) divided by the lower river minimum run size (Table 65 or 66, Columbia River Status Report; WDFW and ODFW 2002). Harvest rates for 2001-2003 were the most recent 5-yr average (1996-2000). Non-indian commercial harvest has not occurred since 1974.
Ocean harvest rate of wild and hatchery steelhead were assumed to be 0.5%.
Wild age composition data for 1977 to 2003 were obtained from WDFW age data.
Hatchery age composition data for 1984-1993 were from Hulett et al. 1995 (Table 1.2). Hatchery age composition for 1990 RY only sums to .994; thus 0.6% of the run not apportioned to an age class. Hatchery age composition for 1991 RY only sums to .99; thus 1.0% of the run not apportioned to an age class.
Hatchery age composition data for 1977-1983 and 1994-2001 were obtained from the NMFS SimSalmon database.
Hatchery age composition data for 2002-2003 was the average from all years of available data (1977-2001).

APPENDIX A-8. Wind River Summer Steelhead Run Reconstruction Table

	Escapement											Spawners			Tributary Harvest/Rate	
Run Year	Wind River Escapement	Panther Creek Escapement	Trout Creek Escapement	Index Spawning Escapement	Adjustment Factor	Basin Escapement	Total Escapement	Proportion Wild	Wild Escapement	Hatchery Escapement	Prespawn Mortality	Wild Spawners	Hatchery Spawners	Total Spawners	Wild	Hatchery
1985	238	34	162				434	0.76	369	65	0.05	351	61	412	0.010	0.180
1986	216	26	186				428	0.76	370	58	0.05	352	55	407	0.010	0.195
1987	250	28	330				608	0.76	542	66	0.05	515	63	578	0.010	0.540
1988	464	114	248			1,547	1,547	0.66	1,021	526	0.05	970	500	1,470	212	0.448
1989	250	63	151			684	684	0.82	561	123	0.05	533	117	650	103	0.576
1990	98	31	99			807	807	0.74	597	210	0.05	567	199	767	74	0.689
1991	159	26	109			825	825	0.65	536	289	0.05	509	274	784	96	0.578
1992	192	44	51			718	718	0.94	675	43	0.05	641	41	682	107	0.458
1993				101	1	617	617	0.76	469	148	0.05	445	141	586	58	0.458
1994				104	1	718	718	0.76	546	172	0.05	518	164	682	54	0.458
1995				136	1	518	518	0.9	466	52	0.05	443	49	492	49	0.458
1996				94	1	901	901	0.81	730	171	0.05	693	163	856	74	0.458
1997				106	1	382	382	0.84	321	61	0.05	305	58	363	23	0.458
1998				44	1	385	385	0.84	323	62	0.05	307	59	366	22	0.458
1999				43	1	197	197	0.96	189	8	0.05	180	7	187	16	0.458
2000				26	1	508	508	0.98	498	10	0.05	473	10	483	32	0.458
2001						647	647	0.99	641	6	0.05	609	6	615	41	0.458
2002						939	939	0.99	930	9	0.05	883	9	892	59	0.458

	Wind River Run Size		Mainstem Harvest Rate		Columbia River Run Size		Ocean Harvest Rate		Ocean Escapement		Age Composition					Wild Recruits by Age					Hatchery Recruits by Age				
Run Year	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild	Hatchery	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
1985	354	75	0.028	0.124	364	86	0.005	0.005	366	86	0.004	0.119	0.610	0.197	0.070	1	43	223	72	26	0	10	53	17	6
1986	355	68	0.018	0.104	362	76	0.005	0.005	364	76	0.004	0.119	0.610	0.197	0.070	1	43	222	72	26	0	9	47	15	5
1987	520	137	0.048	0.104	546	153	0.005	0.005	549	153	0.004	0.119	0.610	0.197	0.070	2	65	335	108	39	1	18	94	30	11
1988	1,182	905	0.037	0.123	1,227	1,031	0.005	0.005	1,234	1,037	0.004	0.119	0.610	0.197	0.070	4	146	753	243	87	4	123	632	205	73
1989	636	276	0.034	0.119	658	313	0.005	0.005	662	315	0.022	0.148	0.584	0.240	0.006	15	98	386	159	4	7	47	184	75	2
1990	641	640	0.029	0.129	661	735	0.005	0.005	664	738	0.000	0.162	0.569	0.226	0.042	0	108	378	150	28	0	120	420	167	31
1991	605	650	0.038	0.127	629	745	0.005	0.005	632	749	0.000	0.063	0.697	0.146	0.094	0	40	441	92	59	0	47	522	109	70
1992	748	76	0.026	0.146	768	88	0.005	0.005	772	89	0.005	0.163	0.588	0.203	0.040	4	126	454	157	31	0	14	52	18	4
1993	503	260	0.028	0.138	518	301	0.005	0.005	521	303	0.000	0.046	0.697	0.174	0.082	0	24	363	91	43	0	14	211	53	25
1994	572	302	0.017	0.104	582	337	0.005	0.005	585	339	0.000	0.099	0.511	0.301	0.088	0	58	299	176	52	0	34	173	102	30
1995	492	91	0.014	0.118	499	103	0.005	0.005	501	103	0.000	0.082	0.623	0.175	0.121	0	41	312	88	61	0	8	64	18	13
1996	767	300	0.011	0.083	776	327	0.005	0.005	780	329	0.000	0.110	0.619	0.198	0.074	0	86	483	154	58	0	36	204	65	24
1997	328	107	0.012	0.089	332	118	0.005	0.005	333	118	0.000	0.086	0.620	0.194	0.100	0	29	207	65	33	0	10	73	23	12
1998	329	108	0.024	0.074	337	117	0.005	0.005	339	117	0.004	0.145	0.604	0.176	0.070	1	49	205	60	24	0	17	71	21	8
1999	196	14	0.020	0.074	200	15	0.005	0.005	201	15	0.004	0.146	0.605	0.178	0.067	1	29	121	36	13	0	2	9	3	1
2000	505	18	0.008	0.059	509	19	0.005	0.005	512	19	0.007	0.144	0.608	0.176	0.065	4	74	311	90	33	0	3	12	3	1
2001	650	11	0.015	0.076	659	12	0.005	0.005	663	12	0.005	0.147	0.606	0.178	0.065	3	97	402	118	43	0	2	7	2	1
2002	942	16	0.015	0.076	956	18	0.005	0.005	961	18	0.004	0.119	0.610	0.197	0.070	3	114	586	190	68	0	2	11	4	1

	Wild Recruits by Age							Hatchery Recruits by Age							Total Recruits		Productivity		
Brood Year	2	3	4	5	6	Total Wild Recruits	Wild R/S	2	3	4	5	6	Total Hatchery Recruits	Hatchery R/S	Total Recruits	Total R/S	Natural log (Wild R/S)	Natural log (Hatchery R/S)	Natural log (Total R/S)
1986	4	98	378	92	31	603	1.720	4	47	420	109	4	583	9.485	1,187	2.878	0.542	2.250	1.057
1987	15	108	441	157	43	762	2.166	7	120	522	18	25	691	12.638	1,454	3.575	0.773	2.537	1.274
1988	0	40	454	91	52	636	1.236	0	47	52	53	30	182	2.894	818	1.416	0.211	1.063	0.348
1989	0	126	363	176	61	726	0.748	0	14	211	102	13	340	0.680	1,065	0.725	-0.290	-0.385	-0.322
1990	4	24	299	88	58	472	0.886	0	14	173	18	24	230	1.966	702	1.081	-0.120	0.676	0.078
1991	0	58	312	154	33	558	0.984	0	34	64	65	12	175	0.878	733	0.956	-0.016	-0.130	-0.045
1992	0	41	483	65	24	612	1.202	0	8	204	23	8	243	0.887	855	1.092	0.184	-0.120	0.088
1993	0	86	207	60	13	366	0.570	0	36	73	21	1	131	3.204	497	0.728	-0.562	1.164	-0.317
1994	0	29	205	36	33	302	0.679	0	10	71	3	1	85	0.603	387	0.661	-0.387	-0.506	-0.415
1995	0	49	121	90	43	304	0.586	0	17	9	3	1	30	0.185	334	0.489	-0.535	-1.690	-0.714
1996	1	29	311	118	68	527	1.191	0	2	12	2	1	18	0.359	545	1.107	0.174	-1.024	0.102
1997	1	74	402	190				0	3	7	4								
1998	4	97	586					0	2	11									
1999	3	114						0	2										
2000	3							0											
2001																			
2002																			
2003																			

Notes:
Escapement data by tributary or index count (run year 1985-2000) were obtained from Hymer et al. (1992), WDF et al. (1993), and WDFW (2003). Basin escapement data for 1988-2002 (BY 1989-2003) were expanded escapements from WDFW data. The total escapement values used in the run reconstruction were the tributary escapements for run year 1985-1987 and the basin escapement for run year 1988-2002.
Proportion of wild spawners for 1988-2002 (BY 1989-2003) was from WDFW steelhead data; proportion for years 1985-87 was 5-year average from 1988-1992.
Tributary harvest rate of wild steelhead for 1985-1987 was assumed to be 1%.
Tributary harvest rate of wild steelhead for 1988-2002 was actual harvest (in fish) from WDFW data.
Tributary harvest rate of hatchery steelhead for 1985-1991 was calculated based on Hymer et al. (1992; Table 2); harvest rate for 1992-2000 was the average of all years of available data (1985-1991).
Mainstem harvest rate of wild steelhead was assumed to be 10% of the lower Columbia sport catch of Group A steelhead (WDFW and ODFW 2002; Table 67) plus the Zone 6 number of Wild Group A steelhead in the commercial catch (with a 35% reduction factor; WDFW and ODFW 2002; Table 68) divided by the total minimum run Group A steelhead in the Columbia River (WDFW and ODFW 2002; Table 67).
Mainstem harvest rate of hatchery steelhead was the lower Columbia sport catch of Group A steelhead (WDFW and ODFW 2002; Table 67) plus the Zone 6 number of hatchery Group A steelhead in the commercial catch (with a 35% reduction factor; WDFW and ODFW 2002; Table 68) divided by the total minimum run Group A steelhead in the Columbia River (WDFW and ODFW 2002; Table 67).
Mainstem harvest rate of hatchery and wild steelhead for 2001 and 2002 was the most recent 5-year average (1996-2000).
Ocean harvest rate of wild and hatchery steelhead was assumed to be 0.5%.
Age composition for 1985-1988 and 2002 was average based on the NMFS SimSalmon database covering years 1989-2001.
Age composition for 1989-2001 was actual age composition in NMFS SimSalmon database.

APPENDIX A-9. Grays River Summer Steelhead Run Reconstruction Table

	Escapement						Spawners		Harvest					
Year	Mainstem Natural Escapement	West Fork Natural Escapement	Crazy Johnson Creek	Gorley Creek	Fossil Creek	Total Natural Escapement	Prespawn Mortality	Natural Spawners	Tributary Harvest Rate	Grays River Run Size	Mainstem Harvest Rate	Columbia River Run Size	Ocean Harvest Rate	Ocean Escapement
1959	1,810	666			2	2,478	0.05	2,354	0.01	2,378	0.636	6,539	0.01	6,605
1960	1,180	367			1	1,548	0.05	1,471	0.01	1,485	0.433	2,621	0.01	2,648
1961	1,289	907				2,196	0.05	2,086	0.01	2,107	0.419	3,629	0.01	3,666
1962	468	238				706	0.05	671	0.01	677	0.684	2,145	0.01	2,167
1963	466	420				886	0.05	842	0.01	850	0.400	1,417	0.01	1,431
1964		92			2	94	0.05	89	0.01	90	0.594	222	0.01	224
1965	238	58	89		0	385	0.05	366	0.01	369	0.333	554	0.01	560
1966	1,581	660	102		7	2,350	0.05	2,233	0.01	2,255	0.290	3,178	0.01	3,210
1967	477	371	106		1	955	0.05	907	0.01	916	0.429	1,604	0.01	1,620
1968		90	146		39	275	0.05	261	0.01	264	0.500	528	0.01	533
1969	429	177	71		9	686	0.05	652	0.01	658	0.273	905	0.01	914
1970	84	100	111			295	0.05	280	0.01	283	0.500	566	0.01	572
1971	55	26	311		31	423	0.05	402	0.01	406	0.455	744	0.01	752
1972	1,085	56	81		54	1,276	0.05	1,212	0.01	1,224	0.542	2,672	0.01	2,699
1973	42	48	212		24	326	0.05	310	0.01	313	0.778	1,408	0.01	1,422
1974	12	31	47		31	121	0.05	115	0.01	116	0.750	464	0.01	469
1975	81	45	147		85	358	0.05	340	0.01	344	0.625	916	0.01	925
1976	475	0	16		1	492	0.05	467	0.01	472	0.800	2,361	0.01	2,384
1977	440	63	192		0	695	0.05	660	0.01	667	0.125	762	0.01	770
1978	503	0	76			579	0.05	550	0.01	556	0.789	2,639	0.01	2,666
1979	239	0	21		0	260	0.05	247	0.01	249	0.333	374	0.01	378
1980	192	20	61		1	274	0.05	260	0.01	263	0.400	438	0.01	443
1981		8	13		0	21	0.05	20	0.01	20	0.933	302	0.01	305
1982	1,465	10	102		0	1,577	0.05	1,498	0.01	1,513	0.621	3,990	0.01	4,030
1983	321	8	40			369	0.05	351	0.01	354	0.333	531	0.01	537
1984	1,077	32	41	0	0	1,150	0.05	1,093	0.01	1,104	0.783	5,076	0.01	5,128
1985	1,488	8	0	0	0	1,496	0.05	1,421	0.01	1,436	0.538	3,110	0.01	3,142
1986	904	201	226	480	0	1,811	0.05	1,720	0.01	1,738	0.600	4,345	0.01	4,388
1987	1,571	71	2	4	0	1,648	0.05	1,566	0.01	1,581	0.520	3,295	0.01	3,328
1988	1,073	73	338	847		2,331	0.05	2,214	0.01	2,237	0.521	4,668	0.01	4,715
1989	389	41	140	25		595	0.05	565	0.01	571	0.650	1,631	0.01	1,648
1990	569	0	117	482	2	1,170	0.05	1,112	0.01	1,123	0.276	1,550	0.01	1,566
1991	327	37	239	260		863	0.05	820	0.01	828	0.308	1,196	0.01	1,208
1992	3,881	491	320	611	1	5,304	0.05	5,039	0.01	5,090	0.143	5,938	0.01	5,998
1993	2,334	113	78	256	1	2,782	0.05	2,643	0.01	2,670	0.022	2,730	0.01	2,758
1994	42	0	90	75	0	207	0.05	197	0.01	199	0.083	217	0.01	219
1995	219	0	413	293		925	0.05	879	0.01	888	0.067	951	0.01	961
1996	1,302	408	396	348	0	2,454	0.05	2,331	0.01	2,355	0.030	2,428	0.01	2,453
1997	79	55	485	185		804	0.05	764	0.01	772	0.059	820	0.01	828
1998	154	214	145	430	0	943	0.05	896	0.01	905	0.053	955	0.01	965
1999	222	100	927	496	0	1,745	0.05	1,658	0.01	1,674	0.042	1,747	0.01	1,765
2000	1,124	833	249			2,206	0.05	2,096	0.01	2,117	0.040	2,205	0.01	2,227
2001	759					759	0.05	721	0.01	728	0.042	761	0.01	768

	Age Composition				Ocean Escapement by Age				Results								
Year	3	4	5	6	3	4	5	6	Brood Year	3	4	5	6	Total Recruits	Recruits per Spawner	Natural log (R/S)
1959	0.410	0.570	0.020		2,708	3,765	132		1959	888	816	4		1,709	0.726	-0.320
1960	0.410	0.570	0.020		1,086	1,509	53		1960	587	128	11		726	0.494	-0.706
1961	0.410	0.570	0.020		1,503	2,090	73		1961	92	319	64		475	0.228	-1.479
1962	0.410	0.570	0.020		888	1,235	43		1962	230	1,830	32		2,091	3.118	1.137
1963	0.410	0.570	0.020		587	816	29		1963	1,316	923	11		2,250	2.673	0.983
1964	0.410	0.570	0.020		92	128	4		1964	664	304	18		986	11.045	2.402
1965	0.410	0.570	0.020		230	319	11		1965	219	521	11		751	2.054	0.720
1966	0.410	0.570	0.020		1,316	1,830	64		1966	375	326	15		716	0.321	-1.137
1967	0.410	0.570	0.020		664	923	32		1967	234	428	54		717	0.790	-0.235
1968	0.410	0.570	0.020		219	304	11		1968	308	1,538	28		1,875	7.176	1.971
1969	0.410	0.570	0.020		375	521	18		1969	1,106	811	9		1,926	2.956	1.084
1970	0.410	0.570	0.020		234	326	11		1970	583	267	19		869	3.100	1.132
1971	0.410	0.570	0.020		308	428	15		1971	192	527	48		767	1.910	0.647
1972	0.410	0.570	0.020		1,106	1,538	54		1972	379	1,359	15		1,754	1.447	0.369
1973	0.410	0.570	0.020		583	811	28		1973	978	439	53		1,470	4.746	1.557
1974	0.410	0.570	0.020		192	267	9		1974	316	1,519	0		1,835	15.965	2.770
1975	0.410	0.570	0.020		379	527	19		1975	1,093	63	148		1,304	3.833	1.344
1976	0.410	0.570	0.020		978	1,359	48		1976	315	197	9		521	1.114	0.108
1977	0.410	0.570	0.020		316	439	15		1977	98	218	314	12	642	0.972	-0.028
1978	0.410	0.570	0.020		1,093	1,519	53		1978	78	3,016	83	42	3,220	5.855	1.767
1979	0.833	0.167	0.000		315	63	0		1979	700	441	460		1,602	6.484	1.869
1980	0.222	0.444	0.333		98	197	148		1980	0	4,332	63		4,395	16.885	2.826
1981	0.257	0.714	0.030		78	218	9		1981	293	1,791	88		2,171	108.841	4.690
1982	0.174	0.749	0.078		700	3,016	314		1982	1,288	2,501	67		3,856	2.574	0.945
1983	0.000	0.822	0.156	0.022	0	441	83	12	1983	1,799	1,897	94		3,790	10.813	2.381
1984	0.057	0.845	0.090	0.008	293	4,332	460	42	1984	1,364	2,688	33		4,085	3.739	1.319
1985	0.410	0.570	0.020		1,288	1,791	63		1985	1,933	939	31		2,904	2.043	0.715
1986	0.410	0.570	0.020		1,799	2,501	88		1986	676	893	24		1,592	0.926	-0.077
1987	0.410	0.570	0.020		1,364	1,897	67		1987	642	689	120		1,451	0.927	-0.076
1988	0.410	0.570	0.020		1,933	2,688	94		1988	495	3,419	55		3,969	1.792	0.584
1989	0.410	0.570	0.020		676	939	33		1989	2,459	1,572	4		4,036	7.139	1.966
1990	0.410	0.570	0.020		642	893	31		1990	1,131	125	19		1,275	1.147	0.137
1991	0.410	0.570	0.020		495	689	24		1991	90	548	49		686	0.837	-0.178
1992	0.410	0.570	0.020		2,459	3,419	120		1992	394	1,398	17		1,809	0.359	-1.025
1993	0.410	0.570	0.020		1,131	1,572	55		1993	1,006	472	19		1,497	0.566	-0.568
1994	0.410	0.570	0.020		90	125	4		1994	339	550	35		925	4.702	1.548
1995	0.410	0.570	0.020		394	548	19		1995	396	1,006	45		1,446	1.646	0.498
1996	0.410	0.570	0.020		1,006	1,398	49		1996	724	1,270	15		2,009	0.862	-0.149
1997	0.410	0.570	0.020		339	472	17		1997	913	438					
1998	0.410	0.570	0.020		396	550	19		1998	315						
1999	0.410	0.570	0.020		724	1,006	35		1999							
2000	0.410	0.570	0.020		913	1,270	45		2000							
2001	0.410	0.570	0.020		315	438	15		2001							

Notes:
Escapement data for mainstem and West Fork from 1959-2001 was total live fish counts from WDFW escapement data and WDFW (2003).
Escapement data for Crazy Johnson, Gorley, and Fossil Creeks through 1991 was the expanded population estimates from Hymer (1993; Table 24).
Escapement data for Crazy Johnson, Gorley, and Fossil Creeks from 1992 to present was the peak count from Grays subbasin plan.
Total escapement used in the run reconstruction was the summation of escapement data for each tributary.
Tributary harvest was assumed to be 1%.
Mainstem harvest rate for 1959-2000 was calculated from the commercial catch in Zones 1-5 divided by the minimum Columbia River run size (WDFW and ODFW 2002; Table 62).
Mainstem harvest rate for 2001 was the 5-year average based on 1996-2000 harvest.
Ocean harvest was assumed to be 1%.
Age composition data for 1959-1978 and 1985-present were obtained from the NMFS SimSalmon database.
Age composition data for 1979-1984 were obtained from Hymer et al. (1992).

Volume VI, Chapter 3
Coho Capacity Estimation

Estimation of Coho Smolt Production Potential in the Lower Columbia Subbasins

Introduction:

As part of the Lower Columbia River Recovery Planning process, coho smolt production potential was estimated using the EDT in each of the lower Columbia subbasins. Coho smolt capacity estimates were generated via an independent model to provide empirical support for EDT smolt production potential estimates.

This appendix describes methods used to estimate the coho (*Oncorhynchus kisutch*) smolt production potential of select lower Columbia Basins. First, we describe the model chosen to best estimate production potential, and how that model was adapted to be used with data available in the lower Columbia Basins. This report also presents the estimates of production potential and frames those estimates in the context of coho smolt production observed in other basins of the Pacific Northwest. Coho production potential estimates were made in the following basins: Coweeman, East Fork Lewis, Elochoman, Grays, Kalama, lower Cowlitz, lower North Fork Lewis, Skamakowa, Toutle, and Washougal.

Rather than develop a new method for estimating coho smolt production potential, an existing model was adapted to fit the data available in the lower Columbia Basin. The Habitat Limiting Factors Model (HLFM) was proposed in its original version in Nickelson et al. (1992a), and further developed by Solazzi et al. (1998). The HLFM was developed to determine stream capacity and limiting habitat for coho in Oregon coastal streams. The model is based on the concept that a "habitat bottleneck," limits the potential smolt production of a stream. The model in its full capacity consists of the simultaneous examination of the seasonal habitat needs of coho and the availability of this habitat. Data used to develop the model include: seasonal rearing densities specific to different habitat unit types, estimates of spawning habitat requirements, average fecundity, and estimates of density-independent survival rates specific to different life stages. Densities by unit type reflect densities at capacity because they were derived from fully seeded streams. The estimates of coho smolt capacity generated by this model for coastal Oregon streams have been shown to be similar to actual production when summer habitat was fully seeded (Nickelson 1998).

The model estimates capacity for each juvenile life stage of coho (eggs, fry, parr and pre-smolts), and then applies density independent survival rates to estimate smolt production based on the capacity at each of those life stages. The stream capacity is determined by whichever life stage generates the lowest smolt production potential. The habitat required by that life stage is considered the limiting habitat of the stream. For further detail on the HLFM refer to Nickelson et al. (1992a; 1992b) and Solazzi et al. (1998).

METHODS

Modification of the HLFM

Seasonal estimates of surface area by habitat type within a stream are needed to fully utilize the HLFM and determine the life stage that habitat within a stream limits coho smolt production. However, stream surveys by which these data are obtained typically are done during the summer, so data are not usually available to estimate spring and winter seasonal capacity. Nickelson (1998) acknowledged this challenge and cited research that showed that in Oregon coastal streams, winter habitat availability was typically the limiting habitat (Nickelson 1992b). Nickelson (1998) subsequently developed a multiple regression model by which winter habitat capacity could be predicted using summer habitat data. That regression was developed using 74 stream reaches where both summer and winter habitat surveys had been conducted, and predicted smolt production potential (as estimated by the HLFM) from stream reach characteristics estimated during summer habitat surveys. The regression incorporated active channel width, gradient, percentage of pools, and beaver dam frequency to estimate smolt density. The resultant density was subsequently multiplied by the winter surface area of the reach defined as the active channel width multiplied by the length of the reach. Smolt capacities predicted by the multiple regression model were significantly correlated with smolt capacities estimated using the original version of the HLFM ($r = 0.874$, $p<0.001$).

We used an adapted version of the multiple regression of Nickelson (1998) to estimate coho capacity in the lower Columbia Basins. The lack of reliable data on the frequency of beaver dams in stream reaches in the lower Columbia Basin precluded the use of the regression model as presented by Nickelson (1998). We used that regression model to estimate coho smolt capacity density (smolts/m^2) for 1,290 reaches from the Oregon coastal basins and Umpqua Basin where all parameters needed to run the model were available. In selecting those 1,290 reaches, any reach greater than 20m wide or with a gradient greater than 6% was excluded. Reaches greater than 20m wide were not included because the original HLFM was based on data primarily from streams smaller than that width (Tom Nickelson, ODFW, personal comm. 11/03). Reaches with gradient greater than 6% were excluded because coho typically do not use those reaches (Nickelson 2001). The estimated densities from the 1,290 reaches were subsequently correlated to active channel width, gradient and percent pools by reach via multiple regression ($r^2 = 0.56$, $P = 0.000$) as defined by the equation:

$$\ln(\text{Density}) = -1.57712 - 0.226581*G - 0.700359*\ln(ACW) + 3.06529*\text{Pools}$$

where:
Density = smolts/m^2
G = gradient in percent
ACW = active channel width in meters
Pools = arcsine square root transformation of proportion of reach surface area comprised of pools.

This equation was subsequently used to estimate coho capacity in the lower Columbia Basin. Data used to run the model in the lower Columbia Basin were derived from EDT input files for reaches where EDT attributes were available and coho are distributed or suspected to be distributed.

Estimating Capacity in Large Streams

The ability of the HLFM to reliably estimate capacity in streams with active channel widths greater than 15-20m has not yet been tested (Tom Nickelson, ODFW, personal comm. 11/03). The habitat specific densities used to develop the HLFM came primarily from 4th order and smaller streams. Application of the HLFM (or any regressions derived from it) generates exceedingly high capacities as active channel width increases above 15m. The model assumes that all stream area is usable area, though field surveys have shown that in large streams use of mid-channel waters by rearing salmonids is less than that in small streams (Johnson 1985; Cramer 2001). To model this behavior and its effect on capacity, we assumed that in all reaches greater than 15m wide, that *usable* area of the reach would be calculated as the length of the reach multiplied by 15m. This assumes that coho are primarily using the edges of large streams for rearing, but not the middle sections. Also, when calculating rearing density with the multiple regression described earlier, we designated 15m as the maximum active channel width that would be applied in the equation. In reaches greater than 15m wide, 15m was used as the width. This was done because the model was developed and validated by Nickelson (1992a; 1998) with reaches generally narrower than 15m, and to use greater widths would mean going outside the bounds of the model's capabilities.

Habitat Quality Rating

A habitat quality rating was developed for each reach in the lower Columbia Basin supporting coho based on EDT patient and template attribute ratings for each reach. The HLFM was developed in Oregon in the late 1980's and early 1990's when Oregon coastal natural (OCN) coho returns were among lowest observed since 1970. However, habitat specific densities used in the model were derived from streams expected to be at full seeding. Streams were assumed to be at full seeding when spawning populations the previous fall were greater than 25 spawners/km (Nickelson 1992b; Biedler et al. 1980). We inferred that in years of generally low spawner returns, streams that supported these levels of spawners had high quality habitat.

We assumed that habitat quality in those fully seeded Oregon streams was better than the habitat quality of the average coho producing stream in the lower Columbia Basin. We used EDT template and patient attribute ratings to develop a habitat quality index. Specific EDT attributes rated on a scale of 0-4 were incorporated (Table 1). Patient ratings are intended to reflect current stream conditions, and template attributes are intended to reflect stream conditions prior to European settlement of the region. For each attribute included in the index, the difference in the patient and template attribute ratings was calculated, and these differences were summed across all attributes included for the reach. A larger difference in patient and template conditions indicates a greater degree of degradation with respect to template conditions for that reach. The frequency distribution of resultant habitat quality index scores from all reaches ($n = 440$) was calculated, and it was determined that reaches with scores in the upper 50th percentile of all the reaches scored would be classified as "degraded". Higher scores indicated a higher degree of degradation relative to template conditions. Capacity density in degraded reaches was estimated using the lower 95% confidence limit predicted by the capacity prediction equation described earlier.

Table 1. EDT attributes incorporated into the habitat quality index used in the estimation of coho capacity.

Attribute
Alkalinity
Bed Scour
Benthos diversity
Confinement-natural
Confinement-hydromodifications
Dissolved oxygen
Embeddedness
Flow - Intra daily (diel) variation
Fine sediment
Fish community richness
Fish pathogens
Fish species introductions
Harassment (harvest)
Hatchery fish outplants
Hydrologic regime – natural
Hydrologic regime – regulated
Icing
Metals/Pollutants - in sediments/soils
Metals - in water column
Miscellaneous toxic pollutants - water column
Nutrient enrichment
Obstructions to fish migration
Predation risk
Riparian function
Salmon Carcasses
Temperature - daily minimum (by month)
Temperature - daily maximum (by month)
Temperature - spatial variation
Turbidity
Wood
Water withdrawals

Accounting for Reaches without Data

Coho capacity was estimated using the equation described earlier for all reaches where EDT data were available and coho were distributed. Not all reaches used by coho for rearing had EDT data available. In each basin, we calculated the coho capacity/meter of habitat where EDT data were available. This density was multiplied by the linear length of coho habitat where EDT data were not available. The resultant capacity was added to the capacity of reaches with EDT data to determine total capacity for the basin.

Model Validation

Coho capacity estimates were validated using observations of coho production from basins around the Pacific Northwest. Results were evaluated in two manners including coho/meter, and coho/mi^2 of watershed area. Coho/meter for the lower Columbia basin was calculated as the total capacity divided by the summed length of reaches within the basin that coho capacity was estimated for.

Coho/mi^2 of watershed was calculated as the total coho capacity for the basin divided by the watershed area of the basin. We only used data from other basins that were greater than 50mi^2 because coho production per watershed area decreases as watershed area increases and watershed areas in the lower Columbia Basin ranged from 63-512 mi^2. We used data from eight migrant traps in the Clackamas, Coquille, Umpqua and Rogue basins. Data from those basins were obtained from Shibahara and Taylor (2001), Vogt (2003), data received from ODFW Salmonid Life Cycle Monitoring Project (Mario Solazzi, personal comm. 3/02), and ODFW (Dave Harris, personal comm. 3/03). Watershed areas above those traps ranged from 61-681 mi^2. From these traps we compiled the maximum outmigration estimate from each trap for the years that the trap was operated. The maximum observations of outmigrants from each trap were chosen because it was believed that those numbers most closely represented the production potential of the basin. Then we calculated the median and maximum number of smolts per watershed area from that data set.

Model performance was also tested by estimating capacity in the Elochoman and Skamokawa basins, and comparing our capacity estimate the EDT smolt equilibrium abundance estimates.

RESULTS AND DISCUSSION

Capacity Estimates

Total smolt production potential estimates among the basins ranged from 22,000 in the East Fork Lewis to 279,000 in the Toutle (Figure 1,Table 2).

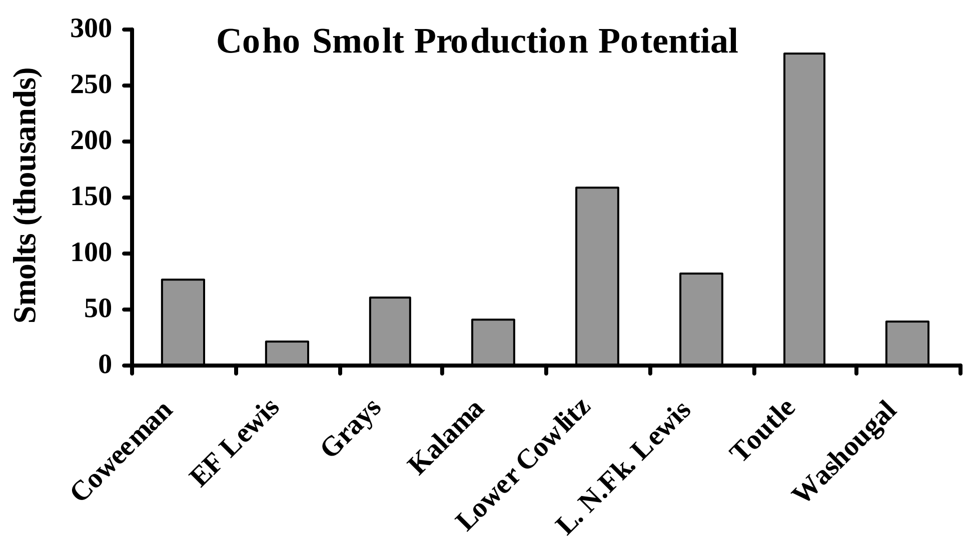

Figure 1. Coho smolt production potential estimates for basins within the lower Columbia Basin.

Table 2. Estimated coho smolt production potential, smolts/meter of available coho habitat, smolts/mi² of watershed, percentage of reaches with EDT data that were rated as degraded, and percentage of reaches where coho are suspected to exist where EDT data were available.

Basin	Smolt Capacity	Smolts per meter	Smolts per mi^2 of Watershed	% of Reaches Degraded	Percent of coho habitat without EDT data
Coweeman	76,651	0.53	360	11%	27%
EF Lewis	22,189	0.16	94	100%	38%
Grays	60,419	0.32	491	40%	30%
Kalama	41,860	1.10	174	0%	43%
Lower Cowlitz	159,482	0.24	370	72%	48%
L. N.Fk. Lewis	82,502	0.54	821	96%	43%
Toutle	278,985	0.35	545	40%	51%
Washougal	38,848	0.29	181	85%	33%

Measures of estimated production potential compared favorably to observed levels of smolt production in other basins of the Pacific Northwest. Solazzi et al. (2003) presented estimates of coho production per meter of habitat in 14 coastal Oregon streams. Migrant traps were operated at those locations for 3-5 years (period varied depending on the trap), and coho outmigrant abundance estimates were made for each year by expanding trap counts by trap efficiency. Of 67 observations (multiple traps in multiple years), coho per meter estimates varied from 0.00 to 1.19 with a median of 0.20. The estimates of coho production potential per meter in the lower Columbia Basins compare favorably to these because no estimate was greater than the maximum reported by Solazzi et al. (2003), and all but one were greater than the median observation (Figure 2). This means that production potential estimates in the lower Columbia Basins are sufficiently high to reflect conditions better than realized in 50% of coastal Oregon observations, but are low enough that they don't exceed the maximum observation. Some of the observations of Solazzi et al. (2002) have taken place following years of extremely high seeding levels as recent years have produced near record returns from Oregon coastal coho. It should be noted that the data reported by Solazzi et al. (2002) is for basins ranging in size from 3.5 to 24.4 mi². Basins of the lower Columbia for which production potential estimates were made range from 63-512 mi².

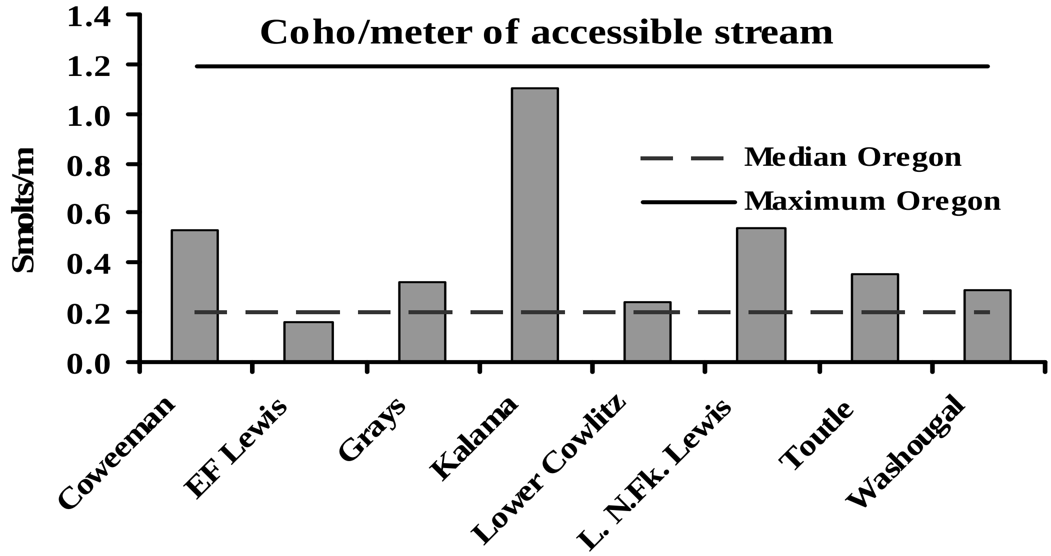

Figure 2. Estimates of coho production per meter of available habitat in the lower Columbia Basins in comparison to values reported by Solazzi et al. (2002) from outmigrant trapping studies on 14 Oregon coastal streams.

Production potential estimates by watershed area in the lower Columbia basins were greater than the median observation at migrant traps in the Coquille, Clackamas, Umpqua and Rogue basins. In 5 of 8 basins, the production potential estimate was greater than the maximum observed outmigration at the migrant traps (Figure 3).

This comparison is useful because it shows that our estimates of production potential are not likely too conservative. However, it also suggests that for the Lower North Fork Lewis, Grays and Toutle the estimates are too high. The Lower North Fork Lewis is unique in that the upper point of the main watershed terminates at a dam, and the proportion of rearing area to watershed area is likely much larger than in a typical basin. This situation likely gives rise to the inflated smolt per watershed area estimate for this basin. Also, the maximum trap estimate was generated from a limited pool of data, and likely does not reflect the true maximum outmigration density that could be achieved in large basins.

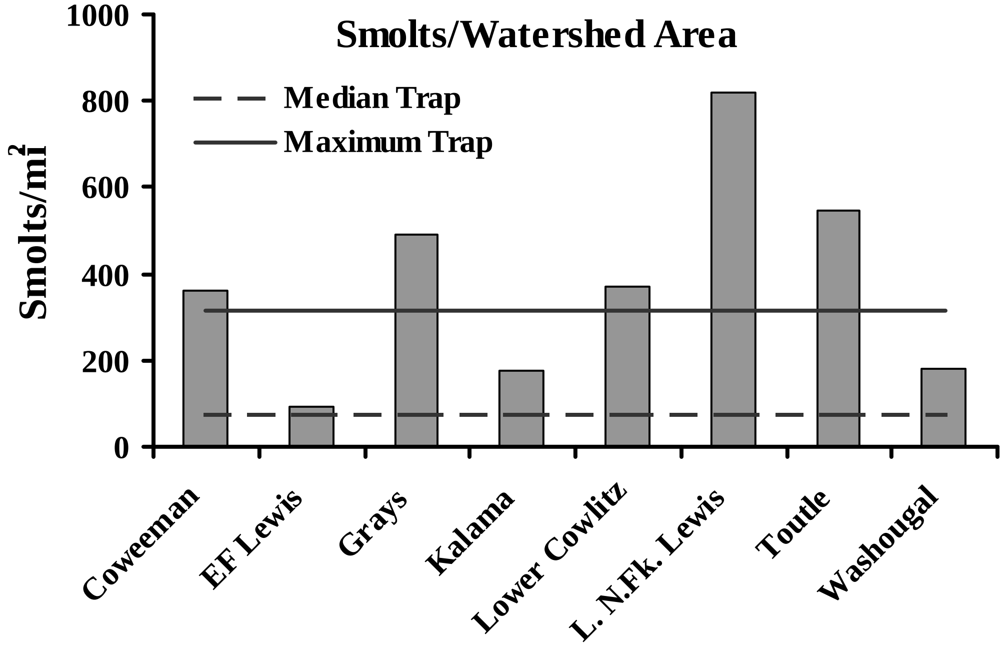

Figure 3. Production potential in terms of coho smolts per watershed area for the lower Columbia basins in comparison to observations from migrant traps of similar sized basins.

Coho production potential estimates made by the HLFM derived regression for the Elochoman and Skamakowa basins were greater than the smolt equilibrium abundances estimated by EDT for those basins, though the estimates were reasonably similar to one another (Table 3). The relative proportion of the Elochoman to the Skamokawa estimate via the HLFM derived regression was similar to the proportion of the EDT estimates. These observations indicate that while the estimates of the two models are somewhat different, both models similarly rated relative production potential between the two basins.

Table 3. Production potential estimates for the Elochoman and Skamakowa basins generated by the EDT and the HLFM derived regression.

	Elochoman	Skamakowa	Ratio
EDT	27,015	19,736	1.37
HLFM	37,364	23,283	1.62

Model Assumptions and Constraints

Several assumptions were made in applying the HLFM derived regression to streams in the lower Columbia Basin. Primarily, the HLFM was developed for estimating coho smolt production potential in coastal Oregon streams, and was developed based on data from those streams. By applying the HLFM to streams within the lower Columbia basin, the model is being applied to streams in a region that it was not developed or validated for. This may cause erroneous estimates that might arise by inherent differences in coho production potential between basins in the lower Columbia and those along the Oregon coast.

Secondly, by using the regression developed by Nickelson (1998) to derive a secondary regression, we are assuming that the habitat bottleneck for coho in the lower Columbia Basins is winter habitat availability. In the winter, coho seek slow off channel habitat types such as beaver ponds, alcoves and backwater pools for refuge (Nickelson 1992a; Bustard and Narver 1975; Tshaplinski and Hartman 1983). It is likely that in the lower Columbia Basin, as in the Oregon coastal basins that anthropogenic influences of the last 150 years have reduced the availability of these habitat types, and caused the lack of these habitats to be limiting coho production. If the habitat availability of another life stage is limiting, then we have overestimated production potential in this exercise.

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Volume VI, Chapter 4
Integrated Watershed Assessment

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4.0 Integrated Watershed Assessment (IWA): GIS Based Screening of Watershed Process Conditions for Salmon Recovery Planning

4.1 Abstract

The Lower Columbia Region (LCR) includes several major river basins comprising 5,300 square miles (3.4 million acres) in southwest Washington. State, local, tribal and federal entities in the LCR are working cooperatively to develop recovery plans for Pacific salmon and steelhead listed under the Endangered Species Act (ESA). A key objective of this effort is to identify priority areas for preservation and restoration of key habitats. This requires an understanding of the existing and probable future status of fish populations and associated habitats, and the watershed and fluvial processes that influence them. We developed a GIS-based watershed screening and prioritization approach, referred to as Integrated Watershed Assessment (IWA), that explicitly considers three processes known to affect the quality and quantity of fish habitat: hydrology, sediment delivery, and LWD recruitment potential (as inferred from riparian condition). We used the IWA to evaluate existing and probable future conditions in 545 planning subwatersheds (3,000 to 12,000 acres) covering the entire LCR. Results of the IWA, in combination with outputs from the Ecosystem Diagnosis and Treatment (EDT) model, provide a 'top down' view of factors affecting instream habitat conditions, and a 'bottom up' view of the effects of these limiting factors on the performance of fish populations. This assessment tool enables identification and prioritization of specific management actions at appropriate temporal and spatial scales.

4.2 Integrated Watershed Assessment – Rationale, Methodology, and Application

Over the past decade, several population segments of salmon and steelhead (*Oncorhynchus* spp.) and native char (*Salvelinus* spp.) in the Pacific Northwest region of the United States have been listed as threatened or endangered under the Endangered Species Act (ESA). Currently, federal, state, tribal and local agencies and stakeholders are responding to ESA to develop comprehensive recovery plans for listed species. Recovery planning intersects with regional subbasin planning efforts also currently underway in the region. Ongoing recovery planning efforts are organized by planning units based on jurisdictions, previously defined sub-basin basin boundaries, and the geographic range of newly defined population segments. One such planning unit is the Lower Columbia Region of Washington State (LCR), comprised of five planning subbasins and covering several major river drainages, covering a total of 5,300 square miles (3.4 million acres). The LCR is further divided into 545 3,000 to 12,000 acre planning subwatersheds.

One element of recovery planning in the LCR is the synthesis of several complex sources of information to describe habitat conditions and identify factors that contribute to the decline of the listed species, or that limit their recovery. Consideration of watershed processes is acknowledged to be a necessary component of recovery planning. Measures of instream habitat conditions, which can be used to estimate the productivity of salmonid populations, provide an instantaneous 'snapshot' that are not reliable for describing trends in habitat quality when used alone, or for identifying management actions. Watershed processes (e.g., hydrology, sediment supply and transport, woody debris) are fundamental determinants of instream habitat conditions. The functionality or impairment of these processes is in turn suggestive of trends in habitat conditions over time, and of the potential as well as limitations of mitigation and restoration measures (Barinaga 1996, Beamer et al. 2000, Booth and Jackson 1997, Featherston et al. 1995, Gregory and Bisson 1997, Naiman et al. 1992, Ralph et al. 1994, Roper et al. 1998, Stanford and Ward 1992, Stanford et al. 1996). It is further recognized that many regional stream restoration projects have not performed as expected because the influence of degraded watershed processes was not adequately considered during the design process (Bisson et al. 1992, Doppelt et al. 1993, Roper et al. 1998). Therefore, an understanding of the condition of watershed processes is critical information both from the standpoint of planning restoration projects, and for developing a strategic understanding of the likely future contribution of a given subwatershed to recovery planning efforts.

There are several watershed processes that directly or indirectly affect the quality and quantity of salmon habitat in Pacific Northwest watersheds. For example, heat flux is a determinant of the temperature regime of surface waters, which in turn affects the suitability of habitats for various stages of salmonid life history. Sediment delivery and transport is a critical watershed process, which fundamentally affects channel morphology, substrate stability, and the structural diversity of available salmonid habitats. While multiple watershed processes important to salmonid habitat can be identified, the delivery and routing of sediment, water, and woody debris into and through the stream channel are viewed to be the fundamental determinants of watershed health (Beamer et al. 2000, Bisson et al. 1987, Gregory and Bisson 1997, Naiman et al. 1992). The condition of these watershed processes can be described by measures of sediment supply, hydrology, and riparian condition.

Watershed processes occur over a range of scales, from local (e.g., riparian zone condition and large woody debris recruitment) to basin levels (e.g., watershed level hydrologic condition). The scale and complexity over which these processes operate has resulted in a variety of modeling or predictive approaches used to estimate present, future and historical conditions. For example, sophisticated hydrologic models such as the Distributed Hydrology Soil-Vegetation Model (Wigmosta et al. 1994, Wigmosta and Perkins 2001), or the HEC-GeoHMS (USACE 2000) can be used to estimate hydrologic conditions in Pacific Northwest watersheds based on widely available GIS data. In comparison to hydrology, modeling of sediment delivery to stream channels is in its relative infancy (UCCCWE 2001). Empirical and stochastic models of sediment delivery have been applied in watershed management practices, but these models are typically data and calculation intensive. In general, computational requirements and data limitations do not allow for these and other more sophisticated modeling approaches to be applied systematically across large areas being considered in regional subbasin and salmon recovery planning.

For the purpose of recovery planning in the LCR, it was desirable to develop a screening level, GIS based modeling approach that can be used to evaluate the likely condition of sediment, hydrologic and riparian processes at subwatershed scales across the region. These three measures form the core of the modeling approach for the following reasons:

- They are fundamental drivers of watershed health
- Their condition could be inferred from synoptically available GIS data in the LCR
- Additional natural and human-derived factors affecting these processes, readily derived from available GIS data sets, can be rated against generally accepted effects thresholds

The value of the process-based approach to subwatershed categorization is that the processes examined are linked either directly or indirectly to habitat conditions that directly or indirectly affect the viability of fish populations. The focus on watershed processes allows for both an understanding of likely current conditions, as well as the ability to project likely future trends. Because the condition of watershed processes and associated trend factors are identified at subwatershed and watershed scales, the results of the analysis are suggestive of the general categories of habitat protection and restoration measures that could be included in salmon recovery planning.

4.2.1 General Approach

As discussed above, the IWA analysis examines hydrologic, sediment, and riparian conditions as fundamental drivers of watershed health. The approach relies on spatial analysis of landscape level GIS data against generally accepted or newly derived effects thresholds to determine the condition of these processes. IWA results are developed at local levels for sediment, hydrology, and riparian conditions, and at watershed levels for sediment and hydrology in all subwatersheds. The local level results describe the condition of factors affecting watershed processes within each subwatershed (i.e., not including upstream effects). The watershed level results describe the condition of watershed processes in the subwatershed including the influence of upstream areas (e.g., the entire drainage area).

The development of both local and watershed level results for each subwatershed provides two benefits for recovery planning purposes. The watershed level results provide an indication of the probable condition of watershed processes within each subwatershed because they include the influence of upstream effects. The local level results, because they are based solely on conditions within each subwatershed, can be used to identify which subwatersheds are probable source areas for degraded watershed processes having adverse downstream effects.

4.3 Applications for Identifying Likely Future Trends & Categories of Appropriate Management Actions

For recovery planning purposes, it is desirable to identify the likely future trends in process conditions in Key Subwatersheds over the next 20 years. This helps to further focus the direction of potential recovery planning Efforts. Given an understanding of current conditions and likely trends, it is then possible to identify general categories of appropriate watershed level management actions that can be used to maintain and improve conditions that advance recovery planning goals.

IWA results, in combination with additional sources of information on current and future land use and other landscape scale data, can be used to develop qualitative predictions of future trends and to identify appropriate categories of management measures. This approach is based on some general assumptions. For example, it is assumed that in subwatersheds where areas zoned for development exhibit a high proportion of currently undeveloped land, hydrologic and riparian conditions are likely to deteriorate over the next 10 to 20 years as development proceeds. In such areas, it would be appropriate to limit development where practical, protect riparian zones to the greatest extent possible, and invest in storm water management infrastructure to mitigate these effects. In contrast, it is assumed that hydrologic, sediment and riparian conditions in timber harvest watersheds under public ownership or subject to Habitat Conservation Plans would be expected to remain stable or to improve gradually over time.

Appropriate management measures would include promoting vegetation recovery, retiring forest roads where practicable, and managing the road drainage network to minimize sediment and hydrologic impacts.

The approach used to identify future trends and categories of management actions is described in Section 5.2.2.

4.4 IWA Methodology

The IWA methodology includes three primary elements: 1) analysis of the condition of watershed processes; 2) the prediction of likely future trends; and 3) the identification of appropriate categories of management actions to maintain or improve the condition of watershed processes. These elements are described in the following sections.

4.4.1 Watershed Process Condition Analysis

Evaluation of the condition of watershed processes is based primarily on available GIS data on describing landscape characteristics such as vegetation, geology and slope class, and other landscape scale factors such as road density, and zoning and development. These data sources describe landscape conditions that determine the condition of watershed processes, which are described in terms of functionality or degrees of impairment. A subwatershed with landscape conditions lying within natural ranges would be considered to have functional process conditions. Landscape conditions outside of natural ranges are indicative of varying degrees of impaired process conditions.

For example, a given subwatershed will have a natural sediment supply rate determined by its geology, topography, climate, soils, and vegetation. Subwatersheds of a similar type (e.g., high gradient mountainous headwaters) will have similar characteristics and would be expected to have similar sediment supply rates within a natural range. If a subwatershed of this type has perturbing factors leading to an estimated sediment supply rate outside of this range, then it would be considered impaired.

This approach requires a three-step analytical process:

1. Stratification of subwatersheds: Partitioning of subwatersheds into strata based on drainage area, elevation, geology, and hydrograph
2. Assessment of current subwatershed and watershed conditions based on GIS-derived, indicator-based estimates of sediment supply rates, hydrology, and riparian condition.
3. Classification of subwatersheds by level of process impairment, determined by comparison with impairment threshold values derived from the scientific literature or from observed distributions of subwatershed estimates.

Subwatershed stratification involves grouping subwatersheds based on natural characteristics that cause variation in watershed process conditions. Different combinations of landscape characteristics were used to create nine distinct subwatershed strata (Table 4-4.). To facilitate assessment of natural process conditions, subwatersheds that are relatively homogeneous with respect to these characteristics will be assigned to the same strata. The result is a more efficient and discriminating evaluation of subwatershed condition.

The action and influence of hydrologic, sediment and riparian processes are, by nature, broadly distributed within downstream and in some cases upstream gradients. Degraded process conditions in headwaters areas can have wide reaching effects in downstream areas. For these reasons, it is desirable to model the downstream influences of degraded process conditions to more fully capture the potential effects on instream habitat conditions. Subwatersheds are spatially linked in the IWA model to capture the influence of upstream drainage area on conditions within each subwatershed. In this way, the condition of factors affecting watershed processes in a subwatershed can be evaluated at both local (i.e., within that subwatershed) and watershed scales (i.e., incorporating conditions in upstream subwatersheds). The result of this process is two different types of information about each individual subwatershed. The local level results describe the condition of factors affecting watershed processes within the subwatershed boundary, while the watershed level effects describe the condition of watershed processes within the entire drainage area affecting that subwatershed.

Methods for assessment and classification of hydrologic, sediment and riparian conditions are described in the following sections. Subwatershed strata, and local and watershed level results for sediment, hydrologic and riparian conditions for all 545 subwatersheds in the LCR are listed by Subbasin and recovery planning watershed in Volume IV, Chapter 6.

Table 4-1. Subwatershed stratification matrix

	Topography/Hydrology/Geology		
Drainage Area	**Lowland/Rain Dominated/ Low to Moderate Erodability**	**Lowland/Rain Dominated/ High Erodability**	**High Elevation/Snow Dominated/ Low Erodability**
Small (>15,000 acres)	Strata 1 Lowland Tributaries	Strata 2 Lowland Tributaries	Strata 3 Headwater Streams
Medium (15,000-75,000 acres)	Strata 4 Lowland Watersheds	Strata 5 Lowland Watersheds	Strata 6 High Elevation Mainstems
Large (>75,000 acres)	Strata 7 Low Gradient Large River Mainstems	Strata 8 Low Gradient Large River Mainstems	Strata 9 High Elevation Large River Mainstems

Sediment Assessment and Classification Methods

Excessive instream sedimentation has been recognized as a substantial cause of degraded salmonid habitat throughout the Pacific Northwest (Reiser, 1998). This sedimentation resulted from increased rates of sediment delivery from hill slopes to stream channels, typically linked to land management activities (e.g., Salo and Cundy, 1987). For this reason, URS determined that evaluating relative sediment delivery rates could aid in the screening of watersheds within the study area for purposes of salmon recovery planning.

Our evaluation of sediment delivery rates rests on three important assumptions:

- Over the long term (from a human planning perspective), sediment delivery is controlled by geology and related physiographic properties of the landscape (i.e., slope). Locally, sediment delivery occurs from a range of active erosional processes, generally not including surface erosion.
- Over the short and intermediate term, climate (as measured by precipitation volume and intensity patterns) is effectively constant, varying within a defined range.

- Over the short term, removal of substantial vegetation and other drainage alterations result in a rapid increase in sediment delivery rates from a range of active erosional practices, including but not limited to surface erosion.
- Measured sediment delivery rates are quite variable in time and space, and locally sensitive to the specific nature of the landscape perturbations and the timing of these perturbations with regard to climatic events.

This sediment-screening tool needed to be able to distinguish the effects of landscape management practices on sediment delivery from natural sediment delivery rates. Several potential proxies for landscape management practices were considered. The Skagit System Cooperative (Beamer et al. 2002) developed a approach for calculating sediment delivery rates from different geology types based on the extent of vegetation coverage and slope. This approach was found to be impractical in the LCR, because the extent of vegetation coverage based on geology type could not be clearly correlated to sediment delivery rates.

Whole-landscape models of sediment delivery, such as the Forest Service's Water Erosion Prediction Project (WEPP) model, are not sufficiently well developed to account for erosional processes other than surface erosion. Yet, watershed analyses conducted in southwestern Washington have noted the relative importance of mass wasting and, less commonly, gullying or streambank erosion, as major contributors to sediment delivery. These include watershed analyses in the Kosmos, Upper Skookumchuck, and Panakanic drainages (Murray-Pacific 1997, Western Watershed Analysts 1997, Weyco n.d.). At the same time, these analyses do not quantify sediment delivery except for that predicted from the surface erosion of roads. This is due to the fact that the effort and complexity of such quantification does not serve the purpose of the watershed analyses, which is to understand watershed processes at a level of detail sufficient to identify probable sources of habitat limiting factors. However, the density of unsurfaced forest roads can serve as a useful proxy for the effect of landscape management practices on sediment delivery. This approach has precident in the surface erosion component of Washington State's watershed analyses guidance. The sediment component of Washington State's watershed analysis manual is based on detailed studies of road-related sediment delivery rates and habitat effects by Cederholm and Reid (1987) by the type of road and use patterns in the Clearwater River basin of the Olympic Peninsula. Road density is arguably a useful proxy measure of the intensity of land use at the landscape scale.

There are no watershed assessments or other comprehensive investigations within the LCR with sufficient information to quantify sediment delivery rates for processes other than surface erosion, and, as mentioned, surface erosion appears to play a less important role in the delivery of sediment to stream channels. However, the general agreement that forest roads are an important factor in the delivery of sediment to stream channels, and the fact road density is readily applied in a modeling context suggests that forest road density can be combined with other factors to provide a reasonable screening level evaluation of the condition of sediment processes.

Therefore, rather than explicitly calculating sediment delivery rates, we have developed an ***index of erodability*** that can be used to predict the relative magnitude of sediment delivery from a watershed over short and intermediate time scales. The index of erodability is calibrated to account for the observed non-linear relationship between measured erosion and sediment delivery to stream channels. While this non-linear relationship cannot be fully quantitatively established, there are several observations of soil erosion and sediment delivery that are suggestive of the relative magnitude of sediment delivery resulting from erosion of differing geology types by slope class. These include compilation of sediment yield rates in experimental (i.e., instrumented) basins by Swanson et al. (1987) for the western Oregon Cascades (equivalent to the southern Washington Cascades) and the Coast Range (equivalent to the Willapa Hills area), and inventoried sediment delivery volumes from older forest roads in four watersheds in western Washington (Veldhuisen and Russel 1999). Sediment delivery in this study was partitioned by source (gully vs. landslides) vs. land surface slope, as described by Veldhuisen and Russell (1999).

The experimental work by Swanson et al. (1987) and Velduisen and Russel (1999) was conducted in watersheds with generally steeper terrain. While much of the LCR is comparable to the watersheds examined in these studies, a significant proportion of the LCR has relatively flat terrain that would be expected to have less natural erodability. To account for this variability, K-factors for soil associations mapped in Lewis County are used to scale the index for areas of the LCR with shallower terrain (Evans and Fibich 1987). The "K" factor is the soil erodability factor used in the Universal Soil Loss Equation and its decedents, including the soil erosion component of WEPP. Soil associations were matched to the slope and rock types on which they formed, which allowed for the use of geology data as a proxy for soil type.

The erodability index was calculated for subwatersheds in the LCR using the following sources of synoptically available GIS data:

- Geology (WDNR 1:100,000 scale coverage)
- Slope class (WDNR 1:100,000 scale coverage)
- Unsurfaced road density (Class 0, 4 and 5 roads, WDNR 1:24,000 scale coverage)
- Subwatershed attributes (total area, upstream subwatersheds)

This GIS data was used to develop the following parameters, which are combined and the results averaged on an area-weighted basis for each subwatershed:

- The relative erodability of the underlying bedrock, divided into three erodability classes:
  - Low for massive igneous and sedimentary rocks
  - Moderate for thinly bedded sedimentary rocks and pyroclastic deposits (i.e., volcanic materials not related to lava flows)
  - High for unconsolidated sediments of alluvial, glacial, or volcanic origin.
- The land surface slope, defined by three slope classes as provided by the source data:
  - <35% slope
  - 35-65% slope
  - >65% slope
- Road density of unsurfaced roads, divided into three classes related to the log-normal mean density of unsurfaced roads (WDNR class 0, 4 and 5) within each unique polygon combination of slope and erodability class:
  - High road density: > +1 standard deviation from the mean (>8.3 miles/mile^2)
  - Moderately high road density: 0 to + 1 standard deviations from the mean (3.3 to 8.3 miles/mile^2)

- Moderately low road density: 0 to – 1 standard deviations from the mean (2 to 3.3 miles/mile^2)
- Low road density: < – 1 standard deviations from the mean (<2 miles/mile^2)

These four data themes and parameters described above were intersected to identify the area in each subwatershed in each unique combination of slope and erodability class, and the unsurfaced road density in each of these combinations. The road density thresholds cited apply to the geology and slope class polygons, rather than the subwatershed or watershed level road density. These data were then used to calculate natural and currently existing subwatershed erodability ratings using the following three step methodology:

First, a background sediment delivery index value, referred to as the GeoSlope Sediment Delivery (GSSD) index, was developed for each GIS polygon representing a unique combination of slope and geology type. The GSSD provides an estimate of the relative sediment delivery rates to the watershed under natural conditions. The GSSD is calculated by summing the area weighted erodability ratings for each unique combination of slope and erodability classes found at local and watershed levels. Erodability ratings by geologic erodability and slope classes are shown in Table 4-2. These arbitrary index values were developed from data reported by Swanson et al. (1987) and the Lewis County soil survey (Evans and Fibich 1987).

Next, an estimate of the effect on sediment delivery from managed lands was calculated for each polygon, using unsurfaced road density as a proxy for land use activities, referred to as the Road Susceptibility to Sediment Delivery (R) index. The presence of unsurfaced forest roads is widely recognized as the major cause of accelerated sediment delivery for forestlands, but can also a major contributor to sediment delivery from agricultural or other cleared lands. The R index was scaled to account for the estimated acceleration in sediment delivery based on results of Reid and Cederholm (1987) and Veldhuisen and Russell (1999). Veldhuisen and Russell (1999) reported their data on a land-slope basis only, and found that inventoried sites with both low and high slopes had the highest rate of gully erosion, while only sites in the highest slope class were found to have mass wasting features. While recent modeling suggests that road density is less important than road location and use in predicting sediment delivery (Kahklen, 2001), road density is used here because it can be reliably calculated at the scale of each slope and geology type polygon across the LCR.

Finally, the GSSD and R indices were combined to arrive at a Managed Condition Sediment Delivery (MCSD) index. The average unsurfaced road density in the study area was calculated as 5.8 mi/mi^2, with a standard deviation of 2.5 mi/mi^2 (log-normal distribution). For low road density values (2 to 3.3 mi/mi^2), the MCSD was calculated as the average of the GSSD and R values. For intermediate road density values, the MCSD was set equal to the R value. For high road density values, the MCSD was set equal to 3 times the R value. MCSD index values by erodability, slope and R class are shown in Table 4-3.

It is important to note that relative road density thresholds rather than absolute thresholds for watershed scale road density from the literature because the individual area of analysis is not the drainage, but individual spatial polygons representing a combination of a single erodability class and slope category. The data set used to develop this relative rating represents several thousand distinct GIS polygons with a broad range of road densities ranging from zero to tens of miles per square mile of area, suggesting a representative range of effects. It is interesting to note that the resulting thresholds are comparable to existing literature values for drainage scale road densities (Wade 2000, 2001).

Table 4-2. Natural erodability ratings used to calculate GeoSlope Sediment Delivery (GSSD) index values

Geology Type*	Geology Type Erodability Class**	Natural Erodability Rating Based on Slope Class***		
		Slope < 30%	Slope 30-65%	Slope >65%
ice	NONE	0	0	0
water				
acidic intrusive rocks	LOW	1	5	10
andesite flows				
basalt flows				
basalt flows (Frenchman Springs Member [CRB, WB])				
basalt flows (Grande Ronde Basalt, undivided [CRB])				
basalt flows (GrandeRondeBasalt,upper flows of norm.mag.pol.)				
basalt flows (GrandeRondeBasalt,upper flows of rev.mag.pol.)				
basalt flows (Pomona Member [CRB, SMB])				
basalt flows, invasive (CRBG, undivided)				
basalt flows, invasive (Grande Ronde Basalt,undiv.[CRB])				
basalt flows, invasive (Pomona Member [CRB, SMB])				
basic intrusive rocks				
dacite flows				
diorite				
gabbro				
granite				
granodiorite				
intrusive andesite				
intrusive andesite and dacite				
intrusive basaltic andesite				
intrusive dacite				
intrusive rhyolite				
intrusive rocks, undivided				
quartz diorite				
rhyolite flows				
argillic alteration	MODERATE	25	50	75
basalt flows and flow breccias, Crescent Formation				
continental sedimentary deposits or rocks				
continental sedimentary deposits or rocks, conglomerate				
marine sedimentary rocks				
nearshore sedimentary rocks				
pyroclastic flows				
quartz monzonite				
talus deposits				

Geology Type*	Geology Type Erodability Class**	Natural Erodability Rating Based on Slope Class***		
		Slope < 30%	Slope 30-65%	Slope >65%
tuffs and tuff breccias				
volcanic and sedimentary rocks				
volcanic rocks				
volcaniclastic deposits or rocks				
alluvial fan deposits	HIGH	50	75	150
alluvium				
alluvium, older				
alpine glacial drift, pre-Fraser				
alpine glacial outwash, Fraser-age				
alpine glacial till, Fraser-age				
artificial fill, including modified land				
glacial drift, undivided				
lahars				
mass-wasting deposits, mostly landslides				
outburst flood deposits, gravel, late Wisconsin				
outburst flood deposits, sand and silt, late Wisconsin				
peat deposits				
pebble breccia				
terraced deposits				

* Washington Department of Natural Resources (WDNR) lithological term (LITH_TERM) used in the State of Washington geology 1:100,000 GIS coverage.

** Relative erodability of geology class based on observed regional relationships

*** Natural erodability rating for each polygon having the defined geology and slope class combination

Table 4-3. Road Susceptibility to Sediment Delivery (R) index values used to calculate the Managed Condition Sediment Delivery (MCSD) index

Erodability Class	Slope Class	Natural Erodability Rating*	R Index Value**			
			Road Density < 2 m/m^2	Road Density 2 - 3.3 m/m^2	Road Density 3.3 - 8.3 m/m^2	Road Density >8.3 m/m^2
Low	<30%	1	1	1.5	2	5
	30-65%	5	5	5	5	15
	>65%	10	10	30	50	150
Moderate	<30%	25	25	38	50	150
	30-65%	50	50	50	50	150
	>65%	75	75	288	500	1500
High	<30%	50	50	75	100	300
	30-65%	75	75	75	75	225
	>65%	150	150	575	1000	3000

* From Table 5-3

** Road Susceptibility to Sediment Delivery index values reflect non-linear relationship between road density and the Natural Erodability Rating

The attribute information in GIS derived polygons based on the intersection of slope class, geology type and forest roads were used to calculate the GSSD and MCSD index values. GSSD and MCSD for each individual polygon are aggregated to derive local ($GSSD_{sws}$, $MCSD_{sws}$) and watershed level ($GSSD_{ws}$, $MCSD_{ws}$) index values for each subwatershed. A conceptual diagram of this analytical process is shown in

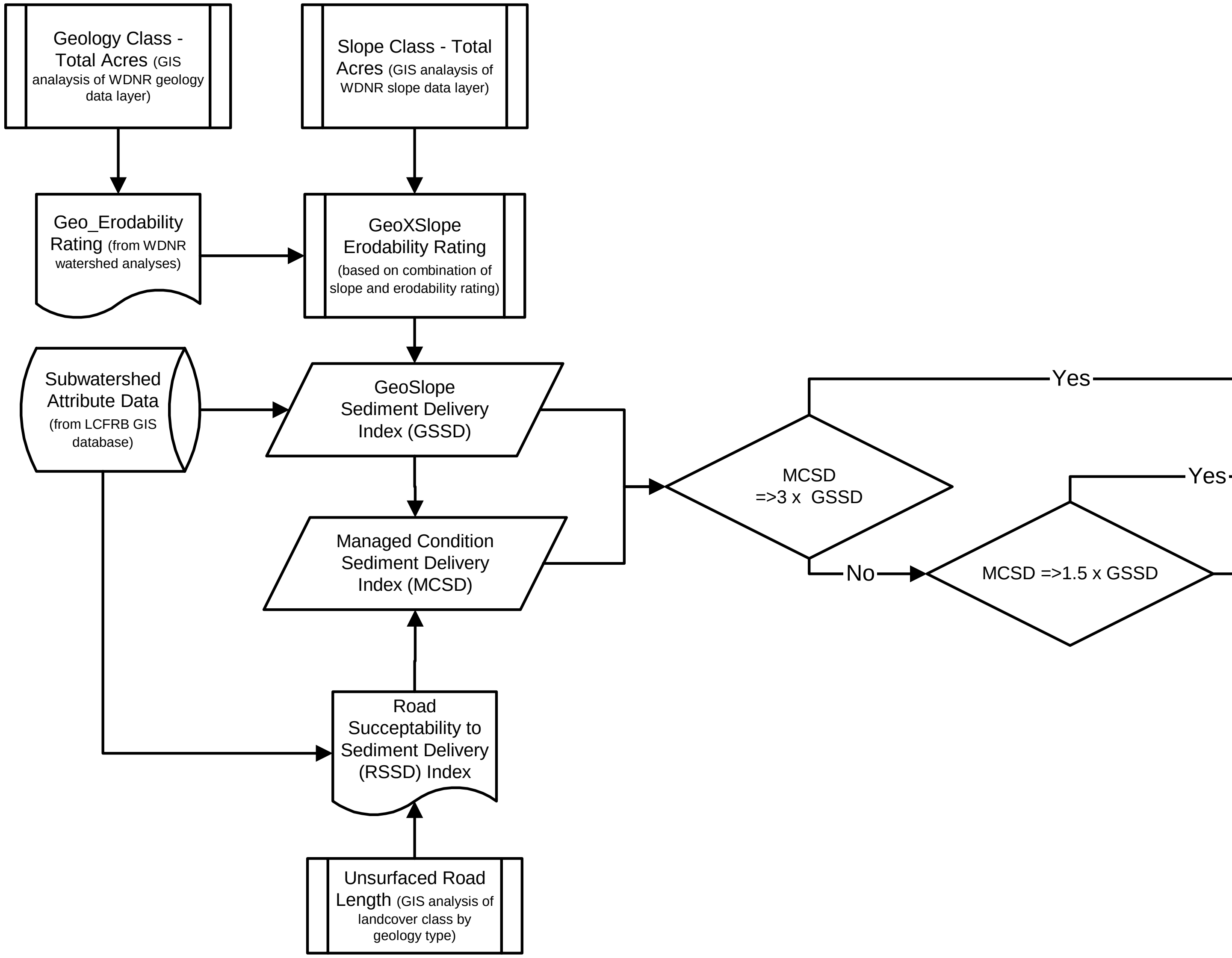
Geology Class - Total Acres (GIS analaysis of WDNR geology data layer)
Slope Class - Total Acres (GIS analaysis of WDNR slope data layer)
Geo_Erodability Rating (from WDNR watershed analyses)
GeoXSlope Erodability Rating (based on combination of slope and erodability rating)
Subwatershed Attribute Data (from LCFRB GIS database)
GeoSlope Sediment Delivery Index (GSSD)
Managed Condition Sediment Delivery Index (MCSD)
MCSD =>3 x GSSD
Yes
No
MCSD =>1.5 x GSSD
Yes
Road Succeptability to Sediment Delivery (RSSD) Index
Unsurfaced Road Length (GIS analysis of landcover class by geology type)

Figure 4-1.

The natural (or background) watershed level $GSSD_{ws}$ for subwatershed *j* is calculated as:

Eq. (1n) $$GSSD_{ws} = \frac{\sum_{j=1}^{m} P_i G_i}{\sum_{j=1}^{m} A_{sws}}$$

and the natural local level $GSSD_{sws}$ for subwatershed *j* is defined as:

Eq. (2n) $$GSSD_{sws} = \frac{\sum_{i=1}^{n} P_i G_i}{A_{sws}}$$

based on subwatershed area A_{sws}:

Eq. (3) $$A_{sws} = \sum_{i=1}^{n} P_i$$

where:

$GSSD_{ws}$ = Watershed level natural erodability rating

$GSSD_{sws}$ = Subwatershed level erodability rating; $j = 1, 2, \ldots, m$

A_{sws} = Area of contributing polygons(s) within subwatershed; $j = 1, 2, \ldots, m$

n = number of polygons

m = number of subwatersheds

P_i = Total area of polygons with unique GSSD erodability and slope class combinations area (acres); $i = 1, 2, \ldots, n$

G_i = The natural erodability rating each combination of P_i; $i = 1, 2, \ldots, n$ (see Table 4-2)

Current erodability index values at the watershed level $MCSD_{ws}$ are calculated similarly, substituting R_{sws} for G_{sws}. Eq. (1n) and Eq. (2n) are replaced with:

Eq. (1c) $$MCSD_{ws} = \frac{\sum_{j=1}^{m} P_i R_i}{\sum_{j=1}^{m} A_{sws}}$$

and:

Eq. (2c) $$MCSD_{sws} = \frac{\sum_{i=1}^{n} P_i R_i}{A_{sws}}$$

respectively, where:

$MCSD_{sws}$ = The erodability index value for the subwatershed under current managed conditions

R_i = The R index value for the polygons slope, geologic erodability and unsurfaced road density combination; $i = 1, 2, \ldots, n$ (seeTable 4-3)

The condition of sediment processes in each subwatershed is determined at the local and watershed levels by comparing the current condition ($MCSD_{sws}$ or $MCSD_{ws}$) to the background condition ($GSSD_{sws}$ or $GSSD_{ws}$) at the appropriate scale. At the local level, only the areas within the subwatershed boundary that contribute sediment are examined. At the watershed level, all upstream areas contributing sediment to the subwatershed are examined. GSSD and MCSD values vary significantly between subwatersheds, reflecting differences in geology, slope and intensity of land use.

The following threshold values have been established based on calibration of results to conditions observed in existing watershed assessments (Veldhuisen and Russel 1999):

Functional: $GSSD < 1.5 \times MCSD$

Moderately Impaired: $1.5 \times GSSD \leq MCSD < 3 \times GSSD$

Impaired: $MCSD \geq 3 \times GSSD$

In addition to the impairment rating, the natural erodability index values (GSSDsws, GSSDws) also provide useful information on the likelihood of sediment problems occurring in a subwatershed. Those areas with high natural erodability index values are more likely to suffer from high levels of sediment supply and the subsequent effects on stream channel conditions. In contrast, those areas with very low erodability index values are more likely to suffer from sediment starved conditions, particularly in locations below dams where upstream recruitment of sediment is limited.

It is important to note that these thresholds and the ratings values presented in Tables 5-3 and 5-4 are derived from the described watershed assessment studies and information about the erodability of various geology types. While these values are quantitative, they should not be viewed as quantitative rates of erosion resulting from a given combination of slope and geology type under varying management conditions. Rather, they are an aggregate scale of relative erodability which has been calibrated against available information.

The semiquantitative nature of these index values, and potential data accuracy issues contribute to uncertainty in this analysis. This uncertainty should be considered when interpreting the results of this analysis. The nature and implications of this uncertainty are described in Section 5.3.

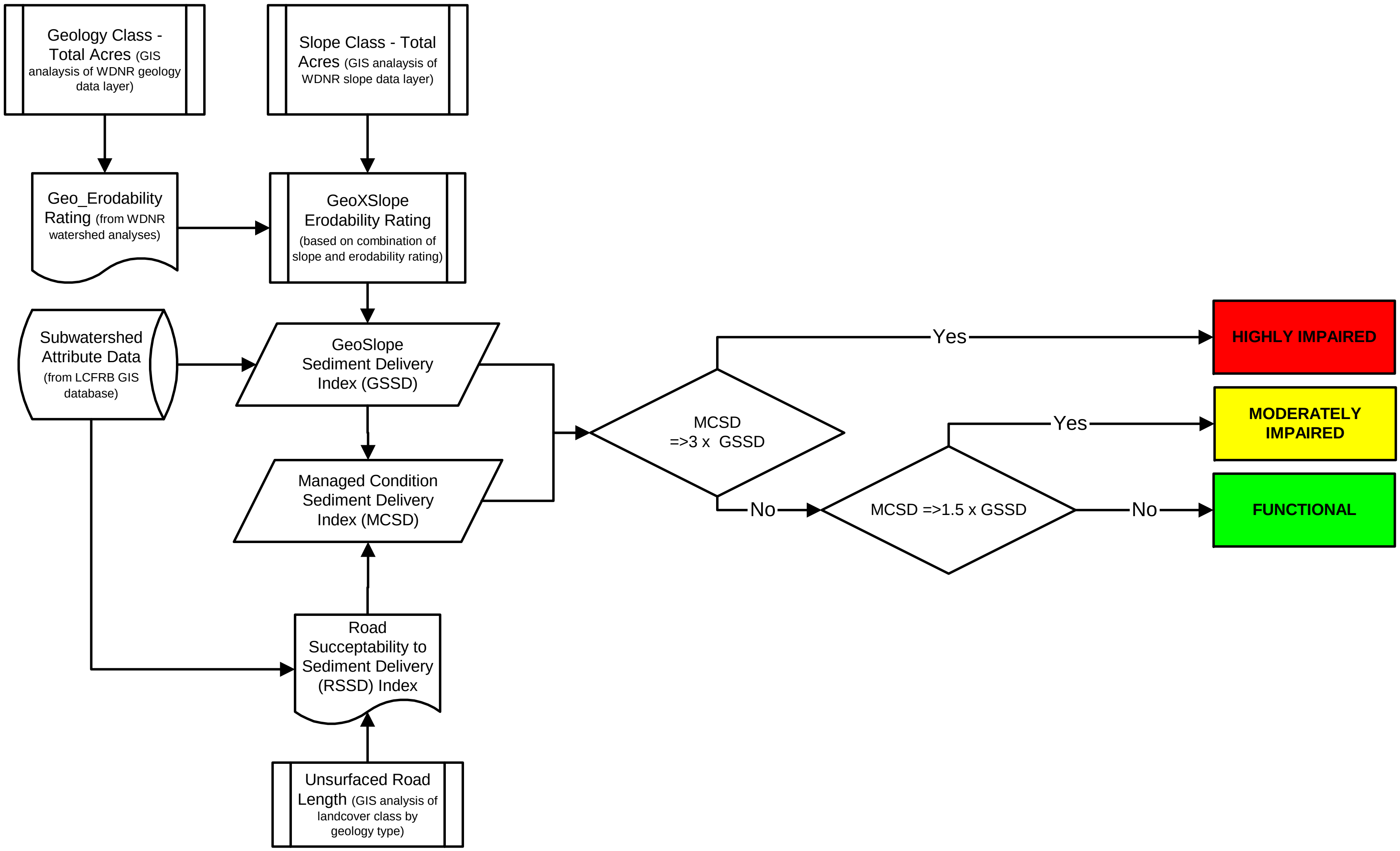

Figure 4-1. Conceptual diagram of subwatershed process condition analysis methodology for sediment supply, and selected additional

factors.

Hydrology Assessment and Classification Methods

Several well developed hydrologic models are in existence. For example, sophisticated hydrologic models such as the Distributed Hydrology Soil-Vegetation Model (Wigmosta et al. 1994, Wigmosta and Perkins 2001), or the HEC-GeoHMS (USACE 2000) can be used to estimate hydrologic conditions in Pacific Northwest watersheds based on widely available GIS data. However, computational requirements and data limitations do not allow for these and other more sophisticated modeling approaches to be applied systematically across the entire LCR. For these reasons, it is desirable to develop a screening level tool to evaluate the condition of hydrologic processes in recovery planning subwatersheds. A simplified approach to evaluating the condition of hydrologic processes was developed following the example provided by the Skagit System Cooperative (Beamer et al. 2002).

Like sediment supply, watershed hydrologic conditions can significantly affect channel conditions, instream habitat parameters, and the overall quality and quantity of available habitat for focal species. Again like sediment supply, the condition of hydrologic processes in recovery planning subwatershed can be degraded by either local or watershed levels factors. Following the guidance provided by Beamer et al. (2002), the condition of subwatershed hydrologic processes is calculated based on the intersection of the following GIS themes and calculated values:

- Impervious surface (calculated from GIS zoning coverages for Clark County and effective impervious surface (EIS) values).
- Subwatershed attributes (total area, upstream subwatersheds)
- Land cover (vegetation, 1:100,000 scale 1993 LANDSAT coverage)
- Road density (WDNR road coverage)

These data themes are intersected using a two-stage analysis process to determine hydrologic functionality or impairment in urbanizing and undeveloped lands based on effective impervious surface and vegetative cover (Beamer et al. 2000). These data sources are used to calculate the hydrologic condition in the subject subwatershed, and in upstream subwatersheds. A conceptual diagram of the analysis method is shown in . Stage 1 involves the calculation of acres of effective impervious surface (EIS), calculated for each subwatershed zoning class polygon based on zoning specific EIS values (Beamer et al. 2000). EIS for each subwatershed is calculated using the following formula:

Effective impervious surface (I_{ws}) for a given watershed is calculated as:

Eq. (4)
$$I_{ws} = \frac{\sum_{j=1}^{m} I_{sws} A_{sws}}{\sum_{j=1}^{m} A_{sws}}$$

where subwatershed area A_{sws} is calculated as Eq. (3) above and subwatershed EIS (I_{sws}) is defined as:

Eq. (5)
$$I_{sws} = \frac{\sum_{i=1}^{n} P_i E_i}{A_{sws}}$$

And:

I_{ws} = Effective watershed impervious surface area (%)

I_{sws} = Subwatershed impervious surface area (%); $j = 1, 2, \ldots, m$

A_{sws} = Area of contributing subwatersheds (acres); $j = 1, 2, \ldots, m$

n = number of polygons

m = number of subwatersheds

P_i = Polygon area (acres); $i = 1, 2, \ldots, n$

E_i = Effective impervious surface area for zoning class x (%); $i = 1, 2, \ldots, n$

Subwatershed and watershed hydrologic impairment is determined by comparing EIS values to the following provisional threshold values. If EIS exceeds 10 percent at the local or watershed levels, the subwatershed is considered to be hydrologically impaired. If EIS is between 3 and 10 percent at the local or watershed levels, the subwatershed is considered to be moderately impaired. If the subwatershed has less than 3 percent impervious surface, Stage 2 of the hydrologic analysis is conducted.

Stage 2 of the hydrologic condition involves analysis of land cover and road density at local and contributing watershed scales. Vegetation class is calculated using existing land cover data using the following formulas:

Land cover for a given watershed (LC_{ws}) is calculated as:

Eq. (6) $$LC_{ws} = \frac{\sum_{j=1}^{m} LC_{sws}}{\sum_{j=1}^{m} A_{sws}} \times 100\%$$

where subwatershed area A_{sws} is calculated as Eq. (3) above, and percent of subwatershed land cover LC_{sws} in vegetation classes 3, 4 or 15 is defined as:

Eq. (7) $$LC_{sws} = \frac{\sum_{i=1}^{n} (F_3 + F_4 + F_{15})_i}{A_{sws}} \times 100\%$$

and:

LC_{ws} = Watershed land cover in vegetation classes 3, 4 and 15 (%); (from Lunetta et al. 1997)

LC_{sws} = Subwatershed land cover in vegetation class 3, 4,or 15 (%)j = 1, 2, …, m

A_{sws} = Area of contributing subwatersheds, j = 1, 2, …, m

N = number of polygons

M = number of subwatersheds

F_3 = Polygon area in vegetation class 3, early-seral (acres)

F_4 = Polygon area in vegetation class 4, other forest (acres)

F_{15} = Polygon area in vegetation class 15, non-forest (acres)

Subwatershed or watershed road densities are calculated by dividing the miles of total road per square mile of subwatershed or contributing watershed area. The combination of these two factors is used to categorize unclassified subwatersheds as hydrologically impaired, likely to be impaired, or functional. A conceptual diagram of the analysis methodology with impairment thresholds is shown in Figure 4-2.

The effects thresholds used in the hydrologic analysis include:

- Percent hydrologically mature vegetation: >50% vegetation class 3, 4 or 15
- Road density: >3 miles/mile^2
- Impervious surface area: 3% and 10%

As shown in Figure 5-4, the interaction of these thresholds within a given subwatershed and its drainage area are used to determine its impairment rating. The 50 percent threshold for hydrologically mature vegetation is a conservative (i.e., allowing for less mature vegetation) threshold derived from several sources, including US Forest Serivce watershed assessments (USFS 1996, 2001), and the Skagit System Cooperative watershed screening approach for the Skagit River basin (Beamer et al. 2002). It relies on the percentage of immature to mature forest present in a watershed, as measured by the watershed area not in vegetation classes 3, 4, or 15 in the GIS vegetation coverage (Lunetta et al. 1997). These data classes represent immature forest, clearcut areas, rock and ice, urbanization, or other unvegetated open ground. The remaining vegetation classes, data values 1 and 2, are representative of late seral forest, and mid-seral forest classes, respectively.

The road density threshold of 3 miles per square mile is derived from the Skagit System Cooperative watershed screening approach (Beamer et al. 2002). This includes roads of all classes. Road densities exceeding this threshold value have been observed to correlate with changes in subwatershed level hydrologic regime.

Finally, the impervious surface thresholds are similarly based on empirical evidence of changes in hydrologic conditions with adverse effects on instream habitats. These thresholds were applied by the Skagit System Cooperative (Beamer et al. 2002), and are derived from ongoing research on urbanization effects in Western Washington.

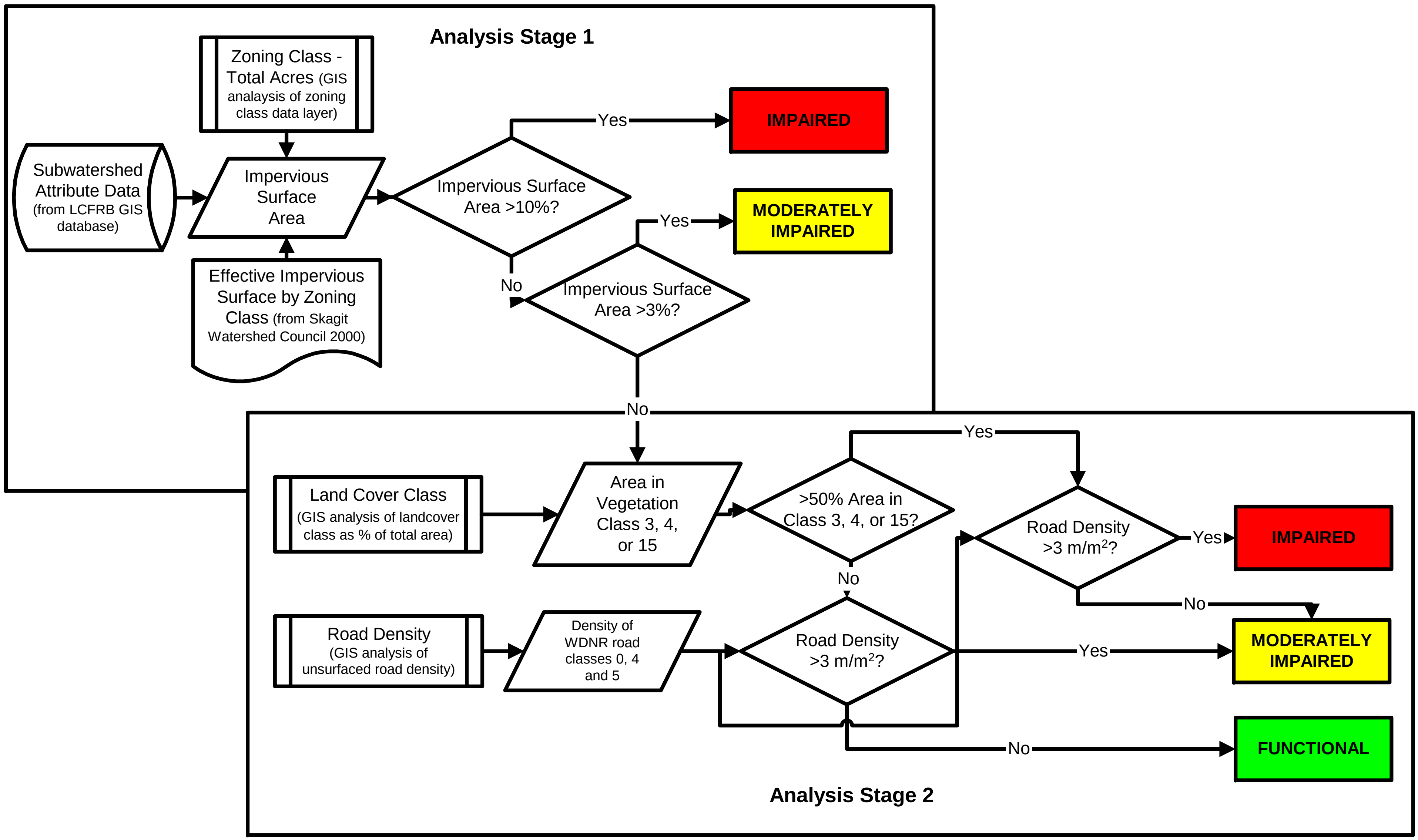

Figure 4-2. Conceptual diagram of subwatershed process condition analysis methodology for hydrology, and selected additional factors

Riparian Assessment and Classification Methods

Riparian condition and LWD recruitment directly affect channel morphology, substrate conditions, nutrient cycling, stream temperature, and the structural diversity of available habitats for focal species. Riparian condition is selected as a proxy measure of these watershed processes. The IWA approach to riparian condition relies on previous GIS based analyses and data developed by Lunetta et al. (1997), and further refined by Beamer et al. (2002). Beamer et al. (2002) conducted ground truthing of the Lunetta et al. (1997) data set, which was developed for all areas of Western Washington, including the majority of the LCR.

Unlike the sediment and hydrologic analysis, no feasible analytical approach could be developed for routing of riparian functions between subwatersheds. Analyses of watershed level sediment and hydrologic conditions incorporate additive effects based on drainage area as a primary calculation tool. The riparian analysis does not include this type of calculation, and a detailed analysis of the transport capacity of woody materials between subwatersheds based on other factors is beyond the scope of this analysis. Therefore, the riparian condition analysis applies only at the local level, no watershed level (i.e., incorporating riparian conditions in upstream subwatersheds) analysis is conducted. The implications of this are expected to be minor however because riparian influence on large woody debris recruitment is expected to be limited primarily to subwatershed scales. Only the larger mainstem rivers (i.e., subwatershed strata 7 and 8) are capable of ongoing transport of large woody materials over distances that would regularly cross subwatershed boundaries. This does however limit the ability to evaluate transport of smaller woody material and organic debris between subwatersheds.

Riparian zone condition is evaluated using the following data sources:

- Land cover (LANDAT TM 1993 GIS data coverage)
- Streams (SSHIAP 1:24,000 scale GIS hydrology coverage)

These data themes are merged to estimate the proportion of intact versus degraded riparian zone condition, based on total stream length. These proportions are then compared to derived threshold values to determine functionality or the degree of impairment, as described below.

Riparian zone condition is evaluated using a data layer developed following the methods of Lunetta et al. 1997. The data layer describes the proportion of streamside buffer acreage by vegetation class, based on the intersection of the LANDSAT TM 1993 data layer with a 30 meter buffer polygon around 1:24,000 SSHIAP stream segments.

Functionality or impairment of riparian vegetation is based on the proportion of total buffer area in five vegetation classes: class 1, late seral vegetation, including old growth and mature second growth riparian forests; class 2, mid seral vegetation, including maturing second and third growth coniferous forests; class 3, early seral vegetation, including a mix of young coniferous and/or primarily deciduous vegetation types; class 4, ‘other forested’ lands, clear cuts, brush, young deciduous forest, and; class 5, ‘non-forested’ lands, including rock, snowfield, urban areas, agricultural land, etc. Based on field observations, each of these vegetation classes has been observed to correspond to a proportion of area in functional versus impaired condition. These observations were used to develop a functionality modifier for each vegetation class (Beamer et al. 2000). A conceptual diagram of the riparian process analysis methodology is shown in **Error! Reference source not found.**.

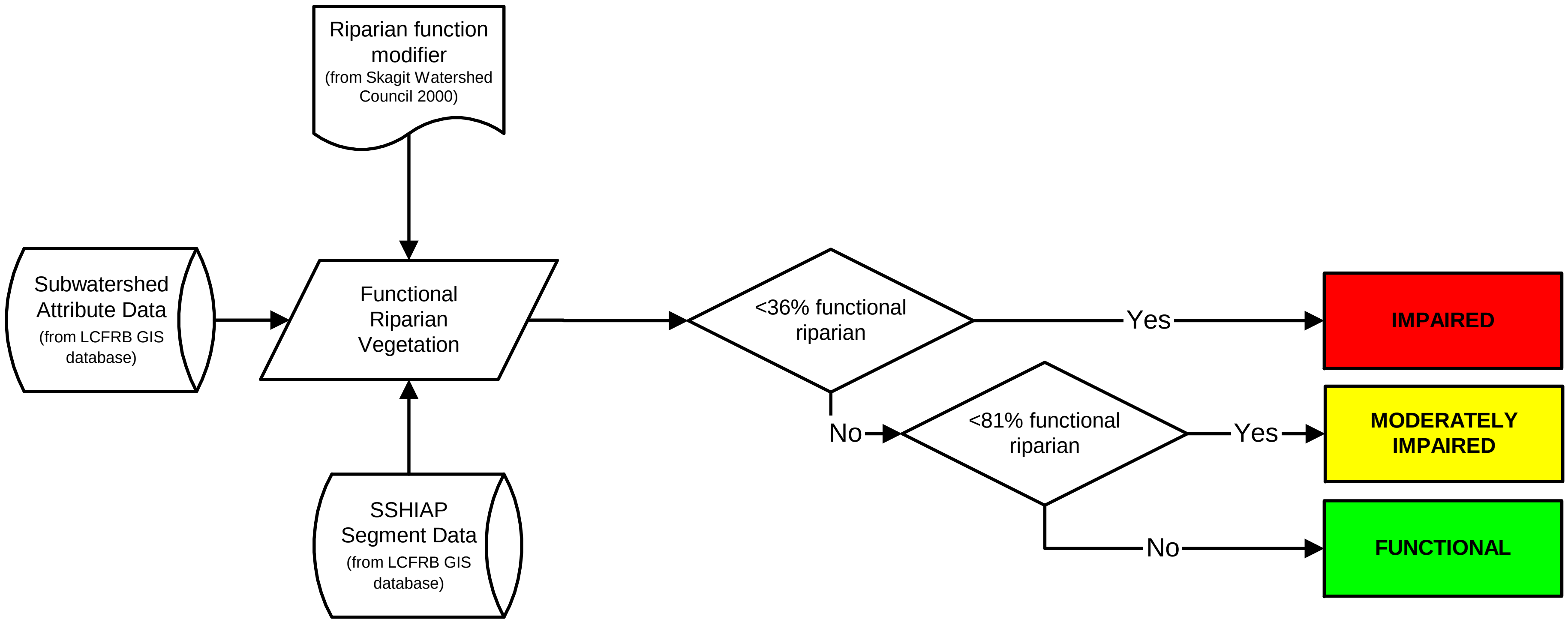

Figure 4-3. Conceptual diagram of subwatershed process condition analysis methodology for riparian function, and selected additional factors

Percent of functional riparian area is calculated from vegetation class and functionality modifiers using the following formula:

$$\text{Eq. (8)} \qquad R_{sws} = \frac{C_1M_1 + C_2M_2 + C_3M_3 + C_4M_4 + C_{15}M_{15}}{B_{sws}} \times 100\%$$

Where:

R_{sws} = Percent functional riparian zone vegetation (%)
B_{sws} = Total buffer area (acres)
C_1 = Buffer area in vegetation class 1, late-seral (acres)
C_2 = Buffer area in vegetation class 2, mid-seral (acres)
C_3 = Buffer area in vegetation class 3, early-seral (acres)
C_4 = Buffer area in vegetation class 4, other forest (acres)
C_{15} = Buffer area in vegetation class 15, non-forest (acres)
M_1 = Vegetation class 1 functionality modifier (100%)
M_2 = Vegetation class 2 functionality modifier (92%)
M_3 = Vegetation class 3 functionality modifier (88%)
M_4 = Vegetation class 4 functionality modifier (43%)
M_{15} = Vegetation class 15 functionality modifier (4%)

Functionality and degree of impairment is determined by comparing R_{sws} for each subwatershed to selected threshold values for riparian condition. The threshold values applied were derived from a relative ranking of riparian functions across the Lower Columbia region. Using untransformed riparian condition data, the mean and, resulting in the following values:

- Functional (>1 standard deviations above mean): ≥ 81% functional riparian zone
- Moderately impaired (± 1 standard deviation from mean): 36% ≤ functional riparian zone <81%
- Impaired (>1 standard deviation below mean): < 36% functional riparian conditions

This relative rating is difficult to compare to other existing thresholds for riparian conditions, because these thresholds are typically based on different units of measurement. For example, the Environmental Protection Agency's Rapid Bioassessment Protocol (Barbour et al. 1999), and the Washington Conservation Commission salmonid habitat condition ratings (Wade 2001) are based on the average riparian zone width containing appropriate vegetation for the habitat type at the reach level. However, because these thresholds are believed to be valid because they are based on a large data set representing riparian conditions ranging from intact and nearly pristine to highly impaired across a broad range of habitats.

4.4.2 Predicting Future Trends & Developing Management Recommendations

As mentioned in the introduction to this chapter, the IWA analysis includes a quantitative analysis of watershed process conditions, described previously, and a qualitative assessment of likely future trends in these conditions and potential management options for protecting or improving these conditions. This qualitative assessment is based on the results of the quantitative analysis, and consideration of additional factors which are likely to influence watershed process conditions in the future.

Characteristics such as land cover, road density and impervious surface are related to land use patterns that have generally predictable patterns. These characteristics, in combination with additional factors that are measurable at landscape scales are suggestive of likely future trends in watershed process conditions. In turn, the extent and nature of these characteristics and the predicted future trends are suggestive of management options appropriate for maintaining or improving the condition of these watershed processes.

Landscape level characteristics and additional factors used to predict future trends and identify appropriate management actions are defined below. The approach to the Future Trends and Management Recommendations analyses are described in the following sections.

Additional Factors

Additional factors include the data sets used in the IWA analyses, and other GIS data sets describing additional landscape scale characteristics which influence watershed process conditions. These additional factors include:

- Erodability Index: Subwatershed specific indices of natural (GSSD) and current (MCSD) erodability ratings from the IWA analysis
- Floodplains: Percentage of total area defined as FEMA floodplains
- Land ownership: Percentage of subwatershed area in federal, state, or other land ownership.
- Rain on snow: Percentage of total subwatershed and drainage area in the rain on snow zone.
- Wetlands: Percentage of total subwatershed area defined as wetlands in the National Wetlands Inventory
- Land cover: Percentage of subwatershed area in hydrologically mature forest, Class 1, Class 2 and/or Class 3 from Lunetta et al. (1997)
- Currently zoned but vacant lands: Percent of subwatershed area zoned for development but currently vacant
- Road density: Subwatershed road density, miles/mile^2
- Stream crossing density: Number of road stream crossings per mile of defined streams (1:24,000)
- Streamside road density: Subwatershed density of roads within 100 feet of a defined stream (1:24,000 scale)

The first three of these characteristics are interpreted qualitatively in the evaluation of future trends and management recommendations. The remaining additional factors are used in the same fashion, further informed by threshold values describing a relative range of conditions for these characteristics. These threshold values are described in **Error! Reference source not found.**.

Additional Factors values for all 545 subwatersheds in the LCR are listed by Subbasin and recovery planning watershed in Chapter 6.

Future Trends

The future trends analysis is a qualitative exercise, using best professional judgement to predict likely trends based on the quantitative analysis results, qualitative evaluation of additional data on subwatershed characteristics (additional factors), and the predominant likely future land uses. Whether the hydrologic condition, sediment supply and transport, or riparian condition of a subwatershed is likely to change in the foreseeable future depends on its current status and the prevalence of factors that predispose the process dynamics to change. Predicted changes in impervious surface, land cover and road density, the primary indicators used in analysis of hydrologic conditions, can be used to directly calculate future hydrologic conditions. The prevalence of other extenuating factors, such as percent of area in urban growth reserve and streamside road density can change in ways that increase or decrease the likelihood of impaired hydrologic conditions. In the case of sediment, land cover, and road density and streamside road density can change in ways that increase or decrease the likelihood of impaired sediment supply conditions. Predicted changes in land cover values can be used to directly calculate future sediment supply conditions in the same way that current conditions are calculated. Predicted changes in road density can be measured against existing thresholds to determine the likelihood of improving or degrading sediment supply conditions. Similarly, for riparian conditions predicted changes in land cover over time can be used to predict natural recovery. The prevalence of other extenuating factors, such as percent of area in urban growth reserve and streamside road density can change in ways that increase or decrease the likelihood of impaired riparian conditions.

A set of basic assumptions was used to guide the future trends analysis. These assumptions are detailed in Table 4-4.

Table 4-4. Process trend factor characteristics, metric thresholds, and general metric rating thresholds

		Metric Thresholds/Rating Criteria				
Characteristic	**Metric**	**Low/Poor**	**Moderate Low/Fair**	**Moderate High/Good**	**High/Excellent**	**Data Source**
Wetlands	Acreage of palustrine or littoral lacustrine wetlands directly associated with habitat channel (within 200 feet of channel less than 4% gradient	<1 acres total in SWS	1-20 acres total in SWS	>20 to 100 acres total in SWS	>100 acres total in SWS	Derived from NWI and SSHIAP data sets (see Ch. 6 for description). Thresholds derived from relative rating for subwatersheds in the LCR
Subwatershed area with hydrologically mature vegetation	% of subwatershed area in vegetation class 1, 2 or 3	<25% class 1, 2, or 3	25 to 50% class 1, 2, or 3	>50 - 75% class 1, 2, or 3	>75% class 1, 2, or 3	Derived from Lunetta et. al (1997) data set provided by Lewis County GIS. Thresholds derived from Beamer et al. (2002)
Urbanization potential	% of SWS area with currently zoned but vacant lands	>15% zoned but vacant	>7.5 to 15% zoned but vacant	>4.5 to 7.5% zoned but vacant	0 to 4.5% zoned but vacant	Derived from Clark County zoning data and thresholds from Beamer et al. (2000). Thresholds derived from a relative rating of zoned LCR subwatersheds.
Future development potential	% of SWS area with potential to be impervious surface based on currently vacant lands zoned industrial, commercial, or residential	>10% effective impervious surface	>5 to 10% effective impervious surface	>3 to 5% effective impervious surface	0-3% effective impervious surface	Derived from available GIS zoning coverages. Threshold values from Beamer et al. (2000).
Road density	Road density in miles/mile^2 (m/m^2) of SWS area	Road density >6 m/m^2	Road density >3-6 m/m^2	Road density >2-3 m/m^2	Road density 0 to 2 (m/m^2)	WSDOT/USFS/DNR GIS data. Thresholds derived from Wade (2001).

		Metric Thresholds/Rating Criteria				
Characteristic	**Metric**	**Low/Poor**	**Moderate Low/Fair**	**Moderate High/Good**	**High/Excellent**	**Data Source**
Streamside road density	Miles of streamside road per mile of stream	>0.71 miles of road/mile of stream	>0.37 to 0.71 miles of road/mile of stream	>0.04 to 0.37 miles of road/mile of stream	0 to 0.04 miles of road/mile of stream	WCC GIS coverage developed for LFA report. Thresholds derived from a relative rating of LCR subwatersheds.
Stream crossing density	Number of stream crossings per mile of stream	>3.9 stream crossings/mile	>2.7 to 3.9 stream crossings/mile	>1.4 to 2.7 stream crossings/mile	0 to 1.4 stream crossings/mile	Relative rating of stream crossing densities across the LCR. Thresholds derived from a relative rating of LCR subwatersheds.

Table 4-5. General assumptions used for prediction of future trends

Process Conditions	Predominant Land Use: Urban/Residential	Forestry	Agriculture*	Recreation
Sediment	Trend towards increasing degradation as development increases	Trend stable on private lands where continuing timber harvest is expected. Trend towards gradual improvement on public lands where timber harvest is expected to decline	Trend stable with some gradual improvement as incentive programs for sediment best management practices progress	Trend stable or towards improvement on public recreational lands.
Hydrology	Trend towards increasing degradation as development increases	Trend stable on private timber lands where ongoing harvest is expected. Trend towards gradual improvement on public lands where harvest is expected to decline.	Trend stable (assuming that lands remain in agriculture)	Trend stable or towards improvement on public recreational lands.
Riparian	Trend stable with gradual degradation as development increases	Trend towards gradual improvement on both public and private timber lands.	Trend towards gradual improvement as incentive programs for riparian protection/restoration progress	Trend stable or towards improvement on public recreational lands.

* For the purpose of future trends analysis, agricultural lands are expected to remain in agriculture unless they are inside an urban growth boundary or urban growth reserve.
Future trends assumptions do not include impacts on watershed process conditions from significant natural events, such as wildfire or volcanisms.

Categories of Management Actions

The IWA methodology is dependent on landscape scale data to determine the condition of watershed processes, and factors that contribute to impaired conditions. Categories of appropriate management actions are suggested by the landscape conditions (e.g., extent of vegetative cover) and the Additional Factors affecting that contribute to current conditions. For example:

> *Subwatershed condition:* Hydrologic conditions are moderately impaired due to vegetation cover high road density.
>
> *Management options:* Promote recovery of vegetation where possible, examine road drainage network and maintain or make improvements where necessary.
>
> *Subwatershed condition:* watershed level sediment conditions highly impaired.
>
> *Management options:* Identify key contributing upstream subwatersheds, promote vegetation recovery in these subwatersheds and manage Additional factors that can exacerbate degradation such as the road network and streamside road drainage where possible and appropriate.
>
> *Subwatershed condition:* Hydrologic and riparian conditions are highly impaired due to urban development and high impervious surface levels.
>
> *Management options:* Design and implement or improve existing stormwater management infrastructure, promote programs to protect and restore riparian vegetation where possible and appropriate.

Several possible permutations of management actions exist. The management recommendations will be tailored to the general sources of impairment and additional contributing factors that are indicated by available data. In addition, specific recommendations related to major watershed-specific problems will be developed based on available information.

4.5 Uncertainty Analysis

The IWA is a screening level tool for evaluating the condition of watershed processes and identifying likely future trends and management options. There are several potential sources of uncertainty that must be considered when interpreting and applying IWA results, and developing recovery planning scenarios. These sources of uncertainty fall into the following categories:

- Input data reliability: Is the scale of the data used appropriate for the application, and do the data accurately represent current conditions?
- Methodological uncertainty: How accurately do the quantitative methods reflect the condition of the processes they attempt to describe?
- Subjectivity: How greatly do subjective elements of the analysis affect the results of the IWA analysis?

These sources of uncertainty apply in varying degrees to the quantitative and qualitative aspects of the IWA. The extent to which each of these sources of uncertainty impacts the quantitative and qualitative components of the IWA analysis is discussed below.

4.6 Quantitative Sediment Analysis

The quantitative sediment analysis relies on the combination of GIS data at different scales and newly derived and arbitrary ratings describing the relative erodability of different geology types. The rating thresholds are calibrated against available field assessments of erosion and sediment delivery to stream channels in the LCR. Sources of uncertainty inherent to this approach include the combination of input data with different scales, and the arbitrary nature of the arbitrarily derived erodability rating scales, and the thresholds used to determine impairment ratings.

The GIS data sets used in the sediment analysis represent a range of scales, from 1:24,000 to 1:250,000 scale. Stream and road data are more detailed 1:24,000 scale data. In contrast, slope data are 1:100,000 scale, and soils and geology data are at the coarse 1:250,000 scale. Because the scale of the input data used in an analysis limits the scale at which one can infer the accuracy of results, the sediment analysis results should be considered relatively accurate at the 1:250,000 scale, with decreasing accuracy at finer scales. For this analysis, the scale of the input data are appropriate for interpreting results at the subwatershed scale, with decreasing accuracy as the results are applied at finer scales (e.g., individual 1:24,000 scale stream reach level).

There is a moderate degree of uncertainty associated with the quantitative methodology used in the sediment analysis because it is based on arbitrarily derived rating scales for the erodability of different geology types. As noted, these erodability rating scales were derived from available literature sources and calibrated using available studies and data, but this approach is inherently subjective. The level of uncertainty associated with this approach could be reduced by ground truthing the analysis and using the results to calibrate the methodology.

The sediment analysis results determine the degree of impairment by how many times the value of MSCD exceeds GSSD. Under this approach, subwatersheds with low erodability are treated the same as those with high erodability for the purpose of determining degree of impairment. The logical basis for this approach is that channel conditions and sediment storage and transport capacity in each subwatershed have formed based on the natural sediment regime. However, this approach may lead to identification of less degraded conditions in subwatersheds where absolute sediment input has increased far more than subwatersheds rated more highly degraded. An alternative approach would be to develop threshold values based on the absolute difference in the GSSD and MSCD ratings in future analyses.

In the aggregate, the level of uncertainty associated with the sediment condition results should be considered moderate. The results of this analysis are considered relatively accurate at the subwatershed level, with progressively decreasing accuracy at the reach level.

4.7 Quantitative Hydrologic Analysis

Like the sediment analysis, the quantitative hydrologic analysis relies on the combination of GIS data sets at different scales. In contrast however, the analytical approach is simpler and depends on thresholds that have been broadly applied for determining hydrologic impacts using GIS based lanscape scale data . Sources of uncertainty inherent to this approach include the accuracy of the input data, and of the impact thresholds.

The input data include GIS land cover (or vegetation) data at 1:100,000 scale, and roads and zoning data at 1:24,000 scale, and effective impervious surface area percentages for different zoning categories. Several factors affect the accuracy of these input data, leading to uncertainty regarding the results of the analysis.

First, the land cover data used in the IWA analysis is based on the 1992 LANDSAT Thematic Mapper imaging data set, which is derived from images taken in 1990. This data is now 13 years out of date and may not accurately represent the landcover conditions existing in 2003. This will lead to overestimation of degraded conditions in subwatersheds with large areas of vegetation that have become hydrologically mature over the past decade, and underestimation of degraded conditions that have been recently harvested. The extent of potential error is currently unknown. However, a LANDSAT data set from year 2000 has recently come available for use in future analyses. These two data sets can be compared and the IWA results updated to more accurately reflect current conditions.

In addition, the land cover data set is cagegorized in such a way that subwatersheds with large areas of naturally treeless vegetation (e.g., praire or meadow) cannot be readily differentiated from developed areas. This will lead to overestimation of degraded conditions. This tendency is mitigated in developed areas by the reliance on zoning data to determine EIS. The tendency to overestimate degradation is also mitigated by the reliance on road density information to determine hydrologic condition. Road density and zoning information is believed to be relatively accurate at the subwatershed scale. However, these data may not reflect recent road construction and development. In smaller subwatersheds where development is ongoing, these data may not fully represent current conditions.

In contrast, there is considerable uncertainty associated with the EIS values used. EIS values were based on zoning data for Skagit and Whatcom Counties used by Beamer et al. (2000). The zoning categories provided by Beamer et al. (2000) are generally comparable to those used by Clark County and portions of Lewis County (the only counties for zoning data is available), but are not necessarily a one to one match. This may lead to over- or underestimation of EIS associated with a given zoning category. There is additional uncertainty associated with EIS on zoned but currently vacant lands. Zoned but vacant lands are considered to have zero EIS for the purpose of this analysis. However, this assumption is believed to lead to underestimation of EIS on lands that have been cleared or developed in the past but are not currently built up. This will in turn lead to potential underestimation of hydrologic impacts in subwatersheds with large areas of zoned but currently vacant lands. In addition the uncertainty in assignment of EIS values, the IWA analysis does not account for the influence of stormwater controls that can mitigate the effect of impervious surface area on hydrologic condition. This will lead to overestimation of degraded conditions in urbanized areas.

The relatively crude methodology used in the hydrologic analysis is also a source of uncertainty, primarily because it relies on absolute thresholds to describe what is in reality a gradual and progressive progression in impairment. For example, the analysis relies on threshold values of 50 percent of subwatershed area in hydrologically mature vegetation and 3 miles/mile^2 to determine degree of impairment. As a result, a subwatershed with 49.9 percent impervious surface and road density of 2.9 miles/mile^2 would be rated hydrologically functional, while a neighboring subwatershed with 50.1 percent mature vegetation and 3.1 miles/mile^2 of roads would be rated as impaired. In reality, these two subwatersheds are quite similar in condition but they are rated quite differently by the IWA approach. This effect leads to a relatively high degree of uncertainty in the hydrology results. However, it is useful to recognize that the thresholds chosen have been broadly applied by USFS and other entities for screening level watershed assessments. Further, the use of three distinct data sets (EIS, hydrologically mature vegetation, and road density) mitigates the uncertainty that would result from reliance on any one subwatershed characteristic to determine hydrologic condition.

In the aggregate, the level of uncertainty associated with the hydrologic condition results should be considered moderate. Uncertainty in the results for subwatersheds in urbanizing areas or areas zoned for development, there is a lesser degree of uncertainty due to greater confidence in the influence of EIS on hydrologic conditions.

4.8 Quantitative Riparian Analysis

The riparian condition analysis has several inherent sources of uncertainty which affect the interpretation of results. The analytical approach is relatively simple, relying on combination of two GIS data sets and a modifier based on ground truthing of the data set to describe current conditions. Sources of uncertainty inherent to this approach include input data accuracy, and methodological limitations.

The riparian condition analysis mixes 1:24,000 scale hydrography with 1:100,000 scale vegetation coverages to arrive at a interim reach specific 1:24,000 scale rating. The individual 1:24,000 scale ratings are then aggregated at the subwatershed level to rate the riparian conditions in each subwatershed as a whole. The individual reach level ratings have limited accuracy because of the mixing of finer scale hydrography with coarser scale land cover data. This effect is mitigated by aggregation of reach level data to the subwatershed level.

In addition to the scale issue, the vegetation data used is the same 1992 LANDSAT TM set used in the hydrologic analysis. This suggests a similar uncertainty related to input data accuracy. This effect is expected to result in greater uncertainty in riparian results for lowland subwatersheds with increasing residential development. Riparian zones in higher elevation forested subwatersheds are generally well protected by the broad implementation of riparian protection zones in forestlands.

Methodological issues also lead to uncertainty in the riparian condition results. Specifically, the analytical approach assumes that vegetation types outside of the selected ‘functional’ vegetation classes do not provide adequate riparian function. This is an issue particularly for subwatersheds with extensive floodplain area with different natural vegetation types from forested drainages. While the application of groundtruthed riparian function modifiers mitigate this effect, there is a bias towards an impairment rating for these subwatersheds in the analysis. This leads to a potential overestimation of degraded conditions in lowland subwatersheds.

The riparian analysis methodology also relies on thresholds derived from a relative rating of the percent of functional riparian vegetation across all LCR subwatersheds with vegetation data. This approach was necessary because existing literature derived thresholds for determining riparian condition are not compatible with the model outputs. The use of relative ratings introduces an unknown level of uncertainty in the results. However, the thresholds used are intuitively logical for a screening level approach (for example, a subwatershed must have greater than 81 percent of stream length with ‘functional’ riparian vegetation to be rated functional overall). Moreover, a relative rating resulting in the logical separation of planning subwatersheds into best, intermediate and worst condition is useful for the purpose of prioritizing subwatersheds for recovery actions.

Similar to the sediment and hydrologic analyses, the aggregate the level of uncertainty associated with the riparian results is considered moderate. Results in lowlying subwatersheds with a high percentage of area in floodplain should be viewed as less accurate overall than results in higher elevation, forested subwatersheds.

4.9 Qualitative Prediction of Future Trends

The future trends analysis is a qualitative exercise, using best professional judgement to predict likely trends based on the quantitative analysis results, qualitative evaluation of additional data on subwatershed characteristics (additional factors), and the predominant likely future land uses. The basic assumptions used to inform this analysis are presented in Table 5-6. Being an inherently subjective process, there is a relative degree of uncertainty associated with these projections. The degree of uncertainty associated with these predictions is presumed to be high.

4.10 Summary

In summary, the IWA analysis is a combined quantitative and qualitative method for evaluating the condition of key watershed processes that are fundamental drivers of instream habitat condition, and the likely future trends in these conditions. The IWA should be considered a screening level evaluation of watershed conditions, useful for preliminary identification of priority areas, and probable sources of some important habitat limiting factors. Collectively, this information informs the identification of categories of management options for preserving and restoring watershed processes. Together with EDT results, the results of the IWA analysis can be used as lines of evidence for identifying areas important for recovery planning.

There are several sources of uncertainty associated with the IWA analysis. While the extent of these sources of uncertainty remains to be tested with ground truthing, the collective uncertainty associated with the sediment, hydrology, and riparian analysis is tentatively classified as moderate. The prediction of future trends is a more qualitative and subjective process, with a higher associated degree of uncertainty. While the uncertainty regarding future trends is relatively high, these predictions can serve as a point of discussion around which recovery planning scenario development can proceed.

4.11 References

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Volume VI, Chapter 5
Integrated Watershed Assessment
Results & Additional Factors

Table 6-1. Integrated Watershed Assessment Results and Additional Factors Information by Recovery Planning Subwatershed

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Public Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
25	Elochoman	Germany-Abernathy	17080003050101	7,164	18,245	1	42	247	I	I	I	I	I	0	0	11.49	80.7	0.0	4	860	12	6.4	0	0	93.6	83	8.5	3	0.49	1.9	nd	nd
			17080003050102	5,644	5,644	1	43	257	I	I	I	I	I	0	0	18.45	96.5	0.0	4	1187	21	0.8	1.63	2.4	95.2	100	16.8	4	0.73	1.8	nd	nd
			17080003050103	7,130	42,295	4	14	29	I	M	I	I	I	0	2	41.42	54.5	0.9	4	889	12	0	24.8	25.0	50.2	100	3.9	3	0.12	1.5	nd	nd
			17080003050104	5,436	5,436	1	20	98	I	I	I	I	I	0	0	0.27	7.4	2.6	4	195	4	0	0.35	0	99.7	100	8.3	3	0.28	3.7	nd	nd
			17080003050201	9,074	16,921	1	9	20	I	M	M	I	M	0	4	0.51	1.3	13.0	4	17	0	0	0	0	100	100	6.2	3	0.36	5.4	nd	nd
			17080003050202	7,846	7,846	1	3	8	I	M	M	I	M	9	9	0.64	0	24.7	4	0	0	0	0	0	0	100	6.1	3	0.19	5.4	nd	nd
			17080003050301	6,313	14,809	1	3	8	I	M	M	I	M	2	26	2.44	4.3	11.1	4	83	1	24.6	74.8	0	0.6	100	6.2	3	0.13	6.2	nd	nd
			17080003050302	8,496	8,496	1	12	18	I	M	M	I	M	43	43	0.19	0	27.6	3	4	0	0	100	0	0	100	6.0	3	0.13	5.5	nd	nd
			17080003050401	7,880	7,880	1	3	4	M	M	M	M	M	42	42	0.03	0.1	51.1	2	6500	82	0	99.89	0	0.1	100	4.8	3	0.09	3.3	nd	nd
			17080003050402	5,460	18,667	1	1	2	I	M	M	I	M	0	18	4.94	3.5	31.6	3	3824	70	0	98.04	1.8	0.2	100	4.8	3	0.1	2.1	nd	nd
			17080003050403	5,327	13,207	1	1	2	I	M	M	I	M	1	25	0.57	2.7	29.2	3	885	17	10.7	87.42	1.8	0.02	100	5.8	3	0.3	5.0	nd	nd
			17080003050501	10,980	10,980	1	2	4	I	M	M	I	M	4	4	6.68	7.1	40.0	3	2631	24	0	99.74	0	0.3	10	4.7	3	0.07	1.4	nd	nd
			17080003050502	7,014	21,238	4	2	3	M	F	M	M	M	0	2	0.84	1.6	57.2	2	5741	82	0	100	0	0	52	4.1	3	0.12	2.4	nd	nd
			17080003050503	3,244	3,244	1	1	2	M	M	F	M	M	4	4	1.4	0	71.5	2	1991	61	0	100	0	0	39	4.6	3	0.06	2.4	nd	nd
		Skamokawa-Elochoman	17080003060101	6,142	6,142	3	10	29	I	M	M	I	M	55	55	0.06	0	30.1	3	0	0	0	0	0	0	0	6.0	3	0.07	4.8	nd	nd
			17080003060102	9,009	17,432	1	10	19	M	M	M	M	M	30	24	0.27	1.8	59.5	2	2611	29	0	100	0	0	21	3.8	3	0.12	3.1	nd	nd
			17080003060103	8,423	8,423	1	7	17	I	M	M	I	M	17	17	0.07	0	47.2	3	1654	20	0	100	0	0	70	3.2	3	0.05	2.5	nd	nd
			17080003060201	7,471	42,408	4	23	36	I	M	M	I	M	3	20	0.81	4.1	22.5	4	952	13	0	96.07	3.9	0	0	6.2	3	0.16	4.3	nd	nd
			17080003060202	6,546	30,121	4	14	23	M	M	M	M	M	4	26	0.11	3.8	59.9	2	3115	48	0	99.85	0.2	0	0	6.1	3	0.17	4.9	nd	nd
			17080003060203	4,817	4,817	1	11	20	M	M	M	M	M	7	7	0.54	0.8	58.6	2	3750	78	0	99.61	0.4	0	0	4.8	3	0.17	3.2	nd	nd
			17080003060204	4,586	46,994	4	27	63	I	M	M	I	M	1	18	10.01	18.2	13.3	4	0	0	0	0	0	0	0	4.7	3	0.11	2.0	nd	nd
			17080003060301	6,062	6,062	1	11	20	M	M	M	M	M	32	32	0.47	0	56.0	2	3890	64	0	100	0	0	0	3.2	3	0.03	2.4	nd	nd
			17080003060302	5,369	11,432	1	25	46	I	M	M	I	M	3	18	0.8	8.1	22.3	4	3128	58	0	100	0	0	0	4.3	3	0.08	2.4	nd	nd
			17080003060303	9,596	9,596	1	24	41	I	M	M	I	M	0	0	10.44	12.4	6.7	4	360	4	0	100	0	0	0	5.3	3	0.11	3.6	nd	nd
			17080003060304	4,934	4,934	1	23	48	I	M	M	I	M	0	0	1.26	3.3	43.4	3	0	0	0	0	0	0	0	6.1	3	0.09	2.5	nd	nd
			17080003060305	7,184	7,184	1	29	52	I	M	M	I	M	0	1	37.82	40.5	6.2	4	1416	20	90.8	9.16	0	0	0	4.0	3	0.13	1.4	nd	nd
			17080003060306	6,975	33,751	4	24	33	I	F	M	I	M	0	9	4.88	12.7	15.0	4	2842	41	0	100	0	0	0	3.5	3	0.08	1.4	nd	nd
			17080003060307	5,749	5,749	1	22	59	I	M	M	I	M	17	17	0.12	0.9	17.4	4	720	13	0	100	0	0	0	5.6	3	0.1	3.8	nd	nd
			17080003060308	5,697	5,697	1	8	14	I	M	M	I	M	0	0	34.71	36.4	8.2	4	0	0	0	0	0	0	0	3.0	3	0.07	1.3	nd	nd
			17080003060401	8,814	55,808	4	11	22	I	M	I	I	M	1	15	44.01	46	6.5	4	1472	17	74.4	25.6	0	0	0	3.7	3	0.1	1.0	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
25	Elochoman	Skamokawa-Elochoman	17080003060402	8,372	8,372	3	28	42	M	F	I	M	F	0	0	60	99.7	0.0	4	396	5	0	73.2	26.8	0	0	2.0	2	0.03	0.1	nd	nd
	Grays River	Chinook-Grays River	17080006030101	6,894	11,068	1	18	29	I	M	M	M	M	38	47	0.67	0	45.1	3	0	0	0	0	0	0	0	6.0	3	0.06	4.3	nd	nd
			17080006030102	4,141	9,620	3	12	43	I	I	M	I	I	48	65	0.1	0	34.3	3	0	0	0	0	0	0	0	6.1	3	0.02	5.7	nd	nd
			17080006030103	4,687	25,375	4	11	18	I	M	M	I	M	24	50	0.32	0	48.6	3	39	1	0	100	0	0	0	5.7	3	0.12	5.2	nd	nd
			17080006030104	4,174	4,174	3	17	30	M	M	F	M	M	62	62	0.24	0	72.6	2	0	0	0	0	0	0	0	4.8	3	0.06	3.4	nd	nd
			17080006030105	5,478	5,478	3	5	10	I	M	M	I	M	79	79	0.14	0	34.1	3	0	0	0	0	0	0	0	6.7	3	0.04	7.6	nd	nd
			17080006030201	5,808	10,407	1	19	58	I	I	M	I	M	18	31	0.84	1.1	43.0	3	561	10	0	98.5	1.5	0	0	5.3	3	0.08	4.6	nd	nd
			17080006030202	4,599	4,599	1	8	31	I	I	M	I	I	47	47	0	0	25.6	3	1277	28	0	100	0	0	0	5.2	3	0.09	5.6	nd	nd
			17080006030301	5,089	12,943	3	5	9	I	M	M	M	M	42	69	0.18	0	45.1	3	2105	41	0	100	0	0	0	4.6	3	0.03	4.3	nd	nd
			17080006030302	4,027	42,345	6	9	22	I	M	M	I	M	18	52	2.42	3.2	33.0	3	675	17	0	100	0	0	0	5.4	3	0.07	5.0	nd	nd
			17080006030303	7,854	7,854	3	2	3	M	M	F	M	M	86	86	0.18	0	74.2	2	1978	25	0	100	0	0	0	4.3	3	0.06	3.0	nd	nd
			17080006030401	9,809	77,943	4	30	97	I	I	I	I	M	0	33	14.02	21.8	12.7	4	430	4	0	98.8	1.2	0	0	6.0	3	0.12	3.7	nd	nd
			17080006030402	7,663	7,663	1	22	39	I	M	M	I	M	1	1	0.36	2.1	37.6	3	4248	55	0	100	0	0	0	4.8	3	0.07	2.6	nd	nd
			17080006030403	7,718	60,471	4	25	45	I	M	M	I	M	2	42	2.52	7.3	18.7	4	46	1	0	87.18	12.82	0	0	6.1	3	0.05	5.1	nd	nd
			17080006030404	8,805	8,805	1	21	38	I	M	M	I	M	0	0	10.82	8.4	30.5	3	0	0	0	0	0	0	0	4.0	3	0.09	2.1	nd	nd
			17080006030405	8,831	8,831	1	12	29	F	M	M	F	M	0	0	45.61	1.6	8.4	4	19	0	0	100	0	0	0	2.9	2	0.06	2.5	nd	nd
			17080006030406	6,367	92,737	4	10	20	F	M	I	I	M	0	28	86.25	82.2	0.7	4	24	0	0	0	100	0	0	1.3	2	0.05	2.2	nd	nd
			17080006030407	8,428	8,428	1	31	95	I	I	I	I	I	0	0	20.35	19.8	8.9	4	162	2	0	99.97	0.03	0	0	6.5	3	0.22	5.0	nd	nd
			17080006030501	5,308	5,308	1	16	26	M	M	nd	M	M	0	0	23.16	34.1	6.1	4	273	5	0	100	0	0	0	2.8	2	0	0.0	nd	nd
			17080006030502	8,292	11,895	1	22	44	M	M	nd	M	M	0	0	69.81	58.9	4.2	4	0	0	0	0	0	0	0	2.2	2	0.05	0.1	nd	nd
			17080006030503	8,917	8,917	1	9	31	F	I	nd	F	I	0	0	48.97	32.8	9.2	4	441	5	0	0	100	0	0	1.7	2	0.21	0.6	nd	nd
			17080006030504	3,603	3,603	1	12	37	I	M	nd	I	M	0	0	15.01	11.7	12.3	4	385	11	0	72.5	27.5	0	0	3.3	3	0.09	0.6	nd	nd
26	Cowlitz	Upper Cowlitz River	17080004010101	8,040	8,040	3	10	13	F	F	F	F	F	3	3	0.22	0	75.5	1	8030	100	100	0	0	0	100	1.4	2	0.06	0.3	nd	nd
			17080004010102	6,751	21,126	6	14	23	F	M	F	F	F	13	5	2.86	0	65.9	2	6691	99	100	0	0	0	100	2.6	2	0.07	0.4	nd	nd
			17080004010103	6,335	6,335	3	2	2	F	F	F	F	F	0	0	5.02	0	66.4	2	6335	100	100	0	0	0	99	1.2	2	0.1	0.5	nd	nd
			17080004010201	7,130	7,130	3	14	19	M	F	M	M	F	0	0	0.62	0	49.4	3	7130	100	100	0	0	0	0	1.6	2	0.07	0.4	nd	nd
			17080004010202	7,890	7,890	3	2	3	M	F	M	M	F	2	2	0.72	0	30.3	3	7890	100	100	0	0	0	0	0.4	1	0.02	0.2	nd	nd
			17080004010203	6,351	13,481	3	11	13	F	F	F	F	F	3	1	0.59	0	60.0	2	6351	100	100	0	0	0	0	0.9	1	0.07	0.3	nd	nd
			17080004010204	7,626	7,626	3	20	24	F	F	F	F	F	0	0	0.33	0	66.2	2	7626	100	100	0	0	0	56	0.6	1	0	0.0	nd	nd
			17080004010205	5,054	34,051	6	27	42	F	M	F	F	F	19	4	2.13	2.9	90.6	1	5054	100	100	0	0	0	100	1.4	2	0.09	0.4	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080004010206	9,870	65,047	6	28	38	F	F	F	F	F	35	9	0.25	2.1	87.3	1	9870	100	100	0	0	0	100	2.4	2	0.13	0.8	nd	nd
26	Cowlitz	Upper Cowlitz River	17080004010301	7,465	7,465	3	6	10	F	M	F	F	M	8	8	0.35	0	71.9	2	7465	100	100	0	0	0	100	1.9	2	0.01	0.0	nd	nd
			17080004010302	5,572	138,373	6	20	31	M	M	F	F	F	34	10	0.39	1.8	69.2	2	5572	100	100	0	0	0	100	3.0	3	0.12	0.6	nd	nd
			17080004010303	4,685	32,810	6	7	8	F	F	F	F	F	22	5	0.05	0	75.8	1	4685	100	100	0	0	0	100	2.2	2	0.03	0.3	nd	nd
			17080004010304	3,843	3,843	3	12	15	F	F	F	F	F	0	0	0.24	0	56.8	2	3843	100	100	0	0	0	99	2.2	2	0.19	0.3	nd	nd
			17080004010305	7,882	7,882	3	19	20	F	F	F	F	F	0	0	0.11	0	63.5	2	7882	100	100	0	0	0	100	0.7	1	0.02	0.2	nd	nd
			17080004010306	4,916	16,641	3	8	9	F	F	F	F	F	0	0	0.39	0	73.1	2	4916	100	100	0	0	0	100	0.8	1	0.07	0.3	nd	nd
			17080004010307	4,019	4,019	3	6	11	F	M	F	F	M	0	0	1.53	0	77.8	1	4019	100	100	0	0	0	100	1.2	2	0.02	0.3	nd	nd
			17080004010401	9,945	9,945	3	0	0	M	M	I	M	M	0	0	1.02	0.6	17.3	4	9945	100	100	0	0	0	19	0.1	1	0.01	0.1	nd	nd
			17080004010402	6,836	6,836	3	1	5	M	I	M	M	I	1	1	1.49	0	12.5	4	6836	100	100	0	0	0	82	1.5	2	0.09	0.5	nd	nd
			17080004010403	3,250	3,250	3	9	11	F	F	M	F	F	0	0	0.62	0	66.7	2	3250	100	100	0	0	0	64	0.8	1	0.03	0.4	nd	nd
			17080004010404	6,092	26,124	6	7	8	F	F	M	M	F	13	3	0.5	0	61.4	2	6092	100	100	0	0	0	100	0.5	1	0.02	0.2	nd	nd
			17080004010405	8,820	34,944	6	13	16	F	F	F	M	F	36	12	0.46	1.1	68.4	2	8793	100	100	0	0	0	100	1.2	2	0.02	0.2	nd	nd
			17080004020101	7,572	16,383	3	18	27	F	F	F	F	M	23	11	5.83	5.7	73.3	2	7500	99	100	0	0	0	100	2.9	2	0.02	1.0	nd	nd
			17080004020102	8,810	8,810	3	13	23	F	M	M	F	M	0	0	2.74	2	50.8	2	8810	100	100	0	0	0	100	1.1	2	0.04	0.3	nd	nd
			17080004020201	5,541	179,125	6	19	34	M	M	M	F	M	31	11	6.1	14.4	58.0	2	4070	73	100	0	0	0	100	4.1	3	0.1	1.3	nd	nd
			17080004020202	6,586	6,586	3	13	26	F	M	F	F	M	11	11	0.46	0	72.2	2	6533	99	100	0	0	0	100	1.7	2	0.05	0.2	nd	nd
			17080004020301	7,387	7,387	3	5	8	M	M	M	M	M	3	3	0.12	0	40.6	3	7387	100	100	0	0	0	100	1.1	2	0.05	0.5	nd	nd
			17080004020302	4,856	12,242	3	5	8	F	M	M	F	M	24	11	0.17	1.4	66.5	2	4705	97	99	1	0	0	100	1.1	2	0.05	0.4	nd	nd
			17080004020401	4,686	13,122	3	16	20	F	F	M	F	F	2	3	0.29	0	63.6	2	4686	100	100	0	0	0	100	1.5	2	0.07	0.5	nd	nd
			17080004020402	8,436	8,436	3	19	26	M	F	F	M	F	3	3	1.2	0	67.3	2	8436	100	100	0	0	0	100	3.0	3	0.11	0.9	nd	nd
			17080004020403	9,283	22,406	6	13	21	F	M	M	F	F	30	14	0.91	1.9	65.7	2	8500	92	94.9	5.1	0	0	100	2.1	2	0.1	1.5	nd	nd
			17080004020501	9,853	31,102	6	19	21	F	F	M	F	F	20	8	0.2	0.1	63.2	2	9798	99	100	0	0	0	100	2.2	2	0.01	1.0	nd	nd
			17080004020502	5,786	5,786	3	12	18	F	M	F	F	M	4	4	0.65	0	74.1	2	5786	100	100	0	0	0	100	1.0	1	0.01	0.1	nd	nd
			17080004020503	6,528	6,528	3	24	34	F	F	M	F	F	1	1	0.03	0	61.5	2	6528	100	100	0	0	0	100	2.1	2	0.04	1.5	nd	nd
			17080004020504	8,935	8,935	3	15	23	F	M	F	F	M	3	3	0.39	0	67.1	2	8935	100	100	0	0	0	100	1.5	2	0.07	0.1	nd	nd
			17080004020601	8,578	245,341	9	24	39	I	M	M	F	F	23	11	7.41	25.5	40.2	3	4466	52	91.6	8.4	0	0	100	4.7	3	0.07	3.6	nd	nd
			17080004020602	4,131	4,131	3	11	19	I	M	M	I	M	10	10	0.07	0.3	48.5	3	4085	99	100	0	0	0	100	3.7	3	0.03	2.5	nd	nd
			17080004030101	4,969	10,297	3	11	20	F	M	M	F	M	14	7	0.64	0.1	63.8	2	4855	98	100	0	0	0	100	1.7	2	0.05	1.6	nd	nd
			17080004030102	5,327	5,327	3	24	61	F	M	M	F	M	0	0	0.71	0	55.6	2	5327	100	100	0	0	0	100	2.6	2	0.02	1.3	nd	nd
			17080004030201	3,735	3,735	3	25	42	I	M	M	I	M	4	4	0.13	0	38.4	3	3735	100	100	0	0	0	100	4.4	3	0.09	5.5	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080004030202	9,686	13,420	3	16	25	F	M	F	M	M	36	27	0.27	0.3	64.6	2	9669	100	100	0	0	0	100	3.0	2	0.02	3.8	nd	nd
26	Cowlitz	Upper Cowlitz River	17080004030301	6,896	275,953	9	11	19	F	M	M	F	F	20	12	3.38	15.1	66.3	2	5481	79	98.2	1.8	0	0	100	1.6	2	0.02	0.6	nd	nd
			17080004030302	7,034	282,988	9	13	22	F	M	M	F	F	20	12	2.99	13.5	64.5	2	5560	79	98.3	1.7	0	0	100	1.8	2	0.05	0.8	nd	nd
			17080004030303	5,136	288,124	9	26	49	F	M	M	F	M	13	12	0.91	14.7	55.2	2	3960	77	97.9	2.1	0	0	100	3.0	2	0.02	3.3	nd	nd
			17080004030401	8,328	296,452	9	15	29	M	M	M	F	M	19	12	2.43	11.5	53.6	2	6869	82	99.1	0.9	0	0	100	3.1	3	0.04	3.3	nd	nd
			17080004030402	9,232	338,685	9	17	25	F	F	M	F	M	21	13	10.48	28.6	51.8	2	5520	60	95.9	4.1	0	0	100	2.8	2	0.07	1.5	nd	nd
			17080004030501	5,601	5,601	3	9	14	I	M	M	I	M	7	7	0	0	19.7	4	3638	65	100	0	0	0	100	5.6	3	0.19	7.3	nd	nd
			17080004030502	5,888	5,888	3	28	66	M	M	M	M	M	5	5	0.12	0	49.7	3	5888	100	100	0	0	0	100	4.3	3	0.06	6.0	nd	nd
			17080004030503	5,133	10,734	3	12	26	I	M	M	I	M	31	19	0.03	0	19.0	4	171	3	37.5	62.5	0	0	100	6.6	3	0.19	9.2	nd	nd
			17080004030504	7,319	23,941	6	7	10	M	F	M	I	M	29	19	0.09	0	51.8	2	7302	100	100	0	0	0	100	5.4	3	0.1	7.7	nd	nd
			17080004030505	3,889	3,889	3	22	42	I	M	M	I	M	21	21	0.5	0	33.5	3	959	25	100	0	0	0	100	5.1	3	0.1	6.3	nd	nd
			17080004030506	5,172	33,002	6	10	24	M	M	M	I	M	37	22	0.4	1.7	66.4	2	4991	97	100	0	0	0	100	3.2	3	0.08	3.5	nd	nd
			17080004030601	7,881	7,881	3	9	19	I	M	M	I	M	24	24	1.72	3.6	30.5	3	0	0	0	0	0	0	100	5.0	3	0.1	5.5	nd	nd
			17080004030602	9,328	348,013	9	21	38	I	M	M	F	M	19	14	8.33	26.4	28.0	3	3139	34	89.7	7.6	2.7	0	100	5.1	3	0.16	5.0	nd	nd
			17080004030701	8,255	8,255	1	15	23	M	M	M	M	M	13	13	6.94	10.4	59.9	2	5960	72	98.9	1.1	0	0	100	4.8	3	0.15	5.3	nd	nd
		Cispus River	17080004040101	9,404	9,404	3	2	4	M	M	M	M	M	0	0	1.72	0	40.9	3	9404	100	100	0	0	0	100	1.4	2	0.06	0.4	nd	nd
			17080004040102	3,594	3,594	3	2	2	F	M	F	F	M	0	0	0.02	0	67.3	2	3594	100	100	0	0	0	100	0.9	1	0.01	0.1	nd	nd
			17080004040201	9,745	9,745	3	4	4	F	F	F	F	F	0	0	5.48	4.4	52.6	2	9745	100	100	0	0	0	99	1.2	2	0.08	0.5	nd	nd
			17080004040301	9,874	32,617	6	16	25	F	M	F	F	F	0	0	4.17	3.6	65.2	2	9874	100	100	0	0	0	98	2.9	2	0.11	0.6	nd	nd
			17080004040302	8,541	41,158	6	10	13	F	F	M	F	F	0	0	7.86	1.1	59.0	2	8541	100	100	0	0	0	32	2.1	2	0.17	0.9	nd	nd
			17080004040401	8,771	17,738	3	4	7	M	M	F	M	F	0	0	3.85	0	42.0	3	8771	100	100	0	0	0	0	2.1	2	0.2	1.3	nd	nd
			17080004040402	8,967	8,967	3	6	7	M	F	M	M	F	0	0	1.3	0	31.6	3	8967	100	100	0	0	0	0	1.0	2	0.05	0.3	nd	nd
			17080004040501	6,358	15,692	3	8	13	F	M	F	F	F	0	0	1.74	0	79.2	1	6358	100	100	0	0	0	0	1.1	2	0.06	0.2	nd	nd
			17080004040502	9,333	9,333	3	3	4	M	F	M	M	F	0	0	1.93	0	37.2	3	9333	100	100	0	0	0	0	1.1	2	0.11	0.8	nd	nd
			17080004040601	8,376	18,315	3	7	14	F	M	M	F	M	11	5	0.76	0	56.5	2	8376	100	100	0	0	0	0	2.1	2	0.12	0.7	nd	nd
			17080004040602	9,939	9,939	3	8	13	F	M	F	F	M	0	0	1.93	0	70.4	2	9939	100	100	0	0	0	0	2.5	2	0.12	0.7	nd	nd
			17080004040701	5,306	5,306	3	27	38	F	F	M	F	F	0	0	0.17	0	57.1	2	5306	100	100	0	0	0	11	2.8	2	0.21	0.9	nd	nd
			17080004040702	6,609	70,812	6	14	20	F	F	F	F	F	10	1	1.53	0	57.7	2	6609	100	100	0	0	0	0	2.9	2	0.09	0.5	nd	nd
			17080004040703	6,868	111,686	6	21	28	F	F	F	F	M	35	4	0.62	0	77.2	1	6868	100	100	0	0	0	0	2.0	2	0.14	0.9	nd	nd
			17080004040801	9,942	127,330	6	17	23	F	F	M	F	F	32	7	3.27	4.8	71.6	2	9942	100	100	0	0	0	93	1.8	2	0.11	0.8	nd	nd
			17080004040802	5,702	117,388	6	13	18	F	F	M	F	M	26	5	0.94	0	65.9	2	5702	100	100	0	0	0	0	1.6	2	0.05	0.5	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080004040901	5,598	27,918	6	17	29	M	M	F	F	M	35	13	0.29	1.9	64.7	2	5598	100	100	0	0	0	100	3.3	3	0.18	2.8	nd	nd
26	Cowlitz		17080004040902	7,680	7,680	3	21	32	M	M	M	M	M	0	0	0.44	0	45.6	3	7680	100	100	0	0	0	100	2.1	2	0.05	0.3	nd	nd
			17080004040903	5,806	22,320	6	17	28	M	M	M	M	M	23	7	0.4	1.7	64.3	2	5806	100	100	0	0	0	100	3.5	3	0.15	1.3	nd	nd
			17080004040904	8,834	16,514	3	20	29	M	F	M	M	F	2	1	0.2	0	41.5	3	8834	100	100	0	0	0	100	2.1	2	0.14	1.0	nd	nd
			17080004050101	7,282	12,844	3	10	30	F	M	M	F	M	15	8	0.01	0	62.7	2	7282	100	100	0	0	0	5	1.4	2	0.05	0.4	nd	nd
			17080004050102	5,562	5,562	3	18	56	M	I	M	M	I	0	0	0.01	0	44.5	3	5562	100	100	0	0	0	0	2.3	2	0.09	0.7	nd	nd
			17080004050201	7,025	42,777	6	12	22	F	M	M	F	M	45	16	1.23	1.8	74.5	2	7025	100	100	0	0	0	100	2.5	2	0.2	1.8	nd	nd
			17080004050202	4,892	22,909	6	20	44	F	M	F	F	M	29	10	0.06	0	72.7	2	4892	100	100	0	0	0	17	2.8	2	0.17	1.4	nd	nd
			17080004050203	7,559	7,559	3	6	10	F	M	M	F	M	4	4	0.33	0	50.8	2	7559	100	100	0	0	0	0	2.1	2	0.11	0.7	nd	nd
			17080004050204	4,201	10,458	3	13	26	F	M	F	F	M	15	6	0.02	0	67.6	2	4201	100	100	0	0	0	0	1.7	2	0.07	0.5	nd	nd
			17080004050205	6,257	6,257	3	10	29	F	M	M	F	M	0	0	0.18	0	53.1	2	6257	100	100	0	0	0	0	2.6	2	0.17	1.3	nd	nd
		Cispus River	17080004050301	4,401	159,650	6	12	22	M	M	M	F	F	24	8	3.84	6.5	57.1	2	4401	100	100	0	0	0	100	3.2	3	0.1	1.7	nd	nd
			17080004050302	7,002	209,429	9	19	32	M	M	M	F	M	24	10	3.03	7.7	75.5	1	6341	91	100	0	0	0	100	3.3	3	0.17	1.3	nd	nd
			17080004050401	9,999	9,999	3	13	21	F	M	F	F	M	14	14	0.01	0.1	71.9	2	9999	100	100	0	0	0	63	2.8	2	0.18	1.1	nd	nd
			17080004050501	6,985	23,140	6	18	36	F	M	F	M	M	30	17	0.05	0.3	75.0	1	6562	94	100	0	0	0	74	3.0	2	0.12	3.2	nd	nd
			17080004050502	8,756	16,155	3	8	14	M	M	F	M	M	18	11	0.01	0	56.5	2	8756	100	100	0	0	0	0	4.0	3	0.09	3.1	nd	nd
			17080004050503	7,399	7,399	3	11	21	M	M	M	M	M	4	4	0.23	0	54.9	2	7399	100	100	0	0	0	0	4.4	3	0.14	2.6	nd	nd
			17080004050601	8,129	8,129	1	14	22	M	M	M	M	M	28	28	1.31	1.4	67.4	2	6839	84	100	0	0	0	100	3.6	3	0.18	3.8	nd	nd
			17080004050602	9,968	252,536	9	13	20	M	M	F	F	M	25	12	1.36	5.9	81.0	1	6996	70	100	0	0	0	100	3.1	3	0.17	3.4	nd	nd
			17080004050701	8,782	278,828	9	15	28	M	M	M	F	M	28	13	1.57	8.4	60.4	2	3697	42	100	0	0	0	100	3.1	3	0.05	3.3	nd	nd
			17080004050702	9,381	9,381	3	3	5	F	M	M	F	M	21	21	0.23	0	66.5	2	9381	100	100	0	0	0	68	2.4	2	0.04	2.8	nd	nd
		Mayfield-Tilton	17080005010101	8,796	8,796	3	25	52	I	M	M	I	M	51	51	0.39	2.8	27.8	3	0	0	0	0	0	0	100	6.3	3	0.17	5.9	nd	nd
			17080005010102	7,851	12,213	3	10	18	I	M	M	I	M	61	44	0.4	0	27.1	3	0	0	0	0	0	0	100	4.9	3	0.08	4.1	nd	nd
			17080005010103	4,362	4,362	3	17	37	I	M	M	I	M	15	15	0	0	30.0	3	0	0	0	0	0	0	100	5.8	3	0.12	8.1	nd	nd
			17080005010104	5,081	17,294	3	14	40	I	M	M	I	M	56	48	0.11	0.6	32.4	3	4	0	0	100	0	0	100	5.4	3	0.1	4.4	nd	nd
			17080005010201	5,951	5,951	3	17	32	I	M	M	I	M	49	49	0.55	0	41.2	3	0	0	0	0	0	0	100	4.7	3	0.12	5.6	nd	nd
			17080005010202	5,357	11,308	3	33	73	I	M	M	I	M	63	56	0.16	0.6	31.5	3	0	0	0	0	0	0	100	5.7	3	0.13	6.0	nd	nd
			17080005010301	8,317	80,894	6	14	27	I	M	M	I	M	39	46	3.32	4.8	30.1	3	302	4	0	100	0	0	100	5.0	3	0.12	4.2	nd	nd
			17080005010302	6,829	6,829	1	22	41	I	M	I	I	M	34	34	12.02	8.4	20.9	4	79	1	0	100	0	0	100	5.1	3	0.11	3.0	nd	nd
			17080005010303	7,526	44,923	6	30	76	I	M	M	I	M	38	49	1.44	4.4	34.8	3	158	2	0	100	0	0	100	5.4	3	0.15	4.1	nd	nd
			17080005010401	6,462	6,462	3	3	9	I	M	M	I	M	53	53	0.25	0	47.8	3	0	0	0	0	0	0	100	4.3	3	0.02	5.0	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Public Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080005010402	6,892	13,355	3	4	17	I	I	M	I	M	58	56	0.11	0	39.7	3	0	0	0	0	0	0	100	5.1	3	0.04	6.1	nd	nd
26	Cowlitz	Mayfield-Tilton	17080005010403	7,470	20,825	6	6	19	I	I	M	I	M	31	47	0.56	1.2	31.3	3	0	0	0	0	0	0	100	6.4	3	0.12	7.8	nd	nd
			17080005010501	5,121	94,911	6	14	28	I	M	M	I	M	33	45	0.36	1.1	40.4	3	1991	39	0	100	0	0	100	5.1	3	0.06	4.3	nd	nd
			17080005010502	4,764	89,790	6	19	31	I	M	M	I	M	26	45	3.26	7.3	29.6	3	543	11	0	100	0	0	100	3.5	3	0.11	2.4	nd	nd
			17080005010503	4,452	103,195	6	36	68	I	M	M	I	M	0	43	9.91	9.5	5.1	4	790	18	0	60.7	39.3	0	100	4.6	3	0.02	2.1	nd	nd
			17080005010504	4,132	85,026	6	11	17	I	M	M	I	M	49	46	2.74	7.5	33.3	3	856	21	0	100	0	0	100	4.5	3	0.11	3.4	nd	nd
			17080005010505	3,832	3,832	3	26	63	I	M	M	I	M	43	43	1.14	0	14.9	4	2	0	0	0	100	0	100	5.8	3	0.03	5.6	nd	nd
			17080005020501	7,076	13,002	1	18	33	I	M	M	I	M	9	42	1.8	0.6	18.0	4	424	6	0	100	0	0	100	5.2	3	0.21	4.7	nd	nd
			17080005020502	3,559	8,933	3	23	49	I	M	M	M	M	15	53	0.7	0.2	38.8	3	931	26	0	100	0	0	100	3.8	3	0.1	2.8	nd	nd
			17080005020503	5,925	5,925	3	20	37	M	M	F	M	M	80	80	0.65	0	64.3	2	252	4	0	100	0	0	100	4.0	3	0.1	4.8	nd	nd
			17080005020504	5,374	5,374	3	22	33	M	M	F	M	M	77	78	0.9	0	85.6	1	2763	51	0	100	0	0	100	3.7	3	0.09	4.5	nd	nd
			17080005020505	7,016	28,951	4	35	75	I	M	M	I	M	0	35	2.75	4.3	12.5	4	2554	36	0	100	0	0	100	5.8	3	0.18	4.1	nd	nd
			17080005020601	8,635	743,849	9	19	38	I	M	I	F	M	7	15	7.79	8	4.3	4	482	6	0	91.4	8.6	0	100	5.1	3	0.1	3.1	nd	nd
			17080005020602	7,377	7,377	1	28	42	I	F	I	I	F	0	0	5.82	2	2.6	4	2	0	0	100	0	0	100	4.8	3	0.1	2.6	nd	nd
			17080005020603	5,819	860,240	9	31	47	I	M	I	F	M	0	18	24.69	25.3	3.8	4	114	2	0	33.5	22.8	43.7	100	3.9	3	0.12	3.3	nd	nd
		Riffe Lake	17080005020101	6,715	13,939	3	11	22	I	M	M	F	M	34	25	1.42	2	21.4	4	0	0	0	0	0	0	100	4.3	3	0.06	3.8	nd	nd
			17080005020102	7,422	25,065	6	32	49	I	M	I	I	M	32	27	14.23	17	9.7	4	52	1	0	40.4	0	59.6	100	4.7	3	0.13	3.1	nd	nd
			17080005020103	3,704	3,704	1	13	26	I	M	M	I	M	23	23	0.7	0	31.0	3	0	0	0	0	0	0	100	5.0	3	0.21	4.2	nd	nd
			17080005020201	3,839	660,462	9	14	33	F	M	M	F	M	16	13	3.67	8.4	62.2	2	1550	40	100	0	0	0	100	2.7	2	0.08	3.7	nd	nd
			17080005020202	7,224	7,224	3	3	9	F	M	F	F	M	16	16	0.33	0	87.6	1	6455	89	100	0	0	0	100	1.0	1	0.01	1.1	nd	nd
			17080005020301	6,763	698,618	9	10	22	I	M	M	F	M	10	14	35.56	35.4	14.8	4	0	0	0	0	0	0	100	3.6	3	0.11	3.7	nd	nd
			17080005020302	6,327	666,789	9	21	40	I	M	M	F	M	26	14	11.19	12.5	22.4	4	221	3	100	0	0	0	100	4.2	3	0.09	5.0	nd	nd
			17080005020303	6,537	6,537	3	32	59	M	M	F	M	M	51	51	2.38	0.9	54.5	2	0	0	0	0	0	0	100	4.9	3	0.09	4.7	nd	nd
			17080005020401	8,416	735,214	9	4	7	I	M	M	F	M	12	15	32.82	33.7	9.5	4	4	8,4160	100	100	0	0	100	3.5	3	0.12	2.6	nd	nd
			17080005020402	3,992	3,992	3	1	2	M	M	M	M	M	64	64	0.52	0	25.1	3	0	0	0	0	0	0	100	3.0	2	0.09	1.6	nd	nd
			17080005020403	8,441	722,654	9	4	8	F	M	M	F	M	11	15	38.63	38.9	16.5	4	0	0	0	0	0	0	100	2.4	2	0.07	1.9	nd	nd
			17080005020404	4,144	4,144	1	29	55	I	M	M	I	M	23	23	7.55	5.4	20.6	4	175	4	100	100	0	0	100	4.6	3	0.14	3.5	nd	nd
			17080005020405	5,066	710,221	9	13	26	M	M	M	F	M	31	14	36.14	35.8	26.8	3	0	0	0	0	0	0	100	3.4	3	0.1	3.4	nd	nd
			17080004030801	6,337	377,795	9	34	68	I	M	M	F	M	3	14	4	9.8	21.7	4	0	0	0	0	0	0	100	4.7	3	0.11	2.2	nd	nd
			17080004030802	7,309	371,459	9	29	58	I	M	M	F	M	14	14	6.44	23.9	34.9	3	1281	18	78.5	21.5	0	0	100	3.7	3	0.05	2.9	nd	nd
		Toutle River	17080005030101	7,670	11,513	3	13	25	M	M	M	M	M	25	22	12.4	1.1	0.0	4	7437	97	100	0	0	0	0	2.1	2	0.01	2.1	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080005030102	7,466	7,466	3	1	1	M	F	M	M	F	0	0	26.36	0	0.0	4	7374	99	100	0	0	0	0	0.0	1	0	0.1	nd	nd
26	Cowlitz	Toutle River	17080005030103	3,842	3,842	3	16	33	I	M	M	I	M	17	17	3.4	0.9	0.0	4	3842	100	100	0	0	0	0	4.5	3	0.07	6.3	nd	nd
			17080005030104	4,479	11,945	3	3	3	M	F	M	M	F	0	0	14.14	0	0.0	4	4479	100	100	0	0	0	0	0.2	1	0	0.3	nd	nd
			17080005030201	8,818	47,633	6	40	59	I	F	M	M	F	43	21	4.17	1.1	0.8	4	7027	80	70.1	29.9	0	0	0	5.1	3	0.07	6.1	nd	nd
			17080005030202	5,993	53,625	6	25	42	I	M	M	M	F	46	23	4.48	3.3	3.4	4	5662	94	29.9	65.6	4.5	0	0	5.0	3	0.07	4.0	nd	nd
			17080005030203	5,428	22,283	6	1	2	M	M	M	M	F	32	8	3.73	2	0.0	4	5428	100	100	0	0	0	0	0.2	1	0	0.2	nd	nd
			17080005030204	4,910	16,855	3	?	?	M	F	M	M	F	0	0	0.14	0	0.0	4	4910	100	100	0	0	0	0	0.0	1	0	0.1	nd	nd
			17080005030205	5,019	5,019	3	25	45	M	M	M	M	M	33	33	7	2.3	0.0	4	5019	100	99.5	0.5	0	0	0	2.7	2	0.02	3.5	nd	nd
			17080005030301	4,168	16,912	3	30	60	I	M	M	I	M	60	55	2.42	5.3	16.3	4	820	20	0	65.4	30.8	3.8	100	5.3	3	0.13	3.2	nd	nd
			17080005030302	7,091	7,091	3	37	77	I	M	M	I	M	59	59	0.18	0	0.0	4	0	0	0	0	0	0	100	6.7	3	0.14	5.8	nd	nd
			17080005030303	7,974	7,974	3	6	11	M	M	M	M	M	61	61	0.09	0.1	54.9	2	4481	56	0	100	0	0	100	6.0	3	0.12	4.8	nd	nd
			17080005030304	7,646	94,106	6	19	33	I	M	M	I	M	24	34	4.88	4.8	32.6	3	3203	42	0	98.9	1.1	0	100	6.6	3	0.1	4.1	nd	nd
			17080005030305	5,654	12,745	3	37	57	I	M	M	I	M	45	53	6.75	1.3	0.4	4	1436	25	0	0.9	99.1	0	100	7.0	3	0.1	6.1	nd	nd
			17080005030306	7,948	61,573	6	34	59	I	M	M	M	M	45	26	6.4	4.7	44.0	3	7926	100	0	83.9	16.1	0	100	5.0	3	0.1	3.6	nd	nd
			17080005040101	8,571	17,916	3	17	34	F	M	F	M	M	25	14	1.48	0	73.9	2	7311	85	100	0	0	0	79	1.8	2	0.05	1.7	nd	nd
			17080005040102	9,345	9,345	3	10	20	M	M	M	M	M	3	3	1.53	0	4.2	4	8949	96	100	0	0	0	0	2.6	2	0.04	3.0	nd	nd
			17080005040201	8,244	38,913	6	37	68	I	M	M	I	M	49	26	2.35	2.9	1.8	4	192	2	100	0	0	0	100	6.7	3	0.15	7.4	nd	nd
			17080005040202	5,075	5,075	3	16	28	I	M	M	I	M	15	15	1.12	0	11.5	4	3150	62	100	0	0	0	11	3.6	3	0.05	4.7	nd	nd
			17080005040203	7,678	7,678	3	34	124	I	I	M	I	I	39	39	3.16	0.1	0.0	4	22	0	0.5	99.5	0	0	0	6.9	3	0.12	6.6	nd	nd
			17080005040301	4,524	50,690	6	16	25	I	M	M	I	M	84	40	0.43	1.8	31.9	3	0	0	0	0	0	0	100	6.4	3	0.14	7.0	nd	nd
			17080005040302	7,252	7,252	3	10	33	I	I	M	I	I	84	84	1.69	0.4	34.5	3	0	0	0	0	0	0	100	6.5	3	0.12	6.4	nd	nd
			17080005040401	9,369	60,058	6	25	41	I	M	M	I	M	73	45	0.38	1.9	14.1	4	0	0	0	0	0	0	100	6.6	3	0.15	6.7	nd	nd
			17080005040402	6,297	84,206	6	9	17	I	M	M	I	M	6	39	2.95	4.7	35.0	3	1153	18	0	100	0	0	100	5.1	3	0.1	3.6	nd	nd
			17080005040403	8,779	8,779	1	4	7	M	M	M	M	M	38	38	0.05	1.3	52.8	2	1423	16	0	100	0	0	100	4.9	3	0.09	4.8	nd	nd
			17080005040404	9,071	69,129	6	18	38	M	M	M	I	M	24	42	0.97	3.6	50.3	2	0	0	0	0	0	0	100	5.7	3	0.15	4.9	nd	nd
			17080005050101	5,875	12,097	3	21	42	M	M	M	M	M	19	14	0.45	0	16.6	4	5556	95	59.6	40.4	0	0	0	3.0	2	0.06	4.0	nd	nd
			17080005050102	6,223	6,223	3	18	34	M	M	M	M	M	10	10	4.88	1.6	44.3	3	5094	82	100	0	0	0	0	2.7	2	0.04	2.6	nd	nd
			17080005050201	7,069	19,167	3	29	62	I	M	M	I	M	30	20	0.17	2	9.0	4	5365	76	0.2	99.8	0	0	0	6.4	3	0.13	7.3	nd	nd
			17080005050202	4,466	4,466	3	12	44	I	I	M	I	I	33	33	0.5	0.8	10.7	4	45	1	100	0	0	0	0	6.1	3	0.14	6.4	nd	nd
			17080005050301	9,223	41,233	6	10	16	M	M	M	I	M	46	33	0.83	2.4	61.6	2	4994	54	0	100	0	0	100	6.5	3	0.13	4.7	nd	nd
			17080005050302	8,377	32,009	6	12	27	I	M	M	I	M	47	29	1.29	1.5	46.2	3	1724	21	0	100	0	0	100	5.9	3	0.12	5.4	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080005050401	9,402	67,814	6	5	7	I	M	M	I	M	22	34	0.68	1.8	45.9	3	0	0	0	0	0	0	100	6.5	3	0.22	5.4	nd	nd
26	Cowlitz		17080005050402	6,246	6,246	1	9	19	I	M	M	I	M	0	0	1.34	0.1	23.0	4	564	9	0	99.9	0	0.1	100	6.7	3	0.19	3.9	nd	nd
			17080005050403	9,109	76,923	6	10	40	I	I	M	I	M	18	32	2.89	6.9	37.0	3	1298	14	0	98.8	0	1.2	100	7.1	3	0.26	6.4	nd	nd
			17080005050404	7,893	58,412	6	10	15	M	M	M	I	M	34	36	0.36	2	69.1	2	2579	33	0	100	0	0	100	5.7	3	0.16	5.2	nd	nd
			17080005050405	9,287	50,520	6	9	20	M	M	M	I	M	53	36	0.58	1.9	69.7	2	4444	48	0	100	0	0	100	6.0	3	0.11	5.0	nd	nd
			17080005070602	3,035	3,035	1	22	44	M	M	M	M	M	0	0	0.35	0	51.4	2	0	0	0	0	0	0	100	4.9	3	0.22	2.8	nd	nd
			17080005070603	6,966	312,520	9	23	45	I	M	M	I	M	0	29	7.86	4.8	22.4	4	321	5	36.1	0	0	100	100	5.3	3	0.13	1.9	nd	nd
		Toutle River	17080005070604	8,083	320,603	9	19	38	I	M	M	I	M	0	29	3.78	2.3	34.5	3	168	2	0	2.5	95.2	2.3	100	5.4	3	0.19	2.3	nd	nd
			17080005070301	8,796	194,595	6	19	38	I	M	M	I	M	0	34	5.71	6.6	22.6	4	65	1	0	99.2	0	0.8	100	7.1	3	0.21	4.2	nd	nd
			17080005070302	7,488	7,488	1	8	15	I	M	M	I	M	22	22	1.37	2.1	33.6	3	0	0	0	0	0	0	100	6.7	3	0.15	4.7	nd	nd
			17080005070401	9,240	110,959	4	15	29	I	M	M	I	M	0	23	28.11	20.1	23.6	4	560	6	0	77.8	0	22.2	100	4.5	3	0.16	2.7	nd	nd
			17080005070402	9,162	9,162	1	16	31	I	M	M	I	M	0	0	16.86	13.3	22.6	4	388	4	0	52.4	47.2	0.5	100	5.6	3	0.21	3.5	nd	nd
			17080005070403	9,388	9,388	1	2	3	I	M	M	I	M	3	3	1.17	0.4	35.2	3	174	2	0	100	0	0	100	6.7	3	0.18	4.2	nd	nd
			17080005070607	4,221	327,859	9	29	59	I	M	M	I	M	0	28	5.48	8.1	24.0	4	444	11	0	2.8	0	97.2	100	6.1	3	0.19	4.3	nd	nd
		East Willapa	17080005060101	9,747	911,132	9	38	76	I	M	M	M	M	0	18	6.88	5.6	18.1	4	2285	23	0	100	0	0	100	4.1	3	0.09	1.9	nd	nd
			17080005060102	6,085	922,257	9	35	85	I	M	M	M	M	0	18	9.61	7.6	28.9	3	55	1	0	100	0	0	100	5.5	3	0.09	1.8	nd	nd
			17080005060103	8,631	12,194	1	46	91	I	M	M	I	M	0	8	3.84	8.3	3.2	4	160	2	0	100	0	0	100	4.4	3	0.11	2.2	nd	nd
			17080005060104	3,562	3,562	1	28	43	I	M	M	I	M	27	27	2.96	7.4	22.0	4	0	0	0	0	0	0	100	4.0	3	0.06	3.7	nd	nd
			17080005060201	6,736	6,736	1	34	66	M	M	F	M	M	0	0	0.34	2.4	68.1	2	952	14	0	100	0	0	100	5.5	3	0.15	3.7	nd	nd
			17080005060202	7,879	14,615	1	27	52	I	M	M	I	M	0	0	0.69	4.9	26.7	3	0	0	0	0	0	0	100	5.5	3	0.15	2.9	nd	nd
			17080005060301	9,637	23,590	4	23	45	I	M	M	I	M	0	4	1.43	2.7	41.4	3	0	0	0	0	0	0	100	5.7	3	0.13	3.1	nd	nd
			17080005060302	7,727	45,933	4	23	45	I	M	M	I	M	0	2	0.64	0.7	34.3	3	0	0	0	0	0	0	100	4.8	3	0.12	2.4	nd	nd
			17080005060303	7,711	53,643	4	37	39	I	F	I	I	M	0	2	9.17	3.9	15.8	4	94	1	0	100	0	0	100	3.3	3	0.07	1.9	nd	nd
			17080005060304	6,459	13,953	1	13	26	I	M	M	I	M	0	6	0.74	2.7	41.5	3	0	0	0	0	0	0	100	5.5	3	0.1	3.3	nd	nd
			17080005060305	7,493	7,493	1	26	52	I	M	M	I	M	12	12	0.37	0	36.3	3	3311	44	0	100	0	0	100	4.6	3	0.11	3.3	nd	nd
			17080005060401	8,806	8,806	1	47	71	I	F	I	I	F	0	0	7.16	4.7	9.6	4	620	7	0	0	100	0	100	3.6	3	0.14	2.0	nd	nd
			17080005060402	5,039	5,039	1	38	57	I	M	M	I	M	0	0	6.23	0	12.4	4	191	4	0	100	0	0	100	3.3	3	0.05	1.3	nd	nd
			17080005060403	6,779	929,036	9	41	62	I	F	M	M	M	0	18	13.6	10.3	9.7	4	0	0	0	0	0	0	100	3.3	3	0.11	1.5	nd	nd
			17080005060404	5,685	5,685	1	43	43	M	F	I	M	F	0	0	12.83	0	16.1	4	0	0	0	0	0	0	100	2.0	2	0.07	1.0	nd	nd
			17080005060405	4,118	12,925	1	41	62	I	M	M	I	F	0	0	12.5	16	10.5	4	5	0	0	0	100	0	100	3.9	3	0.1	2.1	nd	nd
			17080005060406	7,506	26,116	4	43	84	I	M	M	I	F	0	0	8.46	2.9	10.0	4	0	0	0	0	0	0	100	5.0	3	0.09	3.2	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080005060407	5,215	987,894	9	44	88	I	M	I	I	M	0	17	14.31	39.7	4.4	4	41	1	0	0	0	100	100	5.5	3	0.13	2.1	nd	nd
26	Cowlitz		17080005060408	8,509	1,022,518	9	40	63	I	M	I	I	M	0	16	10.69	23.2	9.5	4	40	0	0	100	0	0	100	4.8	3	0.11	2.5	nd	nd
			17080005070101	6,731	6,731	1	24	39	I	M	M	I	M	0	0	0.01	0	36.1	3	513	8	0	100	0	0	100	4.6	3	0.08	3.3	nd	nd
			17080005070102	6,106	24,354	4	28	52	I	M	I	I	M	0	4	0.4	5	11.2	4	76	1	0	99.8	0	0.2	100	6.4	3	0.1	4.5	nd	nd
			17080005070103	4,905	64,320	4	11	21	I	M	M	I	M	0	1	1.03	4.5	22.2	4	1437	29	0	99.9	0	0.1	100	5.9	3	0.19	4.7	nd	nd
			17080005070104	7,296	7,296	1	25	44	I	M	M	I	M	6	6	0.57	2	23.2	4	18	0	0	3.7	0	96.3	100	6.6	3	0.12	4.8	nd	nd
			17080005070105	4,221	4,221	1	22	38	I	M	M	I	M	11	11	0.14	0.7	24.3	4	0	0	0	0	0	0	100	5.4	3	0.05	3.7	nd	nd
			17080005070201	5,918	5,918	1	44	66	I	M	I	I	M	0	0	12.68	0	10.1	4	39	1	0	85.9	14.1	0	100	4.6	3	0.06	3.4	nd	nd
			17080005070202	7,157	7,157	1	19	37	I	M	M	I	M	0	0	0.67	2.9	25.0	4	1755	25	0	100	0	0	100	4.5	3	0.19	3.9	nd	nd
			17080005070203	8,231	14,150	1	43	65	I	M	I	I	M	0	0	11.11	0.9	22.3	4	8	0	0	99.1	0.9	0	100	4.9	3	0.11	2.7	nd	nd
			17080005070204	8,512	29,818	4	37	73	I	M	I	I	M	0	0	0.61	2.2	14.2	4	547	6	0	100	0	0	100	5.1	3	0.15	4.1	nd	nd
		East Willapa	17080005070205	5,243	35,061	4	37	73	I	M	I	I	M	0	0	1.18	5.7	17.3	4	40	1	0	100	0	0	100	5.8	3	0.23	4.0	nd	nd
			17080005070501	6,876	6,876	1	19	33	I	M	M	I	M	8	9	0.44	0	16.7	4	0	0	0	0	0	0	100	6.7	3	0.11	4.8	nd	nd
			17080005070502	5,644	12,520	1	19	34	I	M	I	I	M	0	5	0.55	6.4	4.6	4	190	3	0	98.8	0	1.1	100	6.5	3	0.15	4.5	nd	nd
			17080005070503	4,730	4,730	1	7	22	I	I	M	I	I	42	42	0.64	0	40.4	3	0	0	0	0	0	0	100	5.9	3	0.13	5.4	nd	nd
			17080005070504	5,536	28,640	4	26	44	I	M	I	I	M	0	10	0.3	5.9	6.9	4	31	1	0	91.9	0	8.1	100	6.4	3	0.19	3.5	nd	nd
			17080005070505	5,854	5,854	1	22	51	I	M	M	I	M	3	3	0.17	0	11.0	4	1	0	0	100	0	0	100	7.1	3	0.15	5.2	nd	nd
			17080005070601	4,669	4,669	1	35	70	I	M	M	I	M	0	0	2.13	2.5	44.7	3	1070	23	0	100	0	0	100	5.6	3	0.11	3.0	nd	nd
			17080005070605	6,287	1,097,795	9	11	22	I	M	M	I	M	0	15	3.09	5.5	24.0	4	2641	42	0	99.4	0	0.6	100	6.5	3	0.12	5.2	nd	nd
			17080005070606	5,491	1,431,145	9	28	129	I	I	I	I	M	0	18	4.97	18.9	3.0	4	277	5	0	22.9	0	77.1	100	9.2	3	0.17	4.2	nd	nd
			17080005080201	8,828	1,468,613	9	29	54	I	M	I	I	M	0	18	3.47	12.5	15.9	4	435	5	0	24.2	0.7	75.1	98	8.3	3	0.31	4.1	nd	nd
			17080005080202	6,678	1,475,291	9	26	47	I	M	I	I	M	0	18	3.62	10.9	2.4	4	18	0	0	57.3	0	42.7	100	6.5	3	0.18	3.2	nd	nd
			17080005080203	7,854	1,501,736	9	26	139	I	I	I	I	M	0	17	6.72	22.8	4.6	4	329	4	0	5.9	0	94.1	74	11.0	4	0.29	4.7	nd	nd
		Coweeman River	17080005080101	9,839	9,839	1	14	26	I	M	M	I	M	0	0	0.03	1.2	29.9	3	508	5	0	97.7	0	2.3	100	6.9	3	0.26	4.9	nd	nd
			17080005080102	8,752	18,591	1	21	34	I	M	M	I	M	0	0	0.71	1.3	20.3	4	40	0	0	40.2	0	59.8	100	7.1	3	0.21	3.8	nd	nd
			17080005080301	6,897	50,495	4	13	30	I	M	M	I	M	0	29	0.4	1.4	19.3	4	8	0	0	0	0	100	100	7.3	3	0.3	4.4	nd	nd
			17080005080302	5,728	11,870	1	9	16	I	M	M	I	M	0	24	0	0.1	30.0	3	0	0	0	0	0	0	100	6.4	3	0.1	3.8	nd	nd
			17080005080303	7,792	31,728	4	4	9	I	M	M	M	M	6	37	0.06	4.2	20.0	4	1	0	6.9	100	0	0	100	7.5	3	0.19	4.7	nd	nd
			17080005080304	5,359	5,359	3	2	3	M	F	M	M	F	56	56	0.05	0.1	53.8	2	0	0	0	0	0	0	100	5.4	3	0.12	4.8	nd	nd
			17080005080305	9,457	9,457	3	5	9	M	M	F	M	M	61	61	0.25	0	71.9	2	0	0	0	0	0	0	100	4.5	3	0.09	4.7	nd	nd
			17080005080306	6,142	6,142	1	2	2	M	F	M	M	F	45	45	0.01	0	55.8	2	0	0	0	0	0	0	100	5.8	3	0.1	3.8	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080005080307	9,121	18,578	3	5	10	M	M	M	M	M	27	44	0.03	2.6	54.2	2	0	0	0	0	0	0	100	6.4	3	0.19	6.1	nd	nd
			17080005080401	6,088	72,785	4	14	24	I	M	M	I	M	0	24	1.03	2.2	35.3	3	0	0	0	0	0	0	100	5.8	3	0.18	2.9	nd	nd
			17080005080402	5,324	82,827	4	27	144	I	I	I	I	M	0	21	3.16	26.9	10.8	4	692	13	0	38.2	0	61.8	80	11.3	4	0.44	5.1	nd	nd
			17080005080403	4,719	77,504	4	16	27	I	M	M	I	M	0	22	2.69	7	28.8	3	104	2	0	100	0	0	100	6.1	3	0.2	4.2	nd	nd
26	Cowlitz	Coweeman River	17080005080404	7,246	7,246	1	3	6	I	M	M	I	M	22	22	0.08	0.3	16.7	4	0	0	0	0	0	0	100	6.6	3	0.16	3.7	nd	nd
			17080005080405	8,956	16,202	1	7	20	I	M	M	I	M	13	17	0.03	0.4	31.2	3	340	4	0	100	0	0	100	6.0	3	0.18	3.7	nd	nd
			17080005080406	4,937	4,937	1	4	9	I	M	M	I	M	0	0	0.27	2.6	17.8	4	4	0	0	0	0	100	100	5.2	3	0.22	2.7	nd	nd
			17080005080407	6,505	1,596,006	9	11	25	I	M	I	I	M	0	17	40.31	50.5	5.6	4	206	3	23.4	89.8	0	10.2	80	4.8	3	0.32	3.3	nd	nd
27			17080003040101	9,740	24,607	6	21	32	I	F	M	I	M	51	41	0	3.9	44.0	3	2291	24	71	28	0	0	0.0	5.2	3	0.534	5.8	nd	nd
			17080003040102	7,087	7,087	3	11	11	M	F	F	M	F	26	26	0	0.5	46.0	3	7087	100	100	0	0	0	0.0	1.2	2	0.086	1.1	nd	nd
			17080003040103	7,780	7,780	3	19	37	I	M	M	I	M	42	42	0	0	36.0	3	3424	44	100	0	0	0	0.0	4.7	3	0.274	5.8	nd	nd
			17080003040201	9,558	42,271	6	7	13	I	M	M	I	M	45	44	0	2.5	23.0	4	47	0	0	100	0	0	0.0	6.0	3	0.728	6.5	nd	nd
			17080003040202	8,105	8,105	3	11	17	I	M	M	I	M	50	50	0	0	9.0	4	0	0	0	0	0	0	0.0	6.1	3	0.523	7.3	nd	nd
			17080003040301	7,375	71,993	6	4	11	I	I	M	I	M	14	42	0	0	26.0	3	623	8	0	100	0	0	0.0	6.6	3	0.893	5.9	nd	nd
			17080003040302	7,362	64,618	6	3	6	I	M	M	I	M	33	45	0	0	37.0	3	194	3	0	100	0	0	0.0	6.6	3	0.619	5.5	nd	nd
			17080003040303	7,936	50,207	6	5	8	I	M	M	I	M	57	46	0	0.4	43.0	3	384	5	0	100	0	0	0.0	6.4	3	0.653	6.5	nd	nd
			17080003040304	7,049	7,049	3	3	5	I	M	M	I	M	50	50	0	0	50.0	3	0	0	0	0	0	0	0.0	5.9	3	0.516	6.3	nd	nd
	Kalama	Kalama River	17080003040401	10,156	95,818	6	3	3	I	F	M	I	M	16	36	0	0.6	35.0	3	2834	28	0	100	0	0	0.0	5.5	3	0.528	2.9	nd	nd
			17080003040402	7,033	13,669	1	3	5	I	M	M	I	M	17	20	0	0	16.0	4	805	11	0	100	0	0	0.0	7.4	3	0.7	5.8	nd	nd
			17080003040403	6,636	6,636	1	3	3	I	F	M	I	F	23	24	0	0	48.0	3	33	0	0	100	0	0	0.0	5.6	3	0.378	4.4	nd	nd
			17080003040501	9,410	133,714	4	13	26	I	M	M	I	M	0	26	0	21.1	12.0	4	1432	15	0	35	11	54	0.0	6.1	3	0.904	2.4	4.4	1
			17080003040502	11,596	120,516	4	2	3	I	F	M	I	M	1	29	0	1.6	21.0	4	476	4	0	77	21	2	0.0	5.5	3	0.655	3.3	nd	nd
			17080003040503	5,744	101,562	6	2	2	I	F	M	I	M	7	34	0	1.2	16.0	4	37	1	0	100	0	0	0.0	6.6	3	0.756	4.7	nd	nd
			17080003040504	3,788	3,788	1	3	3	I	F	M	I	F	0	0	0	0	4.0	4	11	0	0	0	99	1	0.0	6.5	3	0.59	3.2	8.1	2
			17080003040505	7,358	7,358	1	2	3	I	M	M	I	M	8	8	0	1.5	26.0	3	1360	18	0	100	0	0	0.0	5.1	3	0.6	3.1	0.0	1
			17080003040601	8,429	8,429	1	3	10	I	M	M	I	M	0	0	0	8.1	9.0	4	402	5	0	34	5	61	0.0	7.0	3	0.808	3.1	5.3	2
	Lewis	North Fork Lewis - Above Dam	17080002010101	9,373	9,373	3	2	4	F	M	M	F	M	0	0	1.59	0	69.9	2	9373	100	100	0	0	0	0.0	1.2	2	0.42	0.3	nd	nd
			17080002010102	6,080	6,080	3	5	5	F	F	F	F	F	0	0	1.28	0	51.6	2	6080	100	100	0	0	0	nd	0.8	1	0.3	nd	nd	nd
			17080002010201	5,456	20,909	6	18	18	F	F	F	F	F	16	16	0.81	0	66.7	2	5456	100	100	0	0	0	0.0	2.2	2	0.84	0.7	nd	nd
			17080002010301	9,933	9,933	3	10	16	F	M	F	F	M	9	9	4.61	0	70.2	2	9933	100	100	0	0	0	0.0	2.4	2	1.23	0.8	nd	nd
			17080002010401	5,472	5,472	3	5	5	F	F	F	F	F	3	3	0.55	0	88.2	1	5472	100	100	0	0	0	0.0	1.0	2	0.29	0.1	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080002010501	5,680	47,716	6	7	18	F	M	F	F	F	45	57	0.94	0	84.3	1	5680	100	100	0	0	0	0.0	2.6	2	0.93	0.6	nd	nd
27	Lewis	North Fork Lewis - Above Dam	17080002010502	5,722	5,722	3	19	30	F	M	F	F	M	0	32	1.46	0	58.2	2	5722	100	100	0	0	0	nd	3.0	3	1.31	nd	nd	nd
			17080002010601	7,699	7,699	3	4	5	F	F	F	F	F	11	11	1.97	0	61.9	2	7699	100	100	0	0	0	0.0	3.3	3	1.4	0.9	nd	nd
			17080002010701	8,877	8,877	3	7	8	F	F	F	F	F	16	6	0.06	0	83.4	1	8877	100	100	0	0	0	0.0	1.2	2	0.31	0.3	nd	nd
			17080002010702	7,073	10,431	3	15	37	F	M	F	F	M	0	24	0.35	0	60.4	2	7073	100	100	0	0	0	nd	2.7	2	0.81	nd	nd	nd
			17080002010703	3,357	3,357	3	7	14	F	M	F	F	M	0	19	0.13	0	67.5	2	3357	100	100	0	0	0	nd	2.0	2	0.7	nd	nd	nd
			17080002010801	7,038	81,760	6	7	10	F	F	F	F	M	40	40	0.84	0	69.4	2	7038	100	100	0	0	0	0.0	3.6	3	1.32	0.8	nd	nd
			17080002010901	8,276	90,036	6	4	7	F	M	F	F	M	36	30	1.11	0	75.9	1	8276	100	100	0	0	0	0.0	2.2	2	0.69	0.6	nd	nd
			17080002010902	7,013	7,013	3	13	17	F	F	F	F	F	0	43	3.87	0	69.7	2	7013	100	100	0	0	0	nd	2.8	2	1.03	nd	nd	nd
			17080002011001	5,053	10,141	3	1	2	F	M	F	F	F	3	7	5.93	0	63.6	2	5053	100	100	0	0	0	0.0	3.2	3	1.17	0.5	nd	nd
			17080002011002	5,088	5,088	3	17	22	F	F	M	F	F	6	6	7.81	0	75.3	1	5088	100	100	0	0	0	nd	2.7	2	2.26	nd	nd	nd
			17080002011201	5,650	12,330	3	2	2	F	F	F	F	F	20	20	1.89	0	53.7	2	5650	100	100	0	0	0	0.0	2.9	2	1.18	0.7	nd	nd
			17080002011202	6,680	6,680	3	4	5	F	F	M	F	F	0	6	4.36	0	62.3	2	6680	100	100	0	0	0	nd	2.3	2	1	nd	nd	nd
			17080002011301	6,897	130,970	6	8	12	F	M	F	F	F	52	58	1.02	0	51.7	2	6897	100	100	0	0	0	0.0	3.1	3	1.92	0.5	nd	nd
			17080002011302	5,962	149,262	6	23	26	F	F	F	F	F	0	20	0.97	0.4	75.6	1	5876	99	98.5	1.5	0	0	nd	2.6	2	1.07	nd	nd	nd
			17080002011303	9,869	16,883	3	3	4	F	F	M	F	F	0	6	2.73	0	60.2	2	9869	100	100	0	0	0	nd	3.1	3	1.63	nd	nd	nd
			17080002011304	7,014	7,014	3	47	51	F	F	M	F	F	0	0	5.51	0	45.5	3	7014	100	100	0	0	0	nd	2.6	2	1.06	nd	nd	nd
			17080002020101	3,731	3,731	3	31	32	F	F	M	F	F	35	20	0	0	0.0	4	3731	100	100	0	0	0	0.0	3.6	3	0.6	3.4	nd	nd
			17080002020102	8,806	12,537	3	28	32	F	F	M	F	F	0	27	0.23	0	4.9	4	8806	100	100	0	0	0	nd	2.7	2	0.4	nd	nd	nd
			17080002020103	7,783	20,320	6	29	54	F	M	M	F	F	0	35	1.78	0	32.2	3	7783	100	100	0	0	0	nd	2.5	2	0.39	nd	nd	nd
			17080002020201	5,769	5,769	3	16	30	F	M	M	F	M	30	11	0.44	0	20.9	4	5769	100	100	0	0	0	0.0	4.1	3	0.91	4.5	nd	nd
			17080002020202	8,752	14,521	3	23	50	F	M	M	F	M	0	24	0.09	0	32.3	3	8752	100	100	0	0	0	nd	4.7	3	1.19	nd	nd	nd
			17080002020203	5,300	5,300	3	28	38	F	F	M	F	F	0	23	0.5	0	0.8	4	5300	100	100	0	0	0	nd	3.3	3	0.56	nd	nd	nd
			17080002020204	5,549	25,370	6	22	29	F	F	M	F	M	0	31	0.4	0	70.9	2	5549	100	100	0	0	0	nd	3.6	3	1.04	nd	nd	nd
			17080002020301	7,534	7,534	3	12	22	F	M	F	F	M	13	9	0.41	0	59.3	2	7534	100	100	0	0	0	0.0	3.8	3	1.39	0.5	nd	nd
			17080002020302	5,476	5,476	3	4	6	F	M	F	F	M	0	9	0.1	0	84.6	1	5476	100	100	0	0	0	nd	1.6	2	0.48	nd	nd	nd
			17080002020303	5,040	18,049	3	3	3	F	F	F	F	M	0	13	0.76	0	57.7	2	5040	100	100	0	0	0	nd	2.4	2	0.77	nd	nd	nd
			17080002020401	6,574	24,623	6	7	8	F	F	F	F	F	48	48	0.17	0	74.4	2	6574	100	100	0	0	0	0.0	1.7	2	0.6	0.6	nd	nd
			17080002020402	5,802	30,425	6	24	27	F	F	F	F	F	0	28	0.83	0	79.5	1	5802	100	100	0	0	0	nd	2.1	2	0.68	nd	nd	nd
			17080002020501	5,886	51,577	6	31	67	F	M	M	F	M	47	65	0.41	0	57.0	2	5464	93	100	0	0	0	0.0	4.8	3	0.93	4.5	nd	nd
			17080002020502	4,636	35,061	6	56	77	F	F	M	F	F	0	27	4.63	1.1	57.3	2	3792	82	100	0	0	0	nd	4.0	3	1.43	nd	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080002030101	9,412	9,412	3	43	59	F	F	M	F	F	60	59	0.38	0	22.8	4	6478	69	100	0	0	0	0.0	4.4	3	0.79	3.5	nd	nd
27	Lewis	North Fork Lewis - Above Dam	17080002060101	5,904	10,291	3	26	48	M	M	M	M	M	43	37	0	0	57.0	2	5904	100	100	0	0	0	0.0	4.0	3	0.185	3.7	nd	nd
			17080002060102	4,387	4,387	3	22	51	I	M	M	I	M	29	29	0	0	44.0	3	4387	100	100	0	0	0	0.0	5.0	3	0	3.3	nd	nd
			17080002060103	2,050	2,050	3	31	63	I	M	M	I	M	54	54	0	0	42.0	3	2050	100	100	0	0	0	0.0	4.5	3	0.221	3.1	nd	nd
			17080002060201	5,760	42,548	6	14	51	I	I	M	I	M	15	51	0	0.2	44.0	3	661	11	11	89	0	0	98.1	4.8	3	0.563	5.8	nd	nd
			17080002060202	6,859	19,200	3	22	39	I	M	F	I	M	50	44	0	0	49.0	3	6857	100	100	0	0	0	0.0	5.0	3	0.129	4.4	nd	nd
			17080002060203	5,725	12,175	3	2	5	I	M	M	I	M	51	73	0	0	29.0	3	0	0	0	0	0	0	100.0	5.0	3	0.4	5.4	nd	nd
			17080002060204	6,450	6,450	3	9	26	I	M	M	I	M	93	94	0	0	41.0	3	982	15	100	0	0	0	83.7	5.9	3	0.497	5.5	nd	nd
			17080002060205	5,412	5,412	3	18	43	M	M	F	M	M	63	64	0	0	64.0	2	4360	81	100	0	0	0	17.5	4.0	3	0.113	3.5	nd	nd
			17080002060301	7,146	467,606	9	2	6	I	M	M	M	M	18	33	0	11.9	37.0	3	4282	60	0	100	0	0	15.3	4.1	3	0.514	4.8	nd	nd
			17080002060302	11,985	456,103	9	4	6	F	F	M	M	M	31	33	0	17.6	49.0	3	4360	36	1	99	0	0	17.6	2.6	2	0.323	2.2	nd	nd
			17080002060303	6,302	444,118	9	9	18	M	M	M	M	M	11	33	0	9.1	47.0	3	1910	30	0	99	0	1	10.1	5.4	3	0.536	3.5	nd	nd
			17080002060304	3,873	437,815	9	8	17	M	M	M	M	M	0	34	0	17	37.0	3	122	3	0	100	0	0	32.2	4.6	3	0.308	2.6	nd	nd
			17080002060305	1,109	391,395	9	13	24	I	M	M	F	M	0	32	0	3.3	29.0	3	117	11	25	74	1	0	32.2	5.3	3	1.15	2.6	nd	nd
			17080002060306	4,357	4,357	1	3	5	I	F	M	I	F	37	37	0	0.4	23.0	4	383	9	0	98	1	2	0.0	5.8	3	0.767	4.9	nd	nd
			17080002030102	5,766	5,766	3	25	53	F	M	M	F	M	0	61	0.86	0	36.6	3	505	9	88.4	11.6	0	0	nd	6.3	3	1.14	nd	nd	nd
			17080002030201	9,038	13,282	3	16	37	F	M	F	F	M	41	46	3.41	3.4	52.5	2	5470	61	86	14	0	0	0.0	3.6	3	0.69	2.1	nd	nd
			17080002030202	4,244	4,244	3	22	52	F	M	M	F	M	0	29	3.68	0	29.5	3	3907	92	100	0	0	0	nd	3.9	3	0.7	nd	nd	nd
			17080002030301	6,961	261,982	9	11	39	F	I	M	F	F	40	45	12.5	13	18.9	4	1277	18	71.8	28.2	0	0	0.0	4.8	3	1.42	4.8	nd	nd
			17080002030302	3,943	194,032	6	24	40	F	M	M	F	F	0	23	7.39	6.4	33.6	3	950	24	78	22	0	0	nd	6.1	3	1.82	nd	nd	nd
			17080002030401	5,162	12,148	3	18	49	F	M	M	F	M	51	51	5.06	2.2	42.4	3	2396	46	100	0	0	0	0.0	4.5	3	1.15	2.4	nd	nd
			17080002030402	6,987	6,987	3	15	43	F	M	F	F	M	0	51	0.55	0	71.7	2	6900	99	100	0	0	0	nd	3.3	3	0.89	nd	nd	nd
			17080002030501	8,327	291,061	9	16	23	F	F	M	F	M	45	47	13.99	14.7	37.9	3	2524	30	6.2	93.8	0	0	0.0	5.2	3	1.35	6.1	nd	nd
			17080002030502	4,385	270,585	9	14	50	F	I	M	F	M	0	28	35.49	37	13.9	4	1065	24	0	100	0	0	nd	4.0	3	1.36	nd	nd	nd
			17080002030503	4,218	4,218	3	43	103	F	M	M	F	M	0	51	5.61	5.7	22.0	4	1027	24	56.8	43.2	0	0	nd	5.8	3	1.49	nd	nd	nd
			17080002040101	5,022	14,594	3	3	5	F	M	F	F	M	61	50	0	0	95.0	1	4944	98	100	0	0	0	0.0	0.3	1	0	1.1	nd	nd
			17080002040102	3,689	3,689	3	21	62	M	M	F	M	M	57	57	0	0	71.0	2	3689	100	100	0	0	0	0.0	3.6	3	0.206	2.0	nd	nd
			17080002040103	5,884	5,884	3	16	43	M	M	F	M	M	36	36	0	0	59.0	2	5962	101	100	0	0	0	0.0	3.4	3	0.012	2.4	nd	nd
			17080002040201	5,877	25,955	6	23	37	F	M	M	F	M	33	47	0	0	84.0	1	5701	97	44	56	0	0	15.2	1.8	2	0.104	2.0	nd	nd
			17080002040202	5,484	20,078	6	13	14	F	F	F	F	M	52	51	0	0	89.0	1	5484	100	96	4	0	0	0.0	1.1	2	0.019	1.2	nd	nd
			17080002040301	3,520	42,814	6	11	21	F	M	M	F	M	22	47	0	5.6	66.0	2	3394	96	0	100	0	0	95.2	2.5	2	0.329	3.2	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Public Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080002040302	8,328	13,338	3	25	39	F	M	F	F	M	57	55	0	0	82.0	1	8328	100	0	100	0	0	30.4	1.5	2	0.15	1.8	nd	nd
27	Lewis	North Fork Lewis - Above Dam	17080002040303	5,010	5,010	3	11	18	F	M	F	F	M	52	52	0	0	78.0	1	4446	89	25	75	0	0	0.0	1.3	2	0.033	2.2	nd	nd
			17080002040401	5,772	328,000	9	20	45	M	M	M	M	M	37	30	0	5.9	48.0	3	2610	45	91	9	0	0	4.4	4.0	3	0.531	5.0	nd	nd
			17080002040402	5,927	5,927	3	3	6	F	M	F	F	M	38	38	0	0	57.0	2	5902	100	100	0	0	0	0.0	2.2	2	0.057	2.6	nd	nd
			17080002040501	1,568	390,286	9	3	8	F	M	M	F	M	0	32	0	36.9	41.0	3	725	46	2	98	0	0	53.3	2.7	2	1.27	2.7	nd	nd
			17080002040502	9,754	345,904	9	10	27	F	M	M	M	M	18	30	0	27.1	43.0	3	4811	49	1	98	0	1	28.0	2.2	2	0.441	1.9	0.1	1
			17080002040503	3,925	316,301	9	19	40	I	M	M	M	M	13	30	0	2.9	42.0	3	2338	60	42	55	0	4	18.4	4.3	3	0.733	2.9	nd	nd
			17080002040504	3,304	3,304	3	3	5	M	F	M	M	F	34	34	0	0	38.0	3	3287	99	99	1	0	0	0.0	1.4	2	0.186	1.1	nd	nd
			17080002040505	8,150	8,150	3	3	3	M	F	M	M	F	52	52	0	0.1	60.0	2	5483	67	0	100	0	0	0.0	3.1	3	0.27	2.8	nd	nd
			17080002040506	4,729	4,729	3	21	29	F	F	F	F	F	59	59	0	0	89.0	1	4672	99	0	100	0	0	31.3	1.3	2	0.199	1.0	nd	nd
		East Fork Lewis River	17080002050101	9,547	9,547	3	22	39	F	M	F	F	M	52	52	0	0	61.0	2	9547	100	100	0	0	0	0.0	2.2	2	0.202	1.3	nd	nd
			17080002050201	6,078	19,912	3	16	28	M	M	M	F	M	49	51	0	0	57.0	2	5457	90	99	1	0	0	11.7	3.1	3	0.424	2.2	nd	nd
			17080002050202	923	923	3	2	2	I	F	M	I	F	61	61	0	0	25.0	4	0	0	0	0	0	0	100.0	3.3	3	0.535	3.7	nd	nd
			17080002050203	4,286	13,834	3	18	32	M	M	F	F	M	55	53	0	0	65.0	2	4286	100	100	0	0	0	0.0	3.1	3	0.287	2.2	nd	nd
			17080002050301	4,804	10,592	3	3	7	F	M	M	M	M	45	50	0	0	59.0	2	4712	98	87	13	0	0	15.0	2.4	2	0.286	1.6	nd	nd
			17080002050302	4,865	4,865	3	2	4	M	M	M	M	M	53	53	0	0	37.0	3	4865	100	100	0	0	0	0.0	1.9	2	0.255	1.3	nd	nd
			17080002050401	10,120	21,077	4	7	11	M	F	M	F	F	18	33	0	0	64.0	2	7029	69	7	93	0	0	94.0	3.2	3	0.44	2.1	4.4	1
			17080002050402	5,755	7,076	1	2	2	F	F	M	M	F	28	36	0	0	83.0	1	5509	96	0	100	0	0	100.0	2.9	2	0.301	1.6	nd	nd
			17080002050403	2,899	2,899	3	2	2	F	F	F	F	F	55	55	0	0	63.0	2	2742	95	24	76	0	0	93.7	1.9	2	0.559	1.4	nd	nd
			17080002050404	1,321	1,321	3	5	9	M	M	F	M	M	72	72	0	0	94.0	1	1321	100	0	100	0	0	100.0	3.8	3	0.19	1.6	nd	nd
			17080002050405	983	983	3	2	2	I	F	M	I	F	92	93	0	0	30.0	3	713	73	0	100	0	0	100.0	3.9	3	0.765	3.1	nd	nd
			17080002050501	2,177	80,082	4	2	4	I	M	M	M	M	0	34	0	2.4	36.0	3	445	20	0	85	0	15	98.3	4.4	3	0.851	3.3	nd	nd
			17080002050502	3,891	77,905	4	1	2	M	F	M	M	M	0	35	0	3	57.0	2	1961	50	0	79	1	21	80.7	4.0	3	0.722	2.9	10.6	3
			17080002050503	3,649	39,691	6	1	2	M	M	M	F	M	11	45	0	0	57.0	2	510	14	0	82	18	0	91.9	4.0	3	0.67	2.8	5.7	2
			17080002050504	4,231	6,933	1	4	7	M	M	M	M	M	25	31	0	0.3	67.0	2	42	1	0	56	0	44	98.1	5.3	3	0.532	4.6	1.5	1
			17080002050505	5,011	5,011	1	21	41	I	M	M	I	M	0	0	0	5.5	19.0	4	95	2	0	90	0	10	57.8	5.6	3	0.488	2.8	40.1	4
			17080002050506	2,702	2,702	1	1	2	M	M	M	M	M	41	41	0	0	54.0	2	0	0	0	0	0	0	100.0	5.4	3	0.212	3.4	nd	nd
			17080002050507	1,302	1,302	1	1	2	I	M	M	I	M	17	17	0	0	43.0	3	0	0	0	0	0	0	97.6	3.2	3	0.791	2.9	2.4	1
			17080002050508	982	982	1	1	2	M	F	M	M	F	42	42	0	0	41.0	3	0	0	0	0	0	0	100.0	2.8	2	0.391	2.0	nd	nd
			17080002050509	4,556	4,556	1	1	2	M	M	M	M	M	34	35	0	0	70.0	2	3542	78	12	86	2	0	92.5	3.5	3	0.339	2.0	nd	nd
			17080002050601	5,280	11,016	1	32	49	M	M	M	M	M	0	0	0	34.2	4.0	4	847	16	86	3	8	2	17.6	4.0	3	0.46	1.6	41.4	4

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Public Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080002050602	2,528	135,781	4	26	53	M	M	M	I	M	0	20	0	16.2	3.0	4	370	15	0	0	42	58	1.6	7.7	3	0.434	3.7	75.9	4
27	Lewis	East Fork Lewis River	17080002050603	5,376	125,388	4	47	73	I	M	I	I	M	0	22	0	20.4	0.0	4	709	13	0	0	4	96	0.0	4.9	3	0.448	2.2	94.8	4
			17080002050604	6,772	103,944	4	34	72	I	M	M	I	M	0	26	0	18.8	11.0	4	690	10	0	0	0	100	7.0	6.9	3	0.531	2.2	87.6	4
			17080002050605	8,591	8,591	1	10	16	I	M	I	I	M	0	0	0	0.2	16.0	4	506	6	0	100	0	0	34.9	5.4	3	0.565	3.3	65.1	4
			17080002050606	3,838	3,838	1	37	58	M	M	I	M	M	0	0	0	8.3	7.0	4	153	4	0	62	0	38	9.0	5.6	3	0.436	2.7	71.2	4
			17080002050607	2,958	2,958	1	23	45	I	M	I	I	M	0	0	0	0.1	7.0	4	27	1	0	10	74	16	19.0	6.0	3	1.036	3.8	79.9	4
			17080002050608	2,105	2,105	1	23	39	I	M	I	I	M	0	0	0	0.7	4.0	4	12	1	0	0	0	100	29.5	5.7	3	0.579	1.6	67.0	4
			17080002050609	2,803	2,803	1	47	71	I	M	I	I	M	0	0	0	0.4	0.0	4	26	1	0	0	0	100	0.0	5.9	3	0.313	3.0	92.9	4
			17080002050610	5,736	5,736	1	47	72	I	M	I	I	M	0	0	0	0.7	1.0	4	0	0	0	0	0	100	0.0	6.5	3	0.626	2.6	97.9	4
			17080002050611	1,546	1,546	1	21	42	I	M	M	I	M	0	0	0	0	14.0	4	0	0	0	0	0	0	17.0	6.4	3	0.819	3.1	83.0	4
			17080002050612	5,024	6,570	1	22	32	I	F	M	I	M	0	0	0	1	8.0	4	0	0	0	0	0	0	26.0	4.9	3	0.674	2.8	74.0	4
			17080002050613	6,923	6,923	1	33	53	I	M	M	I	M	0	0	0	2.1	8.0	4	4	0	0	0	0	100	17.0	5.5	3	0.686	3.9	83.0	4
			17080002050614	2,576	2,576	1	38	62	I	M	I	I	M	0	0	0	4.7	7.0	4	0	0	0	0	0	0	0.0	4.8	3	0.377	2.5	100.0	4
			17080002050615	2,417	2,417	1	39	78	I	M	M	I	M	0	0	0	2.6	13.0	4	0	0	0	0	0	0	0.0	6.8	3	0.191	3.8	99.5	4
			17080002050616	6,082	86,164	4	13	26	I	M	M	M	M	0	32	0	2.1	28.0	3	84	1	0	0	100	0	39.2	5.9	3	0.807	3.4	60.0	4
		North Fork Lewis - Below Dam	17080002060401	3,011	35,715	4	14	20	I	F	M	I	M	0	5	0	3.3	23.0	4	17	1	0	0	100	0	41.0	4.0	3	0.43	4.8	59.0	4
			17080002060402	3,951	29,374	4	23	41	I	M	M	I	M	0	6	0	2.5	9.0	4	585	15	0	12	88	0	57.0	5.1	3	0.625	4.2	39.4	4
			17080002060403	3,330	3,330	1	19	29	M	M	M	M	M	1	1	0	0	51.0	2	1219	37	0	100	0	0	95.2	3.8	3	0.715	3.7	4.8	1
			17080002060404	8,521	25,422	4	18	34	I	M	M	I	M	2	7	0	3.2	21.0	4	2098	25	0	100	0	0	62.7	4.8	3	0.787	3.2	37.1	4
			17080002060405	8,791	8,791	1	9	18	I	M	M	I	M	16	16	0	2	34.0	3	0	0	0	0	0	0	86.5	5.5	3	0.612	3.5	13.5	3
			17080002060406	8,110	8,110	1	25	39	I	M	I	I	M	1	1	0	2.4	11.0	4	645	8	0	100	0	0	65.9	4.8	3	0.561	3.8	34.1	4
			17080002060501	8,039	531,961	9	32	65	I	M	I	M	M	0	30	0	54.3	6.0	4	592	7	0	81	1	19	17.9	6.6	3	1.149	3.7	54.3	4
			17080002060502	8,809	523,921	9	23	42	I	M	M	M	M	0	30	0	11.8	6.0	4	216	2	7	0	4	89	11.0	5.1	3	0.565	3.8	25.9	4
			17080002060503	7,952	515,113	9	11	21	I	M	M	M	M	10	31	0	7.4	27.0	3	3747	47	0	99	1	1	3.7	4.9	3	0.795	3.3	14.0	3
			17080002060504	3,840	471,446	9	13	30	I	M	M	M	M	3	33	0	5.8	32.0	3	1617	42	0	96	4	0	13.7	4.7	3	0.569	4.2	12.5	3
			17080003040602	12,056	12,056	1	26	51	I	M	I	I	M	0	0	0	68.5	6.0	4	461	4	0	9	7	85	0.0	3.7	3	0.574	2.0	44.4	4
28	Columbia Lower Tribs	Columbia Gorge Tributaries	17080001070101	6,789	6,789	1	26	50	M	M	M	M	M	23	21	0	10.9	43.0	3	1275	19	8	92	0	0	0.0	4.2	3	0.274	1.4	nd	nd
			17080001070102	8,533	8,533	3	7	11	F	M	F	F	M	46	46	0	0	64.0	2	4485	53	0	64	36	0	0.0	2.0	2	0.111	0.7	nd	nd
			17080001070201	8,015	8,015	1	28	51	I	M	M	I	M	24	22	0	17.7	17.0	4	1808	23	34	66	0	0	0.0	3.4	3	0.487	1.6	nd	nd
			17080001070202	9,669	9,669	1	17	38	I	M	M	I	M	35	35	0	7.9	32.0	3	4197	43	7	27	66	0	0.0	3.8	3	0.434	1.8	nd	nd
			17080001070301	6,361	6,361	1	22	44	M	M	M	M	M	15	14	0	26.1	10.0	4	881	14	2	98	0	0	0.0	2.9	2	0.24	1.8	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080001070401	9,654	9,654	1	23	38	M	M	M	M	M	0	0	0	37	5.0	4	1836	19	59	0	39	3	4.4	5.0	3	0.384	1.4	56.2	4
28	Columbia Lower Tribs	Columbia Gorge Tributaries	17080001070402	5,641	5,641	1	11	27	I	M	M	I	M	0	0	0	18.1	8.0	4	26	0	100	0	0	0	2.5	3.4	3	0.226	1.7	22.1	4
		Salmon Creek	17080001090101	7,113	105,966	4	33	50	M	M	I	M	M	0.0	0.6	1.0	99.7	0.0	4	4580	64	100	0	0	0	0.0	1.8	2	0.419	0.4	10.3	3
			17080001090102	3,289	3,289	1	40	61	I	M	I	I	M	0.0	0.0	0.0	6.5	1.0	4	58	2	65	0	0	35	0.0	5.3	3	0.184	2.2	90.4	4
			17080001090103	3,607	7,643	1	93	96	I	F	I	M	M	0.0	0.0	0.0	5.6	1.0	4	79	2	0	0	0	100	0.0	6.3	3	0.433	1.9	98.1	4
			17080001090104	2,038	56,995	4	42	84	M	M	M	M	M	0.0	1.0	0.0	20.1	1.0	4	358	18	0	0	0	100	0.0	9.4	3	0.031	0.3	67.2	4
			17080001090105	2,124	2,124	1	43	65	I	F	I	I	F	0.0	0.0	0.0	7.2	0.0	4	64	3	0	0	0	100	0.0	15.7	4	0.421	2.7	70.7	4
			17080001090106	3,994	53,050	4	57	89	I	M	I	M	M	0.0	1.1	0.0	8.2	0.0	4	529	13	0	0	29	71	0.0	14.9	4	0.688	0.9	64.5	4
			17080001090107	5,031	39,594	4	48	96	I	M	I	M	M	0.0	1.5	0.0	6.4	2.0	4	356	7	0	69	8	23	0.0	6.8	3	0.285	0.6	97.4	4
			17080001090108	6,201	22,781	4	35	70	I	M	I	I	M	0.0	2.6	0.0	5.1	11.0	4	135	2	0	74	0	26	0.0	6.8	3	0.457	1.6	91.3	4
			17080001090109	6,888	6,888	1	3	6	I	M	M	I	M	9.0	8.6	0.0	0.8	44.0	3	1318	19	0	100	0	0	69.7	6.3	3	0.835	2.8	29.2	4
			17080001090110	7,349	7,349	1	46	70	M	M	I	M	M	0.0	0.0	0.0	3.1	2.0	4	188	3	0	21	78	2	0.0	6.8	3	0.344	1.5	86.4	4
			17080001090111	4,922	4,922	1	30	47	M	M	I	M	M	0.0	0.0	0.0	2.2	12.0	4	438	9	0	52	44	4	0.1	9.6	3	0.384	3.3	80.2	4
			17080001090112	4,867	4,867	1	6	10	I	M	M	I	M	0.0	0.0	0.0	3.1	31.0	3	971	20	0	100	0	0	40.7	6.7	3	0.854	3.4	59.3	4
			17080001090113	4,826	4,826	1	24	37	I	M	I	I	M	0.0	0.0	0.0	1.9	15.0	4	236	5	0	100	0	0	11.3	6.7	3	0.595	2.2	85.3	4
			17080001090114	889	18,262	1	46	68	M	F	I	I	F	0.0	0.0	0.0	10.1	0.0	4	86	10	0	0	0	100	0.0	18.5	4	0.519	1.1	73.9	4
			17080001090115	1,907	1,907	1	49	99	I	M	I	I	M	0.0	0.0	0.0	2.2	0.0	4	55	3	0	0	0	100	0.0	16.4	4	0.234	0.0	68.7	4
			17080001090116	999	999	1	100	100	I	F	I	I	F	0.0	0.0	0.0	4.1	0.0	4	10	1	0	0	0	100	0.0	16.5	4	1.164	1.5	64.0	4
			17080001090117	1,114	1,114	1	126	126	I	F	M	I	F	0.0	0.0	0.0	4.5	0.0	4	26	2	0	0	0	100	0.0	15.7	4	0.044	0.0	68.4	4
			17080001090118	6,860	6,860	1	50	75	I	M	I	I	M	0.0	0.0	0.0	3.7	0.0	4	77	1	0	0	0	100	0.0	10.9	4	0.055	0.6	80.4	4
			17080001090119	1,720	2,915	1	49	74	I	M	I	I	M	0.0	0.0	0.0	4.6	0.0	4	28	2	0	0	0	100	0.0	13.1	4	0.004	2.4	67.2	4
			17080001090120	1,448	14,458	1	48	97	M	M	I	I	F	0.0	0.0	0.0	2.9	0.0	4	129	9	0	0	0	100	0.0	24.0	4	0.815	1.8	78.9	4
			17080001090121	1,195	1,195	1	50	74	I	F	I	I	F	0.0	0.0	0.0	0.8	0.0	4	6	0	0	0	0	100	0.0	17.9	4	0.042	0.0	72.1	4
			17080001090122	753	753	1	68	102	I	M	I	I	M	0.0	0.0	0.0	0.7	0.0	4	13	2	0	0	0	100	0.0	16.6	4	0.067	75.5	69.1	4
			17080001090123	743	12,258	1	98	98	I	F	I	I	F	0.0	0.0	0.0	16.3	0.0	4	61	8	0	0	0	100	0.0	11.4	4	0.724	0.5	63.0	4
			17080001090124	3,315	11,515	1	50	75	I	F	I	I	F	0.0	0.0	0.0	3.7	0.0	4	241	7	0	1	0	99	0.0	16.3	4	0.117	1.7	69.4	4
			17080001090125	808	2,029	1	49	73	I	F	I	I	F	0.0	0.0	0.0	0	2.0	4	71	9	0	15	0	85	0.0	20.3	4	0.058	0.0	64.9	4
			17080001090126	701	1,221	1	50	100	I	M	nd	I	F	0.0	0.0	0.0	0	0.0	4	0	0	0	0	0	100	0.0	18.9	4	0	0.0	82.6	4
			17080001090127	520	520	1	50	75	I	F	nd	I	F	0.0	0.0	0.0	0	0.0	4	0	0	0	0	0	0	0.0	15.5	4	0	0.0	74.5	4
			17080001090128	3,089	3,089	1	49	73	I	F	I	I	F	0.0	0.0	0.0	11.3	3.0	4	36	1	0	1	0	99	0.0	15.1	4	0.172	1.3	78.5	4

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080001090129	2,540	3,083	1	50	75	I	F	nd	I	F	0.0	0.0	0.0	0.5	1.0	4	69	3	0	0	0	100	0.0	17.1	4	0	0.0	78.9	4
			17080001090130	542	542	1	33	33	I	F	nd	I	F	0.0	0.0	0.0	0	10.0	4	12	2	0	0	0	100	0.0	18.0	4	0	0.0	78.2	4
28			17080001090131	10,539	30,925	4	28	28	M	F	I	M	F	0.0	0.0	1.0	99.2	0.0	4	2589	25	0	7	60	33	0.0	1.5	2	0.031	0.2	47.2	4
	Columbia Lower Tribs	Salmon Creek	17080001090132	14,710	18,435	1	41	82	I	M	I	I	M	0.0	0.0	0.0	18.9	0.0	4	973	7	28	0	5	67	0.0	17.9	4	0.107	0.9	72.6	4
			17080001090133	4,036	4,036	1	39	75	I	M	M	I	M	0.0	0.0	0.0	0	4.0	4	622	15	0	0	0	100	0.0	8.3	3	0.486	1.3	72.3	4
			17080001090134	3,725	3,725	1	35	53	I	M	M	I	M	0.0	0.0	0.0	0.1	5.0	4	61	2	0	0	0	100	0.0	8.5	3	0.07	0.8	60.1	4
	Washougal	Washougal River	17080001060101	7,761	14,093	3	21	41	F	M	F	F	M	91	84	0	0.2	81.0	1	7550	97	0	100	0	0	0.0	2.1	2	0.42	1.5	nd	nd
			17080001060102	1,775	1,775	3	9	10	F	F	F	F	F	69	69	0	0.4	61.0	2	1775	100	45	55	0	0	0.0	0.3	1	0.025	0.1	nd	nd
			17080001060103	4,557	4,557	3	13	20	F	M	M	F	M	78	78	0	0	63.0	2	4557	100	56	44	0	0	0.0	1.1	2	0	0.3	nd	nd
			17080001060201	7,038	28,056	6	21	49	M	M	M	F	M	56	72	0	2.7	63.0	2	4786	68	0	100	0	0	0.0	3.4	3	0.537	1.4	nd	nd
			17080001060202	5,296	5,296	3	13	25	F	M	F	F	M	62	62	0	0	72.0	2	3915	74	0	100	0	0	0.0	2.7	2	0.194	2.0	nd	nd
			17080001060203	3,552	3,552	3	29	58	I	M	M	I	M	68	69	0	0	37.0	3	1687	47	0	100	0	0	0.0	4.2	3	0.498	2.8	nd	nd
			17080001060204	1,629	1,629	3	8	8	F	F	M	F	F	61	61	0	0.5	76.0	1	1288	79	49	51	0	0	0.0	0.3	1	0.14	0.1	nd	nd
			17080001060301	5,213	19,078	3	2	3	M	F	M	I	M	10	44	0	0.7	55.0	2	1709	33	0	100	0	0	20.4	4.6	3	0.491	1.7	0.8	1
			17080001060302	5,232	5,232	3	5	6	M	F	M	M	F	66	67	0	0	21.0	4	3335	64	79	21	0	0	0.0	2.1	2	0.297	1.3	nd	nd
			17080001060303	5,091	5,091	1	12	28	I	M	M	I	M	37	37	0	0	27.0	3	969	19	0	100	0	0	0.0	4.9	3	0.681	2.8	nd	nd
			17080001060304	3,542	3,542	3	2	2	F	F	F	F	F	72	73	0	0	61.0	2	3164	89	20	80	0	0	67.1	2.1	2	0.173	1.0	nd	nd
			17080001060401	9,443	60,130	6	8	14	I	M	M	M	M	31	56	0	3.2	34.0	3	2434	26	0	100	0	0	0.0	4.5	3	0.428	1.9	nd	nd
			17080001060402	3,166	3,166	1	1	2	I	M	M	I	M	15	15	0	0	26.0	3	164	5	0	100	0	0	0.0	3.3	3	0.452	0.8	nd	nd
			17080001060501	4,031	94,683	4	26	42	I	M	I	I	M	0	39	0	21.9	2.0	4	130	3	0	0	10	90	0.0	10.0	3	0.433	2.3	65.8	4
			17080001060502	6,520	15,566	1	10	20	I	M	M	I	M	0	18	0	3.4	30.0	3	595	9	0	100	0	0	34.5	5.7	3	0.759	2.0	65.5	4
			17080001060503	4,615	4,615	1	2	3	M	F	M	M	F	35	35	0	0	65.0	2	1740	38	0	100	0	0	77.1	4.5	3	0.649	1.7	22.9	4
			17080001060504	8,595	75,086	6	18	35	I	M	M	I	M	0	46	0	3.1	19.0	4	453	5	0	94	5	1	12.6	5.8	3	0.608	2.2	62.8	4
			17080001060505	3,195	3,195	1	1	2	I	M	M	I	M	1	1	0	0	39.0	3	1628	51	0	100	0	0	75.1	3.3	3	0.254	1.8	24.4	4
			17080001060506	4,430	4,430	1	2	3	M	M	M	M	M	25	25	0	0	64.0	2	2738	62	0	100	0	0	100.0	5.4	3	0.672	2.3	nd	nd
			17080001060601	3,864	42,946	4	17	29	I	M	I	M	M	0	3	0	44.5	1.0	4	43	1	0	0	0	100	0.0	9.7	3	0.555	1.2	39.3	4
			17080001060602	6,518	39,082	4	26	26	M	F	M	I	M	0	3	0	10.4	9.0	4	596	9	0	20	6	74	1.5	5.6	3	0.21	0.7	81.8	4
			17080001060603	5,253	32,564	4	35	42	M	F	I	I	M	0	4	0	24.6	9.0	4	407	8	0	79	0	21	6.7	6.4	3	0.163	0.7	76.7	4
			17080001060604	1,411	14,349	1	28	52	I	M	I	I	M	0	9	0	12.1	5.0	4	18	1	100	0	0	0	6.6	7.1	3	0.559	1.3	93.4	4
			17080001060605	8,656	8,656	1	6	11	M	M	M	M	M	14	14	0	2.4	67.0	2	6259	72	49	51	0	0	90.5	4.5	3	0.301	2.1	4.6	1
			17080001060606	4,282	4,282	1	8	13	I	M	M	I	M	1	1	0	2.9	23.0	4	470	11	14	86	0	0	13.1	6.7	3	0.456	2.5	86.9	4

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17080001060607	891	12,962	1	41	59	M	F	I	I	F	0	0	0	6.6	7.0	4	5	1	0	0	0	100	0.0	8.6	3	0.33	1.8	84.1	4
			17080001060608	6,261	6,261	1	52	55	I	F	I	I	F	0	0	0	2.9	1.0	4	281	4	0	99	0	1	0.0	5.2	3	0.485	1.3	97.7	4
28	Washougal	Washougal River	17080001060609	2,937	2,937	1	20	32	I	M	I	I	M	0	0	0	5.9	7.0	4	72	2	100	0	0	0	28.3	6.6	3	0.618	3.2	66.5	4
			17080001060610	2,873	2,873	1	17	34	I	M	M	I	M	0	0	0	1.9	25.0	4	0	0	0	0	0	0	17.1	7.5	3	0.358	2.3	64.6	4
29	Wind	Wind River	17070105110101	5,330	20,078	6	11	15	nd	F	nd	nd	F	74	50	1.03	0	nd	nd	5330	100	100	0	0	0	nd	2.2	2	0.74	0.7	nd	nd
			17070105110102	4,338	9,361	3	9	16	nd	M	nd	nd	F	76	44	0.14	0	nd	nd	4338	100	100	0	0	0	nd	3.7	3	1.31	1.2	nd	nd
			17070105110103	5,024	5,024	3	8	8	nd	F	nd	nd	F	17	17	3.05	0	nd	nd	5024	100	100	0	0	0	nd	1.7	2	0.71	0.4	nd	nd
			17070105110104	5,387	5,387	3	5	9	nd	M	nd	nd	M	37	37	0.45	0	nd	nd	5387	100	100	0	0	0	nd	1.9	2	0.56	0.2	nd	nd
			17070105110201	4,566	13,898	3	7	11	nd	M	nd	nd	M	83	49	0.79	0	nd	nd	4566	100	100	0	0	0	nd	3.2	3	2.01	1.7	nd	nd
			17070105110202	5,776	5,776	3	8	12	nd	F	nd	nd	F	7	7	0.83	0	nd	nd	5776	100	100	0	0	0	nd	1.9	2	0.86	0.7	nd	nd
			17070105110203	3,556	3,556	3	8	15	nd	M	nd	nd	M	73	73	5.8	0	nd	nd	3556	100	100	0	0	0	nd	2.9	2	2.3	1.0	nd	nd
			17070105110301	7,433	7,433	3	30	56	nd	M	nd	nd	M	43	43	0.28	0	nd	nd	7433	100	100	0	0	0	nd	1.8	2	0.45	1.0	nd	nd
			17070105110302	9,949	9,949	3	24	33	nd	F	nd	nd	F	49	49	0.24	0	nd	nd	9949	100	100	0	0	0	nd	2.6	2	0.74	1.1	nd	nd
			17070105110401	6,486	68,591	6	22	32	nd	F	nd	nd	F	24	48	3.33	4.9	nd	nd	4737	73	100	0	0	0	nd	3.5	3	1.34	2.3	nd	nd
			17070105110402	6,037	62,105	6	21	23	nd	F	nd	nd	F	49	50	2.73	0.9	nd	nd	5731	95	100	0	0	0	nd	3.1	3	1.06	1.4	nd	nd
			17070105110403	4,710	38,686	6	16	20	nd	F	nd	nd	F	74	53	0	0	nd	nd	4710	100	100	0	0	0	nd	2.5	2	0.81	0.7	nd	nd
			17070105110501	3,975	21,768	6	13	21	nd	M	nd	nd	M	36	60	0.46	0.4	nd	nd	3545	89	89.5	10.5	0	0	nd	4.7	3	1.48	1.5	nd	nd
			17070105110502	4,269	17,793	3	15	16	nd	F	nd	nd	M	74	65	0.33	0	nd	nd	4269	100	100	0	0	0	nd	2.5	2	1.05	1.6	nd	nd
			17070105110503	6,844	13,524	3	28	39	nd	F	nd	nd	M	67	62	0.68	0	nd	nd	6844	100	100	0	0	0	nd	3.5	3	1.06	3.2	nd	nd
			17070105110504	6,680	6,680	3	31	67	nd	M	nd	nd	M	57	57	0.12	0	nd	nd	6680	100	100	0	0	0	nd	4.0	3	1.07	3.0	nd	nd
			17070105110601	7,082	26,468	6	29	44	nd	M	nd	nd	F	42	50	0.03	0.2	nd	nd	5817	82	100	0	0	0	nd	2.7	2	0.7	0.6	nd	nd
			17070105110602	5,914	19,386	3	30	43	nd	F	nd	nd	F	52	52	1.17	0	nd	nd	5817	98	100	0	0	0	nd	3.0	3	0.82	1.5	nd	nd
			17070105110603	4,872	13,473	3	29	39	nd	F	nd	nd	F	66	53	0.01	0	nd	nd	4872	100	100	0	0	0	nd	3.1	3	0.92	1.2	nd	nd
			17070105110604	8,601	8,601	3	18	24	nd	F	nd	nd	F	45	45	0.05	0	nd	nd	8601	100	100	0	0	0	nd	3.6	3	1.38	0.8	nd	nd
			17070105110701	5,746	9,496	3	35	38	nd	F	nd	nd	F	35	45	0.03	0.2	nd	nd	5359	93	100	0	0	0	nd	2.1	2	0.49	1.1	nd	nd
			17070105110702	3,750	3,750	3	29	44	nd	F	nd	nd	F	61	61	0	0	nd	nd	3750	100	100	0	0	0	nd	1.9	2	0.47	0.2	nd	nd
			17070105110801	5,380	143,732	6	20	33	nd	M	nd	nd	F	2	46	3.56	6.1	nd	nd	2139	40	68.5	31.5	0	0	nd	3.9	3	1.24	1.2	nd	nd
			17070105110802	6,096	96,455	6	16	24	nd	F	nd	nd	M	18	49	0.59	6.9	nd	nd	3529	58	28.5	71.5	0	0	nd	2.3	2	0.79	1.7	nd	nd
			17070105110803	5,932	5,932	1	36	60	nd	M	nd	nd	M	39	39	0.23	0.1	nd	nd	3527	59	97.8	2.2	0	0	nd	3.1	3	0.91	1.4	nd	nd
			17070105120301	6,388	6,388	1	27	51	nd	M	nd	nd	M	11	12	16.9	15.1	nd	nd	2660	42	97	3	0	0	nd	3.1	3	1.06	1.4	nd	nd
			17070105130201	8,094	27,472	6	14	27	nd	M	nd	nd	M	24	42	3.56	3	nd	nd	2599	32	0	100	0	0	nd	5.1	3	1.59	3.7	nd	nd

WRIA	Subbasin	Recovery Planning Watershed	LCFRB HUC	HUC Area (Acres)	Drainage Area (Acres)	Subwatershed Strata	Natural Sediment Index	Managed Sediment Index	Local Level Hydro Condition*	Local Level Sediment Condition*	Local Level Riparian Condition*	Watershed Level Hydro Condition*	Watershed Level Sediment Condition*	HUC % Rain on Snow Area	WS % Rain on Snow Area	HUC % Wetland Area	HUC % Floodplain Area	HUC % Mature Forest	HUC Forest Cover Rating	Total Publc Acres	Public Lands % HUC Area	Public land % Federal	Public Land % DNR	Public % State	Public Land % Other Ownership	HUC % Commercial Forest Zoning or Parcels	HUC Road Density	HUC Road Density Rating	HUC Streamside Road Density	HUC Stream Crossing Density	HUC Zoned but Vacant %	HUC Zoned but Vacant Rating
			17070105130202	4,605	19,378	3	2	3	nd	F	nd	nd	M	29	50	0.05	0	nd	nd	3383	73	0	100	0	0	nd	3.6	3	1.04	4.2	nd	nd
			17070105130203	6,233	14,773	3	3	4	nd	F	nd	nd	M	55	57	0.11	0	nd	nd	5917	95	13.7	86.3	0	0	nd	1.3	2	0.37	1.1	nd	nd
29	Wind	Wind River	17070105130204	8,540	8,540	3	19	59	nd	I	nd	nd	I	57	57	0.55	0	nd	nd	8265	97	51.8	48.2	0	0	nd	3.2	3	0.8	1.8	nd	nd
			17070105130401	3,983	3,983	1	31	64	nd	M	nd	nd	M	2	2	16.86	13.3	nd	nd	497	12	0	100	0	0	nd	3.9	3	1.22	1.3	nd	nd
			17070105130402	8,605	8,605	1	3	6	nd	M	nd	nd	M	8	9	18.59	18.6	nd	nd	1113	13	0	100	0	0	nd	5.3	3	2	3.6	nd	nd
	Little White Salmon	Little White Salmon River	17070105100101	6,964	11,734	3	17	26	nd	F	nd	nd	F	0	0	2.62	0	nd	nd	6964	100	100	0	0	0	nd	2.6	2	1.14	0.5	nd	nd
			17070105100102	4,770	4,770	3	29	43	nd	M	nd	nd	M	0	0	0.24	0	nd	nd	4770	100	100	0	0	0	nd	2.8	2	1.85	0.5	nd	nd
			17070105100201	7,438	46,198	6	14	20	nd	F	nd	nd	F	75	21	1.32	0	nd	nd	6743	91	100	0	0	0	nd	2.8	2	1.1	1.9	nd	nd
			17070105100202	7,932	38,759	6	15	25	nd	M	nd	nd	F	51	10	0	0	nd	nd	7932	100	100	0	0	0	nd	2.0	2	0.73	0.6	nd	nd
			17070105100203	7,097	30,827	6	8	11	nd	F	nd	nd	F	0	0	0.03	0	nd	nd	7097	100	100	0	0	0	nd	1.6	2	1.82	0.4	nd	nd
			17070105100204	8,773	8,773	3	12	23	nd	M	nd	nd	M	0	0	2.03	0	nd	nd	8773	100	100	0	0	0	nd	2.3	2	1.04	1.1	nd	nd
			17070105100205	3,223	3,223	3	22	29	nd	F	nd	nd	F	0	0	2	0	nd	nd	3223	100	100	0	0	0	nd	2.5	2	1.47	0.5	nd	nd
			17070105100301	7,866	14,024	3	31	39	nd	F	nd	nd	F	69	65	0.92	0	nd	nd	7511	95	99.8	0.2	0	0	nd	2.4	2	0.82	1.4	nd	nd
			17070105100302	6,158	6,158	3	30	42	nd	F	nd	nd	F	61	61	0.03	0	nd	nd	6158	100	99.7	0.3	0	0	nd	3.2	3	0.98	1.6	nd	nd
			17070105100401	7,345	26,391	6	24	35	nd	F	nd	nd	F	48	59	1.67	0.2	nd	nd	5473	75	63.7	36.3	0	0	nd	3.5	3	1.04	2.2	nd	nd
			17070105100402	5,022	19,046	3	27	34	nd	F	nd	nd	F	58	63	4.38	0	nd	nd	4351	87	96	4	0	0	nd	3.0	2	0.88	2.8	nd	nd
			17070105100501	9,328	86,858	6	18	31	nd	M	nd	nd	M	30	34	3.97	4.7	nd	nd	1483	16	83.4	16.6	0	0	nd	4.7	3	1.6	3.1	nd	nd
			17070105100502	4,941	77,530	6	14	24	nd	M	nd	nd	M	34	35	0.06	1.7	nd	nd	1592	32	14.9	85.1	0	0	nd	6.2	3	1.77	3.4	nd	nd
			17070105120302	4,617	4,617	1	8	13	nd	M	nd	nd	M	39	40	13.36	13.5	nd	nd	3519	76	95.5	4.5	0	0	nd	2.9	2	1.03	2.0	nd	nd
			17070105120303	4,218	4,218	1	2	4	nd	M	nd	nd	M	7	8	28.95	27.3	nd	nd	37	1	100	0	0	0	nd	5.2	3	3.03	3.4	nd	nd

Notes:

* IWA Condition Ratings
F: Functional
M: Moderately Impaired
I: Impaired
nd: No data

Volume VI, Chapter 6
Application of the EDT model

Application of the EDT model to Lower Columbia Recovery Planning

Outline

I. Introduction

Ecosystem Diagnosis & Treatment (EDT) is an approach to developing and implementing watershed plans (MBI 1999). EDT includes three primary components; a conceptual framework, analytical model, and a step-by-step procedure. For Lower Columbia River recovery and subbasin planning, we have limited our use of EDT to the analytical model itself, and have integrated it into a broader conceptual framework. For our purposes, the EDT model is used as one of several tools to assess fish population performance and fish / habitat interactions. Specifically, the model allows us to estimate fish population performance based on characteristics of physical habitat. Included in the EDT analyses are comparisons of model scenarios, which highlight geographic areas and reach-specific habitat attributes that are believed to be the most limiting for salmonid populations.

A strength of the model is its applicability to population viability criteria (McElhany et al. 2000). EDT addresses most of the Viable Salmonid Population (VSP) parameters, which include productivity, abundance, diversity, and spatial structure. Another major strength of the model is its comprehensiveness. In accounting for the important link between aquatic habitat and fish performance, EDT considers 46 different reach level habitat attributes, integrates all potential life history trajectories, and calculates 4 population performance parameters. Furthermore, the EDT Reach Analysis identifies potential restoration and preservation benefits and the specific habitat attributes that need to be restored. This level of comprehensiveness is not possible with other fish / habitat assessment techniques. Application of EDT across the planning area also allows for a high level of consistency. Consistency of results is especially important in the large and diverse Lower Columbia region, which consists of over 80 salmonid populations across nearly 20 basins. Conducting EDT across the entire planning area allows for a reasonable comparison of results among populations.

Despite the benefits and utility of using EDT, the model also has potential drawbacks. A commonly cited weakness of EDT is its complexity. The complexity can obscure transparency in underlying assumptions, which has led to its characterization as a *black box*. We have attempted to address this by describing the EDT model in sufficient detail, however, an in-depth description of model functions is beyond the scope of this document. Interested readers can learn more by visiting the EDT website (www.edthome.org), which contains links to supporting documentation. Another criticism of EDT is that it allows for the use of expert opinion for input variables where empirical data is unavailable. While this increases flexibility in areas where data is scarce, it can possibly result in erroneous outputs that are difficult to assess for accuracy. We have attempted to address this concern by comparing EDT inputs to the outputs of a watershed process model and by comparing EDT results to empirical fish abundance data. These comparisons are presented in other appendices to this document. The other major criticism of EDT is that it is not explicit with respect to uncertainty in model functions and sensitivity to inputs or errors. Model uncertainty is difficult to assess due to its complexity, breadth, and the use of expert opinion. The evaluations presented here provide insight into the degree of prediction and parameter uncertainty. An analysis to investigate the sensitivity of outputs to errors in input parameters is currently underway by NOAA Fisheries and Mobrand Biometrics Inc.

This document consists of two primary sections. First, we give a brief description of how the EDT model works in general and how it was specifically applied to the lower Columbia region. Second, we present an evaluation of the lower Columbia EDT runs by comparing model outputs with empirical fish abundance data and by comparing model inputs with outputs of a watershed process model that has been applied in the lower Columbia region. These evaluations are intended to provide information on the appropriate utility of EDT for lower Columbia recovery planning.

II. EDT Overview

A. Baseline Runs

EDT can be classified as a mechanistic model that is based on the relationships between aquatic habitat characteristics and fish performance. Model inputs include descriptions of the physical stream environment, at a reach level, which are then related through a set of rules to life-stage specific survival. These survival characteristics are then integrated across the entire life history of the population. Results include estimates of population productivity, capacity, equilibrium abundance, and diversity. EDT is typically used to model conditions for the current (patient), historical (template), and Properly Functioning Condition (PFC) scenarios.

Descriptions of physical habitat are made for individual reaches, and take the form of scores (0-4) for each of 46 habitat attributes, known as Level 2 attributes (Table 1). Guidelines have been developed that specify appropriate scores according to available coarse scale data (Level 1 data) and the scenario being considered. If no data exists, scores may be inferred from similar areas where there is data or can be estimated using expert opinion. Model inputs also include a description of stream size and the relative quantity of habitat unit types (e.g. backwater pools). Level 2 habitat attribute scores are then combined through a set of rules into relative survivals for 16 Level 3 attributes (Table 1). For instance, the level 2 attributes of turbidity, embeddedness, and fine sediment are combined to create a relative survival for the level 3 attribute Sediment Load. The rules used to combine level 2 attributes into level 3 relative survivals depend on the life stage being considered. For instance, for the egg incubation stage, fine sediment receives more ‘weight’ than embeddedness, and turbidity has no effect. These rules are based on empirical data or assumed relationships based on the current state of the knowledge of fish / habitat relationships. For each life stage in each reach, Level 3 relative survivals are applied to a theoretical optimum survival to obtain a realized survival (productivity) estimate. This value is then applied to a density dependent Beverton-Holt survival function which uses a theoretical optimum capacity based on the spatial extent of available habitat unit types in the reach. The extent of biologically possible life history trajectories is another model input and typically involves assigning percentage use of several different life history patterns that are offered as options in the model. In order to correctly estimate life history trajectories, model users must have knowledge of which life stages are carried out in which stream reaches. This information may also be inferred from physical stream channel characteristics such as gradient and channel width. Reach and life-stage specific survival functions are integrated across all life history stages in all life history trajectories in order to arrive at population performance parameters. A conceptual diagram of the EDT model is presented in Figure 1.

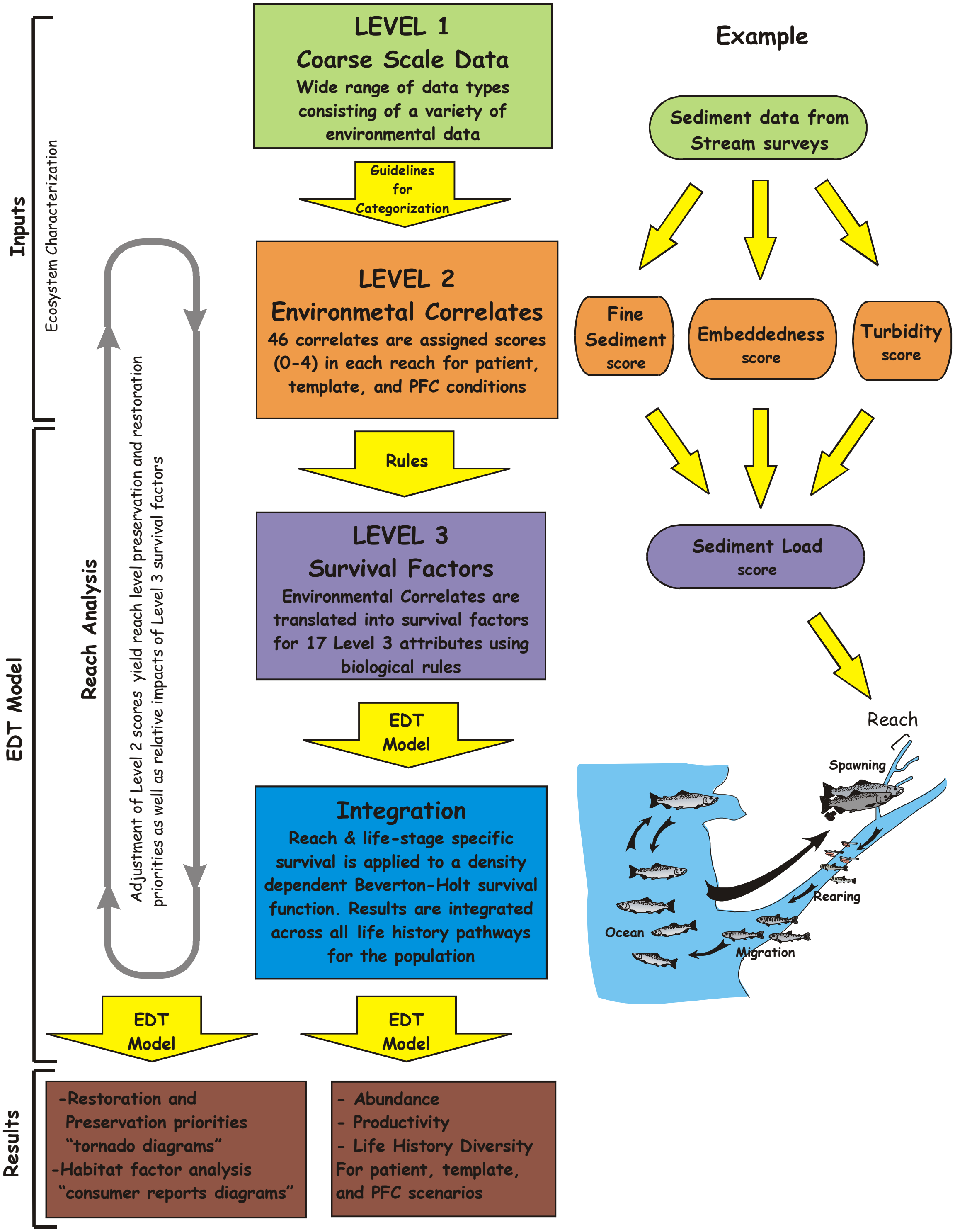

Figure 1. Conceptual diagram of the EDT model.

Final model results include smolt and adult productivity, equilibrium abundance, capacity, and diversity estimates. Adult productivity is the measure of density independent survival, and can be thought of as a population's capacity to replace itself. It is represented in EDT as the number of adults produced in the next generation per spawner. Smolt productivity is expressed as the number of smolts per spawner. Adult and smolt capacity are the theoretical maximum capacities that the habitat can support, but that it cannot sustain over multiple generations due to density dependent effects (i.e. superimposition). Adult abundance (equilibrium abundance or Neq) is the density dependent abundance at the point where the population is just replacing itself. It can generally be thought of as the average abundance of the population. Mathematically, it is the intersection of the stock recruit (Beverton-Holt) curve with the 1:1 replacement line (Figure 2). Smolt abundance is calculated similarly but is concerned with the equilibrium abundance of smolts leaving the system. Diversity in EDT is expressed as the percentage of theoretically possible life history trajectories that are viable under the specified habitat conditions. Estimates of smolt productivity and abundance are useful for describing effects of subbasin spawning and rearing habitats independent of out-of-basin fishery, mainstem, estuary, and ocean concerns.

EDT estimates have been generated for historical (template), current (patient), and "Properly Functioning Conditions" (PFC). The historical/template condition is defined as pre-non-Native American European influence and represents a hypothetical optimum. The current/patient condition represents the immediate past few years. PFC represents favorable habitat conditions for salmonids throughout the basin based on criteria identified by NMFS (1996). PFC conditions are less optimum than the pristine historical template but are assumed to ensure population persistence (i.e. avoid extinction).

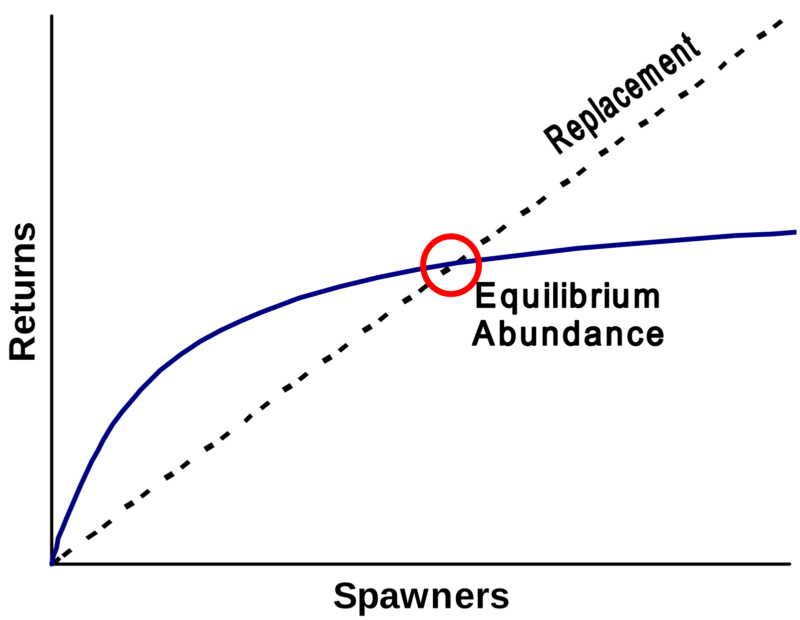

Figure 2. Example of a stock recruitment curve generated using a density dependent survival function. The equilibrium abundance (Neq) is the intersection of the spawner-recruit curve with the 1:1 replacement line and represents a theoretically sustainable abundance.

Table 1. Definition of EDT Level 3 attributes and their associated level 2 correlates. The primary effects and secondary effects are generalizations of the primary and modifying level 2 environmental correlates used by the EDT model. Specific primary and modifying effects depend on species and life stage.

Level 3 Attribute	Definition	Modifying Level 2 Attributes Primary effects	Secondary effects
Channel stability	The effect of stream channel stability (within reach) on the relative survival or performance of the focus species; the extent of channel stability is with respect to its streambed, banks, and its channel shape and location.	Bed scour	Icing Riparian function Wood Confinement -natural Confinement -artificial Flow – change in interannual high flow variation Flow – intraannual flow pattern
Chemicals	The effect of toxic substances or toxic conditions on the relative survival or performance of the focus species. Substances include chemicals and heavy metals. Toxic conditions include low pH.	Miscellaneous toxic pollutants – water column	Metals – in water column Metals / Pollutants – in sediment / soils Nutrient enrichment
Competition (with hatchery fish)	The effect of competition with hatchery produced animals on the relative survival or performance of the focus species; competition might be for food or space within the stream reach.	Hatchery Fish Outplants	Alkalinity Benthos Diversity and Production Riparian Function Salmon Carcasses
Competition (with other species)	The effect of competition with other species on the relative survival or performance of the focus species; competition might be for food or space.	Fish Community Richness	Alkalinity Benthos Diversity and Production Riparian Function Salmon Carcasses
Flow	The effect of the amount of stream flow, or the pattern and extent of flow fluctuations, within the stream reach on the relative survival or performance of the focus species. Effects of flow reductions or dewatering due to water withdrawals are to be included as part of this correlate.	Flow – change in daily variation Flow – change in interannual high flow variation Flow – change in interannual low flow variation	Confinement -natural Confimement -artificial Gradient Riparian function Wood Embeddedness Habitat type
Food	The effect of the amount, diversity, and availability of food that can support the focus species	Benthos diversity and production	Alkalinity Riparian function Salmon carcasses
Habitat diversity	The effect of the extent of habitat complexity within a stream reach on the relative survival or performance of the focus species.	Gradient	Confinement –natural Confinement -artificial Riparian function Wood Icing

Harassment (harvest)	The effect of harassment, poaching, or non-directed harvest (i.e., as can occur through hook and release) on the relative survival or performance of the focus species.	Harassment	Habitat type – primary pools Riparian function Turbidity Wood
Key habitat	The relative quantity of the primary habitat type(s) utilized by the focus species during a life stage; quantity is expressed as percent of wetted surface area of the stream channel.	Habitat type - backwater pools Habitat type - beaver ponds Habitat type - Glides Habitat type - large cobble/boulder riffles Habitat type - off-channel habitat factor Habitat type - primary pools Habitat type - pool tailouts Habitat type - small cobble/gravel riffles	
Obstructions	The effect of physical structures impeding movement of the focus species on its relative survival or performance within a stream reach; structures include dams and waterfalls.	Obstructions to fish migration	
Oxygen	The effect of the concentration of dissolved oxygen within the stream reach on the relative survival or performance of the focus species.	Dissolved Oxygen	
Pathogens	The effect of pathogens within the stream reach on the relative survival or performance of the focus species. The life stage when infection occurs is when this effect is accounted for.	Fish Pathogens	Fish species introductions Temperature – daily maximum (by month) Nutrient enrichment
Predation	The effect of the relative abundance of predator species on the relative survival or performance of the focus species, apart from the influence of the amount of cover habitat used by the focus species.	Predation risk	Fish community richness Fish species introductions Hatchery fish outplants Temperature – daily maximum (by month) Flow – change in interannual low flow variation
Sediment	The effect of the amount of fine sediment present in, or passing through, the stream reach on the relative survival or performance of the focus species.	Turbidity Fine sediment Embeddedness	Temperature – daily maximum (by month) Flow – change in interannual high flow variation Flow – change in interannual low flow variation
Temperature	The effect of water temperature in the stream reach on the relative survival or performance of the focus species.	Temperature – daily maximum (by month)	Temperature – spatial variation
Withdrawals (entrainment)	The effect of entrainment (or injury by screens) at water withdrawal structures within the stream reach on the relative survival or performance of the focus species. This effect does not include dewatering due to water withdrawals, which is covered by the flow correlate.	Water withdrawals	

B. Reach Analysis

EDT reach analyses have been conducted for all populations assessed with EDT in the lower Columbia. The reach analysis function in EDT adjusts the level 2 input scores up or down for individual reaches and then ranks the reaches according the effect that the adjustment has on total population performance parameters. Reach analysis considers the same population performance parameters as the baseline run analysis though it provides a greater level of detail as it identifies reaches based on their relative preservation and restoration value. Reach analysis results are specific to each fish species because of the different fish habitat requirements of each.

The assessment of restoration value in a particular reach is conducted by hypothetically *restoring* all of the level 2 scores for that reach from patient to template conditions, with the assumption that template conditions represent habitat conditions that would result from full reach restoration. The model is then re-run in order to capture the percent change in fish performance due to this hypothetical restoration in the reach. This is conducted for all reaches independently and the reaches are ranked accordingly. A higher ranked reach for restoration would therefore become high priority for habitat restoration measures because of the greater potential benefit to the population than from restoration of lower ranked reaches. A similar exercise is conducted to identify preservation value, except that level 2 scores in a particular reach are artificially *degraded* and the reaches are ranked according to how great of a negative impact they have on total population performance. If degradation of habitat scores has a large negative effect on population performance, then that reach has high preservation value. Reaches with a high preservation value should be protected because of the disproportionately high negative impact on the population that would result from degradation. In order to reduce the influence of reach length on reach importance, the population change that results from hypothetical restoration or preservation was normalized by reach length. This results in percentage change in population values that are expressed per 1000 meters of reach length. Results are typically displayed in a graphical format that is often referred to as a ladder or tornado diagram (Figure 3).

Many reaches have both high preservation and high restoration value. These tend to be highly productive or potentially highly productive reaches, where relatively modest changes in habitat quality can have a significant effect on population performance. In these reaches, management strategies should work to both preserve existing functional attributes and restore degraded attributes.

Reach Group (H, M, L) and Recovery Emphasis (P, R, PR) are designations developed for recovery planning purposes and are not generated by the EDT model. A description of these designations is presented in section II.C.2.a below.

A limitation of the reach analysis is that it analyzes reach restoration and degradation independently for each reach. An example of this limitation is that a reach that may actually hold a lot of promise for restoration may show no positive effect to the population if a severely degraded or impassable reach (bottleneck) exists downstream. It is therefore important to be aware of where such bottlenecks are located, and if necessary eliminate them from the reach analysis to prevent misleading results.

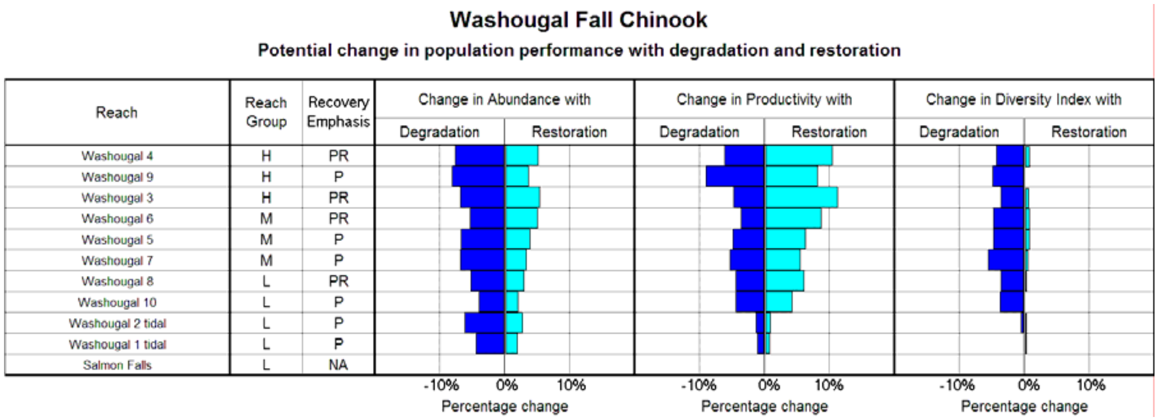

Figure 3. Example of ladder diagram for Washougal Fall Chinook. The longer the bars, the greater the change in the population performance parameters (abundance, productivity, and life history diversity) when reach scores are changed to Template conditions (restoration analysis) or set to a degraded condition (preservation analysis). The percentage change values are expressed as the percentage change in population performance per 1000 meters of channel length within the reach.

Another assessment conducted as part of the EDT reach analysis evaluates the effect of the Level 3 survival factors on reach and life-stage productivity. The results are displayed on "consumer report diagrams" (Figure 4). While this level of detail is useful for local restoration practitioners, it is generally too specific for comparisons across populations or even across reaches. For this reason, we chose to summarize the effect of survival factors across all life history stages in a reach. We termed this assessment a Habitat Attribute Impact Analysis. It is described in the following section.

Species/Component:	Fall Chinook	***Washougal Watershed - Reach Analysis - Fall Chinook***
Restoration Potential:	Current Conditions versus Historic Potential	
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories	

Geographic Area:	Washougal 6			**Stream:**	
Reach:			0	**Reach Length (mi):**	2.40
				Reach Code:	Washougal 6
Restoration Benefit Category:1/	A	**Productivity Rank:1/**	3	**Potential % change in productivity:2/**	16.2%
Overall Restoration Potential Rank:1/	2	**Average Abundance (Neq) Rank:1/**	2	**Potential % change in Neq:2/**	9.9%
(lowest rank possible - with ties)1/	11	**Life History Diversity Rank:1/**	1	**Potential % change in diversity:2/**	0.0%
Preservation Benefit Category:1/	A	**Productivity Rank:1/**	4	**loss in productivity with degradation:2/**	-13.8%
Overall Preservation Rank:1/	4	**Average Abundance (Neq) Rank:1/**	4	**% loss in Neq with degradation:2/**	-15.9%
(lowest rank possible - with ties)1/	12	**Life History Diversity Rank:1/**	4	**% loss in diversity with degradation:2/**	-9.3%

Life stage	**Relevant months**	**% of life history trajectories affected**	**Productivity change (%)**	Life Stage Rank	**Change in attribute impact on survival:** Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Oct-Nov	11.2%	-10.8%	4							●	●					•	●		
Egg incubation	Nov-May	11.2%	-25.4%	6	⬤							•					●	•		
Fry colonization	Apr-May	31.9%	-17.1%	7	●			•	⬤	●	⬤					●	●			•
0-age active rearing	Mar-Oct	48.4%	-1.0%	3	•		•			•	●					•				●
0-age migrant																				
0-age inactive																				
1-age active rearing																				
1-age migrant																				
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Sep-Oct	67.9%	-0.2%	2							•	•						•		
Prespawning holding	Oct-Nov	11.2%	-10.8%	5					●		⬤	●					•	●		•
All Stages Combined		67.9%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	•	∘
Moderate	●	○
High	⬤	◯
Extreme	⬤	◯

Figure 4. Example of "Consumer Report Diagram" for Washougal Fall Chinook. Top rows give information on preservation and restoration benefit. Note that "Benefit category" does not apply for our analysis. Dots represent the relative impact of the level 3 habitat attributes (survival factors) on life-stage specific productivity in the reach. One of these reports is created for each reach utilized by the population.

C. Specific applicability to Lower Columbia Recovery Planning

1. Spatial Extent

A total of 83 Lower Columbia anadromous fish populations have been assessed through the EDT Model. These runs represent all of the major basins with significant anadromous fish use on the Washington side of the Lower Columbia, extending from the Columbia River mouth east to the Wind River. Populations include native runs of winter and summer steelhead, chum, fall and spring chinook, and coho. EDT has not been fully developed for Bull Trout, cutthroat, and the many other resident fish species present in the study area. However, model results for species that inhabit the same stream reaches can provide insight into habitat effects for non-modeled species.

EDT model runs have been conducted by various agencies and organizations depending on the river system. A map of EDT progress in the region and the organization(s) that have been most involved with the model runs are presented in Figure 5. Table 2 provides a list of all the populations that have been assessed using EDT.

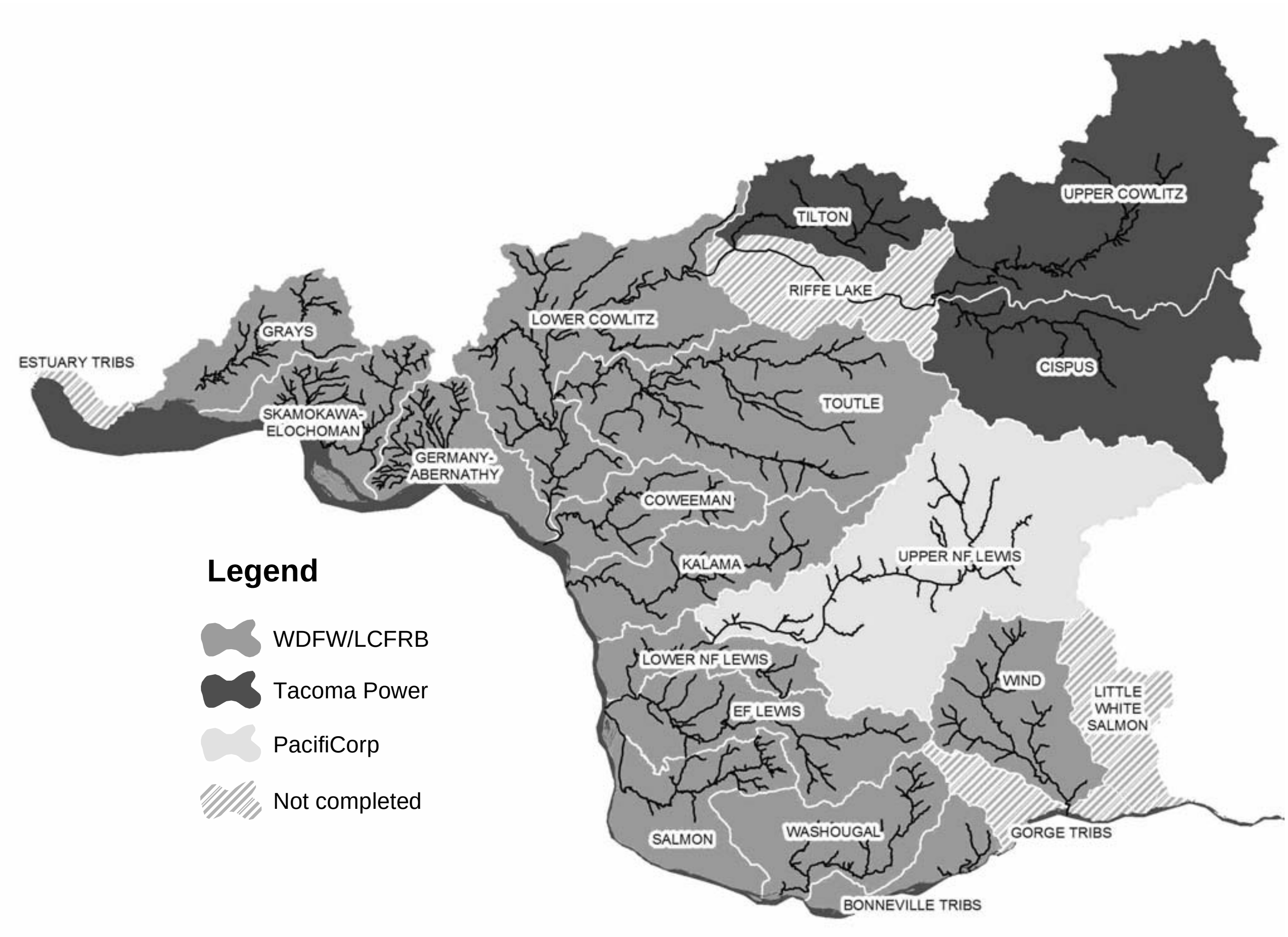

Figure 5. Map of lower Columbia region showing EDT modeling status.

Table 2. Status of EDT modeling for populations on the Washington side of the lower Columbia River.

Organization	River basin	Species: chum	fall chinook	spring chinook	summer steelhead	winter steelhead	coho
--WA Dept. of Fish & Wildlife --Lower Columbia Fish Recovery Board (2003/2004)	Grays	✓	✓			✓	✓
	Skamokawa	✓	✓			✓	✓
	Elochoman	✓	✓			✓	✓
	Mill	✓	✓			✓	✓
	Abernathy	✓	✓			✓	✓
	Germany	✓	✓			✓	✓
	Lower Cowlitz	✓	✓			✓	✓
	Coweeman	✓	✓			✓	✓
	Toutle	✓	✓	✓		✓	✓
	Kalama	✓	✓	✓	✓	✓	✓
	Lower NF Lewis	✓	✓			✓	✓
	EF Lewis	✓	✓		✓	✓	✓
	Salmon Creek	✓	✓			✓	✓
	Washougal	✓	✓		✓	✓	✓
	Bonneville Tributaries	✓	✓			✓	✓
	Wind	✓	✓		✓	✓	✓
Tacoma Power (2003)	Tilton		✓	✓		✓	✓
	Upper Cowlitz/Cispus		✓	✓		✓	✓
PacifiCorp (2003)	Upper Lewis			✓		✓	✓

2. Additional Analyses

Additional analyses have been applied to EDT results for the purposes of recovery planning. The two primary additional analyses include the identification of reach priority rankings and the assessment of the relative effects of Level 3 Habitat Attributes (Survival Factors).

a) Reach ranking

In order to narrow the focus of habitat recovery planning such that the most important reaches are targeted for restoration or preservation, reaches were ranked according to where recovery actions would yield the greatest benefits to a particular population. Based on reach rank, the reaches were then binned into high, medium, and low priority categories.

Reach rankings were determined by summing the potential change values for preservation and restoration across the 3 performance measures (i.e. summing the values for all bars of the ladder diagram for each reach). Reach rankings therefore reflect the contribution of the reach to current AND potential population performance. In the ladder diagrams (Figure 3) reaches are ordered according to their prioritized rank.

The binning of reaches into high, medium, and low categories was conducted using the following methodology. Beginning with the top ranked reach and working down in ranked order, the running sum of performance values (using population change values not normalized for reach length in this case) was calculated until at least one-third of the cumulative sum of all reach performance values was reached. These reaches were placed into the high category. The process was continued until two-thirds of the cumulative sum was reached and these reaches were designated as medium priority. The remainder were designated low priority. This process results in approximately one-third (or slightly less on average) of the channel lengths allocated to the high category, one-third to the medium category, and one-third to the low category.

Reaches were also given a recovery emphasis designation. A designation of P indicates that preservation measures should be emphasized within the reach. A designation of R indicates that restoration measures should be emphasized. A designation of PR means that both preservation and restoration are equally important. Reaches were designated P or R if greater than 60% of total population change (the summing of the bars in the ladder diagram) resulted from preservation or restoration, respectively. Reach priority groups (H, M, L) and reach recovery emphasis (P, R, PR) are displayed in the ladder diagrams (Figure 3).

b) Habitat Attribute Impact Analysis

An assessment of the effect of degraded habitat attributes in specific reaches is necessary to evaluate causes of population decline and to identify recovery measures. In the EDT reach analysis, the relative impact of the various level 3 habitat attributes (see discussion in section II.B above) is evaluated. The model accomplishes this by artificially restoring each of the habitat attributes in a reach to template conditions one at a time and evaluating the change to reach productivity. This is done for individual life stages within individual reaches. These results are displayed in what are commonly termed "consumer report diagrams" (Figure 4). While this level of detail is useful for practitioners who are implementing specific recovery measures in specific reaches, it is too detailed for an effective comparison of habitat impairments across reaches in a basin. In order to expand the analysis to the population-scale, we combined all life stages within a reach and weighted the reach values according to the relative contribution of the reach to overall population abundance. Similar to consumer report diagrams, the result is a chart with sized dots representing the level of impact of the 16 level 3 attributes, only there is just one dot per reach and all the reaches for a population are combined in one chart (Figure 6). These are referred to as Habitat Attribute Impact charts. A similar analysis can be conducted using the EDT model itself and is termed an "attribute splice", but it has the disadvantage of requiring additional model runs.

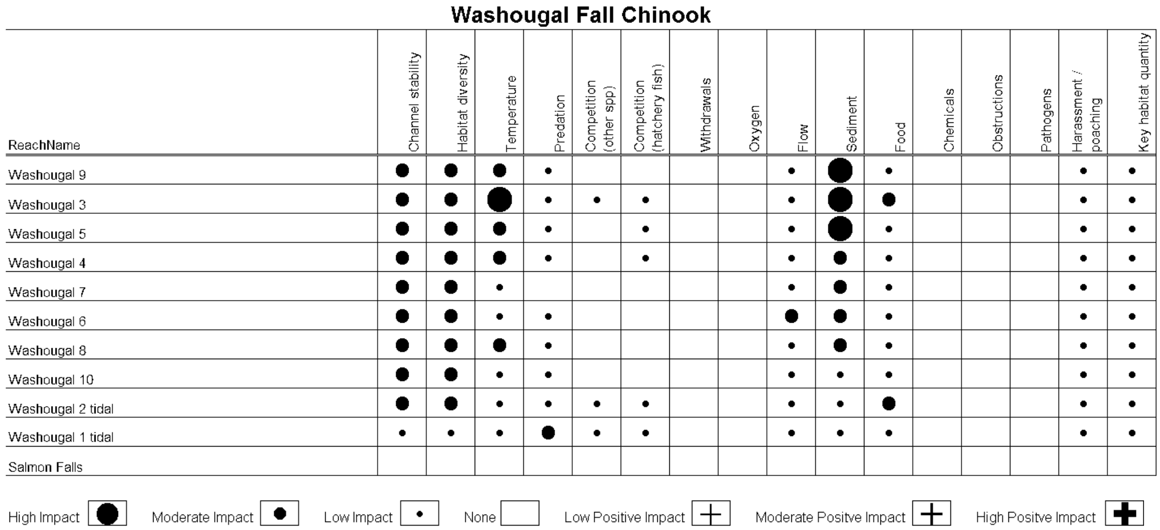

Figure 6. Example of Habitat Factor Analysis diagram for Washougal Fall Chinook. The dots represent the relative impact of level 3 habitat attributes (survival factors) within all reaches utilized by the population.

III. Evaluation of EDT

A. Introduction

The EDT model has several potential sources of error and uncertainty due to the many inputs, functions, and their associated assumptions. These include input parameters, which include reach delineation, level 2 scores, level 2 scoring guidelines, and life history pathways / trajectories; benchmarks, which are productivity and capacity estimates under optimal conditions; and biological rules, which translate level 2 scores to level 3 survival factors. Due to the large number of calculations involved with integrating all life stages across life history trajectories, the potential for compounded error and uncertainty is a concern. There are several approaches to evaluating the aforementioned sources of error and uncertainty. In this document, we focus on two primary approaches; comparison of results (performance parameters) to empirical data, and comparison of input scores to watershed process modeling results. An analysis of model sensitivity to error and uncertainty in inputs, biological benchmarks, rules, and trajectory selection is beyond the scope of this evaluation; however, analyses that have been conducted to date by others are briefly summarized.

Once again, an exhaustive technical evaluation of EDT is beyond the scope of this project, but is being conducted in pieces by other entities. Relevant references are provided for those wishing to obtain additional information. The primary objective of this analysis is to shed some light on the adequacy of the model as a tool for recovery planning and thus better inform the interpretation of results.

B. Evaluations

1. Comparison of EDT with empirical observations[1]

In this analysis, the smolt production (abundance) estimates of lower Columbia EDT runs are compared to actual smolt outmigration estimates from trap data throughout the Northwest. A comparison of modeled and empirical smolt data was chosen for two reasons: 1) reliable smolt data from trapping studies is readily available for many regional streams, and 2) compared to adult return data, smolt abundance is less affected by the potentially confounding variability of out-of-basin (i.e. ocean) conditions. It should be noted that this assessment provides a “first glance” evaluation of EDT reasonableness. A more thorough evaluation is underway by WDFW that will compare the suite of EDT performance parameters (capacity, Neq, initial productivity) to estimates derived from empirical data. Results will be incorporated into the technical foundation as this effort moves forward.

a) Methods

Data Description

EDT smolt production estimates were made for salmonid populations including chum, spring and fall chinook, summer and winter steelhead and coho for basins on the Washington side of the Columbia River from the Grays River to the Wind River (Figure 5). Estimates reflect equilibrium abundance (Neq or realized capacity) for the entire basin upstream of the mouth of each river. Only patient (current) estimates of smolt equilibrium abundance were considered in this analysis. Equilibrium abundance reflects the average expected performance of a population given average environmental conditions. The EDT data used in this analysis are presented in Table 3.

[1] The EDT smolt abundance data used in this analysis are from year 2003 model runs. Subsequent runs have been conducted using updated model inputs.

Table 3. EDT data used in analysis. Data are Patient (current) smolt equilibrium abundance (Neq).

Basin	Basin Size (mi^2)	Patient Neq Fall Chinook	Patient Neq Steelhead[4]	Patient Neq Coho	Patient Neq Smolts/mi^2 of watershed Fall Chinook	Patient Neq Smolts/mi^2 of watershed Steelhead[4]	Patient Neq Smolts/mi^2 of watershed Coho
Coastal Region							
Grays River	61	57,260	8,941	--	945	148	--
Skamokawa Creek	17	95,719	2,513	19,736	5,501	144	1,134
Elochoman River	66	182,410	6,265	27,015	2,772	95	411
Germany Creek	23	120,843	5,846	11,040	5,277	255	482
Abernathy Creek	20	101,917	5,254	13,575	5,021	259	669
Mill Creek	28	82,379	2,623	4,287	2,911	93	151
Cascade Region							
Cowlitz River[1]	445	1,976,934	5,739	--	4,443	13	--
Toutle River	511	758,300	16,388	--	1,484	32	--
Coweeman River	119	192,384	10,221	--	1,617	86	--
Kalama River	205	80,908	24,700	--	395	120	--
Lewis River							
E.Fk. Lewis River	235	221,799	10,160	--	942	43	--
N.Fk. Lewis River[2]	101	1,172,483	3,223	--	11,666	32	--
Upper Lewis[3]	731	114,154	32,330	254,912	156	44	349
Washougal River	108	366,647	13,076	--	3,395	121	--
Gorge Region							
Duncan/Hardy/ Hamilton Creeks	52	--	1,053	--	--	20	--
Wind River	225	129,563	29,312	--	576	130	--
Little White Salmon R.	134	--	--	--	--	--	--
White Salmon River	294	--	--	--	--	--	--

[1] Cowlitz below Mayfield Dam
[2] Lewis below Merwin Dam; not including E. Fk. Lewis
[3] Lewis River above Swift Reservoir - hypothetical population
[4] Includes summer and winter steelhead

Estimates of smolt outmigration from field trapping were gathered from throughout the Pacific Northwest for steelhead, coho, and fall chinook. Data were used from traps located in the Cascades, the Gorge, the Coast, and the Umpqua Basin because these regions were the same as or similar to those in the lower Columbia Basin where EDT estimates were made. No spring chinook trap data were found in these regions, and thus no comparisons are made to EDT spring chinook results. For each trapping location, data were obtained for all years where estimates were made. Only spring smolt outmigrants were included in the analysis except with fall chinook where all outmigrants were used. Trap location, years data were available, and range of values across years are presented in Table 4. A complete list of trap locations where data were obtained and the source of the data can be found in the Supplemental Information section at the end of this document.

Table 4. Information on smolt traps and trap data used for comparison with EDT.

Basin	Subbasin	Est. Drainage Area (mi^2) Above Trap	Years of Estimates	Outmigration Estimates ($outmigrants/mi^2$) (min-max) Steelhead	Coho	Fall Chinook
Coastal Region						
Alsea	Cascade Cr.	5.6	1998-2002	13 - 25	2 - 314	206 - 206
Alsea	E.Fk. Lobster	6	1998-2002	--	152 - 633	--
Alsea	Upper Lobster	5	1998-2002	--	75 - 900	--
Coos	Bottom Cr.	17.8	1999	9 - 9	144 - 144	--
Coos	Fall Cr.	15	1999-2001	--	22 - 234	288 - 848
Coos	Winchester Cr.	10	1999-2002	--	100 - 460	--
Coquille	N. Fk. Coquille R.	291	1998	15 - 15	9 - 9	--
Kilchis	Little S. Fk. Kilchis R.	12	1998-2002	118 - 300	3 - 191	380 - 12,874
Lower Columbia	Abernathy Cr.	28.7	2001-2002	188 - 369	216 - 244	--
Lower Columbia	Germany Cr.	22.5	2001-2002	333 - 338	311 - 363	--
Lower Columbia	Mill Cr.	29.1	2001-2002	43 - 59	217 - 326	--
Nehalem	N. Fk. Nehalem R.	24.4	1998-2002	140 - 715	777 - 1901	6,593 - 79,391
Nestucca	Little Nestucca R.	45.3	1998	176 - 176	278 - 278	--
Oregon Coast	Cummins Cr.	10	1998-2002	142 - 321	1 - 222	--
Oregon Coast	Tenmile Cr.	23	1998-2002	262 - 864	73 - 403	210 - 1,515
Siletz	Mill Cr.	13	1998-2002	18 - 87	332 - 1328	27 1,303
Wilson	Little N. Fk. Wilson	20	1998-2002	176 - 1034	112 - 722	11,306 - 61,197
Yaquina	Bales Cr.	3.5	1998-2002	--	118 - 464	633 - 71,231
Yaquina	Mill Cr.	8	1999-2002	35 - 109	--	4 - 919
Yaquina	Mill Cr.	8	1998-2002	--	278 - 878	--
Cascade Region						
Clackamas	Big Bottom	139	1994 & 1998	21 - 23	34 - 314	--
Clackamas	Fish Cr.	47	1989-2000	22 - 198	1 - 176	--
Clackamas	Mainstem Above N. Fk. Dam	681	1994-1996	18 - 37	41 - 180	--
Clackamas	N. Fk. Clackamas	32	1998	63 - 63	--	--
Clackamas	N. Fk. Eagle Cr.	28	1999	134 - 134	--	--
Clackamas	Oak Grove Fk.	142	1998-1999	8 - 11	0 - 30	--
Kalama	Kalama R.	179	1978-84,92-94,98-02	48 - 254	--	--
Lewis	Cedar Cr.	30	2001-2001	90 - 119	805 - 1167	--
Gorge Region						
Hood	Hood R.	352	1994-2001	8 - 70	--	--
Wind	Wind R.	225	1995-1999	36 - 109	--	--
Umpqua Region						
Umpqua	W. Fk. Smith R.	26	1998-2002	103 - 295	418 - 862	36 - 4,913
Umpqua	Smith R.	202	1998-2002	1 - 144	535 - 7197	--
Umpqua	Big Tom Folley Cr.	22.2	1998-2002	7 - 113	19 - 302	--
Umpqua	Brush Cr.	21	1998-2002	12 - 66	39 - 319	--
Umpqua	Elk Cr.	104	2002	14 - 14	--	--
Umpqua	Rock Cr.	98	2001	376 - 376	65 - 65	--
Umpqua	Cow Cr.	499	1999-2002	6 - 30	15 - 79	--

Data Analysis

To compare EDT and actual outmigrant estimates, estimates were standardized by watershed area, resulting in a smolt density value (i.e. number of fish per watershed area). For EDT estimates, watershed area for the entire basin was used, and for migrant traps, the watershed area above the trap was used. Watershed areas were derived from published reports, GIS analysis, or from published watershed areas above nearby USGS gauges.

Maximum, as opposed to average, annual outmigrant estimates from trapping data in recent years were used for comparison to EDT. The maximum outmigrant estimate was chosen because recent trapping studies have taken place during years of low adult returns that resulted in underseeded habitat. We therefore believe that the maximum value best represents long-term average capacities.

For each species, the distribution of EDT estimates and maximum observed outmigrations at migrant traps (by watershed area) were plotted via box plots. All available EDT estimates in the lower Columbia were used, and data from all migrant traps were used.

To facilitate more specific comparisons, basins were grouped into regions including: Coastal, Cascade, and Gorge. Data from different basins were pooled with others within their region for analysis. Data from the Umpqua Basin were not used in this comparison because that basin represents somewhat of an overlap in coastal and cascade habitats. Estimated EDT and observed outmigration densities by watershed area were compared between like regions and species.

Basin specific comparisons were made in situations where both migrant trap and EDT estimates were available for lower Columbia Basins. These comparisons were made by examining the EDT/trap ratio. There were no recent and reliable fall chinook outmigrant estimates in the lower Columbia tributaries, thus no comparison for fall chinook was made.

b) Results

Broad-scale Comparisons

The distribution of EDT and trap estimates indicated that medians of each group were similar to each other, but that the distributions were somewhat dissimilar (Figure 7). For each species, medians were within 30%. The range of migrant trap estimates was greater than EDT estimates for each species and the migrant trap distributions tended to be right-skewed, indicating the presence of some very high values; a condition not seen with EDT results. Most notably, the greatest fall chinook trap estimate was near 80,000 smolts/mi^2 as compared to 12,000 smolts/mi^2 for the greatest EDT estimate (Figure 7).

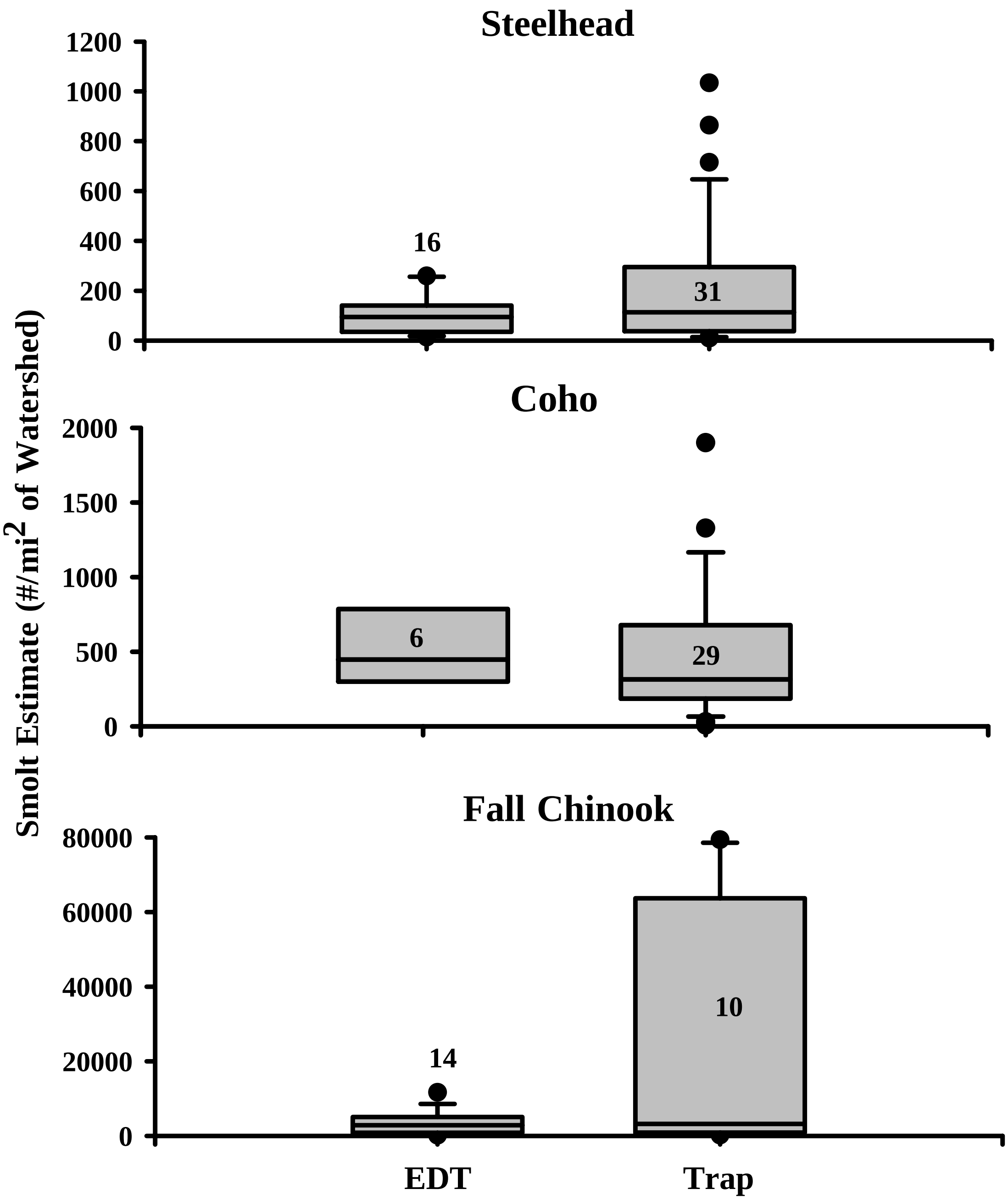

Figure 7. Box plots of EDT smolt Neq (lower Columbia Washington populations) and maximum trap estimates (Western Washington and Oregon) per watershed area. Bars represent 10th, 25th, 50th, 75th, and 90th percentiles. Points indicate outliers. Sample sizes are indicated.

Regional Comparisons

Comparisons by region showed that median estimates were reasonably similar between EDT and migrant traps for all three species in each region where comparisons were possible (Figure 8). The largest differences were in fall chinook in coastal streams and in steelhead in Cascade streams. As with the broad-scale comparison, the range of values observed at migrant traps was greater than that for EDT (Table 5).

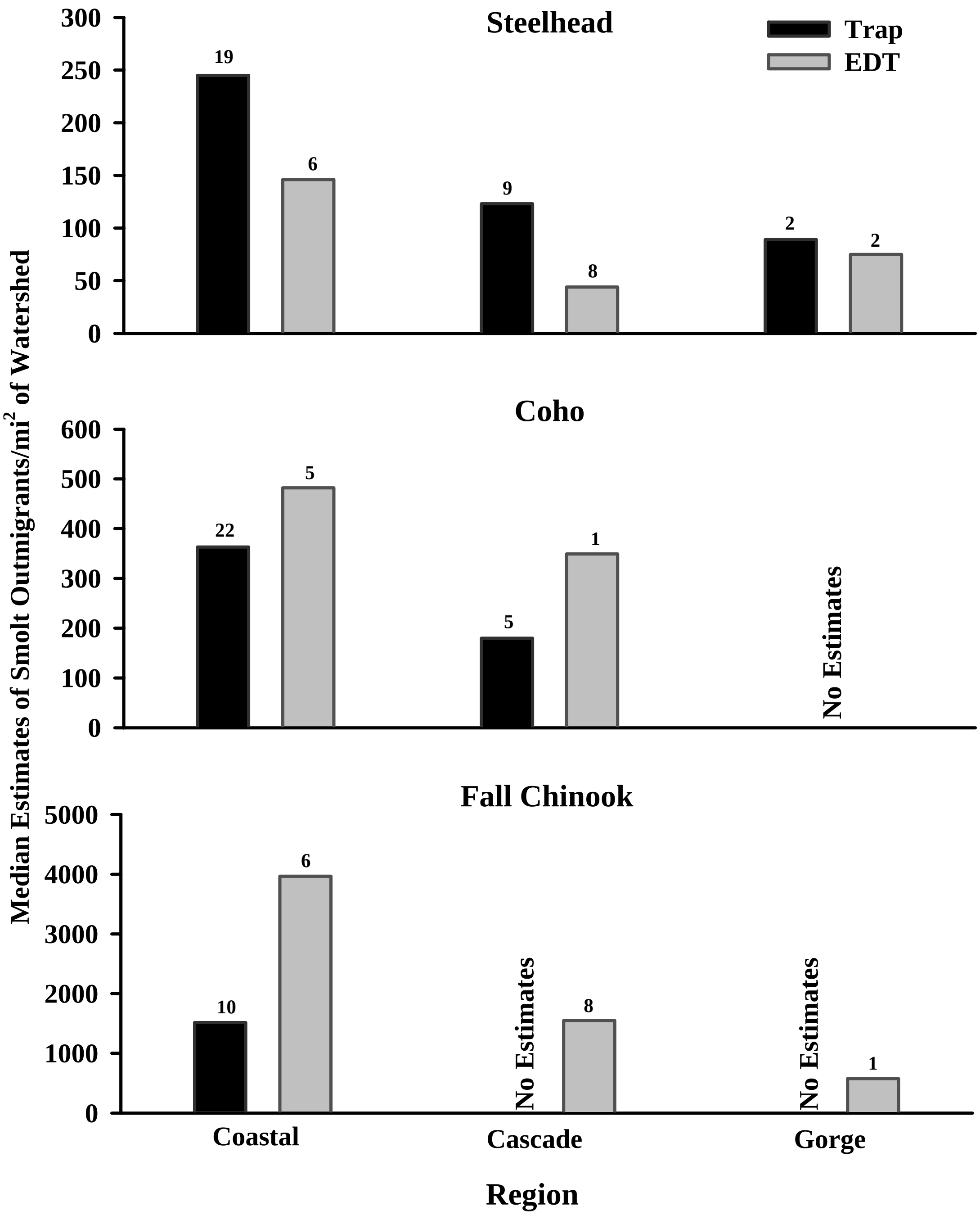

Figure 8. Comparison of median EDT and migrant trap estimates of steelhead, coho, and chinook for three different regions. Migrant trap data is the median of maximum observations at several traps. Sample sizes are indicated above bars.

Table 5. Median, minimum and maximum EDT and migrant trap smolt density estimates by species for three different regions. Trap Count values are based on the maximum value recorded for the period of record.

		Smolts/watershed mi^2					
		Trap Counts			EDT* Patient		
Species	**Region**	**Med.**	**Min.**	**Max.**	**Med.**	**Min.**	**Max.**
Steelhead	Coastal	245	9	1,034	146	93	259
	Cascade	123	11	254	44	13	121
	Gorge	89	70	109	75	20	130
Coho	Coastal	363	9	1,901	482	151	1134
	Cascade	180	30	1,167	349	349	349
	Gorge	--	--	--	--	--	--
Fall Chinook	Coastal	1,515	206	71,231	3,966	945	5,501
	Cascade	--	--	--	1,551	156	11,666
	Gorge	--	--	--	576	576	576

* Lower Columbia Basins only

Lower Columbia Specific Comparisons

In the lower Columbia, paired (within the same basin) comparisons were possible for five steelhead populations and three coho populations. Paired comparisons have a few advantages over grouped comparisons. First, watershed area is held constant, allowing absolute estimates of smolt abundance can be compared instead of smolt densities, allow for the comparison of absolute values instead of smolt densitiesRatios closer to 1:1 indicate better correlation between EDT and trap data. For both species at all traps, ratios ranged from 0.4:1 to 3:1 (Figure 9). Coho EDT tended to be greater than trap estimates and steelhead EDT tended to be less than trap estimates. Mill Creek is an exception to this pattern.

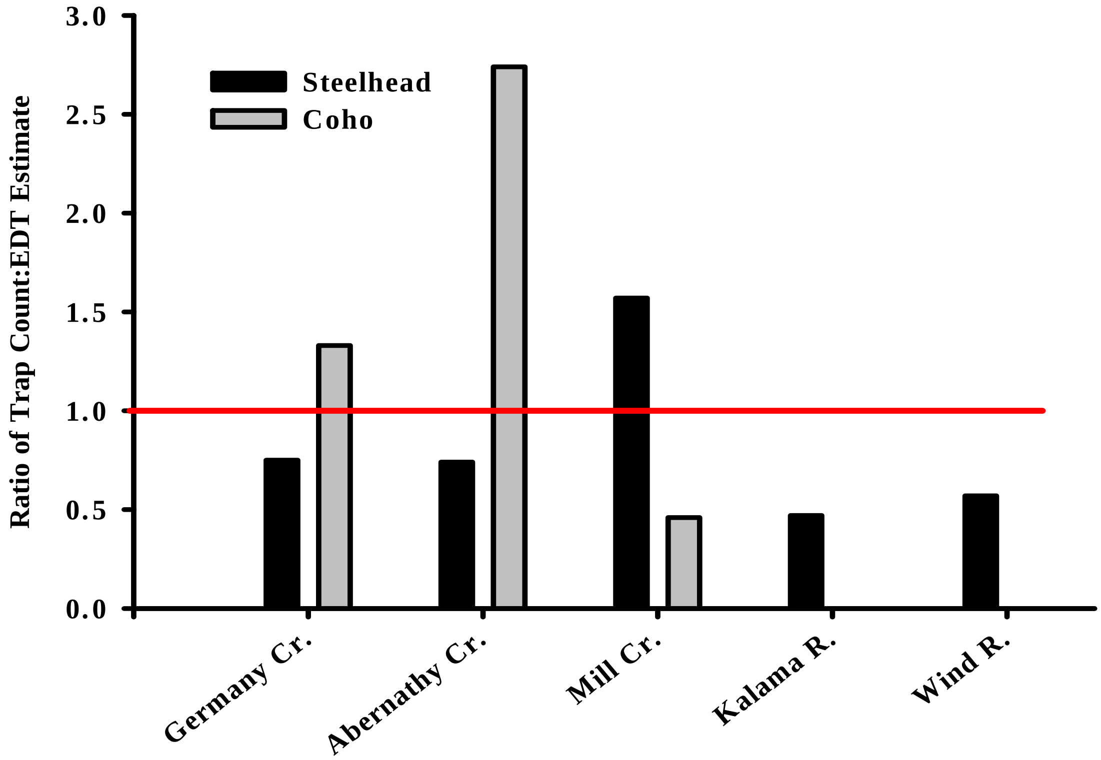

Figure 9. Lower Columbia basin-specific (paired) evaluations of EDT Neq and trap estimates. Data are expressed as the EDT / trap ratio.

c) Discussion

In the broad- and regional-scale comparisons, the similarity between median trap and median EDT values were within reason for most cases, although trap values had a considerably greater range. The smaller range of EDT values may be partly due to the use in EDT of 'equilibrium abundance', which does not reflect the potentially high variability in productivity between years. Moreover, use of maximum trap values may have skewed trap distributions unreasonably. In some basins, the use of average trap values may be more appropriate. The greatest differences between trap data and EDT at the regional scale are observed for Cascade steelhead and coastal fall chinook. In general, the data show that within regions, steelhead EDT runs tend to estimate lower values than trap data, whereas fall chinook and coho EDT runs potentially over-estimate actual smolt abundance. This same trend is seen at the river basin scale (Figure 9), with the exception of Mill Creek, which shows the inverse pattern.

This assessment suggests that EDT results are within the range of empirical observations throughout the region. Differences between EDT and trap data are related to natural variability, measurement error, model error, and model uncertainty, though the specific contribution of each is difficult to assess. In general, we can be relatively confident, albeit cautious, in our use of EDT population performance results for recovery planning. The inherent uncertainty in EDT suggests that results be used primarily in a relative sense, with less weight on absolute numbers and instead an emphasis on the relative magnitude of values between populations and between scenarios (i.e. historic versus current). The greatest use of EDT for recovery planning is not in specifying exact numbers of fish abundance and productivity for a population, but rather in determining how impacts to a population are distributed throughout the fishes' life cycle and the degree to which recovery measures at particular life stages will improve the potential for population persistence.

2. Comparison of EDT and the Integrated Watershed Assessment (IWA)[2]

In the Recovery Planning Technical Foundation, the EDT model is linked with the IWA in order to identify the spatial extent of impaired and functional watershed processes that most affect the habitat of focal fish species. The two assessments are used together to pinpoint the location and type of salmon restoration and/or preservation measures that will yield the greatest benefit to populations. This linking of EDT and IWA thus warrants an examination of the level of consistency between the two approaches.

The IWA is a GIS-based watershed process model that uses remotely sensed and spatially referenced data in order to rate subwatersheds (7^{th} field Hydrologic Unit Codes, HUCs) according to their hydrology, sediment, and riparian impairment. IWA looks at the effect of land use and land cover on watershed processes, whereas EDT looks at the effect of instream habitat on fish performance. Considering that watershed processes are driving factors of fish habitat condition, then EDT picks up where IWA leaves off. Thus, while EDT and IWA look at different pieces of the fish and habitat puzzle, IWA *outputs* have direct relevance to certain EDT *inputs*. Since these two processes will be used collectively to identify recovery measures, it is important to know the level of consistency between EDT inputs and IWA outputs. Ideally, IWA outputs and EDT inputs would be compared to empirical data, however, applicable empirical data is scarce, especially in regards to land-use induced changes to watershed hydrology and sediment regime. With a lack of suitable benchmarks to compare to EDT and IWA, we have conducted this comparison simply to determine the level of correlation between the two.

Comparing EDT and IWA will help identify potential deficiencies in each approach, which will aid in our interpretation of model results. Furthermore, the comparison will determine where future updates to EDT inputs would benefit most from the use of IWA results. Specifically, the comparison presented here will:

1. Identify limitations in using a linkage of IWA and EDT for recovery planning.
2. Identify strengths and potential limitations with both EDT and IWA.
3. Identify where future updates to EDT would benefit most from applying IWA outputs.
4. Identify the error associated with using expert opinion versus remotely sensed data to populate EDT level 2 scores.

EDT level 2 input scores have been developed by the WDFW through a combination of available direct data, proxy measures, and expert opinion. IWA, on the other hand, is

[2] The EDT input scores used in this analysis are from year 2003 model runs. Subsequent runs include updated input scores.

based on remotely sensed and spatially referenced GIS data that was derived in a similar fashion for all areas of the lower Columbia. In some cases, EDT scores have been developed using the same data sources as used in the IWA model (i.e. road densities), but in many cases, different data or approaches have been used. We therefore expect good consistency between the two models in some cases and less consistency in other cases.

Caution is necessary when comparing IWA outputs and EDT inputs. For instance, it may seem logical that IWA sediment impairment rating should correspond to EDT fine sediment scores. However, further investigation into these parameters indicates that important differences exist in how they are determined. While both rely heavily on road densities as an indicator of increased sediment levels, EDT inputs, which are concerned with *accumulation* of sediment, have been developed by factoring in stream gradient and the presence of tidal influence. In contrast, IWA, which is interested in the *delivery* of sediment from hillslopes, factors in watershed slope and natural soil erodability. Since the techniques differ according to their different application in the models, it makes a valid comparison very difficult. Table 6 summarizes the relationship of IWA ratings to the most relevant EDT level 2 attributes.

EDT / IWA comparisons were conducted for each of the three IWA categories; hydrology, sediment, and riparian. In each case, one or two EDT scores were selected for comparison to IWA based on Table 6 and the discussions below. Two river basins from the region were chosen for the evaluation; the Washougal and the Elochoman. The Washougal was selected because 1) it represents an older run (spring 2003) that relied more on expert opinion than newer runs (summer/fall 2003), 2) it is not affected by hydro-regulation (IWA does not specifically evaluate the effect of hydro-regulation) or other potentially confounding factors, and 3) unlike some basins, it has a complete data set to run all IWA assessments. The Elochoman was selected because 1) it is a newer run representing improved scoring techniques and 2) it encompasses a greater number of IWA subwatersheds than other newer runs, thus increasing the sample size.

In the comparisons discussed below, EDT reach scores were compared to the impairment category of the IWA subwatershed that encompasses them. For the hydrology and sediment comparisons, IWA watershed-level impairment, which considers the effect of the entire contributing watershed, was used as opposed to subwatershed-level ("local") impairment (see Appendix ?? - IWA Methods). The riparian IWA rating, on the other hand, only considers local conditions. The identification of appropriate reach/subwatershed pairings for the comparisons was conducted using a GIS overlay of IWA subwatersheds (polygons) on EDT reaches. In a few cases, there was overlap between reaches and subwatershed polygon boundaries. In these instances, reaches with 50% or more of their length within a polygon (subwatershed) are compared to that polygon. It is helpful here to have an understanding of the difference in scale of subwatersheds versus EDT reaches. With rare exceptions, EDT reaches are at a finer scale than subwatersheds. An example is presented in Figure 10. The scale difference is mostly a concern for the riparian comparison, where reach-level riparian conditions may have been used to determine EDT scores as opposed to conditions at the subwatershed level used in IWA.

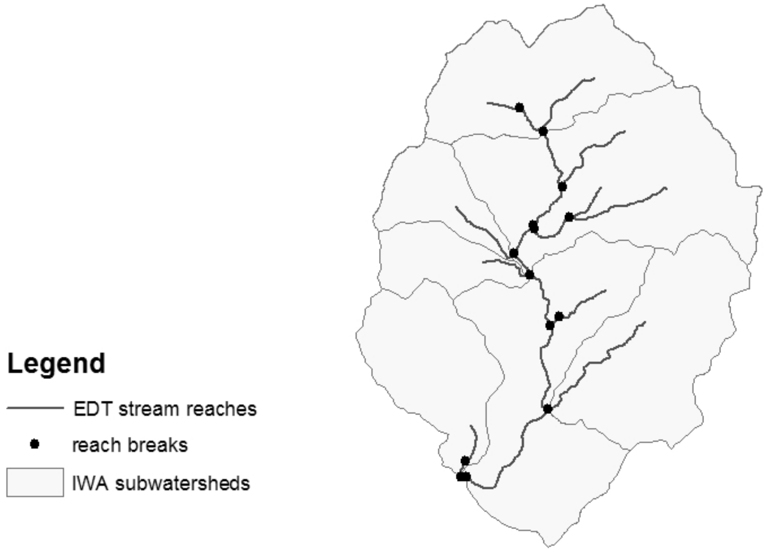

Figure 10. Example of typical difference in scale between EDT stream reaches and IWA subwatershed polygons (Upper Washougal River).

Table 6. Relationship of IWA to EDT level 2 attributes

IWA		EDT			
Process	Data used / attributes considered	EDT level 2	Data used / attributes considered (WDFW older runs)	Data used / attributes considered (WDFW newer runs)	Valid Comparison?
Sediment	Road densities, watershed slope, soil erodability	Turbidity	Expert opinion (except Toutle and coastal basins)	Determined by estimating Scale of Severity using existing turbidity data.	Yes- With caution. Different data sources used. However, correlation expected in some cases
		Embeddedness	Expert opinion	Based on road densities, stream gradient, tidal influence	Yes- With caution. EDT looks at additional factors
		Fine sediment	Expert opinion	Based on road densities, stream gradient, tidal influence	Yes- With caution. EDT looks at additional factors
Hydrology	Forested areas - Vegetation, road densities Urban areas - impervious surfaces	Flow – inter annual variability in high flows (FlowHigh)	USFS watershed analysis data used. For forested basins not analyzed by USFS but with roads, assumed a 10% increase in high flow.	USFS watershed analysis data used. For forested basins not analyzed by USFS but with roads, assumed a 10% increase in high flow.	Yes

IWA		EDT			
Process	Data used / attributes considered	EDT level 2	Data used / attributes considered (WDFW older runs)	Data used / attributes considered (WDFW newer runs)	Valid Comparison?
		Flow – inter annual variability in low flows	Assumed a slight decrease in summer low flows for most basins due to land use. No consideration of water withdrawals.	WDFW rated no change in this parameter due to land use b/c of inconclusive relationships. Water withdrawal data was used in some cases.	Partial- Not for newer runs b/c WDFW assumed no relation with land use and they factored in withdrawals.
		Flow – intra daily (diel) variation	Assumed no change in coastal basins and moderate change (1 score) in other basins due to roads and vegetation impacts.	Rated same as pristine b/c of no metro areas or hydro development in any of the basins.	No- no significant urbanization
		Flow – intra annual flow pattern	WDFW rated same as FlowHigh	WDFW rated same as FlowHigh	Yes
Riparian	(vegetation, buffer size)	Riparian function	Based on vegetation, development, and hydro confinement (artificial). Inferences made to reference sites where data unavailable.	Based on vegetation, development, and hydro confinement (artificial). Inferences made to reference sites where data unavailable.	Yes- With caution. EDT factors in additional conditions not used in IWA.

a) Hydrology Comparison

EDT has four level 2 flow attributes, however, the IWA hydrology rating is most directly comparable to only two of them: "Flow – inter annual variability in high flows" (FlowHigh) and "Flow – intra annual flow pattern" (FlowPattern) (Table 6). IWA does not consider the processes affecting "Flow – intra daily (diel) variation", which is primarily a measure of ramping rates due to hydro-regulation, or "Flow – inter annual variability in low flows", which is mostly related to hydro regulation or water withdrawals. FlowHigh scores range from 0 to 4, with 2 representing pristine conditions and values greater than 2 representing the impaired condition of increased variability in peak flows due to land-use changes.

The two comparable parameters, FlowHigh and FlowPattern, were ranked identically in EDT, therefore only FlowHigh is used in the comparison. EDT reaches were compared to the IWA subwatershed encompassing them. The EDT value used in the comparison was the Patient score minus the Template score (P – T), or the Patient score minus 2, since all Template conditions were given a 2 for the FlowHigh attribute. This value represents the level of impairment compared to pristine conditions. The frequency distributions of EDT scores (P – T) within IWA impairment categories were compared to assess consistency between the values (see Figure 11).

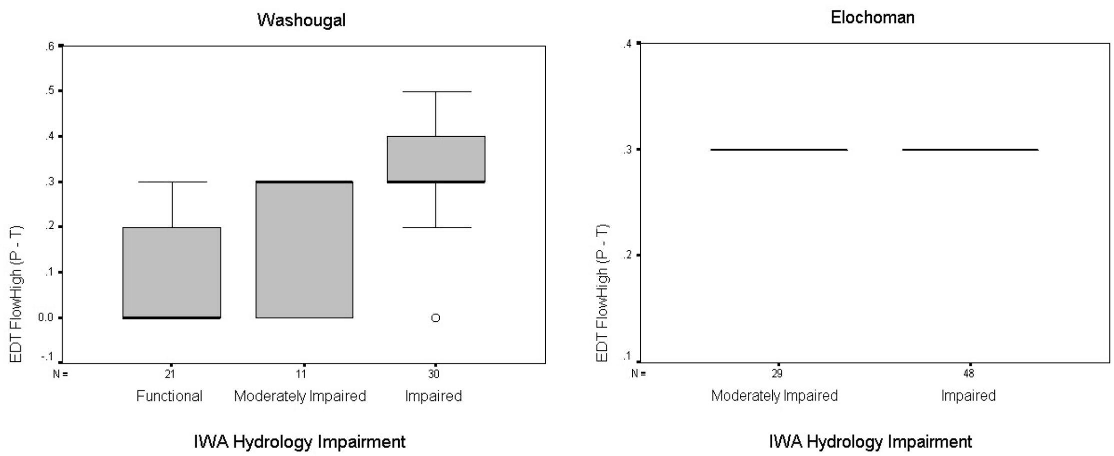

Figure 11. Frequency distribution of EDT FlowHigh scores (P – T) within IWA Hydrology impairment categories for the Washougal and Elochoman Rivers. The box represents the interquartile range which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. The bold line across the box indicates the median.

In the Washougal, the EDT inputs follow the general trend of increasing impairment as one moves from IWA Functional to IWA Impaired, though there is significant overlap. In the Elochoman, however, all EDT reaches were scored the same and there were no IWA Functional subwatersheds. EDT FlowHigh scoring in the Washougal relied partly on USFS watershed analysis results (where available) and partly on the assumption that forested basins with road systems had a 10% increase in peak flows. General correlation between EDT and IWA in the Washougal is likely because of the use of the USFS watershed analysis peak flow rating, which considers similar landscape conditions as those used in IWA (e.g. vegetation and roads). In the Elochoman, however, no previous hydrology assessment had been conducted and therefore WDFW's 10% assumption was applied to the entire basin. In this instance, EDT scoring could benefit from the use of IWA modeling. In general, IWA, which has been applied uniformly to all areas in the region, could assist in the development of EDT flow scores.

Recommendation:

Use IWA hydrology rating to score FlowHigh and FlowPattern, the later of which is a measure of a stream's "flashiness" due to watershed development or hydro-development. Data on subwatershed imperviousness gathered as part of the IWA analysis could be used to further modify FlowPattern in cases of intense urbanization.

b) Sediment Comparison

The three EDT level 2 attributes that relate to sediment are fine sediment, embeddedness, and turbidity. Fine sediment and embeddedness are evaluated similarly in EDT and therefore, of these two, fine sediment was used in the IWA comparison. EDT turbidity scores were developed using a different approach and therefore were compared to IWA separately.

The development of IWA sediment scores involves the calculation of a natural sediment delivery index (GSSD) and a managed condition sediment delivery index (MCSD), with road density as the primary change variable. Subwatersheds are considered ‘moderately impaired’ if they have a MCSD that equals or exceeds 1.5 times the GSSD and are considered ‘impaired’ if the MCSD equals or exceeds 3 times the GSSD. For comparison to EDT, the EDT fine sediment and turbidity scores are also expressed in terms of change from natural conditions, using the Patient scores minus the Template scores (P – T).

EDT fine sediment scores for the Washougal (older run) were determined primarily through expert opinion, whereas scores for the Elochoman (newer run) were inferred from landscape conditions. The newer EDT runs used a two-step process to derive fine sediment scores. First, road density was used to determine percent fines based on a relationship established by Rittmueller (1986), using sample sites consisting primarily of low to moderate gradient reaches. Higher gradient streams do not retain sediment to the same degree as low or moderate gradient streams and therefore, WDFW adjusted the percent fines value downward in higher gradient reaches. Additionally, scores were adjusted upward if tidal influence was present in the reach. The final percent fines value was applied to the EDT guidelines to obtain the EDT score. Fine sediment scores range from 0 to 4, with 0 representing pristine conditions. EDT reaches were compared to the IWA subwatershed encompassing them. The distributions of EDT values (P – T) are compared within IWA sediment impairment categories to assess consistency between the two.

EDT turbidity scores were developed primarily by expert opinion for the Washougal. Scores for the Elochoman used a combination of empirical data and expert opinion, generally following the guidelines set forth in the EDT manual. Scores were extrapolated to other reaches without data. EDT turbidity scores range from 0 to 4, with 0 representing pristine conditions. EDT reach level turbidity scores (P – T) were compared to the IWA subwatershed encompassing them, in the same fashion as described above for fine sediment.

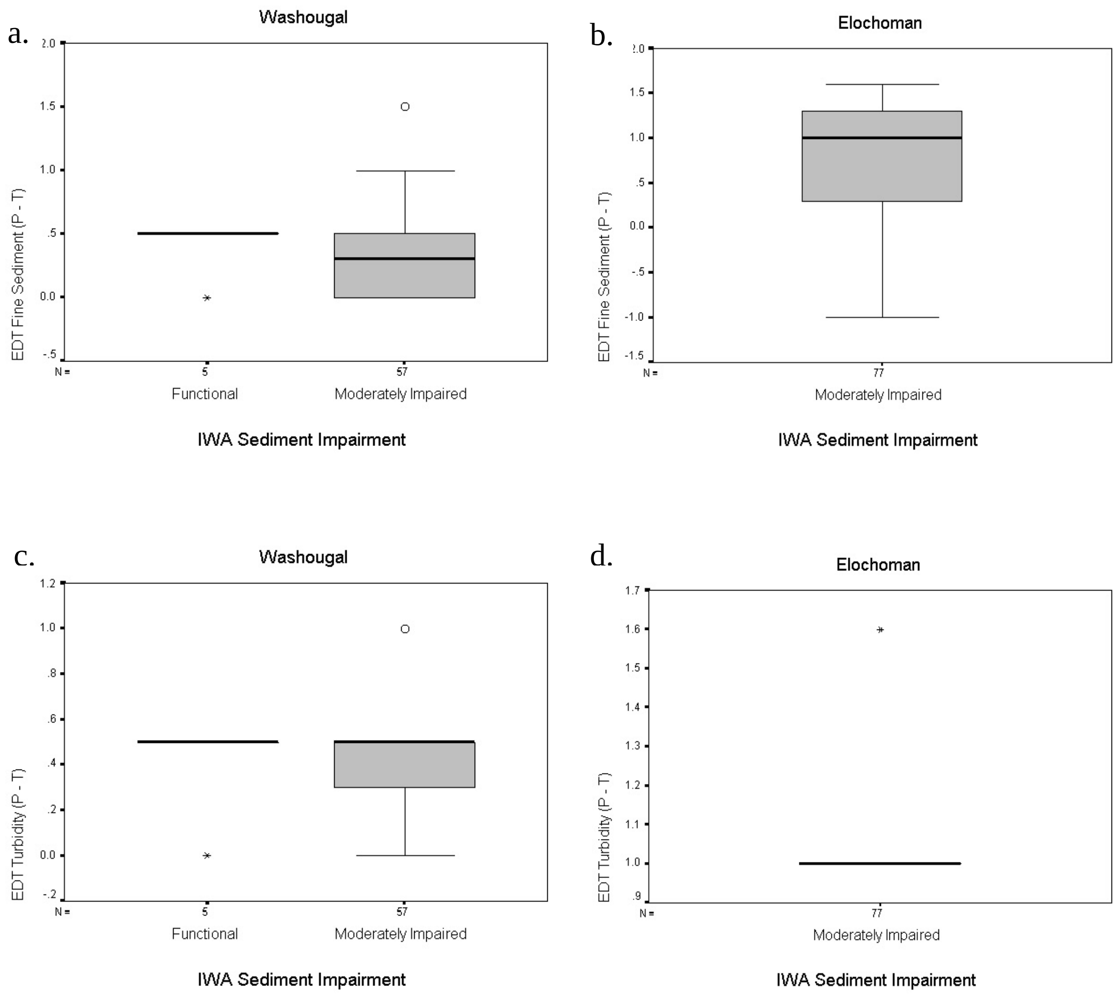

Figure 12. Frequency distribution of EDT Fine Sediment scores (P – T) in IWA Sediment impairment categories for the Washougal (a) and the Elochoman (b). Frequency distribution of EDT Turbidity scores (P – T) in IWA Sediment impairment categories for the Washougal (c) and the Elochoman (d). The box represents the interquartile range which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median.

For the Elochoman and the Washougal, all or nearly all of the subwatersheds are ranked Moderately Impaired in IWA, whereas the fine sediment and turbidity EDT values exhibit more variability, except for Elochoman turbidity (Figure 12). This pattern is similar for all of the subwatersheds throughout the region. This suggests that the IWA sediment rating may not be fine enough to segregate out modest changes in road densities. EDT, on the other hand, does break out sediment impacts to a finer scale, although it is impossible to assess the suitability of the values using this analysis. In the Washougal, where we have two IWA categories, the correlation is poor between EDT and IWA (Figure 12a and Figure 12c). The reason for this discrepancy is not entirely clear, but may be related to the use of expert opinion in EDT and/or the different attributes considered in EDT versus IWA. A comparison of expert opinion derived scores (Washougal) versus scores derived using newer techniques (Elochoman) was not possible due to the low variability in IWA categories.

Recommendations:

Use IWA to assist in the development of EDT fine sediment scores. IWA has an advantage over the Rittmueler (1986) relationship in that it considers soil erodability and watershed slope, in addition to road density. Thus, a watershed with high soil stability and low slope would not be as affected by high road density as would a steep, unstable basin. A disadvantage of using IWA to derive EDT scores is that a relationship between IWA values and percent fines would need to be established. In addition, IWA would essentially predict sediment delivery rates, and would need to be adjusted for accumulation as WDFW has done for the values derived using the Rittmueler (1986) relationship.

Where turbidity data is scarce or absent, IWA sediment impairment could be used to generate EDT turbidity scores, however, where data exists, using the Scale of Severity index as outlined in the EDT guidelines (MBI 2003) would provide a more direct representation of turbidity.

c) Riparian Comparison

A number of EDT level 2 attributes are related to riparian condition in some fashion (i.e. confinement, bed scour, wood); however, the 'riparian function' attribute is most related to the IWA riparian rating. The EDT riparian function score is based on vegetation conditions, hydro-confinement, and the presence of road or development impacts. The score ranges from 0 to 4, with 0 representing pristine conditions and 4 representing fully degraded conditions. The IWA riparian rating uses only the percent of the riparian area within a particular vegetation class. The EDT and IWA values are expected to generally conform, though inconsistencies are expected in some cases due to the different rating techniques. EDT reaches were compared to the IWA subwatershed encompassing them. The EDT and IWA values are compared by looking at the frequency distribution of EDT scores within IWA riparian impairment categories.

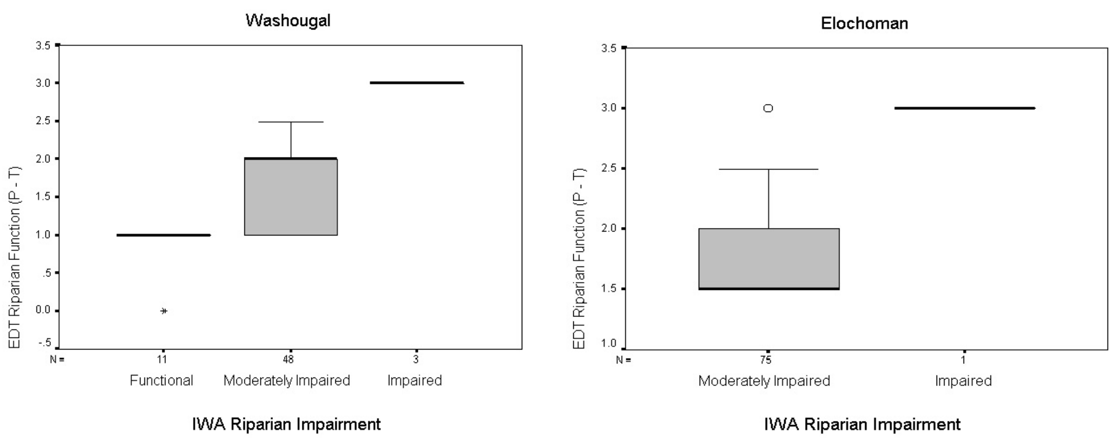

Figure 13. Frequency distribution of EDT Riparian Function scores (P – T) in IWA Riparian impairment categories. The box represents the interquartile range which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. A line across the box indicates the median.

For the Washougal basin, EDT riparian scores generally conform to IWA riparian impairments, with only minor overlap (Figure 13). The similarity is because of the use of vegetation conditions in both models. Most of the subwatersheds were rated Moderately Impaired in IWA, which corresponds to a range of 1.0 to 2.5 for EDT P – T. There is also conformity in the Elochoman, although true conformity is difficult to assess because there is only one impaired subwatershed in the basin and that subwatershed contains only one EDT reach. Nevertheless, the EDT P – T scores in the Moderately Impaired category exhibit a similar range (1.5 – 2.5, excluding outliers) as in the Washougal. These results demonstrate that IWA and EDT are generally consistent with regards to riparian function.

Recommendations:
EDT inputs could benefit from using the same data sources used in IWA but not the IWA ratings themselves because of the shorter length of EDT reaches compared to IWA subwatersheds (Figure 10). EDT scoring could be accomplished using a simple GIS overlay of vegetation class polygons (the same info used in IWA) on EDT reach riparian buffers. This information could be further adjusted based on artificial confinement and the presence of roads / development. Incorporating artificial confinement and the presence of roads / development into IWA could serve to bolster IWA and allow for a direct link with EDT inputs.

d) Discussion

EDT and IWA correlate fairly well for the hydrology and riparian attributes. Sediment shows the weakest correlation. It is difficult, however, to determine the source of the discrepancy. Comparison of EDT sediment scores and IWA ratings to empirical data could assist with determining potential error; however, a severe lack of empirical sediment data throughout the region complicates such an evaluation. Poor correlation in the case of sediment may also be due to the fact that IWA is concerned with sediment delivery and EDT is concerned with sediment accumulation, so it is not entirely an ‘apples to apples’ comparison.

IWA could be used to derive EDT scores for fine sediment, embeddedness, FlowHigh, and FlowPattern, and could possibly assist with rating other EDT attributes. Linking watershed process modeling to EDT scoring in this fashion could decrease the reliance on expert opinion. Such a link could also benefit EDT scenario-building and other techniques using IWA and EDT to identify land-use changes that yield fish benefits.

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V. Supplemental Information

Table 7. Trap locations where outmigrant data were obtained and the source of those data.

Basin	Trap Location	Source
Alsea	Cascade Cr.	Solazzi et al. 2003
Alsea	E. Fk. Lobster Cr.	Solazzi et al. 2003
Clackamas	Fish Cr.	Shibahara and Taylor 2001
Clackamas	Big Bottom (mainstem)	Shibahara and Taylor 2001
Clackamas	Oak Grove Fk.	Shibahara and Taylor 2001
Clackamas	N. Fk. Clackamas	Shibahara and Taylor 2001
Clackamas	N. Fk. Eagle Cr.	Shibahara and Taylor 2001
Clackamas	Above N. Fk. Dam (mainstem)	Shibahara and Taylor 2001
Coos	Fall Cr.	Solazzi et al. 2002
Coos	Bottom Cr.	Mario Solazzi, ODFW, personal comm. 2003
Coos	N. Fk. Coquille R.	Mario Solazzi, ODFW, personal comm. 2003
Coos	Winchester Cr.	Solazzi et al. 2003
Hood	Hood R. (mainstem)	Olsen draft 2003
Kalama	Gobar Cr.	Loch et al. 1985
Kalama	Kalama R. (trap near Kalama Falls Hatchery)	Loch et al. 1985; Cameron Sharpe, WDFW, personal comm. 2003
Kilchis	Little S. Fk. Kilchis R.	Solazzi et al. 2003
L. Columbia	N. Fk. Scappoose Cr.	Solazzi et al. 2003
L. Columbia	Germany Cr.*	Patrick Hanratty, WDFW, personal comm. 2003
L. Columbia	Mill Cr.*	Patrick Hanratty, WDFW, personal comm. 2003
L. Columbia	Abernathy Cr.*	Patrick Hanratty, WDFW, personal comm. 2003
Lewis	Cedar Cr.	Dan Rawding, WDFW, personal comm. 2003
Nehalem	N. Fk. Nehalem R.	Solazzi et al. 2003
Nehalem	Upper N. Fk. Nehalem R.	Solazzi et al. 2002
Nehalem	Upper Nehalem R.	Mario Solazzi, ODFW, personal comm. 2003
Nestucca	Little Nestucca R.	Mario Solazzi, ODFW, personal comm. 2003
Oregon Coast	Tenmile Cr.	Solazzi et al. 2003
Oregon Coast	Cummins Cr.	Solazzi et al. 2003

Oregon Coast	Euchre Cr.	Tom Satterthwaite, ODFW, personal comm. 2003
Oregon Coast	Hunter Cr.	Tom Satterthwaite, ODFW, personal comm. 2003
Oregon Coast	Hinkle Cr.	Dave Harris, ODFW, personal comm. 2003
Siletz	Mill Cr.	Solazzi et al. 2003
Umpqua	W. Fk. Smith R.	Solazzi et al. 2003
Umpqua	Smith R.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Big Tom Folley Cr.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Brush Cr.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Elk Cr.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Rock Cr.	Dave Harris, ODFW, personal comm. 2003
Umpqua	Cow Cr.	Dave Harris, ODFW, personal comm. 2003
Wilson	Little N. Fk. Wilson R.	Solazzi et al. 2003
Wind	Wind R. (mainstem)**	Rawding 2000
Yaquina	Mill Cr.	Solazzi et al. 2003
Yaquina	Bales Cr.	Solazzi et al. 2003

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Documentation used in the Ecosystem Diagnosis and Treatment Model (EDT) for Washington Lower Columbia Salmon and Steelhead Populations

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7.0 Documentation used in EDT Model

7.1 Germany, Abernathy, Mill, Elochoman, and Skamokawa Watersheds

7.1.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treament Model (EDT) for Skamokawa Creek, Elochoman River, Mill Creek, Abernathy Creek, and Germany Creek. In this project we rated over 300 reaches with 46 environmental attributes per reach for current conditions and another 45 for historical conditions. Over 27,000 ratings were assigned and empirical observations within these reaches were not available for all of these ratings. In fact less than 20% of these ratings are from empirical data. To develop the remaining data we used expansion of empirical observations, derived information, expert opinion, and hypothetical information. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute we could find no data within these watersheds. However, Rittmueller (1986) established a relationship between road density and fine sediment in Olympic Peninsula watersheds. We applied this relationship to these watersheds; this is an example of derived information. In some cases such as bed scour we had no data for these basins. However, data is available from the Gobar Creek in the Kalama River and observations have been made in the Wind River. We noted that bed scour is related to gradient, stream width, and confinement. Based on these observations expert opinion was used to estimate bed scour. For rationale behind the ratings see the text below. For specific reach scale information please see the EDT database for the watershed of interest.

Current EDT estimates can be validated when long-term estimates of wild spawners, hatchery spawners, reproductive success of hatchery spawners, and smolts are available. This information in a long enough time series was not available for these watersheds. However, the predicted estimates of steelhead smolt production at equilibrium are reasonably close to estimates from current Washington Department of Fish & Widlife (WDFW) trapping in Mill, Abernathy, and Germany Creeks. Predicted estimates for coho at equilibrium are higher than the observed coho smolt production estimates. However, when current coho harvest rates are considered, the predicted and actual estimates converge. Chum salmon surveys indicate that these fish are at very low abundance levels in these watersheds but current EDT model estimates suggest they may be sustainable at low levels. There was not sufficient information for a comparison for chinook salmon. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.1.2 Recommendations

Adult chum salmon, chinook salmon, and steelhead population estimates should continue. However, more emphasis should be placed on determining the number of hatchery spawners and their reproductive success. Adult population estimates for coho salmon should be initiated. Coho, steelhead, and cutthroat smolt population estimates on Mill, Abernathy, and Germany Creeks should continue for another 10 years and be expanded to include chum and chinook salmon. Adult and juvenile population estimates will allow for more accurate assessments of population status, validation of EDT, and to determine if subbasin restoration actions are effective.

The Cowlitz-Wahkiakum Conservation District data suggests that maximum temperatures in the middle mainstem of these watersheds increase rapidly. A temperature monitoring program should be established to assess maximum water temperatures for each watershed used by anadromous fish and to locate stream reaches where rapid increase in temperature occurs. The factors that cause the increased reach temperatures should be examined and actions to correct the increase in maximum temperature should be developed.

Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating as would field surveys.

Sediment estimates were derived information or expanded information from a few observations. A sediment monitoring program should be developed to assess % fines, embeddedness, and turbidity in reaches used by anadromous fish.

Differences existed between field and GIS ratings of natural confinement. The SSHIAP database should be field verified.

Flow and bed scour are not monitored in these basins and estimates were obtained from derived information and expert opinion. To accurately estimate bed scour and flow, stream gauges should be established or re-established in these watersheds.

WDFW habitat surveys in 2002 were opportunistic; that is, based on a limited amount of resources, we chose to survey only a lower, middle, and high mainstem reach and important representative tributary reaches in each watershed. In addition, glides and pools were distinguished subjectively and not quantitatively. To accurately estimate stream habitat type within the anadromous distribution type a statistically valid sampling design should be developed and applied (Hankin and Reeves1988 or EMAP). Surveys methodology should differentiate between pools and glides and be repeatable. Currently USFS surveys do not differentiate between pools and glides while TFW surveys allow this distinction.

We used an older EDT guideline to derive an estimate of benthos diversity. Estimates of benthic diversity should be made using a Benthic Index of Biological Integrity (B-IBI).

Not all obstructions were rated using SSHIAP database. Obstruction ratings need to be finalized. Estimates of coho performance may change with undated ratings.

7.1.3 Attributes

7.1.3.1 Hydrologic regime—natural

Definition—The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale—These watersheds originate from the Willapa Hills. The maximum elevation is approximately 3,000 ft, which is below the elevation of substantial snow accumulation. These elevations are consistent with rainfall-dominated watershed and are classified as such. These watersheds were given an EDT rating of three for the historic and current conditions. The rainfall pattern was used to shape, estimates of flow and temperature in the EDT model.

Level of Proof—Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.1.3.2 Hydrologic regime—regulated

Definition—The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale—These watersheds do not have artificial flow regulation. These watersheds were given an EDT rating of 0 for the historical and current conditions.

Level of Proof—Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.1.3.3 Flow—change in interannual variability in high flows

Definition—The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale—By definition the template conditions for this attribute are rated as a value of two because this describes this attribute rating for watersheds in pristine conditions. Direct measures of inter annual high flow variation are not available for most basins. USFS has conducted watershed analysis in the EF Lewis, NF Lewis, Wind, White Salmon, Washougal, Kalama, Cowlitz, and Cispus Rivers and Rock Creek (USFS 1995a, USFS 1995b, USFS 1996a, USFS 1996b , USFS 2000). Peak flow analysis was conducted using the State of Washington *Standard Methodology for Conducting Watershed Analysis.* The primary data used for the peak flow analysis is vegetation condition, elevation, road network, and aspect. The results for increased risk in peak flow from the USFS watershed analysis are shown in Table 7-1. For watersheds in which the two-year peak flow increases 10% the EDT rating is 2.3. For increases of 5% the EDT rating is 2.13. Based upon the above USFS watershed analyses, when no basin specific data was available for forested watersheds with road systems we assumed a peak flow increase of 10%, and assigned an EDT rating of 2.3.

Table 7-1.Summary of USFS Watershed Analysis for the change in peak flow

Basin	# of Subbasins	Increase in Peak Flow
Wind	26	2-14%
East Fork Lewis	9	5-13%
Lower Lewis		10-12%
Rock Creek		1-5%
Upper Kalama		5-10%
Cispus		<10%

Level of Proof—Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.1.3.4 Flow—changes in interannual variability in low flows

Definition—The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale—By definition the template conditions for this attribute are rated as a value of two because this describes this attribute rating for watersheds in pristine conditions. Research on the effects of land use practices on summer low flow is inconclusive. Therefore, we rated the template and current conditions the same (EDT rating of 2).

However, water withdrawals may reduce summer flow and the specific withdrawals listed below reduced summer low flow. The Abernathy Technology Center intake removes as much as 70% of flow at summer low flows (pers. com. Abernathy Technology Center). From its withdrawal point to the hatchery outflow, this reach was rated as 3.0. The tide gate and pumping station on Brooks Slough in the Skamokawa subbasin prevents tidal flooding of Brooks 2 reducing estuarine habitat. This reach was rated at 2.5. The Elochoman Hatchery has 3 intakes. Two are located on the mainstem Elochoman in reach 8 and another in Clear Creek in reach 3. Since the Clear Creek intake is not operated in the late summer months and Clear Creek was rated as 2.0. The intakes in Elochoman River affect 20% of reach 8. 1940-71 avg August flow was 43 cfs. The Elochoman Hatchery uses 8-10 cfs or approx. 20-25% of total Elochoman flow in August. Based on this information Elochoman 8 was rated at 2.25. The intake for the water supply for Cathlamet is located at the top end of Elochoman reach 3 and supplies 100% of the town's water. The exact amount of water withdrawn was unavailable, but likely significantly reduces flows in the reach. Elochoman 3 was rated 3. Elochoman 1 & 2 are downstream, but tidal, so the affects of the withdrawal are lessened by tidal influence. These reaches were rated at 2.5 for summer low flow.

Level of Proof—Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.1.3.5 Flow—intra daily (diel) variation

Definition—Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale—By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. This attribute was given an EDT rating of 0 for the current conditions due to the lack of storm water runoff and hydroelectric development. There are no major metropolitan areas in these watersheds with large areas of impervious surfaces.

Level of Proof—Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.1.3.6 Flow—Intra annual flow pattern

Definition—The average extent of intra-annual flow variation during the wet season—a measure of a stream's flashiness during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale—By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in these watershed. Based on USFS watershed analyses we assumed a 10% increase in peak high flows. Since there was no data for this attribute, it was suggested that its rating should be similar to that for changes in lnter variability in high flows, which translates to an EDT rating for intra-annual flow of 2.3 (pers. com. Larry Lestelle, Mobrand, Inc).

Level of Proof—Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.7 Channel length

Definition—Length of the primary channel contained within the stream reach—Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only—multiple channels do not add length.

Rationale—Ned Pittman (WDFW) provided the length of each reach from SSHIAP GIS layers. We assumed the stream length was the same in both the historical and current conditions.

Level of Proof—Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.1.3.8 Channel width—month minimum width

Definition—Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale—We assigned the same value for both the current and historical conditions, unless a major hydromodification within the reach affects stream width. Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). Wetted widths corresponding to average summer low flows (August) were measured as part of these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement. For reaches above a split (confluence of 2 tributaries), wetted width was calculated by: {(1.5*downstream reach width)*0.5} for even splits. For uneven splits, the multiplier was adjusted to compensate. In a

60:40 split: (1.5*drw)*0.6 and (1.5*drw)*0.4; and for a 70:30 split: (1.25*drw)*0.7 and (1.25*drw)*0.3. These calculations were referred to as the split rule.

For example, in Abernathy Creek mainstem reaches not surveyed were given the same values as surveyed reaches either directly above or below, depending on which had the most similar confinement and gradient. Unnamed tributaries were assigned a width equal to 75% of the value for Weist Creek (Weist 1); the smallest creek surveyed. Reaches Weist 2-8, Sarah 1, Erick 1, and Slide 1-2 were assigned the same value as Weist 1. Values for upstream reaches of Erick/Midway, Sarah, and Ordway creeks were calculated using the split rule. We used similar methodology in the remaining basins.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.9 Channel width—month maximum width

Definition—Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale—Representative reaches in lower Columbia River tributaries were surveyed by Steve VanderPloeg (WDFW) in 2003. Wetted widths corresponding to average winter high flows (January) were measured as part of these surveys. (VanderPloeg 2003). Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Typically less reaches per subbasin were measured during average winter flow as compared to summer flow. We compared the percent increase between low and high flow widths to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data. A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris and hydroconfinement. Therefore, we used actual “wetted width-high” values in reaches where data was available, and a 1.6 multiplier (60%) to expand “wetted width-low” values for reaches without high flow data.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.10 Gradient

Definition—Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale—The average gradient for each stream reach (expressed as % gradient) was calculated by dividing the change in reach elevation by the reach length and multiplying by 100. Ned Pittman (WDFW) used SSHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof—Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical gradient.

7.1.3.11 Confinement—natural

Definition—The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale—Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003. Confinement ratings were estimated during these surveys (VanderPloeg 2003). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps were consulted when SSHIAP ratings fell between the 0.5 increments to determine which rating should be applied. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4. There are often multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings.

Table 7-2. Comparison of SSHIAP and EDT ratings for confinement.

Project	Unconfined	Equal unconfined & mod. confined	Moderately confined	Equal mod confined & confined	Confined
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

Level of Proof—Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.1.3.12 Confinement—hydro-modifications

Definition—The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream’s floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called *headcutting*). Flow access to the floodplain can be partially or wholly cutoff due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees—consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale—In the historic condition (prior to manmade structures and activity) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Most hydro-modification consists of roads in the floodplain and diking. We consulted the SSHIAP GIS roads layer, SSHIAP digital ortho-photos, USGS maps, and WRIA 25 LFA and used professional judgment to assign EDT ratings.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.1.3.13 Habitat type

Definition—Backwater pools is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 in diameter), small cobble (2.9 to 5 in diameter), large cobble (5 to 11.9 in diameter), boulder (>11.9 in diameter).

Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale—Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Habitat type composition was measured during these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement. Lower tidal/slough-like reaches of Elochoman & Skamokawa/ Brooks Slough were rated as 100% glides. One small tributary reach in Mill (Trib1232392462718-3) historically supported salmonids, but an impassable, failed culvert has created a lake. This reach is rated at 100% pool.

2002 habitat surveys primarily followed USFS stream survey level 2 protocols, which delineate between riffles and slow water but not pools and glides. Glide habitat is the most difficult habitat to identify, therefore was estimated but not surveyed. WDFW survey methodology did not appear to work for glides. Therefore, we examined the Wind River data to help differentiate between these two habitat types. Wind River data showed a positive relationship between gradient and/or confinement and riffle. It also showed a negative relationship between pools and gradient and confinement. However, there was no relationship between pools and glides. There was variation between surveyors when the same reach was walked. This may be due to habitat changes but it could also be due to measurement error between surveyors. In general, glides accounted for 30% to 50% of the non-riffle habitat. For this exercise glides were assumed to be 40% of non-riffle habitat. An exception was Elochoman, above the concrete bridge (Hwy. 407 Bridge) we assumed 60% glide and below the salmon hatchery and rock creek 50% glide. Assumptions about glide and pool habitat are most likely to affect coho salmon since they prefer pool habitat during their extended freshwater rearing.

Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991) presented in the Forest Ecosystem Management document July 1992, page V-23. and applying this to current habitat type composition estimates. On Germany Creek, Elochoman River and Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. We assumed current primary pool habitat has been reduced by 50% on average. Stable historical flows and abundant large woody debris maintained higher levels of spawning gravel than the current condition. Due to increases in primary pools and spawning riffles/tailouts, glides were assumed to be less abundant in the template condition.

In general, we assumed for historical conditions that the percentage of pools was twice the current percentage. We assumed that tail-outs represent 15% of pool habitat. In addition we assumed that primary pool capacity is capped at 45%, with a minimum of 20%. Maximum spawning riffles were capped at 20% and glides were approximately 10% except lower sections of the Elochoman River, which were higher. The net affect was spawning riffles were increased by 33%, and glides reduced appropriately. Rosgen C channels historically had more backwater habitat than they currently do.

In Skamokawa Creek for reaches less than 0.2% slope, the habitat was mainly tidal and/or slough-like. We assumed 100% glides. For reaches between 0.2% and 0.9%, habitat is similar and ratings in Skamokawa were based on LF Skamokawa-1 surveys and Elochoman surveys. For reaches between 1% and 2.5%, habitat is similar and ratings for Skamokawa were based on the averages of McDonald-1 and Wilson-2 and Elochoman ratings were based on the averages of WF Eloch-1, EF Eloch-1, and Eloch-12. For reaches greater than 2.5%, habitat is similar and Elochoman and Skamokawa ratings were based on the averages of NF Eloch-3 and Trib1232562463641 (North North Fork Elochoman).

Table 7-3. Reference reaches used to develop ratings for similar reaches

Reference Reaches	Estimated Reaches
Eloch-4	Eloch-3,5&6
Eloch-8	Eloch-9&10
WF Eloch-1	WF Eloch-2
Eloch-12	Eloch-11
EF Eloch-1	EF Eloch-2,3&5 and Trib1231980463654
NF Eloch-3	NF Eloch-2&4

In Germany Creek, we identified six mainstem areas with similar habitat, gradients, and confinement: Germany 1-3, 5 & 6, 7 & 8, 9 & 10, 11-13, 14 & 15. Surveys from these reaches within these areas were expanded for the entire area. For all small tributaries, we used the survey data from Trib1231282461874-1. In Abernathy Creek, we identified the following areas with similar habitat, gradients, and confinement: Abernathy 1&2, 3-7, 8-10, and 11&12; Cameron 1-4; and Ordway 1-6. For all small tributaries, we used the data from Weist-1.

Since we had no WDFW survey data on habitat types for Mill Cr, we assumed a relationship between Mill Creek and Abernathy/Germany Creeks. For reaches less than 0.2% slope, the habitat was mainly tidal and/or slough-like. Glides were weighted at 100%. For reaches between 0.2% and 0.9%, habitat is similar. Mill-1 inferred from Abernathy-1 minus the current Beaver Ponds. The remaining reaches were applied Germany-4's ratings.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.14 Habitat types—off-channel habitat factor

Definition—A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale—When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A , B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis. An EDT rating of 0 was assigned to Aa+ and A channels, a rating of 0 to 1 for B channels, while low gradient C channels were assign EDT ratings of 1 to 2 for the current rating and 2 to 3 for the historical rating. Off-channel habitat was significant in Skamokawa Creek and the Elochman River but not other basins.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.15 Obstructions to fish migration

Definition—Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale—WDFW SSHIAP database was used to identify existing barriers within these watersheds. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. This has not been completed for all barriers. In most cases known fish distribution stopped at all barriers. In some cases where known distribution occurred above barriers passage was assumed to be 100% for the species and all life stages. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon due to their preference for spawning in small tributaries are impacted by barriers. The ratings should be completed for barrier analysis later this month.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.16 Water withdrawals

Definition—The number and relative size of water withdrawals in the stream reach.

Rationale—No water withdrawals occurred in the pristine condition. Most watersheds in this unit are forested with limited agriculture and residential use. Water withdrawals were assumed to be minimal in most areas. Reaches with low gradient, unconfined areas (i.e. farmland) and/or reaches with dwellings built next to the stream were given an EDT rating of 0.1 to account for occasional withdrawals. All other reaches were rated at 0

Abernathy Technology Center utilizes a water intake above the facility for hatchery operations. This intake is screened to prevent entrainment. This reach was given an EDT rating of 1.5. No major withdrawals are known to occur in Germany Creek. In Skamokawa Creek the tide gate/pumping station at the downstream end of Brooks Slough is designed to prevent flooding of the Columbian Whitetail Deer Refuge. Water is pumped out of reach into Brooks Slough-1, reducing estuarine habitat. Pumps are believed to be screened; given an EDT rating of 1.5. The Elochoman Salmon Hatchery has a total of 3 intakes. Two are on the mainstem Elochoman (Elochoman-8): (1) upstream 0.4 miles, and (2) at the hatchery swim-in pond (upper pond). The third is on Clear Creek in Clear-3 just across Elochoman Valley Rd. All are screened and operate at different levels throughout the year depending on water needs. Elochoman-8 was given an EDT rating of 2. Clear-3 was rated at 1.5. The water supply for Cathlamet is just below the concrete bridge (Hwy 407) in Elochoman-3 (top of reach) and supplies 100% of the town's water. The intake is subterranean 2-4 ft below the riverbed. Actual amount of water withdrawn was unavailable. Elochoman-3 was given a rating of 2. Beaver Creek Hatchery is no longer in operation and the intake is shut down.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.1.3.17 Bed scour

Definition—Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 in diameter), small cobble (2.9 to 5 in diameter), large cobble (5 to 11.9 in diameter), boulder (>11.9 in diameter).

Rationale—No bed scour data was available for these basins. Historic bed scour was rated using the look-up table (pers. com. Dan Rawding, WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table relates bed scour to confinement, wetted width (high flow), and gradient and assumes scour increases as gradient and confinement increase. In tidal reaches such as Elochoman-1 and Skamokawa –1 where reach was historically estuarine/wetland bed scour was rated as 0. In tidal reaches such as Germany-1, where scour likely occurred during low tides and high flow events, the pristine look-up table ratings were reduced by ½.

Current EDT ratings were developed and used as the baseline for scour in the current condition. Template ratings for bed scour was increased as follows: Peak flow increased from 2.0 to 2.3 from the template to the patient and we assumed this had a similar effects on bed scour; as hydro-confinement ratings increase 1 point we increased bed scour ratings by 0.1. In tidal reaches such as Elochoman-1 and Skamokawa –1 where reach is currently slough-like (mud bottom) bed scour was rated as 0. In tidal reaches such as Germany-1, where scour likely occurs during low tides and high flow events, the current look-up table ratings (plus added tenths) were reduced by half.

Level of Proof—Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.18 Icing

Definition—Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale—These watersheds are rainfall dominated. Anchor ice and icing events do not occur. EDT ratings of 0 were assigned to all reaches in the historical and current condition.

Level of Proof—Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.1.3.19 Riparian

Definition—A measure of riparian function that has been altered within the reach.

Rationale—By definition the template conditions for this attribute are rated as a value of zero because this describes this attribute rating for watersheds in pristine conditions. Riparian zones with mature conifers are rated at 1.0. Riparian with saplings and deciduous trees are rated as 1.5 due to lack of shade and bank stability. Riparian zones with brush and few trees would be rated as 2. For an EDT rating to exceed 2 residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees it should have a score of two or better. Most current vegetated riparian zones with no hydro-confinement should be rated as a 1 to 1.5. When hydro-confinement exists rating from rules on hydro-confinement were used to increase the riparian rating. Ratings also increased based on lack of vegetation. Key reaches were established for current riparian function through out these watersheds. Other reaches were referenced to these key reaches to develop a final EDT rating.

Key reaches in the Abernathy watershed were rated. Abernathy 1 has 10% hydro-confinement, and a mix of alder and conifers. Alder and immature stands give a score of 1.5 and hydro-confinement led to a score of 0.5. The total riparian score was 2 = (0.5 + 1.5). Based on habitat survey data from Cowlitz-Wahkiakum Conservation District, Ordway-2 is set at an EDT rating of 1 because the riparian area has no roads, 90% conifers within the riparian zone, an average DBH of 14 ines, and average tree height of 80 ft. Abernathy-4 was set at a rating of 2 because the riparian zone lacks trees and where trees are present, they are mid-aged alder. In addition, this reach has a hydro-confinement rating of 1 indicating the road disrupted floodplain connectivity. All riparian ratings in Abernathy Creek will range from 1 to 2.

On Abernathy Creek, the Cowlitz-Wahkiakum Conservation District surveyed all mainstem reaches. For those tributaries with no data we expanded ratings for the following: everything above Cameron-1 we used ratings from Cameron-1, everything above Weist-4 we used ratings from Weist-4, everything above Erik-3.

Key reaches to set riparian function ratings on Germany Creek were Germany-12 and Germany-7, which receive a 2 and a 1, respectively. Other reaches were referenced to these reaches. On Germany Creek, the Cowlitz-Wahkiakum Conservation District surveyed all mainstem reaches. Only 7 tributary reaches were surveyed, with a mean rating of 2. Therefore unsurveyed tributaries were assigned a rating of 2.

Skamokawa 1-3 are rated at 4 due to diking of both banks and lack of riparian vegetation. From Skamokawa 4 to 5, reaches are rated as a 3 due to lack of riparian vegetation and bank erosion. McDonald Creek was rated as a 1 due to presence of old-growth spruce and maple, lack of roads (no hydro-confinement), and lesser bank erosion. Skamokawa 6 was rated as a 2, similar to Abernathy-4.

Table 7-4. Expanded reaches for riparian ratings used for Skamokawa Creek

Measured Reaches	Reaches expanded into
Beaver Cr-2	Trib1233963462747, Alger-3&4, Risk 3&4
Wilson-6	Trib1234882462959-1&2, Trib1233243462950-1 thru 3, and Trib1233218462941
Cadman-3	Cadman-4, Kelly-1 thru 3, Trib1234786463114, and Trib1234799463228
Trib1233641463035-1	Trib1233641463035-3
Falk-3	Falk-1&2
Pollard-2	Pollard-3
Skamokawa-5	Trib1234475463088
LF Skam-2	Trib1234547463284-1&2, Trib1234642463345-1,2&4 and Trib1234695463368
Quarry-1	Quarry-2&3
McDonald-3	McDonald-4&5, and Trib1233973463412-1&2
Standard-2	Standard-3

Elochoman 4 received a rating of 1.5 for its good floodplain connectivity, large mature alders and maples, but lack of conifers. The EF Elochoman received a similar rating because there are no hydromodifications, and the reach has good shade because it is forested. However, the lack of conifers, bank stability and large woody debris recruitment cause a rating of 1.5. The mainstem Elochoman downstream of EF Elochoman was given a rating of 2 for its lack of abundant conifers, and the presence of stream-adjacent road (hydro-confinement). Eloch-12 was given a rating of 2 due to mature mixed stand present on only one side and an old road and fields on right bank, causing a loss of bank stability and shade. The WF Elochoman was given a 1.5 due to lack of conifers, resulting in loss of stability and shade. Although there is more lwd on the

WF than EF, it’s hard to differentiate the two. NF Elochoman received a 2, mainly due to the presence of the road, which decreases shade trees, and sporadic rip-rapping. Elochoman-5 was set at a rating of 2 due to the hydro-confinement rating of 1 because of riprap at hatchery. The right hand bank below Beaver Creek is devoid of vegetation, the left bank has combination of alder and maple with few conifers.

Table 7-5. Expanded reaches for riparian ratings used for Elochoman River

Measured Reaches	Reaches expanded into
Trib1233032462252-3	Trib1233032462252-5
Beaver-6	Beaver-8
Average rating for Beaver & Duck Cr = 3	Clear-1,3&5, Rock-1&3, Trib1232859462932, and Trib1233126462580
Average rating for WF & EF Elochoman, and Otter Cr =4	Otter-2,3&4, Tribs:1231932463600, 1231980463654, 1231991463706, 1232156463572, 1232189463844, 1232307463467, 1232312463788, 1232328463648, 1232792463272, 1232902463299, 1233089463480-2, 1233115463513

There was limited data for the Mill Creek basin. Due to lack of reach specific knowledge and data, and based on recent logging practices within the basin, all reaches were rated at a 1.5, except those with a hydro-confinement rating of 1, which were rated at a 2.

Level of Proof—There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.20 Wood

Definition—The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to large pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Rationale—LWD density was calculated from the Cowlitz-Wahkiakum County Conservation District surveys where density of LWD equals pieces * length/width. Template condition for wood is assumed to be 0 for all reaches except large Canyon sections on the Grays, Coweeman, Kalama, EF Lewis, Washougal, and Wind, which are assumed to be 2. When the Cowlitz-Wahkiakum County Conservation District surveys not available WDFW habitat survey data (VanderPloeg 2003) was used and extrapolated to other reaches. Since WDFW measured large LWD (> 0.5 meters in diameter), we increased the associated EDT rating by 1 to account for small diameter pieces (.1 to .5 meter), which are typically retained in debris jams.

On Germany Creek, the Cowlitz-Wahkiakum Conservation District surveyed all mainstem reaches. Only 7 tributary reaches were surveyed, with a mean rating of 2. Therefore unsurveyed tributaries were assigned a rating of 2. On Mill Creek, the Cowlitz-Wahkiakum Conservation District surveyed reaches Mill-1 thru Mill-7A. The average rating was 3, which was applied to the remaining reaches.

On Abernathy Creek, the Cowlitz-Wahkiakum Conservation District surveyed all mainstem reaches. For those tributaries with no data we expanded ratings for the following: everything above Cameron-1 we used ratings from Cameron-1, everything above Weist-4 we used ratings from Weist-4, everything above Erik-3 and Midway we used ratings from Erick-3, everything above Ordway-3 & 5 we used ratings from Ordway-3.

Table 7-6. Expanded reaches for wood ratings used for Skamokawa Creek

Measured Reaches	Reaches expanded into
Beaver Cr-2	Trib1233963462747, Alger-3&4, Risk 3&4
Wilson-6	Trib1234882462959-1&2, Trib1233243462950-1 thru 3, and Trib1233218462941
Cadman-3	Cadman-4, Kelly-1 thru 3, Trib1234786463114, and Trib1234799463228
Trib1233641463035-1	Trib1233641463035-3
Falk-3	Falk-1&2
Pollard-2	Pollard-3
Skamokawa-5	Trib1234475463088
LF Skam-2	Trib1234547463284-1&2, Trib1234642463345-1,2&4 and Trib1234695463368
Quarry-1	Quarry-2&3
McDonald-3	McDonald-4&5, and Trib1233973463412-1&2
Standard-2	Standard-3

Table 7-7. Expanded reaches for wood ratings used for Elochoman River

Measured Reaches	Reaches expanded into
Trib1233032462252-3	Trib1233032462252-5
Beaver-6	Beaver-8
Average rating for Beaver & Duck Cr = 3	Clear-1,3&5, Rock-1&3, Trib1232859462932, and Trib1233126462580
Average rating for WF & EF Eloch, and Otter Cr =4	Otter-2,3&4, Tribs:1231932463600, 1231980463654, 1231991463706, 1232156463572, 1232189463844, 1232307463467, 1232312463788, 1232328463648, 1232792463272, 1232902463299, 1233089463480-2, 1233115463513

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations were used to estimate the ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.1.3.21 Fine sediment (intragravel)

Definition—Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of fine sediment here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale—In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et. al. 1992) and EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3. Reaches above tidal with low gradient and slower flows likely also had increased fine sediment and embeddeness and were given an EDT rating of 1.

Rittmueller (1986) found that as road density increased by 1 km/sq.km, fine sediment levels increased by 4.3%. To rate % fines in the current condition, a scale was developed relating road density to % fines. The majority of Rittmueller's data was on streams with gradients of 0.5% to 1.5%. As gradients increased % fines would decreased. For gradients between 2% and 5%, we assumed fines were reduced by 25% and for gradients above 5% we assumed fines decrease by 50%.

Tidal reaches with lower gradients were given an EDT rating of 4. Slough-like reaches above tidal reaches or tidal reaches with increased flow during outgoing tide (i.e. Germany Ck.) were rated as follows: rating from road density scale + 1.

For Germany, Abernathy, Mill, Skamokawa, Elochoman, and North Elochoman the road densities (mi/mi^2) were 5.8, 4.2, 4, 4, and 2.5, respectively (Lunetta et al., 1997 and Eric Doyle, URS Pers Com).

Level of Proof—A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.1.3.22 Embeddedness

Definition—The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale—In the template (pristine) condition, SW Washington watersheds were assumed to have less than 10% embeddedness. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2. Reaches above tidal with low gradient and slower flows likely also had increased fine sediment and embeddeness and were given an EDT rating of 1.

Rittmueller (1986) found that as road density increased by 1 km/sq.km, fine sediment levels increased by 4.3%. To rate embeddedness for the current condition, We assumed that the percent embeddness was directly related to percentage of fines in spawning gravel. A scale was then developed relating road density to percent embeddedness. The majority of Rittmueller's data was on streams with gradients of 0.5% to 1.5%. As gradients increased percent embeddedness would decrease. For gradients between 2% and 5%, we assumed embeddedness was reduced by 25% and for gradients above 5% we assumed embeddedness decreased by 50%.

Tidal reaches with lower gradients were given an EDT rating of 3. Slough-like reaches above tidal reaches or tidal reaches with increased flow during outgoing tide (i.e. Germany Ck.) were rated as follows: rating from road density scale + 1.

For Germany, Abernathy, Mill, Skamokawa, Elochoman, and North Elochoman the road densities (mi/mi^2) were 5.8, 4.2, 4, 4, and 2.5, respectively (Lunetta et al 1997 and Eric Doyle URS Pers Com).

Level of Proof—A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.23 Turbidity (suspended sediment)

Definition—The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale—Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. An EDT rating of 0 was assigned to all reaches.

Suspended sediment, turbidity, and flow data does not exist or is limited for the Skamokawa, Abernathy, Mill, Germany and Coal Creek watersheds. Flow data and limited turbidity data are available for the Elochoman River from the USGS website (http://wa.water.usgs.gov/realtime/historical.html). Historical turbidity data was plotted versus flow data from the same time period. Prior to 1978, USGS turbidity data was recorded in JTU. Since 1978, turbidity data has been recorded in NTU. There is not a direct conversion from JTU to NTU, making it difficult to interpret turbidity data prior to 1978.] Maximum turbidity was recorded at 65 JTU on 12/26/1972 at a flow of 3700 cfs. Assuming a 1:1 conversion this equals 65 NTU. Assuming a 1:4 conversion this equals 260 NTU. Excluding the maximum turbidity on 12/26/72, turbidity ranged from 2.7 to 60 JTU/NTU (depending on the conversion used) at flows greater than 1000 cfs.

To try and understand the duration of high flow and turbidity events, the 1940 to 1971 Elochoman River discharge dataset was queried to determine the average number of days/year, in which discharge exceeded 1000, 2000, 2500, 3000, and 3700 cfs. Results were: 29, 6, 3, 2, and 1 days/year, respectively. The average monthly flow for this time period was 794 cfs for December and 783 cfs for January. The turbidity to suspended sediment (SS) relationship for Puget lowlands provided in the EDT guidelines was used to equate turbidity to SS. This relationship shows that at approximately 100 NTU suspended sediment equals approximately 500 mg/l. 260 NTU would equal approximately 1800 mg/l SS.

From these results we determined that flows greater than 2000 cfs were infrequent. At flows less than 2000 cfs, turbidity was found to be less than 60 NTU. The infrequent events greater than 2000 cfs may produce SS readings greater than 1000 mg/l for short durations. An EDT rating of 1.6 was determined to best fit these results. The turbidity ratings were taken in the lower Elochoman watershed below agriculture lands, where sediment inputs can be high. Above Beaver Creek, the watershed was given a rating of 1.

Based on this information the EDT rating of 1.0 was used for entire Abernathy, Germany, and Mill Creek watersheds. The lower Skamokawa (Wilson Creek down) and Brooks Slough (1&2) were rated at 1.6, which is similar to the lower Elochoman. All other reaches in Skamokawa were rated at 1.0.

Level of Proof—A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.1.3.24 Temperature—daily maximum (by month)

Definition—Maximum water temperatures within the stream reach during a month.

Rationale—The Cowlitz-Wahkiakum County Conservation District placed temperature loggers in various locations within Elochoman, Grays, Skamokawa, Abernathy, Mill, Germany, and Coal creek watersheds during the summer of 2002. This data was entered into the EDT temperature calculator provided by Mobrand, Inc. to produce EDT ratings for August. To develop maximum temperature ratings for the remaining months, we used the template monthly pattern "TmpMonMax Rainfall" (9) for the rainfall dominated watersheds in SW Washington. Elochoman River and Clear Creek temperatures are taken daily at the Elochoman Hatchery from intakes for each stream. The 12-year average from the Elochoman and 4-year average from Clear Creek for temperatures on these streams was compared to the 2002 temperatures. It was found that August 2002 temperatures were very near average. It was assumed temperatures recorded in other watersheds during 2002 were also near average.

The EDT ratings generated by the temperature calculator were used for reaches with a temperature logger present, and ratings for other reaches were inferred/extrapolated from these based on proximity and similar gradient, habitat, and confinement. If temperature loggers were mid-reach we used the reading for the entire reach. If temperature loggers were at the end of the reach and evidence from other temperature loggers above indicated there was cooling within the reach (as you move upstream), professional judgment was used to develop an average for the reach. The same logic was applied to reaches without temperature loggers located between reaches with temperature loggers—ratings from reaches with temperature loggers were feathered for reaches in between. Readings from loggers at the end of a reach were used to estimate the rating for the reaches downstream.

The Regional Ecosystem Assessment Project estimated the range of historical maximum daily stream temperatures for the Cowlitz at 12-19 C, the Lewis at 15-19 C, the Hood/Wind at 7-20 C (USFS 1993). However, this broad range was not very informative for historical individual reach scale temperatures.

Historical maximum stream temperature data was limited in the Lower Columbia River domain. The only historical temperatures data that we located were temperatures recorded in the

1930's and 40's while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of a spot measurement and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate maximum temperature we had to look at the effect of human activities that effect thermal energy transfer to the stream. Six primary process transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2002). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. Elevation of stream reaches is estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated bankfull width and assumed that trees in the riparian zone were present at the edge of bankfull delineation in the smallest tributaries but averaged 5 meters from the bankfull with class 3 streams . Next we assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these tress are estimated to be between 40—50 meters for cedar to 60 to 80 meters for Douglas fir (Pojar and MacKinnon 1994). USFS uses 51 meters as the average tree height in the riparian within the western hemlock zone (Brian Bair, USFS personal communication). The combination of the height of the bank and average effective tree height was 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade we used the relationship between forest angle and percentage of shade (Doughty et al 1991, page 35 Table 5.1). Finally we used the relationship between elevation, percentage of shade and the maximum daily stream temperature to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for historical water temperature.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams our estimates of stream shade were slightly lower (70% to 80%). These differences are not unexpected, since the Doughty et al. (1991) developed their shade and forest relationship for larger stream (class 1-3) and it does not account for the increased shade provided by tree limbs in small streams.

Level of Proof—A combination of derived information and expert opinion was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.1.3.25 Temperature—daily minimum (by month)

Definition—Minimum water temperatures within the stream reach during a month.

Rationale—Elochoman Hatchery monitors temperature in the Elochoman River and Clear Creek. The 12-year average for Elochoman and the 4 year average for Clear Creek for temperatures on these streams was compared to the 2002 temperatures from the Cowlitz/Wahkiakum County Conservation District temperature loggers in Elochoman, Grays, Skamokawa, Abernathy, Mill, Germany, and Coal creek watersheds during 2002. It was found that January 2002 temperatures were average. This data was plugged into the EDT temperature calculator (MS Access) provided by Mobrand, Inc. to produce EDT ratings. These data indicate that the minimum water temperature rarely dropped below 4 degrees. The historic minimum temperature was assumed to be the same as current minimum temperatures—with the coldest day >4 deg C.

Level of Proof—Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.1.3.26 Temperature—spatial variation

Definition—The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale—Historically there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. These reaches were given an EDT rating of 1. Higher gradient reaches of the mainstem and tributaries higher in the watershed likely had less groundwater input. These reaches were given an EDT rating of 2. We could not find any data on the current or historical conditions for ground water input. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2. Higher gradient reaches in the upper watershed are likely similar to the historic condition and were given an EDT rating of 2.

Level of Proof—Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.27 Alkalinity

Definition—Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.

Rationale—Alkalinity was estimated from historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) for conductivity on the Elochoman, Washougal, Wind, Kalama, and Lewis Rivers using the formula: Alkalinity =0.421*Conductivity—2.31 from Ptolemy (1993). Alkalinity values for the five aforementioned rivers were averaged resulting in 17.8mg/l or an EDT rating of 1.8. This value was used for Abernathy, Germany, Mill and Skamokawa Creeks. For the Elochoman River alkalinity was calculated as 26.7 mg/l or an EDT rating of 2.1. Alkalinity in the historic condition was given the same value as the current condition.

Level of Proof—A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.1.3.28 Dissolved oxygen

Definition—Average dissolved oxygen within the water column for the specified time interval.

Rationale—Dissolved oxygen in the template (historic) condition was assumed to be unimpaired. Summers (2001) reported that in surveyed creeks dissolved oxygen levels were greater than 8 mg/l in August. All reaches in these watersheds were assumed to be unimpaired for dissolved oxygen, except for the lower slough reaches of Elochoman and Skamokawa where water temperatures are consistently elevated in July/August.

WRIA 25 LFA reports Skamokawa is 303 D listed for temperature, dissolved oxygen, and turbidity (Wade 2002). A 1975 fish kill prompted a water assessment. “Aerating falls and riffles as well as attached aquatic plants are almost nonexistent in the lower reaches of the creek due to the silty bottom conditions which prevail. During the early morning hours when the dissolved oxygen concentration reaches a minimum, the added burden of several hundred fish moving upstream to spawn probably caused critical dissolved oxygen concentrations to be reached,” (Tracy 1975 cited in Norton 1981). Based on this information, Skamokawa 1-3, WF Skamokawa 1, Brooks 1-2, Alger 1A, and Risk 1 were given an EDT rating of 1.0. All other reaches in the basin are assumed to be unimpaired and were rated at 0.

WRIA 25 LFA reports Elochoman is 303 D listed for temperature (Wade 2002). There is a correlation between water temperatures and dissolved oxygen. Elochoman 1-2, and Nelson 1-2 are slough-like and lack aerating falls and riffles and aquatic plants. Elochoman reaches from Beaver Creek Hatchery to tidal (3-5) are wide with little shading from riparian cover. Warm August temperatures, low summer flows, and nutrient enrichment in these areas likely reduce DO levels. Elochoman 1-5 and Nelson 1-2 were given an EDT rating of 1.0. All other reaches were rated at 0.

Level of Proof—A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. There is more uncertainty in the ratings for reaches with sloughs, than for riverine reaches.

7.1.3.29 Metals—in water column

Definition—The extent of dissolved heavy metals within the water column.

Rationale—Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof—Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because, of the lack of data.

7.1.3.30 Metals/Pollutants—in sediments/soils

Definition—The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale—Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof—Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.1.3.31 Miscellaneous toxic pollutants—water column

Definition—The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale—Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof—Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.1.3.32 Nutrient enrichment

Definition—The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale—Actual data for this attribute is very limited. Historically nutrient enrichment did not occur because watersheds were in the pristine state. To determine the amount of nutrient enrichment in various reaches the following factors were examined: fertilizing by timber companies, reaches downstream from hatcheries, agriculture effects, septic tanks, and storm water run-off.

Except for Elochoman and Skamokawa valleys, Nutrient enrichment throughout these watersheds was assumed to be non-existent or at low levels. Fertilizing by timber companies is very minimal—less than 250 acres @ 435 lbs. fertilizer/acre in 2002. (pers. com. Mebust, Cathlamet Timber Company).

A small amount of nutrient enrichment may be occurring below Abernathy Technology Center from hatchery operations there. The reach directly below the hatchery was given an EDT rating of 1. Effects were assumed to be diluted by incoming tributaries. The EDT rating was reduced to 0.75 below Slide Creek and 0.5 below Cameron Creek.

In Germany Creek a small amount of nutrient enrichment may be occurring in reaches 4-6. This area is less confined and the river valley bottom is used for agriculture by private landowners—mostly grazing of cattle and other livestock as well as growing hay. Reach 5 is probably the most heavily impacted, and was given an EDT rating of 0.8. Reaches 1-4 (downstream) were diluted only slightly (0.5) as there are no major tributaries entering in these reaches, only small feeder streams and seepage. Reach 6 was given a rating of 0.5.

The lower portion of Mill-3 has a few homes along the creek, but aerial photos indicate agriculture use next to the stream is minimial—this reach was rated at 0. South Fork Mill-1 is low gradient/unconfined and has some small scale agriculture and potential for septic inputs from homes in the reach. This reach was given an EDT rating of 0.5. Mill 1 and 2 (below confluence with SF-1) likely dilute the effects of nutrient enrichment and were given a rating of 0.25.

The lower reaches of the Skamokawa watershed (West, Middle, East Valley. & lower Skamokawa) have a significant amount of agriculture (mostly grazing of livestock), and the potential for fertilizing. The valleys are rural, but with a significant amount of homes, with the potential for septic input into the watershed. A 1975 WQ assessment (prompted by a fish kill) found that fecal coliform was above state standards and probably caused by human and animal sources (Wade 2002). Lower valley reaches were rated between 1 and 1.5. Upper watershed reaches were rated at 0.

The lower reaches of the Elochoman watershed (Elochoman 1-6 and Nelson 1-2) have a significant amount of agriculture (livestock) and the potential for fertilizing and septic inputs from homes along the stream. The Elochoman Salmon Hatchery outflow channel is in reach Elochoman 7. The hatchery may produce some low level nutrient enrichment from hatchery operations. Dilution by downstream tributaries is negated by agricultural/septic inputs in downstream reaches. Eloch 1-7 and Nelson 1-2 were given an EDT rating of 1.5. All other reaches were rated at 0.

Level of Proof—Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.1.3.33 Fish community richness

Definition—Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale—Historical fish community richness was estimated from the current distribution of native fish in these watersheds (see below). Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness was estimated from direct observation (stream surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, and local knowledge. Anadromous fish distribution was estimated from the above as well as the SSHIAP fish distribution layer & EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in SW Washington watersheds: 1) smolt trapping activities on Abernathy, Germany, and Mill creeks (pers. com. Hanratty, WDFW), 2) electro-shocking in 2002 by USFWS in Abernathy Creek (pers. com. Zydlewski, USFWS), 3) electroshocking by WDFW in many SW Washington tributaries (pers. com. Hallock, WDFW), 4) WDFW snorkel surveys on the Elochoman River (pers. com. Byrne, WDFW), 5) species present in Hardy Slough (pers. com. Coley, USFWS), 6) Reimers and Bond (1967), and 7) McPheil (1967).

A spreadsheet summarizing the above data sources was developed: (EDT 2003 Data.xls pers. com. Glaser WDFW). Lower Elochoman River and Skamokawa Creek/Brooks Slough (slough-like) likely have many species present from the Lower Columbia River. An estimated 29 species were included in this list: chinook, chum, coho, steelhead/rainbow, cutthroat, sculpin sp(3) (torrent, coastrange, reticulate), bridgelip and largescale sucker, peamouth, northern pikeminnow, smelt, sandroller, redside shiner, large & smallmouth bass, carp, goldfish, white & black crappie, eastern banded killifish, yellow perch, sunfish, pumpkinseed, brown & yellow bullhead, white sturgeon, 3-spine stickleback. Most of these fish likely drop out as gradient increases and water temperatures are reduced. The eastern banded killifish is an exception to this, it has been found in higher reaches of the Elochoman River (pers. com. Byrne, WDFW) and trapped on Abernathy Creek (pers. com. Hanratty, WDFW). The majority of these species were dropped out at Wilson Creek and WF Skamokawa 2 and at the end of the tidal zone (Elochoman-2 and Nelson-2). E. banded killifish was presumed to be present up to the Elochoman Hatchery.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.1.3.34 Fish species introductions

Definition—Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale—By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Introduced species were derived from current fish species richness data (see Fish Community Richness above).

The only non-native species documented in Abernathy Creek is the eastern banded killifish captured in smolt trap (pers. com. Hanratty, WDFW). In Abernathy Creek, the distribution most likely stops at or near Slide Creek. In Germany and Mill, we assume this species drops out in the in Germany 6 and Mill 3, receptively. The eastern banded killifish, reported from Elochoman River snorkel surveys (pers. com. Byrne, WDFW), was presumed to be present up to the Elochoman Hatchery.

The tidal reaches Abernathy 1, Germany 1, and Mill 1 have potential for more exotics from the Columbia River. Non-native species in upper Germany Creek, upper Mill Creek, and Abernathy Creek above the falls and in upper tributaries, have not been documented by electroshocking in these reaches (pers. com. Hallock, WDFW & Zydlewski, USFWS).

The lower reaches of Skamokawa Creek and Elochoman River likely have many non-native fish from the Lower Columbia River. An estimated 12 species were included in this list: large & smallmouth bass, carp, goldfish, white & black crappie, Eastern banded killifish, yellow perch, pumpkinseed, sunfish, brown & yellow bullhead. Most of these fish likely drop out as gradient increases and water cools down. The majority of these species were dropped out on Skamokawa Creek at Wilson Creek and WF Skamokawa 2, and on the Elochoman River at Elochoman 2 and Nelson 2.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.1.3.35 Hatchery fish outplants

Definition—The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. Drainage here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale—By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency (pers. com. Glaser, WDFW).

Annual plants of chinook and steelhead were discontinued in Abernathy Creek in 1999. Steelhead plants resumed in 2003. Cutthroat were released in 1995-97 and 1999. An EDT rating of 2 was given from Abernathy Falls downstream (mainstem only). In Germany Creek, annual plants of hatchery steelhead in the watershed were discontinued after 1999. Cutthroat releases were terminated after 1996. Releases of coho and steelhead in Mill Creek were discontinued in 1996 and 1997, respectively. Annual plants of hatchery steelhead in the Skamokawa Creek watershed occurred through 1997. Another release occurred in 2000. Since the hatchery programs were discontinued in Mill, Germany, and Skamokawa Creeks, an EDT rating of 0 was given to all reaches within these watersheds.

Annual releases of early/late coho, fall chinook, summer/winter steelhead occur in the Elochoman River (pers. com. D. Miller, WDFW). Sea-run Cutthroat trout were released from 1994-97. An EDT rating of 3 was given to reaches downstream of the hatchery including Elochoman 1-7 and Nelson 1-2. Beaver Creek Hatchery is closed and no longer releases fish.

Level of Proof—For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.1.3.36 Fish pathogens

Definition—The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale—For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition there were no hatcheries or hatchery outplants and we assumed an EDT rating of zero. Hatcheries are currently in operation on the Elochoman River and Abernathy creek. Hatchery personnel were asked about known viral incidents among hatchery releases. Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency.

In Abernathy Creek annual plants of chinook and steelhead were discontinued in 2000. Steelhead plants resumed in 2003. Cutthroat were released in 1995-97 and 1999 and have been discontinued. An EDT rating of 2 was given from Abernathy Falls downstream (mainstem only). All other reaches were rated at 0. Annual plants of hatchery steelhead in the Germany creek watershed were discontinued in 2000. Cutthroat were released in 1996. An EDT rating of 1 was given to reaches Germany 1-6, where planted salmonids were released. All other reaches were rated at 0. A release of coho was made in 1996 and a release of steelhead in 1997 into Mill Creek. Plants have been discontinued. Mill 1,2, & 3 were given an EDT rating of 1. All other reaches were rated at 0.

Annual plants of hatchery steelhead in the Skamokawa Creek watershed occurred through 1997 with the final release in 2000. An EDT rating of 1was given to reaches Skamokawa 1-6. All other reaches were rated at 0. Elochoman Hatchery annually releases early/late coho, fall chinook, summer/winter steelhead. (pers com D. Miller, WDFW). Sea-run cutthroat releases were discontinued in the late 1990's. The hatchery is located in reaches 7 and 8 (intake & upper ponds in 8 and outflow & lower ponds in 7) and these reaches were rated as 3. Elochoman 1-6 and Nelson 1-2 were rated at 2. All other reaches were rated at 0.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations, and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.1.3.37 Harassment

Definition—The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale—In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions.

Topographic maps were examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT ratings of 4 was given to reaches with extensive road/boat access and high recreational use (i.e. Elochoman between upper hatchery and Risk Rd. bridge due to extensive road access and high recreational use and lower Kalama River); 3 was given to areas with road/boat access and proximity to population center and moderate use (i.e. Abernathy 1&2 road/boat access and moderate recreational use); 2 was given to reaches with multiple access points (or road parallels reach) through public lands or unrestricted access through private lands (i.e. above salmon hatchery on Elochoman and Abernathy); 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands (i.e. Skamokawa Middle Valley—private farm lands with road access, but limited public access); 0 was given to reaches with no roads and that are far from population centers.

Level of Proof—There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.1.3.38 Predation risk

Definition—Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale—By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions.

The magnitude and timing of yearling hatchery smolt releases, and increases in exotic/native piscivorous fishes were considered when developing this rating. The status of top-level carnivores and other fish eating species is unknown in these watersheds.

For Abernathy, Germany, and Mill Creeks, no known populations of non-native piscivorous fish have been documented from smolt traps and electroshocking (pers. com. Hanratty, WDFW, Hallock, WDFW, & Zydlewski, USFWS). Current predation levels were assumed to be the same as the template. The tidal reaches (Ab-1, Gem-1, Mill1) were assigned an EDT rating of 2.5 as non-native piscivorous fish species known to exist in the Lower Columbia River may utilize this reach.

Skamokawa Creek from the mouth up to Wilson Creek (reaches 1-3), Brooks Slough (1-2) and West Valley Creek (1-2) are tidal and/or slough-like. The Elochoman River from the mouth up to the Foster Rd. bridge (reaches 1-2), and Nelson Creek 1-2 are also tidal and/or slough-like. Populations of non-native piscivorous fish from the Lower Columbia River are known to exist in this type of habitat although the exact number of species and their distribution have not been well documented. Skamokawa, Brooks Slough, and West Valley Creek reaches were given an EDT rating of 2.5. In addition, the WDFW Elochoman Salmon Hatchery releases hatchery early & late coho, fall chinook, and winter & summer steelhead. Predation is likely increased on native fish in all mainstem reaches below the hatchery. Eloch 1-2 and Nelson 1-2 were given an EDT rating of 3. Eloch 3-7 were given a rating of 2.5. In all other reaches, we assumed current predation levels were the same as the template.

Level of Proof—There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.1.3.39 Salmon carcasses

Definition—Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale—Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Reaches with historic chum presence (spawning) were given a rating of 0. Mainstem reaches with chinook and coho, but no chum were given a rating of 2. Reaches with only coho were given a rating of 3. Reaches with only cutthroat or steelhead were given a rating of 4, since these fish do not die after spawning. Tidal reaches below areas of chum spawning were given a 1 (it was assumed carcasses from spawning reaches above are washed into these reaches).

In Abernathy, Germany, Mill, Elochoman, and Skamokawa all template carcass information was determined by the above rules. Historically, only winter steelhead passed above Abernathy Falls. Reaches above the falls were given an EDT rating of 4 for low carcass abundance. Below the falls, carcasses per mile was determined by the above rules. In Skamokawa Creek—McDonald 1, Standard 1 and Quarry 1 are listed as having historic chum distribution, but due to their distance from the mouth and small size these tributaries were given an EDT rating of 3 (instead of 0).

An estimate of the current number of salmon carcasses per mile was derived from natural spawn escapement estimates for salmonids in each basin, EDT reach length data, and fish distribution data. Natural spawn escapement estimates for fall Chinook and chum are available from WDFW stream surveys. For Chinook, the ten-year average (1992-2001) was used. For chum, 2001 escapement estimates were used. Natural spawn escapement estimates are not available for coho from stream surveys.

Coho estimates on Germany, Mill, and Abernathy creeks were back-calculated from 2001 & 2002 smolt production estimates (pers. com. Hanratty, WDFW). Calculations were made assuming a 4% smolt to adult survival rate, and adding a coho jack estimate calculated as 10% of the total adult run. (pers. com. Seiler, WDFW). Coho estimates on Elochoman were derived from 2001 stream surveys below the hatchery, hatchery escapement numbers from 1982-2001, counts of coho placed upstream of the hatchery barrier, and estimates of barrier efficiency. Coho escapements were not available for Skamokawa Creek. Skamokawa does not have a hatchery or hatchery plants of coho. Abernathy coho carcass densities were used as a surrogate for Skamokawa Creek.

During template development, EDT reaches were delineated by Ned Pittman (WDFW) according to current/potential fish distribution. Using potential fish distribution, EDT reach lengths were summed to develop the total number of miles of available habitat for each species. The natural spawn escapement estimate was divided by the corresponding number of miles of habitat to generate the average number of carcasses per mile for each species. These values were summed according to the species present within each reach to develop the total number of carcasses per mile within the reach.

Level of Proof—A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive

7.1.3.40 Benthos diversity and production

Definition—Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale—No direct measures of benthos diversity were available for these watersheds. We assigned an EDT rating of 0 and assumed that in the historic condition macroinvertebrate populations were healthy, diverse, and productive and in the natural/pristine state.

Nutrient enrichment levels and mean August temperatures were applied to the *lookup table* in the September 2000 EDT Guidelines to generate an EDT rating. This rating is most likely biased low (indicating macroinvertebrates are better than they actually are) because the look-up table does not take into account fine sediment loads, riparian function, and toxic chemicals. For the majority of reaches, nutrient enhancement was minimal and average August water temperatures fell between 12 and 20 deg. C producing an EDT rating of 0.

For reaches below Abernathy Technology Center where nutrient enhancement may be increased due to hatchery operation an EDT ratings were as follows: 1 below Tech center (Abernathy-4), 0.5 in Abernathy-3, and 0.25 in Abernathy1 & 2. In Germany Creek reaches below the canyon where nutrient enrichment may be increased due to agriculture, an EDT rating of 0.8 was assigned in Germany-5, and 0.5 in reaches 1-4 and 6. SF Mill –1 potentially has some nutrient enrichment and was given a rating of 0.5. Mill 1&2 were rated at 0.25. All other reaches were rated at 0.

West, Middle, & East valley and lower Skamokawa, plus Brooks Slough have nutrient enrichment values of 1 to 1.5. EDT ratings for macroinvertebrates were the same (from look up table), except for Skamokawa 1-3, Brooks 1-2, Risk 1, and Alger 1A. These reaches are slough-like and likely have increased fine sediment. Look up table values in these reaches were increased by 0.5.

Elochoman 1-7 and Nelson 1-2 have nutrient enrichment values of 1.5. EDT ratings for macroinvertebrates were the same (from look up table), except Elochoman 1-2 and Nelson 1-2. These reaches are slough-like and likely have increased fine sediment. Look up table values were increased by 0.5.

7.2 Coweeman

7.2.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treatment Model (EDT) for the Coweeman River. In this project we rated over 60 reaches with 46 environmental attributes per reach for current conditions and another 46 for historical conditions. Over 2,700 current ratings were assigned and empirical observations within these reaches were not available for all of these ratings. In fact, less than 20% of these ratings are from empirical data. To develop the remaining data, we used expansion of empirical observations, derived information, expert opinion, and hypothetical information. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute, data was very limited or non-existent. WDFW established a relationship between road density and fine sediment in the Wind River. We applied this relationship to all subwatersheds; this is an example of derived information. In some cases, such as bed scour, we had no data for most reaches. However, data is available from Gobar Creek (a Kalama River tributary) and observations have been made in the Wind River as to which flows produce bed load movement. We noted that bed scour is related to gradient, stream width, and confinement. Based on these observations expert opinion was used to develop a look-up table to estimate bed scour. For rationale behind the EDT ratings assigned, see the text below. For specific reach scale information, please see the EDT database for the watershed of interest. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.2.2 Recommendations

1) Adult chinook salmon, and steelhead population estimates should continue for the basin. Currently, winter steelhead estimates are based upon redd count expansion, while chinook estimates have been generated from index counts and peak count expansion. There are no hatcheries operating in the Coweeman Basin, and the only hatchery plants consist of summer steelhead. The NMFS identified Coweeman Tule fall chinook salmon as an indicator stock to determine recovery exploitation rates (RER) for all naturally produced LCR Tules that are consistent with the recovery of tule fall chinook. Chum and coho salmon counts are periodic and not population estimates. Funding should be secured to develop accurate and precise adult estimates for chum, fall chinook and coho salmon and winter steelhead. Smolt populations are currently not monitored in the basin. Funding should be secured to generate smolt population estimates for the above species as well. Accurate and precise adult and juvenile population estimates will allow for better population status estimates, validation of EDT, and to determine if subbasin restoration actions are effective.
2) Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating, as would field surveys.
3) Empirical sediment data was not available for most of the basin. A sediment monitoring program should be developed to assess the percentage of fines in spawning gravels, embeddedness, and turbidity in reaches used by anadromous fish.

4) Differences existed between field and GIS ratings of natural confinement. The SSHIAP database should be field verified.
5) Flow monitoring in the mainstem Coweeman River was discontinued in the early 1980s. Flow monitoring should be resumed. Bed scour estimates were not available for this basin and bed scour data should be collected and related to peak flows.
6) USFS and USGS habitat surveys do not directly measure all habitat types needed for EDT. WDFW habitat surveys in 2002 were opportunistic; that is, based on a limited amount of resources, we chose to survey only a few "representative" mainstem and tributary reaches. In addition, glides and pools were distinguished subjectively and not quantitatively. To accurately estimate stream habitat type within the anadromous distribution, a statistically valid sampling design should be developed and applied (Hankin and Reeves 1988 or EMAP). Survey methodology should differentiate between pools and glides and be repeatable.
7) A combination of DOE and OSU estimates of Benthic Index of Biological Integrity (B-IBI) collected in the Wind and Cowlitz River basins were used to develop EDT ratings. These estimates should be completed in this and other SW Washington watersheds.
8) Obstructions were not rated and passage was assumed to be 100%. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. These ratings should be updated using SSHIAP database.

7.2.3 Attributes

7.2.3.1 Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: This watershed originates from foothills below 3000 feet (Wade 2000). Washboard falls is likely the uppermost barrier to anadromous fish on the mainstem Coweeman, and is at an elevation of approximately 1150 feet. Upper elevations of the Coweeman watershed likely experience rain-on-snow events. These events influence lower mainstem reaches, but effects are likely masked by tributary flow inputs as one progresses downstream. The Integrated Watershed Assessment (IWA) completed for the Lower Columbia Fish Recovery Board (LCFRB) examined the current condition of key watershed processes by Hydrologic Unit Code (HUC) (LCFRB 2003). IWA results present the percent rain-on-snow area by HUC. EDT reaches were linked to the appropriate HUC(s) by examining a map of HUC boundaries (LCFRB 2003). Rain-on-snow percentages range from 0 to 61% for HUCS with associated EDT reaches (Table 7-8). As a general rule, reaches with percentages >45% were given an EDT rating of two (rain-on-snow transitional), and reaches with <45% were given an EDT rating of three (rainfall dominated). Exceptions to this rule are as follows: (1) EDT reaches Coweeman 19 & 20 were rated as rain-on-snow transitional due to influence from upstream reaches (below Coweeman 19 rainfall dominated tributaries likely begin to dilute rain-on snow effects), and (2) all of Mulholland Creek was rated rain-on-snow transitional. Natural flow regime ratings were used for both historical and current conditions. Each reaches natural flow regime was used to assign shape patterns when rating other EDT attributes.

Table 7-8. % Rain-on-Snow Area for HUCs with associated EDT reaches.

LCFRB HUC	EDT Reaches associated with HUCS	HUC % Rain on Snow Area
17080005080301	C7(.5), C8, C9, C10, C11, C12, LB2, LB3, RB3, Jim Watson Cr, Sam Smith Cr	0
17080005080302	M1, M2, RB6, LB5	0
17080005080303	C13, C14, C15, RB4, LB4	6
17080005080304	B1, B2, B3, LB6, Little Baird Cr	56
17080005080305	RB5, C21, C22	61
17080005080306	M3, M4, RB7	45
17080005080307	C16, C17, C18, C19, C20, Nineteen Cr, Skipper Cr, Brown Cr, O'neil Cr, Martin Cr	27
17080005080401	C5, C6, C7(.5), RB2, Canyon 2, Nye Cr	0
17080005080402	C2(.5), C3, LB1	0
17080005080403	C4, RB1, Canyon 1, Turner Cr	0
17080005080404	NF Goble Cr	22
17080005080405	G1, G2, G3, G4	13
17080005080407	C1 tidal, C2(.5)	0

Actual flow data is limited for the Coweeman watershed. One gauge was operated by USGS near Kelso, WA from 1950-1982 (USGS 2004). An examination of mean monthly flow data from this gauge supports the above ratings for the lower watershed. Mean monthly flow data was plotted and compared to EDT flow patterns for a rainfall dominated watershed and a rain-on-snow transitional watershed. Gauge data showed a clear rainfall dominated pattern with high winter flows decreasing steadily through the spring into summer.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion were used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

7.2.3.2 Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale: This watershed does not have artificial flow regulation, and was given an EDT rating of 0 for the historical and current conditions.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.2.3.3 Flow - change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition the template conditions for this attribute are rated as a value of two because this describes this attribute's rating for watersheds in pristine condition. Direct measures of interannual high flow variation are not available for most basins. USFS has conducted watershed analysis in the EF Lewis, NF Lewis, Wind, White Salmon, Washougal, Kalama, Cowlitz, and Cispus Rivers and Rock Creek (USFS 1995a, USFS 1995b, USFS 1996a, USFS 1996b, USFS 2000). Peak flow analysis was conducted using the State of Washington "Standard methodology for conducting watershed analysis". The primary data used for the peak flow analysis is vegetation condition, elevation, road network, and aspect. The results for increased risk in peak flow from the USFS watershed analysis are shown in Table 7-9. For watersheds in which the two-year peak flow increases 10% the EDT rating is 2.25. For increases of 20% the EDT rating is 2.5. Data for the Upper Kalama Basin indicated an increase in peak flow of 5 to >10% (Table 2). A Q2yr analysis of peak flow data (using EDT manual protocol) for USGS gauge data on the Kalama River below the lower falls (1934-1977) indicated a peak flow increase of 17% (EDT rating ~ 2.4). Upper and lower basin ratings were averaged and an EDT rating of 2.3 was used on the Kalama. The flow-data time series on the Coweeman River was not long enough to conduct a Q2yr analysis. The Kalama was used as a surrogate and all Coweeman reaches were given an EDT rating of 2.3.

Table 7-9. Summary of USFS Watershed Analysis for the change in peak flow

Basin	# of Subbasins	Increase in Peak Flow
Wind	26	2 – 14%
East Fork Lewis	9	5 –13%
Lower Lewis		10-12%
Rock Cr		1-5%
Upper Kalama		5- >10%
Cispus		<10%

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. A combination of derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.4 Flow - changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of two because this describes this attribute's rating for watersheds in pristine condition. Research on the effects of land use practices on summer low flow is inconclusive. Therefore, template and current conditions were rated the same (EDT rating of 2), except where noted.

The LCFRB Level 1 assessment for WRIA 25 & 26 (2001) presents average current water usage in 2000 (surface water) for the Coweeman River as 29.4 million gallons/day, which translates to 45.5 cfs. Total water rights for the Coweeman are listed as an annual quantity of 1336 AcreFeet/Year or an instantaneous quantity of 16,570 gpm (37cfs). Exhibit 4-1 presents a figure of surface water rights distribution, which is clustered in the lower reaches of the Coweeman and Lower Cowlitz Rivers. Median low flow (July to September) for the Coweeman is 50 cfs (Caldwell 1999). Usage seems to be significant, but usage data by month was unavailable. Therefore, a comparison of usage during low flow months was not possible. The effects of these withdrawals on low flow are unknown. It was assumed that if the bulk of these withdrawals occur in the lowest reaches there would likely be a decrease in low flows there as well, with the cumulative effect being the greatest in Coweeman 1- tidal and 2; these reaches were given a rating of 2.5.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. A combination of derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.5 Flow – intra daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. This attribute was given an EDT rating of 0 for current conditions due to the lack of storm water runoff and hydroelectric development in the watershed. There are no major metropolitan areas in this watershed with large areas of impervious surfaces.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.2.3.6 Flow –Intra annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute's rating for watersheds in pristine condition. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in this watershed. Based on USFS watershed analyses and a Q2yr analysis for the Kalama River, it was assumed peak high flows increased by 13%. Since there was no data for this attribute, it was suggested that its rating should be similar to that for changes in interannual variability in high flows (pers. com. Lestelle, Mobrand Biometrics, Inc). Ratings for interannual variability in high flow were translated directly into ratings for intra-annual flow.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.7 Channel length

Definition: Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: Ned Pittman (WDFW) provided the length of each reach from SSHIAP GIS layers. Stream length was assumed to be the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.2.3.8 Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). Wetted widths corresponding to average summer low flows (August) were measured as part of these surveys. To determine if surveys were conducted during average low flow conditions, streamflows corresponding to survey dates were compared to mean August flows (for all available years). USGS (2004) streamflow data was not available for the Coweeman River in 2002, however, gauge data from the South Fork (SF) Toutle River (near Toutle, WA) and East Fork (EF) Lewis River (near Heisson, WA) were assumed to be good surrogates for identifying fluctuations in streamflow caused by rain events. Mean August streamflow for the SF Toutle (1940-2002) was 118 cfs (range: 79 to 172 cfs), and flows corresponding to 2002 survey dates were 67, 71 and 371 cfs (USGS 2004). Mean August streamflow for the EF Lewis (1930-2002) was 83 cfs (range: 44 to 278 cfs), and flows corresponding to 2002 survey dates were 47,49, and 301 cfs (USGS 2004). It was assumed conditions on the Coweeman River were similar. Widths measured on the first and second survey dates may be biased slightly low, and those measured on the third slightly high, but in general surveys were conducted during near average low flow conditions.

Where representative reach data (VanderPloeg 2003) was available, it was used in rating the corresponding EDT reaches. Minimum wetted widths for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement and/or by using the "split rule" (

Table 7-10). The “split rule” is defined as follows: for reaches above a split (confluence of 2 tributaries), or where significant tributaries entered the mainstem, wetted width was calculated by: [(1.5*downstream reach width)*0.5] for even splits. For uneven splits, the multiplier was adjusted to compensate: in a 60:40 split: [(1.5*drw)*0.6] and [(1.5*drw)*0.4]; for a 70:30 split: **[**(1.25*drw)*0.7] and [(1.25*drw)*0.3]; and for an 80:20 split: [(1.25*drw)*0.8] and [(1.25*drw)*0.2]. The “split rule” was applied by working both upstream and downstream between surveyed reaches.

Table 7-10. EDT reaches surveyed and/or split (using the "split rule") to develop minimum widths for non-surveyed reaches.

EDT Reaches Surveyed/Split	Split Rule used	Non –surveyed Reaches Applied To
Canyon 2	None	Coweeman 1 - 4 & Canyon 1
Coweeman 5	**70**/30	Coweeman 5 & Canyon 3
Coweeman 9	**70**/30	Coweeman 6 - 9
Coweeman 10	**70**/30	Coweeman 10
Coweeman 12	**70**/30	Coweeman 11 & 12
Coweeman 15	None	Coweeman 13 - 15
Coweeman16	**70**/30	Coweeman 16 - 22
Coweeman16	80/**20**	Brown, O'neill, Martin, Nineteen, Nye, Sam Smith, Skipper, Turner
Baird 1	**None**	Baird 1
Baird 1	**70**/30	Baird 2 & 3
Baird 1	70/**30**	Little Baird, Jim Watson, LB Trib 1-6, RB Trib 1-7
NF Goble	None	NF Goble
NF Goble	**60**/40	Goble 1, Mulholland 1
Mulholland 1	**80**/20	Mulholland 2
Mulholland 2	**70**/30	Mulholland 3 & 4
Goble 1	**60**/40	Goble 2
Goble 2	**50/50**	Goble 3 & 4
Bold Type indicates surveyed reaches (VanderPloeg 2003) & the portion of the split rule applied.		

Hydroconfinement in Coweeman 1-tidal & Coweeman 2 was not thought to significantly reduce minimum width and values for these reaches were applied to both the current and historical conditions.

Level of Proof: A combination of empirical observations, expansion of empirical, observations, derived information and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations, derived information and expert opinion were used and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.9 Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Representative reaches in lower Columbia River tributaries were surveyed by Steve VanderPloeg (WDFW) in 2003. Wetted widths corresponding to average winter high flows (January) were measured as part of these surveys. To determine if surveys were conducted during average high flow conditions, streamflows corresponding to survey dates were compared to mean January flows (for all available years). USGS (2004) streamflow data is not available for the Coweeman River in 2000 and 2002, however, gauge data from the South Fork (SF) Toutle River (near Toutle, WA) and East Fork (EF) Lewis River (near Heisson, WA) were assumed to be good surrogates for identifying fluctuations in streamflow caused by rain events. Mean January streamflow for the SF Toutle (1940-2002) was 1031 cfs (range 318 to 2488 cfs), and flow corresponding to the 2003 survey date was 819 cfs (USGS 2004). Mean January streamflow for the EF Lewis (1930-2002) was 1407 cfs (range 303 to 3459 cfs), and flow corresponding to the 2003 survey date was 892 cfs (USGS 2004). SF Toutle and EF Lewis flows were both slightly lower than average. It was assumed conditions on the Coweeman River were similar, indicating surveys were conducted during near average flow conditions. Wetted widths recorded during these surveys were used without adjustment, realizing they may be biased slightly low.

Typically less reaches per subbasin were measured during average winter flow as compared to summer flow. The percent increase between low and high flow widths for all subbasins was compared to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data (EDT reach Kalama 14). A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris and hydroconfinement. Using only Kalama mainstem reach data (EDT reaches Kalama 2, 5, 11, 17) the mean increase in stream width is 30%. A possible explanation for this is that most of the Lower Kalama watershed is currently confined and/or hydroconfined. Based on this data, general "rules" were developed relating wetted width minimum and maximum values. A 1.6 multiplier (60%) was assumed to be appropriate for expanding wetted width minimum values in reaches with moderate confinement and in all tributary reaches. In unconfined mainstem reaches, where down-cutting has not occurred, it was assumed minimum widths would (on average) double under average high flow conditions, and a 2.0 (100%) multiplier was used for these reaches. Conversely, in heavily confined mainstem areas (i.e. canyons) it was assumed minimum widths can not increase much as flow increases and a 1.3 (30%) multiplier was used in these reaches.

For the Coweeman, actual "wetted width-high" values were used in reaches where data was available from surveys. For reaches without high flow width data, the rules described above were used to expand “wetted width-low” values. The 1.6 multiplier was used on all tributary and mainstem reaches except as follows. The 1.3 multiplier was used on confined/hydroconfined mainstem reaches Coweeman 1-tidal, 2, 12, 13, Canyon1 & 3. Unconfined reaches of the lower Coweeman (Coweeman 1-tidal & 2) are currently heavily diked and channelized. In the historic condition these areas were likely more braided and wider during winter flows. The 2.0 multiplier was used to develop historic "wetted width-high" values for these reaches.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, expanded empirical observations and expert opinion were used and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.10 Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as % gradient) was calculated by dividing the change in reach elevation by the reach length and multiplying by 100. Ned Pittman (WDFW) used SSHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical gradient.

7.2.3.11 Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003. Confinement ratings were estimated during these surveys (VanderPloeg 2003). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps (1:24,000) were consulted (via GIS) to verify and/or adjust ratings. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4 (Table 7-11). There are often multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings.

Table 7-11. Comparison of SSHIAP and EDT ratings for confinement.

Project	Unconfined	Equal unconfined and mod. confined	Moderately confined	Equal mod confined and confined	Confined
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.2.3.12 Confinement – hydro-modifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cut off due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures and activity) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. Most hydro-modification consists of roads in the floodplain and diking. The SSHIAP and DNR GIS roads layers, DNR digital ortho-photos, USGS topography maps (1:24,000 via GIS), and WRIA 26 LFA (Wade 2000) were reviewed and professional judgment was used to assign EDT ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.2.3.13 Habitat Type

Definition: *Backwater pools* is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are believed to be the primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991 - Forest Ecosystem Management July 1992, page V-23), and applying this to current habitat type composition estimates. On Germany Creek, the Elochoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, it was assumed that for historical conditions the percentage of pools was significantly higher than for current conditions. For gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5%, pool habitat was estimated to be 40% and 30% respectively (WFPB 1994). Tailouts were assumed to represent 15-20% of pool habitat, which is the current range from WDFW surveys (VanderPloeg 2003). Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5% to 6% for gradients greater then 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat increased with gradient. WDFW field data (VanderPloeg 2003) indicated the percentage of gravel riffle habitat decreased with stream gradient, and cobble/boulder riffle habitat increased with stream gradient; the percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1% to 15% at gradients greater than 6%. WDFW surveys indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Representative reaches of lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). Habitat type composition was measured during these surveys. Surveys primarily followed USFS stream survey level 2 protocols, which delineate between riffles and slow water, but not pools and glides. Glide habitat is the most difficult habitat to identify, and, therefore, was estimated but not surveyed. In general, WDFW survey methodology did not appear to work for glides. Therefore, Wind River data (USGS) was examined to help differentiate between these two habitat types. Wind River data showed a positive relationship between gradient and/or confinement and riffle habitat. It also showed a negative relationship between pool habitat and gradient and/or confinement. However, there was no relationship between pools and glides. There was variation between surveyors when the same reach was walked. This may be due to habitat changes but it could also be due to measurement error between surveyors. In general, glides accounted for 30% to 50% of the non-riffle habitat.

For the Coweeman, habitat types were measured by VanderPloeg (WDFW 2003) within mainstem EDT reaches Canyon 2, Coweeman 9 & 15, and tributary reaches North Fork Goble and Baird Creeks. The three mainstem reaches and the two tributary reaches were averaged to develop representative ratings for the two categories, respectively. Back-water pools were thought to be minimal in the mainstem, due to confinement, and ratings were reduced to 0. Tailout percentages for mainstem and tributary ratings were adjusted to be 20% of pool habitat. After adjustment, glide habitat for the averaged mainstem reach data was 62.9 % of non-riffle habitat, and 48.4% for averaged tributary data. The mainstem Coweeman has many areas of confined bedrock canyon with long sections of pool/glide habitat. Based on this and comparison with Wind River data, Coweeman River glide percentage estimates seemed reasonable and no further adjustments were made.

All tributary reaches on the Coweeman are >=1.5% gradient and confined; averaged habitat ratings were thought to be representative and were applied to all Coweeman tributaries. Averaged mainstem habitat ratings were applied to all mainstem reaches with the following exceptions. Coweeman 1-tidal & 2 are currently hydroconfined by diking and were rated as 100% glides. Historically these reaches likely were meandering, low-gradient, braided streams with increased back-water pools and gravel riffles and were rated as such. Canyon 1 currently has a gravel pit operation within the reach and several old gravel pits have increased backwater pools in this reach. Backwater pool habitat was increased for this reach under current conditions.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations and expert opinion were used and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.14 Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A , B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis. Most of the Coweeman basin is confined with some areas of moderate confinement. An EDT rating of 0% off-channel was assigned to moderately confined/confined reaches. Only the lowest reaches are completely unconfined (Coweeman 1 – 4). For the historic condition, Coweeman 1, 2, 3 and 4 were given EDT ratings of 20%, 20%, 5%, and 1% off-channel habitat, respectively. Currently, these reaches are diked and channelized and have little if any off-channel habitat (~1%).

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations and expert opinion were used and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.15 Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: Currently, there are no barriers identified in the Coweeman Basin EDT model. Most tributaries are represented in the EDT model by a single reach. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon are more impacted by barriers, due to their preference for spawning in small tributaries. As barrier inventories become more complete and available for the Coweeman Basin it would be valuable to incorporate these into the EDT model.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.16 Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach.

Rationale: No water withdrawals occurred in the pristine condition. By definition, all reaches were given an EDT rating of 0 for the historical condition.

EDT reaches Coweeman 1- tidal & 2 run through the town of Kelso, Washington, and are heavily diked and channelized. Coweeman 3 is an agricultural area and likely has withdrawals for irrigation and livestock. Above Coweeman 2, the watershed is rural with limited stream adjacent housing, and runs through narrow canyons and/or private land managed for timber harvest (i.e. The Mark Andrews Tree Farm). The majority of homes adjacent to the stream occur in reaches Coweeman 8-14, Goble Creek 1 & 2, and NF Goble Creek. EDT reaches above

Baird Creek are behind closed gates on private lands primarily owned and managed by Weyerhaeuser for timber harvest. Most tributary reaches, except Goble Creek, are sparsely populated and/or on private lands managed for timber harvest. The intake for the lower Coweeman steelhead acclimation pond (operated by Cowlitz Game & Anglers) is located on Turner Creek. The intake is gravity fed and screened. Water is returned to Turner Creek at the lower end of the pond. Withdrawals in these areas are thought to be minor or non-existent.

The LCFRB Level 1 assessment for WRIA 25 & 26 (2001) presents average current water usage in 2000 (surface water) for the Coweeman River as 29.4 million gallons/day, which translates to 45.5 cfs. Total water rights for the Coweeman are listed as an annual quantity of 1336 AF/Year or an instantaneous quantity of 16,570 gpm (37cfs). In comparison, median low flow (July to September) for the Coweeman is 50 cfs (Caldwell 1999). Exhibit 4-1 of the Level 1 assessment presents a figure of surface water rights distribution, which is clustered in the lower reaches of the Coweeman and lower Cowlitz. Water rights identified were small scale and likely equate to limited withdrawals for domestic and agricultural use. Specific areas of significant single-source water withdrawals were not identified, however the cumulative effects of small scale withdrawals may equate to significant total water usage during low flow periods.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.2.3.17 Bed scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for these basins. Historic bed scour was rated using the look-up table developed by Dan Rawding (WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table is based on professional judgment. It relates bed scour to confinement, wetted width (high flow), and gradient and assumes scour increases as gradient and confinement increase. In Coweeman 1-tidal, where scour likely occurred during low tides and high flow events, the look-up table rating was reduced by ½.

Historic EDT ratings were developed and used as the baseline for scour in the current condition. Template ratings for bed scour were increased as follows: it was assumed increases in peak flow and hydroconfinement also increased bed scour, and scour ratings were increased 0.049 for each tenth (0.1) of increase in the EDT peak flow rating and for each point (1.0) increase in the hydroconfinement rating. In Coweeman 1-tidal and 2, where reaches are currently slough-like (mud bottom), bed scour was rated by reducing the current look-up table rating by ½.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.18 Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale: Most Lower Coweeman EDT reaches are rainfall dominated. EDT reaches Coweeman 19 – 22, Baird 1-3, Mulholland 1-4, Little Baird, LB6 and RB7 were rated as rain-on-snow transitional. Anchor ice and major icing events are rare or non-existent. EDT ratings of 0 were assigned to all reaches in the historical and current condition.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.2.3.19 Riparian

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition.

For current conditions, riparian zones with mature conifers are rated at 1.0. Riparian zones with saplings and primarily deciduous trees are rated as 1.5 due to lack of shade and bank stability. Riparian zones with brush and few trees are rated as 2. For an EDT rating to exceed 2, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees it should have a score of 2 or better. Most current vegetated riparian zones with no hydro-confinement should be rated as a 1 to 1.5. When vegetation is lacking and/or hydroconfinement/residential development exists, riparian ratings were increased based upon the severity of each.

Information on the status of riparian zones in the Coweeman watershed was compiled from: the LFA for WRIA 26 (Wade 2000), EDT Habitat Surveys by WDFW (VanderPloeg 2003), the SSHIAP and DNR GIS roads layers, DNR digital ortho-photos, and USGS topography maps (1:24,000 via GIS). EDT reaches Coweeman 1- tidal & 2 run through the town of Kelso, Washington, and are heavily diked and channelized. Above Coweeman 2, the watershed is rural with limited stream adjacent housing, and runs through narrow canyons and/or private land managed for timber harvest. The LFA for WRIA 26 (Wade 2000) describes riparian conditions as "generally poor throughout the Coweeman subbasin", due to diking in the lower reaches and agricultural activities/forest practices throughout. WDFW habitat surveys (VanderPloeg 2003) were conducted in EDT reaches Coweeman 9 & 15, Canyon 2, NF Goble, and Baird Creek. Notes on riparian composition were taken as part of these surveys. Most reaches had a mix of alder, big-leaf maple, Douglas fir, cedar, and hemlock at various stages of growth. While all areas surveyed had conifers within the reach, stands of old/mature conifers were noted as being sporadic, most were described as “even aged” indicating areas of re-growth after logging. Stream adjacent roads and visible clear-cuts outside of buffer areas were noted in many areas.

Coweeman 1 & 2 are diked and channelized with few trees, and were given an EDT rating of 3. Coweeman 3 and 4 run through agricultural areas. Much of the south bank in these reaches is bordered by fields used for grazing livestock with down-cut banks and sporadic deciduous trees, while the north bank is forested with a deciduous/coniferous mixture. These reaches were given a rating of 1.5. All other reaches with vegetated riparian zones and no hydroconfinement were given a rating of 1.0, with the following exceptions. Canyon reaches, where riparian function (except shade) is near 100%, were rated at 0.5. Tributary reaches, where ortho-photos showed fresh clear-cuts adjacent to the stream and little or no buffer, were rated between 1.5 and 2.

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.2.3.20 Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Rationale: In general, the template condition for wood in Lower Columbia River tributaries was assumed to be at an EDT rating of 0 (complex mixture/plentiful) for all areas except large canyon sections on the Grays, Coweeman, Kalama, EF Lewis, Washougal, and Wind Rivers, which likely did not hold LWD as well. These areas were assumed to be at a rating of 1 to 2, based on the width and length of the canyon. For the Coweeman watershed, mainstem canyon reaches Canyon 1 - 3 and Coweeman 13 were given an EDT rating of 2 for the template condition. All other reaches were given an EDT rating of 0.

The Timber Fish and Wildlife (TFW) Effectiveness Monitoring Report entitled “A Watershed-Scale Baseline Inventory of Large Woody Debris in the Upper Coweeman WAU” (Volkhardt 1999) presents LWD counts and densities for many stream segments in the Coweeman subbasin above Mulholland Creek. Volkhardt (1999) expresses LWD densities as pieces per channel width (CW) using bank full width as CW. For EDT purposes these densities may be biased high, as LWD densities for EDT are calculated as pieces/CW where CW equals the average wetted width during the high flow month (< bank full). Despite this potential bias, these LWD densities represent the best and most complete data set available for the Coweeman subbasin and were used without adjustment. Using figure 2 of Volkhardt’s report, surveyed segments were linked to their corresponding EDT reach(s) (

Table 7-12). Additionally, LWD counts were made in several lower Coweeman EDT reaches during WDFW Habitat surveys (VanderPloeg 2003) and WDFW steelhead redd surveys (spring 2003) using EDT protocol (Table 7-13).

These three data sources were used to generate EDT LWD ratings for the Coweeman watershed as follows. LWD densities for each surveyed segment were, first, converted to EDT ratings according to EDT definitions (

Table 7-12 & Table 7-13). EDT ratings were averaged for all surveyed mainstem segments above Coweeman 12 (Mulholland Creek upstream), generating an average rating of 2.5, which was applied to Coweeman 13 – 22. Similarly, ratings from surveyed reaches between Coweeman 5 and 12 were averaged to generate a rating of 3.5 for these reaches. A rating of 3.6 from a survey conducted in Canyon 2 was applied to reaches Coweeman 3 & 4 and Canyon 1 - 3. No surveys were conducted in Coweeman 1-tidal or 2. These reaches were assumed to have low LWD densities and were given an EDT rating of 4. EDT ratings from surveys conducted in tributary reaches were assumed to representative of the entire reach and were used to rate the reach. If more than one survey was conducted within a tributary reach, the average reach rating was used. The average EDT rating for all tributary segments surveyed was 2.4. Based on this, non-surveyed tributary reaches were given a categorical rating of 2.

Table 7-12. Coweeman subbasin stream segments surveyed by Volkhardt (1999) and the corresponding EDT reach names and EDT LWD ratings.

Stream Name	Volkhardt 1999 Segment #	Approximate EDT Reach	EDT Rating
Coweeman	2	Coweeman 13	1.4
Coweeman	4	Coweeman 13	2.4
Coweeman	6	Coweeman 14 & 15	2.7
Unnamed	11	No EDT reach	3.3
Unnamed	23	LB 4	0.5
Unnamed	37	RB 4	3.9
Unnamed	38	RB 4	3.7
Unnamed	40	RB 4	3.6
Unnamed	50	No EDT reach	3.4
Sam Smith Ck	60	Sam Smith	3.4
Blackman Ck	69	No EDT reach	3.7
Mulholland	103	Mulholland 2	3.2
Mulholland	104	Mulholland 2	1.4
Mulholland	105	Mulholland 2	2.4
Mulholland	106	Mulholland 2	0.1
Mulholland	107	Mulholland 2&3	0.4
Mulholland trib	125	LB 5	3.1
Mulholland trib	138	No EDT Reach	2
Mulholland trib	146	No EDT Reach	1.5
Mulholland trib	150	No EDT Reach	3.1
Baird	201	Baird 1	0.3
Baird	203	Baird 1	1.7
Little Baird	224	Little Baird	2.5
Little Baird	225	Little Baird	2.2

Baird Crk. Trib	243	No EDT reach	1.8
Nineteen	250	Nineteen	2
Coweeman	300	Coweeman 16 & 17	1.8
Coweeman	301	Coweeman 18	1.1
Coweeman	303	Coweeman 18 & 19	3
Coweeman	304	Coweeman 19	2.8
Coweeman	305	Coweeman 21	2.4
Coweeman	306	Coweeman 22	1.5
Unnamed	322	Martin Ck	0.8
Brown	328	Brown	2.7
Brown trib	333	No EDT Reach	2.2
Brown trib	338	No EDT Reach	3.8
Skipper	346	Skipper	3.4
Skipper	347	Skipper	3.3
Skipper trib	353	No EDT Reach	2.7
O'neil	361	O'neil	0.3
O'neil	362	O'neil	0.5
O'neil trib	372	No EDT Reach	2.7
Coweeman	401	Above Washboard Falls	0.5
Coweeman	403	Above Washboard Falls	0.9
Coweeman	406	Above Washboard Falls	0.5
Coweeman Trib	413	Above Washboard Falls	0
Coweeman Trib	414	Above Washboard Falls	0.3
Coweeman Trib	423	Above Washboard Falls	0.3
Butler	460	Above Washboard Falls	2.4
Butler	461	Above Washboard Falls	2
Butler	476	Above Washboard Falls	3.6

Table 7-13. Coweeman EDT reaches where LWD counts were conducted during WDFW stream surveys and the corresponding EDT LWD ratings.

EDT Reach	Data Source	EDT Rating
Canyon 2	WDFW Habitat Survey - VanderPloeg 2003	3.6
Coweeman 9	WDFW Habitat Survey - VanderPloeg 2003	3.7
NF Goble Cr	WDFW Habitat Survey - VanderPloeg 2003	4
Coweeman 15	WDFW Habitat Survey - VanderPloeg 2003	3.1
Baird 1	WDFW Habitat Survey - VanderPloeg 2003	2.3
Baird 1	WDFW Steelhead Redd Survey - 2003	1.9
Baird 1	WDFW Steelhead Redd Survey - 2003	3.1
Coweeman 10,11,12	WDFW Steelhead Redd Survey - 2003	3.1
Coweeman 7,8,9	WDFW Steelhead Redd Survey - 2003	3.7
Coweeman 15	WDFW Steelhead Redd Survey - 2003	3.8
Coweeman 13	WDFW Steelhead Redd Survey - 2003	3.8
Mulholland 1	WDFW Steelhead Redd Survey - 2003	2.8
Mulholland 1	WDFW Steelhead Redd Survey - 2003	2.9
Goble 1	WDFW Steelhead Redd Survey - 2003	3.7
Goble 3	WDFW Steelhead Redd Survey - 2003	3.3
Goble 2	WDFW Steelhead Redd Survey - 2003	3.7
Goble 2	WDFW Steelhead Redd Survey - 2003	3
NF Goble	WDFW Steelhead Redd Survey - 2003	3.6
NF Goble	WDFW Steelhead Redd Survey - 2003	3.3

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.2.3.21 Fine Sediment (intragravel)

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et. al. 1992). The average percentage of fines (8.5%) was used, which corresponds to an EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3.

To rate the percentage of fines in the current condition, a scale was developed relating road density to fines. Rittmueller (1986) examined the relationship between road density and fine sediment levels in coastal watersheds of Washington State's Olympic Peninsula region, and found that as road density increased by 1 km/sq.km fine sediment levels increased by 4.3% (2.65% per 1 mi./sq.mi.) However, Duncan and Ward (1985) found a lower increase in percentage of fines in southwest Washington, but attributed much of the variation in fines to different soil types. The Wind River is a Lower Columbia River tributary located in SW Washington and is likely representative of other watersheds in the region. USFS used a McNiel core to collect gravel samples from 1998 to 2000 in 8 subwatersheds in the Wind River subbasin. Fines were defined as less than 0.85mm. A regression was run comparing the percentage for each year to road densities. The increase was 1.04% per 1 mi/mi^2 of roads for all watersheds (R^2 = 0.31, n=17). The increase was 1.52% per 1 mi/mi^2 for all watersheds (R^2= 0.73, n= 14) when Layout Creek, which was recently restored, was excluded. Rather than use all three years of Layout Creek data, only the median was used and the final relationship used for EDT was a 1.34% increase in fines per 1 mi/mi^2 (R^2=0.56, n=15) (Figure 1).

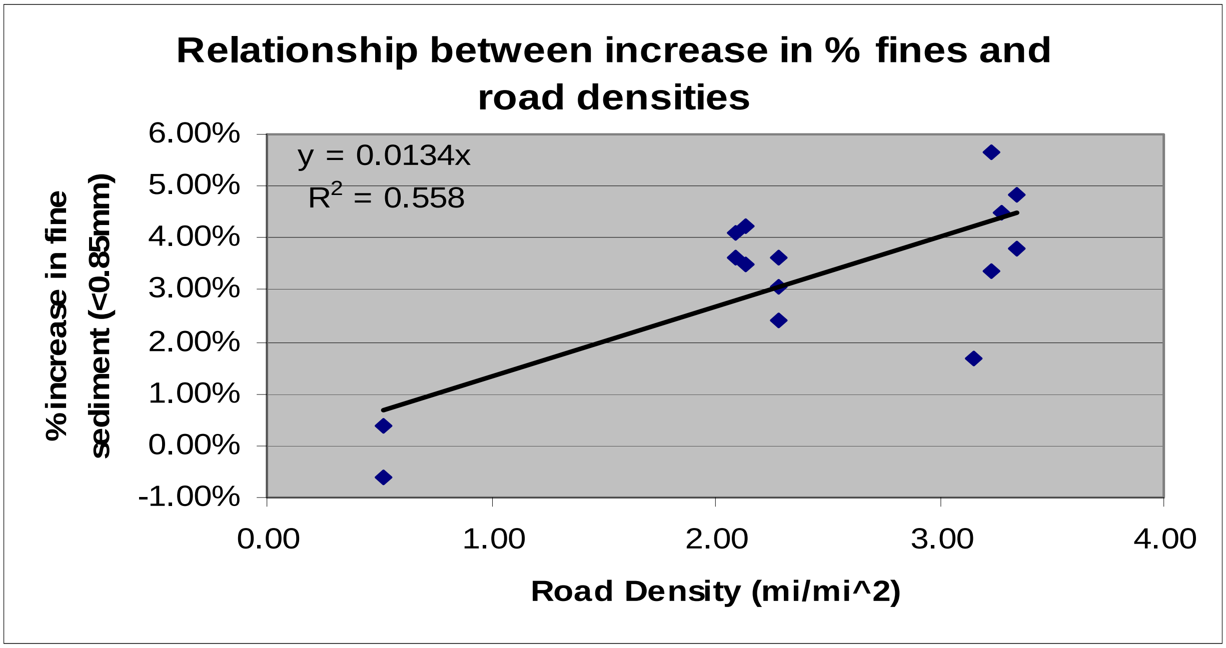

Figure 7-1**.** Relationship between road densities and the percentage increase in fines (<0.85mm) from USFS data.

Coweeman River watershed road density values were taken from IWA results for LCFRB subwatersheds (HUCs) (LCFRB 2003). EDT reaches were linked to the appropriate HUC(s) by examining a map of HUC boundaries. Table 7-14 presents IWA road density by HUC for HUCs with associated EDT reaches. An exception to this is Coweeman 1- tidal and Coweeman 2. These reaches, with lower gradients and diking, are slough-like and were given an EDT rating of 4 for current conditions.

Table 7-14. IWA Road Densities for HUCS with Associated EDT Reaches

LCFRB HUC	EDT Reaches associated with HUCS	HUC Road Density (mi./sq.mi.)	Wind Relationship- EDT Fines Rating
17080005080301	C7(.5), C8, C9, C10, C11, C12, LB2, LB3, RB3, Jim Watson Cr, Sam Smith Cr	7.3	2.5
17080005080302	M1, M2, RB6, LB5	6.4	2.25
17080005080303	C13, C14, C15, RB4, LB4	7.5	2.57
17080005080304	B1, B2, B3, LB6, Little Baird Cr	5.4	2.08
17080005080305	RB5, C21, C22	4.5	1.99
17080005080306	M3, M4, RB7	5.8	2.1
17080005080307	C16, C17, C18, C19, C20, Nineteen Cr, Skipper Cr, Brown Cr, O'neil Cr, Martin Cr	6.4	2.25
17080005080401	C5, C6, C7(.5), RB2, Canyon 2, Nye Cr	5.8	2.1
17080005080402	C2(.5), C3, LB1	11.3	2.94
17080005080403	C4, RB1, Canyon 1, Turner Cr	6.1	2.18
17080005080404	NF Goble Cr	6.6	2.25
17080005080405	G1, G2, G3, G4	6	2.15
17080005080407	C1 tidal, C2(.5)	4.8	2.03

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.22 Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: In rating this attribute it was assumed that percent embeddedness is directly related to the percentage of fines in spawning gravel.

In the template (pristine) condition, SW Washington watersheds were assumed to have a low level of embeddedness. Based on the historic level of fines in spawning gravels (8.5%), it was assumed embeddedness was less than 10%, which corresponds to and EDT rating of 0.5. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2.

Using the USFS Wind River data and analysis described above for rating fine sediment, a scale was developed relating road density to percent embeddedness. This scale was used to generate embeddedness ratings for all EDT reaches in the watershed. An exception to this is Coweeman 1- tidal and Coweeman 2. These reaches, with lower gradients and diking, are slough-like and were given an EDT rating of 3 for current conditions.

Coweeman River watershed road density values were taken from IWA results for LCFRB subwatersheds (HUCs) (LCFRB 2003). EDT reaches were linked to the appropriate HUC(s) by examining a map of HUC boundaries. Table 7-15 presents IWA road density by HUC for HUCs with associated EDT reaches.

Table 7-15. IWA Road Densities for HUCS with Associated EDT Reaches

LCFRB HUC	EDT Reaches associated with HUCS	HUC Road Density (mi./sq.mi.)	Wind Relationship-EDT Emb. Rating
17080005080301	C7(.5), C8, C9, C10, C11, C12, LB2, LB3, RB3, Jim Watson Cr, Sam Smith Cr	7.3	1
17080005080302	M1, M2, RB6, LB5	6.4	0.89
17080005080303	C13, C14, C15, RB4, LB4	7.5	1.05
17080005080304	B1, B2, B3, LB6, Little Baird Cr	5.4	0.81
17080005080305	RB5, C21, C22	4.5	0.78
17080005080306	M3, M4, RB7	5.8	0.84
17080005080307	C16, C17, C18, C19, C20, Nineteen Cr, Skipper Cr, Brown Cr, O'neil Cr, Martin Cr	6.4	0.89
17080005080401	C5, C6, C7(.5), RB2, Canyon 2, Nye Cr	5.8	0.84
17080005080402	C2(.5), C3, LB1	11.3	1.37
17080005080403	C4, RB1, Canyon 1, Turner Cr	6.1	0.87
17080005080404	NF Goble Cr	6.6	0.9
17080005080405	G1, G2, G3, G4	6	0.85
17080005080407	C1 tidal, C2(.5)	4.8	0.8

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.23 Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. No historical information is available for this attribute. Fire was historically a natural disturbance process that occasionally increased turbidity after an extensive hot burn. Background turbidity levels were assumed to increase with stream size. Professional opinion set these levels at an EDT rating of 0 in small tributaries (<35 ft. ww-high), 0.3 in medium tributaries (>35 ft. ww-high), and 0.5 in mainstem reaches.

Current increases in turbidity are likely associated with human activities that lead to bank instability in the riparian area and roads associated with logging, urbanization, and agriculture. Suspended sediment and turbidity data is limited to grab samples by USFS and UCD for the Wind River. Flow data and limited turbidity data are available for the Elochoman River from the USGS website (2004). Historical turbidity data was plotted versus flow data from the same time period. Prior to 1978, USGS turbidity data was recorded in JTU. Since 1978, turbidity data has been recorded in NTU. There is not a direct conversion from JTU to NTU, making it difficult to interpret turbidity data prior to 1978. Bank stability and roads analyses support a small increase in turbidity. Limited data suggests during high water events Wind River suspended sediment exceeds 100 mg/L, while Lower Trout Creek, Panther Creek, and the Middle Wind are over 40 mg/L, and other basins are 5-40mg/L with most less than 25mg/L. However, the duration of these turbidity levels is unknown. If suspended sediment levels of 100mg/L last for 24 hours the EDT rating is 1.0. If the 25 mg/L levels last 24 hours, the EDT rating is 0.8. These provided the basis for current ratings. These generally support EDT ratings of 0.3 for small tributaries, 0.7 for larger tributaries, and 1.0 for lower mainstem reaches.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.2.3.24 Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: Historical temperatures are unknown the in the Coweeman River subbasin. The only historical temperature data that was located were temperatures recorded in the 1930's and 40's while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary processes transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2000). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State watershed analysis manual (WFPB 1997). Elevation of stream reaches can be estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters back from the maximum wetted width. Next it was assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these tress are estimated to be between 40 – 50 meters for cedar and 60 - 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, 49 meters was used as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was approximately 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade, the relationship between forest angle and percentage of shade was used (WFPB 1997 Appendix G-33). Finally, the relationship between elevation, percentage of shade and the maximum daily stream temperature was used to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for maximum historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams, our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. A correction factor was developed for small tributaries, which consisted of adding 0.3 to the estimated historical EDT rating. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature and shade, while Pelletier (2002) used QUAL2K which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However, due to limited resources available for this study, the shade/elevation model was used for consistency throughout the Lower Columbia River.

For current conditions, the EDT maximum temperature calculator (MS Access) provided by Mobrand Biometrics, Inc. (MBI) was used to generate ratings for reaches where temperature data was available. Temperature data corresponding to summertime low flows (August) was available from the Cowlitz/Wahkiakum Conservation District (pers. com.), and Sullivan et. al. (1990). Table 7-16 lists the EDT reaches where temperature data was available, the year data was collected, and the data source. Temperature data collected within an EDT reach was assumed to be representative of the entire reach and was used to generate an EDT rating for the reach. Ratings for mainstem reaches without temperature data were extrapolated based on elevation, and proximity to reaches with temperature data. For tributaries, current and historic EDT ratings for reaches with current temperature data were compared, indicating that on average current ratings are 1 point higher than historic ratings. This relationship was used to develop ratings for tributary reaches without temperature data.

Table 7-16. Coweeman River EDT reaches with August temperature data, the year data was collected, & the data source.

EDT Reach	Year	Temperature Data Source
Coweeman 4	2002	Cowlitz/Wahkiakum Cons. Dist.
Canyon 1	1988	Sullivan et. al. 1990
Coweeman 5	2002	Cowlitz/Wahkiakum Cons. Dist.
Coweeman 6	1988	Sullivan et. al. 1990
Coweeman 13	1988	Sullivan et. al. 1990
Coweeman 16	1988	Sullivan et. al. 1990
Baird 1	1988	Sullivan et. al. 1990
Goble 1	2002	Cowlitz/Wahkiakum Cons. Dist.
Goble 1	1988	Sullivan et. al. 1990
Jim Watson Creek	2002	Cowlitz/Wahkiakum Cons. Dist.
Mulholland 1	1988	Sullivan et. al. 1990

Level of Proof: A combination of derived information and expert opinion was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations, expansion of empirical observations, derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.2.3.25 Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: Minimum temperature data was lacking in the basin. Wind River temperature data was used to develop a relationship between elevation and maximum temperature for elevations up to 2000 feet as follows: EDT min temp = 1.0248 Ln(elev) –5.8305 (R^2= 0.32, n=27). This relationship was used to generate categorical ratings (Table 7-17) based on elevation.

Table 7-17. Estimated categorical ratings for minimum temperature based on elevation from Wind River data.

Elevation	EDT Rating
< 600 ft	0
600-1200	1
1300-3000 ft	2

Minimum temperature ratings were assigned to both the historical and current conditions. Tributary ratings were assigned based on the elevation at the mouth unless they have more than one reach. In this case, elevations within each reach were used.

Level of Proof: A combination of expanded empirical observations, derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

7.2.3.26 Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: No data was found regarding current or historical conditions for groundwater inputs in this basin. Historically, there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. These reaches were given an EDT rating of 1. Higher gradient reaches of the mainstem and tributaries in the upper watershed likely had less groundwater input. These reaches were given an EDT rating of 2. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2. Higher gradient reaches in the upper watershed are likely similar to the historic condition and were given an EDT rating of 2.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.27 Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.

Rationale: Alkalinity was estimated from historical USGS (2004) data for conductivity using the formula: Alkalinity =0.421*Conductivity – 2.31 from Ptolemy (1993). Conductance data was available from three stations on the Coweeman, two near Kelso, WA and one above Sam Smith Creek. Conductance/Alkalinity data was averaged for these three locations and used to develop an EDT rating of 2.2 for the watershed. Alkalinity in the historic condition was given the same rating as the current condition for all reaches.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.2.3.28 Dissolved oxygen

Definition: Average dissolved oxygen within the water column for the specified time interval.

Rationale: Dissolved oxygen in the template (historic) condition was assumed to be unimpaired, an EDT rating of 0 (>8mg/l in August). Summers (2001) reported that in surveyed creeks dissolved oxygen levels were greater than 8 mg/l in August. For the Coweeman River, USGS (2004) water quality data (1971 & 1975) collected at gauging station 14244600 above Sam Smith Creek (Coweeman 12) indicate dissolved oxygen levels averaged 9.2 mg/l in August. Data from this site from 1970 - 1975 show no excursions below 8 mg/l during sampling. All reaches of the Coweeman were assumed to have greater than 8mg/l of DO with the following exceptions. USGS (2004) water quality data (1961-1972) collected at gauging station #14245000 indicates dissolved oxygen levels averaged 7.5 mg/L in August. This site is at the lower end of EDT reach Canyon 1. Reaches below this (Coweeman 1 tidal – 4) are unconfined and low gradient with little shade. Coweeman 3 and 4 pass through fields used for grazing livestock and are down-cut. Coweeman 1-tidal and 2 run through the town of Kelso, Washington and are diked/channelized and slough-like. Summertime water temperatures likely increase in these areas and DO problems may be exacerbated. Coweeman 4 was given an EDT rating of 0.7 and Coweeman 1-tidal, 2 & 3 were rated at 1.0.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. There is more uncertainty in the ratings for reaches with sloughs or slough-like conditions, than for riverine reaches.

7.2.3.29 Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because, of the lack of data.

7.2.3.30 Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

An exception to this is Coweeman 1-tidal. With the tidal influence in this reach, there is likely some water exchange with the lower Cowlitz during flood/high tides. The LFA for WRIA 26 (Wade 2000) notes that "the lower Cowlitz was placed on the 1998 303d list for 3 excursions beyond the National Toxic Rule criterion out of three samples for levels of arsenic". Coweeman 1-tidal was given an EDT rating of 0.5.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.2.3.31 Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

An exception to this is Coweeman 1-tidal. With the tidal influence in this reach, there is likely some water exchange with the lower Cowlitz during flood/high tides. The LFA for WRIA 26 (Wade 2000) notes that "the lower Cowlitz was placed on the 1998 303d list for 3 excursions beyond the National Toxic Rule criterion out of three samples for levels of arsenic". Coweeman 1-tidal was given an EDT rating of 0.5.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.2.3.32 Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data for this attribute is very limited. Historically, nutrient enrichment did not occur because, by definition, watersheds were in the “pristine” state. To determine the amount of nutrient enrichment in various reaches under current conditions the following factors were examined: fertilizing by timber companies, reaches downstream from fish hatcheries, agriculture effects, septic tanks, and storm water run-off.

The Coweeman has no fish hatcheries within the watershed. Most of the Coweeman River subbasin above EDT reach Coweeman 10 is owned by Weyerhaeuser and managed for timber harvest as part of the Mount St. Helens South Tree Farm. Stream adjacent homes in this area are rare. Weyerhaeuser utilizes the following protocol for fertilizing the Mount St. Helens North and South Tree Farms (pers. com. Byron Richert, Weyerhaeuser): fertilizer is applied aerially (via helicopter), the fertilizer used is Urea 46-00-0 applied at 440 lbs./acre (210 lbs. active Nitrogen), only Douglas Fir responsive stands (>50% Douglas Fir) are fertilized, fertilization starts at age 18 and is conducted once every seven years until three years before harvest. The effects of this fertilization on stream enrichment are likely difficult to measure, but were assumed to be minimal.

Most enrichment in the watershed likely occurs from stream adjacent septic systems, agriculture and industry. Stream adjacent homes are sporadic throughout the watershed from EDT reach Canyon 1 up to Coweeman 11 (end of county road) and in Goble 1 & 2. Reaches Canyon 1 to Coweeman 11, and Goble 1 & 2 were given an EDT rating of 0.1. Coweeman 3 and 4 are agricultural reaches with a significant amount of livestock grazing and unfenced streambanks and were given a rating of 1.0. Coweeman 1-tidal and 2 run through the City of Kelso, Washington industrial area; storm water runoff from this area likely increases enrichment. Coweeman 1-tidal and 2 were given a rating of 1.5. All other reaches were rated at 0.

Level of Proof: Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.2.3.33 Fish community richness

Definition: Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale: Historical fish community richness was estimated from the current distribution of native fish in these watersheds. Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness in SW Washington watersheds was estimated from direct observation (stream surveys, snorkel surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, local knowledge, and expert opinion. Anadromous fish distribution was estimated from the above as well as the SSHIAP fish distribution layer, which was captured in the EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in SW Washington watersheds: (1) smolt trapping activities on Abernathy, Germany, and Mill creeks (pers. com. Hanratty, WDFW), smolt trapping activities on the Kalama River above Lower Kalama Falls (pers. com. Wagemann WDFW), (3) electro-shocking in 2002 by USFWS in Abernathy Creek (pers. com. Zydlewski, USFWS), (4) electroshocking by

WDFW in many SW Washington tributaries (pers. com. Hallock, WDFW), (5) WDFW stream & snorkel surveys on the Elochoman (pers. com. Byrne, WDFW), Kalama, East Fork Lewis, Toutle and Coweeman Rivers, (5) species present in Hardy Slough (pers. com. Coley, USFWS), (6) Reimers and Bond (1967), and (7) McPheil (1967). A spreadsheet summarizing the above data sources was developed: (EDT 2003 Data.xls).

EDT reaches Coweeman 1-tidal and 2 likely have many species present from the Lower Columbia and Lower Cowlitz Rivers. An estimated 30+ species were included in this list: chinook, chum, coho, steelhead/rainbow trout, cutthroat trout, sculpin sp.(3) (torrent, coastrange, reticulate), bridgelip and largescale sucker, peamouth, northern pikeminnow, smelt, sandroller, redside shiner, large & smallmouth bass, carp, goldfish, white & black crappie, eastern banded killifish, yellow perch, sunfish, pumpkinseed, brown & yellow bullhead, white sturgeon, 3-spine stickleback, and dace. Most of the non-native fish species likely drop out as gradient increases and water temperatures are reduced. The eastern banded killifish is an exception to this, it has been found in higher reaches of the Elochoman River (pers. com. Byrne, WDFW) and trapped on Abernathy Creek (pers. com. Hanratty, WDFW). For EDT reaches Coweeman 3 and 4, chinook, chum, coho, steelhead/rainbow trout, cutthroat trout, sculpin sp.(3), largescale sucker, peamouth, northern pikeminnow, 3-spine stickleback, and Eastern banded Killifish were assumed to be present. All mainstem and tributary reaches above Coweeman 4 (Canyon 1 upstream) were assumed to have coho, steelhead/rainbow trout, cutthroat trout, and sculpin sp.(2). In addition, chinook were assumed to be present in mainstem reaches up to Brown's Creek (Coweeman 18) and in tributary reaches Goble 1 and Mulholland 1.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.2.3.34 Fish species introductions

Definition: Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. Introduced species ratings were derived from current fish species richness data (see Fish Community Richness above). Coweeman 1-tidal and 2 are the reaches most likely to harbor introduced species. The Eastern banded killifish is the only non-native species documented to penetrate into higher reaches of SW Washington watersheds.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.2.3.35 Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

Hatchery steelhead constitute the only hatchery releases in the Coweeman Basin. Annual releases are acclimated at two locations in the lower Coweeman. One acclimation pond is on Turner Creek above EDT reach Canyon 1, and the other is on an unnamed tributary entering in EDT reach Coweeman 6. Mainstem reaches from Coweeman 6 to the mouth and Turner Creek were given and EDT rating of 2. All other reaches were rated at 0.

Level of Proof: For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.2.3.36 Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants and pathogen levels were assumed to be at background levels. All reaches were given an EDT rating of 0.

Hatchery steelhead constitute the only hatchery releases in the Coweeman Basin. Annual releases are acclimated at two locations in the lower Coweeman. One acclimation pond is on Turner Creek above EDT reach Canyon 1, and the other is on an unnamed tributary entering in EDT reach Coweeman 6. Coweeman 6 downstream to the mouth and Turner Creek were given an EDT rating of 2. All other reaches were rated at 0.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.2.3.37 Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition.

Utilizing GIS, the SSHIAP and DNR roads layers, DNR digital ortho-photos, and USGS topography maps (1:24,000) were examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT rating of 4 was given to reaches with extensive road/boat access and high recreational use; a rating of 3 was given to areas with road/boat access and proximity to population center and moderate use; a rating of 2 was given to reaches with multiple access points (or road parallels reach) through public lands or unrestricted access through private lands; a rating of 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands; and a rating of 0 was given to reaches far from population centers with no roads.

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.2.3.38 Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute's rating for watersheds in pristine condition.

The magnitude and timing of yearling hatchery smolt releases, and increases in exotic/native piscivorous fishes were considered when developing this rating. The status of top-level carnivores and other fish eating species (i.e. birds) is unknown in this watershed.

Hatchery steelhead smolts are released from acclimation ponds on Turner Creek (above EDT reach Canyon 1) and an unnamed tributary entering in Coweeman 6, potentially increasing predation in downstream reaches. In addition, the potential presence of exotic piscivorous fishes in Coweeman 1-tidal and 2 may increase predation there. Coweeman 1-tidal was given an EDT rating of 4, Coweeman 2 was given a rating of 3, and Coweeman 3 – 6 & Canyon 1-3 were rated at 2.5. All other reaches were given a rating of 2.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.2.3.39 Salmon Carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Mainstem reaches with historic chum presence (spawning) were given a rating of 0 (super abundant, >800). Mainstem reaches with chinook and coho, but no chum, were given a rating of 2 (moderately abundant, >200 and <400). Reaches with only coho were given a rating of 3 (not abundant, >25 and <200). Reaches with only steelhead and/or cutthroat trout were given a rating of 4 (very few or none, <25), since these fish can spawn more than once (iteroparous). Tidal reaches below areas of chum spawning were given a rating of 1 (very abundant, >400 and <800); it was assumed carcasses from spawning reaches above are washed into these reaches.

An estimate of the current number of salmon carcasses per mile was derived from natural spawn escapement estimates, EDT reach length data, and SSHIAP fish distribution data. SSHIAP categorizes fish distribution into known, presumed, and potential habitat by species, and EDT reaches were delineated using these categories during development of the EDT template. Using potential fish distribution, EDT reach lengths were summed to develop the total number of miles of habitat available for each species. Where available, the natural spawn escapement estimate was divided by the corresponding number of miles of habitat to generate the average number of carcasses per mile for each species. These values were summed according to the species present within each reach to develop an estimate of the total number of carcasses per mile within the reach. Calculations were completed for chum, chinook and coho only, as steelhead and cutthroat trout are iteroparous and likely contribute few carcasses. When escapement data was not available, expert opinion was used to estimate escapement and/or carcass abundance.

The Coweeman River currently supports naturally produced populations of fall chinook, coho, winter steelhead, and cutthroat trout. Chum may exist in low numbers, but fall stream surveys (conducted annually) have not produced any chum carcass recoveries.

WDFW index counts and escapement estimates are available for Coweeman fall chinook, with the ten year average (1992-2001) being 606 adults. Recent (2002 & 2003) estimates are between 1000 and 1500 adults. For developing EDT carcass estimates, it was assumed 1000 chinook carcasses were available annually. Estimates of coho abundance are not available for the Coweeman River, but are available for Germany Creek. These were back-calculated from 2001 & 2002 smolt production estimates (pers. com. Hanratty, WDFW). Calculations were made assuming a 4% smolt to adult survival rate, and adding a coho jack estimate calculated as 10% of the total adult run. (pers. com. Seiler, WDFW). Based solely on watershed size, the Germany Creek estimates were doubled and used as surrogate for the Coweeman. Chum carcasses in the Coweeman were assumed to be non-existent.

For current conditions, mainstem Coweeman reaches from Coweeman 18 downstream to the mouth were given an EDT rating of 3, due to the presence of fall chinook in these areas. All other reaches were given a rating of 4.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information, and expert opinion was used to estimate the historic and current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.2.3.40 Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: A few direct measures of benthos diversity for selected sites are available within the LCR from DOE and OSU. Reference sites in the Wind and Cowlitz Rivers yielded B-IBI ratings between 40 and 43 indicating EDT values of 0.3 to 0.9, which is equivalent to an EDT rating of 0.6. This rating was used as a baseline for benthos diversity and was assigned to all reaches for historic conditions.

Current Wind River data indicates EDT scores in disturbed Rosgen B-channels are similar to historic scores of 0.6 and in disturbed C-channels scores are reduced to 1.3. EDT ratings in Coweeman 2 and 3 were reduced to 1.3. Coweeman 1-tidal is currently, and likely was historically, an area of sediment deposition, and macroinvertebrate complexity is likely reduced. This reach was given a rating of 1.0 and 2.0 for the historic and current conditions, respectively. All other reaches were given a rating of 0.6

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. Expansion of empirical observations, and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

Acknowledgements

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	Appendix A: EDT reaches and descriptions
EDT Reach	**EDT Reach Description**
Baird Creek 1	Description: mouth to Little Baird Creek; Confinement: C; Fish Species present: WS
Baird Creek 2	Description: Little Baird Creek to unnamed LB trib6 at RM 3.7; Confinement: C; Fish Species present: WS—0.3 known, 0.7 presumed
Baird Creek 3	Description: unnamed LB trib6 to extent of presumed steelhead habitat; Confinement: C; Fish Species present: WS presumed
Brown Creek	Description: mouth to extent of presumed steelhead distribution (includes both forks); Confinement: C to M; Fish Species present: WS presumed
Canyon 1	Description: downstream end of canyon to Turner Creek; Confinement: C; Fish Species present: CH presumed, FC, WS
Canyon 2	Description: Turner Creek to Nye Creek; Confinement: C; Fish Species present: CH presumed, FC, WS
Canyon 3	Description: Nye Creek to upstream end of canyon; Confinement: C; Fish Species present: CH presumed, FC, WS
Coweeman 1 tidal	Description: mouth to RM 1.0; Confinement: U; Fish Species present: CH, FC, WS
Coweeman 10	Description: unnamed RB trib3 to Jim Watson Creek; Confinement: C; Fish Species present: CH presumed, FC, WS
Coweeman 11	Description: Jim Watson Creek to Sam Smith Creek; Confinement: C; Fish Species present: CH presumed, FC, WS
Coweeman 12	Description: Sam Smith Creek to Mulholland Creek; Confinement: C; Fish Species present: CH presumed, FC, WS
Coweeman 13	Description: Mulholland Creek to unnamed RB trib4; Confinement: C; Fish Species present: FC, WS
Coweeman 14	Description: unnamed RB trib4 to unnamed LB trib4; Confinement: C; Fish Species present: FC, WS
Coweeman 15	Description: unnamed LB trib4 to Baird Creek; Confinement: C; Fish Species present: FC, WS
Coweeman 16	Description: Baird Creek to Nineteen Creek; Confinement: M; Fish Species present: FC, WS
Coweeman 17	Description: Nineteen Creek to Skipper Creek; Confinement: M; Fish Species present: FC, WS

	Appendix A: EDT reaches and descriptions
Coweeman 18	Description: Skipper Creek to Brown Creek; Confinement: M; Fish Species present: FC, WS
Coweeman 19	Description: Brown Creek to ONeil Creek; Confinement: C; Fish Species present: FC, WS
Coweeman 2	Description: RM 1.0 to unnamed LB trib1; Confinement: C (diked); Fish Species present: CH, FC, WS
Coweeman 20	Description: ONeil Creek to Martin Creek; Confinement: C; Fish Species present: FC, WS
Coweeman 21	Description: Martin Creek to unnamed RB trib5; Confinement: C; Fish Species present: FC, WS
Coweeman 22	Description: unnamed RB trib5 to Washboard Falls; Confinement: C; Fish Species present: FC, WS
Coweeman 3	Description: unnamed LB trib1 to unnamed RB trib1; Confinement: U; Fish Species present: CH, FC, WS
Coweeman 4	Description: unnamed RB trib1 to downstream end of canyon; Confinement: U; Fish Species present: CH, FC, WS
Coweeman 5	Description: upstream end of canyon to Goble Creek; Confinement: C; Fish Species present: CH presumed, FC, WS
Coweeman 6	Description: Goble Creek to unnamed RB trib2; Confinement: C; Fish Species present: CH presumed, FC, WS
Coweeman 7	Description: unnamed RB trib2 to unnamed LB trib2; Confinement: C; Fish Species present: CH presumed, FC, WS
Coweeman 8	Description: unnamed LB trib2 to unnamed LB trib3; Confinement: C; Fish Species present: CH presumed, FC, WS
Coweeman 9	Description: unnamed LB trib3 to unnamed RB trib3; Confinement: C; Fish Species present: CH presumed, FC, WS
Goble Creek 1	Description: mouth to north fork Goble Creek; Confinement: C; Fish Species present: WS
Goble Creek 2	Description: north fork Goble Creek to fork; Confinement: Confined; species present: WS known
Goble Creek 3	Description: forks east to extent of steelhead distribution; Confinement: Confined; species present: WS approx. 1.5 miles known, 1.5 miles presumed
Goble Creek 4	Description: forks south to extent of steelhead presence; Confinement: Confined; species present: WS approx. 1 mile known, .25 miles presumed

	Appendix A: EDT reaches and descriptions
Jim Watson Creek	Description: mouth to extent of steelhead distribution; Confinement: U to M; Fish Species present: WS presumed
LB trib1 (26.0016)	Description: mouth to 0.25 mile up each fork; Confinement: C; Fish Species present: WS presumed
LB trib2 (26.0071)	Description: mouth to extent of available habitat; Confinement: M to C; Fish Species present: WS potential
LB trib3 (26.0072)	Description: mouth to extent of available habitat; Confinement: M to C; Fish Species present: WS potential
LB trib4 (26.0097)	Description: mouth to extent of presumed steelhead distribution; Confinement: C; Fish Species present: WS presumed
LB trib5	Description: mouth to extent of presumed steelhead distribution; Confinement: C to M; Fish Species present: WS presumed
LB trib6	Description: mouth to extent of potential steelhead distribution; Confinement: C to M; Fish Species present: WS—0.6 presumed, 0.7 potential
Little Baird Creek	Description: mouth to extent of potential steelhead distribution; Confinement: C; Fish Species present: WS—0.4 known, 0.9 potential
Lower Cowlitz-1	
Lower Cowlitz-2	
Martin Creek	Description: mouth to extent of presumed steelhead distribution; Confinement: C; Fish Species present: WS presumed
Mulholland Creek 1	Description: mouth to unnamed RB trib6; Confinement: C; Fish Species present: WS, FC
Mulholland Creek 2	Description: unnamed RB trib6 to unnamed LB trib5; Confinement: C; Fish Species present: WS—1.2 known, 1.9 presumed
Mulholland Creek 3	Description: unnamed LB trib5 to unnamed RB trib7; Confinement: C; Fish Species present: WS—0.1 presumed, 1.4 potential
Mulholland Creek 4	Description: unnamed RB trib7 to end of potential steelhead habitat; Confinement: M to C; Fish Species present: WS potential
Nineteen Creek	Description: mouth to extent of presumed steelhead distribution (includes a small RB trib); Confinement: C; Fish Species present: WS presumed
North Fork Goble	Description: mouth to extent of steelhead distribution; Confinement: Confined; species present: WS approx. 3 miles known, 1 mile presumed

	Appendix A: EDT reaches and descriptions
Creek	
Nye Creek	Description: mouth to extent of steelhead potential; Confinement: M to C; Fish Species present: WS—0.1 presumed, 0.3 potential
ONeil Creek	Description: mouth to extent of presumed steelhead distribution; Confinement: C to M; Fish Species present: WS presumed
RB trib1 (26.0019)	Description: mouth to RM 0.5; Confinement: M to C; Fish Species present: WS—0.2 presumed, 0.3 potential
RB trib2 (26.0068)	Description: mouth to extent of steelhead distribution; Confinement: M to C; Fish Species present: WS—0.3 known, 0.5 presumed
RB trib3 (26.0079)	Description: mouth to fork; Confinement: M to C; Fish Species present: WS potential
RB trib4 (26.0096)	Description: mouth to extent of presumed steelhead distribution; Confinement: C; Fish Species present: WS presumed
RB trib5 (26.0014)	Description: mouth to extent of presumed and potential steelhead distribution; Confinement: C to M; Fish Species present: WS—0.8 presumed, 0.9 potential
RB trib6	Description: mouth to extent of presumed steelhead distribution; Confinement: C to M; Fish Species present: WS presumed
RB trib7	Description: mouth to extent of potential steelhead distribution; Confinement: C; Fish Species present: WS potential
Sam Smith Creek	Description: mouth to first road crossing; Confinement: U to M; Fish Species present: WS presumed
Skipper Creek	Description: mouth to extent of presumed steelhead distribution (includes both forks); Confinement: M to C; Fish Species present: WS presumed
Turner Creek	Description: mouth to extent of steelhead potential; Confinement: M to C; Fish Species present: WS—0.3 known, 2.0 potential

7.3 Kalama

7.3.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treatment Model (EDT) for the Kalama River. In this project we rated over 40 reaches with 46 environmental attributes per reach for current conditions and another 46 for historical conditions. Over 1,800 current ratings were assigned and empirical observations within these reaches were not available for all of these ratings. In fact, less than 20% of these ratings are from empirical data. To develop the remaining data, we used expansion of empirical observations, derived information, expert opinion, and hypothetical information. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute, data was very limited or non-existent. WDFW established a relationship between road density and fine sediment in the Wind River. We applied this relationship to all subwatersheds; this is an example of derived information. In some cases, such as bed scour, we had no data for most reaches. However, data is available from Gobar Creek (a Kalama River tributary) and observations have been made in the Wind River as to which flows produce bed load movement. We noted that bed scour is related to gradient, stream width, and confinement. Based on these observations expert opinion was used to develop a look-up table to estimate bed scour. For rationale behind the EDT ratings assigned, see the text below. For specific reach scale information, please see the EDT database for the watershed of interest. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.3.2 Recommendations

1) Adult chum salmon, chinook salmon, and steelhead population estimates should continue for the basin. However, more emphasis should be placed on determining the number of hatchery and wild spawners and the reproductive success of hatchery spawners. Summer & winter steelhead and spring chinook estimates are based on rack counts at Kalama Falls Hatchery (KFH) and are considered accurate and precise. Fall chinook estimates and chum salmon estimates are based on an assumed observer efficiency and are likely to be less reliable. Coho salmon counts are periodic and not population estimates. Spring chinook and steelhead escapement estimates should be continued and funding secured to develop accurate and precise adult estimates for chum, chinook and coho salmon. Smolt population estimates are made for the Kalama basin above KFH for steelhead and spring chinook using mark-recapture. Currently smolt trapping does not occur in the lower Kalama (<KFH). Funding should be secured to estimate fall chinook, chum, coho and steelhead juvenile populations in the lower Kalama River. Accurate and precise adult and juvenile population estimates will allow for better population status estimates, validation of EDT, and to determine if subbasin restoration actions are effective.
2) Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating, as would field surveys.

3) Empirical sediment data was not available for most of the basin. A sediment monitoring program should be developed to assess the percentage of fines in spawning gravels, embeddedness, and turbidity in reaches used by anadromous fish.
4) Differences existed between field and GIS ratings of natural confinement. The SSHIAP database should be field verified.
5) Flow monitoring in the mainstem Kalama River was discontinued in the early 1980s. Flow monitoring should be resumed. Bed scour estimates were not available for this basin and bed scour data should be collected and related to peak flows.
6) USFS and USGS habitat surveys do not directly measure all habitat types needed for EDT. WDFW habitat surveys in 2002 were opportunistic; that is, based on a limited amount of resources, we chose to survey only a few "representative" mainstem and tributary reaches. In addition, glides and pools were distinguished subjectively and not quantitatively. To accurately estimate stream habitat type within the anadromous distribution, a statistically valid sampling design should be developed and applied (Hankin and Reeves 1988 or EMAP). Survey methodology should differentiate between pools and glides and be repeatable.
7) A combination of DOE and OSU estimates of Benthic Index of Biological Integrity (B-IBI) collected in the Wind and Cowlitz River basins were used to develop EDT ratings. These estimates should be completed in this and other SW Washington watersheds.
8) Obstructions were not rated and passage was assumed to be 100%. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. These ratings should be updated using SSHIAP database.

7.3.3 Attributes

7.3.3.1 Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: This watershed originates from Mount St. Helens. The maximum elevation is approximately 8,300 feet on the summit of Mount St. Helens (USFS, 1996). Kalama Falls (Upper) is a barrier to anadromous fish and is at an elevation of approximately 1250 feet. The Upper Kalama River Watershed Analysis (USFS 1996) indicates the Upper Basin is a transient snow zone and flows are likely influenced by snow-melt and rain-on-snow events. These events influence lower mainstem reaches, but effects are likely masked by tributary flow inputs as one progresses downstream. The Integrated Watershed Assessment (IWA) completed for the Lower Columbia Fish Recovery Board (LCFRB) examines the current condition of key watershed processes by Hydrologic Unit Code (HUC) (LCFRB 2003). IWA results present the percent rain-on-snow area by HUC. EDT reaches were linked to the appropriate HUC(s) by examining a map of HUC boundaries (LCFRB 2003). Rain-on-snow percentages range from 0 to 57% for HUCS with associated EDT reaches (Table 7-18). Reaches with percentages >45% were given an EDT rating of 2 (rain-on-snow transitional), and reaches with <45% were given an EDT rating of 3 (rainfall dominated). Natural flow regime ratings were used for both historical and current conditions. Each reaches natural flow regime was used to assign shape patterns when rating other EDT attributes.

Table 7-18. % Rain-on-Snow Area for HUCs with associated EDT reaches.

LCFRB HUC	EDT Reaches associated with HUCS	HUC % Rain on Snow Area
17080003040201	K18,19,20,21, Langdon, LakeView Pk	45
17080003040202	North Fork Kalama	50
17080003040301	K11,12,13(.5), Arnold, Unnamed	14
17080003040302	K13(.5),14,15, Jack, Lost	33
17080003040303	K16,17, Bush, Wolf	57
17080003040304	Elk	50
17080003040401	K9,10, Knowlton, Wildhorse	16
17080003040402	Gobar, Bear	17
17080003040501	K1,2,3,4, Spencer, Cedar	0
17080003040502	K5,6, Indian, Lower Falls	1
17080003040503	K7,8, Summers	7
17080003040504	Hatchery Ck	0
17080003040505	Little Kalama, Dee	8

An examination of mean monthly flow data (USGS 2004) from Kalama River gauges supports the above ratings. Mean monthly flow data was plotted for four Kalama River gauge locations: near Cougar, below falls near Cougar, below Italian creek, and near Kalama. Flow patterns were compared to EDT flow patterns for a rainfall dominated watershed and a rain-on-snow transitional watershed. The two uppermost gauges (near Cougar and below falls near Cougar) show evidence of rain-on-snow effects with high winter flows and increased flows through late spring. The two lower gauges (below Italian Ck. and near Kalama) show a clear rainfall dominated pattern with high winter flows decreasing steadily through the spring into summer.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion were used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

7.3.3.2 Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale: This watershed does not have artificial flow regulation, and was given an EDT rating of 0 for the historical and current conditions.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.3.3.3 Flow - change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition the template conditions for this attribute are rated as a value of two because this describes this attribute's rating for watersheds in pristine condition. Direct measures of interannual high flow variation are not available for most basins. USFS has conducted watershed analysis in the EF Lewis, NF Lewis, Wind, White Salmon, Washougal, Kalama, Cowlitz, and Cispus Rivers and Rock Creek (USFS 1995a, USFS 1995b, USFS 1996a, USFS 1996b, USFS 2000). Peak flow analysis was conducted using the State of Washington "Standard methodology for conducting watershed analysis". The primary data used for the peak flow analysis pertains to vegetation condition, elevation, road network, and aspect. The results for increased risk in peak flow from the USFS watershed analysis are shown in Table 7-19. For watersheds in which the two-year peak flow (Q2yr) increases 10% the EDT rating is 2.25. For increases of 20% the EDT rating is 2.5. Data for the Upper Kalama Basin indicated an increase in peak flow of 5 to >10% (Table 2). We assumed a 10% increase would be representative of the upper basin. Q2yr analysis of peak flow data (using EDT manual protocol) for USGS gauge data (2004) on the Kalama River below the lower falls (1934-1977) indicated a peak flow increase of 17% (EDT rating ~ 2.4). Upper and lower basin ratings were averaged and an EDT rating of 2.3 was assigned for all reaches.

Table 7-19. Summary of USFS Watershed Analysis for the change in peak flow

Basin	# of Subbasins	Increase in Peak Flow
Wind	26	2 – 14%
East Fork Lewis	9	5 –13%
Lower Lewis		10 -12%
Rock Cr		1 -5%
Upper Kalama		5 - >10%
Cispus		<10%

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. A combination of derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.4 Flow - changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of two because this describes this attribute's rating for watersheds in pristine condition. Research on the effects of land use practices on summer low flow is inconclusive. Therefore, template and current conditions were rated the same (EDT rating of 2), except where noted.

The LCFRB Level 1 Technical Assessment Final Report for WRIAS 27&28 (2001) presents water usage by category for the Kalama watershed. Total water usage is estimated at 427 million gallons annually for city water, agriculture, industry, and domestic wells. The largest purveyor is the City of Kalama, which serves a population of 3500 and has approximately 1500 water hook-ups. Estimated water usage for the month of August by the City is 31 million gallons. This translates to an average withdrawal of approximately 1.5 cfs. Hatchery withdrawals occur in Kalama 6 for use at the Kalama Falls Hatchery (KFH), in Kalama 4 and Hatchery Creek for the Fallert Creek Hatchery, and in Gobar Creek for the Gobar acclimation ponds. All water pumped for hatchery usage is returned to the stream at the lower end of the facility/pond. Of these facilities, KFH pumps the most water in August with withdrawals ranging from 9 to 13 cfs (pers. com. Steve Gross WDFW).

Using USGS gauge data, the average flow for the Kalama River in August was calculated. Flows ranged from 263 cfs (measured near Kalama for years 1911-1932) to 310 cfs (measured below Italian Creek for years 1948-1980). The Kalama is atypical of most SW Washington watersheds in that there are many sources of groundwater input, which buffer the effects of hot, dry summers. Low flows are less extreme and more consistent than most SW Washington streams. Withdrawals from the aforementioned facilities were found to be minimal when compared to mean August flows. The Washington State Conservation Commission Limiting Factors Analysis (LFA) for WRIA 27 also notes that "withdrawals are not considered a major concern within the Kalama basin today; however… could become a problem in the near future" (Wade 2000). Low Flow EDT ratings for reaches with these withdrawals were not adjusted.

Flows in the lower 0.1 miles of Hatchery creek are increased in the summer months, due to the release of hatchery-use water pumped from the mainstem Kalama River into the creek. The intake on Hatchery Creek itself is only used December through March and does not impact summer low flows (pers. com. Steve Gross WDFW). This reach was given an EDT rating of 1.9.

The NF Kalama River and Langdon, Jacks, and Wolf Creeks are noted in the LFA for WRIA 27 (Wade 2000) as having potential low flow problems with flows going subsurface. However, these problems are attributed to sediment/gravel accumulation at the mouth rather than from a reduction in flow. EDT ratings of 2 were given for these reaches.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. A combination of derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.5 Flow – intra daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. This attribute was given an EDT rating of 0 for current conditions due to the lack of storm water runoff and hydroelectric development in the watershed. There are no major metropolitan areas in this watershed with large areas of impervious surfaces.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.3.3.6 Flow –Intra annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute's rating for watersheds in pristine condition. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in this watershed. Based on USFS watershed analyses and a Q2yr analysis, we assumed a 13% increase in peak high flows. Since there was no data for this attribute, it was suggested that its rating should be similar to that for changes in interannual variability in high flows (pers. com. Lestelle, Mobrand Biometrics, Inc). Ratings for interannual variability in high flow were translated directly into ratings for intra-annual flow.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.7 Channel length

Definition: Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: Ned Pittman (WDFW) provided the length of each reach from SSHIAP GIS layers. Stream length was assumed to be the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.3.3.8 Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). Wetted widths corresponding to average summer low flows (August) were measured as part of these surveys. In addition, VanderPloeg and Grobelny (pers. com.) took spot measurements of wetted widths at summertime low flow levels in many Kalama EDT reach segments during the year 2000 for use by SSHIAP. Where there was overlap, spot measurements taken in 2000 were compared with representative reaches surveyed in 2002, and were found to be similar. To determine if surveys were conducted during average low flow conditions, streamflows corresponding to survey dates from both these data sources were compared to mean August flows (for all available years). USGS (2004) streamflow data is not available for the Kalama River in 2000 and 2002, however, gauge data from the South Fork (SF) Toutle River (near Toutle, WA) and East Fork (EF) Lewis River (near Heisson, WA) were assumed to be good surrogates for identifying fluctuations in streamflow caused by rain events. Mean August streamflow for the SF Toutle (1940-2002) was 118 cfs (range: 79 to 172 cfs), and flows corresponding to 2000 and 2002 survey dates ranged from 69 to 159 cfs (USGS 2004). Mean August streamflow for the EF Lewis (1930-2002) was 83 cfs (range 44 to 278 cfs), and flows corresponding to 2000 and 2002 survey dates ranged from 48 to 121 cfs (USGS 2004). It was assumed conditions on the Kalama River were similar indicating surveys were conducted during near average low flow conditions.

Where representative reach data (VanderPloeg 2003) was available, it was used in rating the corresponding EDT reaches. For other reaches, spot measurement data from 2000 was used when available. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys and/or spot measurement reaches with similar habitat, gradient and confinement (Table 7-20).

Spot measurements for Hatchery Creek were taken below the hatchery, where water pumped from the Kalama River for hatchery use is returned. Current widths in this area are likely increased from the supplemental flow and are not representative of the entire reach. The measured width was divided by two in order to develop an EDT value for this reach. Hydroconfinement in Kalama 1 was not thought to significantly reduce minimum wetted widths. No adjustments were made for this reach.

Table 7-20. Reference reaches used for reaches not surveyed for minimum wetted widths.

Non-surveyed Reach	Reference reach
Indian Creek	Spencer Creek – spot measurement
Unnamed Cr (27.0087)	Spencer Creek – spot measurement
LakeView Peak Ck	Langdon Creek – spot measurement
Kalama 6	Kalama 5 – representative reach
Kalama 7	Kalama 5 – representative reach
Kalama 10	Kalama 11 – representative reach
Kalama 12	Kalama 11 – representative reach
Kalama 15	Kalama 14 - representative reach
Kalama 16	Kalama 17 – representative reach
Kalama 20	Kalama 21 – spot measurement
Kalama 18	Avg of 2 spot measurements in Kalama 18

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations and expert opinion were used and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.9 Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Representative reaches in lower Columbia River tributaries were surveyed by Steve VanderPloeg (WDFW) in 2003. Wetted widths corresponding to average winter high flows (January) were measured as part of these surveys. (VanderPloeg 2003). To determine if surveys were conducted during average high flow conditions, streamflows corresponding to survey dates were compared to mean January flows (for all available years). USGS (2004) streamflow data is not available for the Kalama River in 2000 and 2002, however, gauge data from the South Fork (SF) Toutle River (near Toutle, WA) and East Fork (EF) Lewis River (near Heisson, WA) were assumed to be good surrogates for identifying fluctuations in streamflow caused by rain events. Mean January streamflow for the SF Toutle (1940-2002) was 1031 cfs (range: 318 to 2488 cfs), and flow corresponding to the 2003 survey date was 1090 cfs (USGS 2004). Mean January streamflow for the EF Lewis (1930-2002) was 1407 cfs (range: 303 to 3459 cfs), and flow corresponding to the 2003 survey date was 2170 cfs (USGS 2004). SF Toutle flows were at average levels, while EF Lewis flows were higher than average. It was assumed conditions on the Kalama River fell somewhere between these two levels, indicating surveys were conducted during near average or slightly higher flow conditions. Wetted widths recorded during these surveys were used without adjustment, realizing they may be biased slightly high.

Typically less reaches per subbasin were measured during average winter flow as compared to summer flow. The percent increase between low and high flow widths for all subbasins was compared to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data (EDT reach Kalama 14). A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris and hydroconfinement. Using only Kalama mainstem reach data (EDT reaches Kalama 2,5,11,17) the mean increase in stream width is 30%. A possible explanation for this is that most of the Lower Kalama watershed is currently confined. Mainstem EDT reaches from Wolf Creek to Spencer Creek (Kalama 4-17) run through natural canyons. Lower EDT reaches (Kalama 1-3) were historically unconfined or moderately confined, but are currently heavily diked and channelized. Mainstem reaches from Wolf Creek to the Upper Falls are generally moderately confined with little or no hydroconfinement.

Therefore, actual “wetted width-high” values were used in reaches where data was available (except Kalama 14). For reaches without high flow width data, a 1.3 multiplier (30%) was used to expand “wetted width-low” data in confined (or hydro-confined) mainstem reaches (Kalama 1 – 17) and a 1.6 multiplier (60%) was used to expand “wetted width-low” values for all tributary and moderately confined mainstem reaches (Kalama 18-21). Unconfined reaches of the Lower Kalama (Kalama 1 & 3) are currently heavily diked and channelized. In the historic condition these areas were likely more braided and wider during winter flows. To develop historic "wetted width-high" values, a 2.0 multiplier was used for Kalama 1 and a 1.6 multiplier was used for Kalama 3 to expand current "wetted width-low" values for these reaches. Kalama 2 is moderately confined and current width values for this reach were used for historic ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, expanded empirical observations and expert opinion were used and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.10 Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as % gradient) was calculated by dividing the change in reach elevation by the reach length and multiplying by 100. Ned Pittman (WDFW) used SSHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical gradient.

7.3.3.11 Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003. Confinement ratings were estimated during these surveys (VanderPloeg 2003). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps (1:24,000) were consulted (via GIS) to verify and/or adjust ratings. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4 (Table 7-21). There are often multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings.

Table 7-21. Comparison of SSHIAP and EDT ratings for confinement.

Project	Unconfined	Equal unconfined and mod. confined	Moderately confined	Equal mod confined and confined	Confined
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.3.3.12 Confinement – hydro-modifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cut off due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures and activity) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. Most hydro-modification consists of roads in the floodplain and diking. The SSHIAP and DNR GIS roads layers, DNR digital ortho-photos, USGS topography maps (1:24,000 via GIS), and WRIA 26 LFA (Wade 2000) were reviewed and professional judgment was used to assign EDT ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.3.3.13 Habitat Type

Definition: *Backwater pools* is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are believed to be the primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991 - Forest Ecosystem Management July 1992, page V-23), and applying this to current habitat type composition estimates. On Germany Creek, the Elochoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, it was assumed that for historical conditions the percentage of pools was significantly higher than for current conditions. For gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5%, pool habitat was estimated to be 40% and 30% respectively (WFPB 1994). Tailouts were assumed to represent 15-20% of pool habitat, which is the current range from WDFW surveys (VanderPloeg 2003). Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5% to 6% for gradients greater then 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat increased with gradient. WDFW field data (VanderPloeg 2003) indicated the percentage of gravel riffle habitat decreased with stream gradient, and cobble/boulder riffle habitat increased with stream gradient; the percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1% to 15% at gradients greater than 6%. WDFW surveys indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Representative reaches of lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). Habitat type composition was measured during these surveys. Surveys primarily followed USFS stream survey level 2 protocols, which delineate between riffles and slow water, but not pools and glides. Glide habitat is the most difficult habitat to identify, and, therefore, was estimated but not surveyed. In general, WDFW survey methodology did not appear to work for glides. Therefore, Wind River data (USGS) was examined to help differentiate between these two habitat types. Wind River data showed a positive relationship between gradient and/or confinement and riffle habitat. It also showed a negative relationship between pool habitat and gradient and/or confinement. However, there was no relationship between pools and glides. There was variation between surveyors when the same reach was walked. This may be due to habitat changes but it could also be due to measurement error between surveyors. In general, glides accounted for 30% to 50% of the non-riffle habitat. For the Kalama River, glide habitat estimated during habitat surveys averaged 38.3% of non-riffle habitat (range: 30.7% to 79.8%), with only one surveyed reach greater than 50%. Glide habitat in Kalama-14 was estimated at 79.8% of non-riffle habitat. This reach is known, from WDFW snorkel surveys, to have fewer pools and more riffle/glide habitat. Based on comparison with Wind River data, Kalama River glide percentage estimates seemed reasonable and were not adjusted. Assumptions about glide and pool habitat are most likely to affect coho salmon since they prefer pool habitat during their extended freshwater rearing.

For the Kalama River, habitat surveys (VanderPloeg 2003) were conducted within EDT reaches Kalama 2, 5, 11, 14, 17, and Gobar Creek. Data from these surveys and professional knowledge were used to develop ratings for EDT reaches within the watershed based on areas of similar habitat, confinement and gradient. Table 7-22 lists the reference reaches surveyed and the EDT reaches data was applied to.

Table 7-22. Reference reaches used to develop ratings for similar reaches.

Surveyed Reference Reach(s)	Data applied to EDT Reach:
Kalama 2	Kalama 1 (adjusted for tidal) & 2
Kalama 5	Kalama 3,4&5
Kalama 11	Kalama 6-11
Kalama 11 & 14 (Average)	Kalama 12-14
Kalama 11,14,&17 (Average)	Kalama 15-21
Gobar Creek	Tributaries <2% Gradient
Gobar Ck, NF Elochoman-3 (Average)	Tributaries >2% - <5%
NF Elochoman-3	Tributaries >5%

EDT reach Kalama-1 is tidal from the mouth to the Camp Kalama area; this area was classified as a glide. Ratings for this reach were generated from Kalama-2 ratings by decreasing the percentage of pool and small-cobble riffle habitat and increasing the glide habitat accordingly. Based on similarities in habitat, confinement and gradient, survey data from Kalama-5 and Kalama-11 was used to rate reaches Kalama 3-5 and Kalama 6-11, respectively. Survey data from Kalama 11 and 14 was averaged to generate ratings for reaches Kalama 12-14, while data from surveys in Kalama 11,14 & 17 was averaged to rate reaches Kalama 15-21.

Habitat survey data for Kalama River tributaries is lacking. Gobar Creek has a gradient <2% and was the only Kalama River tributary surveyed. Survey data from within the reach indicated tailouts comprised 1.3% of habitat, while pools comprised 49.8%. Based on professional knowledge of Gobar Creek, the ratio of tailouts to pools in the surveyed area appeared to be low, and was not felt to be representative of the entire creek. This may be the result of not surveying a large enough area to be truly representative of the reach, or attributable to surveyor discrepancy in identifying where a pool ends and a tailout starts. Tailouts were assumed to be 25% of pool habitat, and ratings were adjusted accordingly. Adjusted Gobar Creek data was applied to tributaries with gradients <2%, of which Spencer Creek was the only one. Of all the representative stream segments surveyed by VanderPloeg (2003), the survey conducted in EDT reach North Fork (NF) Elochoman-3 had the highest gradient at 3.33%. Due to a lack of other information, NF Elochoman-3 habitat composition data was applied to Kalama River tributaries with gradients >5%. The average of Gobar Creek and NF Elochoman-3 data was applied to Kalama River tributaries with gradients between 2 and 5%.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations and expert opinion were used and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.14 Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A , B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis. Most of the Kalama basin is confined with some areas of moderate confinement. An EDT rating of 0% off-channel was assigned to moderately confined/confined reaches. Only the lowest reach is completely unconfined (Kalalma1-tidal). For the historic condition, this reach was given an EDT rating of 20% off-channel habitat. Currently, this reach is diked and channelized and has little if any off-channel habitat (~1%). Moderately unconfined reaches (portions of Kalama 2 & 3) likely had some off-channel habitat, but currently have very little to none due to hydroconfinement.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations and expert opinion were used and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.15 Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: Currently, only one barrier reach is identified in the Kalama Basin EDT model – Lower Kalama Falls. Lower Kalama Falls was an historic barrier to some anadromous species at various life stages. Modifications to the falls (i.e. fish ladder & jump curtain) have affected passability in the current condition. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. This has not been completed for this barrier. Most tributaries are represented in the EDT model by a single reach. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon are more impacted by barriers, due to their preference for spawning in small tributaries. As barrier inventories become more complete and available for the Kalama Basin it would be valuable to incorporate these into the EDT model.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.16 Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach.

Rationale: No water withdrawals occurred in the pristine condition. By definition, all reaches were given an EDT rating of 0 for the historical condition.

Mainstem EDT reaches above Summers Creek are behind closed gates on private lands managed for timber harvest. Tributary reaches above the lower falls are sparsely populated and/or on private lands managed for timber harvest. Withdrawals in these areas are thought to be minimal or non-existent, and were given an EDT rating of 0. The LCFRB Level 1 Technical Assessment Final Report for WRIAS 27&28 (2001) presents water usage by category for the Kalama watershed. Total water usage is estimated at 427 million gallons annually for City water, agriculture, industry, and domestic wells. Most occurs in Kalama1 & 2. The majority of this is pumped as groundwater from pipes or wells under or near the river itself and screening is not an issue. The City of Kalama water withdrawal facility is at the lower end of Kalama 2. Kalama 1 & 2 were given EDT ratings of 1.5 and 2, respectively. Reaches with low gradient, unconfined areas (i.e. farmland) and/or reaches with dwellings built next to the stream were given an EDT rating of 0.1 to account for occasional withdrawals (K3,5,7,&8).

The Kalama Falls hatchery has a screened intake in the mainstem Kalama at the lower end of Kalama 6. This intake operates year round. The Fallert creek hatchery has two intakes, one on Hatchery (Fallert) Creek and the other on the mainstem Kalama at the lower end of Kalama 4, both are screened. The mainstem intake operates year round, while the Hatchery Ck. intake operates only December through March when water is available to supplement the Kalama River intake. Gobar creek has a gravity fed intake that feeds the Gobar acclimation ponds. This intake runs year round and is screened (pers. com. Gross, WDFW). Kalama 6 was given an EDT rating of 2, while Kalama 4, Gobar Ck. and Hatchery Ck. were given a rating of 1.

Level of Proof: A combination of empirical observations, derived information, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.3.3.17 Bed scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for these basins. Historic bed scour was rated using the look-up table developed by Dan Rawding (WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table is based on professional judgment. It relates bed scour to confinement, wetted width (high flow), and gradient and assumes scour increases as gradient and confinement increase. In Kalama –1 tidal, where scour likely occurred during low tides and high flow events, the pristine look-up table rating was reduced by ½.

Historic EDT ratings were developed and used as the baseline for scour in the current condition. Template ratings for bed scour were increased as follows: it was assumed increases in peak flow and hydroconfinement also increased bed scour, and scour ratings were increased 0.049 for each tenth (0.1) of increase in the EDT peak flow rating and for each point (1.0) increase in the hydroconfinement rating. In Kalama 1-tidal, where the reach is currently slough-like (mud bottom) for much of the reach, bed scour was rated by reducing the current look-up table rating by ½.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.18 Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale: Most Lower Kalama EDT reaches are rainfall dominated. Mainstem EDT reaches above Elk Creek and associated tributaries were rated as rain-on-snow transitional. Anchor ice and major icing events are rare or non-existent. EDT ratings of 0 were assigned to all reaches in the historical and current condition.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.3.3.19 Riparian

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute’s rating for watersheds in pristine condition.

For current conditions, riparian zones with mature conifers are rated at 1.0. Riparian zones with saplings and primarily deciduous trees are rated as 1.5 due to lack of shade and bank stability. Riparian zones with brush and few trees are rated as 2. For an EDT rating to exceed 2, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees it should have a score of 2 or better. Most current vegetated riparian zones with no hydroconfinement should be rated as a 1 to 1.5. When vegetation is lacking and/or hydroconfinement/residential development exists, riparian ratings were increased based upon the severity of each.

Information on the status of riparian zones in the Kalama watershed was compiled from: the LFA for WRIA 27 (Wade 2000), EDT Habitat Surveys by WDFW (VanderPloeg 2003), the SSHIAP and DNR GIS roads layers, DNR digital ortho-photos, and USGS topography maps (1:24,000 via GIS). Most of the Kalama River Watershed (~96%) is managed for timber harvest by private timber companies, and was logged heavily from 1960-1980 (Wade 2000). The LFA for WRIA 27 indicates 85 miles out of 97.25 miles of anadromous habitat on the Kalama has "poor" riparian conditions. "TAG [Technical Advisory Group] noted that Wildhorse Creek, North Fork Kalama, Gobar Creek, Lakeview Peak Creek, and Arnold Creek, historically the most productive steelhead streams, have particularly "poor" riparian conditions." A rating of “poor” was defined as riparian areas with vegetation lacking and/or mostly deciduous species (Wade 2000). WDFW habitat surveys (VanderPloeg 2003) were conducted in EDT reaches Kalama 2, 5, 11,14, 17 and Gobar Creek. Notes on riparian composition were taken as part of these surveys. Most reaches had a mix of alder, big-leaf maple, Douglas fir, cedar, and hemlock at various stages of growth. While all mainstem areas surveyed had conifers within the reach, stands of old/mature conifers were noted as being sporadic. Gobar Creek was noted as having alders as the dominant species with young big-leaf maples and Douglas fir also present.

Reaches Kalama 1, 2, 3 & 4 have varying degrees of hydroconfinement, and residential development adjacent to the stream. These reaches were given EDT values for riparian function of 3, 1.5, 2, & 1.5, respectively. Kalama 5 is in a steep, naturally-confined canyon with abundant mature conifers throughout the majority of the reach, and was given a value of 0.5. The NF Kalama and Arnold, Gobar, Lakeview Peak, & Wildhorse Creeks were given a value of 1.5. All other reaches were given a value of 1.

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.3.3.20 Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Rationale: In general, the template condition for wood in Lower Columbia River tributaries was assumed to be at an EDT rating of 0 for all areas except large canyon sections on the Grays, Coweeman, Kalama, EF Lewis, Washougal, and Wind Rivers, which likely did not hold LWD as well. These areas were assumed to be at a rating of 1 to 2, based on the width/length of the canyon. For the Kalama watershed, mainstem canyon reaches Kalama 4,5 and 7-16 were given an EDT rating of 1 for the template condition. All other reaches were given an EDT rating of 0.

LWD counts were made during WDFW Habitat surveys (VanderPloeg 2003) in EDT reaches Kalama 2, 5, 11,14, 17 & Gobar Creek using EDT protocol. All mainstem counts translated into an EDT rating of 4, the Gobar Creek count translated into an EDT rating of 3. Due to large boulder habitat present in the mainstem canyon reaches, LWD ratings were changed to 3 for Kalama 4,5 and 7-16. It was felt large boulder habitat acts as a partial surrogate for LWD in these areas. All other mainstem reaches were given a rating of 4. Medium sized tributaries (>35 ft ww-high), such as Gobar Creek were given a rating of 3. LWD surveys in Mill Germany, and Abernathy Creek watersheds (LCFRB 2003) indicated, on average, small tributaries (<35 feet ww-high) are at an EDT rating of 2 under current conditions. A rating of 2 was applied to small tributaries of the Kalama River.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations were used to estimate the ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.3.3.21 Fine Sediment (intragravel)

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et. al. 1992). The average percentage of fines (8.5%) was used, which corresponds to an EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3.

To rate the percentage of fines in the current condition, a scale was developed relating road density to fines. Rittmueller (1986) examined the relationship between road density and fine sediment levels in coastal watersheds of Washington State's Olympic Peninsula region, and found that as road density increased by 1 km/sq.km fine sediment levels increased by 4.3% (2.65% per 1 mi./sq.mi.) However, Duncan and Ward (1985) found a lower increase in percentage of fines in southwest Washington, but attributed much of the variation in fines to different soil types. The Wind River is a Lower Columbia River tributary located in SW Washington and is likely representative of other watersheds in the region. USFS used a McNiel core to collect gravel samples from 1998 to 2000 in 8 subwatersheds in the Wind River subbasin. Fines were defined as less than 0.85mm. A regression was run comparing the percentage for each year to road densities. The increase was 1.04% per 1 mi/mi^2 of roads for all watersheds ($R^2 = 0.31$, n=17). The increase was 1.52% per 1 mi/mi^2 for all watersheds ($R^2= 0.73$, n= 14) when Layout Creek, which was recently restored, was excluded. Rather than use all three years of Layout Creek data, only the median was used and the final relationship used for EDT was a 1.34% increase in fines per 1 mi/mi^2 ($R^2=0.56$, n=15) (Figure 7-2**:**).

Kalama River watershed road density values were taken from IWA results for LCFRB subwatersheds (HUCs) (LCFRB 2003). EDT reaches were linked to the appropriate HUC(s) by examining a map of HUC boundaries. Table 6 presents IWA road density by HUC for HUCs with associated EDT reaches. An exception to this is the tidal reach of the Kalama (Kalama-1), which is currently heavily diked and slough-like. This reach was given an EDT rating of 4 for the current conditions.

Figure 7-2:

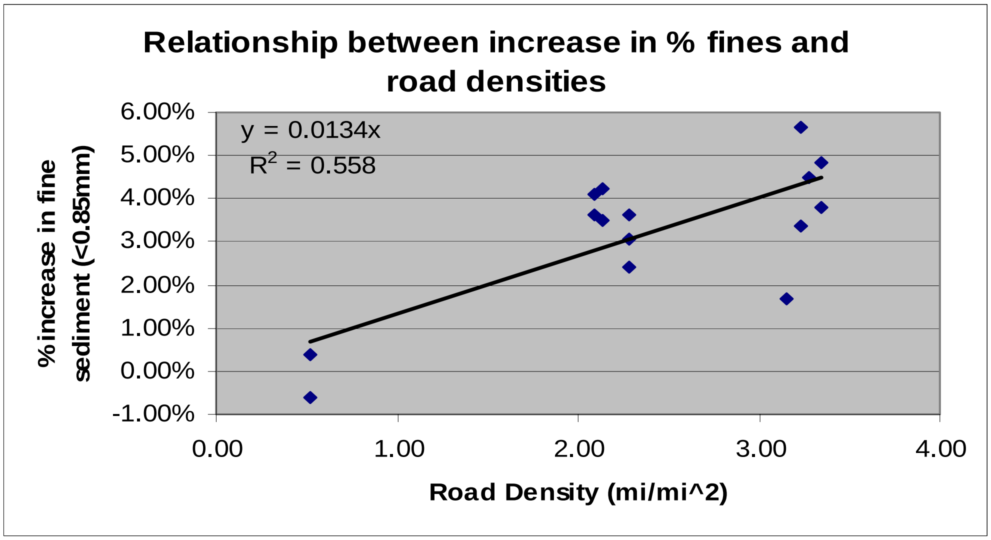

Table 6. IWA Road Densities for HUCS with Associated EDT Reaches and EDT ratings for Fine sediment.

LCFRB HUC	EDT Reaches associated with HUCS	HUC Road Density (mi./sq.mi.)	Wind Relationship-EDT Fines Rating
17080003040201	K18,19,20,21, Langdon, LakeView Pk	6	2.15
17080003040202	North Fork Kalama	6.1	2.15
17080003040301	K11,12,13(.5), Arnold, Unnamed	6.6	2.25
17080003040302	K13(.5),14,15, Jack, Lost	6.6	2.25
17080003040303	K16,17, Bush, Wolf	6.4	2.25
17080003040304	Elk	5.9	2.15
17080003040401	K9,10, Knowlton, Wildhorse	5.5	2.1
17080003040402	Gobar, Bear	7.4	2.5
17080003040501	K1,2,3,4, Spencer, Cedar	6.1	2.15
17080003040502	K5,6, Indian, Lower Falls	5.5	2.1
17080003040503	K7,8, Summers	6.6	2.25
17080003040504	Hatchery Ck	6.5	2.25
17080003040505	Little Kalama, Dee	5.1	2.05

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.22 Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: In rating this attribute it was assumed that percent embeddedness is directly related to the percentage of fines in spawning gravel.

In the template (pristine) condition, SW Washington watersheds were assumed to have a low level of embeddedness. Based on the historic level of fines in spawning gravels (8.5%), it was assumed embeddedness was less than 10%, which corresponds to and EDT rating of 0.5. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2.

Using the USFS Wind River data and analysis described above for rating fine sediment, a scale was developed relating road density to percent embeddedness. This scale was used to generate embeddedness ratings for all EDT reaches in the watershed. An exception to this is the tidal reach of the Kalama (Kalama-1), which is currently heavily diked and slough-like. This reach was given an EDT rating of 3 for the current conditions.

Kalama River watershed road density values were taken from IWA results for LCFRB subwatersheds (HUCs) (LCFRB 2003). EDT reaches were linked to the appropriate HUC(s) by examining a map of HUC boundaries. Table 7-23 presents IWA road density by HUC for HUCs with associated EDT reaches.

Table 7-23. IWA Road Densities for HUCS with Associated EDT Reaches and EDT ratings for Embeddedness.

LCFRB HUC	EDT Reaches associated with HUCS	HUC Road Density (mi./sq.mi.)	Wind Relationship-EDT Emb. Rating
17080003040201	K18,19,20,21, Langdon, LakeView Pk	6	0.86
17080003040202	North Fork Kalama	6.1	0.86
17080003040301	K11,12,13(.5), Arnold, Unnamed	6.6	0.9
17080003040302	K13(.5),14,15, Jack, Lost	6.6	0.9
17080003040303	K16,17, Bush, Wolf	6.4	0.9
17080003040304	Elk	5.9	0.86
17080003040401	K9,10, Knowlton, Wildhorse	5.5	0.83
17080003040402	Gobar, Bear	7.4	1
17080003040501	K1,2,3,4, Spencer, Cedar	6.1	0.86
17080003040502	K5,6, Indian, Lower Falls	5.5	0.83
17080003040503	K7,8, Summers	6.6	0.9
17080003040504	Hatchery Ck	6.5	0.9
17080003040505	Little Kalama, Dee	5.1	0.8

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.23 Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a =

1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. No historical information is available for this attribute. Fire was historically a natural disturbance process that occasionally increased turbidity after an extensive hot burn. Background turbidity levels were assumed to increase with stream size. Professional opinion set these levels at an EDT rating of 0 in small tributaries (<35 ft. ww-high), 0.3 in medium tributaries (>35 ft. ww-high), and 0.5 in mainstem reaches.

Current increases in turbidity are likely associated with human activities that lead to bank instability in the riparian area and roads associated with logging, urbanization, and agriculture. Suspended sediment and turbidity data is limited to grab samples by USFS and UCD for the Wind River. Flow data and limited turbidity data are available for the Elochoman River from the USGS website (2004). Historical turbidity data was plotted versus flow data from the same time period. Prior to 1978, USGS turbidity data was recorded in JTU. Since 1978, turbidity data has been recorded in NTU. There is not a direct conversion from JTU to NTU, making it difficult to interpret turbidity data prior to 1978. Bank stability and roads analyses support a small increase in turbidity. Limited data suggests during high water events Wind River suspended sediment exceeds 100 mg/L, while Lower Trout Creek, Panther Creek, and the Middle Wind are over 40 mg/L, and other basins are 5-40mg/L with most less than 25mg/L. However, the duration of these turbidity levels is unknown. If suspended sediment levels of 100mg/L last for 24 hours the EDT rating is 1.0. If the 25 mg/L levels last 24 hours, the EDT rating is 0.8. These provided the basis for current ratings. These generally support EDT ratings of 0.3 for small tributaries, 0.7 for larger tributaries, and 1.0 for lower mainstem reaches.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.3.3.24 Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: Historical temperatures are unknown the in the Kalama River subbasin. The only historical temperature data that was located were temperatures recorded in the 1930's and 40's while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary processes transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2000). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State watershed analysis manual (WFPB 1997). Elevation of stream reaches can be estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters back from the maximum wetted width. Next it was assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these tress are estimated to be between 40 – 50 meters for cedar and 60 - 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, 49 meters was used as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was approximately 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade, the relationship between forest angle and percentage of shade was used (WFPB 1997 Appendix G-33). Finally, the relationship between elevation, percentage of shade and the maximum daily stream temperature was used to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for maximum historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams, our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. A correction factor was developed for small tributaries, which consisted of adding 0.3 to the estimated historical EDT rating. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature and shade, while Pelletier (2002) used QUAL2K which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However, due to limited resources available for this study, the shade/elevation model was used for consistency throughout the Lower Columbia River.

For current conditions, the EDT maximum temperature calculator (MS Access) provided by Mobrand Biometrics, Inc. (MBI) was used to generate ratings for reaches where temperature data was available. Temperature data corresponding to summertime low flows (August) was limited for the Kalama River watershed. Table 7-24 lists the EDT reaches where temperature data was available and the data source. Temperature data collected within an EDT reach was assumed to be representative of the entire reach and was used to generate an EDT rating for the reach. Ratings for mainstem reaches without temperature data were extrapolated based on elevation, and proximity to reaches with temperature data.

Table 7-24. Kalama River EDT reaches with August temperature data & data source.

EDT Reach	Temperature Data Source
Kalama 1-tidal	Kalama Gauge @ Kalama 2001 & 2002 (USGS 2004)
Kalama 3 (top)	Fallert Creek Hatchery Intake 1984- 2003 (WDFW)
Kalama 5 (top)	Kalama Falls Hatchery Intake 1984-2003 (WDFW)

Temperature data was not available for Kalama River tributaries and reaches above Lower Kalama Falls (>Kalama 6). The Kalama River has several areas of significant groundwater input in the upper watershed that keep mainstem, summertime temperatures colder than most other Southwest Washington tributaries. Reach elevations, location of groundwater inputs, and expert opinion were used to generate maximum temperature ratings for EDT reaches Kalama 7-21. All tributary reaches were assigned an EDT rating of 2.0.

Level of Proof: A combination of derived information and expert opinion was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations, expansion of empirical observations, derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.3.3.25 Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: Minimum temperature data was lacking in the basin. Wind River temperature data was used to develop a relationship between elevation and maximum temperature for elevations up to 2000 feet as follows: EDT min temp = 1.0248 Ln(elev) –5.8305 (R^2= 0.32, n=27). This relationship was used to generate categorical ratings (Table 7-25) based on elevation.

Table 7-25. Estimated categorical ratings for minimum temperature based on elevation from Wind River data.

Elevation	EDT Rating

< 600 ft	0
600-1200	1
1300-3000 ft	2

Minimum temperature ratings were assigned to both the historical and current conditions. Tributary ratings were assigned based on the elevation at the mouth unless they have more than one reach. In this case, elevations within each reach were used. Based on the elevation model, ratings for reach Kalama 21 should be a 2, however, spring water influence in this area is believed to keep this reach at a rating of 1.

Level of Proof: A combination of expanded empirical observations, derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

7.3.3.26 Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: Significant Sources of groundwater input are known to occur from springs just below the Upper Falls in Kalama 21, and from Pigeon Springs in lower portions of Gobar Creek and upper portions of Kalama 10. Kalama 10 and 21 were given an EDT rating of 0 for the historic and current conditions. Upper portions of Gobar Creek are likely unaffected by Pigeon Springs, while lower portions are heavily affected. Gobar Creek was given an EDT rating of 1 for historic and current conditions. Effects from these groundwater inputs likely influence downstream reaches, but the extent of these effects are unknown. Reaches immediately downstream (Kalama 9 & 20) were given an EDT rating of 1 for historic and current conditions. All other reaches were rated using the following guidelines. Historically, there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. These reaches were given an EDT rating of 1. Higher gradient reaches of the mainstem and tributaries in the upper watershed likely had less groundwater input. These reaches were given an EDT rating of 2. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2. Higher gradient reaches in the upper watershed are likely similar to the historic condition and were given an EDT rating of 2.

Level of Proof: A combination of empirical observations, derived information, and expert opinion was used to estimate the historic and current ratings for this attribute in reaches with known sources of significant groundwater input and the level of proof has a strong weight of evidence in support but not fully conclusive.

Expert opinion was used to estimate the current and historical ratings for this attribute in all other reaches and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.27 Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.

Rationale: Alkalinity was estimated from historical USGS data for conductivity (USGS 2004) on the Elochoman, Washougal, Wind, Kalama, and Lewis Rivers using the formula: Alkalinity =0.421*Conductivity – 2.31 from Ptolemy (1993). A relationship was developed between flow and alkalinity assuming a power function. The mean July to September flow was used to determine the mean alkalinity values. For basins without flow data we used mean summer alkalinity values. For the Kalama River alkalinity was calculated as 17.27 mg/l and adjusted for flow, resulting in 22 mg/l, for an EDT rating of 1.9. This rating was applied to all reaches. Alkalinity in the historic condition was given the same rating as the current condition for all reaches.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.3.3.28 Dissolved oxygen

Definition: Average dissolved oxygen within the water column for the specified time interval.

Rationale: Dissolved oxygen in the template (historic) condition was assumed to be unimpaired, an EDT rating of 0 (>8mg/l in August). Summers (2001) reported that in surveyed creeks dissolved oxygen levels were greater than 8 mg/l in August. All reaches of the Kalama were assumed to have greater than 8mg/l of dissolved oxygen, except for Kalama 1-tidal. The lower portions of Kalama 1 are slough-like/tidal. Segments of the lower Kalama are 303-d listed due to excessive water temperature by the Washington Department of Ecology, and a shallow water sand bar at the mouth has been identified as a potential thermal barrier to fish migration during summer low flows (Wade 2000). This area may experience less than optimal dissolved oxygen levels during summer low flows. Kalama 1-tidal was given an EDT rating of 1.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. There is more uncertainty in the ratings for reaches with sloughs or slough-like conditions, than for riverine reaches.

7.3.3.29 Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because, of the lack of data.

7.3.3.30 Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.3.3.31 Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.3.3.32 Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data for this attribute is very limited. Historically, nutrient enrichment did not occur because, by definition, watersheds were in the "pristine" state. To determine the amount of nutrient enrichment in various reaches under current conditions the following factors were examined: fertilizing by timber companies, reaches downstream from fish hatcheries, agriculture effects, septic tanks, and storm water run-off.

Most of the Kalama River Basin above Lower Kalama Falls (>Kalama 5) is owned by Weyerhaeuser and managed for timber harvest as part of the Mount St. Helens South Tree Farm. Stream adjacent homes in this area are rare. Weyerhaeuser utilizes the following protocol for fertilizing the Mount St. Helens North and South Tree Farms (pers. com. Byron Richert, Weyerhaeuser): fertilizer is applied aerially (via helicopter), the fertilizer used is Urea 46-00-0 applied at 440 lbs./acre (210 lbs. active Nitrogen), only Douglas Fir responsive stands (>50% Douglas Fir) are fertilized, fertilization starts at age 18 and is conducted once every seven years until three years before harvest. The effects of this fertilization on stream enrichment are likely difficult to measure, but were assumed to be minimal. All mainstem and tributary reaches (except Gobar Creek) from EDT reach Kalama 6 upstream were given an EDT rating of 0.

The WDFW Kalama Falls Hatchery is located at the top of EDT reach Kalama 5 and the WDFW Fallert Creek Hatchery is located on the lower portion of Fallert (Hatchery) Creek, which enters the Kalama at the top of EDT reach Kalama 3. A WDFW hatchery acclimation pond is operated on Gobar Creek. Some nutrient enrichment likely occurs from hatchery operations. Most other enrichment likely occurs from stream adjacent homes along the mainstem and tributary reaches of the lower Kalama River (<Kalama 6) via septic systems and small-scale agriculture. Industry operations in the historic floodplain below Interstate-5 (Kalama 1-tidal) may contribute to increased enrichment. EDT reaches Kalama 2-5, Gobar Creek and Fallert (Hatchery) Creek were given an EDT rating of 1. Kalama 1-tidal was given a rating of 1.5.

Level of Proof: Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.3.3.33 Fish community richness

Definition: Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale: Historical fish community richness was estimated from the current distribution of native fish in these watersheds. Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness in SW Washington watersheds was estimated from direct observation (stream surveys, snorkel surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, local knowledge, and expert opinion. Anadromous fish distribution was estimated from the above as well as the SSHIAP fish distribution layer, which was captured in the EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in SW Washington watersheds: (1) smolt trapping activities on Abernathy, Germany, and Mill creeks (pers. com. Hanratty, WDFW), smolt trapping activities on the Kalama River above Lower Kalama Falls (pers. com. Wagemann WDFW), (3) electro-shocking in 2002 by USFWS in Abernathy Creek (pers. com. Zydlewski, USFWS), (4) electroshocking by

WDFW in many SW Washington tributaries (pers. com. Hallock, WDFW), (5) WDFW stream & snorkel surveys on the Elochoman (pers. com. Byrne, WDFW), Kalama, East Fork Lewis, Toutle and Coweeman Rivers, (5) species present in Hardy Slough (pers. com. Coley, USFWS), (6) Reimers and Bond (1967), and (7) McPheil (1967). A spreadsheet summarizing the above data sources was developed: (EDT 2003 Data.xls).

The tidal reach of the lower Kalama River (Kalama 1-tidal) likely has many species present from the Lower Columbia River. An estimated 30+ species were included in this list: chinook, chum, coho, steelhead/rainbow trout, cutthroat trout, sculpin sp.(3) (torrent, coastrange, reticulate), bridgelip and largescale sucker, peamouth, northern pikeminnow, smelt, sandroller, redside shiner, large & smallmouth bass, carp, goldfish, white & black crappie, eastern banded killifish, yellow perch, sunfish, pumpkinseed, brown & yellow bullhead, white sturgeon, 3-spine stickleback, and dace. Most of the non-native fish species likely drop out as gradient increases and water temperatures are reduced. The eastern banded killifish is an exception to this, it has been found in higher reaches of the Elochoman River (pers. com. Byrne, WDFW) and trapped on Abernathy Creek (pers. com. Hanratty, WDFW). For EDT reaches Kalama 2-5, chinook, chum, coho, steelhead/rainbow trout, cutthroat trout, sculpin sp.(3), largescale sucker, peamouth, northern pikeminnow, 3-spine stickleback, and Eastern banded Killifish were assumed to be present. Above Lower Kalama Falls (Kalama 6-21 and tributaries), only steelhead/rainbow trout, cutthroat trout, sculpin sp.(2) and spring chinook were assumed to be present. Tributaries below Lower Kalama Falls were assumed to have these species as well as coho.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.3.3.34 Fish species introductions

Definition: Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute’s rating for watersheds in pristine condition. Introduced species ratings were derived from current fish species richness data (see Fish Community Richness above). Kalama 1-tidal is the reach most likely to harbor introduced species. The Eastern banded killifish is the only non-native species documented to penetrate into higher reaches of SW Washington watersheds.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.3.3.35 Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

The WDFW Kalama Falls Hatchery (located at the top of EDT reach Kalama 5) and the WDFW Fallert Creek Hatchery (located at the lower end of Fallert (Hatchery) Creek) combine to release early/late coho, fall chinook, and summer/winter steelhead, annually. In addition, a WDFW acclimation pond on Gobar Creek, which enters the Kalama in EDT reach Kalama 10, is used to acclimate summer/winter steelhead and spring chinook (pers. com. Castenada, WDFW). Wild summer steelhead broodstock scatter plants are made in several areas above Lower Kalama Falls (pers. com. Wagemann, WDFW), but were not included in developing EDT ratings.

Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency.

EDT reaches Kalama 1-5 and Fallert (Hatchery) Creek were given an EDT rating of 4. Gobar Creek and Kalama 10 were given a rating of 3. Kalama 6-9 were given a rating of 2. All other reaches were rated at 0.

Level of Proof: For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.3.3.36 Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants and pathogen levels were assumed to be at background levels. All reaches were given an EDT rating of 0.

The WDFW Fallert Creek Hatchery is located at the downstream end of Fallert (Hatchery) Creek, which enters the Kalama in EDT reach Kalama 3. The WDFW Kalama Falls Hatchery is located at the top of Kalama 5. EDT reaches Kalama 3-6 and Fallert (Hatchery) Creek were given an EDT rating of 3. A WDFW acclimation pond is located in Gobar Creek, which enters the Kalama at the top end of EDT reach Kalama 10. Reaches Kalama 1, 2, 7-11, and Gobar

Creek were given an EDT rating of 2. All other reaches were rated at 0.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.3.3.37 Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition.

Utilizing GIS, the SSHIAP and DNR roads layers, DNR digital ortho-photos, and USGS topography maps (1:24,000) were examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT rating of 4 was given to reaches with extensive road/boat access and high recreational use; a rating of 3 was given to areas with road/boat access and proximity to population center and moderate use; a rating of 2 was given to reaches with multiple access points (or road parallels reach) through public lands or unrestricted access through private lands; a rating of 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands; and a rating of 0 was given to reaches far from population centers with no roads.

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.3.3.38 Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute's rating for watersheds in pristine condition.

The magnitude and timing of yearling hatchery smolt releases, and increases in exotic/native piscivorous fishes were considered when developing this rating. The status of top-level carnivores and other fish eating species (i.e. birds) is unknown in this watershed.

The WDFW Kalama Falls and Fallert Creek Hatcheries release early/late coho, fall chinook and summer/winter steelhead. Steelhead and spring chinook are also acclimated and released on Gobar Creek. Hatchery releases potentially increase predation on native fish. Populations of non-native piscivorous fish from the Lower Columbia River are known to exist in the tidal reach of the Kalama River, although the exact number of these species and their distribution has not been documented. EDT reaches Kalama 1-5, Gobar and Fallert (Hatchery) Creeks were given increased ratings for predation. All other reaches were given an EDT rating of 2.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, derived information, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.3.3.39 Salmon Carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Mainstem reaches with historic chum presence (spawning) were given a rating of 0 (super abundant, >800). Mainstem reaches with chinook and coho, but no chum, were given a rating of 2 (moderately abundant, >200 and <400). Reaches with only coho were given a rating of 3 (not abundant, >25 and <200). Reaches with only steelhead and/or cutthroat trout were given a rating of 4 (very few or none, <25), since these fish can spawn more than once (iteroparous). Tidal reaches below areas of chum spawning were given a rating of 1 (very abundant, >400 and <800); it was assumed carcasses from spawning reaches above are washed into these reaches.

An estimate of the current number of salmon carcasses per mile was derived from natural spawn escapement estimates, weir/trap counts, EDT reach length data, and SSHIAP fish distribution data. SSHIAP categorizes fish distribution into known, presumed, and potential habitat by species, and EDT reaches were delineated using these categories during development of the EDT template. Using potential fish distribution, EDT reach lengths were summed to develop the total number of miles of habitat available for each species. Where available, the natural spawn escapement estimate was divided by the corresponding number of miles of habitat to generate the average number of carcasses per mile for each species. These values were summed according to the species present within each reach to develop an estimate of the total number of carcasses per mile within the reach. Calculations were completed for chum, chinook and coho only, as steelhead and cutthroat trout are iteroparous and likely contribute few carcasses. When escapement data was not available, expert opinion was used to estimate carcass abundance.

The Kalama River currently supports naturally produced populations of fall chinook, coho, winter & summer steelhead, cutthroat trout and possibly spring chinook. Chum may exist in low numbers, but fall stream surveys, weir counts at the WDFW Modrow Road Weir, and trap counts at the WDFW Kalama Falls and Fallert Creek hatcheries recover/trap few (if any) chum, annually. WDFW hatcheries release early/late coho, fall/spring chinook, and summer/winter steelhead into the watershed.

Currently, a jump curtain installed across Lower Kalama Falls (located at the top of Kalama 5) prevents most returning adult salmonids from jumping the falls. Fish accessing the upper watershed are forced to use a fish ladder/trap, where they can be identified and enumerated before being passed upstream (pers. com. Wagemann, WDFW). WDFW current management strategy allows all naturally produced winter/summer steelhead, and cutthroat to be passed upstream. In addition, a pre-determined number of wild broodstock summer/winter steelhead and spring chinook are passed upstream for research purposes. Steelhead and cutthroat trout are iteroparous and provide few carcasses. Based on spring chinook densities, all mainstem and tributary reaches above Lower Kalama Falls (Kalama 6 upstream) were given an EDT rating of 4. Nutrient enhancement through carcass placement does occur above Lower Kalama Falls, but was not included in developing EDT ratings.

Escapement estimates are available for fall chinook below Lower Kalama Falls, and a ten year average (1992-2001) of 3,674 was used for developing carcass estimates. Estimates of coho abundance are not available for the Kalama River. During EDT analysis of the Elochoman River, it was estimated 6800 coho return on average from WDFW Elochoman Hatchery production, which releases fewer coho than WDFW Kalama River hatcheries. This estimate was used as a surrogate for the Kalama River, assuming it was likely biased low. EDT reaches Kalama 1-5 were given an EDT rating of 0, and tributaries below Lower Kalama Falls were given a rating of 3.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information, and expert opinion was used to estimate the historic and current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.3.3.40 Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: A few direct measures of benthos diversity for selected sites are available within the LCR from DOE and OSU. Reference sites in the Wind and Cowlitz Rivers yielded B-IBI ratings between 40 and 43 indicating EDT values of 0.3 to 0.9, which is equivalent to an EDT rating of 0.6. This rating was used as a baseline for benthos diversity and was assigned to all reaches for historic conditions.

Current Wind River data indicates EDT scores in disturbed Rosgen B-channels are similar to historic scores of 0.6 and in disturbed C-channels scores are reduced to 1.3. EDT ratings in Kalama 2 and Fallert (Hatchery) Creek were reduced to 1.3. Kalama 1-tidal is currently, and likely was historically, an area of sediment deposition, and macroinvertebrate complexity is likely reduced. This reach was given a rating of 1.0 and 2.0 for the historic and current conditions, respectively. All other reaches were given a rating of 0.6

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. Expansion of empirical observations, and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

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	Appendix B: EDT reaches and descriptions
EDT Reach	**EDT Reach Description**
Arnold Cr	Description: Arnold Creek (1.9 miles known, 1.9 miles presumed steelhead dist. = 3.8 miles); Confinement: confined; Fish Species present: WS, SS
Bear Cr	Description: Bear Creek (1.8 miles known, 0.3 potential steelhead dist. = 2.1 miles; Confinement: confined; Fish Species present: WS, SS
Bush Cr	Description: Bush Creek (0.9 miles of presumed steelhead dist.); Confinement: unconfined to moderate; Fish Species present: WS, SS
Cedar Cr	Description: Cedar Creek (0.8 miles known steelhead dist.); Confinement: moderate to confined; Fish Species present: WS
Dee Cr	Description: Dee Creek (0.8 miles known steelhead dist.); Confinement: confined; Fish Species present: WS, SS
Elk Cr	Description: Elk Creek (0.4 miles of known steelhead distribution; Confinement: confined; Fish Species present: WS, SS
Gobar Cr	Description: Gobar Creek (6.0 miles known, 4.1 miles presumed steelhead dist. = 10.1 miles); Confinement: confined to moderate; Fish Species present: WS, SS
Hatchery Cr	Description: Hatchery Creek (0.2 miles known steelhead, 2.7 presumed = 2.9 miles); Confinement: confined; Fish Species present: WS
Indian Cr	Description: Indian Creek (0.2 miles known steelhead dist.); Confinement: confined; Fish Species present: WS
Jacks Cr	Description: Jacks Creek (1.7 miles known steelhead dist.); Confinement: confined; Fish Species present: WS, SS
Kalama 1 tidal	Description: mouth to Spencer Creek; Confinement: unconfined; Fish Species present: SC, FC, WS, SS, CH
Kalama 10	Description: Wildhorse Creek to Gobar Creek; Confinement: confined; Fish Species present: SC, WS, SS
Kalama 11	Description: Gobar Creek to Arnold Creek; Confinement: confined; Fish Species present: SC, WS, SS

	Appendix B: EDT reaches and descriptions
EDT Reach	**EDT Reach Description**
Kalama 12	Description: Arnold Creek to unnamed Creek; Confinement: confined; Fish Species present: SC, WS, SS
Kalama 13	Description: unnamed Creek to Jacks Creek; Confinement: confined; Fish Species present: SC, WS, SS
Kalama 14	Description: Jacks Creek to Lost Creek; Confinement: confined; Fish Species present: SC, WS, SS
Kalama 15	Description: Lost Creek to Elk Creek; Confinement: confined; Fish Species present: SC, WS, SS
Kalama 16	Description: Elk Creek to Bush Creek; Confinement: confined; Fish Species present: SC, WS, SS
Kalama 17	Description: Bush Creek to Wolf Creek; Confinement: confined to moderate; Fish Species present: SC, WS, SS
Kalama 18	Description: Wolf Creek to Langdon Creek; Confinement: moderate confinement; Fish Species present: SC, WS, SS
Kalama 19	Description: Langdon Creek to North Fork Kalama River; Confinement: moderate confinement; Fish Species present: SC, WS, SS
Kalama 2	Description: Spencer Creek to Cedar Creek; Confinement: confined; Fish Species present: SC, FC, WS, SS, CH
Kalama 20	Description: North Fork Kalama River to Lakeview Peak Creek; Confinement: moderate confinement; Fish Species present: SC, WS, SS
Kalama 21	Description: Lakeview Peak Creek to Upper Kalama Falls; Confinement: moderate confinement; Fish Species present: SC, WS, SS
Kalama 3	Description: Cedar Creek to Hatchery Creek; Confinement: moderate confinement; Fish Species present: SC, FC, WS, SS, CH
Kalama 4	Description: Hatchery Creek to Indian Creek; Confinement: moderate to confined; Fish Species present: SC, FC, WS, SS, CH
Kalama 5	Description: Indian Creek to lower Kalama Falls; Confinement: confined; Fish Species present: SC, FC, WS, SS, CH

	Appendix B: EDT reaches and descriptions
EDT Reach	**EDT Reach Description**
Kalama 6	Description: lower Kalama Falls to Little Kalama River; Confinement: confined to moderate; Fish Species present: SC, WS, SS
Kalama 7	Description: Little Kalama River to Summers Creek; Confinement: confined; Fish Species present: SC, WS, SS
Kalama 8	Description: Summers Creek to Knowlton Creek; Confinement: moderate confinement; Fish Species present: SC, WS, SS
Kalama 9	Description: Knowlton Creek to Wildhorse Creek; Confinement: moderate to confined; Fish Species present: SC, WS, SS
Knowlton Cr	Description: Knowlton Creek (0.3 miles known steelhead dist.); Confinement: confined; Fish Species present: WS, SS
Lakeview Peak Cr	Description: Lakeview Peak Creek (3.4 miles known steelhead dist.); Confinement: moderate to confined; Fish Species present: WS, SS
Langdon Cr	Description: Langdon Creek (1.6 miles known steelhead distribution); Confinement: unconfined to moderate to confined; Fish Species present: WS, SS
Little Kalama R	Description: mouth to Dee Creek (3.2 miles known steelhead dist.); Confinement: confined; Fish Species present: WS, SS
Lost Cr	Description: Lost Creek (0.7 miles of presumed steelhead dist.); Confinement: confined; Fish Species present: WS, SS
NF Kalama	Description: North Fork Kalama (3.1 miles known, 5.6 miles presumed steelhead dist - total 8.7 miles); Confinement: unconfined to moderate to confined; Fish Species present: WS, SS
Spencer Cr	Description: Spencer Creek (1.3 miles known steelhead dist.); Confinement: confined to moderate to unconfined; Fish Species present: WS
Summers Cr	Description: Summers Creek (0.1 miles known steelhead dist.); Confinement: confined; Fish Species present: WS, SS

	Appendix B: EDT reaches and descriptions
EDT Reach	**EDT Reach Description**
Unnamed Cr (27.0087)	Description: Unnamed Creek (1.3 miles presumed steelhead dist.); Confinement: confined??; Fish Species present: WS, SS
Wildhorse Cr	Description: Wildhorse Creek (2.4 miles known, 1.8 miles presumed, 0.6 miles potential steelhead dist. = 4.8 miles); Confinement: confined; Fish Species present: WS, SS
Wolf Cr	Description: Wolf Creek (1 mile of known steelhead distribution); Confinement: moderate to confined; Fish Species present: WS, SS

7.4 Toutle

7.4.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treatment Model (EDT) for the Toutle River. In this project we rated over 110 reaches with 46 environmental attributes per reach for current conditions and another 46 for historical conditions. Over 5,000 current ratings were assigned and empirical observations within these reaches were not available for all of these ratings. In fact, less than 20% of these ratings are from empirical data. To develop the remaining data, we used expansion of empirical observations, derived information, expert opinion, and hypothetical information. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute, data was very limited or non-existent. WDFW established a relationship between road density and fine sediment in the Wind River. We applied this relationship to all subwatersheds; this is an example of derived information. In some cases, such as bed scour, we had no data for most reaches. However, data is available from Gobar Creek (a Kalama River tributary) and observations have been made in the Wind River as to which flows produce bed load movement. We noted that bed scour is related to gradient, stream width, and confinement. Based on these observations expert opinion was used to develop a look-up table to estimate bed scour. For rationale behind the EDT ratings assigned, see the text below. For specific reach scale information, please see the EDT database for the watershed of interest. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.4.2 Recommendations

1) Adult chum salmon, chinook salmon, and steelhead population estimates should continue for the basin. However, more emphasis should be placed on determining the number of hatchery and wild spawners and the reproductive success of hatchery spawners. Winter steelhead counts on the North Fork Toutle are based on rack counts at the Toutle Collection Facility (TCF) and are considered accurate and precise. Winter steelhead estimates are made for the South Fork Toutle based upon redd count expansion, while fall chinook estimates are made for the South Fork Toutle and Green River based upon index counts and peak count expansion. These estimates are based on an assumed observer efficiency and are likely to be less reliable. Winter steelhead counts on the Green River are index counts only, while chum and coho salmon counts in the Toutle Basin are periodic and not population estimates. Funding should be secured to develop accurate and precise adult estimates for chum, chinook and coho salmon and winter steelhead. Smolt populations are currently not monitored in the basin. Funding should be secured to generate smolt population estimates for the above species as well. Accurate and precise adult and juvenile population estimates will allow for better population status estimates, validation of EDT, and to determine if subbasin restoration actions are effective.
2) Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating, as would field surveys.

3) Empirical sediment data was not available for most of the basin. A sediment monitoring program should be developed to assess the percentage of fines in spawning gravels, embeddedness, and turbidity in reaches used by anadromous fish.
4) Differences existed between field and GIS ratings of natural confinement. The SSHIAP database should be field verified.
5) Flow monitoring in the mainstem, South Fork and North Fork Toutle, and Green Rivers is conducted in several locations. Flow monitoring should be continued. Bed scour estimates were not available for this basin and bed scour data should be collected and related to peak flows.
6) USFS and USGS habitat surveys do not directly measure all habitat types needed for EDT. WDFW habitat surveys in 2002 were opportunistic; that is, based on a limited amount of resources, we chose to survey only a few "representative" mainstem and tributary reaches. In addition, glides and pools were distinguished subjectively and not quantitatively. To accurately estimate stream habitat type within the anadromous distribution, a statistically valid sampling design should be developed and applied (Hankin and Reeves 1988 or EMAP). Survey methodology should differentiate between pools and glides and be repeatable.
7) A combination of DOE and OSU estimates of Benthic Index of Biological Integrity (B-IBI) collected in the Wind and Cowlitz River basins were used to develop EDT ratings. These estimates should be completed in this and other SW Washington watersheds.
8) Obstructions were not rated and passage was assumed to be 100%. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. These ratings should be updated using SSHIAP database.

7.4.3 Attributes

7.4.3.1 Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: This watershed originates from Mount St. Helens. The maximum elevation is approximately 8,300 feet on the summit of Mount St. Helens (USFS, 1997). The anadromous zone extends beyond Miner's Creek on the Green River (~1986 feet elevation), Castle and Coldwater Creeks on the North Fork Toutle (~2200 feet elevation), and Disappointment Creek on the South Fork Toutle (~2200 feet elevation). The Upper Toutle River Watershed Analysis (USFS 1997) indicates 70% of the upper basin is in the transient snow zone and subject to snow-melt and rain-on-snow events. These events influence lower mainstem reaches, but effects are likely masked by tributary flow inputs as one progresses downstream. The Integrated Watershed Assessment (IWA) completed for the Lower Columbia Fish Recovery Board (LCFRB) examined the current condition of key watershed processes by Hydrologic Unit Code (HUC) (LCFRB 2003). IWA results present the percent rain-on-snow area by HUC. EDT reaches were linked to the appropriate HUC(s) by examining a map of HUC boundaries (LCFRB 2003). Rain-on-snow percentages range from 0 to 84% for HUCS with associated EDT reaches (Table 7-26). As a general rule, reaches with percentages >45% were given an EDT rating of two (rain-on-snow transitional), and reaches with <45% were given an EDT rating of three (rainfall dominated). Exceptions to this are as follows: the percentage of rain-on-snow area for the upper portions of the Green, North Fork (NF) Toutle and South Fork (SF) Toutle watersheds decreases due to these areas being snowmelt zones. To determine the split between rainfall dominated and rain-on-snow zones, the percentage of rain-on-snow area was examined starting at the mouth of the Green, NF and SF Toutle Rivers and working upstream until the percentage reached >=45%. Mainstem and tributary reaches upstream of this point were rated as rain-on-snow transitional areas.

Table 7-26. % Rain-on-snow area for HUCs with associated EDT reaches.

LCFRB HUC	EDT Reaches associated with HUCS	HUC % Rain on Snow Area
17080005030101	Coldwater Cr	25
17080005030201	NF Toutle 13(.2)	43
17080005030202	NF Toutle 13(.3)	46
17080005030205	Castle Cr	33
17080005030301	Hoffstadt Cr 1(.75)	60
17080005030302	Hoffstadt Cr 1(.25), Hoffstadt Cr 2	59
17080005030303	Alder Cr	61
17080005030304	NF Toutle 7, 8, 9, 10, 11, RB 8	24
17080005030305	Bear Cr (NF Trib)	45
17080005030306	NF Toutle 12, 13(.5), Deer Cr	45
17080005040201	Green River 7, 8, 9, Tradedollar	49
17080005040202	Miners Cr	15
17080005040203	Shultz Cr 1, 2, Shultz Cr trib	39
17080005040301	Green River 6, Cascade Cr	84
17080005040302	Elk Cr 1, 2, Elk Cr trib	84
17080005040401	Green River 5(.5)	73
17080005040402	Green River 1, 2, 3, Beaver Cr, Jim Cr	6
17080005040403	Green River 4, Devil's Cr	38
17080005040404	Green River 5(.5)	24
17080005050101	SF Toutle 20, Disappointment Cr	19
17080005050201	SF Toutle 16, 17, 18, 19, RB 3, RB 4	30

17080005050202	LB8, Trouble Cr	33
17080005050301	SF Toutle 11, 12, 13, Bear Cr(.5), Harrington Cr	46
17080005050302	SF Toutle 14, 15, LB 7, RB 2, Bear Cr(.5)	47
17080005050401	SF Toutle 4, 5, Brownell Cr 1, 2, Jordan, Thirteen, Eighteen	22
17080005050402	RB 10, Studebaker Cr 1, 2	0
17080005050403	SF Toutle 2, 3, Johnson Cr	18
17080005050404	SF Toutle 6, 7, 8, LB 5, Twenty Cr, Big Wolf Cr	34
17080005050405	SF Toutle 9, 10, LB 6, Whitten Cr	53
17080005070603	Toutle 6, 7, 8, LB 4, RB 1	0
17080005070604	Toutle 3, 4, 5, LB 2, LB 3, Stankey Cr, Rock Cr, Hollywood Gorge	0
17080005070607	Toutle 1, 2, LB 1	0
17080005070301	NF Toutle 1, 2, 3, 4, 5, 6, RB 5, RB 6, RB 7, LB 9	0
17080005070302	SF Toutle 1, LB 10, Wyant Cr 1, 2	22
17080005070401	Toutle 9, Hemlock Cr 1, 2, RB 9, Silver Lake 1, Unnamed Lake trib	0
17080005070402	Silver Lake 2, Sucker Cr	0
17080005070403	Hemlock Cr 3	3

To verify these ratings and determine the extent of downstream influence from rain-on-snow reaches, mean monthly flow data (USGS 2004) was plotted for nine Toutle River gauge locations and compared to EDT flow patterns for groundwater influenced, rainfall dominated, rain-on-snow transitional, spring snowmelt, and glacial runoff systems. EDT ratings for reaches with gauge data were assigned based on the dominant flow regime at each gauge (Table 7-27). Results from USGS gauge data support the ratings assigned by using HUC percent rain-on-snow values.

Natural flow regime ratings were assumed to be the same for both historical and current conditions. Each reaches natural flow regime was used to assign shape patterns when rating other EDT attributes.

Table 7-27. **EDT flow patterns assigned to flow regimes at USGS gauges.**

USGS Gauge Location	Flow Regime	EDT Pattern Assigned
Green R. above Beaver Ck (EDT = Green 3)	February peak with higher (but variable) flows into June before steady decrease through summer.	Rain-on Snow Transitional
Green R. near Toutle (EDT=Green 2 (lower))	February peak with higher (but variable) flows into May before steady decrease through summer.	Rain-on Snow Transitional
NF Toutle at St. Helens (EDT = NF Toutle 11)	March peak with variable high flows through June before steady decrease into summer. Only 4 years of data from the late 1930s. Evidence of snowmelt effects.	Rain-on Snow Transitional
NF Toutle below SRS (EDT = NF Toutle 7 (upper))	February peak with variable high flows through May before steady decrease into summer.	Rain-on Snow Transitional
NF Toutle at Kid Valley (EDT = NF Toutle 3	February peak with general decline through Spring. Flow spikes in late Spring that may be due to rain-on-snow. Primarily rainfall dominated.	Rainfall dominated
SF Toutle at Camp 12 (EDT = SF Toutle 2 (upper))	February peaks with general decline through Spring. Flow spikes in late Spring that may be due to rain-on-snow. Primarily rainfall dominated.	Rainfall dominated
SF Toutle at Toutle (EDT = SF Toutle 2 (lower))	February peak with steady decrease through spring into summer.	Rainfall dominated
Toutle near Silver Lake (EDT = Toutle 8)	January peak with steady decrease through spring into summer.	Rainfall dominated
Toutle at Tower Road (EDT = Toutle 3)	January/February peak with steady decrease through spring into summer.	Rainfall dominated

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion were used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

7.4.3.2 Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale: This watershed does not have artificial flow regulation, and was given an EDT rating of 0 for the historical and current conditions.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.4.3.3 Flow - change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition the template conditions for this attribute are rated as a value of two because this describes this attribute's rating for watersheds in pristine condition. Direct measures of interannual high flow variation are not available for most basins. USFS has conducted watershed analyses in the EF Lewis, NF Lewis, Wind, White Salmon, Washougal, Kalama, Cowlitz, and Cispus Rivers and Rock Creek (USFS 1995a, USFS 1995b, USFS 1996a, USFS 1996b, USFS 2000). Peak flow analysis was conducted using the State of Washington "standard methodology for conducting watershed analysis". Primary data used for the peak flow analysis pertains to vegetation condition, elevation, road network, and aspect. The results for increased risk in peak flow from the USFS watershed analysis are shown in Table 7-28.

Table 7-28. **Summary of USFS Watershed Analysis for the change in peak flow**

Basin	# of Subbasins	Increase in Peak Flow
Wind	26	2 – 14%
East Fork Lewis	9	5 –13%
Lower Lewis		10 -12%
Rock Cr		1 - 5%
Upper Kalama		5 - >10%
Cispus		<10%

For watersheds in which the two-year peak flow (Q2yr) increases 10% the EDT rating is 2.25. For increases of 20% the EDT rating is 2.5. The USFS Upper Toutle River Watershed Analysis (1997) found peak flow increases of >10% in 5 of 9 sub-basins. A Q2yr analysis (using EDT manual protocol) of USGS flow data for the Toutle was inconclusive due to a change in gauge location during the time series. If the effects of moving the gauge are assumed to be negligible, results indicate a peak flow increase ranging from 7 - 31%. Q2yr analyses on the Kalama, Naselle and Wind Rivers showed peak flow increases ranging from 10 to 17%, or an EDT rating of ~2.3 to 2.4. For the Toutle watershed, a 2.3 rating was assumed to be representative of tributaries and forested areas not affected by the eruption of Mount St. Helens (Green River and Silver Lake watersheds). The NF and SF Toutle likely have increased peak flows from eruption damage and the subsequent salvage logging that took place. The NF Toutle (above the Green) and SF Toutle were rated at 2.5 and 2.4, respectively. The mainstem Toutle was rated using an average of the Green, NF Toutle and SF Toutle ratings; a value of 2.4. The NF Toutle below the mouth of the Green River was also given a rating of 2.4; an average of ratings for the Green River and NF Toutle above the mouth of the Green. Coldwater and Castle Creeks originate from Coldwater and Castle Lakes, respectively. These lakes were created by debris flows from the Mount St. Helens eruption. Peak flows in these tributaries are likely buffered by the lakes and were given an EDT rating of 2.0.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. A combination of derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.4 Flow - changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of two because this describes this attribute's rating for watersheds in pristine condition. Research on the effects of land use practices on summer low flow is inconclusive. Therefore, template and current conditions were rated the same (EDT rating of 2), except where noted.

The LCFRB Level 1 assessment for WRIA 25 & 26 (2001) presents average water usage in 2000 (surface water) for the Toutle River at 0.11 million gallons/day, which translates to approximately 0.1 cubic feet /second (cfs). Total water rights for the Toutle Watershed are listed as an instantaneous quantity of 6596 gpm (14.6cfs). Exhibit 4-1 presents a figure of surface water rights distribution, which is clustered in the lower reaches of the Toutle Basin from Kid Valley on the NF Toutle and Studebaker Creek/Silver Lake on the SF Toutle to the mouth. Average low flow (August) for the Toutle River is 484cfs at the USGS Tower Road Gauge (USGS 2004). Water withdrawals were considered minimal and likely do not affect summer low flows.

Historically, Silver Lake was naturally dammed by a mudflow from Mount St. Helens, and lake level was reportedly maintained by a series of beaver dams. Flow was highly variable and floods were common occurrences. An earthen and concrete dam was built in the early 1970's for flood and lake level control, which stabilized flows from the lake. (Caromile and Jackson, 2000) Weyerhaeuser surveyed the Silver Lake watershed in 1994. They found that Outlet Creek (EDT reaches Hemlock 1&2) had the most serious low flow problems with low to non-existent summer flows limiting available pool habitat (Wade 2000). Silver Lake dam regulates flows and keeps lake levels high in summer by reducing flows to Outlet Creek. EDT reaches Silver Lake 1 & 2 were given a rating of 1.5, while Hemlock 1 & 2 (Outlet Creek) were given a rating of 2.5.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. A combination of derived information and expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.5 Flow – intra daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. This attribute was given an EDT rating of 0 for current conditions due to the lack of storm water runoff and hydroelectric development in the watershed. There are no major metropolitan areas in this watershed with large areas of impervious surfaces.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.4.3.6 Flow – Intra-annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute's rating for watersheds in pristine condition. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in this watershed. Since there was no data for this attribute, it was suggested that its rating should be similar to that for changes in interannual variability in high flows (pers. com. Lestelle, Mobrand Biometrics, Inc). Ratings for interannual variability in high flow were translated directly into ratings for intra-annual flow.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.7 Channel length

Definition: Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: Ned Pittman (WDFW) provided the length of each reach from SSHIAP GIS layers. Stream length was assumed to be the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.4.3.8 Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Representative reaches in Lower Columbia River tributaries were surveyed by Steven VanderPloeg (WDFW) in 2003. Wetted widths corresponding to average summer low flows (August) and winter high flows (January) were measured as part of these surveys. (VanderPloeg 2003). Typically less reaches per subbasin were measured during average winter flow as compared to summer flow. The percent increase between low and high flow widths for all subbasins was compared to the EDT confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data (EDT reach Kalama 14). A possible explanation for this relationship is that all unconfined reaches in the dataset have been down-cut due to lack of large woody debris and hydroconfinement. Based on this data, general "rules" were developed relating wetted width minimum and maximum values. A 1.6 multiplier (60%) was assumed to be appropriate for expanding wetted width minimum values in mainstem reaches with moderate confinement and for all tributary reaches. In unconfined mainstem reaches, where down-cutting has not occurred, it was assumed minimum widths would (on average) double under average high flow conditions, and a 2.0 (100%) multiplier was used for these reaches. Conversely, in heavily confined mainstem areas (i.e. canyons) it was assumed minimum widths can not increase much as flow increases and a 1.3 (30%) multiplier was used in these reaches.

For the Toutle Basin, VanderPloeg (2003) was only able to conduct habitat surveys during times of high flow. Additional width data was collected during surveys conducted in October and November of 2000 for use by SSHIAP (pers. com. VanderPloeg and Grobelny, WDFW). These sources were used to develop wetted width maximum values (see "Channel Width – month maximum width" section). Wetted width minimum values were calculated using the general rules described above. Wetted width maximum values for each reach were multiplied by the inverse of the appropriate multiplier determined by the confinement of the reach.

Exceptions/variations to these rules are as follows. Minimum widths for non-surveyed reaches of the SF Toutle were developed from surveyed maximum widths in SF 2, 3 and 13. SF 2 is unconfined, SF 3 is moderately confined, but the survey was conducted in a confined area of the reach, and SF 13 is moderately confined, but post eruption channel widths have increased also increasing sinuosity. Wetted width minimums were calculated by multiplying wetted width maximums by 1/2 for SF 2 and SF 13 and by 1/1.3 for SF 3. Minimum widths for SF 2 and 3 were averaged and applied to SF 1-11 and the minimum for SF 13 was applied to SF 12-15. The SF 13 minimum width value was reduced by 5 feet in SF16 (for SF 16-19) and again in SF 20 to account for flow inputs by Trouble and Disappointment Creeks, respectively. Minimum widths for non-surveyed reaches of the NF Toutle were developed from surveyed maximum widths in NF 6&7 by multiplying by 1/1.6. Minimum values from NF 6 were applied to NF 1-5 and minimums from NF 7 were applied to NF 8-13.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

7.4.3.9 Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Representative reaches in Lower Columbia River tributaries were surveyed by Steve VanderPloeg (WDFW) in 2003. Wetted widths corresponding to average summer low flows (August) and winter high flows (January) were measured as part of these surveys, however, for the Toutle Basin only high flow surveys were conducted (VanderPloeg 2003). Additional surveys were conducted during October and November of 2000 to collect spot measurements of wetted and bankfull width for use by SSHIAP (pers. com. VanderPloeg and Grobelny, WDFW). Using USGS gauge data (2004) for the SF Toutle, stream flows corresponding to survey dates from both these data sources were compared to mean January flows (for all available years). Stream flows during the 2000 and 2003 surveys averaged 37% and 77% of mean January flows, respectively. Wetted widths measured during these surveys are likely less than the true maximum wetted width during average January flows, more so for the 2000 than the 2003 surveys. Due to the lack of other reach specific width data, these values were used with the knowledge that they are likely biased low. Survey locations were linked with the appropriate EDT reach and wetted width measurements were assumed to be representative of the entire reach. Table 7-29 lists the EDT reaches where surveys were conducted.

Table 7-29: **Toutle River EDT reaches surveyed and type of survey conducted.**

EDT Reach	Habitat Survey Conducted
Bear Creek	Spot measurements - VanderPloeg & Grobelny 2000

Cascade Creek	Representative reaches - VanderPloeg 2003
Devils Creek	Representative reaches - VanderPloeg 2003
Eighteen Creek	Spot measurements - VanderPloeg & Grobelny 2000
Elk Creek 1	Representative reaches - VanderPloeg 2003
Green River 1	Representative reaches - VanderPloeg 2003
Green River 5	Representative reaches - VanderPloeg 2003
Green River 8	Representative reaches - VanderPloeg 2003
Harrington Creek	Representative reaches - VanderPloeg 2003
Jim Creek	Representative reaches - VanderPloeg 2003
Johnson Creek	Representative reaches - VanderPloeg 2003
Johnson Creek	Spot measurements - VanderPloeg & Grobelny 2000
LB trib5 (not listed)	Spot measurements - VanderPloeg & Grobelny 2000
LB trib6 (not listed)	Spot measurements - VanderPloeg & Grobelny 2000
NF Toutle 6	Representative reaches - VanderPloeg 2003
NF Toutle 7	Representative reaches - VanderPloeg 2003
SF Toutle 13	Representative reaches - VanderPloeg 2003
SF Toutle 2	Spot measurements - VanderPloeg & Grobelny 2000
SF Toutle 3	Representative reaches - VanderPloeg 2003
Studebaker Cr 1	Spot measurements - VanderPloeg & Grobelny 2000
Thirteen Creek	Spot measurements - VanderPloeg & Grobelny 2000
Toutle 1	Representative reaches - VanderPloeg 2003
Toutle 3	Representative reaches - VanderPloeg 2003
Toutle 9	Representative reaches - VanderPloeg 2003
Trouble Creek	Spot measurements - VanderPloeg & Grobelny 2000
Twenty Creek	Spot measurements - VanderPloeg & Grobelny 2000
Whitten Creek	Spot measurements - VanderPloeg & Grobelny 2000

For non-surveyed reaches, wetted width maximum values were calculated and/or extrapolated from surveyed reach values. Utilizing Lower Columbia River tributary width data from VanderPloeg's 2003 surveys, the percent increase between low and high flow widths for all subbasins was compared to the EDT confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data (EDT reach Kalama 14). A possible explanation for this relationship is that all unconfined reaches in the dataset have been down-cut due to lack of large woody debris and hydroconfinement. Using only Kalama mainstem reach data (EDT reaches Kalama 2, 5, 11, 17) the mean increase in stream width is 30%. A possible explanation for this is that most of the Lower Kalama watershed is currently confined and/or hydroconfined. Based on this data, general "rules" were developed relating wetted width minimum and maximum values. A 1.6 multiplier (60%) was assumed to be appropriate for expanding wetted width minimum values in reaches with moderate confinement and in all tributary reaches. In unconfined mainstem reaches, where down-cutting has not occurred, it was assumed minimum widths would (on average) double under average high flow conditions, and a 2.0 (100%) multiplier was used for these reaches. Conversely, in heavily confined mainstem areas (i.e. canyons) it was assumed minimum widths can not increase much as flow increases and a 1.3 (30%) multiplier was used in these reaches.

These general rules were used to develop wetted width values for the mainstem Toutle, NF Toutle, and SF Toutle as follows. Widths for non-surveyed reaches of the SF Toutle were developed from surveyed maximum widths in SF 2, 3 and 13 by first developing wetted width minimums. SF 2 is unconfined, SF 3 is moderately confined, but the survey was conducted in a confined area of the reach, and SF 13 is moderately confined, but post eruption channel widths have increased also increasing sinuosity. Wetted width minimums were calculated by multiplying maximum widths by 1/2 for SF 2 and SF 13 and by 1/1.3 for SF 3. Width minimums from SF 2 and SF 3 were averaged and applied to SF 1-11 and minimums from SF 13 were applied to SF 12-15. The SF 13 minimum width value was reduced by 5 feet in SF16 (for SF 16-19) and again in SF 20 to account for flow inputs by Trouble and Disappointment Creeks, respectively. Wetted Width maximums were then back-calculated for non-surveyed reaches using the multiplier appropriate to each reaches confinement. Widths for non-surveyed reaches of the NF Toutle were developed from surveyed maximum widths in NF 6&7 by first developing wetted width minimums. Minimum widths were calculated by multiplying maximum widths by 1/1.6. Minimum widths from NF 6 were applied to NF 1-5 and minimums from NF 7 were applied to NF 8-13. Wetted width maximums were then back-calculated for non-surveyed reaches using the multiplier appropriate to each reaches confinement. Wetted width maximums for non-surveyed mainstem Toutle reaches 2,4,6,7,&8 were assigned the average value of surveyed reaches Toutle 1,3 and 9. The reciprocal of the 2 multiplier (1/2) was used to calculate wetted width minimums for these reaches and Toutle 5 & Hollywood Gorge. Wetted width maximums for Toutle 5 were back-calculated from the minimum value using a 1.6 multiplier and for Hollywood Gorge by using a 1.3 multiplier.

For the Green River mainstem and Elk Creek, wetted width maximum values were assigned to non-surveyed reaches using the "split rule", which is defined as follows. For reaches above a split (confluence of 2 tributaries), wetted width was calculated by: {(1.5*downstream reach width)*0.5} for even splits. For uneven splits, the multiplier was adjusted to compensate. In a 60:40 split: (1.5*drw)*0.6 and (1.5*drw)*0.4; and for a 70:30 split: (1.25*drw)*0.7 and (1.25*drw)*0.3. Wetted width data was available for surveyed reaches Green 1,5,8 and Elk Creek 1. Wetted width values produced by the 70:30 "split rule" were found to best fit the width data from surveys and this rule was used to increase or decrease widths working upstream and downstream between surveyed reaches.

For non-surveyed tributary reaches (other than Elk Creek), width data from surveyed tributary reaches was used to develop representative width values for small and medium sized tributaries. Small tributaries were defined as those with a maximum wetted width <20 feet, while medium tributaries were defined as being >=20feet. Maximum wetted width values from surveyed reaches were averaged for each tributary category to develop representative values of 13.5 and 27.6 feet for small and medium sized tributaries, respectively. Non-surveyed tributary reaches were assigned to the small or medium tributary category based upon review of ortho-photos via GIS to determine drainage size and from professional knowledge of the area.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, expansion of empirical observations, derived information and expert opinion were used to develop ratings and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.10 Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as % gradient) was calculated by dividing the change in reach elevation by the reach length and multiplying by 100. Ned Pittman (WDFW) used SSHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical gradient.

7.4.3.11 Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: By definition, template and current values for this attribute are the same. Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003. Confinement ratings were estimated during these surveys (VanderPloeg 2003). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps (1:24,000) and ortho-photos were consulted (via GIS) to verify and/or adjust ratings. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4 (Table 7-30). There are often multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings.

Table 7-30. Comparison of SSHIAP and EDT ratings for confinement.

Project	Unconfined	Equal unconfined and mod. confined	Moderately confined	Equal mod confined and confined	Confined
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.4.3.12 Confinement – hydro-modifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cut off due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures and activity) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. Most hydro-modification consists of roads in the floodplain and diking. The SSHIAP and DNR GIS roads layers, DNR digital ortho-photos, USGS topography maps (1:24,000 via GIS), and WRIA 26 LFA (Wade 2000) were reviewed and professional judgment was used to assign EDT ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.4.3.13 Habitat Type

Definition: *Backwater pools* is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual

(Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are believed to be the primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991 - Forest Ecosystem Management July 1992, page V-23), and applying this to current habitat type composition estimates. On Germany Creek, the Elochoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, it was assumed that for historical conditions the percentage of pools was significantly higher than for current conditions. For gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5%, pool habitat was estimated to be 40% and 30% respectively (WFPB 1994). Tailouts were assumed to represent 15-20% of pool habitat, which is the current range from WDFW surveys (VanderPloeg 2003). Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5% to 6% for gradients greater then 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat increased with gradient. WDFW field data (VanderPloeg 2003) indicated the percentage of gravel riffle habitat decreased with stream gradient, and cobble/boulder riffle habitat increased with stream gradient; the percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1% to 15% at gradients greater than 6%. WDFW surveys indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Data for current habitat types in the Toutle Basin is lacking. The following adjustments were made to historic habitat ratings: the percentages of pool, tail-out, and small cobble riffle habitat were reduced to 80% of the historical ratings. In reaches where historic beaver pond habitat was present, current ratings were reduced to 1% or less. In reaches with historic backwater pool habitat, current ratings were reduced to 1%. The sum of the differences from these adjustments was added to percent glides, insuring the sum of all habitat types equaled 100%.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.14 Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A, B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis. Most of the Toutle basin is moderately confined to confined. An EDT rating of 0% was assigned to moderately confined/confined reaches. Of the unconfined mainstem reaches on the NF, SF, mainstem Toutle and Green Rivers only reaches NF Toutle 1&2, SF Toutle 1&2 and Toutle 1&9 have significant potential for meandering and off-channel habitat formation. Historically, Toutle 1 was given a rating of 20% and NF Toutle 1&2, SF Toutle 1&2 and Toutle 9 were rated at 10%. In the current condition, ratings were reduced to 5% for all of these reaches. Hydroconfinement in Toutle 1 from Interstate-5 has likely caused the greatest reduction in off-channel habitat within the basin.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.15 Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: Currently only two barrier reaches are identified in the Toutle Basin EDT model – the Sediment Retention Structure (SRS) and the Toutle Collection Facility (TCF) referred to as the "fishtrap". Historically, these structures did not exist. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. This has not been completed for these barriers. Most tributaries are represented in the EDT model by a single reach. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon are more impacted by barriers, due to their preference for spawning in small tributaries. As barrier inventories become more complete and available for the Toutle Basin it would be valuable to incorporate these into the EDT model.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical

information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.16 Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition.

The LCFRB Level 1 assessment for WRIA 25 & 26 (2001) Exhibit 4-1 presents a figure of surface water rights distribution. Most surface water rights in the Toutle Watershed are for small-scale domestic and agricultural usage, and are clustered along the mainstem Toutle, Silver Lake, lower Studebaker and Wyant creeks, and the NF Toutle up to Kid Valley. The Level 1 assessment (2001) Table 4-1 lists total consumptive water rights at 6,596 gallons per minute (gpm) (instantaneous usage) which is equivalent to ~14.6 cubic feet/second (cfs). Actual usage in 2000 (Table 3-10B) was estimated at 0.11 million gallons/day or ~0.1 cfs. Average August flow for the Toutle from the USGS Gauge at Tower Road (USGS 2004) is 484 cfs. Most residents in the watershed are on domestic well water. However, the Toutle Regional Community Water System is supplied water pumped from the Cowlitz river, which is returned to the Toutle River via a solid waste treatment facility near the town of Toutle (pers. com. Cowlitz County Public Works Department). Legal water withdrawals for these areas were considered to be minimal and the corresponding EDT reaches were rated at 0.1.

EDT reaches (including tributaries) above the North Toutle Hatchery on the Green River (Green 2 upstream), above NF Toutle 6, and all of the SF Toutle (except for Studebaker 1) are primarily forested areas managed for timber harvest. Stream adjacent homes in these areas are rare or non-existent. Withdrawals above these areas were assumed to be minimal or non-existent and corresponding EDT reaches were given a rating of 0. Other tributary reaches in the lower watershed without stream adjacent homes, etc. were also rated at 0.

The intake for the North Toutle Hatchery is the divider between EDT reaches Green 1&2. This intake provides water to maintain the facility year round. The intake is screened and water is released back into the Green River at the lower end of the facility. EDT reach Green 1 was rated at a 2. The water intake for the acclimation pond on Brownell Creek is in EDT reach Brownell 1. The intake is screened and water is returned into Brownell creek at the lower end of the pond. This reach was given a rating of 1. The intake for the Toutle Collection Facility fish trap is in EDT reach NF Toutle 7. The intake is utilized approximately 1-2 days per week to "water-up" the trap for fish collection. This reach was given a rating of 0.5.

Level of Proof: A combination of empirical observations, derived information, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.4.3.17 Bed scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for these basins. Historic bed scour was rated using the look-up table developed by Dan Rawding (WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table is based on professional judgment. It relates bed scour to confinement, wetted width (high flow), and gradient and assumes scour increases as gradient and confinement increase.

Historic EDT ratings were developed and used as the baseline for scour in the current condition. Template ratings for bed scour were increased as follows: it was assumed increases in peak flow and hydroconfinement also increased bed scour, and scour ratings were increased 0.049 for each tenth (0.1) of increase in the EDT peak flow rating and for each point (1.0) increase in the hydroconfinement rating.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.18 Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale: Reaches of the Lower Toutle Watershed are rainfall dominated. In general, EDT mainstem and tributary reaches on the Green River, above SF Toutle 6, and above NF Toutle 7 were rated as rain-on-snow transitional. Anchor ice and major icing events are rare or non-existent. EDT ratings of 0 were assigned to all reaches in the historical and current condition.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.4.3.19 Riparian

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition.

For current conditions, riparian zones with mature conifers are rated at 1.0. Riparian zones with saplings and primarily deciduous trees are rated at 1.5 due to lack of shade and bank stability. Riparian zones with brush and few trees are rated at 2. For an EDT rating to exceed 2, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees it should have a score of 2 or better. Most current vegetated riparian zones with no hydroconfinement should be rated as a 1 to 1.5. When vegetation is lacking and/or hydroconfinement/residential development exists, riparian ratings were increased based upon the severity of each.

Information was compiled from: the WA State Conservation Commission LFA for WRIA 26 (Wade 2000), EDT Habitat Surveys by VanderPloeg (2002) and VanderPloeg & Grobelny (pers. com. WDFW), the SSHIAP and DNR GIS roads layers, DNR digital ortho-photos, and USGS topography maps (1:24,000 via GIS). The eruption of Mount St. Helens decimated much of the Toutle watershed - mudflows scoured and widened stream channels and destroyed riparian cover. Salvage logging removed much of the timber left after the blast. Currently, the watershed is in a state of recovery with vast tracts of immature trees, and many areas of deciduous growth. Sediment deposition from the eruption has created large reaches with braided, meandering channels, and unstable banks (especially on the NF and SF Toutle). Reaches with mature conifers and no hydro-confinement were rated as a 1. Reaches with immature trees and/or stands of deciduous trees and no hydroconfinement were rated at 1.5. Reaches with visible areas of channel widening, bank failures, immature trees, hydroconfinement, etc were rated between a 2 and 3 depending upon the severity of each within the reach.

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.4.3.20 Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Rationale: In general, the template condition for wood in Lower Columbia River tributaries was assumed to be at an EDT rating of 0 for all areas except large canyon sections on the Grays, Coweeman, Kalama, EF Lewis, Washougal, and Wind Rivers, which likely did not hold LWD as well. These areas were assumed to be at a rating of 1 to 2, based on the length and width of the canyon. For the Toutle watershed all reaches were given an EDT rating of 0 for the template condition except Hollywood Gorge. Hollywood Gorge is a narrow canyon, but not as pronounced as the canyon reaches mentioned above and was given an EDT rating of 1.

LWD counts were made during WDFW wild winter steelhead redd surveys (2003) in EDT reaches Cascade, Devils, Elk 1, Trouble, RB 2, and RB 3 using EDT protocol. No mainstem counts were done. EDT ratings were assumed to be 4 in all mainstem reaches, but, ratings were increased for Hollywood Gorge, Green 2-8, SF Toutle 4-20 and Cascade Creek due to the large boulder habitat present in these areas. It was felt large boulder habitat acts as a partial surrogate for LWD in these areas. EDT ratings for LWD in surveyed tributary reaches averaged 3. Actual ratings were used in reaches where surveys were conducted and were assumed to be representative of the entire reach. All non-surveyed tributary reaches were assigned a value of 3, except Alder-A and NF Toutle 10 where LWD has been deposited due to the effects of the Sediment Retention Structure (SRS).

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations were used to estimate the ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

7.4.3.21 Fine Sediment (intragravel)

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (historic) condition, SW Washington watersheds were assumed to have fine sediment levels of 6%-11% (Peterson et. al. 1992). The average percentage of fines (8.5%) was used, which corresponds to an EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3. The Toutle River enters the Cowlitz River at approximately river-mile 20, and is not tidally influenced. EDT reach Toutle-1 was given an EDT rating of 1. Silver Lake, however, was historically and continues to be a low-gradient wetland complex and is an area of sediment deposition. EDT reaches Silver Lake 1 & 2 were given an EDT rating of 4 for template and current conditions.

To rate the percentage of fines in the current condition, a scale was developed relating road density to fines. Rittmueller (1986) examined the relationship between road density and fine sediment levels in coastal watersheds of Washington State's Olympic Peninsula region, and found that as road density increased by 1 km/sq.km fine sediment levels increased by 4.3% (2.65% per 1 mi./sq.mi.) However, Duncan and Ward (1985) found a lower increase in percentage of fines in southwest Washington, but attributed much of the variation in fines to different soil types. The Wind River is a Lower Columbia River tributary located in SW Washington and is likely representative of other watersheds in the region. USFS used a McNiel core to collect gravel samples from 1998 to 2000 in 8 subwatersheds in the Wind River subbasin. Fines were defined as less than 0.85mm. A regression was run comparing the percentage for each year to road densities. The increase was 1.04% per 1 mi/mi^2 of roads for all watersheds (R^2 = 0.31, n=17). The increase was 1.52% per 1 mi/mi^2 for all watersheds (R^2= 0.73, n= 14) when Layout Creek, which was recently restored, was excluded. Rather than use all three years of Layout Creek data, only the median was used and the final relationship used for EDT was a 1.34% increase in fines per 1 mi/mi^2 (R^2=0.56, n=15) (Figure 7-3).

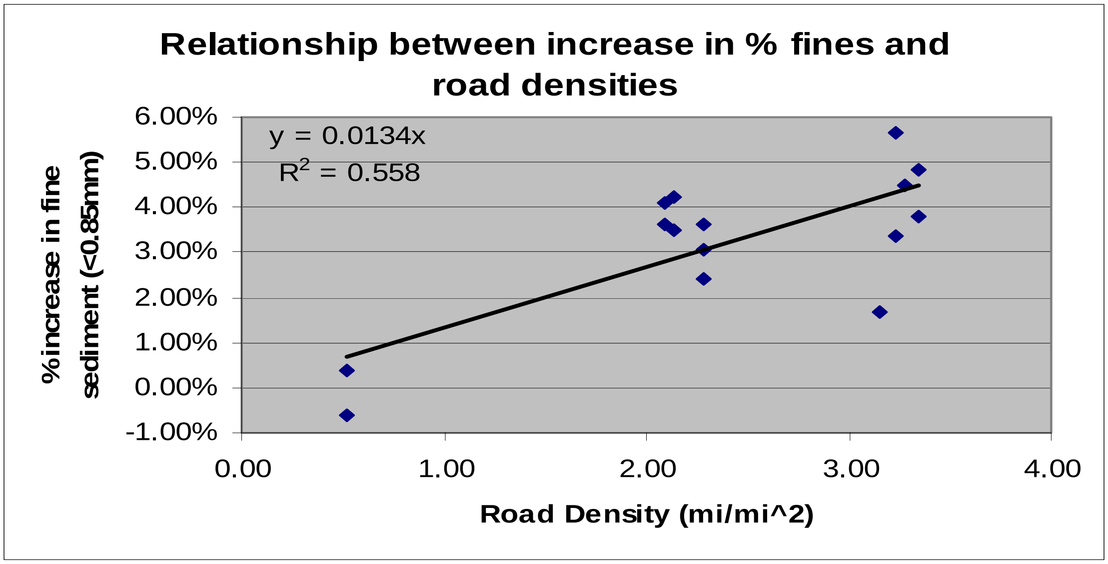

Figure 7-3. Relationship between road densities and the percentage increase in fines (<0.85mm) from USFS data.

Toutle River watershed road density values were taken from IWA results for LCFRB subwatersheds (HUCs) (LCFRB 2003). EDT reaches were linked to the appropriate HUC(s) by examining a map of HUC boundaries.Table 7-31 presents IWA road density by HUC for HUCs with associated EDT reaches and the corresponding EDT fine sediment rating.

Table 7-31. IWA Road Densities for HUCS with Associated EDT Reaches and EDT Fine Sediment Ratings

LCFRB HUC #	EDT Reaches associated with HUCS	HUC Road Density (mi./sq.mi.)	Wind Relationship-EDT Fines Rating
17080005030101	Coldwater Cr	2.1	1.58
17080005030201	NF Toutle 13(.2)	5.1	2.07
17080005030202	NF Toutle 13(.3)	5	2.06
17080005030205	Castle Cr	2.7	1.65
17080005030301	Hoffstadt Cr 1(.75)	5.3	2.05
17080005030302	Hoffstadt Cr 1(.25), Hoffstadt Cr 2	6.7	2.25
17080005030303	Alder Cr	6	2.15
17080005030304	NF Toutle 7, 8, 9, 10, 11, RB 8	6.6	2.25
17080005030305	Bear Cr (NF Trib)	7	2.35
17080005030306	NF Toutle 12, 13(.5), Deer Cr	5	2.06
17080005040201	Green River 7, 8, 9, Tradedollar	6.7	2.25
17080005040202	Miners Cr	3.6	1.8

17080005040203	Shultz Cr 1, 2, Shultz Cr trib	6.9	2.35
17080005040301	Green River 6, Cascade Cr	6.4	2.25
17080005040302	Elk Cr 1, 2, Elk Cr trib	6.5	2.25
17080005040401	Green River 5(.5)	6.6	2.25
17080005040402	Green River 1, 2, 3, Beaver Cr, Jim Cr	5.1	2.05
17080005040403	Green River 4, Devil's Cr	4.9	2.04
17080005040404	Green River 5(.5)	5.7	2.1
17080005050101	SF Toutle 20, Disappointment Cr	3	1.7
17080005050201	SF Toutle 16, 17, 18, 19, RB 3, RB 4	6.4	2.25
17080005050202	LB8, Trouble Cr	6.1	2.18
17080005050301	SF Toutle 11, 12, 13, Bear Cr(.5), Harrington Cr	6.5	2.25
17080005050302	SF Toutle 14, 15, LB 7, RB 2, Bear Cr(.5)	5.9	2.15
17080005050401	SF Toutle 4, 5, Brownell Cr 1, 2, Jordan, Thirteen, Eighteen	6.5	2.25
17080005050402	RB 10, Studebaker Cr 1, 2	6.7	2.25
17080005050403	SF Toutle 2, 3, Johnson Cr	7.1	2.35
17080005050404	SF Toutle 6, 7, 8, LB 5, Twenty Cr, Big Wolf Cr	5.7	2.1
17080005050405	SF Toutle 9, 10, LB 6, Whitten Cr	6	2.15
17080005070603	Toutle 6, 7, 8, LB 4, RB 1	5.3	2.05
17080005070604	Toutle 3, 4, 5, LB 2, LB 3, Stankey Cr, Rock Cr, Hollywood Gorge	5.4	2.05
17080005070607	Toutle 1, 2, LB 1	6.1	2.18
17080005070301	NF Toutle 1, 2, 3, 4, 5, 6, RB 5, RB 6, RB 7, LB 9	7.1	2.35
17080005070302	SF Toutle 1, LB 10, Wyant Cr 1, 2	6.7	2.25
17080005070401	Toutle 9, Hemlock Cr 1, 2, RB 9, Silver Lake 1, Unnamed Lake trib	4.5	1.95
17080005070402	Silver Lake 2, Sucker Cr	5.6	2.1
17080005070403	Hemlock Cr 3	6.7	2.25

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.22 Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: In rating this attribute it was assumed that percent embeddedness is directly related to the percentage of fines in spawning gravel.

In the template (pristine) condition, SW Washington watersheds were assumed to have a low level of embeddedness. Based on the historic level of fines in spawning gravels (8.5%), it was assumed embeddedness was less than 10%, which corresponds to and EDT rating of 0.5. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2. The Toutle River enters the Cowlitz River at approximately river-mile 20, and is not tidally influenced. EDT reach Toutle-1 was given an historical rating of 0.5. Silver Lake, however, was historically and continues to be a low-gradient wetland complex and is an area of sediment deposition. EDT reaches Silver Lake 1 & 2 were given an EDT rating of 4 for template and current conditions.

Using the USFS Wind River data and analysis described above for rating fine sediment, a scale was developed relating road density to percent embeddedness. This scale was used to generate embeddedness ratings for all EDT reaches in the watershed (with the exception of Silver Lake 1 & 2).

Toutle River watershed road density values were taken from IWA results for LCFRB subwatersheds (HUCs) (LCFRB 2003). EDT reaches were linked to the appropriate HUC(s) by examining a map of HUC boundaries. Table 7-32 presents IWA road density by HUC for HUCs with associated EDT reaches and the corresponding EDT embeddedness rating.

Table 7-32. IWA Road Densities for HUCS with Associated EDT Reaches and EDT Embeddedness Ratings.

LCFRB HUC	EDT Reaches associated with HUCS	HUC Road Density (mi./sq.mi.)	Wind Relationship-EDT Emb. Rating
17080005030101	Coldwater Cr	2.1	0.6
17080005030201	NF Toutle 13(.2)	5.1	0.8
17080005030202	NF Toutle 13(.3)	5	0.8
17080005030205	Castle Cr	2.7	0.65
17080005030301	Hoffstadt Cr 1(.75)	5.3	0.81
17080005030302	Hoffstadt Cr 1(.25), Hoffstadt Cr 2	6.7	0.9
17080005030303	Alder Cr	6	0.85
17080005030304	NF Toutle 7, 8, 9, 10, 11, RB 8	6.6	0.9
17080005030305	Bear Cr (NF Trib)	7	0.94
17080005030306	NF Toutle 12, 13(.5), Deer Cr	5	0.8
17080005040201	Green River 7, 8, 9, Tradedollar	6.7	0.9
17080005040202	Miners Cr	3.6	0.71
17080005040203	Shultz Cr 1, 2, Shultz Cr trib	6.9	0.94
17080005040301	Green River 6, Cascade Cr	6.4	0.89
17080005040302	Elk Cr 1, 2, Elk Cr trib	6.5	0.9
17080005040401	Green River 5(.5)	6.6	0.9
17080005040402	Green River 1, 2, 3, Beaver Cr, Jim Cr	5.1	0.8
17080005040403	Green River 4, Devil's Cr	4.9	0.79
17080005040404	Green River 5(.5)	5.7	0.84
17080005050101	SF Toutle 20, Disappointment Cr	3	0.67
17080005050201	SF Toutle 16, 17, 18, 19, RB 3, RB 4	6.4	0.89
17080005050202	LB8, Trouble Cr	6.1	0.87
17080005050301	SF Toutle 11, 12, 13, Bear Cr(.5), Harrington Cr	6.5	0.9
17080005050302	SF Toutle 14, 15, LB 7, RB 2, Bear Cr(.5)	5.9	0.86

17080005050401	SF Toutle 4, 5, Brownell Cr 1, 2, Jordan, Thirteen, Eighteen	6.5	0.9
17080005050402	RB 10, Studebaker Cr 1, 2	6.7	0.9
17080005050403	SF Toutle 2, 3, Johnson Cr	7.1	0.94
17080005050404	SF Toutle 6, 7, 8, LB 5, Twenty Cr, Big Wolf Cr	5.7	0.84
17080005050405	SF Toutle 9, 10, LB 6, Whitten Cr	6	0.85
17080005070603	Toutle 6, 7, 8, LB 4, RB 1	5.3	0.81
17080005070604	Toutle 3, 4, 5, LB 2, LB 3, Stankey Cr, Rock Cr, Hollywood Gorge	5.4	0.81
17080005070607	Toutle 1, 2, LB 1	6.1	0.87
17080005070301	NF Toutle 1, 2, 3, 4, 5, 6, RB 5, RB 6, RB 7, LB 9	7.1	0.94
17080005070302	SF Toutle 1, LB 10, Wyant Cr 1, 2	6.7	0.9
17080005070401	Toutle 9, Hemlock Cr 1, 2, RB 9, Silver Lake 1, Unnamed Lake trib	4.5	0.78
17080005070402	Silver Lake 2, Sucker Cr	5.6	0.83
17080005070403	Hemlock Cr 3	6.7	0.9

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.23 Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. No historical information is available for this attribute. Fire was historically a natural disturbance process that occasionally increased turbidity after an extensive hot burn. Background turbidity levels were assumed to increase with stream size. Professional opinion set these levels at an EDT rating of 0 in small tributaries (<35 ft. ww-high), 0.3 in medium tributaries (>35 ft. ww-high), and 0.5 in mainstem reaches.

Current increases in turbidity are likely associated with human activities that lead to bank instability in the riparian area and roads associated with logging, urbanization, and agriculture. Suspended sediment and turbidity data is limited to grab samples by USFS and UCD for the Wind River. Flow data and limited turbidity data are available for the Elochoman River from the USGS website (2004). Historical turbidity data was plotted versus flow data from the same time period. Prior to 1978, USGS turbidity data was recorded in JTU. Since 1978, turbidity data has been recorded in NTU. There is not a direct conversion from JTU to NTU, making it difficult to interpret turbidity data prior to 1978. Bank stability and roads analyses support a small increase in turbidity. Limited data suggests during high water events Wind River suspended sediment exceeds 100 mg/L, while Lower Trout Creek, Panther Creek, and the Middle Wind are over 40 mg/L, and other basins are 5-40mg/L with most less than 25mg/L. However, the duration of these turbidity levels is unknown. If suspended sediment levels of 100mg/L last for 24 hours the EDT rating is 1.0. If the 25 mg/L levels last 24 hours, the EDT rating is 0.8. These provided the basis for current ratings. These generally support EDT ratings of 0.3 for small tributaries, 0.7 for larger tributaries, and 1.0 for lower mainstem reaches.

These rules were used to generate ratings for all reaches in the historic condition and for all but the Toutle and NF Toutle mainstem reaches in the current condition. The Mount St. Helen's eruption buried much of the NF, SF and mainstem Toutle in mud and debris. Currently, the SF Toutle has flushed itself of much of the sediment from the mud avalanche. The SRS on the NF Toutle was designed to capture mud and debris flushing from the upper NF Toutle (Loch et al.1990). Mud stored behind the SRS provides a consistent source of sediment input into the lower NF and mainstem Toutle. Turbidity ratings were calculated separately for the mainstem Toutle reaches, NF Toutle reaches below the SRS, and NF Toutle reaches above the SRS.

Current turbidity ratings for the mainstem Toutle were generated from USGS suspended sediment and streamflow data collected at the gauge station near Tower Road (USGS 2004). The data set was queried for entry dates where both suspended sediment data and streamflows were available. Prior to 1997, sediment data was either pre-eruption of Mount St. Helens or in the mid to late 1980s when the system was still experiencing extreme sediment loads from the eruption. Data from these years is likely not representative of current conditions and was not used in this analysis. Suspended sediment data (mg/l) from 1997 – 2002 was plotted versus streamflow (cfs). A trend line fit to the dataset ($R^2 = 0.27$) generated the linear equation: $y=0.491x+283.3$ (where y= suspended sediment (mg/l), 0.491 = slope, x = streamflow (cfs), and 283.3 = y-intercept). Using this equation and mean monthly flow data for the Toutle gauge at Tower Road (USGS 2004) average suspended sediment values by month were calculated. In turn, suspended sediment (mg/l) values were applied to the SEV index utilizing the equation described above (Turbidity: definition). Since suspended sediment values were calculated as monthly averages, duration was assumed to be 1 month or 744 hours (24 hours x 31 days). SEV Index values were used to develop EDT ratings by month according to EDT guidelines. The highest EDT rating was entered into the model and the corresponding month was identified as the focus month. EDT ratings for all months were used to generate a monthly shape pattern for this attribute.

Turbidity ratings for the NF Toutle below the SRS were derived from mainstem Toutle suspended sediment values. Water discharged from the Green River, SF Toutle and NF Toutle watersheds flow together to produce the majority of flow in the mainstem Toutle River, while the majority of sediment discharged into the mainstem Toutle comes from the North Fork. USGS gauge data (2004) was queried to acquire mean monthly flow values for the Green River gauge near Toutle, the NF Toutle gauge at Kid Valley, and the SF Toutle gauge at Toutle. Monthly flows from these three systems were summed (by month) and the percentage of flow attributable to the NF Toutle was calculated. It was assumed that suspended sediment levels in the NF Toutle are diluted by flows from the Green River and SF Toutle before reaching the Tower Road gauge. Average monthly suspended sediment values calculated for the mainstem Toutle were divided by the percentage of flow attributable to the NF Toutle to estimate suspended sediment values for the NF Toutle below the SRS. Following the same methods used for the Toutle, SEV Index values, EDT ratings and monthly patterns were developed.

Turbidity ratings for NF Toutle above the SRS were adjusted from ratings below the SRS based on professional knowledge of the area. Much of the mud and debris from the Mount St. Helens eruption has been flushed from the upper North Fork, as evidenced by the material captured by the SRS. It was assumed that during low flow months turbidity in the upper NF Toutle is much less than in areas below the SRS, but during high flow events sediment continues to be flushed from the watershed. The maximum EDT rating and focus month from below the SRS was applied to reaches above the SRS, but a separate monthly shape pattern was created for the upper North Fork reflecting reduced turbidity during low flow months.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.4.3.24 Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: Historical temperatures are unknown the in the Toutle River subbasin. The only historical temperature data that was located were temperatures recorded in the 1930's and 40's while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary processes transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al.

1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2000). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State watershed analysis manual (WFPB 1997). Elevation of stream reaches can be estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters back from the maximum wetted width. Next, it was assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these tress are estimated to be between 40 – 50 meters for cedar and 60 - 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, 49 meters was used as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was approximately 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade, the relationship between forest angle and percentage of shade was used (WFPB 1997 Appendix G-33). Finally, the relationship between elevation, percentage of shade and the maximum daily stream temperature was used to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for maximum historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams, our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. A correction factor was developed for small tributaries, which consisted of adding 0.3 to the estimated historical EDT rating. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature and shade, while Pelletier (2002) used QUAL2K which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However, due to limited resources available for this study, the shade/elevation model was used for consistency throughout the Lower Columbia River.

For current conditions, the EDT maximum temperature calculator (MS Access) provided by Mobrand Biometrics, Inc. (MBI) was used to generate ratings for reaches where temperature data was available. Temperature data corresponding to summertime low flows (August) was limited for the Toutle River watershed. Table 7-33 lists the EDT reaches where temperature data was available and the data source. Temperature data collected within an EDT reach was assumed to be representative of the entire reach and was used to generate an EDT rating for the reach.

Ratings for mainstem reaches without temperature data were extrapolated based on elevation, and proximity to reaches with temperature data.

Table 7-33: **Toutle River EDT reaches with August temperature data & data source.**

EDT Reach	Temperature Data Source
Green 1	WDFW North Toutle Salmon Hatchery
Harrington Creek	Timber/Fish/Wildlife (Sullivan et al, 1990)
Hoffstadt Creek	Timber/Fish/Wildlife (Sullivan et al, 1990)
Schultz Creek	Timber/Fish/Wildlife (Sullivan et al, 1990)
SF Toutle 2	SF gauge @ Camp 12 (USGS 2004)
Silver Lake 1 & 2	Silver Lake Phase II Study (Scherer 1996)

EDT maximum temperature ratings for Harrington, Hoffstadt and Schultz Creeks in the current condition were compared to historic ratings generated by the "shade" model. Ratings in the current condition were found to be 1.5 points higher than historic for Harrington creek, a forested tributary, and an average of 1.8 points higher for Hoffstadt and Schultz Creeks, tributaries deforested by the Mount St. Helens eruption. By using ortho-photos via GIS, this relationship was used to develop ratings for tributary reaches without temperature data. Exceptions to this were tributaries from Johnson Creek upstream on the SF Toutle and Elk, Devils, Beaver, and Jim Creeks on the Green River, where Harrington creek was thought to be an appropriate surrogate and Harrington Creek ratings (current condition) were used.

Level of Proof: A combination of derived information and expert opinion was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.4.3.25 Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: Minimum temperature data was lacking in the basin. Wind River temperature data was used to develop a relationship between elevation and maximum temperature for elevations up to 2000 feet as follows: EDT min temp = 1.0248 Ln(elev) –5.8305 (R^2= 0.32, n=27). This relationship was used to generate categorical ratings (Table 7-34) based on elevation.

Table 7-34. Estimated categorical ratings for minimum temperature based on elevation from Wind River data.

Elevation	EDT Rating
< 600 ft	0
600-1200	1
1300-3000 ft	2

Minimum temperature ratings were assigned to both the historical and current conditions. Tributary ratings were assigned based on the elevation at the mouth unless they have more than one reach. In this case, elevations within each reach were used.

Level of Proof: A combination of expanded empirical observations, derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive.

7.4.3.26 Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: No data was found regarding current or historical conditions for groundwater inputs in this basin. Historically, there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. These reaches were given an EDT rating of 1. Higher gradient reaches of the mainstem and tributaries in the upper watershed likely had less groundwater input. These reaches were given an EDT rating of 2. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2. Higher gradient reaches in the upper watershed are likely similar to the historic condition and were given an EDT rating of 2.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.27 Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.

Rationale: Alkalinity was estimated from historical USGS (2004) data for conductivity using the formula: Alkalinity =0.421*Conductivity – 2.31 from Ptolemy (1993). Conductance data was limited in the Toutle River watershed. Most USGS data was collected in the year after the eruption of Mount St. Helens when sediment levels/turbidity were extremely high, which elevated specific conductance values. This data was not used. USGS conductance data prior to the eruption was available for the USGS Toutle River gauge near Castle Rock. This data translated to an alkalinity value of 26.7 or an EDT rating of ~2.1. Specific conductance data was available from three stations on the Coweeman; alkalinity = 31.5 or an EDT rating of 2.2. Specific conductance data for three Weyerhaeuser diversion ponds fed by Sucker Creek translated to an alkalinity of 45 or an EDT rating of ~2.25 (Beak Consultants 1998). A rating of 2.1 was applied to the entire Toutle River watershed except for Sucker creek, which was rated at 2.25. One sample from USGS data was available for Silver Lake, which indicated the lake may have an alkalinity value of 12 (EDT =1.6), however ratings were left at 2.1 for Silver Lake reaches. Alkalinity in the historic condition was given the same rating as the current condition for all reaches.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.28 Dissolved oxygen

Definition: Average dissolved oxygen within the water column for the specified time interval.

Rationale: Dissolved oxygen in the template (historic) condition was assumed to be unimpaired, an EDT rating of 0 (>8mg/l in August). Summers (2001) reported that in surveyed creeks dissolved oxygen levels were greater than 8 mg/l in August. USGS (2004) dissolved oxygen data is limited post 1980 (after Mount St. Helens eruption). Prior to 1980, USGS sampling within the Toutle River watershed indicated dissolved oxygen levels were >8 mg/l. For the current condition, an EDT rating of 0 was given to all reaches.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.4.3.29 Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because, of the lack of data.

7.4.3.30 Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.4.3.31 Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.4.3.32 Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data for this attribute is very limited. Historically, nutrient enrichment did not occur because, by definition, watersheds were in the "pristine" state. To determine the amount of nutrient enrichment in various reaches under current conditions the following factors were examined: fertilizing by timber companies, reaches downstream from fish hatcheries, agriculture effects, septic tanks, and storm water run-off.

Most of the NF Toutle, SF Toutle and Green River sub-basins are owned by Weyerhaeuser and managed for timber harvest. Other than the Kid Valley area on the NF Toutle, stream adjacent homes in these areas are rare. Weyerhaeuser utilizes the following protocol for fertilizing the Mount St. Helens North and South Tree Farms (pers. com. Byron Richert, Weyerhaeuser): fertilizer is applied aerially (via helicopter), the fertilizer used is Urea 46-00-0 applied at 440 lbs./acre (210 lbs. active Nitrogen), only Douglas Fir responsive stands (>50% Douglas Fir) are fertilized, fertilization starts at age 18 and is conducted once every seven years until three years before harvest. The effects of this fertilization on stream enrichment are likely difficult to measure, but were assumed to be minimal. The WDFW North Toutle Salmon Hatchery is located at the top of EDT reach Green-1 (downstream reach = NF Toutle-6). Some nutrient enrichment likely occurs from hatchery operations. Enrichment from a hatchery acclimation pond located on Brownell creek was thought to be minimal due to the short duration of its operation annually. Most enrichment, other than from hatchery operations, likely occurs from sporadic stream adjacent homes along the mainstem Toutle River via septic systems and small-scale agriculture. The town of Toutle is located near Hemlock (Outlet) Creek and has a sewage treatment/disposal site near the creek. EDT reaches Green-1 and NF Toutle 1-6 were rated at a 1 due to homes and hatchery operations. Hatchery effects are likely diluted at the confluence of the NF and SF Toutle. Toutle 1-9 and Hollywood Gorge were rated at a 0.5 due to upstream hatchery effects, stream adjacent homes (septic), inputs from the Silver Lake watershed, and agriculture. Studebaker 1(SF Trib.) and Wyant 1 (NF Trib) have low gradient reaches with stream adjacent homes and some agriculture. These reaches were rated at 0.5. All other reaches of the NF Toutle, SF Toutle, and Green Rivers were rated at 0.

Nutrient enrichment levels are likely increased in the Silver Lake watershed, which is heavily populated with lake adjacent homes. Wade (2000) states: "The natural phosphorus and nitrogen levels in soils within the Silver Lake watershed are comparatively high. Both applications of forest fertilizer and residential septic systems are likely contributors to elevated nitrogen and phosphorus levels within the watershed (Weyerhaeuser 1994; Houpt et al. 1994)". Results of a Weyerhaeuser study found Silver Lake is in an advanced state of eutrophication (Weyerhaeuser 1994). EDT reaches Silver Lake 1 & 2 and Hemlock (Outlet) Creek 1 & 2 were rated at a 1.5. Hemlock creek 3 and Unnamed Lake tributary were rated at 0. The Weyerhaeuser Headquarter Camp/ Solid Waste Facility is located on Sucker Creek; Sucker Creek was rated at 0.5.

Level of Proof: Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.4.3.33 Fish community richness

Definition: Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale: Historical fish community richness was estimated from the current distribution of native fish in these watersheds. Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness in SW Washington watersheds was estimated from direct observation (stream surveys, snorkel surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, local knowledge, and expert opinion. Anadromous fish distribution was estimated from the above as well as the SSHIAP fish distribution layer, which was captured in the EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in SW Washington watersheds: (1) smolt trapping activities on Abernathy, Germany, and Mill creeks (pers. com. Hanratty, WDFW), (2) electro-shocking in 2002 by USFWS in Abernathy Creek (pers. com. Zydlewski, USFWS), (3) electroshocking by WDFW in many SW Washington tributaries (pers. com. Hallock, WDFW), (4) WDFW stream & snorkel surveys on the Elochoman (pers. com. Byrne, WDFW), Kalama, East Fork Lewis, Toutle and Coweeman Rivers, (5) species present in Hardy Slough (pers. com. Coley, USFWS), (6) Reimers and Bond (1967), and (7) McPheil (1967). A spreadsheet summarizing the above data sources was developed: (EDT 2003 Data.xls).

The Toutle River enters the Cowlitz River above tidal influence. Non-native species from the Lower Columbia River that are often found in the lower, tidally influenced reaches of its tributaries are not as likely to penetrate into the Toutle system, but may exist at some level. The exact number of these species and their distribution have not been documented and were not included when rating this attribute. Generally, historic and current fish community richness in the Toutle Basin were assumed to be similar and the above sources were used to develop EDT ratings. An exception to this is the Silver Lake watershed. Silver Lake received historic plants of many warmwater fish species (WDF), which are now self-sustaining. In the late 1990s grass carp (sterile) were introduced into the lake to control aquatic vegetation. Currently, the lake receives annual plants of rainbow trout. These fish can potentially exit the lake via the fish ladder at the Silver Lake Dam and warmwater species have been found in Outlet Creek (EDT reaches Hemlock 1& 2). A weir just below the dam has been constructed to prevent grass carp from emigrating from the lake. (pers. com. Kelsey, WDFW and Manlow, WDFW). Current fish community richness in the Silver Lake Watershed was estimated from surveys conducted by Lavier (1973) and Caromile & Jackson (2000).

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate both the historic and current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.4.3.34 Fish species introductions

Definition: Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. Introduced species were derived from current fish species richness data (see Fish Community Richness above).

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.4.3.35 Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

The WDFW North Toutle Hatchery (located at top of EDT reach - Green 1) releases early coho, fall chinook, and summer steelhead, annually. In addition, the Cowlitz Game and Anglers club operates an acclimation pond on Brownell Creek (EDT reach Brownell 1) for summer steelhead released into the SF Toutle. (pers. com. Dammers, WDFW). Silver lake receives an annual plant of approximately 10,000 rainbow trout for a put-and-take fishery (pers. com. Kelsey, WDFW).

These fish potentially can move down through Outlet Creek (EDT reaches Hemlock 1 & 2) into the mainstem Toutle. Green 1 and reaches downstream (NF Toutle 1-6 and all mainstem Toutle reaches) were rated at a 4, Green 2, SF Toutle 1-4, Brownell 1, Silver Lake 1 & 2 and Hemlock 1 & 2 (Outlet Creek) were rated at a 2.

Level of Proof: For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.4.3.36 Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition there were no hatcheries or hatchery outplants and pathogen levels were assumed to be at background levels. All reaches were given an EDT rating of 0.

The WDFW North Toutle Hatchery is the divider between EDT reaches Green 1 & 2, and releases early coho, fall chinook, and summer steelhead, annually.

These reaches and NF Toutle 6 (downstream reach from Green 1) were given an EDT rating of 3. In addition, the Cowlitz Game and Anglers club operates a summer steelhead acclimation pond in EDT reach Brownell 1, which flows into SF Toutle 3 (pers. Com. Dammers, WDFW). Silver lake receives an annual plant of approximately 10,000 rainbow trout for a put-and-take fishery (pers. com. Kelsey, WDFW). These fish potentially can move down through Outlet Creek (EDT reaches Hemlock 1 & 2) into the mainstem Toutle. SF Toutle 1-4, Brownell 1, NF Toutle 1-5, Silver Lake 1&2, Hemlock 1&2 (Outlet Creek), Toutle 1-9 and Hollywood Gorge were given an EDT rating of 2 . All other reaches were given an EDT rating of 0.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.4.3.37 Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute's rating for watersheds in pristine condition.

Utilizing GIS, the SSHIAP and DNR roads layers, DNR digital ortho-photos, and USGS topography maps (1:24,000) were examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT rating of 4 was given to reaches with extensive road/boat access and high recreational use; a rating of 3 was given to areas with road/boat access and proximity to population center and moderate use; a rating of 2 was given to reaches with multiple access points (or road parallels reach) through public lands or unrestricted access through private lands; a rating of 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands; and a rating of 0 was given to reaches far from population centers with no roads.

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.4.3.38 Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute’s rating for watersheds in pristine condition.

The magnitude and timing of yearling hatchery smolt releases, and increases in exotic/native piscivorous fishes were considered when developing this rating. The status of top-level carnivores and other fish eating species (i.e. birds) is unknown in these watersheds.

The WDFW North Toutle Hatchery releases early coho, fall chinook and summer steelhead. Summer steelhead are also acclimated and released on Brownell Creek. Silver Lake receives annual plants of rainbow trout. Hatchery releases potentially increase predation on native fish. Populations of non-native piscivorous fish from the Lower Columbia River and Lower Cowlitz River may exist in the lower reaches of the Toutle River, although the Toutle is above tidal influence and the exact number of these species and their distribution has not been documented. Also, plants of hatchery coho and steelhead from Cowlitz River hatcheries may utilize the mouth and lowest reach of the Toutle River adding to the potential for predation. Silver Lake supports populations of several non-native warm water species from historic fish plants. These species and planted rainbow trout can escape the lake and have been found in Outlet Creek (Hemlock 1&2), and may also enter the mainstem Toutle River. Toutle 1-9, Hollywood Gorge, SF 1-4, Brownell 1, Green 1&2, NF 1-6 , Silver Lake 1&2, and Hemlock 1&2 (Outlet Creek) were given increased ratings for predation. All other reaches were given a rating of 2.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.4.3.39 Salmon Carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Mainstem reaches with historic chum presence (spawning) were given a rating of 0 (super abundant, >800). Mainstem reaches with chinook and coho, but no chum, were given a rating of 2 (moderately abundant, >200 and <400). Reaches with only coho were given a rating of 3 (not abundant, >25 and <200). Reaches with only steelhead and/or cutthroat trout were given a rating of 4 (very few or none, <25), since these fish can spawn more than once (iteroparous). Tidal reaches below areas of chum spawning were given a rating of 1 (very abundant, >400 and <800); it was assumed carcasses from spawning reaches above are washed into these reaches.

An estimate of the current number of salmon carcasses per mile was derived from natural spawn escapement estimates, weir/trap counts, EDT reach length data, and SSHIAP fish distribution data. SSHIAP categorizes fish distribution into known, presumed, and potential habitat by species, and EDT reaches were delineated using these categories during development of the EDT template. Using potential fish distribution, EDT reach lengths were summed to develop the total number of miles of habitat available for each species. Where available, the natural spawn escapement estimate was divided by the corresponding number of miles of habitat to generate the average number of carcasses per mile for each species. These values were summed according to the species present within each reach to develop an estimate of the total number of carcasses per mile within the reach. Calculations were completed for chum, chinook and coho only, as steelhead and cutthroat trout are iteroparous and likely contribute few carcasses. When escapement data was not available, expert opinion was used to estimate carcass abundance.

The Toutle River currently supports naturally produced populations of fall chinook, coho, winter steelhead and cutthroat trout. Chum may exist in low numbers, but fall stream surveys, and trap counts at the North Toutle Salmon Hatchery and the Toutle Collection Facility (TCF) have recovered/trapped few, if any, chum. In addition, the WDFW North Toutle Salmon Hatchery releases fall chinook, early coho and summer steelhead. The majority of hatchery origin fall chinook and coho return to the Green River, however, straying into the SF Toutle likely occurs. Natural spawn escapement estimates for fall chinook are available from WDFW stream surveys for the Green and SF Toutle, and a ten-year average (1992-2001) of 1021 and 93, respectively, was used for calculating carcass abundance. A weir installed annually at the North Toutle Salmon Hatchery during fall salmonid returns provides a means of enumerating returning adult coho passed upstream on the Green River. The weir is not 100% effective at blocking fish passage. High water events, weir undermining and controlled weir openings can allow fish to pass uncounted, therefore weir counts were considered minimum estimates of Green River coho escapement, and carcass abundance estimates may be biased low; an eight-year average (1994-2001) of 9541 coho was used for calculations. The Sediment Retention Structure (SRS) is an impassable barrier to returning adults and is located at the top of NF Toutle 9. The TCF, located at the top of NF Toutle 7, traps returning adult fish. Only coho and wild steelhead are trucked upstream and released into Alder and Hoffstadt Creeks. Chinook and hatchery steelhead are returned downstream or trucked to the North Toutle Hatchery. Densities of coho transported above the SRS are low; a seven-year average (1997-2003) of 295 coho was used for calculating carcass abundance above the SRS. Coho escapements are not available for the SF Toutle, but numbers/carcass densities are thought to be low. Escapement estimates for the mainstem Toutle, its tributaries and the Silver Lake watershed were not available, but densities are thought to be low.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information, and expert opinion was used to estimate the historic and current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.4.3.40 Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: A few direct measures of benthos diversity for selected sites are available within the LCR from DOE and OSU. Reference sites in the Wind and Cowlitz Rivers yielded B-IBI ratings between 40 and 43 indicating EDT values of 0.3 to 0.9, which is equivalent to an EDT rating of 0.6. This rating was used as a baseline for benthos diversity and was assigned to all reaches for historic conditions.

Current Wind River data indicates EDT scores in disturbed Rosgen B-channels are similar to historic scores of 0.6 and in disturbed C-channels scores are reduced to 1.3. The Mount St. Helen's eruption buried much of the NF, SF and mainstem Toutle in mud and debris. Macroinvertebrate abundance and diversity was likely severely impacted. High sediment loads in the NF and mainstem Toutle River provide for continual deposition of sediment over substrate that macroinvertebrates might use. Diversity and abundance of macroinvertebrates were found to be higher below the Toutle Collection Facility (TCF) (NF Toutle) and on the Green River, than in the upper NF Toutle. Areas of the upper NF Toutle that were most heavily impacted by the Mount St. Helen's mud flow had the lowest macroinvertebrate abundance and diversity (pers com. Loch WDFW). Loch (WDFW) found a diverse group of macroinvertebrates on Maretta Creek (NF tributary) that may be providing recruitment to the NF Toutle. Currently, the SF Toutle has flushed itself of much of the sediment from the mud avalanche. Accordingly, macroinvertebrate abundance and diversity is most likely recovering. Tributaries unaffected by the Mount St. Helen's eruption are a likely source of macroinvertebrate recruitment. The mainstem Toutle, NF Toutle, and SF Toutle 1&2 were given a rating of 1.5. Disturbed reaches of lower Studebaker, Wyant, and Johnson were rated at a 1.5. NF 10 & 11 and the lower reaches of Alder Creek are buried in sediment that has collected behind the SRS. These reaches were rated at a 4. All other reaches were rated at 0.6.

Level of Proof: A combination of empirical observations, expansion of empirical observations, derived information, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

Expansion of empirical observations, and expert opinion were used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

Acknowledgements

This project was funded by the Lower Columbia Fish Recovery Board and Washington Department of Fish and Wildlife. We thank Weyerhaeuser for access to these streams for spawning ground surveys and to collect habitat data used in this modeling effort. We thank the staff at Mobrand Biometric for running the model especially Kevin Malone and Jennifer Garrow.

	Appendix C: EDT reaches and descriptions
EDT Reach	**EDT Reach Description**
Alder Creek A	Description: mouth upstream approximately 1.3 miles to road crossing.
Alder Creek B	Description: road crossing at ~1.3 miles to RM 6.4
Bear Creek	Description: mouth to RM 2.5 (includes small LB trib); Confinement: confined; Fish Species present: WS presumed
Bear Creek (NF Trib.)	Description: mouth to RM 3.8 ; Confinement: unconfined; Fish Species Present : WS
Beaver Creek	Description: mouth to forks (in beaver pond); Confinement: confined to moderate; Fish Species present: WS presumed
Big Wolf Creek	Description: mouth to RM 0.2; Confinement: confined; Fish Species present: WS
Brownell Creek 1	Description: mouth to Jordan Creek; Confinement: moderate; Fish Species present: WS—0.1 known, 0.3 potential
Brownell Creek 2	Description: Jordan Creek to light-duty road; Confinement: moderate to unconfined; Fish Species present: WS potential
Cascade Creek	Description: mouth to fork at RM 1.2; Confinement: confined; Fish Species present: WS
Castle Creek	Description: mouth to end of available habitat; Confinement: unconfined to moderate; Fish Species Present: WS (presumed)
Coldwater Creek	Description: mouth to end of available habitat; Confinement: unconfined to moderate; Fish Species Present: WS (presumed)
Deer Creek	Description: mouth to RM 1.6; Confinement: moderate; Fish Species Present: WS
Devils Creek	Description: mouth to fork at RM 5; Confinement: confined; Fish Species present: WS
Disappointment Cr	Description: mouth to fork to 0.5 up left fork, 0.8 up right fork; Confinement: moderate; Fish Species present: WS—0.8 known, 0.7 presumed
Eighteen Creek	Description: mouth to fork; Confinement: confined; Fish Species present: WS
Elk Cr trib	Description: mouth to road crossing; Confinement: confined to moderate; Fish Species present: WS

	Appendix C: EDT reaches and descriptions
Elk Creek 1	Description: mouth to RB trib at RM 2.5; Confinement: confined; Fish Species present: WS
Elk Creek 2	Description: RB trib to fork at RM 5; Confinement: confined; Fish Species present: WS presumed
Green River 1	Description: mouth to hatchery intake; Confinement: moderate to confined; Fish Species present: WS, FC, SC
Green River 2	Description: hatchery intake to Beaver Creek; Confinement: confined; Fish Species present: WS, FC, SC
Green River 3	Description: Beaver Creek to Jim Creek; Confinement: confined; Fish Species present: WS, FC, SC
Green River 4	Description: Jim Creek to Devils Creek; Confinement: confined; Fish Species present: WS, FC, SC
Green River 5	Description: Devils Creek to Cascade Creek; Confinement: confined; Fish Species present: WS, FC, SC
Green River 6	Description: Cascade Creek to Elk Creek; Confinement: moderate; Fish Species present: WS, FC, SC
Green River 7	Description: Elk Creek to Shultz Creek; Confinement: moderate; Fish Species present: WS, FC, SC
Green River 8	Description: Schultz Creek to Tradedollar Creek; Confinement: moderate to confined; Fish Species present: WS, FC, SC
Green River 9	Description: Tradedollar Creek to Miners Creek; Confinement: moderate to confined; Fish Species present: WS, SC for 0.6 mile of this reach to RM 25
Harrington Creek	Description: mouth to RM 1.5; Confinement: confined; Fish Species present: WS
Hemlock Cr 1	Description: mouth to unnamed RB trib9; Confinement: unconfined to moderate; Fish Species present: WS, FC presumed
Hemlock Cr 2	Description: unnamed RB trib9 to Silver Lake; Confinement: unconfined; Fish Species present: WS, FC presumed
Hemlock Cr 3	Description: Silver Lake to end of anadromous presence; Confinement: unconfined to moderate; Fish Species present: WS, FC
Hoffstadt Cr 1	Description: mouth to Bear Creek; Confinement: Unconfined; Fish Species Present: WS
Hoffstadt Cr 2	Description: Bear Creek to Forks; Confinement: moderate to confined; Fish Species Present: WS

	Appendix C: EDT reaches and descriptions
Hollywood Gorge	Description: Rock Creek to head of Gorge; Confinement: confined; Fish Species present: CH, WS, FC, SC
Jim Creek	Description: mouth to increased gradient (end of beaver ponds); Confinement: confined; Fish Species present: WS—0.5 known, 1.0 potential
Johnson Creek	Description: mouth top extent of distribution (includes small tribs); Confinement: unconfined to moderate; Fish Species present: FC—1.2 known; 'WS—3.3 known, 2.5 presumed, 0.75 potential
LB trib1 (26.0228)	Description: mouth to fork, to culvert (road) on right fork, to pond on left fork; Confinement: moderate to confined; Fish Species present: WS presumed
LB trib10 (not listed)	Description: mouth to limit of steelhead presence (including potential) (includes both forks at headwaters); Confinement: unconfined to confined; Fish Species present: WS—2.6 known, 1.9 potential, 0.7 presumed
LB trib2 (26.0229)	Description: mouth to RM 1.3; Confinement: confined; Fish Species present: WS
LB trib3 (26.0235)	Description: mouth to RM 1.8; Confinement: moderate to confined; Fish Species present: WS—0.8 known, 1.0 potential
LB trib4 (not listed)	Description: mouth to limit of sthd dist.; Confinement: unconfined to moderate; Fish Species present: WS—0.7 known, 1.8 presumed
LB trib5 (not listed)	Description: mouth to RM 0.2; Confinement: confined; Fish Species present: WS presumed
LB trib6 (not listed)	Description: mouth to RM 1.2; Confinement: confined; Fish Species present: WS presumed
LB trib7 (not listed)	Description: mouth to RM 3 (includes small LB trib; Confinement: confined; Fish Species present: WS presumed
LB trib8 (not listed)	Description: mouth to RM 1.0; Confinement: moderate; Fish Species present: WS presumed
LB trib9 (not listed)	Description: mouth to fork; Confinement: moderate; Fish Species present: WS potential
Lower Cowlitz-1	Cowlitz R from the Columbia R to Coweeman R
Lower Cowlitz-2	Cowlitz R from Coweeman R to Toutle R
Miners Creek	Description: mouth to increased gradient; Confinement: moderate to confined; Fish Species present: WS

	Appendix C: EDT reaches and descriptions
NF Toutle 1	Description: mouth to Wyant Creek; Confinement: unconfined; Fish Species present: CH, WS, FC, SC
NF Toutle 10	Description: SRS to Alder Creek; Confinement: unconfined; Fish Species present: WS, FC, SC
NF Toutle 11	Description: Alder Creek to Hoffstadt Creek; Confinement: unconfined; Fish Species present: WS, FC, SC
NF Toutle 12	Description: Hoffstadt Creek to Deer Creek; Confinement: unconfined; Fish Species present: WS, FC, SC
NF Toutle 13	Description: Deer Creek to Coldwater Creek outlet and Castle Creek (opposite each other); Confinement: unconfined to moderate; Fish Species present: WS, FC, SC
NF Toutle 2	Description: Wyant Creek to unnamed RB trib5; Confinement: unconfined; Fish Species present: CH, WS, FC, SC
NF Toutle 3	Description: unnamed RB trib5 to unnamed RB trib6; Confinement: moderate to confined; Fish Species present: CH, WS, FC, SC-chum drop out at half this reach
NF Toutle 4	Description: unnamed RB trib6 to unnamed LB trib9 (about RM 7 at stream gauge); Confinement: confined; Fish Species present: WS, FC, SC
NF Toutle 5	Description: unnamed LB trib9 to unnamed RB trib7 (at 19 mile camp); Confinement: confined; Fish Species present: WS, FC, SC
NF Toutle 6	Description: unnamed RB trib7 to Green River; Confinement: moderate; Fish Species present: WS, FC, SC
NF Toutle 7	Description: Green River to Fish Trap; Confinement: unconfined; Fish Species present: WS, FC, SC
NF Toutle 8	Description: Fish Trap to unnamed RB trib8; Confinement: moderate; Fish Species present: WS, FC, SC
NF Toutle 9	Description: unnamed RB trib8 to sediment retention structure; Confinement: moderate; Fish Species present: WS, FC, SC
RB trib1 (26.0237)	Description: mouth to RM 2.2; Confinement: unconfined to moderate; Fish Species present: WS—0.5 known, 1.0 presumed, 0.7 pot.
RB trib10 (not listed)	Description: mouth to road crossing; Confinement: moderate to confined; Fish Species present: WS presumed
RB trib2 (not listed)	Description: mouth to RM 1.3; Confinement: confined; Fish Species present: WS

	Appendix C: EDT reaches and descriptions
RB trib3 (not listed)	Description: mouth to RM 0.5; Confinement: moderate; Fish Species present: WS
RB trib4 (not listed)	Description: mouth to RM 1.5; Confinement: moderate; Fish Species present: WS—0.5 known, 1.0 presumed
RB trib5 (not listed)	Description: mouth to RM 1.2; Confinement: unconfined to confined; Fish Species present: WS presumed
RB trib6 (not listed)	Description: mouth to extent of available habitat (includes small tribs); Confinement: moderate to confined; Fish Species present: WS potential
RB trib7 (26.0320)	Description: mouth to increased gradient; Confinement: unconfined; Fish Species present: WS
RB trib9 (not listed)	Description: mouth to fork; Confinement: unconfined; Fish Species present: WS potential
Rock Creek	Description: mouth to headwaters; Confinement: unconfined to moderate; Fish Species present: WS—0.6 known, 1.8 potential
SF Toutle 1	Description: mouth to Studebaker Creek; Confinement: unconfined; Fish Species present: CH, WS, FC, SC
SF Toutle 10	Description: unnamed LB trib6 to Whitten Creek; Confinement: confined; Fish Species present: WS, FC presumed, SC
SF Toutle 11	Description: Whitten Creek to Bear Creek; Confinement: confined; Fish Species present: WS, FC presumed, SC
SF Toutle 12	Description: Bear Creek to Harrington Creek; Confinement: confined; Fish Species present: WS, FC presumed, SC
SF Toutle 13	Description: Harrington Creek to unnamed LB trib7; Confinement: confined; Fish Species present: WS, SC
SF Toutle 14	Description: unnamed LB trib7 to unnamed RB trib2; Confinement: confined; Fish Species present: WS, SC
SF Toutle 15	Description: unnamed RB trib2 to Trouble Creek; Confinement: confined; Fish Species present: WS, SC
SF Toutle 16	Description: Trouble Creek to unnamed LB trib8; Confinement: confined; Fish Species present: WS, SC
SF Toutle 17	Description: unnamed LB trib8 to unnamed RB trib3; Confinement: moderate; Fish Species present: WS, SC
SF Toutle 18	Description: unnamed RB trib3 to unnamed RB trib4; Confinement: moderate; Fish Species present: WS, SC

	Appendix C: EDT reaches and descriptions
SF Toutle 19	Description: unnamed RB trib4 to Disappointment Creek; Confinement: moderate to confined; Fish Species present: WS, SC
SF Toutle 2	Description: Studebaker Creek to Johnson Creek; Confinement: unconfined; Fish Species present: CH, WS, FC, SC
SF Toutle 20	Description: Disappointment Creek to end of anadromous distribution; Confinement: confined; Fish Species present: WS, SC
SF Toutle 3	Description: Johnson Creek to Brownell Creek; Confinement: unconfined to moderate; Fish Species present: WS, FC, SC
SF Toutle 4	Description: Brownell Creek to Thirteen Creek; Confinement: moderate to confined; Fish Species present: WS, FC presumed, SC
SF Toutle 5	Description: Thirteen Creek to Eighteen Creek; Confinement: confined; Fish Species present: WS, FC presumed, SC
SF Toutle 6	Description: Eighteen Creek to Twenty Creek; Confinement: confined; Fish Species present: WS, FC presumed, SC
SF Toutle 7	Description: Twenty Creek to Big Wolf Creek; Confinement: confined; Fish Species present: WS, FC presumed, SC
SF Toutle 8	Description: Big Wolf Creek to unnamed LB trib5; Confinement: confined; Fish Species present: WS, FC presumed, SC
SF Toutle 9	Description: unnamed LB trib5 to unnamed LB trib6; Confinement: confined; Fish Species present: WS, FC presumed, SC
Shultz Cr trib	Description: mouth to road crossing; Confinement: confined; Fish Species present: WS presumed
Shultz Creek 1	Description: mouth to LB trib at quarry; Confinement: unconfined to moderate; Fish Species present: WS presumed
Shultz Creek 2	Description: LB trib at quarry to RM 2.5; Confinement: confined; Fish Species present: WS presumed
Silver Lake 1	Description: Silver Lake from Hemlock outlet to Hemlock inlet; Confinement: unconfined; Fish Species present: WS, FC presumed
Silver Lake 2	Description: Silver Lake to Sucker Creek; Confinement: unconfined; Fish Species present: WS presumed, FC presumed
Stankey Cr	Description: mouth to nearly all available habitat; Confinement: moderate to confined; Fish Species present: WS—1.7miles known, 3 miles potential, 0.3 miles presumed
Studebaker Cr 1	Description: mouth to unnamed RB trib 10; Confinement: unconfined to moderate; Fish Species present: FC 2 miles

	Appendix C: EDT reaches and descriptions
Studebaker Cr 2	Description: unnamed RB trib10 to Fork; Confinement: unconfined; Fish Species present: WS—0.5 known, 0.3 presumed, 1.2 potential
Sucker Cr	Description: Silver Lake to fork to 1 mile up right fork, 1.5 mile up left fork; Confinement: confined; Fish Species present: WS Presumed, FC presumed for 1 mile
Thirteen Creek	Description: mouth to fork; Confinement: moderate to confined; Fish Species present: WS
Toutle 1	Description: mouth to unnamed LB trib1; Confinement: unconfined to moderate; Fish Species present: CH, WS, FC, SC
Toutle 2	Description: unnamed LB trib1 to unnamed LB trib2; Confinement: moderate to confined; Fish Species present: CH, WS, FC, SC
Toutle 3	Description: unnamed LB trib to Stankey Creek; Confinement: moderate confinement; Fish Species present: CH, WS, FC, SC
Toutle 4	Description: Stankey Creek to unnamed LB trib3; Confinement: moderate; Fish Species present: CH, WS, FC, SC
Toutle 5	Description: LB trib3 to Rock Creek; Confinement: moderate to confined; Fish Species present: CH, WS, FC, SC
Toutle 6	Description: head of gorge to unnamed LB trib4; Confinement: moderate; Fish Species present: CH, WS, FC, SC
Toutle 7	Description: unnamed LB trib4 to unnamed RB trib1; Confinement: moderate; Fish Species present: CH, WS, FC, SC
Toutle 8	Description: unnamed RB trib1 to Hemlock Creek; Confinement: moderate; Fish Species present: CH, WS, FC, SC
Toutle 9	Description: Hemlock Creek to Fork; Confinement: unconfined; Fish Species present: CH, WS, FC, SC
Tradedollar Creek	Description: mouth to increased gradient; Confinement: moderate to confined; Fish Species present: WS presumed
Trouble Creek	Description: mouth to RM 3.3; Confinement: confined; Fish Species present: WS presumed
Twenty Creek	Description: mouth to RM 0.3; Confinement: confined; Fish Species present: WS
unnamed Lake trib	Description: Silver Lake to end of available habitat; Confinement: confined; Fish Species present: WS presumed, FC presumed
Whitten Creek	Description: mouth to RM 0.3; Confinement: confined; Fish Species present: WS presumed

	Appendix C: EDT reaches and descriptions
Wyant Cr 1	Description: mouth to unnamed LB trib10; Confinement: unconfined to moderate; Fish Species present: WS, FC to RM 1.7
Wyant Cr 2	Description: LB trib10 to fork at RM 5; Confinement: moderate to confined; Fish Species present: WS—1.0 known, 1.5 potential

7.5 Wind

7.5.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treament Model (EDT) for the Wind River. In this project we rated over 60 reaches with 46 environmental attributes per reach for current conditions and another 46 for historical conditions. Over 2,700 current ratings were assigned and empirical observations within these reaches were not available for all of these ratings. In fact less than 20% of these ratings are from empirical data. To develop the remaining data, we used expansion of empirical observations, derived information, expert opinion, and hypothetical information. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute, data was very limited or non-existent. WDFW established a relationship between road density and fine sediment in the Wind River. We applied this relationship to all subwatersheds; this is an example of derived information. In some cases, such as bed scour, we had no data. However, data is available from Gobar Creek (Kalama River tributary) and observations have been made in the Wind River as to which flows produce bed load movement. We noted that bed scour is related to gradient, stream width, and confinement. Based on these observations expert opinion was used to develop a look-up table to estimate bed scour. For rationale behind the EDT ratings assigned, see the text below. For specific reach scale information, please see the EDT database for the watershed of interest. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.5.2 Recommendations

1) Adult chum salmon, chinook salmon, and steelhead population estimates should continue. However, more emphasis should be placed on determining the number of hatchery and wild spawners and the reproductive success of hatchery spawners. Summer steelhead and spring chinook estimates are based on mark-recapture and are considered accurate and precise. Fall chinook estimates and chum salmon estimates are based on an assumed observer efficiency and are likely to be less reliable. Winter steelhead and coho salmon counts are periodic and not population estimates. Spring chinook and summer steelhead escapement estimates should be continued and funding secured to develop accurate and precise adult estimates. Smolt population estimates are made for steelhead and spring chinook, for the entire basin and key watersheds, using mark-recapture. It is not possible to estimate fall chinook or chum juvenile production since no suitable trapping sites exist lower in the basin and the trap cannot be moved downstream. Accurate and precise adult and juvenile population estimates will allow for better population status estimates, validation of EDT, and to determine if subbasin restoration actions are effective.
2) Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating as would field surveys.
3) Empirical sediment data was only available for a few reaches and derived estimates were used for most of the basin. A sediment monitoring program should be developed to

assess the percentage of fines in spawning gravels, embeddedness, and turbidity in reaches used by anadromous fish.

4) Differences existed between field and GIS ratings of natural confinement. The SSHIAP database should be field verified.
5) Flow monitoring in the mainstem Wind River has been inconsistent since the gauge was re-installed. The reliability of this monitoring should be improved. Bed Scour estimates were not available for this basin and bed scour data should be collected and related to peak flows. Re-installation of gauges in Trout, Panther, and Upper Wind should be considered along with the bed scour monitoring.
6) USFS and USGS habitat surveys do not directly measure all habitat types needed for EDT. WDFW habitat surveys in 2002 were opportunistic; that is, based on a limited amount of resources, we chose to survey only a lower, and middle mainstem reach and one section of the Little Wind River. In addition, glides and pools were distinguished subjectively and not quantitatively. To accurately estimate stream habitat type within the anadromous distribution, a statistically valid sampling design should be developed and applied (Hankin and Reeves1988 or EMAP). Survey methodology should differentiate between pools and glides and be repeatable.
7) A combination of DOE and OSU estimates of the Benthic Index of Biological Integrity (B-IBI) were used to develop EDT ratings. These data were clustered above the CNFH and in Trout Creek. They should be expanded to other basins
8) Obstructions were not rated and passage was assumed to be 100%. These ratings should be updated using the SSHIAP database.

7.5.3 Attributes

7.5.3.1 Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: This watershed originates from McClellan Meadows, and the maximum elevation is approximately 3,000 ft. The upper elevations are consistent with a rain-on-snow hydrologic regime and the lower elevations are consistent with a rainfall-dominated watershed. The Little Wind River was rated as rainfall dominated for the historic and current conditions. All other watersheds were rated as rain-on-snow (USFS 1996) except Tyee springs and Cold Creek, which had groundwater run-off patterns. These runoff patterns were used to shape estimates of flow and temperature in the EDT model.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale: These watersheds do not have artificial flow regulation. These watersheds were given an EDT rating of 0 for the historical and current conditions except for the lowest two reaches of the mainstem Wind River, which are inundated by the Bonneville pool. These reaches were rated as 1.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established except for the lowest reaches of the Wind which are inundated by the Bonneville pool. There is more uncertainty for this rating because water retention time in these reaches has not been measured.

7.5.3.2 Flow - change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. From 1935 to 1957 annual timber harvest in the Wind River Ranger District was low and consistent (USFS 1996). In the late 1950's harvest increased dramatically. The change in Q2yr, calculated using EDT methodology, from 1935-57 to 1958-79 was 12% (Figure 7-4). For watersheds in which the two-year peak flow increases 12% the EDT rating is 2.3, and this was used for the mainstem Wind River. Direct measures of inter-annual high flow variation are not available for most subwatersheds in the Wind River. USFS has conducted watershed analysis in the Wind River (USFS 1996). Peak flow analysis was conducted using the State of Washington "Standard methodology for conducting watershed analysis". The primary data used for the peak flow analysis is vegetation condition, elevation, road network, and aspect. The results for increased risk in peak flow from the USFS watershed analysis are shown in Table 7-35. USFS estimates were used for subwatersheds.

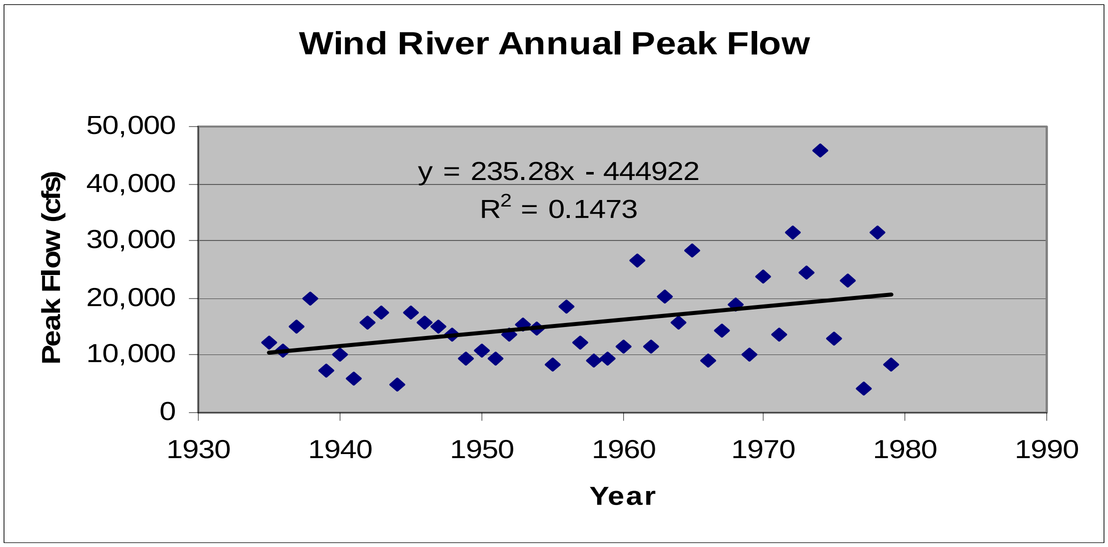

Figure 7-4.

Table 7-35. Summary of USFS Watershed Analysis for the change in peak flow

Basin	# of Subbasins	Increase in Peak Flow
Wind	26	2 – 14%

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. A combination of empirical information (mainstem Wind River) and derived information (remainder of the basin) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.5.3.3 Flow - changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Research on the effects of land use practices on summer low flow is inconclusive (Spencer et al. 1996). Therefore, we rated the template and current conditions the same (EDT rating of 2).

However, water withdrawals may reduce summer flow. USFWS has water rights for the operation of Carson National Fish Hatchery (CNFH) from the mainstem Wind River and Tyee Springs. USFS has water rights for the former nursery on Trout Creek, although they are not currently used. Water withdrawals are variable for the hatchery depending on the amount of water available from Tyee springs and fish production needs. Recently, USFWS has tried to minimize mainstem Wind River withdrawals. In Trout Creek, the USFS has closed the nursery. No change in low flow was used in this modeling effort, but if irrigation is resumed in Trout Creek or if the hatchery water withdrawals increase, this attribute should be adjusted accordingly.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.5.3.4 Flow – intra daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. This attribute was given an EDT rating of 0 for the current conditions due to the lack of storm water runoff and hydroelectric development in this subbasin. There are no major metropolitan areas in these watersheds with large areas of impervious surfaces. The lowest two mainstem reaches have diel variation caused by the operation of Bonneville Dam and were rated accordingly.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.5.3.5 Flow –Intra annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in these watersheds. Based on change in Q2yr from the USGS gauge, we estimated a 12% increase in peak high flows in the lower mainstem, with other subbasins ranging from 0% to 14%. Since there was no data for this attribute, it was suggested that its rating should be the same as the changes in inter-annual variability in high flows (pers. com. Larry Lestelle, Mobrand, Inc).

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.6 Channel length

Definition: Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: Ned Pittman (WDFW) provided the length of each reach from SSHIAP GIS layers. We assumed the stream length was the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.5.3.7 Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: We assigned the same value for both the current and historical conditions, unless a major hydromodification or water withdrawal was located within the reach. Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). USFS and USGS surveyed widths as part of habitat surveys from the late 1980's to the present (Pat Connoly -USGS and Brian Bair-USFS unpublished data). Wetted widths corresponding to average summer low flows (August) were measured as part of these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement.

Level of Proof: A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof ranged from thoroughly established in reaches with direct observations to a strong weight of evidence in support but not fully conclusive in reaches were expanded information was used. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.8 Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Wetted widths corresponding to average winter high flows (January) were measured as part of these surveys. (VanderPloeg 2003). Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Typically less reaches per subbasin were measured during average winter flow as compared to summer flow. We compared the percent increase between low and high flow widths to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data. A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris and hydroconfinement. Therefore, we used actual "wetted width-high" values in reaches where data was available, and a 1.6 multiplier (60%) to expand "wetted width-low" values for reaches without high flow data. In canyon areas, summer flows were expanded by 20-40% depending of reach characteristics.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.9 Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as percentage gradient) was calculated by dividing the change in reach elevation by the reach length. Ned Pittman (WDFW) used SSHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical gradient.

7.5.3.10 Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed for confinement ratings (VanderPloeg 2003). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps were consulted when SSHIAP ratings fell between the 0.5 increments to determine which rating should be applied. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4. There are often multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings (Table 7-36).

Table 7-36. Comparison of SSHIAP and EDT ratings for confinement.

Project	Unconfined	Equal unconfined and mod. confined	Moderately confined	Equal mod confined and confined	Confined
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.5.3.11 Confinement – hydro-modifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cut off due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Most hydro-modification consists of roads in the floodplain and diking. We consulted the SSHIAP GIS roads layer, SSHIAP digital ortho-photos, USGS maps, and Limiting Factors Analysis (LFA) to estimate EDT ratings. Ratings were categorical due to the lack of field surveys to corroborate GIS, map, and photo estimates.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.5.3.12 Habitat Type

Definition: *Backwater pools* is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter). Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Habitat type composition was measured during these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement. Lower reaches inundated by the construction of Bonneville Dam were rated as glides and pools depending on the amount of inundation.

WDFW and USFS habitat surveys in 2002 followed USFS stream survey level 2 protocols, which delineate between riffles and slow water but not pools and glides. Glide habitat is the most difficult habitat to identify, therefore it was estimated but not surveyed by WDFW. USGS used modified USFS stream survey level 2 protocols, and delineated glide habitat.

Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are believed to be the primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991 - Forest Ecosystem Management July 1992, page V-23), and applying this to current habitat type composition estimates. On Germany Creek, the Elochoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, we assumed for historical conditions that the percentage of pools was significantly higher than the current percentage. For gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5%, we estimated pool habitat to be 40% and 30%, respectively (DNR 1994). We assumed that tailouts represent 15-20% of pool habitat, which is the current range from WDFW surveys. Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5% to 6% for gradients greater then 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat increased with gradient. WDFW field data indicated the percentage of gravel riffle habitat decreased with stream gradient, and cobble/boulder riffle habitat increased with stream gradient; the percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1% to 15% at gradients greater than 6%. WDFW surveys indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information we assumed pool habitats were in the "good" range and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.13 Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A , B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis. An EDT rating of 0 was assigned to Aa+ and A channels, a rating of 0 to 1 for B channels, while low gradient C channels were assigned EDT ratings of 1 to 2 for the current rating and 2 to 3 for the historical rating. Off-channel habitat is not significant in the Wind River, with the exception of the inundated reach. Old photographs suggested that substantial off-channel habitat was historically present.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.14 Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: WDFW SSHIAP database was used to identify existing barriers within these watersheds. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. This has not been completed for any barriers except Hemlock Dam. In most cases known fish distribution stopped at all barriers. In some cases, where known distribution occurred above barriers, passage was assumed to be 100% for the species and all life stages. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon due to their preference for spawning in small tributaries are impacted by barriers. The ratings should be completed after a barrier analysis.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.15 Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach.

Rationale: No water withdrawals occurred in the pristine condition. Most watersheds in this unit are forested with limited agriculture and residential use. Water withdrawals were assumed to be minimal in most areas. Reaches with low gradient, unconfined areas (i.e. farmland) and/or reaches with dwellings built next to the stream were given an EDT rating of 0 to 1 to account for occasional withdrawals. All other reaches were rated at 0. Known water withdrawals occur at Carson National Fish Hatchery and Hemlock Dam. Data was reviewed to develop ratings for these reaches.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.5.3.16 Bed scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for these basins. Historic bed scour was rated using the look-up table (pers. com. Dan Rawding, WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table is based on professional judgment and relates bed scour to confinement, wetted width (high flow), and gradient. It assumes bed scour increases as gradient, wetted width, and confinement increase. For low gradient slough like reaches, we reduced the bed scour rating to ~1, since these reaches are unconfined and influenced by the Columbia River.

Current EDT ratings were developed and used as the baseline for scour in the current condition. Template ratings for bed scour were increased as peak flow and hydro-confinement increased. For example, if in the template condition a reach had a peak flow of 2.0 and in the current condition peak flow increased to 2.3, while hydro-confinement ratings increased from 0 to 1, we assumed a 0.05 increase in bed scour for every 0.1 increase in peak flow and a 0.1 increase for every 1.0 increase in hydro-confinement. In this example the bed scour increased by 0.25

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.17 Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale: In watersheds that are rainfall dominated anchor ice and icing events do not occur. For elevations less than 1000 ft., EDT ratings of 0 were assigned to all reaches in the historical and current condition. For those from 1,000 to 2000 ft. EDT ratings of 1 were assigned. This was based on personal winter observation in the Wind River and discussions with CNFH staff.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.5.3.18 Riparian

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition the template conditions for this attribute are rated as a value of zero because this describes this attribute rating for watersheds in pristine conditions. Riparian zones with mature conifers are rated at 0.0 -1.0 depending on the density of large trees and bank stability. Riparian zones with saplings and deciduous trees are rated as 1.5 due to lack of shade and bank stability. Riparian zones with brush and few trees would be rated as 2. For an EDT rating to exceed 2, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees it should have a score of 2 or better. Most current vegetated riparian zones with no hydro-confinement should be rated as a 1 to 1.5. When hydro-confinement exists rating from rules on hydro-confinement were used to increase the riparian rating. Ratings also increased based on lack of vegetation. Key reaches were established for current riparian function through out these watersheds. Other reaches were referenced to these key reaches to develop a final EDT rating.

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.19 Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Rationale: Wood density was estimated during USFS and WDFW habitat surveys where density of wood equals pieces * length/width. Template condition for wood is assumed to be 0 for all reaches except large Canyon sections on the Grays, Coweeman, Kalama, EF Lewis, Washougal, and Wind, which are assumed to be 2. Due to their confinement, it was believed during high flows these reaches did not retain wood as well as other sections. When survey data was not available, wood densities were extrapolated from reaches with data. EDT Rating based on TFW standard of all wood. USFS surveys measured large wood or key pieces. Key pieces were converted to wood based on surveys comparison of Key pieces to total wood that indicate key pieces ~35% of all wood. If wood in a reach was unknown, a rating from adjacent reach was used or the subbasin average of 2 was used.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations were used to estimate the ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.5.3.20 Fine Sediment (intragravel)

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et. al. 1992). The average percentage of fines (8.5%) was used, which corresponds to an EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3.

To rate percentage of fines in the current condition, a scale was developed relating road density to fines. Rittmueller (1986) found that as road density increased by 1 mi/mi^2, fine sediment levels increased by 2.65%. However, Duncan and Ward (1985) found a lower increase in the percentage of fines in southwest Washington, but attributed much of the variation in fines to different geology. USFS used a McNiel core to collect gravel samples from 1998 to 2000 in 8 subwatersheds in the Wind River subbasin. Fines were defined as less than 0.85mm. A regression was run comparing the percentage for each year to road densities. The increase was 1.04% per 1 mi/mi^2 of roads for all watershed (R^2 = 0.31, n=17). The increase was 1.52% per 1 mi/mi^2 for all watersheds (R^2= 0.73, n= 14) when Layout Creek, which was recently restored was excluded. Rather than use all three years of Layout Creek data , only the median was used and the final relationship used for EDT was 1.34% increase in fines per1 mi/mi^2 (R^2=0.56, n=15) (Figure 7-5).

Tidal reaches with lower gradients were given an EDT rating of 4. Slough-like reaches above tidal reaches or tidal reaches with increased flow during outgoing tide (i.e. Germany Ck.) were rated as follows: rating from road density scale + 1.

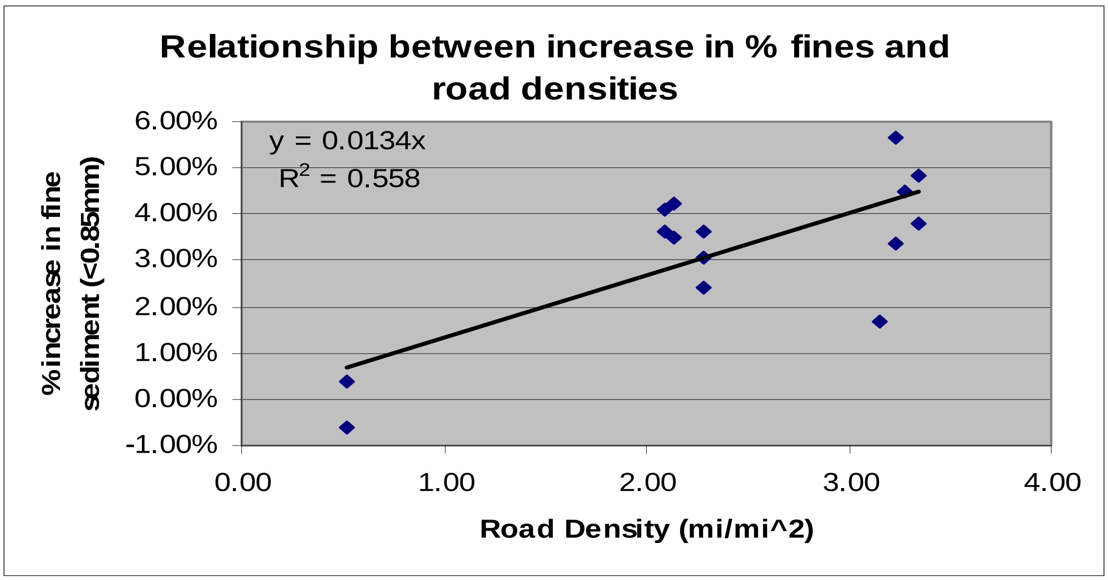

Figure 7-5. Relationship between road densities and the percentage increase in fines (<0.85mm) from USFS data.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.5.3.21 Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have a low level of embeddedness. Based on the historic level of fines in spawning gravels (8.5%), we assumed this level was the same for embeddedness, which corresponds to and EDT rating of 0.5. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2. Reaches above tidal with low gradient and slower flows likely also had increased fine sediment and embeddeness and were given an EDT rating of 1.

We assumed that the percent embeddedness was directly related to percentage of fines in spawning gravel. We used the Wind River data mentioned above to develop a scale relating road density to percent embeddedness. Tidal reaches with lower gradients were given an EDT rating of 3. Slough-like reaches above tidal reaches or tidal reaches with increased flow during outgoing tide (i.e. Germany Ck.) were rated as follows: rating from road density scale + 1.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.22 Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. No historical information is available for this attribute. Fire was historically a natural disturbance process, that occasionally increases turbidity after an extensive hot burn. Current increases in turbidity are likely associated with human activities that lead to bank instability in the riparian area and roads associated with logging, urbanization, and agriculture. Background turbidity levels were assumed to increase with stream size. Professional opinion set these levels to be an EDT rating of 0 in small tributaries, 0.3 in medium tributaries, and 0.5 in the mainstem.

Suspended sediment and turbidity data is limited to grab samples by USFS and UCD for the Wind River. Flow data and limited turbidity data are available for the Elochoman River from the USGS website (http://wa.water.usgs.gov/realtime/historical.html). Historical turbidity data was plotted versus flow data from the same time period. Prior to 1978, USGS turbidity data was recorded in JTU. Since 1978, turbidity data has been recorded in NTU. There is not a direct conversion from JTU to NTU, making it difficult to interpret turbidity data prior to 1978. Bank stability and roads analyses support a small increase in turbidity. Limited data suggests during high water events Wind River suspended sediment exceeds 100 mg/L, while Lower Trout, Panther, and Middle Wind are over 40 mg/L, and other basins are 5-40mg/L, with most less than 25mg/L. However, the duration of these turbidity levels is unknown. If levels of 100mg/L last for 24 hours the EDT rating is 1.0. If the 25 mg/L level lasts 24 hours, the EDT rating is 0.8. These provided the basis for current ratings. These generally support ratings of 0.3 for small tributaries, 0.7 for larger tributaries, and 1.0 for the lower mainstem.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.5.3.23 Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: Temperature loggers have been extensively placed in the Wind River subbasin by USFS, UCD, USGS, and USFWS. This data was entered into the EDT temperature calculator provided by Mobrand, Inc. to produce EDT ratings for August. To develop maximum temperature ratings for the remaining months, we used the template monthly pattern “TmpMonMax Rainfall”, TmpMonMax Groundwater“, and TmpMonMax Transitional” for the rainfall, groundwater and rain-on-snow-transitional watersheds, respectively.

The EDT ratings generated by the temperature calculator were used for reaches with a temperature logger present, and ratings for other reaches were inferred/extrapolated from these based on proximity and similar gradient, habitat, and confinement. If temperature loggers were mid-reach we used the reading for the entire reach. If temperature loggers were at the end of the reach and evidence from other temperature loggers above indicated there was cooling within the reach (as you move upstream), professional judgment was used to develop an average for the reach. The same logic was applied to reaches without temperature loggers located between reaches with temperature loggers – ratings from reaches with temperature loggers were “feathered” for reaches in between. Readings from loggers at the end of a reach were used to estimate the rating for the reaches downstream. Pelletier (2002) estimated current maximum temperatures in the Wind River temperature TMDL and this information was also used to fill in missing data.

Historical temperatures are unknown the in the Wind River subbasin. The Regional Ecosystem Assessment Project estimated the range of historical maximum daily stream temperatures for the Hood/Wind at 7-20 degrees C (USFS 1993). However, this broad range was not very informative for historical individual reach scale temperatures. The only historical temperature data that we located were temperatures recorded in the 1930’s and 40’s while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary process transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2002). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State watershed analysis manual (WFPB 1997). Elevation of stream reaches is estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters back from the maximum wetted width. Next we assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these trees are estimated to be between 40 – 50 meters for cedar and 60 - 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, we used 49 meters as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was approximately 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade, we used the relationship between forest angle and percentage of shade (WFPB 1997 Appendix G-33.). Finally we used the relationship between elevation, percentage of shade and the maximum daily stream temperature to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for maximum historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. We developed a correction factor for small tributaries, which consisted of adding 0.3 to the estimated historical EDT rating. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature and shade, while Pelletier (2002) used QUAL2K which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However, due to limited resources available for this study, the shade/elevation model was used for consistency throughout the Lower Columbia River.

Level of Proof: Derived information was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.5.3.24 Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: Wind River temperature data was used to develop a relationship between elevation and maximum temperature for elevations up to 2000 feet as follows: EDT min temp = 1.0248 Ln(elev) –5.8305 (R^2= 0.32, n=27). This was used to generate categorical ratings (Table 7-37) based on elevation. For the Wind, we used actual data, where available, to develop non-categorical ratings. It should be noted that reaches with lakes/wetlands (Falls and EF Trout) and immediate downstream reaches have colder minimum temperatures (higher EDT ratings) and those with strong groundwater influence (Upper Trout) have warmer minimum temperatures (lower EDT ratings).

Table 7-37. Estimated categorical ratings for minimum temperature based on elevation from Wind River data.

Elevation	EDT Rating
< 600 ft	0
600-1200	1
1300-3000 ft	2

The historic minimum temperature was assumed to be the same as current minimum temperatures except for the Hemlock Dam reach which is 0.3 (EDT rating) lower than current. There is some support that historical minimum temperatures were warmer due to more mature forest stands, but we did not use this information due to the limited support and the fact that fire disturbance regimes in these forests would have periodically led to these conditions naturally.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established in the Wind. Expansion of empirical ratings was used for the remainder of the Wind and other basins.

7.5.3.25 Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: Historically there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. These reaches were given an EDT rating of 1. Higher gradient reaches of the mainstem and tributaries higher in the watershed likely had less groundwater input. These reaches were given an EDT rating of 2. We could not find any data on the current or historical conditions for ground water input. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2. Higher gradient reaches in the upper watershed are likely similar to the historic condition and were given an EDT rating of 2.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.5.3.26 Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.

Rationale: Alkalinity was estimated from historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) for conductivity on the Wind, Lower Washougal, Middle Washougal, NF Lewis, EF Lewis, Cedar, Kalama, Elochoman, and Grays Rivers using the formula: Alkalinity =0.421*Conductivity – 2.31 from Ptolemy (1993). A relationship was developed between flow and alkalinity assuming a power function. We used the mean July to September flow to determine the mean alkalinity values. For basins without flow data, we used mean summer alkalinity values. Alkalinity values were 22, 15, 12, 16, 20, 27, 21, 27, and 30 mg/L, respectively. Additional data was available on the Wind River for reach specific ratings from UCD and USFS water quality sampling. For other basins, the standard basin alkalinity value was used. Alkalinity in the historic condition was given the same value as the current condition.

Level of Proof: Derived information was used to estimate this attribute from conductivity measurements. Since alkalinity is did not vary much between adjacent basins and is believed to be relatively constant within a basin, estimated values were expanded for all reaches within a basin. Expert opinion was used to estimate the historical ratings for this attribute since historical data was lacking. The level of proof for the current condition is thoroughly established, generally accepted and good peer-reviewed empirical evidence in favor. For the historical data there is has a strong weight of evidence but not fully conclusive due to lack of data.

7.5.3.27 Dissolved oxygen

Definition: Average dissolved oxygen within the water column for the specified time interval.

Rationale: Dissolved oxygen in the template (historic) condition was assumed to be unimpaired. Historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) and Summers (2001) reported that in surveyed creeks dissolved oxygen levels were greater than 8 mg/l in August. All reaches in these watersheds were assumed to be unimpaired for dissolved oxygen. These are representative of free flowing reaches. The lower slough reaches in Hamilton, Hardy, EF Lewis, Kalama, and Coweeman are likely to have increased temperatures and lower DO levels in July/August.

Level of Proof: Empirical information and expert opinion were used to estimate the current and historical ratings for this attribute. Available current data support no problems with dissolved oxygen in flowing reaches. The level of proof for the current condition is thoroughly established, generally accepted and has good peer-reviewed empirical evidence in favor. In slough reaches, where no data was available, derived information and expert opinion was used. For the slough reaches and historical data there is has a strong weight of evidence but not fully conclusive due to lack of data. There is more uncertainty in the ratings for reaches with sloughs, than for riverine reaches.

7.5.3.28 Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to lack of data.

7.5.3.29 Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.5.3.30 Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.5.3.31 Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data for this attribute is very limited. Historically nutrient enrichment did not occur because watersheds were in the "pristine" state. To determine the amount of nutrient enrichment in various reaches the following factors were examined: fertilizing by timber companies, reaches downstream from hatcheries, agriculture effects, septic tanks, and storm water run-off.

Nutrient enrichment throughout these watersheds was assumed to be non-existent or at low levels. Fertilizing by timber companies may have some minimal effect but it is likely that changes in nutrient levels from normal forest activities is near zero (WFPB 1997)

Potential low levels of nutrients from Carson NFH enter in the top of Wind 5c. Potential nutrient sources exist from septic tanks at Trapper Creek (cabins), Wind 5c (Canavina Rd), Wind 5a (homes above Stabler), and Panther 1b (homes and cabins). The mainstem Wind River from CNFH to the mouth of Trout Creek was rated as 1 due to hatchery and homes with septic tanks. The ratings were reduced to 0.5 below Trout, and to 0 below Panther. Septic at other sites was assumed to be negligible based on low fecal coliform samples and was rated at 0. If the Wind River nursery is re-opened water quality sampling for nutrients below this site is recommended.

Level of Proof: Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.5.3.32 Fish community richness

Definition: Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale: Historical fish community richness was estimated from the current distribution of native fish in these watersheds (see below). Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness was estimated from direct observation (stream surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, and local knowledge. Anadromous fish distribution was estimated from the above as well as the SSHIAP fish distribution layer & EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in SW Washington watersheds: (1) smolt trapping activities on Lower Wind, Upper Wind, Panther Creek, and Trout Creek (pers. com. Cochran, WDFW), (2) electro-shocking in 2002 by USFS and USGS in Upper Wind, Panther, and Trout & tributaries (pers. com. Connoly USGS, and Bair USFS), (3) electroshocking by WDFW in many SW Washington tributaries (pers. com. Hallock, WDFW), (4) WDFW snorkel surveys on the Wind and Panther (pers. com. Cochran, WDFW), (5) species present in Hardy Slough (pers. com. Coley, USFWS), (6) Reimers and Bond (1967), and (7) McPheil (1967).

Historic reaches below Shipherd Fall contained chum salmon, steelhead, chinook salmon, coho salmon, sea-run cutthroat, bridgelip sucker, largescale sucker, prickley sculpin, and shorthead sculpin. Historic reaches above Shipherd Falls-include shorthead sculpin, whitefish, steelhead/rainbow; and spring chinook should be added for current distribution. Whitefish have not been observed above Dry Creek. Sculpins are not found in Trout Creek above Hemlock.

Current species in reach 1 (inundated) include the 29 from the Columbia. In Reach 2, the current includes the historic species plus stickleback. Brook trout are found presently found in upper Trout Creek and its tributaries. Lamprey, while present in the basin, are not included in the species count (Larry Lestelle pers com)

A spreadsheet summarizing the above data sources was developed: (EDT 2003 Data.xls pers. com. Glaser WDFW). Sloughs likely have many species present from the Lower Columbia River. An estimated 29 species were included in this list: chinook, chum, coho, steelhead/rainbow, cutthroat, sculpin sp(3) (torrent, coastrange , reticulate), bridgelip and largescale sucker, peamouth, northern pikeminnow, smelt, sandroller, redside shiner, large & smallmouth bass, carp, goldfish, white & black crappie, eastern banded killifish, yellow perch, sunfish, pumpkinseed, brown & yellow bullhead, white sturgeon, 3-spine stickleback. Most of these fish likely drop out as gradient increases and water temperatures are reduced. The eastern banded killifish is an exception to this, it has been found in higher reaches of the Elochoman River (pers. com. Byrne, WDFW) and trapped on Abernathy Creek (pers. com. Hanratty, WDFW). The majority of these species were dropped out at Wind 2.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.5.3.33 Fish species introductions

Definition: Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Introduced species were derived from current fish species richness data (see Fish Community Richness above).

Brook and cutthroat trout plants have been extensive in the Wind River basin but have been discontinued for decades. However, naturally reproducing brook trout are presently found in upper Trout Creek and its tributaries based on smolt trap (WDFW) and electroshock (USFS & USGS) data. Spring chinook salmon were introduced and are currently found below Wind 6b. Bright fall chinook salmon are found through Reach 3. The inundated reach (Wind 1) has potential for more exotics from the Columbia River, as many as 12 species from the Columbia River may migrate up to Reach 1. An estimated 12 species were included in this list: large & smallmouth bass, carp, goldfish, white & black crappie, Eastern banded killifish, yellow perch, pumpkinseed, sunfish, brown & yellow bullhead. Most of these fish likely drop out as gradient increases and water cools down. The majority of these species were dropped out at Wind 2. At the Lower Wind River Smolt trap the catch has included suckers, whitefish, peamouth, shiners sticklebacks, dace, sculpins, and lamprey (Charlie Cochran, pers Com)

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.5.3.34 Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency (pers. com. Glaser, WDFW).

CNFH releases 1.6 million spring chinook smolts from reach Wind 5C. Spawners use up to reach 6b annually. The hatchery steelhead program (20-40,000 annual release) was discontinued in 1997 and hatchery trout releases in Hemlock lake discontinued in 1994. Adult snorkel surveys indicate hatchery steelhead distributions were found in the same reaches as wild steelhead (snorkel survey memos). Therefore we assumed distribution was the same as wild fish. However, hatchery steelhead have not been passed above the Trout Creek Trap since 1992 except when not operated in the middle 1990’s and part of 1999. Hatchery outplants in tributaries and in the mainstem Wind River above Ninemile Creek were reduced to zero, since steelhead releases are discontinued and there was little evidence of straying.

Level of Proof: For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.5.3.35 Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition there were no hatcheries or hatchery outplants and we assumed an EDT rating of zero. CNFH operates in Wind 5C, but hatchery chinook spawn through reach 6B. The reaches from Wind 1 to 6B are rated as 3. Hatchery steelhead plants were discontinued in 1997 and hatchery trout plants in Hemlock Lake were discontinued in 1994. All other reaches were assumed to have impacts from hatchery steelhead and were rated as 1. Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations, and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.5.3.36 Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions.

Topographic maps were examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT rating of 4 was given to reaches with extensive road/boat access and high recreational use (Wind below Shipherd Falls and Hemlock Lake); a rating of 3 was given to areas with road/boat access and proximity to population center and moderate use (Upper Middle Wind or Flats due to Beaver Camp, and intense Sp Chinook Fishery); 2 was given to reaches with multiple access points (Lower Middle Wind, Wind Canyon due to Spring chinook fishery and kayaking, near campgrounds on Wind and Panther, and trailheads) through public lands or unrestricted access through private lands; 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands (most tributaries with limited access); 0 was given to reaches with no roads and that are far from population centers (Headwaters Wind, and tributaries with difficult access).

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.5.3.37 Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. The magnitude and timing of yearling hatchery smolt releases, and increases in exotic/native piscivorous fishes were considered when developing this rating. The status of top-level carnivores and other fish eating species is unknown in these watersheds.

We assumed current predation is similar to template conditions except for the lowest reach (Wind 1), which was given a rating of 4 due to reach inundation by the Bonneville Pool and an increase in Columbia River predatory fishes. We assumed there is an increase in predation at Hemlock Lake due to ducks, birds, and otters. This reach was rated at 3.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.5.3.38 Salmon Carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Reaches with historic chum presence (spawning) were given a rating of 0. Mainstem reaches with chinook and coho, but no chum were given a rating of 2. Reaches with only coho were given a rating of 3. Reaches with only cutthroat or steelhead were given a rating of 4, since these fish do not die after spawning. Tidal reaches below areas of chum spawning were given a 1 (it was assumed carcasses from spawning reaches above are washed into these reaches).

Historic fall chinook and chum spawned from the mouth to Little Wind River and carcasses were very super abundant; from Little Wind to Shipherd Falls, due to coho, chinook, and some chum, carcasses were very abundant (See USFWS hatchery fall chinook records); Little Wind had coho and winter steelhead and was rated as moderately abundant; and reaches above Shipherd Falls had only steelhead and carcasses were not abundant. Currently spring chinook spawn between Beaver Camp to Ninemile ~300 annually (WDFW escapement database). Approximately 600 Tule and Bright fall chinook spawn between the boat ramp and mouth of Little Wind (WDFW escapement database).

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive

7.5.3.39 Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: A few direct measures of benthos diversity for selected sites are available within the LCR from DOE and OSU. Reference sites in the Wind and Cowlitz Rivers yielded B-IBI ratings between 40 and 43 indicating EDT values of 0.3 to 0.9, which is equivalent to an EDT rating of 0.6. Slightly disturbed Rosgen B Channels in the Cowlitz and Grays had ratings of 0.1 to 1.4, but were very close to the averaged undisturbed rating of 0.6. Therefore, for current Rosgen B-channels we assumed the same rating as historic. For disturbed Rosgen C-channels in the Wind River the EDT benthos rating decreased to 1.5. Disturbed C-channels are likely to be more impacted by human activities due to their character than B-channels and the 1.5 EDT rating was used to describe current C-channels. Lower Cedar Creek has a rating B-IBI score of 26 or EDT score of 2.6. This reach is right below a disturbed C-Channel where the riparian encroachment has reduced shade, increased temperature, and nutrient levels (fecal coliform) have increased due to agriculture or septic tanks leaks. Middle to upper portions of Salmon Creek had similar B-IBI scores. Lower Salmon Creek, which is considered to have the most degraded water quality reaches in the LCR, had B-IBI scores that were less than 23. Cedar and Salmon Creek benthos score are not considered typical for most of southwest Washington.

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7.6 Grays

7.6.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treament Model (EDT) for the Grays River. In this project we rated 85 reaches with 45 environmental attributes per reach for current conditions and another 45 for historical conditions. Over 7,650 current ratings were assigned and empirical observations within these reaches were not available for all of these ratings. In fact less than 20% of these ratings are from empirical data. To develop the remaining data, we used expansion of empirical observations, derived information, expert opinion, and hypothetical information. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute, data was very limited or non-existent. WDFW established a relationship between road density and fine sediment in the Wind River. We applied this relationship to all subwatersheds; this is an example of derived information. In some cases, such as bed scour, we had no data. However, data is available from Gobar Creek (Kalama River tributary) and observations have been made in the Wind River as to which flows produce bed load movement. We noted that bed scour is related to gradient, stream width, and confinement. Based on these observations expert opinion was used to develop a look-up table to estimate bed scour. For rationale behind the EDT ratings assigned, see the text below. For specific reach scale information, please see the EDT database for the watershed of interest. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.6.2 Recommendations

1) Adult chum, steelhead, and chinook salmon population estimates should continue. However, more emphasis should be placed on determining the number of hatchery fish and their reproductive success. Accurate and precise adult and juvenile population estimates will allow for better population status estimates, validation of EDT, and to determine if subbasin restoration actions are effective. Juvenile programs should be initiated and adult programs should be maintained and improved as needed.
2) Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating as would field surveys.
3) Empirical sediment data was only available for a few reaches and derived estimates were used for most of the basin. A sediment monitoring program should be developed to assess the percentage of fines in spawning gravels, embeddedness, and turbidity in reaches used by anadromous fish.
4) Differences existed between field and GIS ratings of natural confinement. The SSHIAP database should be field verified.
5) Bed Scour estimates were not available for this basin and bed scour data should be collected and related to peak flows.
6) Conservation district habitat surveys do not directly measure all habitat types needed for EDT. WDFW habitat surveys in 2002 were opportunistic; that is, based on a limited amount of resources, we chose to survey a few representative reaches. To accurately

estimate stream habitat type within the anadromous distribution, a statistically valid sampling design should be developed and applied (Hankin and Reeves1988 or EMAP). Survey methodology should differentiate between pools and glides and be repeatable.

7) Macro invertebrate sampling was not available. A combination of DOE and OSU estimates of the Benthic Index of Biological Integrity (B-IBI) from the Wind River were used to develop EDT ratings in theWashougal Basin.
8) Obstructions were not rated and passage was assumed to be 100%. These ratings should be updated using the SSHIAP database.

7.6.3 Attributes

7.6.3.1 Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: This maximum elevation in these watershed is approximately 2,000 ft. These upper elevations are consistent with a rainfall-dominated watershed. These subbasins were rated as rainfall dominated for the historic and current conditions. Groundwater influences are present in the Crazy Johnson and Gorley Creeks. These runoff patterns were used to shape estimates of flow and temperature in the EDT model.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.6.3.2 Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale: This watersheds, which did not have artificial flow regulation was given an EDT rating of 0 for the historical and current conditions.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.6.3.3 Flow - change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Direct measures of inter-annual high flow variation are not available for this subbasin. Sufficient data was not available to conduct a Q2yr analysis in the Grays River . USFS estimates support a slight peak flow increases for subbasins in Southwest Washington (Table 1). Calculated Q2yr changes are Wind (13%), Washougal (17%), Kalama (17%), and Toutle (31%) after Mt St Helens and intensive logging. We used Naselle as a surrogate for Grays because of the basins similar climate and soils. The estimate increase in peak flow was and EDT rating of 2.4 (Mobrand 2002). Exceptions were Gorley and Crazy Johnson, which are groundwater streams, which did not have increase in peak flow. SF Grays River and Hull Creek had road densities that were less (~4 mi/sq mi) so reduced peak flow to 2.3

Table 1. Summary of USFS Watershed Analysis for the change in peak flow

Basin	**# of Subbasins**	**Increase in Peak Flow**
Wind	26	2 – 14%
East Fork Lewis	9	5 –13%
Lower Lewis		10 -12%
Rock Cr		1 -5%
Upper Kalama		5 - >10%
Cispus		<10%

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.6.3.4 Flow - changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Research on the effects of land use practices on summer low flow is inconclusive (Spencer et al. 1996). Therefore, we rated the template and current conditions the same (EDT rating of 2).

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.6.3.5 Flow – intra daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. This attribute was given an EDT rating of 0 for the current conditions due to the lack of storm water runoff for most of the basin. This attribute is influenced by the % impervious surfaces. Most reaches are influenced by forestry and impervious surfaces are low. We had no information on impervious surfaces but if information becomes available this attribute should be adjusted.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the remaining current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.6.3.6 Flow –Intra annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in these watersheds. USFS (1996) indicated peak flow may have increased by 13% in some subwatersheds. Since there was no data for this attribute, it was suggested that its rating should be the same as the changes in inter-annual variability in high flows (pers. com. Larry Lestelle, Mobrand, Inc).

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.7 Channel length

Definition: Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: Ned Pittman (WDFW) provided the length of each reach from SSHIAP GIS layers. We assumed the stream length was the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.6.3.8 Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: We assigned the same value for both the current and historical conditions, unless a major hydromodification or water withdrawal was located within the reach. Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). Wetted widths corresponding to average summer low flows (August) were measured as part of these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement.

Level of Proof: A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof ranged from thoroughly established in reaches with direct observations to a strong weight of evidence in support but not fully conclusive in reaches were expanded information was used. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.9 Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Wetted widths corresponding to average winter high flows (January) were measured as part of these surveys. (VanderPloeg 2003). Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Typically less reaches per subbasin were measured during average winter flow as compared to summer flow. We compared the percent increase between low and high flow widths to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data. A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris and hydroconfinement. Therefore, we used actual “wetted width-high” values in reaches where data was available, and a 1.6 multiplier (60%) to expand “wetted width-low” values for reaches without high flow data. In canyon areas, summer flows were expanded by 20-40% depending of reach characteristics.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.10 Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as percentage gradient) was calculated by dividing the change in reach elevation by the reach length. Ned Pittman (WDFW) used SSHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical gradient.

7.6.3.11 Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed for confinement ratings (VanderPloeg 2003). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps were consulted when SSHIAP ratings fell between the 0.5 increments to determine which rating should be applied. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4. There are often multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings (Table 2).

Table 2. Comparison of SSHIAP and EDT ratings for confinement.

Project	Unconfined	Equal unconfined and mod. confined	Moderately confined	Equal mod confined and confined	Confined
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.6.3.12 Confinement – hydro-modifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cut off due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Most hydro-modification consists of roads in the floodplain and diking. We consulted the SSHIAP GIS roads layer, SSHIAP digital ortho-photos, USGS maps, and Limiting Factors Analysis (LFA) to estimate EDT ratings. Ratings were categorical due to the lack of field surveys to corroborate GIS, map, and photo estimates.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.6.3.13 Habitat Type

Definition: *Backwater pools* is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter). Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Habitat type composition was measured during these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement. Lower reaches inundated by the construction of Bonneville Dam were rated as glides and pools depending on the amount of inundation.

WDFW habitat surveys followed USFS stream survey level 2 protocols, which delineate between riffles and slow water but not pools and glides. Glide habitat is the most difficult habitat to identify, therefore it was estimated but not surveyed by WDFW.

Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are believed to be the primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991 - Forest Ecosystem Management July 1992, page V-23), and applying this to current habitat type composition estimates. On Germany Creek, the Elochoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, we assumed for historical conditions that the percentage of pools was significantly higher than the current percentage. For gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5%, we estimated pool habitat to be 40% and 30%, respectively (WFPB 1994). We assumed that tailouts represent 15-20% of pool habitat, which is the current range from WDFW surveys. Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5% to 6% for gradients greater then 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat increased with gradient. WDFW field data indicated the percentage of gravel riffle habitat decreased with stream gradient, and cobble/boulder riffle habitat increased with stream gradient; the percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1% to 15% at gradients greater than 6%. WDFW surveys indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information we assumed pool habitats were in the "good" range and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.14 Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A , B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis. These low gradient C channels were assigned up to a 15% off-channel habitat factor, historically and 0% currently. Off-channel habitat is not significant except in the lower reaches. These reaches were assigned an EDT rating of up to 10% historic off-channel habitat factor due to the backwater of the Columbia River and assumed beaver populations. Old photographs suggested that substantial off-channel habitat was historically present.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.15 Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: WDFW SSHIAP database was used to identify existing barriers within these watersheds. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. In most cases known fish distribution stopped at all barriers. In some cases, where known distribution occurred above barriers, passage was assumed to be 100% for the species and all life stages. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon due to their preference for spawning in small tributaries are impacted by barriers. The ratings should be completed after a barrier analysis.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.16 Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach.

Rationale: No water withdrawals occurred in the pristine condition. Most watersheds in this unit are forested with residential use in the lower portion of the subbasin. Water withdrawals occur at the WDFW Hatchery on the WF Grays River and at the Alder Creek ponds in the upper basin. These reaches were rated at a 2.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.6.3.17 Bed scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for these basins. Historic bed scour was rated using the look-up table (pers. com. Dan Rawding, WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table is based on professional judgment and relates bed scour to confinement, wetted width (high flow), and gradient. It assumes bed scour increases as gradient, wetted width, and confinement increase. For low gradient slough like reaches, we reduced the bed scour rating to ~1, since these reaches are unconfined and influenced by the Columbia River.

Current EDT ratings were developed and used as the baseline for scour in the current condition. Template ratings for bed scour were increased as peak flow and hydro-confinement increased. For example, if in the template condition a reach had a peak flow of 2.0 and in the current condition peak flow increased to 2.3, while hydro-confinement ratings increased from 0 to 1, we assumed a 0.05 increase in bed scour for every 0.1 increase in peak flow and a 0.1 increase for every 1.0 increase in hydro-confinement. In this example the bed scour increased by 0.25.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.18 Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale: In watersheds that are rainfall dominated anchor ice and icing events do not occur. For elevations less than 1000 ft., EDT ratings of 0 were assigned to all reaches in the historical and current condition. For those from 1,000 to 2000 ft. EDT ratings of 1 were assigned. This was based on personal winter observation in the Wind River and discussions with CNFH staff. Based on elevation the same icing ratings were used in the Grays River.

Level of Proof: Empirical observations were used to establish an elevation /icing relationship and this derived information was used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.6.3.19 Riparian

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition the template conditions for this attribute are rated as a value of zero because this describes this attribute rating for watersheds in pristine conditions. Riparian zones with mature conifers are rated at 0.0 -1.0 depending on the density of large trees and bank stability. Riparian zones with saplings and deciduous trees are rated as 1.5 due to lack of shade and bank stability. Riparian zones with brush and few trees would be rated as 2. For an EDT rating to exceed 2, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees it should have a score of 2 or better. Most current vegetated riparian zones with no hydro-confinement should be rated as a 1 to 1.5. When hydro-confinement exists rating from rules on hydro-confinement were used to increase the riparian rating. Ratings also increased based on lack of vegetation. Key reaches were established for current riparian function through out these watersheds. Other reaches were referenced to these key reaches to develop a final EDT rating.

Riparian in upper mainstem and tributary reaches (above HWY 14) is considered in good condition, which corresponds to an EDT rating of 1. Below the mouth of the WF Grays riparian function is degraded due to forest clearing and diking. Ratings in these reaches are between two and three.

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.20 Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Rationale: Wood density was estimated during USFS and WDFW habitat surveys where density of wood equals pieces * length/width. Template condition for wood is assumed to be 0 for all reaches except large Canyon sections on the Grays, Coweeman, Kalama, EF Lewis, Washougal, and Wind, which are assumed to be 2. Due to their confinement, it was believed during high flows these reaches did not retain wood as well as other sections. When survey data was not available, wood densities were extrapolated from reaches with data. EDT Rating based on TFW standard of all wood. Conservation district surveys did not appear to follow the TFW protocol and adjustments were made to these surveys based on WDFW habitat surveys. The final rating suggest a significant loss of wood has occurred in this subbasin.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations were used to estimate the ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.6.3.21 Fine Sediment (intragravel)

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et. al. 1992). The average percentage of fines (8.5%) was used, which corresponds to an EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3.

To rate percentage of fines in the current condition, a scale was developed relating road density to fines. Rittmueller (1986) found that as road density increased by 1 mi/mi^2, fine sediment levels increased by 2.65%. However, Duncan and Ward (1985) found a lower increase in the percentage of fines in southwest Washington, but attributed much of the variation in fines to different geology. USFS used a McNiel core to collect gravel samples from 1998 to 2000 in 8 subwatersheds in the Wind River subbasin. Fines were defined as less than 0.85mm. A regression was run comparing the percentage for each year to road densities. The increase was 1.04% per 1 mi/mi^2 of roads for all watershed (R^2 = 0.31, n=17). The increase was 1.52% per 1 mi/mi^2 for all watersheds (R^2= 0.73, n= 14) when Layout Creek, which was recently restored was excluded. Rather than use all three years of Layout Creek data , only the median was used and the final relationship used for EDT was 1.34% increase in fines per1 mi/mi^2 (R^2=0.56, n=15) (Figure 1). Road densities were obtained from URS (2003) report to the LCFRB and these were incorporated into the Wind River relationship to estimate fines. Tidal reaches with lower gradients were rated one point higher.

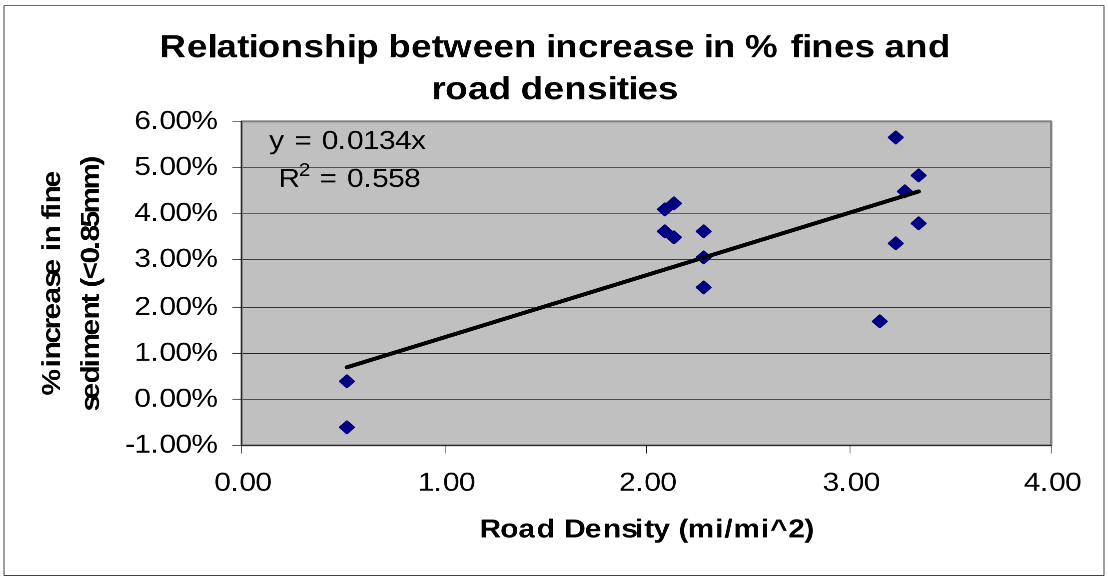

Figure 1. Relationship between road densities and the percentage increase in fines (<0.85mm) from USFS data.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.6.3.22 Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have a low level of embeddedness. Based on the historic level of fines in spawning gravels

(8.5%), we assumed this level was the same for embeddedness, which corresponds to and EDT rating of 0.5. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2. Reaches above tidal with low gradient and slower flows likely also had increased fine sediment and embeddeness and were given an EDT rating of 1.

We assumed that the percent embeddedness was directly related to percentage of fines in spawning gravel. We used the Wind River data mentioned above to develop a scale relating road density to percent embeddedness and applied this to the Grays River. Tidal reaches with lower gradients were rated one point higher.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.23 Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. No historical information is available for this attribute. Fire was historically a natural disturbance process, that occasionally increases turbidity after an extensive hot burn. Current increases in turbidity are likely associated with human activities that lead to bank instability in the riparian area and roads associated with logging, urbanization, and agriculture. Background turbidity levels were assumed to increase with stream size. Professional opinion set these levels to be an EDT rating of 0 in small tributaries, 0.3 in medium tributaries, and 0.5 in the mainstem.

Suspended sediment and turbidity data is limited to grab samples by USFS and UCD for the Wind River. Flow data and limited turbidity data are available for the rivers from the USGS website (http://wa.water.usgs.gov/realtime/historical.html). Historical turbidity data was plotted versus flow data from the same time period. Prior to 1978, USGS turbidity data was recorded in JTU. Since 1978, turbidity data has been recorded in NTU. There is not a direct conversion from JTU to NTU, making it difficult to interpret turbidity data prior to 1978. Bank stability and roads analyses support a small increase in turbidity. Limited data suggests during high water events Wind River suspended sediment exceeds 100 mg/L, while Lower Trout, Panther, and Middle Wind are over 40 mg/L, and other basins are 5-40mg/L, with most less than 25mg/L. However, the duration of these turbidity levels is unknown. If levels of 100mg/L last for 24 hours the EDT rating is 1.0. If the 25 mg/L level lasts 24 hours, the EDT rating is 0.8. These provided the basis for current ratings. These generally support ratings of 0.3 for small tributaries, 0.7 for larger tributaries, and 1.0 for the lower mainstem. These ratings were applied to the Grays River.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.6.3.24 Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: Temperature loggers have been extensively placed in the Grays subbasin by the conservation district and WDFW. This data was entered into the EDT temperature calculator provided by Mobrand, Inc. to produce EDT ratings for August. To develop maximum temperature ratings for the remaining months, we used the template monthly pattern "TmpMonMax Rainfall", TmpMonMax Groundwater", and TmpMonMax Transitional" for the rainfall, groundwater and rain-on-snow-transitional watersheds, respectively.

The EDT ratings generated by the temperature calculator were used for reaches with a temperature logger present, and ratings for other reaches were inferred/extrapolated from these based on proximity and similar gradient, habitat, and confinement. If temperature loggers were mid-reach we used the reading for the entire reach. If temperature loggers were at the end of the reach and evidence from other temperature loggers above indicated there was cooling within the reach (as you move upstream), professional judgment was used to develop an average for the reach. The same logic was applied to reaches without temperature loggers located between reaches with temperature loggers – ratings from reaches with temperature loggers were "feathered" for reaches in between. Readings from loggers at the end of a reach were used to estimate the rating for the reaches downstream.

Historical temperatures are unknown the in this subbasin. The Regional Ecosystem Assessment Project estimated the range of historical maximum daily stream temperatures for the Hood/Wind at 7-20 degrees C (USFS 1993). However, this broad range was not very informative for historical individual reach scale temperatures. The only historical temperature data that we located were temperatures recorded in the 1930's and 40's while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary process transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2002). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State watershed analysis manual (WFPB 1997). Elevation of stream reaches is estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters back from the maximum wetted width. Next we assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these trees are estimated to be between 40 – 50 meters for cedar and 60 - 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, we used 49 meters as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was approximately 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade, we used the relationship between forest angle and percentage of shade (WFPB 1997 Appendix G-33.). Finally we used the relationship between elevation, percentage of shade and the maximum daily stream temperature to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for maximum historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. We developed a correction factor for small tributaries, which consisted of adding 0.3 to the estimated historical EDT rating. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature and shade, while Pelletier (2002) used QUAL2K which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However, due to limited resources available for this study, the shade/elevation model was used for consistency throughout the Lower Columbia River.

Level of Proof: Derived information was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.6.3.25 Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: Wind River temperature data was used to develop a relationship between elevation and maximum temperature for elevations up to 2000 feet as follows: EDT min temp = 1.0248 Ln(elev) –5.8305 (R^2= 0.32, n=27). This was used to generate categorical ratings (Table 3) based on elevation. For the Wind, we used actual data, where available, to develop non-categorical ratings. It should be noted that reaches with lakes/wetlands (Falls and EF Trout) and immediate downstream reaches have colder minimum temperatures (higher EDT ratings) and those with strong groundwater influence (Upper Trout) have warmer minimum temperatures (lower EDT ratings). The Wind River ratings were applied to the Grays River.

Table 3. Estimated categorical ratings for minimum temperature based on elevation from Wind River data.

Elevation	EDT Rating
< 600 ft	0
600-1200	1
1300-3000 ft	2

The historic minimum temperature was assumed to be the same as current minimum temperatures. There is some support that historical minimum temperatures were warmer due to more mature forest stands, but we did not use this information due to the limited support and the fact that fire disturbance regimes in these forests would have periodically led to these conditions naturally.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established in the Wind. Expansion of empirical ratings was used for the remainder of the Wind and other basins.

7.6.3.26 Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: Historically there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. These reaches were given an EDT rating of 1. Higher gradient reaches of the mainstem and tributaries higher in the watershed likely had less groundwater input. These reaches were given an EDT rating of 2. We could not find any data on the current or historical conditions for ground water input. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2. Higher gradient reaches in the upper watershed are likely similar to the historic condition and were given an EDT rating of 2.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.6.3.27 Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.

Rationale: Alkalinity was estimated from historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) for conductivity on the Wind, Lower Washougal, Middle Washougal, NF Lewis, EF Lewis, Cedar, Kalama, Elochoman, and Grays Rivers using the formula: Alkalinity =0.421*Conductivity – 2.31 from Ptolemy (1993). A relationship was developed between flow and alkalinity assuming a power function. We used the mean July to September flow to determine the mean alkalinity values. For basins without flow data, we used mean summer alkalinity values. Alkalinity values were 22, 15, 12, 16, 20, 27, 21, 27, and 30 mg/L, respectively. The Grays River alkalinity data was used for this subbasin . Alkalinity in the historic condition was given the same value as the current condition.

Level of Proof: Derived information was used to estimate this attribute from conductivity measurements. Since alkalinity is did not vary much between adjacent basins and is believed to be relatively constant within a basin, estimated values were expanded for all reaches within a basin. Expert opinion was used to estimate the historical ratings for this attribute since historical data was lacking. The level of proof for the current condition is thoroughly established, generally accepted and good peer-reviewed empirical evidence in favor. For the historical data there is has a strong weight of evidence but not fully conclusive due to lack of data.

7.6.3.28 Dissolved oxygen

Definition: Average dissolved oxygen within the water column for the specified time interval.

Rationale: Dissolved oxygen in the template (historic) condition was assumed to be unimpaired. No data was available for this subbasin. Historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) and WDFW hatchery data found that in surveyed creeks dissolved oxygen levels were greater than 8 mg/l in August . All riverine reaches in these watersheds were assumed to be unimpaired for dissolved oxygen. Coweeman sampling indicated DO levels could drop below 8 mg/L in slough like reaches. This information was used to rate the lower sloughs of the Grays River.

Level of Proof: Empirical information and expert opinion were used to estimate the current and historical ratings for this attribute. Available current data support no problems with dissolved oxygen in flowing reaches. The level of proof for the current condition is thoroughly established, generally accepted and has good peer-reviewed empirical evidence in favor. In slough reaches, where no data was available, derived information and expert opinion was used. For the slough reaches and historical data there is has a strong weight of evidence but not fully conclusive due to lack of data. There is more uncertainty in the ratings for reaches with sloughs, than for riverine reaches.

7.6.3.29 Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to lack of data.

7.6.3.30 Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.6.3.31 Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.6.3.32 Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data for this attribute is very limited. Historically nutrient enrichment did not occur because watersheds were in the "pristine" state. To determine the amount of nutrient enrichment in various reaches the following factors were examined: fertilizing by timber companies, reaches downstream from hatcheries, agriculture effects, septic tanks, and storm water run-off. The potential for an increase in nutrients from septic tanks and agriculture in the lower river is possible, and so is an increase from hatchery operations in the West Fork Grays River. These reaches were rated as 1. Assumed all other reaches are similar to historic levels.

Level of Proof: Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.6.3.33 Fish community richness

Definition: Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale: Historical fish community richness was estimated from the current distribution of native fish in these watersheds (see below). Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness was estimated from direct observation (stream surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, and local knowledge. Anadromous fish distribution was estimated from the above as well as the SSHIAP fish distribution layer & EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in SW Washington watersheds: (1) smolt trapping activities on Lower Wind, Upper Wind, Panther Creek, and Trout Creek (pers. com. Cochran, WDFW), (2) electro-shocking in 2002 by USFS and USGS in Upper Wind, Panther, and Trout & tributaries (pers. com. Connoly USGS, and Bair USFS), (3) electroshocking by WDFW in many SW Washington tributaries (pers. com. Hallock, WDFW), (4) WDFW snorkel surveys on the Wind and Panther (pers. com. Cochran, WDFW), (5) species present in Hardy Slough (pers. com. Coley, USFWS), (6) Reimers and Bond (1967), and (7) McPheil (1967). Lamprey, while present in the basin, are not included in the species count (Larry Lestelle pers com).

A spreadsheet summarizing the above data sources was developed: (EDT 2003 Data.xls pers. com. Glaser WDFW). Sloughs likely have many species present from the Lower Columbia River. An estimated 29 species were included in this list: chinook, chum, coho, steelhead/rainbow, cutthroat, sculpin sp(3) (torrent, coastrange , reticulate), bridgelip and largescale sucker, peamouth, northern pikeminnow, smelt, sandroller, redside shiner, large & smallmouth bass, carp, goldfish, white & black crappie, eastern banded killifish, yellow perch, sunfish, pumpkinseed, brown & yellow bullhead, white sturgeon, 3-spine stickleback. Most of these fish likely drop out as gradient increases and water temperatures are reduced. The eastern banded killifish is an exception to this, it has been found in higher reaches of the Elochoman

River (pers. com. Byrne, WDFW) and trapped on Abernathy Creek (pers. com. Hanratty, WDFW).

Fish community richness has increased due to species introductions. These are warmwater and coolwater fishes from the Columbia River, which migrate through the lower Grays River.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.6.3.34 Fish species introductions

Definition: Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Introduced species were derived from current fish species richness data (see Fish Community Richness above).

The tidal reaches have potential for use by exotic fishes from the Columbia River, as many as 12 species from the Columbia River may migrate into these reaches. An estimated 12 species were included in this list: large & smallmouth bass, carp, goldfish, white & black crappie, Eastern banded killifish, yellow perch, pumpkinseed, sunfish, brown & yellow bullhead. Most of these fish likely drop out as gradient increases and water cools down. Species introductions are due to warmwater fishes in the lower reaches of the Grays River. Lowest reaches were rated 3 based on derived info from other basins. Ratings were reduced above this site based on professional opinion, and WDFW electroshocking data. Blasting falls above in mainstem above WF Grays River allowed coho access. Chinook salmon have difficulty accessing this area. These areas rated as a 1. Tidal and estuary reaches rated 2 through 4 due to introduced fishes from the Columbia River. Grays 2 rated at 1 due to some introduced Columbia River fish migrating into this reach.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.6.3.35 Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency (pers. com. Glaser, WDFW). Current hatchery operates on the WF Grays River; this and downstream reaches were rated at 4. The discontinued hatchery program at Weyco Ponds near Alder Cr was the basis for EDT ratings of 2 in mainstem Grays River above the West Fork Grays River . Both these programs were rated as 3.

Level of Proof: For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.6.3.36 Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition there were no hatcheries or hatchery outplants and we assumed an EDT rating of zero. Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency. Stocking in the WF Grays River and at the Alder Creek ponds was the basis for the ratings for this attribute. All other reaches were as rated as a zero.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations, and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.6.3.37 Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions.

Topographic maps were examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT rating of 4 was given to reaches with extensive road/boat access and high recreational use ; a rating of 3 was given to areas with road/boat access and proximity to population center and moderate use; 2 was given to reaches with multiple access points through public lands or unrestricted access through private lands; 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands; 0 was given to reaches with no roads and that are far from population centers. Accept in the lower basin, much of the access is restricted by private timber companies. Due to limited use and access, EDT ratings ranged from 0 to 2.

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.6.3.38 Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Predation has increased in reaches connected to Columbia River due to warmwater and coolwater species introductions. Predation risks increased due to introduced fish moving up from the Columbia River. Predation risk has also increased due to yearling hatchery release from the Grays River Hatchery.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.6.3.39 Salmon Carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Reaches with historic chum presence (spawning) were given a rating of 0. Mainstem reaches with chinook and coho, but no chum were given a rating of 2. Reaches with only coho were given a rating of 3. Reaches with only cutthroat or steelhead were given a rating of 4, since these fish do not die after spawning. Tidal reaches below areas of chum spawning were given a 1 (it was assumed carcasses from spawning reaches above are washed into these reaches). Chum salmon are the most abundant anadromous salmonid and access reaches up to Highway 14. Current estimates of carcasses were derived from estimates of chum salmon escapement prior to the establishment of a hatchery chum program. Reaches with coho now assumed to be 4 except in reaches near WF Grays River hatchery, where they were increased to 3. Chinook abundance very low in mainstem below WF Grays River and is ~100 adults since the closure of the hatchery. Chum Salmon abundance very high in Crazy Johnson and Gorley Creeks, which corresponds to and EDT rating of 0.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.6.3.40 Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: A few direct measures of benthos diversity for selected sites are available within the LCR from DOE and OSU. Reference sites in the Wind and Cowlitz Rivers yielded B-IBI ratings between 40 and 43 indicating EDT values of 0.3 to 0.9, which is equivalent to an EDT rating of 0.6. Slightly disturbed Rosgen B Channels in the Cowlitz and Grays had ratings of 0.1 to 1.4, but were very close to the averaged undisturbed rating of 0.6. Therefore, for current Rosgen B-channels we assumed the same rating as historic. For disturbed Rosgen C-channels in the Wind River the EDT benthos rating decreased to 1.5. Disturbed C-channels are likely to be more impacted by human activities due to their character than B-channels and the 1.5 EDT rating was used to describe current C-channels. Lower Cedar Creek has a rating B-IBI score of 2.6 or EDT score of 2.6. This reach is right below a disturbed C-Channel where the riparian encroachment has reduced shade, increased temperature, and nutrient levels (fecal coliform) have increased due to agriculture or septic tanks leaks.

B-IBI scores from the Wind River indicate little degradation for Rosgen B channels. Therefore, the 0.6 reference reach rating for current and historical reaches with confined channels. For C channels ratings were degraded to 1.6 based on Wind River data, which supported that B-IBI scores were reduced in less confined channels. Historical less confined channels in the lower basin were rated at 1, current rating was increased to 2 based on nutrients, water temps and DO.

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7.7 Lewis River

7.7.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treament Model (EDT) for the Lewis River. In this project we rated 68 reaches with 45 environmental attributes per reach for current conditions and another 465for historical conditions. Over 2,700 current ratings were assigned and empirical observations within these reaches were not available for all of these ratings. In fact less than 20% of these ratings are from empirical data. To develop the remaining data, we used expansion of empirical observations, derived information, expert opinion, and hypothetical information. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute, data was very limited or non-existent. WDFW established a relationship between road density and fine sediment in the Wind River. We applied this relationship to all subwatersheds; this is an example of derived information. In some cases, such as bed scour, we had no data. However, data is available from Gobar Creek (Kalama River tributary) and observations have been made in the Wind River as to which flows produce bed load movement. We noted that bed scour is related to gradient, stream width, and confinement. Based on these observations expert opinion was used to develop a look-up table to estimate bed scour. For rationale behind the EDT ratings assigned, see the text below. For specific reach scale information, please see the EDT database for the watershed of interest. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.7.2 Recommendations

1) Adult chum salmon, chinook salmon, and steelhead population estimates should continue. However, more emphasis should be placed on determining the number of hatchery and wild spawners and the reproductive success of hatchery spawners. Summer steelhead and spring chinook estimates are based on mark-recapture and are considered accurate and precise. Winter steelhead, fall chinook estimates and chum salmon estimates are based on an assumed observer efficiency and are likely to be less reliable. Coho salmon counts are periodic and not population estimates. Summer steelhead escapement estimates should be continued and funding secured to develop accurate and precise adult estimates. Juvenile outmigrant estimates are made annual for Lewis Rievr fall Chinook and all species at Cedar Creek and in 2000 for EF steelhead and coho in the EF Lewis River. Accurate and precise adult and juvenile population estimates will allow for better population status estimates, validation of EDT, and to determine if subbasin restoration actions are effective. These programs should be maintained and improved as needed.
2) Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating as would field surveys.
3) Empirical sediment data was only available for a few reaches and derived estimates were used for most of the basin. A sediment monitoring program should be developed to

assess the percentage of fines in spawning gravels, embeddedness, and turbidity in reaches used by anadromous fish.

4) Differences existed between field and GIS ratings of natural confinement. The SSHIAP database should be field verified.
5) Gauge stations in Cedar Creek @ Grist Mill, EF Lewis @ Heisson, and Lewis @ Merwin provide flow data. Bed Scour estimates were not available for this basin and bed scour data should be collected and related to peak flows.
6) USFS habitat surveys do not directly measure all habitat types needed for EDT. WDFW habitat surveys in 2002 were opportunistic; that is, based on a limited amount of resources, we chose to survey a few representatative recheas. To accurately estimate stream habitat type within the anadromous distribution, a statistically valid sampling design should be developed and applied (Hankin and Reeves1988 or EMAP). Survey methodology should differentiate between pools and glides and be repeatable.
7) Macro invertebrate sampling was available in Cedar Creek. A combination of DOE and OSU estimates of the Benthic Index of Biological Integrity (B-IBI) from the Wind River were used to develop EDT ratings in the Lewis Basin.
8) Obstructions were not rated and passage was assumed to be 100%. These ratings should be updated using the SSHIAP database.

7.7.3 Attributes

7.7.3.1 Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: This maximum elevation in this watershed is approximately 3,000 ft. The upper elevations are consistent with a rain-on-snow hydrologic regime and the lower elevations are consistent with a rainfall-dominated watershed. This subbasin was rated as rainfall dominated for the historic and current conditions except for upper portions on the EF Lewis River above Horseshoe Falls, which were rated as rain-on-snow. These runoff patterns were used to shape estimates of flow and temperature in the EDT model.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.7.3.2 Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale: The Lewis River below Merwin dam is regulated but no regulation occurs in the remainder of the basin. The watersheds, which did not have artificial flow regulation were given an EDT rating of 0 for the historical and current conditions. Water storage behind the Lewis River dam is in excess of 60 days and Lewis River mainstem reaches below the dam were rated as 4.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.7.3.3 Flow - change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Direct measures of inter-annual high flow variation are not available for most subwatersheds in the Lewis River. The Q2yr calculation showed no difference during the period of record for the EF Lewis. However, EF Lewis was recovering from the Yacolt burn when the gage was installed. USFS watershed analysis suggest >10% increase in peak flow. Washougal and Wind showed a 17% and 13% increase in Q2yr. These rating suggest 2.3 to 2.4 rating. We used 2.3 for the EF Lewis above Lucia Falls and 2.4 for the area below Lucia Falls. Cedar Creek was assumed to be 2.3 and Lewis below Merwin 1.0 due to hydro-regulation.

USFS has conducted watershed analysis in the EF Lewis (USFS 1996). Peak flow analysis was conducted using the State of Washington "Standard methodology for conducting watershed analysis". The primary data used for the peak flow analysis is vegetation condition, elevation, road network, and aspect. The results for increased risk in peak flow from the USFS watershed analysis are shown in Table 1. USFS estimates were used for subwatersheds (Table 1).

Table 1. Summary of USFS Watershed Analysis for the change in peak flow

Basin	# of Subbasins	Increase in Peak Flow
East Fork Lewis	9	5 –13%

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.7.3.4 Flow - changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Research on the effects of land use practices on summer low flow is inconclusive (Spencer et al. 1996). Therefore, we rated the template and current conditions the same (EDT rating of 2). Due to flow regulation below Merwin Dam flow regulation has increased summer low flow. These reaches received an EDT rating of 1. Water withdrawals may occur in the subbasin but these are likely to be for occasional residential use and were not factored into the EDT rating.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.7.3.5 Flow – intra daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. This attribute was given an EDT rating of 0 for the current conditions due to the lack of storm water runoff for most of the basin. Reaches influenced by hydroelectric development in this subbasin were rated 3 for an average change of 8 inches in stage per hour.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Empirical information was used to estimate change in gauge height per hour on below Merwin Dam. Derived information was used to estimate the remaining current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.7.3.6 Flow –Intra annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in these watersheds. USFS (1996) indicated peak flow may have increased by 13% in some subwatersheds. Since there was no data for this attribute, it was suggested that its rating should be the same as the changes in inter-annual variability in high flows (pers. com. Larry Lestelle, Mobrand, Inc).

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.7 Channel length

Definition: Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: Ned Pittman (WDFW) provided the length of each reach from SSHIAP GIS layers. We assumed the stream length was the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.7.3.8 Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: We assigned the same value for both the current and historical conditions, unless a major hydromodification or water withdrawal was located within the reach. Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). USFS surveyed widths as part of habitat surveys from the late 1980's to the present (Darryl Hodges-USFS unpublished data). Wetted widths corresponding to average summer low flows (August) were measured as part of these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement.

Level of Proof: A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof ranged from thoroughly established in reaches with direct observations to a strong weight of evidence in support but not fully conclusive in reaches were expanded information was used. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.9 Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Wetted widths corresponding to average winter high flows (January) were measured as part of these surveys. (VanderPloeg 2003). Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Typically less reaches per subbasin were measured during average winter flow as compared to summer flow. We compared the percent increase between low and high flow widths to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data. A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris and hydroconfinement. Therefore, we used actual “wetted width-high” values in reaches where data was available, and a 1.6 multiplier (60%) to expand “wetted width-low” values for reaches without high flow data. In canyon areas, summer flows were expanded by 20-40% depending of reach characteristics.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.10 Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as percentage gradient) was calculated by dividing the change in reach elevation by the reach length. Ned Pittman (WDFW) used SSHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical gradient.

7.7.3.11 Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed for confinement ratings (VanderPloeg 2003). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps were consulted when SSHIAP ratings fell between the 0.5 increments to determine which rating should be applied. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4. There are often multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings (Table 2).

Table 2. Comparison of SSHIAP and EDT ratings for confinement.

Project	Unconfined	Equal unconfined and mod. confined	Moderately confined	Equal mod confined and confined	Confined
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.7.3.12 Confinement – hydro-modifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cut off due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Most hydro-modification consists of roads in the floodplain and diking. We consulted the SSHIAP GIS roads layer, SSHIAP digital ortho-photos, USGS maps, and Limiting Factors Analysis (LFA) to estimate EDT ratings. Ratings were categorical due to the lack of field surveys to corroborate GIS, map, and photo estimates. Hydroconfinement primarily occurs in the EF Lewis below Daybreak Park and in the NF Lewis Below Woodland due to loss of muti-thread channels into single thread channel in part due to dikes and filling in of side channels

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.7.3.13 Habitat Type

Definition: *Backwater pools* is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter). Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Habitat type composition was measured during these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement. Lower reaches inundated by the construction of Bonneville Dam were rated as glides and pools depending on the amount of inundation.

WDFW, USFWS, and USFS habitat surveys followed USFS stream survey level 2 protocols, which delineate between riffles and slow water but not pools and glides. Glide habitat is the most difficult habitat to identify, therefore it was estimated but not surveyed by WDFW.

Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are believed to be the primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991 - Forest Ecosystem Management July 1992, page V-23), and applying this to current habitat type composition estimates. On Germany Creek, the Elochoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, we assumed for historical conditions that the percentage of pools was significantly higher than the current percentage. For gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5%, we estimated pool habitat to be 40% and 30%, respectively (WFPB 1994). We assumed that tailouts represent 15-20% of pool habitat, which is the current range from WDFW surveys. Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5% to 6% for gradients greater then 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat increased with gradient. WDFW field data indicated the percentage of gravel riffle habitat decreased with stream gradient, and cobble/boulder riffle habitat increased with stream gradient; the percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1% to 15% at gradients greater than 6%. WDFW surveys indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information we assumed pool habitats were in the "good" range and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.14 Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A , B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis. These low gradient C channels were assigned up to a 15% off-channel habitat factor, historically and 0% currently. Off-channel habitat is not significant in the EF Lewis River above Lewisville, NF Lewis above Cedar Creek, and upper and lower Cedar Creek.

These reaches were assigned an EDT rating of 0 for current and historic off-channel habitat factor. Old photographs suggested that substantial off-channel habitat was historically present.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.15 Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: WDFW SSHIAP database was used to identify existing barriers within these watersheds. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. This has not been completed for any barriers except Merwin Dam. In most cases known fish distribution stopped at all barriers. In some cases, where known distribution occurred above barriers, passage was assumed to be 100% for the species and all life stages. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon due to their preference for spawning in small tributaries are impacted by barriers. The ratings should be completed after a barrier analysis.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.16 Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach.

Rationale: No water withdrawals occurred in the pristine condition. Most watersheds in this unit are forested with limited agriculture and residential use. Water withdrawals were assumed to be minimal in most areas. Water withdrawals occur at the Lewis River Hatchery and for the Grist Mill fish ladder on Cedar Creek. Other withdrawals for personal use could be occurring on other reaches but since they were not documented, they were ignored.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.7.3.17 Bed scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for these basins. Historic bed scour was rated using the look-up table (pers. com. Dan Rawding, WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table is based on professional judgment and relates bed scour to confinement, wetted width (high flow), and gradient. It assumes bed scour increases as gradient, wetted width, and confinement increase. For low gradient slough like reaches, we reduced the bed scour rating to ~1, since these reaches are unconfined and influenced by the Columbia River.

Current EDT ratings were developed and used as the baseline for scour in the current condition. Template ratings for bed scour were increased as peak flow and hydro-confinement increased. For example, if in the template condition a reach had a peak flow of 2.0 and in the current condition peak flow increased to 2.3, while hydro-confinement ratings increased from 0 to 1, we assumed a 0.05 increase in bed scour for every 0.1 increase in peak flow and a 0.1 increase for every 1.0 increase in hydro-confinement. In this example the bed scour increased by 0.25. Bed Scour below Merwin Dam was reduced due to hydro-electric operation, which reduces peak flows.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.18 Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale: In watersheds that are rainfall dominated anchor ice and icing events do not occur. For elevations less than 1000 ft., EDT ratings of 0 were assigned to all reaches in the historical and current condition. For those from 1,000 to 2000 ft. EDT ratings of 1 were assigned. This was based on personal winter observation in the Wind River and discussions with CNFH staff. Since the Wind and EF Lewis River have the same headwaters. The same icing ratings were used in the Lewis River.

Level of Proof: Empirical observations were used to establish an elevation /icing relationship and this derived information was used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.7.3.19 Riparian

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition the template conditions for this attribute are rated as a value of zero because this describes this attribute rating for watersheds in pristine conditions. Riparian zones with mature conifers are rated at 0.0 -1.0 depending on the density of large trees and bank stability. Riparian zones with saplings and deciduous trees are rated as 1.5 due to lack of shade and bank stability. Riparian zones with brush and few trees would be rated as 2. For an EDT rating to exceed 2, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees it should have a score of 2 or better. Most current vegetated riparian zones with no hydro-confinement should be rated as a 1 to 1.5. When hydro-confinement exists rating from rules on hydro-confinement were used to increase the riparian rating. Ratings also increased based on lack of vegetation. Key reaches were established for current riparian function through out these watersheds. Other reaches were referenced to these key reaches to develop a final EDT rating. Riparian function in most channel sections (EF above Lewisville and NF above Johnson) remains very functional except for lack of shade. Below these areas lack of connectivity, stability, and shade reduce function.

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.20 Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Rationale: Wood density was estimated during USFS and WDFW habitat surveys where density of wood equals pieces * length/width. Template condition for wood is assumed to be 0 for all reaches except large Canyon sections on the Grays, Coweeman, Kalama, EF Lewis, Washougal, and Wind, which are assumed to be 2. Due to their confinement, it was believed during high flows these reaches did not retain wood as well as other sections. When survey data was not available, wood densities were extrapolated from reaches with data. EDT Rating based on TFW standard of all wood. WDFW surveys suggest that the EDT wood rating in Rock Cr was 3. An EDT rating of 4 was observed in the mainstem Lewis River from Moulton to Rock Creek. For the remainder of the basin an average EDT rating of 3 was used. Additional USFS rating support poor wood for anadromous reaches above Sunset Falls.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical

information, expanded empirical observations were used to estimate the ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.7.3.21 Fine Sediment (intragravel)

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et. al. 1992). The average percentage of fines (8.5%) was used, which corresponds to an EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3.

To rate percentage of fines in the current condition, a scale was developed relating road density to fines. Rittmueller (1986) found that as road density increased by 1 mi/mi^2, fine sediment levels increased by 2.65%. However, Duncan and Ward (1985) found a lower increase in the percentage of fines in southwest Washington, but attributed much of the variation in fines to different geology. USFS used a McNiel core to collect gravel samples from 1998 to 2000 in 8 subwatersheds in the Wind River subbasin. Fines were defined as less than 0.85mm. A regression was run comparing the percentage for each year to road densities. The increase was 1.04% per 1 mi/mi^2 of roads for all watershed (R^2 = 0.31, n=17). The increase was 1.52% per 1 mi/mi^2 for all watersheds (R^2= 0.73, n= 14) when Layout Creek, which was recently restored was excluded. Rather than use all three years of Layout Creek data , only the median was used and the final relationship used for EDT was 1.34% increase in fines per1 mi/mi^2 (R^2=0.56, n=15) (Figure 1).

During relicensing PacifiCorp analyzed spawning gravel below the Merwin Project and found fine sediment in spawning gravel that was very low and corresponded to and EDT rating of 0.5. For the remainder of the basin Lewis River road densities were obtained from URS (2003) report to the LCFRB and these were incorporated into the Wind River relationship to estimate fines.

Tidal reaches with lower gradients were given an EDT rating of 4.

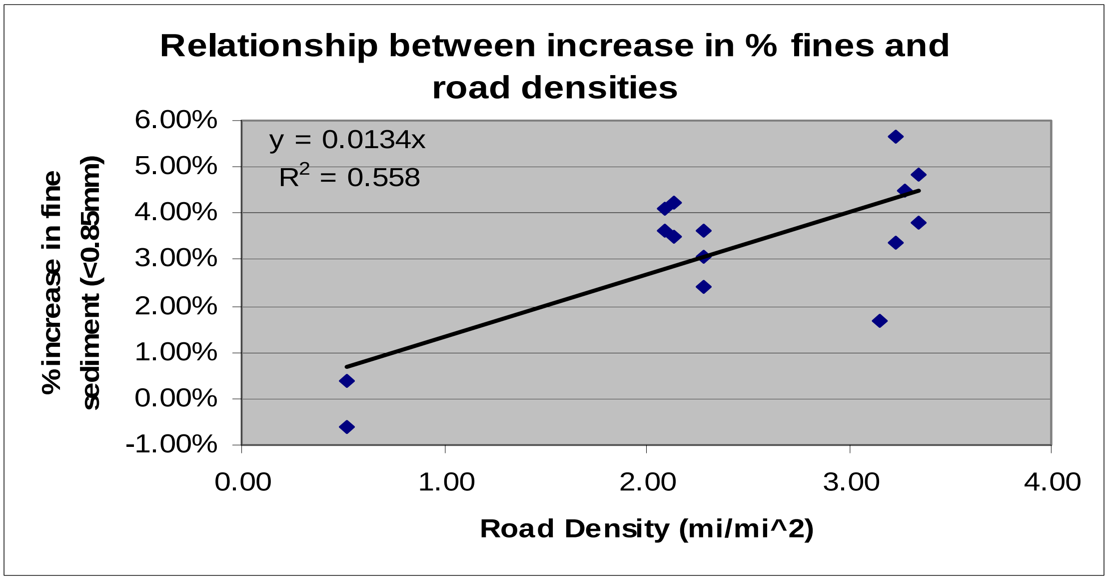

Figure 1. Relationship between road densities and the percentage increase in fines (<0.85mm) from USFS data.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.7.3.22 Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have a low level of embeddedness. Based on the historic level of fines in spawning gravels (8.5%), we assumed this level was the same for embeddedness, which corresponds to and EDT rating of 0.5. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2. Reaches above tidal with low gradient and slower flows likely also had increased fine sediment and embeddeness and were given an EDT rating of 1.

We assumed that the percent embeddedness was directly related to percentage of fines in spawning gravel. We used the Wind River data mentioned above to develop a scale relating road density to percent embeddedness and applied this to the Lewis River. Tidal reaches with lower gradients were given an EDT rating of 3.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.23 Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. No historical information is available for this attribute. Fire was historically a natural disturbance process, that occasionally increases turbidity after an extensive hot burn. Current increases in turbidity are likely associated with human activities that lead to bank instability in the riparian area and roads associated with logging, urbanization, and agriculture. Background turbidity levels were assumed to increase with stream size. Professional opinion set these levels to be an EDT rating of 0 in small tributaries, 0.3 in medium tributaries, and 0.5 in the mainstem.

Suspended sediment and turbidity data is limited to grab samples by USFS and UCD for the Wind River. Flow data and limited turbidity data are available for the Elochoman River from the USGS website (http://wa.water.usgs.gov/realtime/historical.html). Historical turbidity data was plotted versus flow data from the same time period. Prior to 1978, USGS turbidity data was recorded in JTU. Since 1978, turbidity data has been recorded in NTU. There is not a direct conversion from JTU to NTU, making it difficult to interpret turbidity data prior to 1978. Bank stability and roads analyses support a small increase in turbidity. Limited data suggests during high water events Wind River suspended sediment exceeds 100 mg/L, while Lower Trout, Panther, and Middle Wind are over 40 mg/L, and other basins are 5-40mg/L, with most less than 25mg/L. However, the duration of these turbidity levels is unknown. If levels of 100mg/L last for 24 hours the EDT rating is 1.0. If the 25 mg/L level lasts 24 hours, the EDT rating is 0.8. These provided the basis for current ratings. These generally support ratings of 0.3 for small tributaries, 0.7 for larger tributaries, and 1.0 for the lower mainstem. Since Lewis and Wind River subbasins were similar the Wind River ratings were applied to the Lewis River.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.24 Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: Temperature loggers have been extensively placed in the Wind River subbasin by USFS, USFWS, and USFWS. This data was entered into the EDT temperature calculator provided by Mobrand, Inc. to produce EDT ratings for August. To develop maximum temperature ratings for the remaining months, we used the template monthly pattern "TmpMonMax Rainfall", TmpMonMax Groundwater", and TmpMonMax Transitional" for the rainfall, groundwater and rain-on-snow-transitional watersheds, respectively.

The EDT ratings generated by the temperature calculator were used for reaches with a temperature logger present, and ratings for other reaches were inferred/extrapolated from these based on proximity and similar gradient, habitat, and confinement. If temperature loggers were mid-reach we used the reading for the entire reach. If temperature loggers were at the end of the reach and evidence from other temperature loggers above indicated there was cooling within the reach (as you move upstream), professional judgment was used to develop an average for the reach. The same logic was applied to reaches without temperature loggers located between reaches with temperature loggers – ratings from reaches with temperature loggers were "feathered" for reaches in between. Readings from loggers at the end of a reach were used to estimate the rating for the reaches downstream.

Historical temperatures are unknown the in the Lewis River subbasin. The Regional Ecosystem Assessment Project estimated the range of historical maximum daily stream temperatures for the Hood/Wind at 7-20 degrees C (USFS 1993). However, this broad range was not very informative for historical individual reach scale temperatures. The only historical temperature data that we located were temperatures recorded in the 1930's and 40's while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary process transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2002). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State watershed analysis manual (WFPB 1997). Elevation of stream reaches is estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters back from the maximum wetted width. Next we assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these trees are estimated to be between 40 – 50 meters for cedar and 60 - 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, we used 49 meters as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was approximately 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade, we used the relationship between forest angle and percentage of shade (WFPB 1997 Appendix G-33.). Finally we used the relationship between elevation, percentage of shade and the maximum daily stream temperature to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for maximum historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. We developed a correction factor for small tributaries, which consisted of adding 0.3 to the estimated historical EDT rating. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature and shade, while Pelletier (2002) used QUAL2K which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However, due to limited resources available for this study, the shade/elevation model was used for consistency throughout the Lower Columbia River.

Level of Proof: Derived information was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.7.3.25 Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: Wind River temperature data was used to develop a relationship between elevation and maximum temperature for elevations up to 2000 feet as follows: EDT min temp = 1.0248 Ln(elev) –5.8305 (R^2= 0.32, n=27). This was used to generate categorical ratings (Table 3) based on elevation. For the Wind, we used actual data, where available, to develop non-categorical ratings. It should be noted that reaches with lakes/wetlands (Falls and EF Trout) and immediate downstream reaches have colder minimum temperatures (higher EDT ratings) and those with strong groundwater influence (Upper Trout) have warmer minimum temperatures (lower EDT ratings). Since Lewis and Wind River subbasins were similar the Wind River ratings were applied to the Lewis River.

Table 3. Estimated categorical ratings for minimum temperature based on elevation from Wind River data.

Elevation	EDT Rating
< 600 ft	0
600-1200	1
1300-3000 ft	2

The historic minimum temperature was assumed to be the same as current minimum temperatures. There is some support that historical minimum temperatures were warmer due to more mature forest stands, but we did not use this information due to the limited support and the fact that fire disturbance regimes in these forests would have periodically led to these conditions naturally.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established in the Wind. Expansion of empirical ratings was used for the remainder of the Wind and other basins.

7.7.3.26 Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: Historically there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. These reaches were given an EDT rating of 1. Higher gradient reaches of the mainstem and tributaries higher in the watershed likely had less groundwater input. These reaches were given an EDT rating of 2. We could not find any data on the current or historical conditions for ground water input. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2. Higher gradient reaches in the upper watershed are likely similar to the historic condition and were given an EDT rating of 2.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.7.3.27 Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.

Rationale: Alkalinity was estimated from historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) for conductivity on the Wind, Lower Washougal, Middle Washougal, NF Lewis, EF Lewis, Cedar, Kalama, Elochoman, and Grays Rivers using the formula: Alkalinity =0.421*Conductivity – 2.31 from Ptolemy (1993). A relationship was developed between flow and alkalinity assuming a power function. We used the mean July to September flow to determine the mean alkalinity values. For basins without flow data, we used mean summer alkalinity values. Alkalinity values were 22, 15, 12, 16, 20, 27, 21, 27, and 30 mg/L, respectively. EF Lewis alkalinity was estimated to be 20 mg/L at Heisson Gage based on conductivity measurements using Ptolmey (1993). All EF Lewis reaches were rated the same. NF Lewis was estimated to be 16 mg/L from Merwin sampling and all NF reaches were rated the same. Cedar Cr was estimated to be 17 mg/L from Summers (2003). All NF Lewis tributaries were rated same as Cedar Cr. For other basins, the standard basin alkalinity value was used. Alkalinity in the historic condition was given the same value as the current condition.

Level of Proof: Derived information was used to estimate this attribute from conductivity measurements. Since alkalinity is did not vary much between adjacent basins and is believed to be relatively constant within a basin, estimated values were expanded for all reaches within a basin. Expert opinion was used to estimate the historical ratings for this attribute since historical data was lacking. The level of proof for the current condition is thoroughly established, generally accepted and good peer-reviewed empirical evidence in favor. For the historical data there is has a strong weight of evidence but not fully conclusive due to lack of data.

7.7.3.28 Dissolved oxygen

Definition: Average dissolved oxygen within the water column for the specified time interval.

Rationale: Dissolved oxygen in the template (historic) condition was assumed to be unimpaired. Historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) and Summers (2001) reported that in surveyed creeks dissolved oxygen levels were greater than 8 mg/l in August in Cedar Creek. All reaches in these watersheds were assumed to be unimpaired for dissolved oxygen. These are representative of free flowing reaches. The lower slough reaches in Hamilton, Hardy, EF Lewis, Kalama, and Coweeman are likely to have increased temperatures and lower DO levels in July/August.

Level of Proof: Empirical information and expert opinion were used to estimate the current and historical ratings for this attribute. Available current data support no problems with dissolved oxygen in flowing reaches. The level of proof for the current condition is thoroughly established, generally accepted and has good peer-reviewed empirical evidence in favor. In slough reaches, where no data was available, derived information and expert opinion was used. For the slough reaches and historical data there is has a strong weight of evidence but not fully conclusive due to lack of data. There is more uncertainty in the ratings for reaches with sloughs, than for riverine reaches.

7.7.3.29 Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to lack of data.

7.7.3.30 Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.7.3.31 Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.7.3.32 Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data for this attribute is very limited. Historically nutrient enrichment did not occur because watersheds were in the “pristine” state. To determine the amount of nutrient enrichment in various reaches the following factors were examined: fertilizing by timber companies, reaches downstream from hatcheries, agriculture effects, septic tanks, and storm water run-off.

Nutrient enrichment throughout these watersheds was assumed to be non-existent or at low levels. Fertilizing by timber companies may have some minimal effect but it is likely that changes in nutrient levels from normal forest activities is near zero (WFPB 1997)

Potential low levels of nutrients from Merwin and Lewis River Hatcheries enter in the top of Lewis 7 and Lewis 6, respectively. Potential nutrient sources exist from homes and cabins with septic tanks and from cattle. The lower EF Lewis River and Cedar Creek have exceeded state water quality standards for fecal coliform. The mainstem Lewis River from Merwin to the mouth was rated as 1 due to hatchery and homes with septic tanks. The middle and lower portions of Cedar Creek and the Lower EF Lewis River were rated at 1, since sampling suggested thet exceeded state water quality standards. Other sites was assumed to be negligible and rated at 0.

Level of Proof: Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.7.3.33 Fish community richness

Definition: Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale: Historical fish community richness was estimated from the current distribution of native fish in these watersheds (see below). Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness was estimated from direct observation (stream surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, and local knowledge. Anadromous fish distribution was estimated from the above as well as the SSHIAP fish distribution layer & EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in SW Washington watersheds: (1) smolt trapping activities on Lower Wind, Upper Wind, Panther Creek, and Trout Creek (pers. com. Cochran, WDFW), (2) electro-shocking in 2002 by USFS and USGS in Upper Wind, Panther, and Trout & tributaries (pers. com. Connoly USGS, and Bair USFS), (3) electroshocking by WDFW in many SW Washington tributaries (pers. com. Hallock, WDFW), (4) WDFW snorkel surveys on the Wind and Panther (pers. com. Cochran, WDFW), (5) species present in Hardy Slough (pers. com. Coley, USFWS), (6) Reimers and Bond (1967), and (7) McPheil (1967). Lamprey, while present in the basin, are not included in the species count (Larry Lestelle pers com).

A spreadsheet summarizing the above data sources was developed: (EDT 2003 Data.xls pers. com. Glaser WDFW). Sloughs likely have many species present from the Lower Columbia River. An estimated 29 species were included in this list: chinook, chum, coho, steelhead/rainbow, cutthroat, sculpin sp(3) (torrent, coastrange , reticulate), bridgelip and largescale sucker, peamouth, northern pikeminnow, smelt, sandroller, redside shiner, large & smallmouth bass, carp, goldfish, white & black crappie, eastern banded killifish, yellow perch, sunfish, pumpkinseed, brown & yellow bullhead, white sturgeon, 3-spine stickleback. Most of these fish likely drop out as gradient increases and water temperatures are reduced. The eastern banded killifish is an exception to this, it has been found in higher reaches of the Elochoman River (pers. com. Byrne, WDFW) and trapped on Abernathy Creek (pers. com. Hanratty, WDFW).

Anadromous salmonids had access to reaches above Merwin dam on the NF Lewis River. On EF lewis River chum dropped out at lower Rock Cr and all salmonids except steelhead dropped out at Lucia Falls. Only steelhead, cutthroat trout, whitefish, scuplins and lamprey accessed reaches above Lucia Falls.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.7.3.34 Fish species introductions

Definition: Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Introduced species were derived from current fish species richness data (see Fish Community Richness above).

The tidal reaches have potential for use by exotic fishes from the Columbia River, as many as 12 species from the Columbia River may migrate into these reaches. An estimated 12 species were included in this list: large & smallmouth bass, carp, goldfish, white & black crappie, Eastern banded killifish, yellow perch, pumpkinseed, sunfish, brown & yellow bullhead. Most of these fish likely drop out as gradient increases and water cools down. Species introductions are due to warmwater fishes in the lower reaches of EF and NF Lewis Rivers. Lowest reaches were rated 3 based on derived info from other basins. Ratings were reduced above Woodland on NF Lewis River and Mason Cr. on EF Lewis River based on professional opinion and summer snorkel observations.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.7.3.35 Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency (pers. com. Glaser, WDFW). Hatcheries operate on NF Lewis below Merwin Dam and a second hatchery is located a few miles below the dam. Due to these hatchery releases and Remote Site Incubators in the tributaries all Lewis River and tributary reaches were rated at 4. Direct steelhead releases at Lewisville and Daybreak Park in the EF lewis River were used as evidence to support and EDT rating of 4 for the lower EF Lewis River.. The EF Lewis River and tributaries below Horseshoe were rated at a two due to steelhead hatchery straying. The Cedar Creek basin received a rating of three due to ongoing hatchery coho supplementation, and stray hatchery steelhead passing the Grist Mill fish ladder.

Level of Proof: For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.7.3.36 Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition there were no hatcheries or hatchery outplants and we assumed an EDT rating of zero. Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency. The two operating hatcheries on the NF Lewis River support and EDT rating of 3 in the upper reaches. The lowest reaches were reduced to a two due an assumed dilution of pathogens. NF Lewis tributaries including Cedar Creek were rated at a two due to RSI and the presence of stray hatchery salmon and steelhead. The EF Lewis River below Horseshoe Falls supported a rating of a two from hatchery steelhead releases in the lower EF Lewis.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations, and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.7.3.37 Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions.

Topographic maps were examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT rating of 4 was given to reaches with extensive road/boat access and high recreational use (LewisvillePark on the EF Lewis River and on NF lewis River from Woodland to the dam); a rating of 3 was given to areas with road/boat access and proximity to population center and moderate use; 2 was given to reaches with multiple access points (EF Lewis and tidal portions of the NF Lewis River) through public lands or unrestricted access through private lands; 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands (undeveloped section of the EF lewis and tributaries with limited access); 0 was given to reaches with no roads and that are far from population centers .

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.7.3.38 Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. The magnitude and timing of yearling hatchery smolt releases, and increases in exotic/native piscivorous fishes were considered when developing this rating. The status of top-level carnivores and other fish eating species is unknown in these watersheds. Predation risks increase on NF Lewis below hatcheries and EF Lewis below Lewisville Park, which is the (hatchery steelhead release site). These reaches were rated as a three. Cedar Creek coho smolt releases have been discontinued.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.7.3.39 Salmon Carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Reaches with historic chum presence (spawning) were given a rating of 0. Mainstem reaches with chinook and coho, but no chum were given a rating of 2. Reaches with only coho were given a rating of 3. Reaches with only cutthroat or steelhead were given a rating of 4, since these fish do not die after spawning. Tidal reaches below areas of chum spawning were given a 1 (it was assumed carcasses from spawning reaches above are washed into these reaches). Historic spawning areas for chum, chinook, coho in NF and EF Lewis up to Merwin Dam and EF Lewis -7 were rated as 0. NF and EF Lewis River tributaries with chum were rated as 2. Remaining basin were rated as 3 except above Luica Falls was rated as 4, since passage was restricted to steelhead.

Due to reduced abundance of salmon, the salmon carcass attribute was reduced. Since current escapement estimates for salmon occur in only index areas current estimates of carcass were based on professional opinion of spawning distribution. Recent nutrient enhancement programs have contributed surplus hatchery carcasses to some stream reaches. The recent programs were not included in the salmon carcass attribute. However, under recovery scenarios, they should be included.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.7.3.40 Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: A few direct measures of benthos diversity for selected sites are available within the LCR from DOE and OSU. Reference sites in the Wind and Cowlitz Rivers yielded B-IBI ratings between 40 and 43 indicating EDT values of 0.3 to 0.9, which is equivalent to an EDT rating of 0.6. Slightly disturbed Rosgen B Channels in the Cowlitz and Grays had ratings of 0.1 to 1.4, but were very close to the averaged undisturbed rating of 0.6. Therefore, for current Rosgen B-channels we assumed the same rating as historic. For disturbed Rosgen C-channels in the Wind River the EDT benthos rating decreased to 1.5. Disturbed C-channels are likely to be more impacted by human activities due to their character than B-channels and the 1.5 EDT rating was used to describe current C-channels. Lower Cedar Creek has a rating B-IBI score of 2.6 or EDT score of 2.6. This reach is right below a disturbed C-Channel where the riparian encroachment has reduced shade, increased temperature, and nutrient levels (fecal coliform) have increased due to agriculture or septic tanks leaks.

B-IBI scores from the Wind River indicate little degradation for Rosgen B channels. Therefore, the 0.6 reference reach rating for current and historical reaches with confined channels. For C channels ratings were degraded to 1.6 based on Wind River data, which supported that B-IBI scores were reduced in less confined channels. Historical less confined channels in the lower basin were rated at 1, current rating was increased to 2 based on nutrients, water temps and DO. Lower Cedar Creek had B-IBI score of 2.6 Summers (2003). In Cedar Creek, reaches up to Chelatchie were feather to get to score of 1.0 for Cedar 6.

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7.8 Bonneville Tributaries

7.8.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treament Model (EDT) for the Lower Columbia River Gorge tributaries. In this project we rated 23 reaches with 45 environmental attributes per reach for current conditions and another 45 for historical conditions. Over 2,000 current ratings were assigned and empirical observations within these reaches were not available for all of these ratings. In fact less than 20% of these ratings are from empirical data. To develop the remaining data, we used expansion of empirical observations, derived information, expert opinion, and hypothetical information. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute, data was very limited or non-existent. WDFW established a relationship between road density and fine sediment in the Wind River. We applied this relationship to all subwatersheds; this is an example of derived information. In some cases, such as bed scour, we had no data. However, data is available from Gobar Creek (Kalama River tributary) and observations have been made in the Wind River as to which flows produce bed load movement. We noted that bed scour is related to gradient, stream width, and confinement. Based on these observations expert opinion was used to develop a look-up table to estimate bed scour. For rationale behind the EDT ratings assigned, see the text below. For specific reach scale information, please see the EDT database for the watershed of interest. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.8.2 Recommendations

1) Adult chum salmon population estimates should continue. However, more emphasis should be placed on determining the number of hatchery from the Duncan Creek re-introduction program and the reproductive success of hatchery spawners. Juvenile outmigrant counts are made at Duncan Creek and mark-recapture estimates in Hardy Creek and Hamilton Springs. Accurate and precise adult and juvenile population estimates will allow for better population status estimates, validation of EDT, and to determine if subbasin restoration actions are effective. These programs should be maintained and improved as needed.
2) Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating as would field surveys.
3) Empirical sediment data was only available for a few reaches and derived estimates were used for most of the basin. A sediment monitoring program should be developed to assess the percentage of fines in spawning gravels, embeddedness, and turbidity in reaches used by anadromous fish.
4) Differences existed between field and GIS ratings of natural confinement. The SSHIAP database should be field verified.
5) Bed Scour estimates were not available for this basin and bed scour data should be collected and related to peak flows.

6) USWFS habitat surveys do not directly measure all habitat types needed for EDT. WDFW habitat surveys in 2002 were opportunistic; that is, based on a limited amount of resources, we chose to survey a few representative reaches. To accurately estimate stream habitat type within the anadromous distribution, a statistically valid sampling design should be developed and applied (Hankin and Reeves1988 or EMAP). Survey methodology should differentiate between pools and glides and be repeatable.
7) Macro invertebrate sampling was not available. A combination of DOE and OSU estimates of the Benthic Index of Biological Integrity (B-IBI) from the Wind River were used to develop EDT ratings in theWashougal Basin.
8) Obstructions were not rated and passage was assumed to be 100%. These ratings should be updated using the SSHIAP database.

7.8.3 Attributes

7.8.3.1 Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: This maximum elevation in these watershed is approximately 3,000 ft. The upper elevations are consistent with a rain-on-snow hydrologic regime and the lower elevations are consistent with a rainfall-dominated watershed. These subbasins were rated as rainfall dominated for the historic and current conditions because anadromous fish only access the lowest reaches. Groundwater influences are present in the Duncan Springs and Hamilton Springs spawning channels. These runoff patterns were used to shape estimates of flow and temperature in the EDT model.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.8.3.2 Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale: This watersheds, which did not have artificial flow regulation was given an EDT rating of 0 for the historical and current conditions. Hydro operations influence the Duncan Creek Outlet, Hardy 1, Hamilton 1, and Hamilton Slough . However, these are similar to natural variation due to Columbia River runoff patterns so left ratings at zero. Should fill out Hamilton Slough rating is influenced by BON operations.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.8.3.3 Flow - change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Direct measures of inter-annual high flow variation are not available for this subbasin. Wind and White Salmon analysis of Q2yr suggests 12% and 10% increase in high flow (EDT rating of 2.2 to 2.3). USFS has conducted watershed analysis in the Gifford Pinchot streams (USFS 1996). Peak flow analysis was conducted using the State of Washington "Standard methodology for conducting watershed analysis". The primary data used for the peak flow analysis is vegetation condition, elevation, road network, and aspect. The results for increased risk in peak flow from the USFS watershed analysis are shown in Table 1. Road densities from URS (2003) indicate Greenleaf, Upper Hamilton, Duncan, and Hardy/Woodward had densities of 4.2, 2.0, 3.4, and 3.8, respectively. However, Hardy Cr lies almost all with in State Park so road density are close to 1. USFS estimates support a slight peak flow increases for subbasins in Southwest Washington (Table 1). Peak flows were increased from 0% to 10% in subbasin reaches based on road densities.

Table 1. Summary of USFS Watershed Analysis for the change in peak flow

Basin	**# of Subbasins**	**Increase in Peak Flow**
Wind	26	2 – 14%
East Fork Lewis	9	5 –13%
Lower Lewis		10 -12%
Rock Cr		1 -5%
Upper Kalama		5 - >10%
Cispus		<10%

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.8.3.4 Flow - changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Research on the effects of land use practices on summer low flow is inconclusive (Spencer et al. 1996). Therefore, we rated the template and current conditions the same (EDT rating of 2). Low flows may be slightly lower in Duncan Sp, Hardy 2&3, and Hamilton 1&2&springs due to aggradation. However, this is speculative and historic and current ratings remained unchanged.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.8.3.5 Flow – intra daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. This attribute was given an EDT rating of 0 for the current conditions due to the lack of storm water runoff for most of the basin. This attribute is influenced by the % impervious surfaces. Most reaches are influenced by forestry and impervious surfaces are low. We had no information on impervious surfaces but if information becomes available this attribute should be adjusted.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the remaining current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.8.3.6 Flow –Intra annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in these watersheds. USFS (1996) indicated peak flow may have increased by 13% in some subwatersheds. Since there was no data for this attribute, it was suggested that its rating should be the same as the changes in inter-annual variability in high flows (pers. com. Larry Lestelle, Mobrand, Inc).

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.7 Channel length

Definition: Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: Ned Pittman (WDFW) provided the length of each reach from SSHIAP GIS layers. We assumed the stream length was the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.8.3.8 Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: We assigned the same value for both the current and historical conditions, unless a major hydromodification or water withdrawal was located within the reach. Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). Wetted widths corresponding to average summer low flows (August) were measured as part of these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement.

Level of Proof: A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof ranged from thoroughly established in reaches with direct observations to a strong weight of evidence in support but not fully conclusive in reaches were expanded information was used. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.9 Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Wetted widths corresponding to average winter high flows (January) were measured as part of these surveys. (VanderPloeg 2003). Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Typically less reaches per subbasin were measured during average winter flow as compared to summer flow. We compared the percent increase between low and high flow widths to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data. A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris and hydroconfinement. Therefore, we used actual “wetted width-high” values in reaches where data was available, and a 1.6 multiplier (60%) to expand “wetted width-low” values for reaches without high flow data. In canyon areas, summer flows were expanded by 20-40% depending of reach characteristics.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.10 Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as percentage gradient) was calculated by dividing the change in reach elevation by the reach length. Ned Pittman (WDFW) used SSHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical gradient.

7.8.3.11 Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed for confinement ratings (VanderPloeg 2003). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps were consulted when SSHIAP ratings fell between the 0.5 increments to determine which rating should be applied. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4. There are often multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings (Table 2).

Table 2. Comparison of SSHIAP and EDT ratings for confinement.

Project	Unconfined	Equal unconfined and mod. confined	Moderately confined	Equal mod confined and confined	Confined
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.8.3.12 Confinement – hydro-modifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cut off due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Most hydro-modification consists of roads in the floodplain and diking. We consulted the SSHIAP GIS roads layer, SSHIAP digital ortho-photos, USGS maps, and Limiting Factors Analysis (LFA) to estimate EDT ratings. Ratings were categorical due to the lack of field surveys to corroborate GIS, map, and photo estimates. Hydroconfinement areas include the lower portion of Hardy Creek, the riprap in North Bonneville along Hamilton Creek.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.8.3.13 Habitat Type

Definition: *Backwater pools* is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter). Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Habitat type composition was measured during these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement. Lower reaches inundated by the construction of Bonneville Dam were rated as glides and pools depending on the amount of inundation.

WDFW habitat surveys followed USFS stream survey level 2 protocols, which delineate between riffles and slow water but not pools and glides. Glide habitat is the most difficult habitat to identify, therefore it was estimated but not surveyed by WDFW.

Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are believed to be the primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991 - Forest Ecosystem Management July 1992, page V-23), and applying this to current habitat type composition estimates. On Germany Creek, the Elochoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, we assumed for historical conditions that the percentage of pools was significantly higher than the current percentage. For gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5%, we estimated pool habitat to be 40% and 30%, respectively (WFPB 1994). We assumed that tailouts represent 15-20% of pool habitat, which is the current range from WDFW surveys. Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5% to 6% for gradients greater then 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat increased with gradient. WDFW field data indicated the percentage of gravel riffle habitat decreased with stream gradient, and cobble/boulder riffle habitat increased with stream gradient; the percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1% to 15% at gradients greater than 6%. WDFW surveys indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information we assumed pool habitats were in the "good" range and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.14 Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A , B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis. These low gradient C channels were assigned up to a 15% off-channel habitat factor, historically and 0% currently. Off-channel habitat is not significant except in the lower reaches. These reaches were assigned an EDT rating of up to 15% historic off-channel habitat factor due to the backwater of the Columbia River and assumed beaver populations. Old photographs suggested that substantial off-channel habitat was historically present.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.15 Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: WDFW SSHIAP database was used to identify existing barriers within these watersheds. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. In most cases known fish distribution stopped at all barriers. In some cases, where known distribution occurred above barriers, passage was assumed to be 100% for the species and all life stages. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon due to their preference for spawning in small tributaries are impacted by barriers. The ratings should be completed after a barrier analysis.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.16 Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach.

Rationale: No water withdrawals occurred in the pristine condition. Most watersheds in this unit are forested with residential use in the lower portion of the subbasin. Water withdrawals occur in Jones & Boulder Creek for city water, and at WDFW Hatcheries. These reaches were rated at a 2. Some irrigation withdrawals occur for personal use were noted during summer in the mainstem below the WF Washougal and in the Little Washougal. These small withdrawals were rated at a one. The mill in Camas withdraws water but its mouth was outside the Washougal River.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.8.3.17 Bed scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for these basins. Historic bed scour was rated using the look-up table (pers. com. Dan Rawding, WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table is based on professional judgment and relates bed scour to confinement, wetted width (high flow), and gradient. It assumes bed scour increases as gradient, wetted width, and confinement increase. For low gradient slough like reaches, we reduced the bed scour rating to ~1, since these reaches are unconfined and influenced by the Columbia River.

Current EDT ratings were developed and used as the baseline for scour in the current condition. Template ratings for bed scour were increased as peak flow and hydro-confinement increased. For example, if in the template condition a reach had a peak flow of 2.0 and in the current condition peak flow increased to 2.3, while hydro-confinement ratings increased from 0 to 1, we assumed a 0.05 increase in bed scour for every 0.1 increase in peak flow and a 0.1 increase for every 1.0 increase in hydro-confinement. In this example the bed scour increased by 0.25.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.18 Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale: In watersheds that are rainfall dominated anchor ice and icing events do not occur. For elevations less than 1000 ft., EDT ratings of 0 were assigned to all reaches in the historical and current condition. For those from 1,000 to 2000 ft. EDT ratings of 1 were assigned. This was based on personal winter observation in the Wind River and discussions with CNFH staff. Since the Gorge tributaries are adjacent to the Wind River, the same icing ratings were used in the Gorge tributaries.

Level of Proof: Empirical observations were used to establish an elevation /icing relationship and this derived information was used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.8.3.19 Riparian

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition the template conditions for this attribute are rated as a value of zero because this describes this attribute rating for watersheds in pristine conditions. Riparian zones with mature conifers are rated at 0.0 -1.0 depending on the density of large trees and bank stability. Riparian zones with saplings and deciduous trees are rated as 1.5 due to lack of shade and bank stability. Riparian zones with brush and few trees would be rated as 2. For an EDT rating to exceed 2, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees it should have a score of 2 or better. Most current vegetated riparian zones with no hydro-confinement should be rated as a 1 to 1.5. When hydro-confinement exists rating from rules on hydro-confinement were used to increase the riparian rating. Ratings also increased based on lack of vegetation. Key reaches were established for current riparian function through out these watersheds. Other reaches were referenced to these key reaches to develop a final EDT rating.

Riparian in upper most reaches (above HWY 14) in Hamilton and Hardy is in mature forest with much in state park and is in excellent condition. The lower end of Hamilton and Duncan Creeks, which pass through North Bonneville and Skamania Landing, respectively, are degraded and rated as a 2.

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.20 Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Rationale: Wood density was estimated during USFS and WDFW habitat surveys where density of wood equals pieces * length/width. Template condition for wood is assumed to be 0 for all reaches except large Canyon sections on the Grays, Coweeman, Kalama, EF Lewis, Washougal, and Wind, which are assumed to be 2. Due to their confinement, it was believed during high flows these reaches did not retain wood as well as other sections. When survey data was not available, wood densities were extrapolated from reaches with data. EDT Rating based on TFW standard of all wood. Currently, there is limited data for wood on the Washougal River. Surveys of mainstem reaches in other system suggest values of 3 and 4 for most larger mainstem areas. Values of 2 to 3 for tributaries. Base on consultation with biologists from WDFW, PSMFC, and WDFW, these ratings were then applied to the Gorge tributaries. These rating suggest a significant loss of wood.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical

information, expanded empirical observations were used to estimate the ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.8.3.21 Fine Sediment (intragravel)

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et. al. 1992). The average percentage of fines (8.5%) was used, which corresponds to an EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3.

To rate percentage of fines in the current condition, a scale was developed relating road density to fines. Rittmueller (1986) found that as road density increased by 1 mi/mi^2, fine sediment levels increased by 2.65%. However, Duncan and Ward (1985) found a lower increase in the percentage of fines in southwest Washington, but attributed much of the variation in fines to different geology. USFS used a McNiel core to collect gravel samples from 1998 to 2000 in 8 subwatersheds in the Wind River subbasin. Fines were defined as less than 0.85mm. A regression was run comparing the percentage for each year to road densities. The increase was 1.04% per 1 mi/mi^2 of roads for all watershed (R^2 = 0.31, n=17). The increase was 1.52% per 1 mi/mi^2 for all watersheds (R^2= 0.73, n= 14) when Layout Creek, which was recently restored was excluded. Rather than use all three years of Layout Creek data , only the median was used and the final relationship used for EDT was 1.34% increase in fines per1 mi/mi^2 (R^2=0.56, n=15) (Figure 1). Road densities were obtained from URS (2003) report to the LCFRB and these were incorporated into the Wind River relationship to estimate fines. Tidal reaches with lower gradients were rated one point higher.

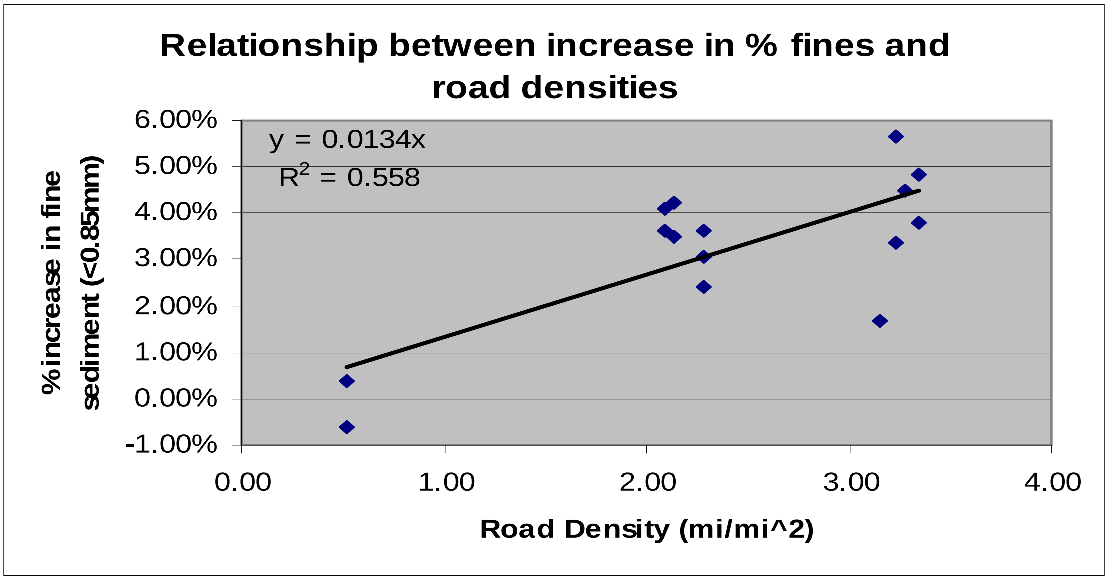

Figure 1. Relationship between road densities and the percentage increase in fines (<0.85mm) from USFS data.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.8.3.22 Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have a low level of embeddedness. Based on the historic level of fines in spawning gravels (8.5%), we assumed this level was the same for embeddedness, which corresponds to and EDT rating of 0.5. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2. Reaches above tidal with low gradient and slower flows likely also had increased fine sediment and embeddeness and were given an EDT rating of 1.

We assumed that the percent embeddedness was directly related to percentage of fines in spawning gravel. We used the Wind River data mentioned above to develop a scale relating road density to percent embeddedness and applied this to the Gorge tributaries. Tidal reaches with lower gradients were rated one point higher.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.23 Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. No historical information is available for this attribute. Fire was historically a natural disturbance process, that occasionally increases turbidity after an extensive hot burn. Current increases in turbidity are likely associated with human activities that lead to bank instability in the riparian area and roads associated with logging, urbanization, and agriculture. Background turbidity levels were assumed to increase with stream size. Professional opinion set these levels to be an EDT rating of 0 in small tributaries, 0.3 in medium tributaries, and 0.5 in the mainstem.

Suspended sediment and turbidity data is limited to grab samples by USFS and UCD for the Wind River. Flow data and limited turbidity data are available for the Elochoman River from the USGS website (http://wa.water.usgs.gov/realtime/historical.html). Historical turbidity data was plotted versus flow data from the same time period. Prior to 1978, USGS turbidity data was recorded in JTU. Since 1978, turbidity data has been recorded in NTU. There is not a direct conversion from JTU to NTU, making it difficult to interpret turbidity data prior to 1978. Bank stability and roads analyses support a small increase in turbidity. Limited data suggests during high water events Wind River suspended sediment exceeds 100 mg/L, while Lower Trout, Panther, and Middle Wind are over 40 mg/L, and other basins are 5-40mg/L, with most less than 25mg/L. However, the duration of these turbidity levels is unknown. If levels of 100mg/L last for 24 hours the EDT rating is 1.0. If the 25 mg/L level lasts 24 hours, the EDT rating is 0.8. These provided the basis for current ratings. These generally support ratings of 0.3 for small tributaries, 0.7 for larger tributaries, and 1.0 for the lower mainstem. Since Gorge tributaries and Wind River subbasins were similar, the Wind River ratings were applied to the Gorge tributaries.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.8.3.24 Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: Temperature loggers have been extensively placed in the Gorge subbasin by USFWS and WDFW. This data was entered into the EDT temperature calculator provided by Mobrand, Inc. to produce EDT ratings for August. To develop maximum temperature ratings for the remaining months, we used the template monthly pattern "TmpMonMax Rainfall", TmpMonMax Groundwater", and TmpMonMax Transitional" for the rainfall, groundwater and rain-on-snow-transitional watersheds, respectively.

The EDT ratings generated by the temperature calculator were used for reaches with a temperature logger present, and ratings for other reaches were inferred/extrapolated from these based on proximity and similar gradient, habitat, and confinement. If temperature loggers were mid-reach we used the reading for the entire reach. If temperature loggers were at the end of the reach and evidence from other temperature loggers above indicated there was cooling within the reach (as you move upstream), professional judgment was used to develop an average for the reach. The same logic was applied to reaches without temperature loggers located between reaches with temperature loggers – ratings from reaches with temperature loggers were "feathered" for reaches in between. Readings from loggers at the end of a reach were used to estimate the rating for the reaches downstream.

Historical temperatures are unknown the in this subbasin. The Regional Ecosystem Assessment Project estimated the range of historical maximum daily stream temperatures for the Hood/Wind at 7-20 degrees C (USFS 1993). However, this broad range was not very informative for historical individual reach scale temperatures. The only historical temperature data that we located were temperatures recorded in the 1930's and 40's while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary process transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2002). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State watershed analysis manual (WFPB 1997). Elevation of stream reaches is estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters back from the maximum wetted width. Next we assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these trees are estimated to be between 40 – 50 meters for cedar and 60 - 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, we used 49 meters as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was approximately 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade, we used the relationship between forest angle and percentage of shade (WFPB 1997 Appendix G-33.). Finally we used the relationship between elevation, percentage of shade and the maximum daily stream temperature to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for maximum historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. We developed a correction factor for small tributaries, which consisted of adding 0.3 to the estimated historical EDT rating. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature and shade, while Pelletier (2002) used QUAL2K which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However, due to limited resources available for this study, the shade/elevation model was used for consistency throughout the Lower Columbia River.

Level of Proof: Derived information was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.8.3.25 Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: Wind River temperature data was used to develop a relationship between elevation and maximum temperature for elevations up to 2000 feet as follows: EDT min temp = 1.0248

Ln(elev) –5.8305 (R^2= 0.32, n=27). This was used to generate categorical ratings (Table 3) based on elevation. For the Wind, we used actual data, where available, to develop non-categorical ratings. It should be noted that reaches with lakes/wetlands (Falls and EF Trout) and immediate downstream reaches have colder minimum temperatures (higher EDT ratings) and those with strong groundwater influence (Upper Trout) have warmer minimum temperatures (lower EDT ratings). Since Gorge tributaries and Wind River subbasins were similar, the Wind River ratings were applied to the Gorge tributaries.

Table 3. Estimated categorical ratings for minimum temperature based on elevation from Wind River data.

Elevation	EDT Rating
< 600 ft	0
600-1200	1
1300-3000 ft	2

The historic minimum temperature was assumed to be the same as current minimum temperatures. There is some support that historical minimum temperatures were warmer due to more mature forest stands, but we did not use this information due to the limited support and the fact that fire disturbance regimes in these forests would have periodically led to these conditions naturally.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established in the Wind. Expansion of empirical ratings was used for the remainder of the Wind and other basins.

7.8.3.26 Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: Historically there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. These reaches were given an EDT rating of 1. Higher gradient reaches of the mainstem and tributaries higher in the watershed likely had less groundwater input. These reaches were given an EDT rating of 2. We could not find any data on the current or historical conditions for ground water input. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2. Higher gradient reaches in the upper watershed are likely similar to the historic condition and were given an EDT rating of 2.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.8.3.27 Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.

Rationale: Alkalinity was estimated from historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) for conductivity on the Wind, Lower Washougal, Middle Washougal, NF Lewis, EF Lewis, Cedar, Kalama, Elochoman, and Grays Rivers using the formula: Alkalinity =0.421*Conductivity – 2.31 from Ptolemy (1993). A relationship was developed between flow and alkalinity assuming a power function. We used the mean July to September flow to determine the mean alkalinity values. For basins without flow data, we used mean summer alkalinity values. Alkalinity values were 22, 15, 12, 16, 20, 27, 21, 27, and 30 mg/L, respectively. The Wind River alkalinity data was used because no alkalinity readings were available for this subbasin . Alkalinity in the historic condition was given the same value as the current condition.

Level of Proof: Derived information was used to estimate this attribute from conductivity measurements. Since alkalinity is did not vary much between adjacent basins and is believed to be relatively constant within a basin, estimated values were expanded for all reaches within a basin. Expert opinion was used to estimate the historical ratings for this attribute since historical data was lacking. The level of proof for the current condition is thoroughly established, generally accepted and good peer-reviewed empirical evidence in favor. For the historical data there is has a strong weight of evidence but not fully conclusive due to lack of data.

7.8.3.28 Dissolved oxygen

Definition: Average dissolved oxygen within the water column for the specified time interval.

Rationale: Dissolved oxygen in the template (historic) condition was assumed to be unimpaired. No data was available for this subbasin. Historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) and WDFW hatchery data found that in surveyed creeks dissolved oxygen levels were greater than 8 mg/l in August . All reaches in these watersheds were assumed to be unimpaired for dissolved oxygen.

Level of Proof: Empirical information and expert opinion were used to estimate the current and historical ratings for this attribute. Available current data support no problems with dissolved oxygen in flowing reaches. The level of proof for the current condition is thoroughly established, generally accepted and has good peer-reviewed empirical evidence in favor. In slough reaches, where no data was available, derived information and expert opinion was used. For the slough reaches and historical data there is has a strong weight of evidence but not fully conclusive due to lack of data. There is more uncertainty in the ratings for reaches with sloughs, than for riverine reaches.

7.8.3.29 Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to lack of data.

7.8.3.30 Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.8.3.31 Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.8.3.32 Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data for this attribute is very limited. Historically nutrient enrichment did not occur because watersheds were in the "pristine" state. To determine the amount of nutrient enrichment in various reaches the following factors were examined: fertilizing by timber companies, reaches downstream from hatcheries, agriculture effects, septic tanks, and storm water run-off. The potential for an increase in nutrients from septic tanks is possible around Duncan Lake and outlet. Therefore these reaches were rated as 1. Assumed all other reaches are similar to historic levels.

Level of Proof: Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.8.3.33 Fish community richness

Definition: Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale: Historical fish community richness was estimated from the current distribution of native fish in these watersheds (see below). Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness was estimated from direct observation (stream surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, and local knowledge. Anadromous fish distribution was estimated from the above as well as the SSHIAP fish distribution layer & EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in SW Washington watersheds: (1) smolt trapping activities on Lower Wind, Upper Wind, Panther Creek, and Trout Creek (pers. com. Cochran, WDFW), (2) electro-shocking in 2002 by USFS and USGS in Upper Wind, Panther, and Trout & tributaries (pers. com. Connoly USGS, and Bair USFS), (3) electroshocking by WDFW in many SW Washington tributaries (pers. com. Hallock, WDFW), (4) WDFW snorkel surveys on the Wind and Panther (pers. com. Cochran, WDFW), (5) species present in Hardy Slough (pers. com. Coley, USFWS), (6) Reimers and Bond (1967), and (7) McPheil (1967). Lamprey, while present in the basin, are not included in the species count (Larry Lestelle pers com).

A spreadsheet summarizing the above data sources was developed: (EDT 2003 Data.xls pers. com. Glaser WDFW). Sloughs likely have many species present from the Lower Columbia River. An estimated 29 species were included in this list: chinook, chum, coho, steelhead/rainbow, cutthroat, sculpin sp(3) (torrent, coastrange , reticulate), bridgelip and largescale sucker, peamouth, northern pikeminnow, smelt, sandroller, redside shiner, large & smallmouth bass, carp, goldfish, white & black crappie, eastern banded killifish, yellow perch, sunfish, pumpkinseed, brown & yellow bullhead, white sturgeon, 3-spine stickleback. Most of these fish likely drop out as gradient increases and water temperatures are reduced. The eastern banded killifish is an exception to this, it has been found in higher reaches of the Elochoman River (pers. com. Byrne, WDFW) and trapped on Abernathy Creek (pers. com. Hanratty, WDFW).

Fish community richness has increased due to species introduction. These are warmwater and coolwater fishes from the Columbia River. The have access up to Duncan Lake, Hamilton 1, and Hardy1.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.8.3.34 Fish species introductions

Definition: Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Introduced species were derived from current fish species richness data (see Fish Community Richness above).

The tidal reaches have potential for use by exotic fishes from the Columbia River, as many as 12 species from the Columbia River may migrate into these reaches. An estimated 12 species were included in this list: large & smallmouth bass, carp, goldfish, white & black crappie, Eastern banded killifish, yellow perch, pumpkinseed, sunfish, brown & yellow bullhead. Most of these fish likely drop out as gradient increases and water cools down. Species introductions are due to warmwater fishes in the lower reaches of Gorge tributaries. Lowest reaches were rated 3 based on derived info from other basins. Ratings were reduced above this site based on professional opinion, USFS, and USGS electroshocking data.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.8.3.35 Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency (pers. com. Glaser, WDFW). The current stocking program for chum salmon was initiated in Duncan Creek in 2001. Steelhead plants were discontinued in 1998 in Hamilton Creek. Both these programs were rated as 3.

Level of Proof: For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.8.3.36 Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition there were no hatcheries or hatchery outplants and we assumed an EDT rating of zero. Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency. Based on stocking of steelhead in Hamilton Creek and Chum Salmon in Duncan Springs, these reaches and downstream reaches were rated as a 2. All other reaches were as rated as a zero.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations, and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.8.3.37 Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions.

Topographic maps were examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT rating of 4 was given to reaches with extensive road/boat access and high recreational use (residences adjacent to Duncan Lake and lower Hamilton Creek); a rating of 3 was given to areas with road/boat access and proximity to population center and moderate use; 2 was given to reaches with multiple access points (most other reaches near highway 14) through public lands or unrestricted access through private lands; 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands (Hardy Creek); 0 was given to reaches with no roads and that are far from population centers (headwater roadless areas).

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.8.3.38 Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Predation has increased in reaches connected to Columbia, Duncan Lake, and Greenleaf Slough due to warmwater and coolwater species introductions. Predation risks increased due to introduced fish moving up from the Columbia River.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.8.3.39 Salmon Carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Reaches with historic chum presence (spawning) were given a rating of 0. Mainstem reaches with chinook and coho, but no chum were given a rating of 2. Reaches with only coho were given a rating of 3. Reaches with only cutthroat or steelhead were given a rating of 4, since these fish do not die after spawning. Tidal reaches below areas of chum spawning were given a 1 (it was assumed carcasses from spawning reaches above are washed into these reaches). Chum salmon are the most abundant anadromous salmonid and access reaches up to Highway 14. Current estimates of carcasses were derived from estimates of chum salmon escapement.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive

7.8.3.40 Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: A few direct measures of benthos diversity for selected sites are available within the LCR from DOE and OSU. Reference sites in the Wind and Cowlitz Rivers yielded B-IBI ratings between 40 and 43 indicating EDT values of 0.3 to 0.9, which is equivalent to an EDT rating of 0.6. Slightly disturbed Rosgen B Channels in the Cowlitz and Grays had ratings of 0.1 to 1.4, but were very close to the averaged undisturbed rating of 0.6. Therefore, for current Rosgen B-channels we assumed the same rating as historic. For disturbed Rosgen C-channels in the Wind River the EDT benthos rating decreased to 1.5. Disturbed C-channels are likely to be more impacted by human activities due to their character than B-channels and the 1.5 EDT rating was used to describe current C-channels. Lower Cedar Creek has a rating B-IBI score of 2.6 or EDT score of 2.6. This reach is right below a disturbed C-Channel where the riparian encroachment has reduced shade, increased temperature, and nutrient levels (fecal coliform) have increased due to agriculture or septic tanks leaks.

B-IBI scores from the Wind River indicate little degradation for Rosgen B channels. Therefore, the 0.6 reference reach rating for current and historical reaches with confined channels. For C channels ratings were degraded to 1.6 based on Wind River data, which supported that B-IBI scores were reduced in less confined channels. Historical less confined channels in the lower basin were rated at 1, current rating was increased to 2 based on nutrients, water temps and DO.

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7.9 Washougal

7.9.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treament Model (EDT) for the Washougal River. In this project we rated 64 reaches with 45 environmental attributes per reach for current conditions and another 45 for historical conditions. Over 2,700 current ratings were assigned and empirical observations within these reaches were not available for all of these ratings. In fact less than 20% of these ratings are from empirical data. To develop the remaining data, we used expansion of empirical observations, derived information, expert opinion, and hypothetical information. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute, data was very limited or non-existent. WDFW established a relationship between road density and fine sediment in the Wind River. We applied this relationship to all subwatersheds; this is an example of derived information. In some cases, such as bed scour, we had no data. However, data is available from Gobar Creek (Kalama River tributary) and observations have been made in the Wind River as to which flows produce bed load movement. We noted that bed scour is related to gradient, stream width, and confinement. Based on these observations expert opinion was used to develop a look-up table to estimate bed scour. For rationale behind the EDT ratings assigned, see the text below. For specific reach scale information, please see the EDT database for the watershed of interest. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.9.2 Recommendations

1) Adult chum salmon, chinook salmon, and steelhead population estimates should continue. However, more emphasis should be placed on determining the number of hatchery and wild spawners and the reproductive success of hatchery spawners. Summer steelhead estimates are based on mark-recapture and are considered accurate and precise. Winter steelhead, fall chinook estimates and chum salmon estimates are based on an assumed observer efficiency and are likely to be less reliable. Coho salmon counts are periodic and not population estimates. Summer steelhead escapement estimates should be continued and funding secured to develop accurate and precise adult estimates. Juvenile outmigrant estimates are not made and should be funded. Accurate and precise adult and juvenile population estimates will allow for better population status estimates, validation of EDT, and to determine if subbasin restoration actions are effective. These programs should be maintained and improved as needed.
2) Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating as would field surveys.
3) Empirical sediment data was only available for a few reaches and derived estimates were used for most of the basin. A sediment monitoring program should be developed to assess the percentage of fines in spawning gravels, embeddedness, and turbidity in reaches used by anadromous fish.

4) Differences existed between field and GIS ratings of natural confinement. The SSHIAP database should be field verified.
5) USGS Gauge stations are no longer operating in this subbasin. Gauges should be re-installed. Bed Scour estimates were not available for this basin and bed scour data should be collected and related to peak flows.
6) USFS habitat surveys do not directly measure all habitat types needed for EDT. WDFW habitat surveys in 2002 were opportunistic; that is, based on a limited amount of resources, we chose to survey a few representative reaches. To accurately estimate stream habitat type within the anadromous distribution, a statistically valid sampling design should be developed and applied (Hankin and Reeves1988 or EMAP). Survey methodology should differentiate between pools and glides and be repeatable.
7) Macro invertebrate sampling was not available. A combination of DOE and OSU estimates of the Benthic Index of Biological Integrity (B-IBI) from the Wind River were used to develop EDT ratings in theWashougal Basin.
8) Obstructions were not rated and passage was assumed to be 100%. These ratings should be updated using the SSHIAP database.

7.9.3 Attributes

7.9.3.1 Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: This maximum elevation in this watershed is approximately 3,000 ft. The upper elevations are consistent with a rain-on-snow hydrologic regime and the lower elevations are consistent with a rainfall-dominated watershed. This subbasin was rated as rainfall dominated for the historic and current conditions except for upper portions on the mainstem above Duggan Falls and WF we assumed a rain-on-snow pattern. These runoff patterns were used to shape estimates of flow and temperature in the EDT model.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.9.3.2 Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale: This watersheds, which did not have artificial flow regulation was given an EDT rating of 0 for the historical and current conditions.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.9.3.3 Flow - change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Direct measures of inter-annual high flow variation are not available for most subwatersheds in the Washougal River. The Q2yr flow calculation on the Washougal increased 17% from 1945 to 1981 and EDT rating of 2.4. The Washougal above Prospector Creek is a roadless area and was rated at 2.0. Some roads along the Washougal below Prospector Creek, and in Timber and Stebbins Creeks increase the rating to a 2.1. In the mainstem from Dugan Cr to WF Washougal, the rating was increased to 2.2. The West Fork was assumed to be 2.3. Mainstem from WF Washougal to Mouth, which covers the USGS gauge location, was rated 2.4. All other tributaries were assumed to be 2.2 except the Little Washougal River and Lacamas Creek, which were assumed to be 2.4 and 2.5, respectively.

USFS has conducted watershed analysis in the EF Lewis (USFS 1996). Peak flow analysis was conducted using the State of Washington "Standard methodology for conducting watershed analysis". The primary data used for the peak flow analysis is vegetation condition, elevation, road network, and aspect. The results for increased risk in peak flow from the USFS watershed analysis are shown in Table 1. USFS estimates support peak flow increases for subbasins in Southwest Washington (Table 1).

Table 1. Summary of USFS Watershed Analysis for the change in peak flow

Basin	**# of Subbasins**	**Increase in Peak Flow**
Wind	26	2 – 14%
East Fork Lewis	9	5 –13%
Lower Lewis		10 -12%
Rock Cr		1 -5%
Upper Kalama		5 - >10%
Cispus		<10%

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.9.3.4 Flow - changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Research on the effects of land use practices on summer low flow is inconclusive (Spencer et al. 1996). Therefore, we rated the template and current conditions the same (EDT rating of 2). Water withdrawals in Jones and Boulder Creeks to supply water for Camas and these reaches received a rating of 4. Occasional water withdrawals for residential use was not factored into the EDT rating.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.9.3.5 Flow – intra daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. This attribute was given an EDT rating of 0 for the current conditions due to the lack of storm water runoff for most of the basin. This attribute is influenced by the % impervious surfaces. Most reaches are influenced by forestry and impervious surfaces are low. The exception for this is occurs in the lower river. We had no information on impervious surfaces but if information becomes available this attribute should be adjusted.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the remaining current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.9.3.6 Flow –Intra annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in these watersheds. USFS (1996) indicated peak flow may have increased by 13% in some subwatersheds. Since there was no data for this attribute, it was suggested that its rating should be the same as the changes in inter-annual variability in high flows (pers. com. Larry Lestelle, Mobrand, Inc).

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.7 Channel length

Definition: Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: Ned Pittman (WDFW) provided the length of each reach from SSHIAP GIS layers. We assumed the stream length was the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.9.3.8 Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: We assigned the same value for both the current and historical conditions, unless a major hydromodification or water withdrawal was located within the reach. Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2002 (VanderPloeg 2003). Wetted widths corresponding to average summer low flows (August) were measured as part of these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement.

Level of Proof: A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof ranged from thoroughly established in reaches with direct observations to a strong weight of evidence in support but not fully conclusive in reaches were expanded information was used. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.9 Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Wetted widths corresponding to average winter high flows (January) were measured as part of these surveys. (VanderPloeg 2003). Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Typically less reaches per subbasin were measured during average winter flow as compared to summer flow. We compared the percent increase between low and high flow widths to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data. A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris and hydroconfinement. Therefore, we used actual “wetted width-high” values in reaches where data was available, and a 1.6 multiplier (60%) to expand “wetted width-low” values for reaches without high flow data. In canyon areas, summer flows were expanded by 20-40% depending of reach characteristics.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.10 Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as percentage gradient) was calculated by dividing the change in reach elevation by the reach length. Ned Pittman (WDFW) used SSHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical gradient.

7.9.3.11 Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankful channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed for confinement ratings (VanderPloeg 2003). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps were consulted when SSHIAP ratings fell between the 0.5 increments to determine which rating should be applied. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4. There are often multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings (Table 2).

Table 2. Comparison of SSHIAP and EDT ratings for confinement.

Project	Unconfined	Equal unconfined and mod. confined	Moderately confined	Equal mod confined and confined	Confined
SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.9.3.12 Confinement – hydro-modifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cut off due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Most hydro-modification consists of roads in the floodplain and diking. We consulted the SSHIAP GIS roads layer, SSHIAP digital ortho-photos, USGS maps, and Limiting Factors Analysis (LFA) to estimate EDT ratings. Ratings were categorical due to the lack of field surveys to corroborate GIS, map, and photo estimates. Hydroconfinement primarily occurs in the lower river due to dikes and filling in of side channels. The Washougal River road also increases confinement in some sections.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.9.3.13 Habitat Type

Definition: *Backwater pools* is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter). Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: Representative reaches in lower Columbia River tributaries were surveyed by WDFW in 2003 (VanderPloeg 2003). Habitat type composition was measured during these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement. Lower reaches inundated by the construction of Bonneville Dam were rated as glides and pools depending on the amount of inundation.

WDFW habitat surveys followed USFS stream survey level 2 protocols, which delineate between riffles and slow water but not pools and glides. Glide habitat is the most difficult habitat to identify, therefore it was estimated but not surveyed by WDFW.

Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are believed to be the primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991 - Forest Ecosystem Management July 1992, page V-23), and applying this to current habitat type composition estimates. On Germany Creek, the Elochoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, we assumed for historical conditions that the percentage of pools was significantly higher than the current percentage. For gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5%, we estimated pool habitat to be 40% and 30%, respectively (WFPB 1994). We assumed that tailouts represent 15-20% of pool habitat, which is the current range from WDFW surveys. Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5% to 6% for gradients greater then 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat increased with gradient. WDFW field data indicated the percentage of gravel riffle habitat decreased with stream gradient, and cobble/boulder riffle habitat increased with stream gradient; the percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1% to 15% at gradients greater than 6%. WDFW surveys indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information we assumed pool habitats were in the "good" range and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.14 Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A , B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis. These low gradient C channels were assigned up to a 15% off-channel habitat factor, historically and 0% currently. Off-channel habitat is not significant in the Washougal River except in the lower reaches. These reaches were assigned an EDT rating of up to 75% historic off-channel habitat factor due to the backwater of the Columbia River and assumed beaver populations. Old photographs suggested that substantial off-channel habitat was historically present.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.15 Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: WDFW SSHIAP database was used to identify existing barriers within these watersheds. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. In most cases known fish distribution stopped at all barriers. In some cases, where known distribution occurred above barriers, passage was assumed to be 100% for the species and all life stages. Since steelhead, chum salmon, and chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon due to their preference for spawning in small tributaries are impacted by barriers. The ratings should be completed after a barrier analysis.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.16 Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach.

Rationale: No water withdrawals occurred in the pristine condition. Most watersheds in this unit are forested with residential use in the lower portion of the subbasin. Water withdrawals occur in Jones & Boulder Creek for city water, and at WDFW Hatcheries. These reaches were rated at a 2. Some irrigation withdrawals occur for personal use were noted during summer in the mainstem below the WF Washougal and in the Little Washougal. These small withdrawals were rated at a one. The mill in Camas withdraws water but its mouth was outside the Washougal River.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical

information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.9.3.17 Bed scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for these basins. Historic bed scour was rated using the look-up table (pers. com. Dan Rawding, WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table is based on professional judgment and relates bed scour to confinement, wetted width (high flow), and gradient. It assumes bed scour increases as gradient, wetted width, and confinement increase. For low gradient slough like reaches, we reduced the bed scour rating to ~1, since these reaches are unconfined and influenced by the Columbia River.

Current EDT ratings were developed and used as the baseline for scour in the current condition. Template ratings for bed scour were increased as peak flow and hydro-confinement increased. For example, if in the template condition a reach had a peak flow of 2.0 and in the current condition peak flow increased to 2.3, while hydro-confinement ratings increased from 0 to 1, we assumed a 0.05 increase in bed scour for every 0.1 increase in peak flow and a 0.1 increase for every 1.0 increase in hydro-confinement. In this example the bed scour increased by 0.25.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.18 Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale: In watersheds that are rainfall dominated anchor ice and icing events do not occur. For elevations less than 1000 ft., EDT ratings of 0 were assigned to all reaches in the historical and current condition. For those from 1,000 to 2000 ft. EDT ratings of 1 were assigned. This was based on personal winter observation in the Wind River and discussions with CNFH staff. Since the Wind and Washougal Rivers have the same headwaters, the same icing ratings were used in the Washougal River.

Level of Proof: Empirical observations were used to establish an elevation /icing relationship and this derived information was used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.9.3.19 Riparian

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition the template conditions for this attribute are rated as a value of zero because this describes this attribute rating for watersheds in pristine conditions. Riparian zones with mature conifers are rated at 0.0 -1.0 depending on the density of large trees and bank stability. Riparian zones with saplings and deciduous trees are rated as 1.5 due to lack of shade and bank stability. Riparian zones with brush and few trees would be rated as 2. For an EDT rating to exceed 2, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees it should have a score of 2 or better. Most current vegetated riparian zones with no hydro-confinement should be rated as a 1 to 1.5. When hydro-confinement exists rating from rules on hydro-confinement were used to increase the riparian rating. Ratings also increased based on lack of vegetation. Key reaches were established for current riparian function through out these watersheds. Other reaches were referenced to these key reaches to develop a final EDT rating.

Many reaches in the upper Washougal are still recovering form Yaclot Burn. These reaches given 0-1. Reaches with housing development between Dugan Falls and the WF Washougal were given a rating of 1.5, since most housing encroachment is at the edge of riparian and elevated from stream banks. The area from the WF Washougal to Little Washougal was rated a 2,due to increased housing and roads in riparian. Reaches below WF given 3 due to roads, houses, and dikes. Little Washougal was rated from 3 in the lower developed reaches to 1 near the headwaters. Other tributaries have minimal development in riparian and were rated between a 1 and 2, depending on the level of riparian disturbance.

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.20 Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition as those > 50 cm diameter at midpoint.

Rationale: Wood density was estimated during USFS and WDFW habitat surveys where density of wood equals pieces * length/width. Template condition for wood is assumed to be 0 for all reaches except large Canyon sections on the Grays, Coweeman, Kalama, EF Lewis, Washougal, and Wind, which are assumed to be 2. Due to their confinement, it was believed during high flows these reaches did not retain wood as well as other sections. When survey data was not available, wood densities were extrapolated from reaches with data. EDT Rating based on TFW standard of all wood. Currently, there is limited data for wood on the Washougal River.

Surveys of mainstem reaches in other system suggest values of 3 and 4 for most larger mainstem areas. Values of 2 to 3 for tributaries. These ratings were then applied to the Washougal River.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expanded empirical observations were used to estimate the ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.9.3.21 Fine Sediment (intragravel)

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et. al. 1992). The average percentage of fines (8.5%) was used, which corresponds to an EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3.

To rate percentage of fines in the current condition, a scale was developed relating road density to fines. Rittmueller (1986) found that as road density increased by 1 mi/mi^2, fine sediment levels increased by 2.65%. However, Duncan and Ward (1985) found a lower increase in the percentage of fines in southwest Washington, but attributed much of the variation in fines to different geology. USFS used a McNiel core to collect gravel samples from 1998 to 2000 in 8 subwatersheds in the Wind River subbasin. Fines were defined as less than 0.85mm. A regression was run comparing the percentage for each year to road densities. The increase was 1.04% per 1 mi/mi^2 of roads for all watershed (R^2 = 0.31, n=17). The increase was 1.52% per 1 mi/mi^2 for all watersheds (R^2= 0.73, n= 14) when Layout Creek, which was recently restored was excluded. Rather than use all three years of Layout Creek data , only the median was used and the final relationship used for EDT was 1.34% increase in fines per1 mi/mi^2 (R^2=0.56, n=15) (Figure 1). Road densities were obtained from URS (2003) report to the LCFRB and these were incorporated into the Wind River relationship to estimate fines. Tidal reaches with lower gradients were rated one point higher.

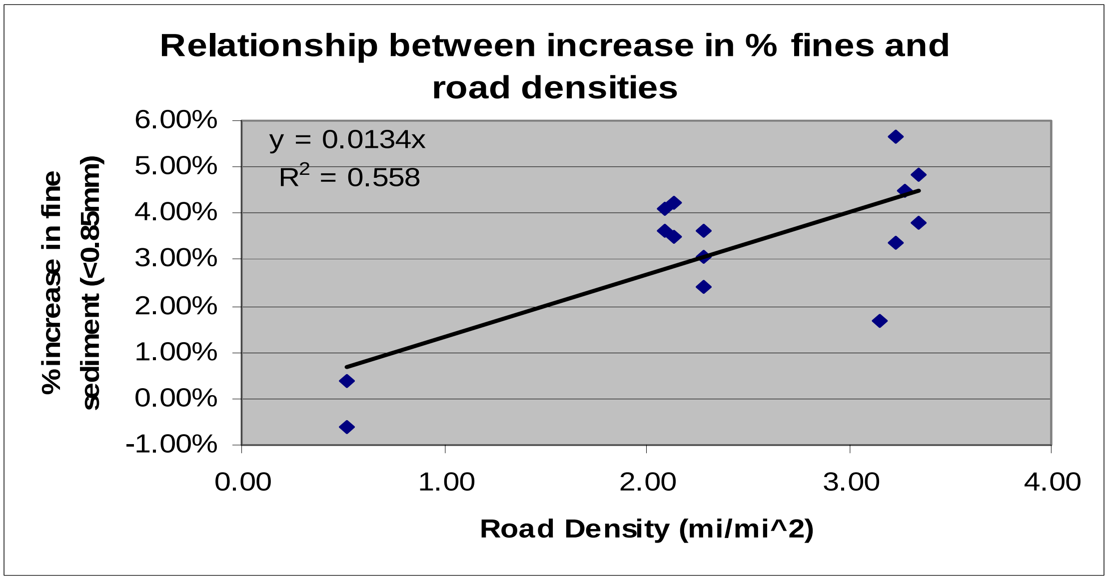

Figure 1. Relationship between road densities and the percentage increase in fines (<0.85mm) from USFS data.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.9.3.22 Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have a low level of embeddedness. Based on the historic level of fines in spawning gravels (8.5%), we assumed this level was the same for embeddedness, which corresponds to and EDT rating of 0.5. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2. Reaches above tidal with low gradient and slower flows likely also had increased fine sediment and embeddeness and were given an EDT rating of 1.

We assumed that the percent embeddedness was directly related to percentage of fines in spawning gravel. We used the Wind River data mentioned above to develop a scale relating road density to percent embeddedness and applied this to the Washougal River. Tidal reaches with lower gradients were rated one point higher.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.23 Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. No historical information is available for this attribute. Fire was historically a natural disturbance process, that occasionally increases turbidity after an extensive hot burn. Current increases in turbidity are likely associated with human activities that lead to bank instability in the riparian area and roads associated with logging, urbanization, and agriculture. Background turbidity levels were assumed to increase with stream size. Professional opinion set these levels to be an EDT rating of 0 in small tributaries, 0.3 in medium tributaries, and 0.5 in the mainstem.

Suspended sediment and turbidity data is limited to grab samples by USFS and UCD for the Wind River. Flow data and limited turbidity data are available for the Elochoman River from the USGS website (http://wa.water.usgs.gov/realtime/historical.html). Historical turbidity data was plotted versus flow data from the same time period. Prior to 1978, USGS turbidity data was recorded in JTU. Since 1978, turbidity data has been recorded in NTU. There is not a direct conversion from JTU to NTU, making it difficult to interpret turbidity data prior to 1978. Bank stability and roads analyses support a small increase in turbidity. Limited data suggests during high water events Wind River suspended sediment exceeds 100 mg/L, while Lower Trout, Panther, and Middle Wind are over 40 mg/L, and other basins are 5-40mg/L, with most less than 25mg/L. However, the duration of these turbidity levels is unknown. If levels of 100mg/L last for 24 hours the EDT rating is 1.0. If the 25 mg/L level lasts 24 hours, the EDT rating is 0.8. These provided the basis for current ratings. These generally support ratings of 0.3 for small tributaries, 0.7 for larger tributaries, and 1.0 for the lower mainstem. Since Washougal and Wind River subbasins were similar the Wind River ratings were applied to the Washougal River.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.9.3.24 Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: Temperature loggers have been extensively placed in the Washougal River subbasin by CSF and WDFW. This data was entered into the EDT temperature calculator provided by Mobrand, Inc. to produce EDT ratings for August. To develop maximum temperature ratings for the remaining months, we used the template monthly pattern “TmpMonMax Rainfall”, TmpMonMax Groundwater“, and TmpMonMax Transitional” for the rainfall, groundwater and rain-on-snow-transitional watersheds, respectively.

The EDT ratings generated by the temperature calculator were used for reaches with a temperature logger present, and ratings for other reaches were inferred/extrapolated from these based on proximity and similar gradient, habitat, and confinement. If temperature loggers were mid-reach we used the reading for the entire reach. If temperature loggers were at the end of the reach and evidence from other temperature loggers above indicated there was cooling within the reach (as you move upstream), professional judgment was used to develop an average for the reach. The same logic was applied to reaches without temperature loggers located between reaches with temperature loggers – ratings from reaches with temperature loggers were “feathered” for reaches in between. Readings from loggers at the end of a reach were used to estimate the rating for the reaches downstream.

Historical temperatures are unknown the in the Lewis River subbasin. The Regional Ecosystem Assessment Project estimated the range of historical maximum daily stream temperatures for the Hood/Wind at 7-20 degrees C (USFS 1993). However, this broad range was not very informative for historical individual reach scale temperatures. The only historical temperature data that we located were temperatures recorded in the 1930’s and 40’s while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary process transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2002). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State watershed analysis manual (WFPB 1997). Elevation of stream reaches is estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters back from the maximum wetted width. Next we assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these trees are estimated to be between 40 – 50 meters for cedar and 60 - 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, we used 49 meters as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was approximately 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade, we used the relationship between forest angle and percentage of shade (WFPB 1997 Appendix G-33.). Finally we used the relationship between elevation, percentage of shade and the maximum daily stream temperature to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for maximum historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. We developed a correction factor for small tributaries, which consisted of adding 0.3 to the estimated historical EDT rating. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature and shade, while Pelletier (2002) used QUAL2K which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However, due to limited resources available for this study, the shade/elevation model was used for consistency throughout the Lower Columbia River.

Level of Proof: Derived information was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations and expansion of empirical observations was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.9.3.25 Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: Wind River temperature data was used to develop a relationship between elevation and maximum temperature for elevations up to 2000 feet as follows: EDT min temp = 1.0248 Ln(elev) –5.8305 (R^2= 0.32, n=27). This was used to generate categorical ratings (Table 3) based on elevation. For the Wind, we used actual data, where available, to develop non-categorical ratings. It should be noted that reaches with lakes/wetlands (Falls and EF Trout) and immediate downstream reaches have colder minimum temperatures (higher EDT ratings) and those with strong groundwater influence (Upper Trout) have warmer minimum temperatures (lower EDT ratings). Since Washougal and Wind River subbasins were similar, the Wind River ratings were applied to the Washougal River.

Table 3. Estimated categorical ratings for minimum temperature based on elevation from Wind River data.

Elevation	EDT Rating
< 600 ft	0
600-1200	1
1300-3000 ft	2

The historic minimum temperature was assumed to be the same as current minimum temperatures. There is some support that historical minimum temperatures were warmer due to more mature forest stands, but we did not use this information due to the limited support and the fact that fire disturbance regimes in these forests would have periodically led to these conditions naturally.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established in the Wind. Expansion of empirical ratings was used for the remainder of the Wind and other basins.

7.9.3.26 Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: Historically there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. These reaches were given an EDT rating of 1. Higher gradient reaches of the mainstem and tributaries higher in the watershed likely had less groundwater input. These reaches were given an EDT rating of 2. We could not find any data on the current or historical conditions for ground water input. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2. Higher gradient reaches in the upper watershed are likely similar to the historic condition and were given an EDT rating of 2.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.9.3.27 Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO_3 or $CaCO_3$.

Rationale: Alkalinity was estimated from historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) for conductivity on the Wind, Lower Washougal, Middle Washougal, NF Lewis, EF Lewis, Cedar, Kalama, Elochoman, and Grays Rivers using the formula: Alkalinity =0.421*Conductivity – 2.31 from Ptolemy (1993). A relationship was developed between flow and alkalinity assuming a power function. We used the mean July to September flow to determine the mean alkalinity values. For basins without flow data, we used mean summer alkalinity values. Alkalinity values were 22, 15, 12, 16, 20, 27, 21, 27, and 30 mg/L, respectively.

USGS sampling suggest a rating of 15 and 12 mg/L for Lower and Middle reaches of the Washougal River, which translate to EDT ratings of 1.7 and 1.5. These were expanded to appropriate reaches. Alkalinity in the historic condition was given the same value as the current condition.

Level of Proof: Derived information was used to estimate this attribute from conductivity measurements. Since alkalinity is did not vary much between adjacent basins and is believed to be relatively constant within a basin, estimated values were expanded for all reaches within a basin. Expert opinion was used to estimate the historical ratings for this attribute since historical data was lacking. The level of proof for the current condition is thoroughly established, generally accepted and good peer-reviewed empirical evidence in favor. For the historical data there is has a strong weight of evidence but not fully conclusive due to lack of data.

7.9.3.28 Dissolved oxygen

Definition: Average dissolved oxygen within the water column for the specified time interval.

Rationale: Dissolved oxygen in the template (historic) condition was assumed to be unimpaired. Historical USGS data (www.wa.water.usgs.gov/realtime/historical.html) and WDFW hatchery data found that in surveyed creeks dissolved oxygen levels were greater than 8 mg/l in August . All reaches in these watersheds were assumed to be unimpaired for dissolved oxygen.

Level of Proof: Empirical information and expert opinion were used to estimate the current and historical ratings for this attribute. Available current data support no problems with dissolved oxygen in flowing reaches. The level of proof for the current condition is thoroughly established, generally accepted and has good peer-reviewed empirical evidence in favor. In slough reaches, where no data was available, derived information and expert opinion was used. For the slough reaches and historical data there is has a strong weight of evidence but not fully conclusive due to lack of data. There is more uncertainty in the ratings for reaches with sloughs, than for riverine reaches.

7.9.3.29 Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to lack of data.

7.9.3.30 Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.9.3.31 Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support due to the lack of data.

7.9.3.32 Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data for this attribute is very limited. Historically nutrient enrichment did not occur because watersheds were in the "pristine" state. To determine the amount of nutrient enrichment in various reaches the following factors were examined: fertilizing by timber companies, reaches downstream from hatcheries, agriculture effects, septic tanks, and storm water run-off.

Nutrient enrichment throughout these watersheds was assumed to be non-existent or at low levels. Fertilizing by timber companies may have some minimal effect but it is likely that changes in nutrient levels from normal forest activities is near zero (WFPB 1997). Assumed nutrient enhancement from a dairy in Little Washougal increased EDT ratings to 2. Reaches with hatcheries and septic systems along river had EDT ratings of 1. Other sites was assumed to be negligible and rated at 0.

Level of Proof: Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.9.3.33 Fish community richness

Definition: Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale: Historical fish community richness was estimated from the current distribution of native fish in these watersheds (see below). Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness was estimated from direct observation (stream surveys and electro-shocking), personal communications with professional fish biologists/hatchery personnel familiar with these areas, and local knowledge. Anadromous fish distribution was estimated from the above as well as the SSHIAP fish distribution layer & EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in SW Washington watersheds: (1) smolt trapping activities on Lower Wind, Upper Wind, Panther Creek, and Trout Creek (pers. com. Cochran, WDFW), (2) electro-shocking in 2002 by USFS and USGS in Upper Wind, Panther, and Trout & tributaries (pers. com. Connoly USGS, and Bair USFS), (3) electroshocking by WDFW in many SW Washington tributaries (pers. com. Hallock, WDFW), (4) WDFW snorkel surveys on the Wind and Panther (pers. com. Cochran, WDFW), (5) species present in Hardy Slough (pers. com. Coley, USFWS), (6) Reimers and Bond (1967), and (7) McPheil (1967). Lamprey, while present in the basin, are not included in the species count (Larry Lestelle pers com).

A spreadsheet summarizing the above data sources was developed: (EDT 2003 Data.xls pers. com. Glaser WDFW). Sloughs likely have many species present from the Lower Columbia River. An estimated 29 species were included in this list: chinook, chum, coho, steelhead/rainbow, cutthroat, sculpin sp(3) (torrent, coastrange , reticulate), bridgelip and largescale sucker, peamouth, northern pikeminnow, smelt, sandroller, redside shiner, large & smallmouth bass, carp, goldfish, white & black crappie, eastern banded killifish, yellow perch, sunfish, pumpkinseed, brown & yellow bullhead, white sturgeon, 3-spine stickleback. Most of these fish likely drop out as gradient increases and water temperatures are reduced. The eastern banded killifish is an exception to this, it has been found in higher reaches of the Elochoman River (pers. com. Byrne, WDFW) and trapped on Abernathy Creek (pers. com. Hanratty, WDFW).

On Washougal River chum dropped out the Little Washougal, chinook salmon at Salmon Falls, and coho salmon at Duggan Falls. All salmonids except steelhead dropped out at Duggan Falls. Only steelhead, cutthroat trout, scuplins and lamprey accessed reaches above Duggan Falls.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical

information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.9.3.34 Fish species introductions

Definition: Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Introduced species were derived from current fish species richness data (see Fish Community Richness above).

The tidal reaches have potential for use by exotic fishes from the Columbia River, as many as 12 species from the Columbia River may migrate into these reaches. An estimated 12 species were included in this list: large & smallmouth bass, carp, goldfish, white & black crappie, Eastern banded killifish, yellow perch, pumpkinseed, sunfish, brown & yellow bullhead. Most of these fish likely drop out as gradient increases and water cools down. Species introductions are due to warmwater fishes in the lower reaches in the Washougal River. Lowest reaches were rated 3 based on derived info from other basins. Ratings were reduced above this site based on professional opinion and summer snorkel observations.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.9.3.35 Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency (pers. com. Glaser, WDFW). Hatchery steelhead are released at Skamaina Hatchery. The distribution of hatchery steelhead continues up the WF Washougal River but snorkel survey data suggest steelhead do not move past mouth of WF Washougal River in mainstem. The Washougal Salmon Hatchery releases coho and fall chinook salmon, which access all areas below Duggan Falls. A hatchery coho program is operated on Little Washougal River. This distribution information was used to develop ratings for this attribute.

Level of Proof: For current and historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.9.3.36 Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition there were no hatcheries or hatchery outplants and we assumed an EDT rating of zero. Hatchery releases of chinook, coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency.). Hatchery steelhead are released at Skamaina Hatchery. The distribution of hatchery steelhead continues up the WF Washougal River but snorkel survey data suggest steelhead do not move past mouth of WF Washougal River in mainstem. The Washougal Salmon Hatchery releases coho and fall chinook salmon, which access all areas below Duggan Falls. A hatchery coho program is operated on Little Washougal River. This distribution information was used to develop ratings for this attribute.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations, and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.9.3.37 Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Rationale: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions.

Topographic maps were examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT rating of 4 was given to reaches with extensive road/boat access and high recreational use (the Washougal River road parallels the river from the mouth to Timber Creek a similar road network exists on the Little Washougal River); a rating of 3 was given to areas with road/boat access and proximity to population center and moderate use; 2 was given to reaches with multiple access points (WF Washougal River) through public lands or unrestricted access through private lands; 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands (tributaries like Stebbins Creek); 0 was given to reaches with no roads and that are far from population centers (roadless areas above Silver Creek) .

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.9.3.38 Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. The magnitude and timing of yearling hatchery smolt releases, and increases in exotic/native piscivorous fishes were considered when developing this rating. The status of top-level carnivores and other fish eating species is unknown in these watersheds. Predation risks increase on Washougal River below the hatcheries, and below the Coho salmon release site in the Little Washougal River. Predation risks increased due to introduced fish moving up from Columbia River.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.9.3.39 Salmon Carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Reaches with historic chum presence (spawning) were given a rating of 0. Mainstem reaches with chinook and coho, but no chum were given a rating of 2. Reaches with only coho were given a rating of 3. Reaches with only cutthroat or steelhead were given a rating of 4, since these fish do not die after spawning. Tidal reaches below areas of chum spawning were given a 1 (it was assumed carcasses from spawning reaches above are washed into these reaches). On Washougal River chum dropped out the Little Washougal, chinook salmon at Salmon Falls, and coho salmon at Duggan Falls. All salmonids except steelhead dropped out at Duggan Falls. Only steelhead, cutthroat trout, scuplins and lamprey accessed reaches above Duggan Falls.

Due to reduced abundance of salmon, the salmon carcass attribute was reduced. Since current escapement estimates for salmon occur in only index areas current estimates of carcass were based on professional opinion of spawning distribution. Recent nutrient enhancement programs have contributed surplus hatchery carcasses to some stream reaches. The recent programs were not included in the salmon carcass attribute. However, under recovery scenarios, they should be included.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive

7.9.3.40 Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: A few direct measures of benthos diversity for selected sites are available within the LCR from DOE and OSU. Reference sites in the Wind and Cowlitz Rivers yielded B-IBI ratings between 40 and 43 indicating EDT values of 0.3 to 0.9, which is equivalent to an EDT rating of 0.6. Slightly disturbed Rosgen B Channels in the Cowlitz and Grays had ratings of 0.1 to 1.4, but were very close to the averaged undisturbed rating of 0.6. Therefore, for current Rosgen B-channels we assumed the same rating as historic. For disturbed Rosgen C-channels in the Wind River the EDT benthos rating decreased to 1.5. Disturbed C-channels are likely to be more impacted by human activities due to their character than B-channels and the 1.5 EDT rating was used to describe current C-channels. Lower Cedar Creek has a rating B-IBI score of 2.6 or EDT score of 2.6. This reach is right below a disturbed C-Channel where the riparian encroachment has reduced shade, increased temperature, and nutrient levels (fecal coliform) have increased due to agriculture or septic tanks leaks.

B-IBI scores from the Wind River indicate little degradation for Rosgen B channels. Therefore, the 0.6 reference reach rating for current and historical reaches with confined channels. For C channels ratings were degraded to 1.6 based on Wind River data, which supported that B-IBI scores were reduced in less confined channels. Historical less confined channels in the lower basin were rated at 1, current rating was increased to 2 based on nutrients, water temps and DO.

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7.10 Salmon Creek

7.10.1 Summary

This report summarizes the values used in the Ecosystem Diagnosis and Treatment Model (EDT) for Salmon Creek. In this project we rated 108 reaches with 45 environmental attributes per reach for current conditions and another 45 for historical conditions. Almost 10,000 (9,720) ratings were assigned and empirical observations within the reach are not available for all of these ratings and comprised only a small percentage of these ratings. To develop the remaining data we used expansion of empirical observations, derived information, expert opinion, and hypothetical. For example, if a stream width measurement existed for a reach and the reach upstream and downstream had similar characteristics then we used the expansion of empirical information from the middle reach to estimate widths in the downstream and upstream reaches. For the fine sediment attribute we could find no data within these watersheds. However, Rittemueller (1986) established a relationship between road density and fine sediment for Olympic Peninsula streams. We applied this relationship to these watersheds; this is an example of derived information. In some cases such as bed scour we had no data for this basin. However, data is available from the Gobar Creek in the Kalama River and observations have been made in the Wind River. We noted that bed scour is related to gradient, stream width, confinement, and confinement-hydromodification. Based on these observations expert opinion was used to estimate bed scour. For rationale behind the ratings see the text below. For specific reach scale information please see the EDT database for the watershed of interest.

Current EDT estimates can be validated when long-term estimates of wild spawners, hatchery spawners, reproductive success of hatchery spawners, and smolts are available. This information in a long enough time series was not available for Salmon Creek. However, the predicted estimates of smolt production for steelhead and Coho are slightly higher than the observed smolt production estimates (DOE 1989). However, when Coho harvest rates are considered, the predicted and actual estimates converge. Chum salmon were extirpated from these watersheds but current EDT model estimates suggest potential chum may be sustainable. The environmental attributes with the most significant impact on salmon performance include: maximum water temperature, riparian function, sediment, bed scour, peak flows, natural confinement, and stream habitat type.

7.10.2 Recommendations

1) Adult chum salmon, Chinook salmon, Coho salmon, and steelhead population estimates should be initiated. Smolt trapping should be initiated for Chum, Chinook Coho, steelhead, and cutthroat for 10 years. Adult and juvenile population estimates will allow for more accurate assessments of population status and to determine if subbasin restoration actions are effective.
2) The CPU/CCWQ data suggests that maximum temperatures in the middle mainstem of these watersheds increase rapidly. A temperature monitoring program should be established to assess maximum water temperatures for each watershed used by anadromous fish and to locate stream reaches where rapid increase in temperature occurs. The factors that cause the increased reach temperatures should be examined and actions to correct the increase in maximum temperature should be developed.

3) Riparian function is qualitatively not quantitatively estimated. The EDT model should provide more quantitative guidelines for rating riparian function. If fine scale GIS data can be developed for riparian areas, this would assist in a more accurate rating.
4) Sediment estimates were derived information or expanded information from a few observations. A sediment monitoring program should be developed to assess % fines, embeddedness, and turbidity in reaches used by anadromous fish.
5) Differences existed between field and GIS ratings of natural confinement. SSHIAP database should be field verified.
6) Flow and bed scour are not monitored in these basins and estimates were from derived information. Stream gauges should be re-established in these watersheds and bed scour should be estimated.
7) WDFW habitat surveys in 2003 were opportunistic and not systematic; that is, based on a limited amount of time, we chose to survey representative mainstem reaches and representative tributary reaches in the watershed. In addition, glides and pools were distinguished subjectively and not quantitatively. Comprehensive stream surveys should be conducted in these watersheds to estimate habitat type.

7.10.3 Attributes

7.10.3.1 Hydrologic regime – natural

Definition: The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.

Rationale: This watershed originates from the east hills of Clark County. The maximum elevation is approximately 2,200 ft, which is well below the elevation of substantial snow accumulation. These elevations are consistent with rainfall-dominated watersheds and are classified as such. This watershed was given an EDT rating of 3 for the historic and current conditions. The exception to this was Curtin Cr, which is a ground-fed system and was given an EDT rating of 0 for the historic and current conditions.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.10.3.2 Hydrologic regime – regulated

Definition: The change in the natural hydrograph caused by the operation of flow regulation facilities (e.g., hydroelectric, flood storage, domestic water supply, recreation, or irrigation supply) in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily variation attribute).

Rationale: Historically, there was no regulation of this watershed. For the current condition we analyzed groundwater and surface water rights. This watershed has a significant amount of groundwater pumped by city and domestic water supply. A total of 168 and 97 surface water rights have been filed for Salmon Creek and Burnt Bridge Creek, respectively. Most are currently not in use (GeoEngineers et al. 2001). Due to intermittent water use and the lack of specific flow measurements, we were unable to estimate changes due to groundwater usage.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.10.3.3 Flow - change in interannual variability in high flows

Definition: The extent of relative change in average peak annual discharge compared to an undisturbed watershed of comparable size, geology, orientation, topography, and geography (or as would have existed in the pristine state). Evidence of change in peak flow can be empirical where sufficiently long data series exists, can be based on indicator metrics (such as TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development. Relative change in peak annual discharge here is based on changes in the peak annual flow expected on average once every two years (Q2yr).

Rationale: By definition, the template conditions for this attribute are rated as an EDT value of 2, which describes this attribute rating for watersheds in pristine conditions. For the current condition, direct measures of inter annual high flow variation are not available for this basin. For the Salmon Creek Watershed Assessment, MGS Engineering (PGG et al. 2002) used HSPF, a precipitation-runoff computer-modeling program (Bicknell et al. 1997), to estimate the effects of land-use changes on peak flow. The model assumed that 100% of the watershed was forested during pre-settlement because the location and size of prairies could not be reconstructed from the meager evidence. Results of the modeling indicate that total runoff (storm runoff plus base-flow) in the Salmon creek watershed has increased by about 3 in/yr, or about 11 percent, from pre-settlement to the present (PGG et al. 2002). Flood frequency analyses with the HSPF model indicate that 10-year peak discharge rates have increased since pre-settlement by 12 to 28 percent on the mainstem and by 37% to over 245% on tributaries (PGG et al. 2002). The results are shown in Table 1. The remaining tributary and mainstem reaches were then feathered and/or given an EDT value of 2.3 where no data exists.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

Table 1. HSPF modeling analyses Q10 year % increases for Salmon Creek Subwatersheds and EDT ratings.

Subwatershed	Q10yr % increase	EDT Rating
Morgan Creek	37%	3.3
Woodin Creek	115%	4.0
Curtin Creek	63%	3.7
Mill Creek	79%	3.8
Cougar Creek	245%	4.0
Upper Salmon Creek	12%	2.3
Salmon Creek @ Northcutt	25%	2.7
Salmon Creek @ Klineline	27%	2.8
Salmon Creek @ Mouth	19%	2.5

7.10.3.4 Flow - changes in interannual variability in low flows

Definition: The extent of relative change in average daily flow during the normal low flow period compared to an undisturbed watershed of comparable size, geology, and flow regime (or as would have existed in the pristine state). Evidence of change in low flow can be empirically-based where sufficiently long data series exists, or known through flow regulation practices, or inferred from patterns corresponding to watershed development. Note: low flows are not systematically reduced in relation to watershed development, even in urban streams (Konrad 2000). Factors affecting low flow are often not obvious in many watersheds, except in clear cases of flow diversion and regulation.

Rationale: By definition the template conditions for this attribute are rated as a value of two because this describes this attribute rating for watersheds in pristine conditions.

A total of 168 and 97 surface water rights have been filed for Salmon Creek and Burnt Bridge Creek, respectively. Most are currently not in use (GeoEngineers 2001). Due to intermittent water use and the lack of specific flow measurements, we were unable to estimate changes in summer low flow. They probably are occurring at some level.

MGS Engineering estimated reductions in flow using the HSPF model in the Salmon Creek watershed. Low flow EDT ratings were then developed by converting categorical ratings to non-categorical ratings by interpolation. EDT ratings ranged from 2.0 to 3.2. Suds, LaLonde, Tenney Creeks and RBtrib1 received the 2.3 rating from Curtin Creek due to high levels of impervious area and residential development in these subwatersheds. Research on the effects of land use practices on summer low flow is inconclusive. Therefore, we rated the current conditions for all other tributaries the same as template conditions (EDT rating of 2). Table 2 shows the results of the model and associated EDT ratings.

Table 2. MGS Engineering HSPF model results showing 7-day low flow statistics at locations in the Salmon Creek Watershed

Location	% Change	EDT Rating
Salmon Creek Nr Battle Ground, Gage S01	0.00%	2.0
Salmon Creek NE 156th St. Gage S04	1.04%	2.0
Salmon Creek Northcutt, Gage S08	3.33%	2.1
Salmon Creek Klineline, Gage S10	4.46%	2.1
Salmon Creek at mouth	4.19%	2.1
Morgan Cr	0.00%	2.0
Woodin Cr	0.00%	2.0
Curtin Cr	12.50%	2.3
Lower Mill Cr	5.00%	2.1
Cougar Cr	40.00%	3.2

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.10.3.5 Flow – intra daily (diel) variation

Definition: Average diel variation in flow level during a season or month. This attribute is informative for rivers with hydroelectric projects or in heavily urbanized drainages where storm runoff causes rapid changes in flow.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. For current conditions, we used the percent impervious surface area in major subwatersheds (PGG et al. 2002) to estimate changes in diel flow using the % impervious surface ratings in the EDT stream reach editor. Diel EDT ratings were then developed by converting categorical ratings to non-categorical ratings by interpolation using % total impervious area. Reaches had ratings from 0.2 to 2.3. Table 3 shows relationship of EDT reaches with PGG's subwatersheds and their corresponding total impervious areas (%) and EDT ratings.

Table 3. PGG Subwatersheds and associated EDT reaches showing total impervious area (% of basin) and EDT current diel variation ratings.

Subwatershed	EDT Reaches	Total Impervious Area (% of Basin)	Diel EDT Rating
119th Tributary (LaLonde)	Lalonde1 & 2	21.00%	1.2
Cougar Creek	CougarCanyon1 & 2	37.40%	2.3
Curtin Creek	Curtin1 & 2	16.90%	0.9
Morgan Creek	BakerCr1-3, LBtrib2 & 4, RBtrib7, Morgan1-4, and Mud1 & 2	8.30%	0.4
Rock Creek (West)	Rock1-8, LBtrib5, 6, 7-1, 7-2, 8-1, 8-2, and 9	4.70%	0.2
South Mill Creek	Mill1-5, RBtrib2-1, 2-2, 3 and 4	9.60%	0.5
Suds Creek	Suds1-6	37.10%	2.3
Tenny Creek	Tenney Cr.	31.00%	1.9
Upper Salmon Creek	Salmon28-32, LBtrib11-1, 11-2, RBtrib11-1, 11-2, 12-1, 12-2, 13 &14, and LittleSalmon1 & 2	3.70%	0.2
Woodin Creek	Weaver1-3, RBtrib5, 6, 8, 9-1 & 2, and 10	15.30%	0.8
Lower Salmon	Salmon1-17, RBtrib1, Klineline1 and KlinelineChannel	23.41%	1.4
Mid Salmon	Salmon18-27	10.75%	0.5

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Derived information was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.10.3.6 Flow –Intra annual flow pattern

Definition: The average extent of intra-annual flow variation during the wet season -- a measure of a stream's "flashiness" during storm runoff. Flashiness is correlated with % total impervious area and road density, but is attenuated as drainage area increases. Evidence for change can be empirically derived using flow data (e.g., using the metric TQmean, see Konrad [2000]), or inferred from patterns corresponding to watershed development.

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions. Similar to high flows, monthly and seasonal flow patterns have been affected by land use practices in this watershed. Since there was no data for this attribute, it was suggested that its rating should be similar to that for changes in inter-variability in high flows (pers. com. Larry Lestelle, Mobrand Biometrics, Inc). The EDT ratings for intra-annual flow were applied the same values as the attribute: Flow - change in interannual variability in high flows.

Level of Proof: Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established. Expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.7 Channel length

Definition: Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a category but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.

Rationale: The length of each reach was provided by Ned Pittman (WDFW) from SSHIAP GIS layers. We assumed the stream length was the same in both the historical and current conditions.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.10.3.8 Channel width – month minimum width

Definition: Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: We assigned the same value for both the current and historical conditions, unless a major hydromodification within the reach affects stream width. Representative reaches in Salmon Cr were surveyed in 2003 (WDFW unpublished), and by in the summer of 2001 (Fishman Environmental, unpublished). Wetted widths corresponding to average summer low flows (August) were measured as part of these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reaches with similar habitat, gradient and confinement. The following rules were developed for use in EDT in the Lower Columbia and used in this analysis (WDFW unplublished). For reaches above a split (confluence of 2 tributaries), wetted width was calculated by: {(1.5*downstream reach width)*0.5} for even splits. For uneven splits, the multiplier was adjusted to compensate. In a 60:40 split: (1.5*drw)*0.6 and (1.5*drw)*0.4; and for a 70:30 split: (1.25*drw)*0.7 and (1.25*drw)*0.3. These calculations were referred to as the “split rule”.

A stream width model was developed by Ned Pittman (WDFW unpublished), which correlated well for smaller tributaries. Widths from this model were applied where there were large gaps in data. Rock, Mill, Morgan, and Mud Creeks all have been observed flowing intermittently or subterranean during summer-time low flow events by the TAG (Wade 2001). The minimum width data collected in the field or extracted from Pittman’s width model, was reduced by 20%

to account for this occurrence. The surrounding reaches were then extrapolated from these reduced widths using the split rule.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.9 Channel width – month maximum width

Definition: Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.

Rationale: Representative in the Salmon Creek basin were surveyed by WDFW in 2003 and in 2001 (WDFW ,unpublished, and Fishman Environmental Services, unpublished). Historical reaches were assigned the same value as the current condition for all reaches, unless a major hydromodification within the reach currently affects stream width.

Winter flow widths were not collected as part of these surveys. We compared the percent increase between low and high flow widths to the EDT (SSHIAP) confinement rating for each reach. Regression analysis demonstrated little correlation between confinement rating and percent increase in stream width. Mean increase in stream width was 60% after removing outliers for subterranean flow in the summer and Kalama questionable data. A possible explanation for this relationship is that all unconfined reaches in the dataset are downcut due to lack of large woody debris and hydroconfinement. Therefore, we used a 1.6 multiplier (60% increase) to expand “wetted width-low” values for reaches without high flow data.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but is not fully conclusive. For historical information, we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.10 Gradient

Definition: Average gradient of the main channel of the reach over its entire length. Note: Categorical levels are shown here but values are required to be input as point estimates for each reach.

Rationale: The average gradient for each stream reach (expressed as % gradient) was calculated by dividing the change in reach elevation by the reach length and multiplying by 100. Ned Pittman (WDFW) used SHIAP GIS layers to provide the beginning elevation, ending elevation, and length for each EDT reach. Historical gradient was assumed to be the same as current gradient.

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive especially for historical length.

7.10.3.11 Confinement – natural

Definition: The extent that the valley floodplain of the reach is confined by natural features. It is determined as the ratio between the width of the valley floodplain and the bankfull channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only.

Rationale: Representative reaches in the Salmon Creek basin were surveyed by WDFW in 2003. Confinement ratings were estimated during these surveys (WDFW, unpublished). In addition, SSHIAP confinement ratings for the watersheds were consulted. Field surveys noted discrepancies between GIS and field ratings. USGS topography maps were consulted when SSHIAP ratings fell between the 0.5 increments to determine which rating should be applied. In turn, EDT confinement ratings were developed by converting SSHIAP ratings of 1-3 to EDT ratings of 0-4:

Table 4. Comparison of EDT and SSHIAP confinement ratings.

SSHIAP	1	1.5	2	2.5	3
EDT	0	1	2	3	4

There is likely to be multiple SSHIAP segments per EDT segment, where the average SSHIAP confinement rating is calculated, then converted into EDT ratings

Level of Proof: Derived information (GIS) was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.10.3.12 Confinement – hydromodifications

Definition: The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized, or has undergone significant streambed degradation due to channel incision/entrenchment (associated with the process called "headcutting"). Flow access to the floodplain can be partially or wholly cutoff due to channel incision. Note: Setback levees are to be treated differently than narrow-channel or riverfront levees--consider the extent of the setback and its effect on flow and bed dynamics and micro-habitat features along the stream margin in reach to arrive at rating conclusion. Reference condition for this attribute is the natural, undeveloped state.

Rationale: In the historic condition (prior to manmade structures and activity) reaches were fully connected to the floodplain. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Most hydro-modification consists of roads in the floodplain and diking. We consulted the SSHIAP GIS roads layer, SSHIAP hydromodification layer, SSHIAP digital orthophotos, USGS maps and used professional judgment to assign EDT ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.10.3.13 Habitat Type

Definition: *Backwater pools* is the percentage of the wetted channel surface area comprising backwater pools. *Beaver ponds* is the percentage of the wetted channel surface area comprising beaver ponds. Note: these are pools located in the main or side channels, not part of off-channel habitat. *Primary pools* is the percentage of the wetted channel surface area comprising pools, excluding beaver ponds. *Pool tailouts* are the percentage of the wetted channel surface area comprising pool tailouts.

Large cobble/boulder riffles is the percentage of the wetted channel surface area comprising large cobble/boulder riffles. *Small cobble/gravel riffles* is the percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Glides is the percentage of the wetted channel surface area comprising glides. Note: There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993), despite a commonly held view that it remains important to recognize a habitat type that is intermediate between pool and riffle. The definition applied here is from the ODFW habitat survey manual (Moore et al. 1997): an area with generally uniform depth and flow with no surface turbulence, generally in reaches of <1% gradient. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. They are generally deeper than riffles with few major flow obstructions and low habitat complexity.

Rationale: Representative reaches the Salmon Creek basin were surveyed in 2003 (WDFW unpublished). Habitat type composition was measured during these surveys. Ratings for non-surveyed reaches were inferred by applying data from representative reach surveys with similar habitat, gradient and confinement. Lower tidal/slough-like reaches from Salmon10 down were rated as 100% glides. Klineline ponds are abandoned gravel pits. Salmon14_B is the mainstem avulsed into one of these ponds east of I-5. Klineline1 is a pond, which has an unscreened outlet with connection to the mainstem. Reservoir1 is a pond, which has been excavated out of the main channel on Mill Creek. These three reaches are rated as 100% pool.

2003 habitat surveys primarily followed TFW protocol using EDT's habitat types as guidelines. TFW protocol identifies 5 core habitat types: riffle, pool, sub-surface flow, wetland, and obscured. Everything's a riffle unless proven otherwise, pools must meet minimum surface area and residual pool depth criteria following the techniques described in the manual:

Table 5. TFW minimum pool unit criteria

Mean Segment BFW (m)	Minimum Surface Area (m^2)	Minimum Residual Pool Depth (m)
<2.5	0.5	0.10
>=2.5 - 5.0	1.0	0.20
>=5.0 - 10	2.0	0.25
>=10 - 15	3.0	0.30
>=15 - 20	4.0	0.35
>= 20	5.0	0.40

One way to think of a pool is like a slightly tipped teacup. If the water supply were to be 'turned off', then water would remain in the pool. "Pools typically form as a result of scour adjacent to channel obstructions and bank resistance during bankfull flows, or due to impoundment of water behind blockages (Pleuss 1999)" TFW lists 10 pool forming factors and 1 more for other/unknown with descriptions of each.

"The classic riffle definition is a shallow and low gradient area with surface turbulence associated with increased flow velocity over gravel or cobble beds. However, riffle classification also includes deeper areas without surface turbulence such as "glides" and "pocket water" conditions, and higher gradient/turbulence areas such as "cascades" and "rapids" (Pleuss 1999)." EDT identifies glides separately which has proven to be difficult. The pool forming factors from above were used as good distinguishing features between some glides and pools along with following the ODFW habitat survey definition of glides.

The results appeared to make sense due to the fact that the watershed has undergone extensive habitat degradation due to urban sprawl, dairies, logging, recreational and other intrusive activities. Therefore, % habitat types were applied to the entire reach where a survey was conducted and reference reaches or averages were applied to reaches un-surveyed showing similarities in gradient, confinement, and land-use activities. Reaches surveyed include: BakerCr1, Morgan3_B, Morgan4, Rock2 & 3, Salmon12, 17, 18, 24, 26, 30, and Weaver1. Estimated surveys include: CougarCanyon1, Morgan2, and Salmon29. A spreadsheet was developed comparing the results of these surveys. Comparisons were made based on field measured gradients and based on GIS gradients. The results showed better relationships using field measured gradients, averages were generated from these results. Table 6 shows reference reach or average of reference reaches expanded into other reaches:

Table 6. Reference reaches used to develop ratings for similar reaches.

Reference Reaches	**Unsurveyed Reaches**
Average for tributaries >1%	Tributary reaches >2% & <5%
Average of Salmon24,25 & 25,26	Salmon25
Morgan3_BChnlzd	Tributary reaches >5%
Salmon12	Salmon9, 10, &11
Salmon22	Mill1
Total Average w/o estimates	Tributary reaches <1%
Total Average w/o estimates >1%	Tributary reaches >1% & <2%
CougarCanyon1	CougarCanyon2
Mainstem Average	Salmon13,14_A,16,19-23,27,28,&31
Morgan2	Mud1 & 2
Morgan3_B(beaver)	Rock1

Habitat simplification has resulted from timber harvest activities. These activities have decreased the number and quality of pools. Reduction in wood and hydromodifications are believed to be the primary causes for reduction in primary pools. Historic habitat type composition was estimated by examining percent change in large pool frequency data (Sedell and Everest 1991 - Forest Ecosystem Management July 1992, page V-23), and applying this to current habitat type composition estimates. On Germany Creek, the Elochoman River and the Grays River the frequency of large pools between 1935 and 1992 has decreased by 44%, 84%, and 69%, respectively. However, the frequency of large pools increased on the Wind River, but this is likely due to different survey times. The original surveys were conducted in November and the 1992 surveys were conducted during the summer, when flows are lower and pools more abundant.

In general, we assumed for historical conditions that the percentage of pools was significantly higher than the current percentage. For gradients less than 2%, historical pool habitat was estimated to be 50%, which is similar to pool frequency for good habitat (Petersen et al. 1992). For habitats with gradients 2-5% and greater than 5%, we estimated pool habitat to be 40% and 30%, respectively (WFPB 1994). We assumed that tailouts represent 15-20% of pool habitat, which is the current range from WDFW surveys. Glide habitat decreased as gradient increased (Mobrand 2002). Habitat surveys on the Washougal River demonstrated a strong relationship between gradient and glides and this regression was used to estimate glide habitat, which ranged from 25% at gradients less than 0.5% to 6% for gradients greater then 3%. Riffle habitat was estimated by subtracting the percentage of pool, tailout, and glide habitat from 100%. This yielded a relationship where the percentage of riffle habitat increased with gradient. WDFW field data indicated the percentage of gravel riffle habitat decreased with stream gradient, and cobble/boulder riffle habitat increased with stream gradient; the percentage of gravel riffles compared to the total riffle habitat ranged from over 60% at gradients of less than 1% to 15% at gradients greater than 6%. WDFW surveys indicated backwater and dammed habitat increased as gradient decreased. For historical ratings, unconfined low gradient reaches were assumed to have some of these habitat types, and expert opinion was used to assign ratings.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute. Stream surveys allowed accurate classification of fast water (riffles) and slow water (pools and glides) habitat. However, there was likely inconsistency in distinguishing pools from glides and this is likely to affect Coho production due to this species' extended freshwater rearing and preference for pools. The level of proof for current ratings has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.14 Habitat types – off-channel habitat factor

Definition: A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat.

Rationale: When rivers are unconfined they tend to meander across their floodplains forming wetlands, marshes, and ponds. These are considered off-channel habitat. Confined and moderately confined reaches (Rosgen Aa+, A , B and F channels) typically have little or no off-channel habitat. Off-channel habitat increases in unconfined reaches (Rosgen C and E channels). Norman et al. (1998) indicated the potential for abundant off-channel habitat in the lower East Fork Lewis and currently off channel habitat is abundant below Cougar Creek. Mainstem reaches below Cougar Creek get 50% off-channel habitat. Mainstem reaches between Cougar Creek and Mill Creek get 3% off-channel habitat. Curtin1, Mill1-3, Morgan1-3_A, Mud1, Rock1,2&6, Salmon18-25, Suds1, and Weaver1&2 all receive 1% off-channel habitat. The % off-channel habitat was applied to both current and historic with the exception of Mud1, which did not receive any off-channel habitat for current due to extreme incision.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.**Obstructions**

7.10.3.15 Obstructions to fish migration

Definition: Obstructions to fish passage by physical barriers (not dewatered channels or hindrances to migration caused by pollutants or lack of oxygen).

Rationale: WDFW SSHIAP database was used to identify existing barriers within these watersheds. EDT requires that obstructions be rated for species, life stages, effectiveness, and percentage of passage effectiveness. This has not been completed for any barriers. In most where known distribution occurred above barriers, passage was assumed to be 100% for the species and all life stages. Since steelhead, chum salmon, and Chinook salmon are generally mainstem and large tributary spawners, barrier effects on these species are minimal. Coho salmon due to their preference for spawning in small tributaries are impacted by barriers. The ratings should be completed after a barrier analysis.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information we expanded empirical observations and used expert opinion and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.16 Water withdrawals

Definition: The number and relative size of water withdrawals in the stream reach.

Rationale: No water withdrawals occurred in the pristine condition. A total of 168 and 97 surface water rights have been filed for Salmon Creek and Burnt Bridge Creek, respectively. Most are currently not in use (GeoEngineers 2001). Salmon Creek flows through residential areas throughout most of its lower reaches. Allocated and illegal water-withdrawals occur throughout the watershed. Entrainment believed to be minimal in most if not all of these withdrawals. Reaches with low gradient, unconfined areas (i.e. farmland) and/or reaches with dwellings built next to the stream were given an EDT rating of 0.1 to account for occasional withdrawals as a placeholder. All other reaches were rated at 0

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.10.3.17 Bed scour

Definition: Average depth of bed scour in salmonid spawning areas (i.e., in pool-tailouts and small cobble-gravel riffles) during the annual peak flow event over approximately a 10-year period. The range of annual scour depth over the period could vary substantially. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1992): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 5 inch diameter), large cobble (5 to 11.9 inch diameter), boulder (>11.9 inch diameter).

Rationale: No bed scour data was available for these basins. Historic bed scour was rated using the look-up table (pers. com. Dan Rawding, WDFW). This table was modified to incorporate the new EDT revisions for bed scour ratings. The table relates bed scour to confinement, wetted width (high flow), and gradient and assumes scour increases as gradient and confinement increase. Current bed scour ratings were increased by 5% for every 0.1 increase in EDT peak flow rating and 5% for each 1.0 increase in EDT hydroconfinement rating. For the tidal reaches of the mainstem Salmon Creek (Salmon 1-10), bed scour ratings were reduced by 50%.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.18 Icing

Definition: Average extent (magnitude and frequency) of icing events over a 10-year period. Icing events can have severe effects on the biota and the physical structure of the stream in the short-term. It is recognized that icing events can under some conditions have long-term beneficial effects to habitat structure.

Rationale: This watershed is rainfall dominated. Anchor ice and icing events do not occur. EDT ratings of 0 were assigned to all reaches in the historical and current condition.

Level of Proof: Empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.10.3.19 Riparian Function

Definition: A measure of riparian function that has been altered within the reach.

Rationale: By definition the template conditions for this attribute are rated as a value of zero because this describes this attribute rating for watersheds in pristine conditions. The following rules were developed for use with EDT analysis in the Lower Columbia. These rules were used as guidelines in rating the Salmon Creek watershed for riparian function in EDT.

Riparian zones with mature conifers are rated at 0.0 - 1.0 depending on floodplain connectivity. Riparian zones with saplings and deciduous trees are rated at 1.5 due to loss of shade and bank stability. Riparian zones with brush and few trees would be rated as 2.0. For an EDT rating to exceed 2.0, residential developments or roads need to be in the riparian zone. Therefore, for current conditions, as long as the riparian area has trees, it should have a score of 2.0 or better.

Most vegetated riparian zones with no hydro-confinement should be rated as a 1.0 - 1.5. When hydro-confinement exists start rating from rules on % hydro-confinement and increase rating based on lack of vegetation. Key reaches were established for current riparian function through out the watershed. Other reaches were referenced to these key reaches to develop a final EDT rating

Level of Proof: There is no statistical formula used to estimate riparian function. Therefore, expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.20 Wood

Definition: The amount of wood (large woody debris or LWD) within the reach. Dimensions of what constitutes LWD are defined here as pieces >0.1 m diameter and >2 m in length. Numbers and volumes of LWD corresponding to index levels are based on Peterson et al. (1992), May et al. (1997), Hyatt and Naiman (2001), and Collins et al. (2002). Note: channel widths here refer to average wetted width during the high flow month (< bank full), consistent with the metric used to define high flow channel width. Ranges for index values are based on LWD pieces/CW and presence of jams (on larger channels). Reference to "large" pieces in index values uses the standard TFW definition of “large logs” as those > 50 cm diameter at midpoint (Schuett-Hames 1999).

Rationale: Density of LWD equals pieces * length/width. Template condition for wood is assumed to be 0 for all reaches. To determine current EDT ratings, WDFW and Fishman habitat survey data (unpublished) were consulted. The Fishman surveys included smaller pieces than the EDT model prefers, so only WDFW data was used to calculate a mean EDT rating of 3 for all reaches surveyed. This mean rating was applied to unsurveyed reaches.

Since Fishman surveys included smaller pieces than the EDT model prefers, no EDT ratings better than the mean of 3 could be used. This is because Fishman’s LWD density will include smaller pieces as well, resulting in scores better (lower # rating) than they actually are. Therefore only the two Fishman surveys that scored worse than 3 could be used: Mill4 and Morgan3_B received 4’s. WDFW survey scores agreed with Morgan3_B’s rating, and Mill4 was given an EDT rating of 4. The WDFW survey EDT scores for LWD ratings are provided in Table 7:

Table 7. Salmon Creek watershed wood ratings for EDT reaches from WDFW habitat surveys.

EDT reach	EDT Rating
Salmon12	4
Salmon17,18	3
Salmon22	3
Salmon24,25	2
Salmon25,26	1
Salmon29	3
Salmon30	3
Morgan3_B, Baker	4
Morgan4	3
Rock2	3
Rock3	4
Weaver1	3
Cougar1	3
Mean	**3.0**

Surveys overlapped EDT sections on four locations: Salmon 17,18, Salmon24,25, Salmon25,26, and Morgan 3_B,Baker. Ratings were applied to both reaches. Salmon 25 was given the lowest EDT rating of 2.

7.10.3.21 Fine Sediment

Definition: Percentage of fine sediment within salmonid spawning substrates, located in pool-tailouts, glides, and small cobble-gravel riffles. Definition of "fine sediment" here depends on the particle size of primary concern in the watershed of interest. In areas where sand size particles are not of major interest, as they are in the Idaho Batholith, the effect of fine sediment on egg to fry survival is primarily associated with particles <1mm (e.g., as measured by particles <0.85 mm). Sand size particles (e.g., <6 mm) can be the principal concern when excessive accumulations occur in the upper stratum of the stream bed (Kondolf 2000). See guidelines on possible benefits accrued due to gravel cleaning by spawning salmonids.

Rationale: In the template (pristine) condition, SW Washington watersheds were assumed to have been 6%-11% fines (Peterson et. al. 1992) and EDT rating of 1. Tidal reaches with slowed flows were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 3. Reaches above tidal with low gradient and slower flows likely also had increased fine sediment and embeddeness and were given an EDT rating of 1. Due to the lower gradient of this subbasin, it was thought that percentage fines was historically higher than Petersen et al.(1992) and we used values of 1.3 for most of the watershed and 3.8 on the lower tidal reaches.

Rittmueller (1986) found as road densities increased by 1 mile per square mile, the % fine sediment in spawning gravels increased by 2.6% in Olympic Peninsula watersheds. To rate % fines in the current condition, a scale was developed relating road density to % fines. Tidal reaches with lower gradients were given an EDT rating of 4. Slough-like reaches above tidal reaches or tidal reaches with increased flow during outgoing tide (i.e. lower Salmon Cr.) were rated as follows: rating from road density scale + 1.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.10.3.22 Embeddedness

Definition: The extent that larger cobbles or gravel are surrounded by or covered by fine sediment, such as sands, silts, and clays. Embeddedness is determined by examining the extent (as an average %) that cobble and gravel particles on the substrate surface are buried by fine sediments. This attribute only applies to riffle and tailout habitat units and only where cobble or gravel substrates occur.

Rationale: Peterson et al. (1992) estimated fines to be 6% to 11% in the template (pristine) condition. Under these same conditions we assumed embeddedness was less than 10%, which corresponds to an EDT rating of 0.5. Tidal reaches with slowed water movement were likely areas of heavy sediment deposition (wetlands) and were given an EDT rating of 2. Reaches above tidal with low gradient and slower flows likely also had increased fine sediment and embeddeness and were given an EDT rating of 1.

Rittmueller (1986) found as road densities increased by 1 mile per square mile, the % fine sediment in spawning gravels increased by 2.6% in Olympic Peninsula watersheds. To rate % fines in the current condition, a scale was developed relating road density to % fines. Using fines as a surrogate for embeddedness, EDT ratings were developed. Tidal reaches with lower gradients and ponds & reservoirs were given an EDT rating of 4.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.23 Turbidity (suspended sediment)

Definition: The severity of suspended sediment (SS) episodes within the stream reach. (Note: this attribute, which was originally called turbidity and still retains that name for continuity, is more correctly thought of as SS, which affects turbidity.) SS is sometimes characterized using turbidity but is more accurately described through suspended solids, hence the latter is to be used in rating this attribute. Turbidity is an optical property of water where suspended, including very fine particles such as clays and colloids, and some dissolved materials cause light to be scattered; it is expressed typically in nephelometric turbidity units (NTU). Suspended solids represents the actual measure of mineral and organic particles transported in the water column, either expressed as total suspended solids (TSS) or suspended sediment concentration (SSC)—both as mg/l. Technically, turbidity is not SS but the two are usually well correlated. If only NTUs are available, an approximation of SS can be obtained through relationships that correlate the two. The metric applied here is the Scale of Severity (SEV) Index taken from Newcombe and Jensen (1996), derived from: $SEV = a + b(\ln X) + c(\ln Y)$, where, X = duration in hours, Y = mg/l, a = 1.0642 , b = 0.6068, and c = 0.7384. Duration is the number of hours out of month (with highest SS typically) when that concentration or higher normally occurs. Concentration would be represented by grab samples reported by USGS. See rating guidelines.

Rationale: Suspended sediment levels in the template (pristine) condition were assumed to be at low levels, even during high flow events. CPU and Clark County have been performing a long term monitoring plan. This plan consists of monthly water quality field measurements using a HACH 2100P turbidimeter and water grabs for laboratory analyses. Somewhere in this process, turbidity data results became inconclusive. Correlations were established at each of the eight monitoring locations between flow (CFS) and the following: field turbidity (NTU), lab turbidity (NTU), total suspended solids (mg/L), and total solids (mg/L). These relationships did not prove to make sense for most streams of the Pacific Northwest. From these relationships, as flow increased, turbidity decreased. The measurements also appeared to be too low for this watershed. This could also be in part due to timing of the water sample grabs. For example, a small rain event in the summer can clean the impervious surfaces but not increase flow very much. The creek can become very turbid at low flows. Or in the case of wintertime flows, water samples can be more diluted due to higher volumes of water after the system has been flushed out.

Based on Rawding's analysis of CPU/CCWQ water quality data, the following ratings were assigned. For gradients less than .5% reaches were given the historical rating of 0.8 and the current rating of 1.2; for gradients greater than or equal to .5% and less than 2% reaches were given the historical rating of 0.5 and the current rating of 1.0; for gradients greater than or equal to 2% reaches were given the historical rating of 0.3 and the current rating of 0.5.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations

7.10.3.24 Temperature – daily maximum (by month)

Definition: Maximum water temperatures within the stream reach during a month.

Rationale: Clark County Water Quality placed continuous temperature loggers in various locations within the Salmon Cr. watershed during the summer of 2002. The loggers were located on Curtin Cr, Mill Cr, Woodin Cr, and the mainstem Salmon Cr at 167th avenue, Caples Road, I205 bridge, and near Rock Cr for the summers of 2000, 2001, and 2002. Temperature loggers for Salmon Cr at Caples Road, I-205 bridge, and near Rock Cr were also in the stream for the summer of 1998. In 2003, Clark Public Utilities, Clark County Water Quality, and Water Resources placed additional temp loggers throughout the watershed. This data was plugged into the EDT temperature calculator (MS Access) provided by Mobrand, Inc. to produce EDT ratings. Table 8 displays the resulting EDT ratings:

Table 8. Salmon Creek watershed temperature monitoring locations and EDT ratings generated by the EDT temp max calculator for maximum temperatures.

	EDT Ratings					
Location	**Avg.**	**2003**	**2002**	**2001**	**2000**	**1998**
Salmon Cr - NW 36th Ave	3.5	3.5				
Cougar Cr - upstream of 119th St	2.2	2.2				
Tenney Cr - 117th St	1.5	1.5				
Salmon Cr - Klineline footbridge	3.5	3.5				
Salmon Cr – Northcutt	3.5		3.5	3.5	3.5	3.5
Mill Cr - 50' above mouth	3.4	3.5	3.3	3.4	3.2	N/A
Salmon Cr - 50th Ave	3.5	3.5				
Curtin Cr - 139th St.	1.5	1.5	1.5	1.5	1.5	N/A
Salmon Cr - 156th St	3.5	3.5				
Woodin Cr – 181st St.	3.5	3.5	3.5	3.5	3.4	N/A
Salmon Cr - Caples Rd.	3.5	3.5	1.5	3.5	3.5	3.5
Morgan Cr - 167th Ave	3.5	3.5				
Salmon Cr - 167th Ave.	3.5		3.5	3.5	3.1	N/A
Salmon Cr - Risto Rd.	3.3	3.5	3.2	3.3	3.2	3.4
Rock Cr - upstream of mouth	3.5	3.5				

All locations displayed similar ratings for each year with the exception of Salmon Creek at Caples Road 2002. This logger clearly had a malfunction and the average EDT rating for the previous and current years (3.5) was used. For the other locations the average EDT rating was applied for all years. The EDT ratings generated by the temperature calculator were used for reaches with a temperature logger present, and ratings for other reaches were inferred/extrapolated from these based on proximity and similar gradient, habitat, and confinement. If loggers were mid-reach we used the reading for the entire reach. If loggers were at the end of the reach and evidence from other loggers above indicated there was cooling within the reach (as you move upstream), professional judgment was used to develop an average for the reach. The same logic was applied to reaches w/o loggers located between reaches with loggers – ratings from reaches w/ loggers were "feathered" for reaches in between. Readings from loggers at the end of a reach were used to "drive" the rating for the reach downstream. Monitored reference reaches and extrapolated reaches are summarized in Table 9..

Table 9. Monitored reference EDT reaches with associated non-monitored EDT reaches and EDT ratings.

Monitored Reference EDT Reaches	**EDT Rating**	**Un-monitored EDT Reaches using reference ratings**
CougarCanyon1	2.2	CougarCanyon2, Suds1-6, LaLonde1&2,
Curtin1	1.5	Curtin2
Mill1	3.4	Mill2-5, Reservoir1
Morgan1	3.5	Morgan2-4, SideChannel, BakerCr1&2, Mud1&2
Rock1	3.5	Rock2-4
Weaver1	3.5	Weaver2
Salmon8,17,18,19,21&24	3.5	LakeRiver1-3, Salmon1-7,9-16,20,22,23,25,26
Salmon27	3.3	Salmon 28&29

*Assumed all small tributaries upstream of Mill Cr (RBtrib2-14, LBtrib2 & 4-11, BakerCr3, Weaver3, Rock5-8) to be rated at 2.5. RBtrib1 rated the same as Salmon Creek (3.5). Salmon 30 (3.0), 31 & 32 (2.5) feathered from Salmon27 (3.3).

On 8/30/2003, WDFW personnel conducted a temperature profile in the watershed. Table 10 shows the temperatures that were recorded:

Table 10. Temperature profile conducted by WDFW in Salmon Creek Watershed on August 30, 2003.

Location	**Morning Temp. C**	**Evening Temp. C**
Salmon Cr @ 36th Ave (near mouth)	18.61	21.94
Cougar Cr @ 119th St	14.44	16.53
Salmon Cr @ Northcutt	16.39	20.14
Mill Cr @ Salmon Cr Ave	15.14	17.92
Salmon Cr @ 50th Ave	16.39	18.33

Curtin Cr @ 139th St	12.50	14.58
*Salmon Cr @ 158th St	16.94	20.00
Salmon Cr @ 112th Ave	16.39	19.44
*Woodin Cr @ Caples Rd	15.56	20.42
Salmon Cr @ Caples Rd	16.39	19.58
*Salmon Cr @ 142nd Ave	N/A	21.39
Morgan Cr @ 167th Ave	15.28	19.72
Salmon Cr @ 167th Ave	17.22	20.83
Salmon Cr @ Risto Rd1	14.17	18.33
*Rock Cr @ 224th St	15.14	18.61
Salmon Cr @ Risto Rd2	14.17	17.92
Salmon Cr @ 199th St (headwaters)	14.17	17.08

* = Questionable Data due to poor representation of temperature from glide or pool habitat or subterranean flow

Tributaries =

Results from the profile displayed a normal decline in temperature moving upstream on the mainstem from 36th avenue to 50th avenue. Then in the upper mainstem, temperatures increasingly got higher between 50th avenue and 167th avenue. This is not normal for a watershed in the Pacific Northwest. Solar input from lack of riparian vegetation (especially on the south bank) on the mainstem above 167th avenue appears to be responsible for these conditions. The input of cooler water from tributaries cools off the mainstem, although EDT ratings remain the same or similar.

Historical temperatures are unknown the in the Salmon Creek subbasin. The Regional Ecosystem Assessment Project estimated the range of historical maximum daily stream temperatures for the Hood/Wind at 7-20 degrees C (USFS 1993). However, this broad range was not very informative for historical individual reach scale temperatures. The only historical temperature data that we located were temperatures recorded in the 1930's and 40's while biologists inventoried salmon abundance and distribution (WDF 1951). Since this data consisted of spot measurements and many basins had been altered by human activity, it was not useful in estimating maximum water temperatures. Stream temperature generally tends to increase in the downstream direction from headwaters to the lowlands because air temperature tends to increase with decreasing elevation, groundwater flow compared to river volume decreases with elevation, and the stream channel widens decreasing the effect of riparian shade as elevation decreases (Sullivan et al. 1990).

To estimate historical maximum temperature, human activities that effect thermal energy transfer to the stream were examined. Six primary process transfer energy to streams and rivers: 1) solar radiation, 2) radiation exchange with the vegetation, 3) convection with the air, 4) evaporation, 5) conduction to the soil, and 6) advection from incoming sources (Sullivan et al. 1990). The four primary environmental variables that regulate heat input and output are: riparian canopy, stream depth, local air temperature, and ground water inflow. Historical riparian conditions along most stream environments in the Lower Columbia River domain consisted of old growth forests. Currently most riparian areas are dominated by immature forest in the lower portions of many rivers. Trees in the riparian zone have been removed for agriculture, and residential or industrial development (Wade 2002). Therefore, on average historical maximum temperatures should be lower than current temperatures.

A temperature model developed by Sullivan et al (1990) assumed there is a relationship between elevation, percentage of shade and the maximum daily stream temperature. This model was further described in the water quality appendix of the current Washington State watershed analysis manual (WFPB 1997). Elevation of stream reaches is estimated from USGS maps. The sky view percentage is the fraction of the total hemispherical view from the center of the stream channel. To estimate the sky view we used the estimated maximum width and assumed that trees in the riparian zone were present an average of 5 meters back from the maximum wetted width. Next we assumed that the riparian zone would consist of old growth cedar, hemlock, Douglas Fir, and Sitka spruce. Mature heights of these trees are estimated to be between 40 – 50 meters for cedar and 60 - 80 meters for Douglas fir (Pojar and MacKinnon 1994). For modeling, we used 49 meters as the average riparian tree height within the western hemlock zone and a canopy density of 85% was assumed (Pelletier 2002). The combination of the height of the bank and average effective tree height was approximately 40 meters for old growth reaches. A relationship was developed between forest shade angle and bankfull width. To estimate the percentage of shade, we used the relationship between forest angle and percentage of shade (WFPB 1997 Appendix G-33.). Finally we used the relationship between elevation, percentage of shade and the maximum daily stream temperature to estimate the maximum temperature (Sullivan et al. 1990, page 204 Figure 7.9). This information was used to establish the base for maximum historical water temperature. These were converted to EDT ratings based on a regression of EDT ratings to maximum temperatures.

The percentage shade from old growth forests in Oregon was estimated to be 84% (Summers 1983) and 80% to 90% in western Washington (Brazier and Brown 1973). For small streams our estimates of stream shade were similar. In comparison to Pelletier (2002), our historical temperatures were slightly lower in small tributaries and slightly higher in the lower mainstem reaches. We developed a correction factor for small tributaries, which consisted of adding 0.3 to the estimated historical EDT rating. These differences are not unexpected, since our simplistic temperature model used only elevation/air temperature and shade, while Pelletier (2002) used QUAL2K, which includes other parameters. We recommend more sophisticated temperature models be used in future analysis because they more accurately estimate temperatures. However, due to limited resources available for this study, the shade/elevation model was used for consistency throughout the Lower Columbia River.

Level of Proof: A combination of derived information and expert opinion was used to estimate the historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive.

7.10.3.25 Temperature – daily minimum (by month)

Definition: Minimum water temperatures within the stream reach during a month.

Rationale: Pacific Groundwater Group (PGG) has maintained a spreadsheet containing all water quality data for Salmon Creek performed by Clark Public Utilities (CPU), Clark County Water Quality (CCWQ), and Washington Department of Ecology (WDOE) from October 1988 through June 2003. The data has been collected by monthly grab samples resulting in an incomplete data set for wintertime temperatures. Ten years were captured on Cougar, Mill, Curtin, and Woodin Cr, whereas eleven years were captured on the mainstem monitoring locations. January of 1997 was the coldest month recorded throughout the watershed. The number of samples below 4° C for the month of January for all years collected are presented in Table 11.

Table 11. Water Quality monitoring grab locations for Salmon Creek with number of samples under 4° C for January and associated EDT reaches (1998-2002).

Location	EDT Reach	Lowest Temp °C	# samples under 4°C
Cougar Cr	CougarCanyon1	4.2	0
Mill Cr	Mill1	1.5	3
Curtin Cr	Curtin1	5.3	0
Woodin Cr	Weaver1	3.6°	1
Salmon Cr @ 36th Ave	Salmon8	2.8°	1
Salmon Cr above Mill Cr	Salmon18	2.5°	1
Salmon Cr above Woodin Cr	Salmon21	2.2°	1
Salmon Cr @ 199th St	Salmon30	3.6°	1

In addition, grab data for the current water year was analyzed with the following <4° temperature results. Table 12 summarizes the results.

Table 12. Water Quality monitoring grab locations for Salmon Creek with temperatures less than 4° C and associated EDT reaches.

Location	EDT Reach	Date	Time	Temp (C)
Woodin Cr at Caples Road	Weaver1	12/09/02	11:43	2.0
Mill Cr at Salmon Creek Avenue	Mill1	12/09/02	10:47	3.6
Salmon Cr at NW 36th Avenue	Salmon8	12/09/02	10:30	3.8
Salmon Cr at NE 50th Avenue	Salmon18	12/09/02	11:00	3.0
Salmon Cr at Caples Road	Salmon21	12/09/02	11:34	2.2
Salmon Cr at NE 199th Street	Salmon30	12/09/02	12:22	3.4

Two other stations were monitored for temperature throughout the cold months for the winter of 2002-2003. Table 13 summarizes the number of days under 4° C.

Table 13. Two Water Quality monitoring grab locations for Salmon Creek with number of days less than 4° C for the winter months of 2002-2003 and associated EDT reaches.

Location	EDT Reach	Month	# Days under 4°C
Salmon Cr @ Klineline Footbridge	Salmon13	November	2
Salmon Cr @ Klineline Footbridge	Salmon13	December	3
Salmon Cr @ Klineline Footbridge	Salmon13	January	2
Salmon Cr @ 156th Street	Salmon19	November	11
Salmon Cr @ 156th Street	Salmon19	December	10
Salmon Cr @ 156th Street	Salmon19	January	2

Salmon Creek @ 156th Street displays questionable data. The habitat there has been altered, resulting in a long, slow-moving glide. This may have some effect on temperature, as well as the location of the temperature monitor. All the above mentioned reaches (Salmon8,13,18,19,21&30, Mill1, CougarCanyon1, Curtin1, and Weaver1) will be given an EDT rating of 1 for the current condition with the exceptions of Cougar Cr and Curtin Cr.

The data could not be plugged into the EDT Temp Calculator, so categorical conclusions were made based on available data. The historic minimum temperature was assumed to be unimpaired thus resulting with the coldest day >4 deg C.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. Expert opinion was used to estimate historic ratings.

7.10.3.26 Temperature – spatial variation

Definition: The extent of water temperature variation within the reach as influenced by inputs of groundwater.

Rationale: Historically there was likely significant groundwater input in low gradient, unconfined to moderately confined reaches of lower watersheds. Presently, it is believed that the number of impervious areas has reduced groundwater recharge and decreased groundwater input.

Higher gradient reaches of the mainstem and tributaries higher in the watershed likely had less groundwater input. These reaches were likely similar to the historic condition and were given an EDT rating of 2 for the current condition. In the current condition, groundwater input in low gradient, unconfined to moderately confined reaches low in the watershed has likely been reduced by current land use practices. These reaches were given an EDT rating of 2 for the current condition. The temperature regime of Curtin Cr has obviously shown the effects of groundwater input, by maintaining more constant temperatures throughout the year. Vegetation has also been observed which indicates upwelling. It is clearly evident that this stream is pre-dominantly groundwater fed and was given an EDT rating of 0.

For the historical condition, reaches with gradients less than 2% and an EDT confinement rating of 2 or less were given an EDT rating of 1 for Temperature-Spatial Variation. The exception to this was Salmon14_C, which has a derived GIS gradient of 2.03%. Historically, this reach was in a lower undisturbed gradient class, and it was also given an EDT rating of 1.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.27 Alkalinity

Definition: Alkalinity, or acid neutralizing capacity (ANC), measured as milliequivalents per liter or mg/l of either HCO3 or CaCO3.

Rationale: Conductivity was calculated using the formula: Alkalinity =0.421*Conductivity – 2.31 from Ptolemy (1993). Conductance values were provided by Clark Public Utilities who recorded monthly grabs by using a Hatch Field Test Kit and/or by taking water samples back to the lab for analysis. EDT values ranged from 1.7 – 3.0 throughout the watershed. The mainstem ranged from 1.7 in the headwaters (Salmon30, @199th St) to 2.7 in the lower watershed (Salmon8, @ 36th Ave) near tidal influence. Cougar Creek at 119th street displayed a moderate flow average alkalinity value of 94.2 mg/L, which corresponded to the high EDT rating of 3.0. Values were applied to entire subwatersheds that include the monitoring grab locations. For example, if Mill1 was monitored, all reaches in the Mill Creek subwatershed (Mill1-5, RBtrib2-1, 2-2, and 3) were given the value of Mill1. Alkalinity in the historic condition was given the same value as the current condition. Table 14 summarizes the alkalinity analysis results for CPU monitoring grabs:

Table 14. Alkalinity analysis results for CPU monitoring grabs during 2000-2002 moderate flows.

Site	**EDT reach**	**EDT Rating**	**Cond. µs**	**Alkalinity mg/L**
Site 1: Salmon Cr. @ NW 36th Ave.	Salmon8	2.7	157.47	63.99
Site 2: Cougar Creek	CougarCanyon1	3	229.26	94.21
Site 3: Mill Creek	Mill1	2.7	159.04	64.65
Site 4: Salmon Cr. above Mill Cr.	Salmon18	2.6	117.61	47.21
Site 5: Curtin Creek	Curtin1	2.8	187.60	76.67
Site 6: Salmon Cr. @ Caples Rd.	Salmon21	2.1	71.21	27.67
Site 7: Woodin Creek	Weaver1	2.7	159.63	64.89
Site 8: Salmon Creek @ NE 199th St.	Salmon30	1.7	46.56	17.29

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations.

7.10.3.28 Dissolved oxygen

Definition: Average dissolved oxygen within the water column for the specified time interval.

Rationale: Dissolved oxygen (DO) in the template (historic) condition was assumed to be unimpaired. Data was based on monthly grabs at long-term monitoring stations on Salmon Creek maintained by Clark Public Utilities (CPU), which was compiled into the Salmon Creek Limiting Factors Analysis (LFA). The LFA analysis was conducted based on Washington Conservation Commission (WCC) rating criteria for basin characteristics. "WCC rates DO as 'poor' if the concentration is below 6 mg/L; 'good' if above 8 mg/L and fair for values in-between"…further rating criteria was established providing "poor, fair, good ratings based on the percent of samples that exceeded WCC values. An exceedence of less than 10 percent of the samples is 'good', 10-20 percent is 'fair' and greater than 20 percent was rated as 'poor'". According to the Salmon Creek LFA, all 8 long-term monitoring locations rated 'good', with the exceptions of Curtin Creek and Salmon Creek at 36th Avenue, which both rated 'fair' (HDR 2002). The good ratings correspond with EDT ratings of 0 and the fair ratings correspond with EDT ratings of 1. Calculations were made on quantitative measurements recorded during CPU's monthly grabs.

Curtin Cr showed an average DO level of 7.13 mg/L for August readings in 2001, 2002, and 2003 which results in an EDT rating of .9. This rating was applied to all of Curtin Cr. Mill Cr @ Salmon Cr Avenue showed a DO level of 7.78 mg/L in August, 2002, which corresponds, to an EDT rating of .2. This rating was applied to all of the Mill Creek reaches. Weaver Cr showed an average DO level of 7.95 mg/L for August readings in 2001, 2002, and 2003 which results in an EDT rating of .1. This rating was applied to the first reach (Weaver1) and 0's for the upstream reaches. Salmon Cr @ 36th Avenue (Salmon8) had an average DO level of 6.7 mg/L for August readings in 2001 and 2003 and received an EDT rating of 1.2. Salmon Cr @ Caples Rd (Salmon21) had a DO level of 7.93 mg/L in August, 2002, which results in an EDT rating of .1. The ratings on the mainstem were feathered between a rating of 1.2 at 36th Ave (Salmon8) and .1 at Caples road (Salmon21).

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. A combination of empirical observations and expert opinion was used to estimate the historical ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. There is more uncertainty in the ratings for reaches with sloughs, than for riverine reaches.

7.10.3.29 Metals – in water column

Definition: The extent of dissolved heavy metals within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition. Therefore all reaches were given an EDT rating of 0 for current and historical conditions.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because, of the lack of data.

7.10.3.30 Metals/Pollutants – in sediments/soils

Definition: The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels.

It should be noted that, "Volatile organic compounds (VOCs) have been detected in two monitoring wells in the lower Salmon Creek basin and in the Bennet well, which is immediately down gradient from the Boomsnub Superfund site" (PGG et al.1998) The VOCs found in the two lower monitoring wells were PCE and TCA, chlorinated solvents which are toxic, mobile, and persistent in groundwater. One of these two lower sites also contains relatively high nitrate concentration. "Boomsnub operated as a metal plating facility from 1967 until June 1994 at 7608 NE 47th Avenue. BOC Gases (formerly Airco), located across the street at 4658 NE 78th Street, is an active compressed gas manufacturing plan. For the purpose of environmental investigation, Boomsnub and BOC Gases are considered as one site because migrating contamination from both facilities has resulted in a merged plume of contaminated groundwater consisting of VOCs and chromium." (PGG et al. 1998) In 1994, the Boomsnub building was demolished and over 6,000 tons of chromium-contaminated soil was removed. Since 1990, a pump-and-treat system has been operating to contain the VOC and chromium plume in the Pleistocene Alluvial aquifer.

Although there is a plume of contaminated groundwater, the effects to the Salmon Creek stream system is unknown, therefore, current levels are unknown and were assumed to be the same as the template condition. All reaches were given an EDT rating of 0 for current and historical conditions.

Level of Proof: A combination of derived information and expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.10.3.31 Miscellaneous toxic pollutants – water column

Definition: The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.

Rationale: Historically (template condition), toxic chemicals and metals in the water column and/or sediment were assumed to be non-existent or at background levels. Current levels are unknown and were assumed to be the same as the template condition. Therefore all reaches were given an EDT rating of 0 for current and historical conditions.

Level of Proof: Expert opinion was used to estimate the current and historical ratings for this attribute and the level of proof is speculative with little empirical support because of the lack of data.

7.10.3.32 Nutrient enrichment

Definition: The extent of nutrient enrichment (most often by either nitrogen or phosphorous or both) from anthropogenic activities. Nitrogen and phosphorous are the primary macro-nutrients that enrich streams and cause build ups of algae. These conditions, in addition to leading to other adverse conditions, such as low DO can be indicative of conditions that are unhealthy for salmonids. Note: care needs to be applied when considering periphyton composition since relatively large mats of green filamentous algae can occur in Pacific Northwest streams with no nutrient enrichment when exposed to sunlight.

Rationale: Actual data for this attribute is very limited. Historically nutrient enrichment did not occur because watersheds were in the "pristine" state. Lack of EDT quantifiable data (Chlorophyll a levels) forced assumptions to be made. An EDT rating of 1 is applied to all reaches with the exception of reaches showing high gradients and/or are surrounded by forested, rural land, which receive a 0. An EDT rating of 2 is applied to Morgan3_A, RBtrib8, Salmon19, Weaver2, which all have dairy operations or a large number of cows/horses directly in the creek, and to Salmon22 where the Cedars Golf Course is located.

Level of Proof: Expert opinion was used to estimate the current ratings for this attribute and the level of proof is speculative with little empirical support because the lack of data. Empirical observations were used to estimate the historical ratings for this attribute and the level of proof is thoroughly established.

7.10.3.33 Fish community richness

Definition: Measure of the richness of the fish community (no. of fish taxa, i.e., species).

Rationale: Historical fish community richness was estimated from the current distribution of native fish in these watersheds (see below). Reimers and Bond (1967) identify 17 species of fish endemic to the Lower Columbia River and its tributaries, and their current distribution.

Current fish community richness was estimated from direct observation (stream surveys and electro-shocking), personal communications with professional fish biologists familiar with these areas, and local knowledge. Anadromous fish distribution was estimated from the above as well as from the SSHIAP fish distribution layer & EDT reach descriptions developed by Ned Pittman (WDFW). Data from the following sources were used to better clarify the current fish distribution in Salmon Cr: (1) Screen panel juvenile trap 1.5 km upstream from the mouth of Cougar Cr (Ecology 1989), (2) species present in Hardy Slough (pers. com. Coley, USFWS), (3) Reimers and Bond (1967), and (4) McPheil (1967).

Sixteen incidental fish species trapped at the screen trap include the following: long nose dace, red side shiner, sculpin, northern squawfish, speckled dace, bridge lip sucker, three-spined stickleback, brown bullhead, bluegill, Chinook salmon, pumpkinseed sunfish, pacific lamprey, chiselmouth, mountain whitefish, peamouth, and goldfish (Ecology 1989).

Lower Salmon Creek below Cougar Cr is tidally influenced from the Columbia River backwaters (Ecology 1989) and will likely have many species present from the Lower Columbia River. An estimated 29 species were included in this list: Chinook, chum, Coho, steelhead/rainbow, cutthroat, sculpin sp(3) (torrent, coastrange, reticulate), bridgelip and largescale sucker, peamouth, northern pikeminnow, smelt, sandroller, redside shiner, large & smallmouth bass, carp, goldfish, white & black crappie, eastern banded killifish, yellow perch, sunfish, pumpkinseed, brown & yellow bullhead, white sturgeon, 3-spine stickleback. Most of these fish likely drop out as gradient increases and water temperatures are reduced.

Spot sightings of fish include redside shiner observed throughout Curtin Cr (Manlow 2003), speckled dace found in tributary to Curtin Cr (Dugger 2003), brown bullhead and blue-gill observed in Mill Cr (Weinheimer 2003) and brown bullhead observed in Morgan Cr (Local 2003). Eastern banded killifish, smallmouth bass, bluegill, pumpkinseed, and goldfish were observed (Kelsey 2003) in the back Klineline pond (EDT reach Klineline1) that has direct connection with Salmon Cr (EDT reach Salmon12).

According to SSHIAP's fish distribution layer, Coho, Steelhead and Cutthroat are present throughout the watershed, with only potential distribution on Baker Cr above failed fishway and Little Salmon Cr above culvert. Although Steelhead do not penetrate as far as Cutthroat and Coho, distribution ends one EDT reach above where the creeks become to skinny to spawn. Private ponds exist throughout the watershed with potential introductions of pan fish being raised, so one more taxa is added to documented fish.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.10.3.34 Fish species introductions

Definition: Measure of the richness of the fish community (no. of fish taxa). Taxa here refers to species.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. Introduced species were derived from current fish species richness data (see Fish Community Richness above). Spot sightings of fish include brown bullhead and blue-gill observed in Mill Cr in 2003 and brown bullhead observed in Morgan Cr ((pers. com. John Weinheimer WDFW). Private ponds exist throughout the watershed with potential introductions of pan fish being raised, so one more taxa is added to documented introductions.

The lower reaches of Salmon Creek likely have many non-native fish from the Lower Columbia River. An estimated 13 species were included in this list: bluegill, large & smallmouth bass, carp, goldfish, white & black crappie, Eastern banded killifish, yellow perch, pumpkinseed, sunfish, brown & yellow bullhead. Most of these fish likely drop out as gradient increases and water cools down. The majority of these species were dropped out on Salmon Cr at Cougar Cr or at the end of tidal influence.

Estimated introductions are:

Table 15. EDT ratings for fish species introductions.

Section/Species	Rating
Curtin Cr=1 species	EDT rating=0.5
Mill Cr=3 species	EDT rating=1.5
Morgan Cr=2 species	EDT rating=1
Upper Mainstem & Rock Cr=1 species;	EDT rating=0.5
Weaver Cr=1 species;	EDT rating=0.5
Other Tribs=1 species	EDT rating=0.5
Mainstem from Morgan – Curtin=2 species	EDT rating=1
Mainstem from Curtin – Mill=3 species;	EDT rating=1.5

Mainstem from Mill – HWY 99 falls=4 species;	EDT rating 1.7
Mainstem from HWY 99 falls – Cougar=5 species;	EDT rating 1.9

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.10.3.35 Hatchery fish outplants

Definition: The magnitude of hatchery fish outplants made into the drainage over the past 10 years. Note: Enter specific hatchery release numbers if the data input tool allows. "Drainage" here is defined loosely as being approximately the size that encompasses the spawning distribution of recognized populations in the watershed.

Rationale: By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions. In the historic condition (prior to 1850 and European settlement), there were no hatcheries or hatchery outplants.

Hatchery releases of Chinook, Coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2003 and were confirmed with discussions with WDFW staff (Dick Johnson and John Weinheimer) were consulted as well. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency. A WDFW Co-operative project, which reared Coho salmon on Baker Cr., was discontinued in 1996. These reaches were given an EDT rating of 0. Net-pen raised Cutthroat in Klineline pond were discontinued after 1999.

90,000 Coho are raised each year via RSI's in a pond by Curt Anderson's house just below 182nd Ave. An EDT rating of 4 was given to this reach (Salmon25) and below. Net-pen raised Steelhead occur in the Klineline pond planting 20,500 in 2002, and 19,950 in 2003. An EDT rating of 4 was given to reaches below Klineline pond (Salmon13 and down).

One remote site incubator (RSI) has been used on Mill Creek in the past just below the reservoir, but the operator passed away a couple years ago. This creek actually drains into two watersheds: Salmon Creek and East Fork Lewis River. Most of the flow goes to the East Fork whereas habitat and flow are very questionable in reaches below the split heading towards Salmon Creek. WDFW Biologist Weinheimer states he has helped landowners rescue mostly wild origin stranded Coho and released them downstream in the creek to outmigrate through the East Fork Lewis River system with much success on returns. Therefore Mill4 receives a rating of 4 and Mill1-3 received a 4 (2003).

CPU operates 5 RSI's for Coho within the drainage, 10,000 eggs each at the following locations: Curtin1, Meadow Glade 'ditch' upstream of Rbtrib4, Salmon22 @ Brush Prairie, Rbtrib9-1, and LittleSalmon1. These reaches and below were given an EDT rating of 4. Net-pen raised

Steelhead occur in the Klineline pond planting 20,500 in 2002, and 19,950 in 2003. An EDT rating of 4 was given to reaches below Klineline pond (Salmon13 and down).

CPU also heads the Salmon in the Classroom program. This program takes aquarium raised Coho (low numbers) and releases them throughout the Salmon Creek and Washougal River watersheds. The number of fish released varies and release sites are concentrated in easy-access park-like locations (pers. comm. Dean Sutherland CPU). One EDT reach above RSI's, access provided, was also rated at 4, and the first reach of tributaries to take into account for the possibility of Coho receiving refuge from high mainstem flows during the winter.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.10.3.36 Fish pathogens

Definition: The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.

Rationale: For this attribute the release of hatchery salmonids is a surrogate for pathogens. In the historic condition there were no hatcheries or hatchery outplants and we assumed an EDT rating of 0. Hatchery releases of Chinook, Coho, steelhead, sea-run cutthroat, and chum were queried from the Columbia River DART (Data Access in Real Time) database (University of Washington, 2003) for the years 1993-2002. A spreadsheet summarizing releases was developed to determine hatchery outplant frequency.

A WDFW Co-operative Coho program on Baker Cr were discontinued in 1996. These reaches will be given an EDT rating of 0. Approximately 90,000 Coho are raised each year via RSI's in a pond just below 182nd Ave. An EDT rating of 2 was given to this reach (Salmon25) and below. Net-pen raised Steelhead occur in the Klineline pond planting 20,500 in 2002, and 19,950 in 2003. Net-pen raised Cutthroat in Klineline pond were discontinued after 1999. An EDT rating of 2 was given to reaches below Klineline pond (Salmon13 and down). The following table was developed:

Table 16. Coho, Steelhead, and cutthroat releases into Salmon Creek.

year	Winter Steelhead	Baker Cr. Coho Salmon	Below 182nd Ave Coho Salmon	Sea-Run Cutthroat
1993	18,910	200,000	nd	10,067
1994	16,962	69,509	nd	0
1995	15,492	13,250	nd	10,705
1996	20,200	1,725	nd	11,020
1997	20,727	0	nd	12,176
1998	40,895	0	nd	0
1999	28,011	0	90,000	12,300
2000	20,000	0	90,000	0
2001	0	0	90,000	0
2002	20,500	0	90,000	0
2003	19,950	0	90,000	0

CPU operates RSI's for Coho in the following locations: Curtin1, Meadow Glade 'ditch' upstream of Rbtrib4, Salmon22 @ Brush Prairie, Rbtrib9-1, and LittleSalmon1. These reaches and below were given an EDT rating of 2.

One RSI has been used on Mill Creek in the past, but the operator passed away a couple years back just below the reservoir. This creek actually drains into two watersheds: Salmon Creek and East Fork Lewis River. Most of the flow goes to the East Fork whereas habitat and flow are very questionable in reaches below the split heading towards Salmon Creek. WDFW has helped landowners rescue mostly wild origin stranded Coho and released them downstream on the creek to outmigrate through the East Fork Lewis River system with much success on returns. Therefore Mill1-4 receive an EDT rating of 2. One EDT reach above RSI's, access provided, and the first reach of tributaries to take into account for the possibility of Coho receiving refuge from high mainstem flows during the winter were also given an EDT rating of 2.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.10.3.37 Harassment

Definition: The relative extent of poaching and/or harassment of fish within the stream reach.

Current: In the historic condition (prior to 1850 and European settlement), harassment levels were assumed to be low. By definition the template conditions for this attribute are rated as a value of 0 because this describes this attribute rating for watersheds in pristine conditions.

Conversations with local fishermen, landowners and biologists were consulted to determine areas of extensive fishing and/or swimming use. County maps were also examined to identify the proximity of stream reaches to population centers, and to estimate access via roads, bridges, gates, boat launches, etc. An EDT rating of 4 was given to reaches with extensive road access and high recreational use (i.e. below the Hwy 99 falls downstream to about ½ mile below Klineline park, Cedar's Golf Course, Woodin Cr through Battleground); an EDT rating of 3 was given to areas with road access and proximity to population center and moderate use (i.e. Salmon Cr above Hwy 99 falls upstream to Mill Cr, Salmon Cr from Woodin Cr to Cedar's Golf Course, Woodin Cr from mouth to Battleground); an EDT rating of 2 was given to reaches with multiple access points (or road parallels reach) through public lands or unrestricted access through private lands (i.e. Salmon Creek through Venersborg and along Risto Road,); an EDT rating of 1 was given to reaches with 1 or more access points behind a locked gate or 1 or more access points but limited due to private lands (i.e. Rock Cr); and an EDT rating of 0 was given to reaches with no roads and/or are far from population centers.

Level of Proof: There is no statistical formula used to estimate harassment. Therefore, expert opinion was used to estimate the current ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations. For historical information, empirical observations were used to estimate the ratings for this attribute and the level of proof is thoroughly established.

7.10.3.38 Predation risk

Definition: Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant). NOTE: This attribute is being updated to distinguish risk posed to small bodied fish (<10 in) from that to large bodied fish (>10 in).

Rationale: By definition the template conditions for this attribute are rated as a value of 2 because this describes this attribute rating for watersheds in pristine conditions An EDT rating of 3 was given to mainstem reaches below LaLonde Creek, due to influence of Columbia River predators in tidally influenced and low gradient accessible reaches.

The magnitude and timing of yearling hatchery smolt releases, and increases in exotic/native piscivorous fishes were considered when developing this rating. The status of top-level carnivores and other fish eating species is unknown in this watershed. We assumed current predation levels were the same as the template, with the following exceptions: below Salmon11 is assumed to have an EDT rating of 4 due to increase in fish community richness, Mill1-5, Morgan1-3_A, Mud1-2, is assumed to have an EDT rating of 4, and Rock1-7 is assumed to have an EDT rating of 3 due to increased predation due to juvenile trapped in isolated pools.

Level of Proof: There is no statistical formula used to estimate predation risk. A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive. For historical information, expansion of empirical observations and expert opinion were used to estimate the ratings for this attribute and the level of proof has theoretical support with some evidence from experiments or observations thoroughly established.

7.10.3.39 Salmon Carcasses

Definition: Relative abundance of anadromous salmonid carcasses within watershed that can serve as nutrient sources for juvenile salmonid production and other organisms. Relative abundance is expressed here as the density of salmon carcasses within subdrainages (or areas) of the watershed, such as the lower mainstem vs. the upper mainstem, or in mainstem areas vs. major tributary drainages.

Rationale: Historic carcass abundance was estimated based on the distribution of anadromous fish in the watershed. Reaches with historic chum presence (spawning) were given a rating of 0. Mainstem reaches with Chinook and Coho, but no chum were given a rating of 2. Reaches with only Coho were given a rating of 3. Reaches with only cutthroat or steelhead were given a rating of 4, since these fish do not die after spawning. Tidal reaches below areas of chum spawning were given a 1 (it was assumed carcasses from spawning reaches above are washed into these reaches).

In Salmon Creek, all template carcass information was determined by the above rules. Historically Coho, cutthroat, and steelhead were distributed throughout the entire basin, which received an EDT rating of 3. Chinook spawned from the end of tidal influence (Salmon11) to Mill Cr (Salmon17) and Chum probably dropped out near the HWY 99 falls (Salmon15). Therefore reaches Salmon11 to Salmon14C receive an EDT rating of 0, and Salmon16 & 17 receive and EDT rating of 2. Tidal reaches (Salmon1 – 10) received a 1.

For the current condition, carcass survey data was consulted. Stream surveys conducted annually by WDFW showed very low redd densities for every reach walked. Harvester and Wille conducted redd surveys in 1988-1989 (Ecology 1989), and their counts expanded to less than 25 carcasses per mile. Current surveys support these low numbers. All reaches receive a 4.

Level of Proof: A combination of empirical observations, expansion of empirical observations, and expert opinion was used to estimate the current ratings for this attribute and the level of proof has a strong weight of evidence in support but not fully conclusive

7.10.3.40 Benthos diversity and production

Definition: Measure of the diversity and production of the benthic macroinvertebrate community. Three types of measures are given (choose one): a simple EPT count, Benthic Index of Biological Integrity (B-IBI)—a multimetric approach (Karr and Chu 1999), or a multivariate approach using the BORIS (Benthic evaluation of ORegon RIverS) model (Canale 1999). B-IBI rating definitions from Morley (2000) as modified from Karr et al. (1986). BORIS score definitions based on ODEQ protocols, after Barbour et al. (1994).

Rationale: FES staff collected benthic macroinvertebrate samples between August 15 and September 10, 2001, at 11 Harvester and Wille (PGG et al. 2002) sites. Macroinvertebrates were sampled and identified using Ecology's Instream Biological Assessment Monitoring Protocols (Plotnikoff, 1994). Aquatic Biology Associates of Corvallis, Oregon, provided taxonomic laboratory services. In addition, data collected in August 1996 by Pratt and others (1998) were reanalyzed for comparison with the 2001 samples. (PGG et al. 2002).

Under Ecology's protocols, erosional (riffle) and depositional (pool/glide) habitat units must be sampled separately at each site. However, some sites—one from the 2001 surveys and three from the 1996 surveys—had no riffles. Consequently, only depositional samples were taken (PGG et al. 2002).

A scale was developed for non-categorical EDT rating and Benthic Macroinvertebrate B-IBI scores. Table 17 shows the results:

Table 17. B-IBI scores and EDT ratings for EDT reaches in the Salmon Creek watershed.

EDT Reach	Habitat Sampled	Year	EDT rating	B-IBI score
Salmon8	pool/glide	1996	3.5	10
Salmon18	riffle	Avg ('96&'01)	2.5	27
Salmon21	riffle	1996	2.7	26
Salmon22	riffle	2001	2.2	30
Salmon25,26	riffle	2001	2.2	30
Salmon30	riffle	Avg ('96&'01)	3.0	23
CougarCanyon1	riffle	1996	3.6	14
Mill1	riffle	Avg ('96&'01)	2.9	24
Mill3	pool/glide	2001	3.0	17
Curtin1	riffle	2001	3.0	22
Weaver1	riffle	2001	2.9	24
Morgan2	riffle	2001	2.0	32
Rock2	riffle	2001	2.4	28
LBtrib8-1 (Rock Cr)	riffle	2001	1.1	40

There were some discrepancies between some of the scores for different years at the same location. An average B-IBI score was applied to come up with an EDT rating.

As the data shows, only two locations in the final ratings were lacking the riffle samples. For all sites where both riffle and pool/glide type habitats were sampled, we compared the difference in EDT ratings. The ratings for pool/glide type habitats averaged 0.4 higher (worse) than the riffle type habitat ratings. Salmon8 and Mill3 were adjusted using this difference resulting in the final EDT ratings shown in the table above. These final EDT ratings were applied to the model and 'feathered' throughout to fill in gaps.

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Washington Lower Columbia
Anadromous Fish Barrier Assessment

8.0 Washington Lower Columbia Anadromous Fish Barrier Assessment

Introduction

For each of six anadromous salmonid species in the LCFRB planning area, we mapped historically accessible stream segments, currently blocked stream segments, and the type and location of passage barriers. This assessment was conducted in GIS using the WDFW Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) fish distribution and barrier datasets (see http://wdfw.wa.gov/hab/sshiap/index.htm).

Methods

The SSHIAP fish distribution and barrier datasets were used as the basis for this assessment. In several cases, the layers were edited where there existed better information on distributions or barriers. To identify historically accessible stream segments, we used those segments coded in the fish distribution layer as either documented, documented trap & haul, documented-historic, presumed, or potential. For the Lewis River above Merwin Dam, there was no distribution of any type identified. For this case, historical distribution was assumed to be the extent of reaches used for runs of the EDT model. This distribution likely underestimates the true distribution, especially for coho.

A conservative approach was taken to identify stream segments currently blocked by artificial barriers. For our analysis, in order for a segment to be identified as blocked, it had to be designated as 'potential' distribution in the fish distribution dataset and had to have a blocking barrier in the barrier dataset. Thus, a two-step method was used to identify blocked segments. First, the segment had to be identified as potential habitat in the fish distribution layer. Potential habitat is defined as that which currently does not support fish for one of three reasons (O'Connor 2002):

1) artificial obstructions

2) poor quality habitat, or

3) extirpation of local fish populations

Second, blocked segments were identified only for areas upstream of artificial barriers documented in the barrier dataset. Barriers created by natural features such as falls, stream gradient, and beaver dams were not considered in this assessment. Barriers designated complete blockage, partial blockage, and unknown blockage in the barrier dataset were all assumed to block passage if located on a potential distribution segment for the species of interest. We did not remove segments where the barrier was designated as a partial blockage or an unknown blockage because some barriers may present different levels of blockage depending on the species; a level of information that was not available in the barrier database.

Although there were many barriers in the barrier dataset that were not located on potential distribution segments, we chose not to infer blocked segments from this information due to the inconsistency with which species-specific blockage information was included in the barrier dataset. Instead, our conservative approach requires conformity between the two datasets in order for a stream segment to be considered blocked.

For each of the 21 LCFRB planning basins, we calculated the amount of blocked habitat, the amount of historically accessible habitat, the amount of currently accessible habitat, the number and type of barriers, and the amount of blocked habitat by each barrier type. For this last calculation, we used only primary barriers; those at the downstream end of the blocked segment. It should be noted that in many cases removing the primary barrier will only restore access to a portion of the blocked segment due to upstream barriers. In most cases, upstream barriers are culverts. Miles of currently accessible stream segments were obtained by subtracting currently blocked miles from historically accessible miles, thus, currently accessible miles do not reflect miles of historically un-accessible stream segments that have been made accessible through human intervention (i.e. fish ladders around falls).

Results

For each species, region-wide maps were developed that depict historically available habitat, currently blocked habitat, and the location and type of barriers (see figures below). Pie charts summarize the amount of historically accessible habitat that is currently blocked by particular types of barriers. The accessible portion of the pie represents the amount of historically accessible habitat that is currently accessible. The information is summarized in a table by species and by each of the 21 LCFRB planning basins.

Discussion

The data presented is limited by the accuracy of the SSHIAP datasets, which have been compiled from a variety of sources and have not been field checked in all cases. Time and resources did not allow for field verification of the information presented in the datasets.

Although we used the most recent datasets that were available, barrier removal projects are on-going throughout the region, and therefore the GIS datasets do not always represent the most recent information. In a few instances, we amended the datasets where more recent information was available.

This assessment likely underestimates the degree of blocked habitat due to the conservative approach taken. There still remain many streams that have not been surveyed for passage barriers. Many of the unsurveyed barriers, however, likely present little in the way of detriment to production at the population scale, as they are primarily located on smaller stream systems with a low amount of potential fish capacity.

This barrier assessment is intended as an overview of the relative degree of blocked habitat by species and by basin. This assessment is useful as a first screen of how much of an impact passage barriers might have on a particular population. Development of specific strategies to restore access should be made with reference to site specific information including Limiting Factors Analyses and the knowledge of local resource managers.

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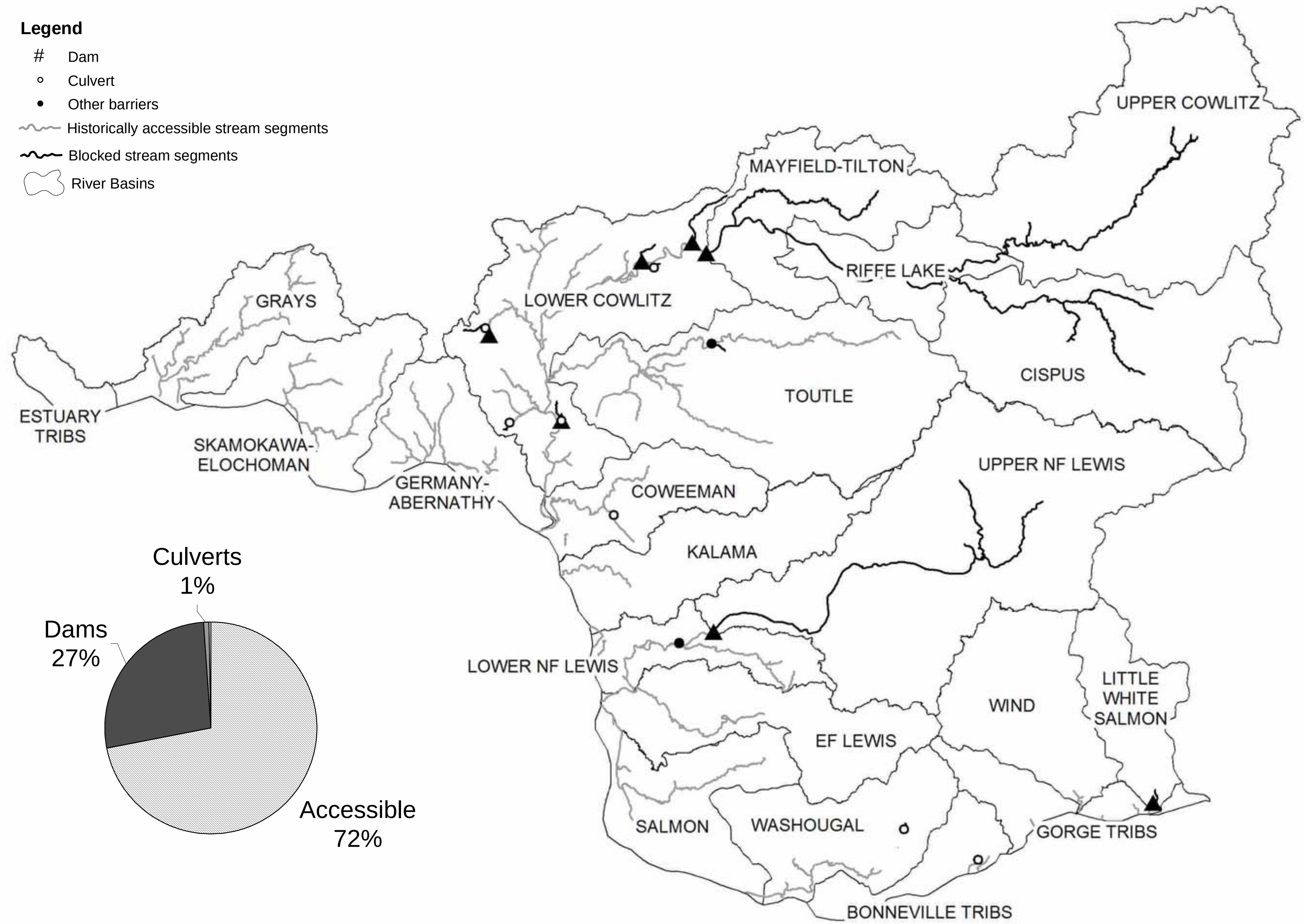
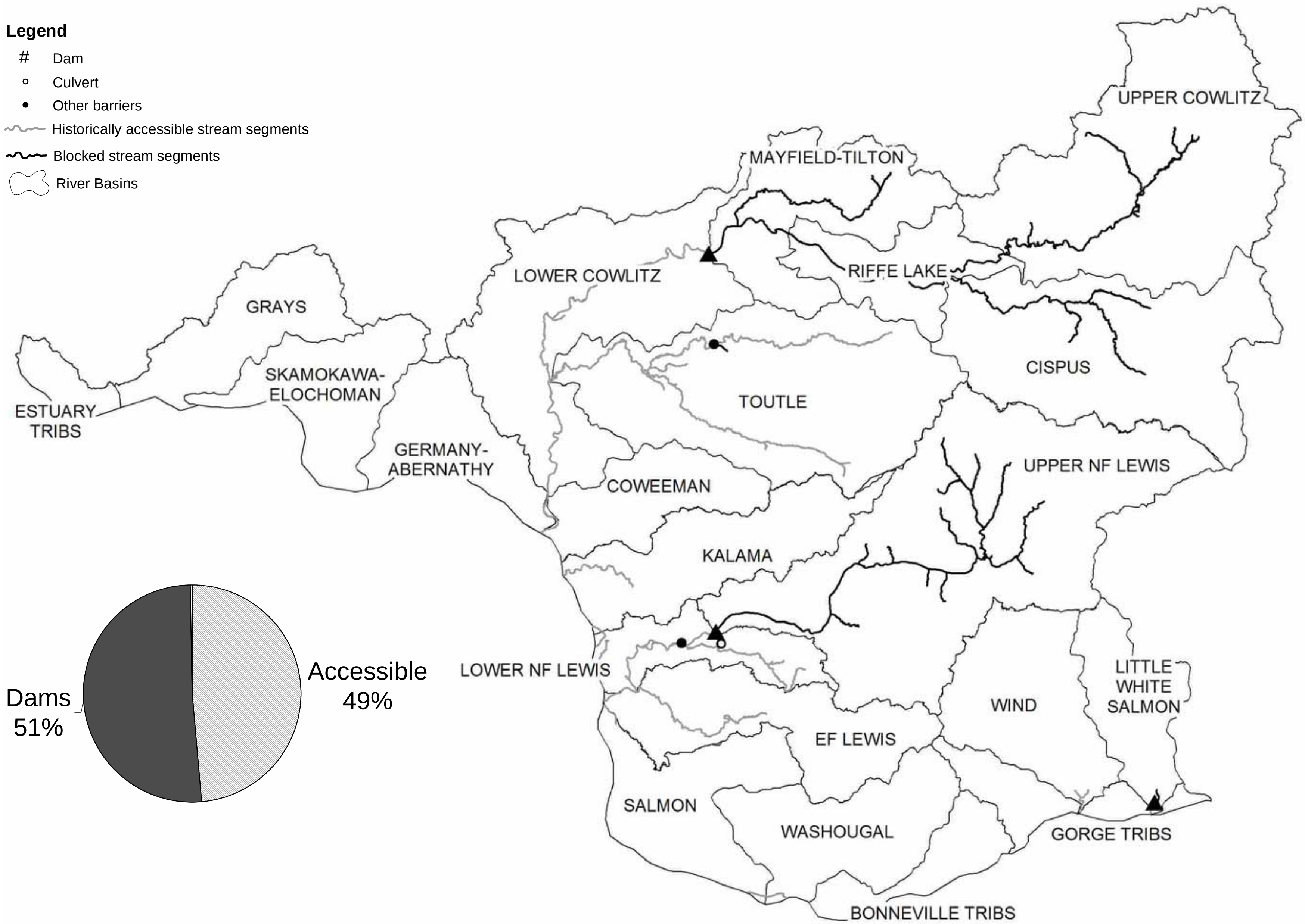
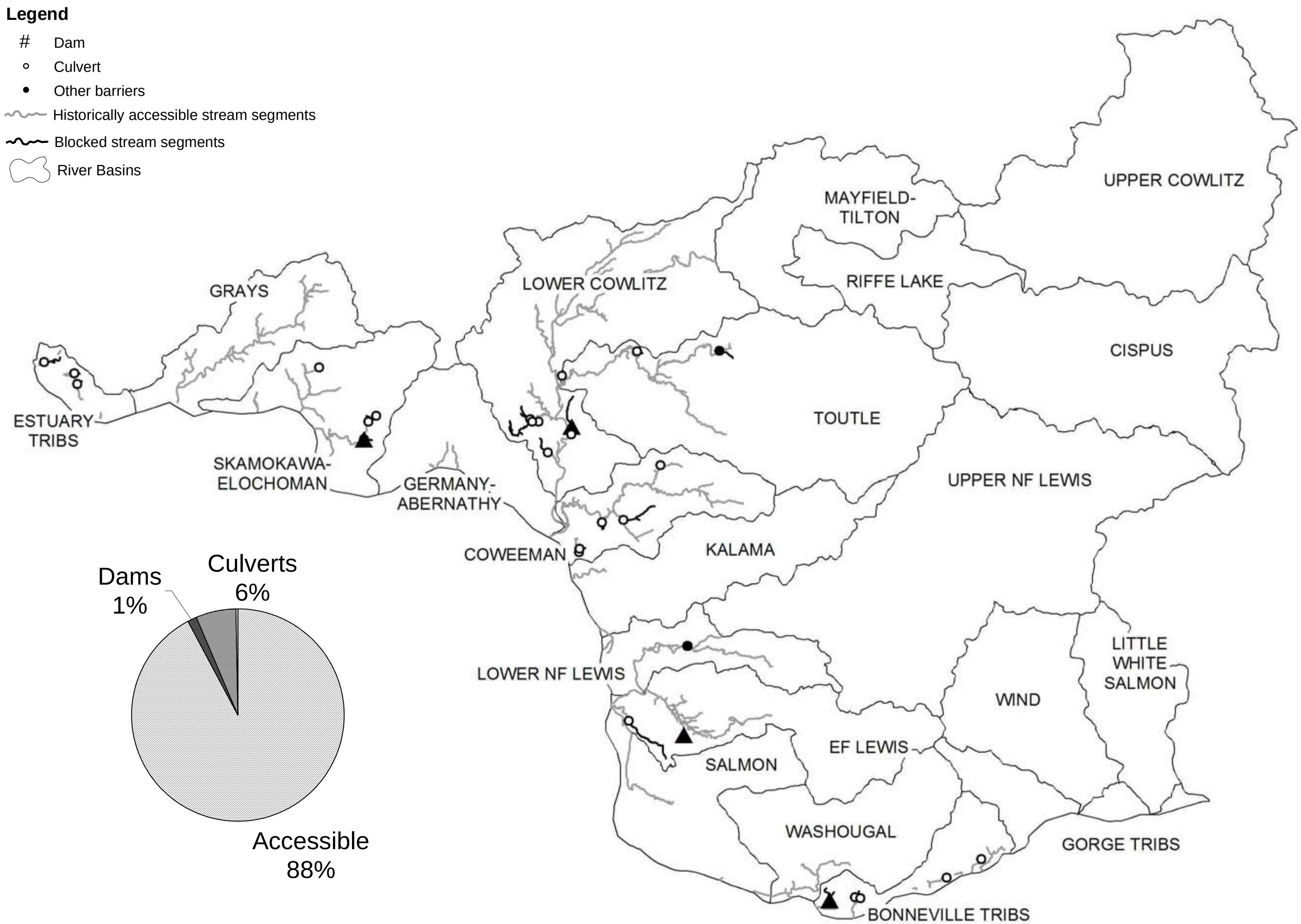
Fall Chinook


Legend
Dam
Culvert
Other barriers
Historically accessible stream segments
Blocked stream segments
River Basins
UPPER COWLITZ
MAYFIELD-TILTON
RIFFE LAKE
LOWER COWLITZ
GRAYS
CISPUS
TOUTLE
ESTUARY TRIBS
SKAMOKAWA-ELOCHOMAN
GERMANY-ABERNATHY
UPPER NF LEWIS
COWEEMAN
KALAMA
LOWER NF LEWIS
WIND
LITTLE WHITE SALMON
EF LEWIS
SALMON
WASHOUGAL
GORGE TRIBS
BONNEVILLE TRIBS
Culverts 1%
Dams 27%
Accessible 72%

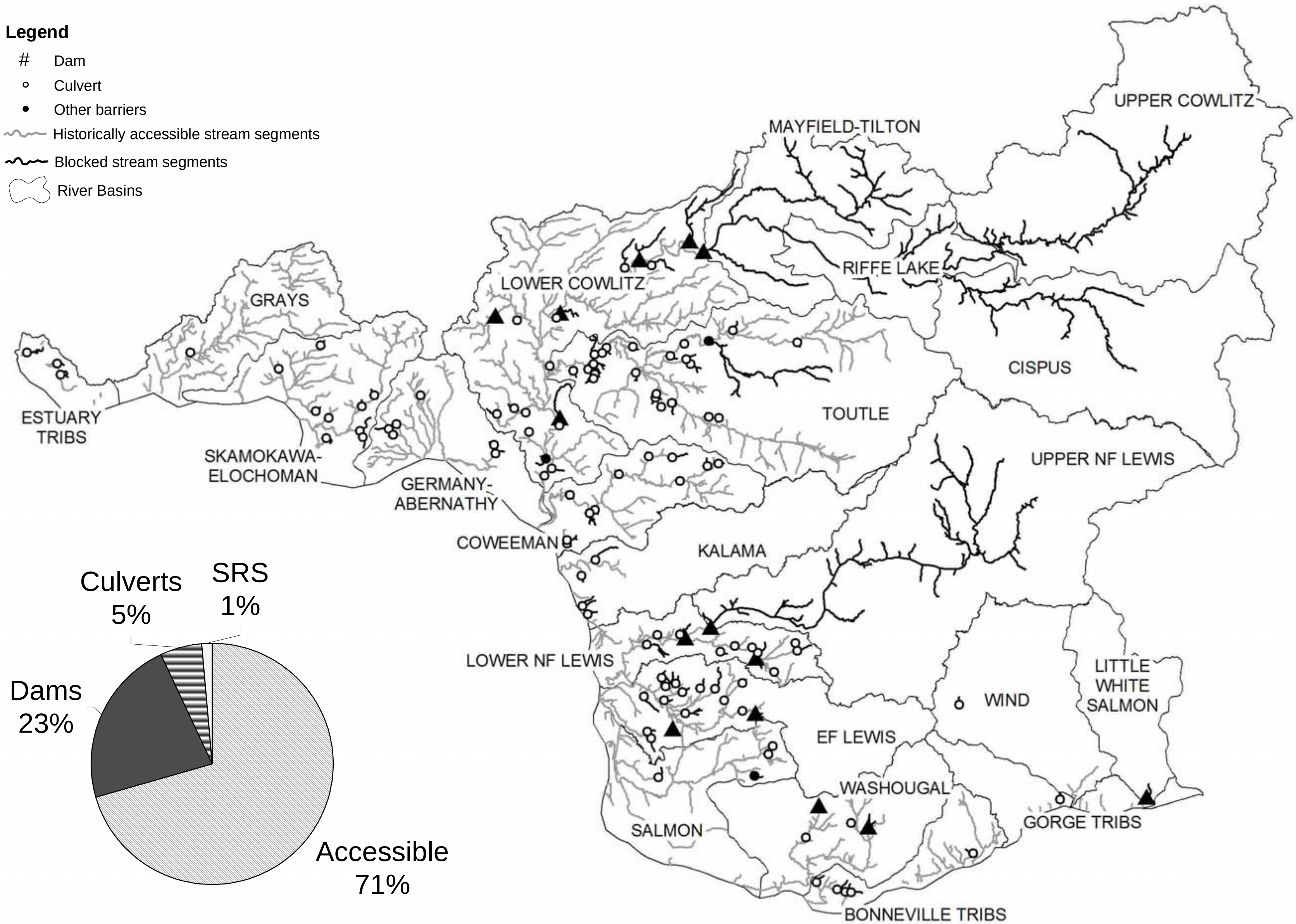
Spring Chinook


Legend
#
Dam
Culvert
Other barriers
Historically accessible stream segments
Blocked stream segments
River Basins
UPPER COWLITZ
MAYFIELD-TILTON
RIFFE LAKE
LOWER COWLITZ
GRAYS
SKAMOKAWA-ELOCHOMAN
ESTUARY TRIBS
TOUTLE
CISPUS
GERMANY-ABERNATHY
COWEEMAN
UPPER NF LEWIS
KALAMA
LOWER NF LEWIS
LITTLE WHITE SALMON
WIND
EF LEWIS
SALMON
WASHOUGAL
GORGE TRIBS
BONNEVILLE TRIBS
Accessible 49%
Dams 51%

Chum

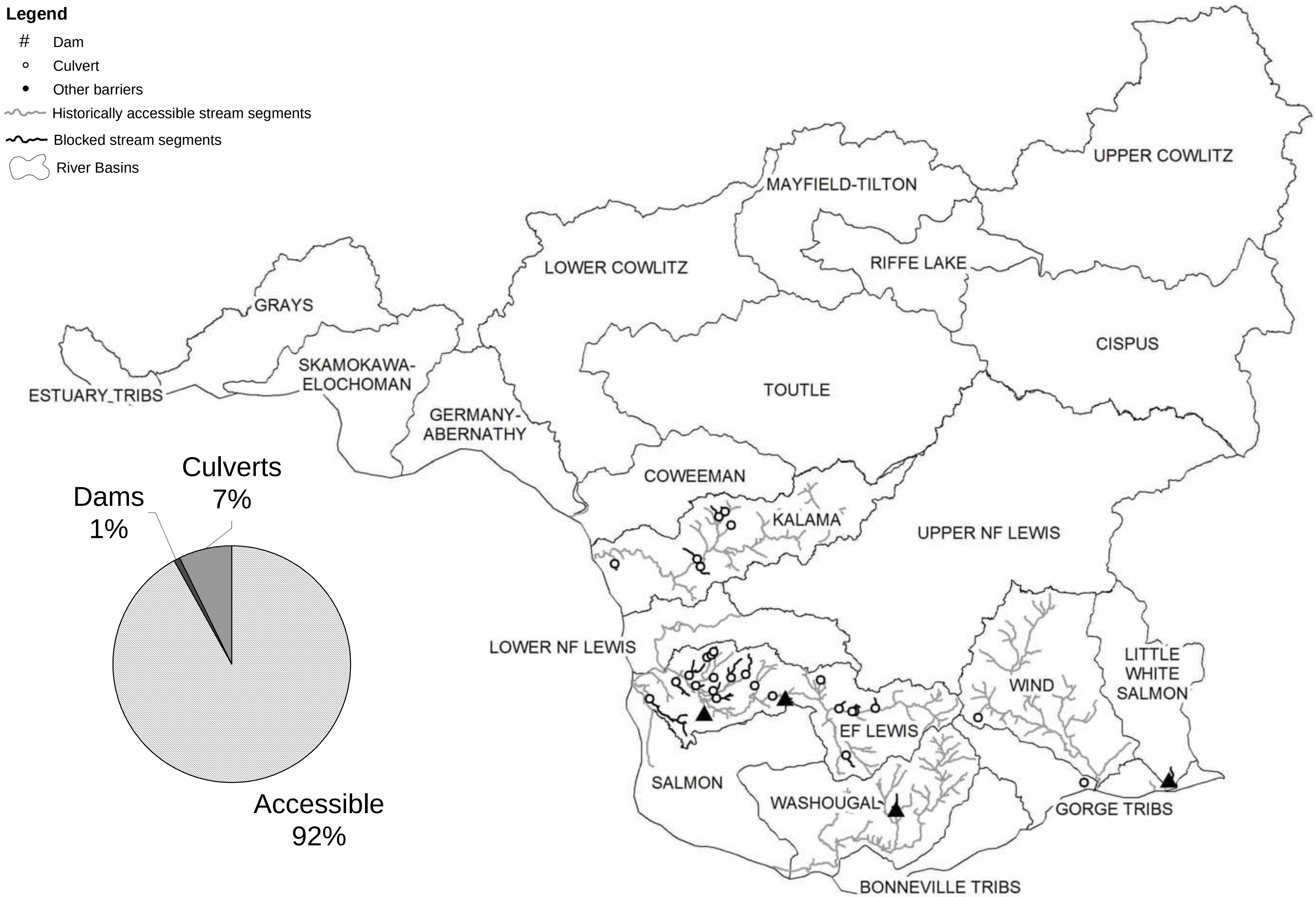

Legend
Dam
Culvert
Other barriers
Historically accessible stream segments
Blocked stream segments
River Basins
UPPER COWLITZ
MAYFIELD-TILTON
RIFFE LAKE
LOWER COWLITZ
GRAYS
CISPUS
TOUTLE
ESTUARY TRIBS
SKAMOKAWA-ELOCHOMAN
GERMANY-ABERNATHY
UPPER NF LEWIS
COWEEMAN
KALAMA
LOWER NF LEWIS
LITTLE WHITE SALMON
WIND
SALMON
EF LEWIS
WASHOUGAL
GORGE TRIBS
BONNEVILLE TRIBS
Dams 1%
Culverts 6%
Accessible 88%

Coho

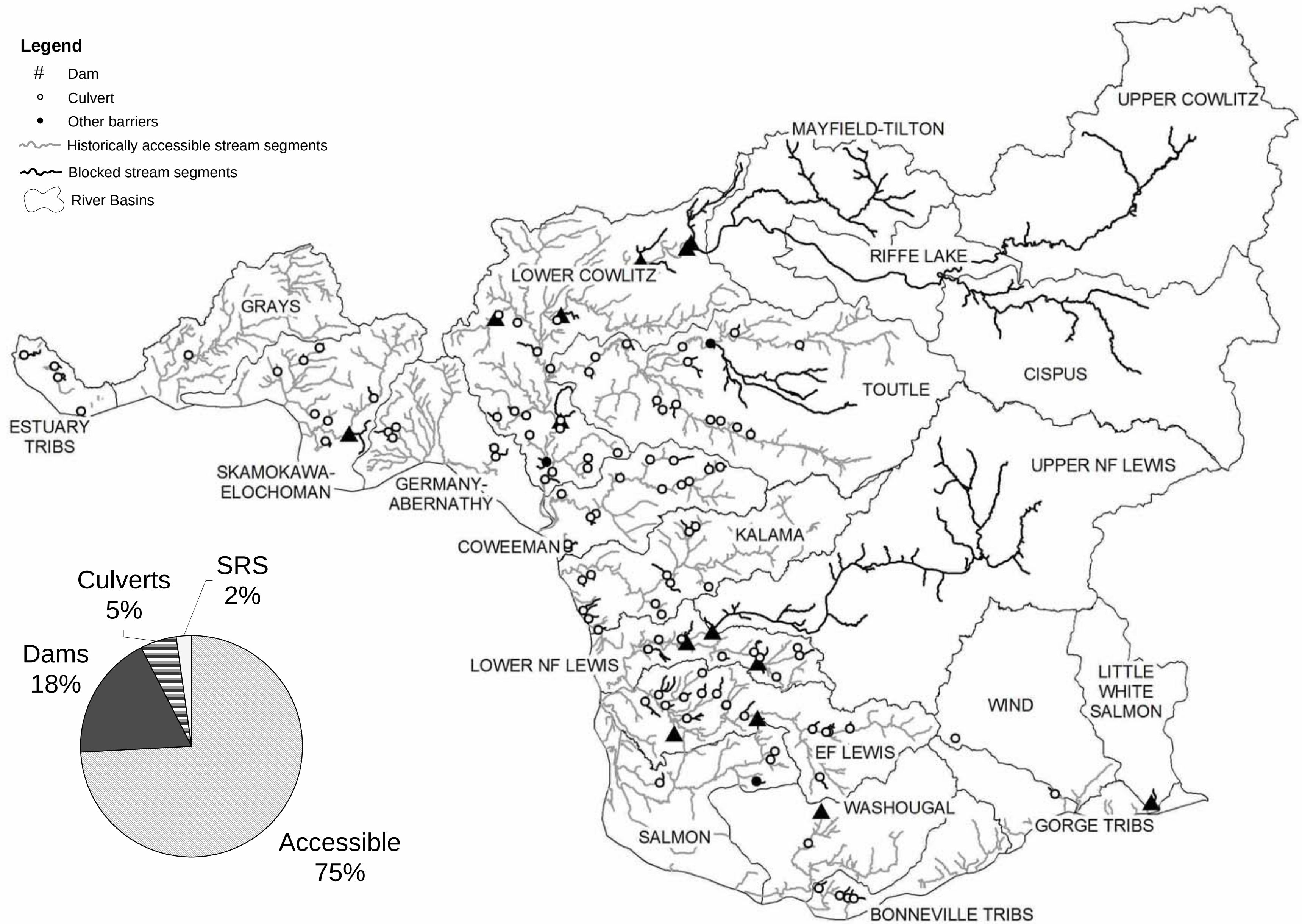


Legend
Dam
Culvert
Other barriers
Historically accessible stream segments
Blocked stream segments
River Basins
UPPER COWLITZ
MAYFIELD-TILTON
RIFFE LAKE
LOWER COWLITZ
GRAYS
CISPUS
TOUTLE
ESTUARY TRIBS
SKAMOKAWA-ELOCHOMAN
GERMANY-ABERNATHY
UPPER NF LEWIS
COWEEMAN
KALAMA
LOWER NF LEWIS
LITTLE WHITE SALMON
WIND
EF LEWIS
WASHOUGAL
GORGE TRIBS
SALMON
BONNEVILLE TRIBS
Culverts 5%
SRS 1%
Dams 23%
Accessible 71%

Summer Steelhead


Legend
Dam
Culvert
Other barriers
Historically accessible stream segments
Blocked stream segments
River Basins
UPPER COWLITZ
MAYFIELD-TILTON
RIFFE LAKE
LOWER COWLITZ
GRAYS
CISPUS
SKAMOKAWA-
ELOCHOMAN
TOUTLE
ESTUARY TRIBS
GERMANY-
ABERNATHY
COWEEMAN
KALAMA
UPPER NF LEWIS
LOWER NF LEWIS
LITTLE
WHITE
SALMON
WIND
EF LEWIS
SALMON
WASHOUGAL
GORGE TRIBS
BONNEVILLE TRIBS
Culverts
7%
Dams
1%
Accessible
92%

Winter Steelhead


Legend
Dam
Culvert
Other barriers
Historically accessible stream segments
Blocked stream segments
River Basins
UPPER COWLITZ
MAYFIELD-TILTON
RIFFE LAKE
LOWER COWLITZ
GRAYS
CISPUS
TOUTLE
ESTUARY TRIBS
SKAMOKAWA-ELOCHOMAN
GERMANY-ABERNATHY
UPPER NF LEWIS
KALAMA
COWEEMAN
Culverts 5%
SRS 2%
Dams 18%
LOWER NF LEWIS
LITTLE WHITE SALMON
WIND
EF LEWIS
WASHOUGAL
GORGE TRIBS
SALMON
Accessible 75%
BONNEVILLE TRIBS

Species Code[1]	Basin	Historical miles	Blocked miles	Accessible miles[2]	Percent miles blocked	Primary[3] Block Type (Count)					Primary[3] Block Type (miles blocked)					Primary[3] Block Type (percent of count)				Primary[3] Block Type (percent miles blocked)			
						Dam	Culvert	SRS[4]	Other[5]	Total	Dam	Culvert	SRS[4]	Other[5]	Total	Dam	Culvert	SRS[4]	Other[5]	Dam	Culvert	SRS[4]	Other[5]
CHFA	BONNEVILLE TRIBS	4.7	0.3	4.4	5%		1		0	1		0.3		0.0	0.3		100%		0		100%		0%
	COWEEMAN	42.3	0.4	41.9	1%		1		0	1		0.4		0.0	0.4		100%		0%		100%		0%
	EF LEWIS	27.0		27.0	0%				0					0.0									
	GERMANY-ABERNATHY	49.5		49.5	0%				0					0.0									
	GORGE TRIBS	2.8		2.8	0%				0					0.0									
	GRAYS	69.7		69.7	0%				0					0.0									
	KALAMA	12.3		12.3	0%				0					0.0									
	LITTLE WHITE SALMON	3.2	1.9	1.3	59%	1			0	1	1.9			0.0	1.9	100%			0%	100%			0%
	LOWER COWLITZ	163.5	19.0	144.6	12%	5	4		0	9	11.2	7.7		0.0	19.0	56%	44%		0%	59%	41%		0%
	LOWER NF LEWIS	47.7	0.2	47.5	0%				2	2				0.2	0.2				100%				100%
	SALMON	42.3		42.3	0%				0					0.0									
	SKAMOKAWA-ELOCHOMAN	44.9		44.9	0%				0					0.0									
	TOUTLE	111.8	1.6	110.2	1%			1	0	1			1.6	0.0	1.6			100%	0%			100%	0%
	UPPER COWLITZ (total)	159.7	159.6	0.0	100%	1			0	1	159.6			0.0	159.6	100%			0%	100%			0%
	CISPUS	48.7	48.7	0.0	100%	1			0	1	48.7			0.0	48.7	100%			0%	100%			0%
	MAYFIELD-TILTON	35.9	35.9	0.0	100%	1			0	1	35.9			0.0	35.9	100%			0%	100%			0%
	RIFFE LAKE	29.3	29.3	0.0	100%	1			0	1	29.3			0.0	29.3	100%			0%	100%			0%
	UPPER COWLITZ	45.8	45.8	0.0	100%	1			0	1	45.8			0.0	45.8	100%			0%	100%			0%
	UPPER NF LEWIS	59.2	59.1	0.1	100%				0		59.1			0.0	59.1					100%			0%
	WASHOUGAL	24.4	0.7	23.7	3%		1		0	1		0.7		0.0	0.7		100%				100%		0%
	WIND	3.3		3.3	0%				0					0.0									
CHFA Total		868.4	242.8	625.6	28%	7	7	1	2	17	231.8	9.1	1.6	0.2	242.8	41%	41%	6%	12%	95%	4%	1%	0%
									0					0.0									
CHSP	COWEEMAN	2.1		2.1	0%				0					0.0									
	EF LEWIS	25.9		25.9	0%				0					0.0									
	GERMANY-ABERNATHY	0.3		0.3	0%				0					0.0									
	GORGE TRIBS	0.4		0.4	0%				0					0.0									
	KALAMA	12.3		12.3	0%				0					0.0									
	LITTLE WHITE SALMON	3.2	1.9	1.3	59%	1			0	1	1.9			0.0	1.9	100%			0%	100%			0%
	LOWER COWLITZ	64.0	0.0	64.0	0%	1			0	1	0.0			0.0	0.0	100%			0%	100%			0%
	LOWER NF LEWIS	49.8	0.6	49.1	1%		1		2	3		0.4		0.2	0.6		33%		67%		69%		31%
	SALMON	3.6		3.6	0%				0					0.0									
	TOUTLE	104.6	1.6	103.0	2%			1	0	1			1.6	0.0	1.6			100%				100%	0%
	UPPER COWLITZ (total)	176.3	176.3	0.0	100%				0		176.3			0.0	176.3					100%			0%
	CISPUS	47.3	47.3	0.0	100%				0		47.3			0.0	47.3					100%			0%
	MAYFIELD-TILTON	40.6	40.6	0.0	100%				0		40.6			0.0	40.6					100%			0%
	RIFFE LAKE	29.3	29.3	0.0	100%				0		29.3			0.0	29.3					100%			0%
	UPPER COWLITZ	59.2	59.2	0.0	100%				0		59.2			0.0	59.2					100%			0%
	UPPER NF LEWIS	104.5	104.4	0.1	100%	1			0	1	104.4			0.0	104.4	100%				100%			0%
	WASHOUGAL	2.5		2.5	0%				0					0.0									
	WIND	4.2		4.2	0%				0					0.0									
CHSP Total		553.5	284.8	268.7	51%	3	1	1	2	7	282.6	0.4	1.6	0.2	284.8	43%	14%	14%	29%	99%	0%	1%	0%

Species Code[1]	Basin	Historical miles	Blocked miles	Accessible miles[2]	Percent miles blocked	Primary[3] Block Type (Count)					Primary[3] Block Type (miles blocked)					Primary[3] Block Type (percent of count)				Primary[3] Block Type (percent miles blocked)			
						Dam	Culvert	SRS[4]	Other[5]	Total	Dam	Culvert	SRS[4]	Other[5]	Total	Dam	Culvert	SRS[4]	Other[5]	Dam	Culvert	SRS[4]	Other[5]
CHUM	BONNEVILLE TRIBS	24.1	4.2	19.9	17%	1	4		0	5	2.4	1.8		0.0	4.2	20%	80%			56%	44%		
	COWEEMAN	65.3	6.1	59.2	9%		6		0	6		6.1		0.0	6.1		100%				100%		
	EF LEWIS	57.1	7.3	49.8	13%	1	1		0	2	0.5	6.7		0.0	7.3	50%	50%			7%	93%		
	ESTUARY TRIBS	13.0	3.9	9.0	30%		5		0	5		3.9		0.0	3.9		100%				100%		
	GERMANY-ABERNATHY	7.2		7.2	0%				0					0.0									
	GRAYS	54.0		54.0	0%				0					0.0									
	KALAMA	6.5		6.5	0%				0					0.0									
	LOWER COWLITZ	146.2	15.9	130.3	11%	1	5		0	6	4.0	11.8		0.0	15.9	17%	83%		0%	26%	74%		0%
	LOWER NF LEWIS	36.0	0.3	35.7	0%				1	1				0.3	0.3				100%		100%		100%
	SALMON	18.5		18.5	0%				0					0.0									
	SKAMOKAWA-ELOCHOMAN	43.7	2.5	41.2	6%	1	10		1	12	0.9	1.6		0.0	2.5	8%	83%		8%	37%	63%		0%
	TOUTLE	65.3	2.9	62.4	4%		2	1	0	3		1.3	1.6	0.0	2.9		67%	33%	0%		43%	57%	0%
	UPPER NF LEWIS	0.1		0.1	0%				0					0.0									
	WASHOUGAL	17.4		17.4	0%				0					0.0									
CHUM Total		554.4	43.1	511.3	12%	4	33	1	2	40	7.9	33.3	1.6	0.3	43.1	9%	81%	2%	5%	11%	86%	2%	0%
									0					0.0									
COHO	BONNEVILLE TRIBS	59.6	6.1	53.5	10%		5		0	5		6.1		0.0	6.1		100%		0%		100%		0%
	COWEEMAN	99.1	9.6	89.5	10%		12		0	12		9.6		0.0	9.6		100%		0%		100%		0%
	EF LEWIS	109.4	19.7	89.6	18%	2	17		0	19	1.8	17.9		0.0	19.7	11%	89%		0%	9%	91%		0%
	ESTUARY TRIBS	14.6	5.2	9.5	35%		5		0	5		5.2		0.0	5.2		100%		0%		100%		0%
	GERMANY-ABERNATHY	96.1	4.0	92.2	4%		6		0	6		4.0		0.0	4.0		100%		0%		100%		0%
	GORGE TRIBS	9.0	0.8	8.1	9%		1		0	1		0.8		0.0	0.8		100%		0%		100%		0%
	GRAYS	153.8	0.5	153.4	0%		1		0	1		0.5		0.0	0.5		100%		0%		100%		0%
	KALAMA	27.0	7.9	19.2	29%		4		0	4		7.9		0.0	7.9		100%		0%		100%		0%
	LITTLE WHITE SALMON	3.2	1.9	1.3	59%	1			0	1	1.9			0.0	1.9	100%			0%	100%			0%
	LOWER COWLITZ	407.1	46.6	360.5	11%	6	12		1	19	23.2	21.3		2.2	46.6	32%	63%		5%	50%	46%		5%
	LOWER NF LEWIS	97.6	13.4	84.2	14%	2	12		0	14	3.4	10.0		0.0	13.4	14%	86%		0%	25%	75%		0%
	SALMON	120.8	2.6	118.2	2%		3		1	4		1.6		1.0	2.6		75%		25%		63%		37%
	SKAMOKAWA-ELOCHOMAN	129.0	8.2	120.8	6%		9		0	9		8.2		0.0	8.2		100%		0%		100%		0%
	TOUTLE	297.4	53.7	243.7	18%		27	1	0	28		23.0	30.6	0.0	53.7		96%	4%	0%		43%	57%	0%
	UPPER COWLITZ (total)	307.6	307.8	-0.1	100%				0		307.8			0.0	307.8					100%			0%
	CISPUS	66.7	66.7	0.0	100%				0		66.7			0.0	66.7					100%			0%
	MAYFIELD-TILTON	94.3	94.3	0.0	100%				0		94.3			0.0	94.3					100%			0%
	RIFFE LAKE	56.1	56.3	-0.2	100%				0		56.3			0.0	56.3					100%			0%
	UPPER COWLITZ	90.6	90.6	0.0	100%				0		90.6			0.0	90.6					100%			0%
	UPPER NF LEWIS	146.4	146.3	0.1	100%	1			0	1	146.3			0.0	146.3	100%			0%	100%			0%
	WASHOUGAL	76.3	3.5	72.8	5%	2	2		0	4	2.7	0.8		0.0	3.5	50%	50%		0%	78%	22%		0%
	WIND	7.0	0.9	6.1	13%		1		0	1		0.9		0.0	0.9		100%		0%		100%		0%
COHO Total		2,161.2	638.5	1,522.6	30%	14	117	1	2	134	487.1	117.6	30.6	3.2	638.5	10%	87%	1%	1%	76%	18%	5%	0%

Species Code[1]	Basin	Historical miles	Blocked miles	Accessible miles[2]	Percent miles blocked	Primary[3] Block Type (Count)					Primary[3] Block Type (miles blocked)					Primary[3] Block Type (percent of count)				Primary[3] Block Type (percent miles blocked)			
						Dam	Culvert	SRS[4]	Other[5]	Total	Dam	Culvert	SRS[4]	Other[5]	Total	Dam	Culvert	SRS[4]	Other[5]	Dam	Culvert	SRS[4]	Other[5]
STSU	COWEEMAN	2.1		2.1	0%				0					0.0									
	EF LEWIS	192.3	35.4	156.8	18%	2	21		0	23	1.6	33.8		0.0	35.4	9%	91%			4%	96%		
	GERMANY-ABERNATHY	0.4		0.4	0%				0					0.0									
	GORGE TRIBS	2.6	0.3	2.3	12%		1		0	1		0.3		0.0	0.3		100%				100%		
	KALAMA	108.2	6.8	101.4	6%		6		0	6		6.8		0.0	6.8		100%				100%		
	LITTLE WHITE SALMON	3.3	1.9	1.4	58%	1			0	1	1.9			0.0	1.9	100%				100%			
	LOWER COWLITZ	0.0		0.0	0%				0					0.0									
	LOWER NF LEWIS	19.3		19.3	0%				0					0.0									
	SALMON	10.7		10.7	0%				0					0.0									
	SKAMOKAWA-ELOCHOMAN	0.0		0.0	0%				0					0.0									
	TOUTLE	0.0		0.0	0%				0					0.0									
	UPPER NF LEWIS	0.2		0.2	0%				0					0.0									
	WASHOUGAL	128.5	2.8	125.7	2%	1	1		0	2	2.4	0.4		0.0	2.8	50%	50%		0%	86%	14%		0%
	WIND	113.8	0.1	113.8	0%		1		0	1		0.1		0.0	0.1		100%		0%		100%		0%
STSU Total		581.3	47.3	534.0	8%	4	30		0	34	5.9	41.4	0.0	0.0	47.3	12%	88%		0%	12%	88%		0%
									0					0.0									
STWI	BONNEVILLE TRIBS	47.6	5.1	42.5	11%		4		0	4		5.1		0.0	5.1		100%		0%		100%		0%
	COWEEMAN	92.3	9.0	83.2	10%		15		0	15		9.0		0.0	9.0		100%		0%		100%		0%
	EF LEWIS	177.7	25.4	152.4	14%	2	17		0	19	1.3	24.1		0.0	25.4	11%	89%		0%	5%	95%		0%
	ESTUARY TRIBS	15.3	5.5	9.8	36%		6		0	6		5.5		0.0	5.5		100%		0%		100%		0%
	GERMANY-ABERNATHY	109.5	4.6	104.8	4%		5		0	5		4.6		0.0	4.6		100%		0%		100%		0%
	GORGE TRIBS	15.0	1.0	14.0	7%		1		0	1		1.0		0.0	1.0		100%		0%		100%		0%
	GRAYS	157.2	0.5	156.6	0%		1		0	1		0.5		0.0	0.5		100%		0%		100%		0%
	KALAMA	135.0	13.6	121.4	10%		15		0	15		13.6		0.0	13.6		100%		0%		100%		0%
	LITTLE WHITE SALMON	3.3	1.9	1.4	57%	1			0	1	1.9			0.0	1.9	100%			0%	100%			0%
	LOWER COWLITZ	377.3	51.9	325.4	14%	6	18		1	25	30.1	19.4		2.4	51.9	24%	72%		4%	58%	37%		5%
	LOWER NF LEWIS	106.6	16.0	90.6	15%	2	10		0	12	4.3	11.7		0.0	16.0	17%	83%		0%	27%	73%		0%
	SALMON	124.3	2.6	121.7	2%		3		1	4		1.7		0.9	2.6		75%		25%		64%		36%
	SKAMOKAWA-ELOCHOMAN	134.5	10.5	123.9	8%	1	7		0	8	5.8	4.8		0.0	10.5	13%	88%		0%	55%	45%		0%
	TOUTLE	293.8	63.5	230.3	22%		17	1	0	18		12.5	51.0	0.0	63.5		94%	6%	0%		20%	80%	0%
	UPPER COWLITZ (total)	228.0	228.0	0.0	100%				0		228.0			0.0	228.0					100%			0%
	CISPUS	63.6	63.6	0.0	100%				0		63.6			0.0	63.6					100%			0%
	MAYFIELD-TILTON	75.8	75.9	0.0	100%				0		75.9			0.0	75.9					100%			0%
	RIFFE LAKE	29.4	29.4	0.0	100%				0		29.4			0.0	29.4					100%			0%
	UPPER COWLITZ	59.2	59.2	0.0	100%				0		59.2			0.0	59.2					100%			0%
	UPPER NF LEWIS	137.1	137.0	0.1	100%	1			0	1	137.0			0.0	137.0	100%			0%	100%			0%
	WASHOUGAL	63.0	0.7	62.3	1%	1	1		0	2	0.4	0.4		0.0	0.7	50%	50%		0%	51%	49%		0%
	WIND	8.5	0.1	8.4	1%		1		0	1		0.1		0.0	0.1		100%		0%		100%		0%
STWI Total		2,225.9	577.0	1,649.0	26%	14	121	1	2	138	408.7	113.9	51.0	3.3	577.0	10%	88%	1%	1%	71%	20%	9%	1%

[1]*Species Codes: CHFA=fall chinook; CHSP=spring chinook; STSU=summer steelhead; STWI=winter steelhead*

[2]*Represents the portion of historically accessible habitat that is currently accessible. Non-native habitat made available to species through human modifications (i.e.laddering falls) are not included in this value.*

[3]*Primary block is the most downstream barrier of the blocked segment. Restoration of only the primary block may not always restore passage to the entire blocked segment due to other barriers upstream of the primary barrier.*

[4]*SRS = Sediment Retention Structure on the NF Toutle River. Fish are blocked by a fish trap located downstream of the structure itself.*

[5]Other includes other types of barriers not included individually. The primary other barriers are pump stations and fish ladders.

Volume VI, Chapter 9
Comparison of Spawner-Recruit Data with Estimates of Ecosystem Diagnosis and Treatment (EDT) Spawner-Recruit Performance

Comparison of Spawner-Recruit Data with Estimates of Ecosystem Diagnosis and Treatment (EDT) Spawner-Recruit Performance

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May 25, 2004

Introduction

In the Lower Columbia River tributaries, the Ecosystem Diagnosis and Treatment (EDT) model was used to develop salmon and steelhead population performance goals for the Washington Department of Fish and Wildlife (WDFW), develop the habitat strategy for the Lower Columbia River Fish Recovery Board (LCFRB), and to identify specific habitat restoration projects. The EDT model is habitat based and estimates the expected salmon and steelhead performance in the environment used by these anadromous fish (Lestelle et al. 1996). WDFW rated habitat for the EDT model in Grays River, Skamokawa Creek, Elochoman River, Mill Creek, Abernathy Creek, Germany Creek, Cowlitz River below the Barrier Dam, Toutle River, Coweeman River, Kalama River, North Fork Lewis River below Merwin Dam, East Fork Lewis River, Salmon Creek, Washougal River, Duncan Creek, Hamilton Creek, Hardy Creek, Wind River, and the White Salmon River. This includes thousands of miles of habitat and stream reaches.

Empirical information was not available for all 45 EDT environmental attributes for any reach. For most reaches there was no empirical information available. To estimate the values when no empirical information was available, derived information or expanded information from adjacent or similar reaches was used. Only a limited amount of expert opinion was used for rating current environmental habitats and this occurred for attributes, where there were no quantitative rules (i.e. riparian function and harassment) or for historical information. For a more detailed description of the rationale behind the expansion of empirical information, and the use of derived information and professional judgment see the documentation reports (i.e. Rawding, Glaser, VanderPloeg, and Pittman 2004) or the EDT Stream Reach Editor (SRE) where reach specific data quality and source information is kept. To be consistent between subbasins, the use of expanded and derived information and professional judgment was standardized and comparisons between reaches or subbasins can be made because the data is standardized. This is the underlying assumption behind the development and use of the LCRFB habitat strategy.

In addition to the habitat data, salmon and steelhead life history information is required for the EDT model. For most individual fall chinook populations, there was information available on adult age structure, sex ratio, and fecundity. However for steelhead data was limited to the Wind, Kalama, and Toutle Rivers. For steelhead, the Kalama River dataset was used as a default when no other information was available because it is the most comprehensive. For chum salmon, less data was available and a common set was combined from many sources. Juvenile life history patterns and ocean survival were standardized from all races and the Columbia River capacity and survival estimates were derived from the Framework Process (Marcot et al. 2002).

The EDT model is a statistical model that explains the performance of salmon and steelhead based on the mechanisms of how salmon move through their environment (MBI 2002). To do this, EDT constructs a working hypothesis for a population within a subbasin based on the model and datasets used to populate the model. Mobrand Biometrics Inc (MBI) suggests three criteria for judging the usefulness of these type of models: 1) its predictions are consistent with observations, 2) it provides a clear and reasonable explanation for the observations, and 3) it provides useful guidance for management and enhancement.

Many models rely on data other than empirical data (ie Bayesian Belief Network). However, the use of non-empirical data has been a specific concern regarding the use of the EDT model in the context of salmon and steelhead recovery. WDFW welcomes the use of empirical information in the EDT model but this data was not always available when constructing the current database. Rather than waiting for more information WDFW has advocated using the "best available science" to move forward toward recovering salmon and steelhead populations that are listed under the Endangered Species Act (ESA). WDFW recommends funding surveys to collect key parameters that drive the model including habitat types, wood, percentage of fines in spawning gravel, bed scour, peak flow, low flow, maximum width, and minimum width.

Methods

The relationship between stock size and recruitment is a keystone in fishery science, because this function translates into the development of reference points used to set sustainable fisheries, and perform population viability analysis (Hilborn and Walters 1992, Chilcote 2000). However, these data sets are problematic due to environmental variation and observational errors (Hilborn and Walters 1992).

In basins with significant proportions of hatchery spawners, the estimates of spawners and recruits can be very uncertain. For fall chinook salmon only a small percentage of all the hatchery fish are marked for identification with coded-wire-tags (CWT). To estimate the number of hatchery fall chinook salmon present in a population, the adults recovered with CWT are expanded by the juvenile or adult tag rate. This expansion often indicates there were more hatchery fish present than total fish present. In addition, hatchery fish may have a different reproductive success in the stream and unless this is known and accounted for the estimate of recruits will be biased. Therefore, streams with significant hatchery populations were excluded from the analysis except for steelhead populations were the reproductive success was estimated (Chiclote at al 1986, Leider et al. 1990, and Hulett et al.1993). These criteria substantially reduced the number of streams to be considered for comparison with EDT.

Observational uncertainty includes measurement and sampling error when estimating the number of spawners and recruits (Francis and Shotton 1997). Spawning escapement estimation methods can be generally categorized as count, mark-recapture, redd counts, and peak count expansion. Counts are direct counts of fish trapped and passed over a weir or barrier. These counting facilities are rare and only a few populations are monitored with direct counts. Counts are assumed to have no sampling or measurement error, and represent the most accurate measure of escapement.

Mark-Recapture (M-R) is used by WDFW at partial barriers to estimate adult summer steelhead abundance using the pooled or stratified Petersen method (Seber 1982 and Arnason et al 1997). Adults are floy tagged and recaptured at upstream traps or "captured" through snorkeling, which is often called mark-resight (Rawding and Cochran 2001a). Juvenile estimates are made using the trap efficiency method (Rawding and Cochran 2001b). For M-R to be accurate the assumptions of the method must be met and WDFW conducts experiments to ensure these assumptions are not being substantially violated. The precision of the estimate is a function of the number of marks and recaptures. In general, WDFW's goal for precision, is that the 95% confidence interval (CI) to be less than 25% but in many cases they are less than 10%. When the assumptions and precision goals are met, these estimates rank just below direct counts for use in spawner-recruit analysis.

Redd surveys are used for winter steelhead since other methods are not available (Freymond and Foley 1986). Redd counts are a combination of a cumulative count of redds in some tributary reaches, an expansion of supplemental redd surveys, an expansion of average redd density to unsurveyed tributaries, and an Area-Under-the-Curve (AUC) estimate for the mainstem. Only redd survey data from the SF Toutle River is used in this analysis because the valley is open to get accurate AUC counts from a helicopter and tributaries are surveyed frequently enough that population estimates are expanded for only a few reaches.

Peak Count Expansion (PCE) is used for fall chinook salmon estimates. In these basins, a population estimate was made by tagging chinook carcasses using the Jolly-Seber (JS) model (Seber 1982). As with the Petersen method, the JS estimate is only valid if the assumptions are met and care is taken to ensure the assumptions were not violated. The PCE factor is developed by comparing the peak count of lives and deads to the total population estimate from carcass tagging. This one time PSE is used to expand previous and future peak counts into a population estimate.

Chum salmon abundance is often estimated using AUC (Ames 1984). Surveyors count the number of live chum salmon spawning and are asked to estimate their “observer efficiency” or the percent of the population they see based on water conditions. The periodic counts are plotted over the course of the season and the number of fish days is estimated by the AUC. The AUC is divided by the average residence time to develop the estimate. Redd counts, PCE, and AUC methodologies are potentially the least precise of the estimates because annual variance estimates are unknown, observation efficiency is varies between surveyors, true observer efficiency estimate is unknown, annual residence time is variable, and the standard residence time from other studies may be slightly different than the actual residence time.

The original EDT model and subsequent datasets focused on ESA listed species, which included chum salmon, chinook salmon, and steelhead. Coho salmon modeling was not fully funded in the subbasin planning effort due to lack of resources. To fully cover coho salmon, additional reaches need to be added since this species has a preference for small creeks not used by other species. Coho salmon were only fully included in the Elochoman River, and Skamokawa, Mill, Abernathy, Germany, and Salmon Creeks.

For Columbia River tributaries spawner-smolt data is a measure of tributary production and the smolt estimate is the number of smolts leaving the tributary. Recent studies have indicated ten fold changes in ocean variability as measured by smolt to adult survival (NRC 1996 , Rawding 2001, and ODFW unpublished). Spawner-smolt data are less variable than spawner-adult data because spawner-adult data also include assumptions from the Framework about survival conditions in the mainstem and estuary from limited studies (Marcot et al. 2002). For chinook salmon assumptions about ocean harvest rates are also included. Since there are less assumptions spawner-smolt data is a better measure for ensuring consistency with EDT than spawner-adult data.

One output of the EDT model is a Beverton-Holt (BH) spawner-recruit curve for adults or smolts (Beverton and Holt 1957, Mousalli and Hilborn 1987, and Lestelle et al 1996). To determine if EDT outputs are consistent with observations, EDT spawner-recruit curves will be compared to actual spawner-recruit data. In Table 1 and 2 are the populations with spawner-recruit data used for comparison with the EDT model. These datasets represent the most accurate information available for comparison with EDT model.

Table 1. Populations used in comparing the predicted EDT Beverton-Holt Curve with actual spawner and smolt data.

Stock	Escapement	Recruits	Age	Comments
Trout Cr	Weir Count	M-R at trap	scales	Some years adjustment when trap not operational and hatchery fish present
Wind R.	M-R at trap	M-R at trap	scales	One year juvenile scale data missing and adjustment for hatchery reproductive success to smolt stage
Cedar	M-R at trap	M-R at trap	All age 2	adjustment for hatchery reproductive success to smolt stage

Table 2. Populations used in comparing the predicted EDT Beverton-Holt Curve with actual spawner and adult recruit data.

Stock	Escapement	Recruits	Age	Comments
Washougal Summer steelhead	Mark-Resight snorkel survey	Same as escapement plus CRC & C&R estimate.	Use Kalama Scales	Used current estimates of snorkel efficiency from M-R estimates to adjust historical counts
Kalama Steelhead – summer & winter populations combined	Mark-Resight snorkel survey for summers and weir count for winters	Same as escapement plus CRC & C&R estimate.	Scales	Used estimates of successful jumpers and snorkel efficiency from M-R estimates to adjust historical counts
Wind River Summer Steelhead	Mark-Resight snorkel survey	Same as escapement plus CRC & C&R estimate.	Scales used avg for some years	Used current estimates of snorkel efficiency from M-R estimates to adjust historical counts
SF Toutle Winter Steelhead	Redd survey	Same as escapement plus CRC & C&R estimate.	Use Kalama Scales	
NF Toutle Winter Steelhead	Weir Count	Same as escapement but no fishery	Scales	
Coweeman Fall Chinook	Carcass Tagging Expansion	Same as escapement but Cowlitz CWT used to estimate fishery	Scales	
EF Lewis Fall Chinook	Carcass Tagging Expansion	Same as escapement but Cowlitz CWT used to estimate fishery	Scales	
NF Lewis Fall Chinook	Carcass Tagging Expansion	Same as escapement but Lewis wild CWT used to estimate fishery	Scales	
Grays River Chum Salmon	Carcass Tagging Expansion and AUC	Assume no fishery	Scales	

The EDT datasets were populated by WDFW and run on the MBI website (http://www.mobrand.com/edt). Results from the website were provided in "Report 1" , which provided an estimate of productivity and capacity for the BH spawner curves for adults and juveniles. The EDT model is deterministic and provides no estimates of uncertainty. The observed spawner-recruit data was fit to the same BH model used by EDT using maximum likelihood estimation (MLE) and assuming lognormal error Hilborn and Waters 1992).

$$R = (\alpha S / (1 + \alpha S/\beta)) * e^{\varepsilon_t} \qquad (1)$$

Where:

R = the number of recruits measured as adults or smolts
S = the number of spawners
α = the intrinsic productivity of the stock, and
β = the freshwater carrying capacity of the stock
ε_t = a normal distributed random variable ($N(0,\sigma)$)

A non-linear search over α, β, and σ was used to minimize the negative log-likelihood and estimate the parameters. A two-dimensional confidence interval on α and β was estimated using a likelihood profile by search over all values that provided a likelihood within a specified range of the negative log-likelihood (Hudson 1971, Hilborn and Mangel 1997). To estimate a 95% confidence region, a chi-squared distribution with two degrees of freedom was used to contour all negative likelihood values three greater than minimum value. The 95% confidence contour created an ellipse with a negative correlation between α and β. If the EDT point estimate of α, β was within the 95% confidence region from the spawner-recruit data, there was no significant difference between the two model estimates.

Results and Discussion

A comparison of EDT generated spawner-recruit curves with the spawner-recruit curves generated from the data was considered. To estimate a spawner recruit relationship from the data Hilborn and Walters (1992) recommend that: 1) data used in spawner-recruit analysis have low measurement error due to the destructive relationship of measurement error on these curves (Ludwig and Walters 1981), 2) the relation be examined for time series bias especially due to auto-correlated environmental events (Hilborn and Starr 1984), 3) the data be non-stationarity due to variablity in ocean regimes (Hare and Francis 1994) with productive periods (pre-1977 and post 1999) and an unproductive period in between, and 4) the data have sufficient contrast to determine the relationship. If data meet the recommendations and a spawner-recruit curve was generated than a comparison could be developed comparing the fit the EDT and data derived curves. Most of the data sets are too sparse or provide insufficient contrast for direct comparisons. Therefore, the EDT model was said to have a good fit if the predicted BH curve ran through the observed data and if the point estimates (α, β) from the EDT model fell within the 95% confidence region from MLE of these same parameters from the observed data.

EDT model was designed to predict average performance, as measured by smolt and adult productivity, capacity, and abundance, of the modeled population over specified environmental conditions. Spawner-smolt estimates are more likely to reflect average environmental conditions due to less environmental variation in freshwater (Cramer 2000). A comparison of EDT spawner-smolt curves to the three steelhead spawner-smolt datasets is found in Figures 1 & 2.

The EDT curves passes through the individual data points reasonably well for all data sets. The point estimate (α, β), depicted by a white sun in the graphs, from the EDT analysis is within the 95% contour from the spawner-recruit data. Based on population monitoring protocols, these datasets are the best datasets to compare to the EDT model.

The adult steelhead comparisons are found in Figures 2, 3, and 4. While the Wind River smolt dataset compared favorably with the EDT output the adult dataset does not (Figure 2). This is due to the relatively recent adult dataset, that was collected primarily during an unproductive ocean regime during the late 1980's and 1990's. Recent returns, which are not included in the dataset because the full brood year has not returned, indicate the new spawner recruit data will fall at or above the EDT line.

Figure 3 contains the winter steelhead populations within the Toutle subbasin. The EDT performance estimate for the North Fork Toutle River above the Sediment Retention Structure (SRS) is outside the 95% confidence interval. The EDT analysis indicated that all steelhead production occurs in the tributaries and production from the mainstem Toutle River above the SRS is not possible due to sediment still working its way downstream after the eruption of Mt. St. Helens. The EDT model indicates that steelhead are very sensitive to sediment concentrations near the levels modeled in the Toutle subbasin. A slight change in the mainstem rating would increase steelhead capacity and the mainstem and the EDT point estimate would fall within the 95% contour.

The SF Toutle River had less sediment and recovered more rapidly after the eruption of Mt. St. Helens than the NF Toutle River. This dataset begins in the mid-1980's and has continued to the present. It exhibits a high level of variation due to favorable ocean conditions in the mid-1980s and unfavorable conditions through the rest of the period. The EDT estimate falls within the center of the 95% confidence region.

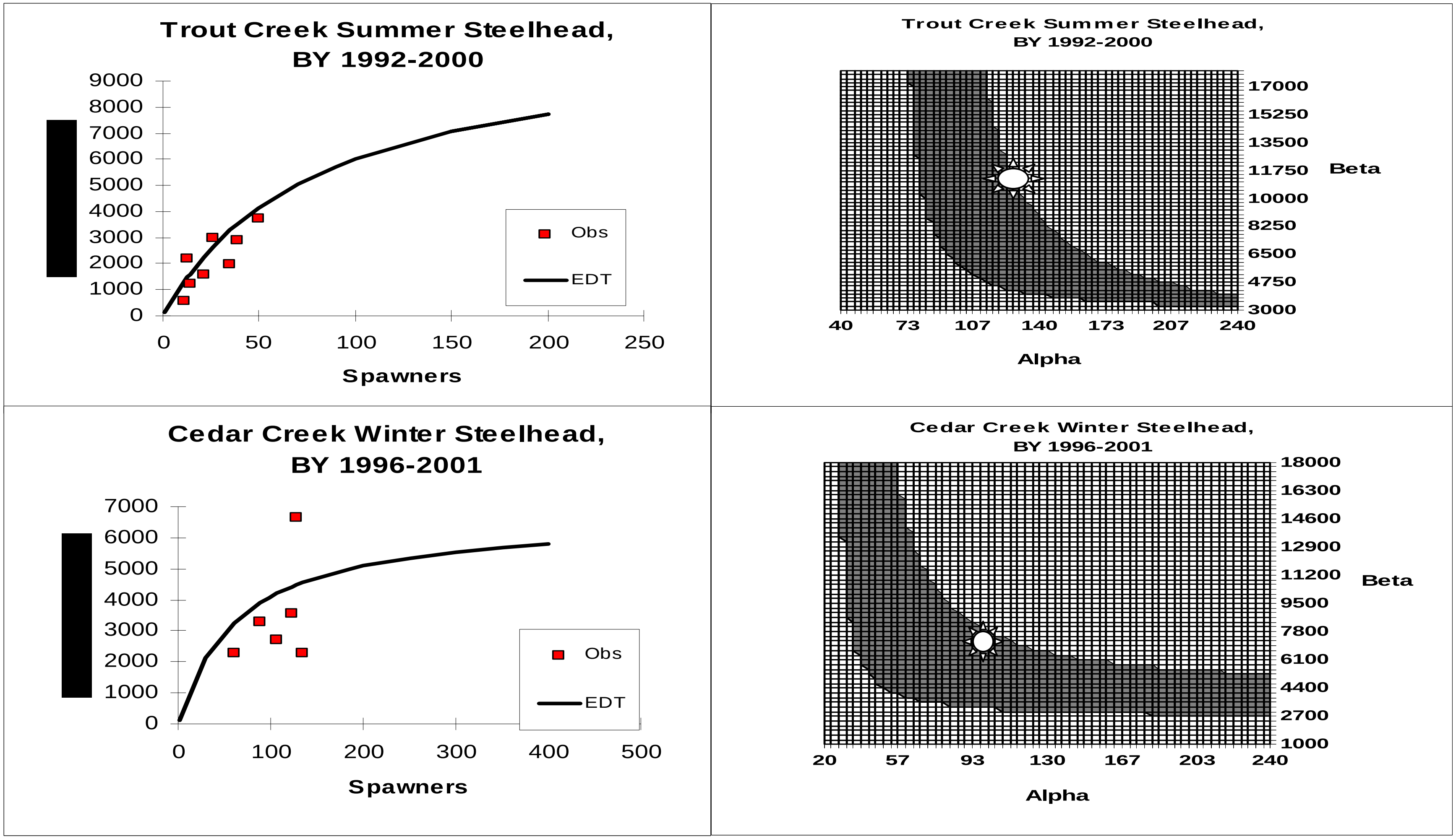

Figure 1. Comparison of EDT estimates of the Beverton-Holt spawner curve (solid line) with observed data (red squares) and the 95% confidence region determined by maximum likelihood analysis (dark grey pattern) compared to the EDT (α, β) point estimate (white sun).

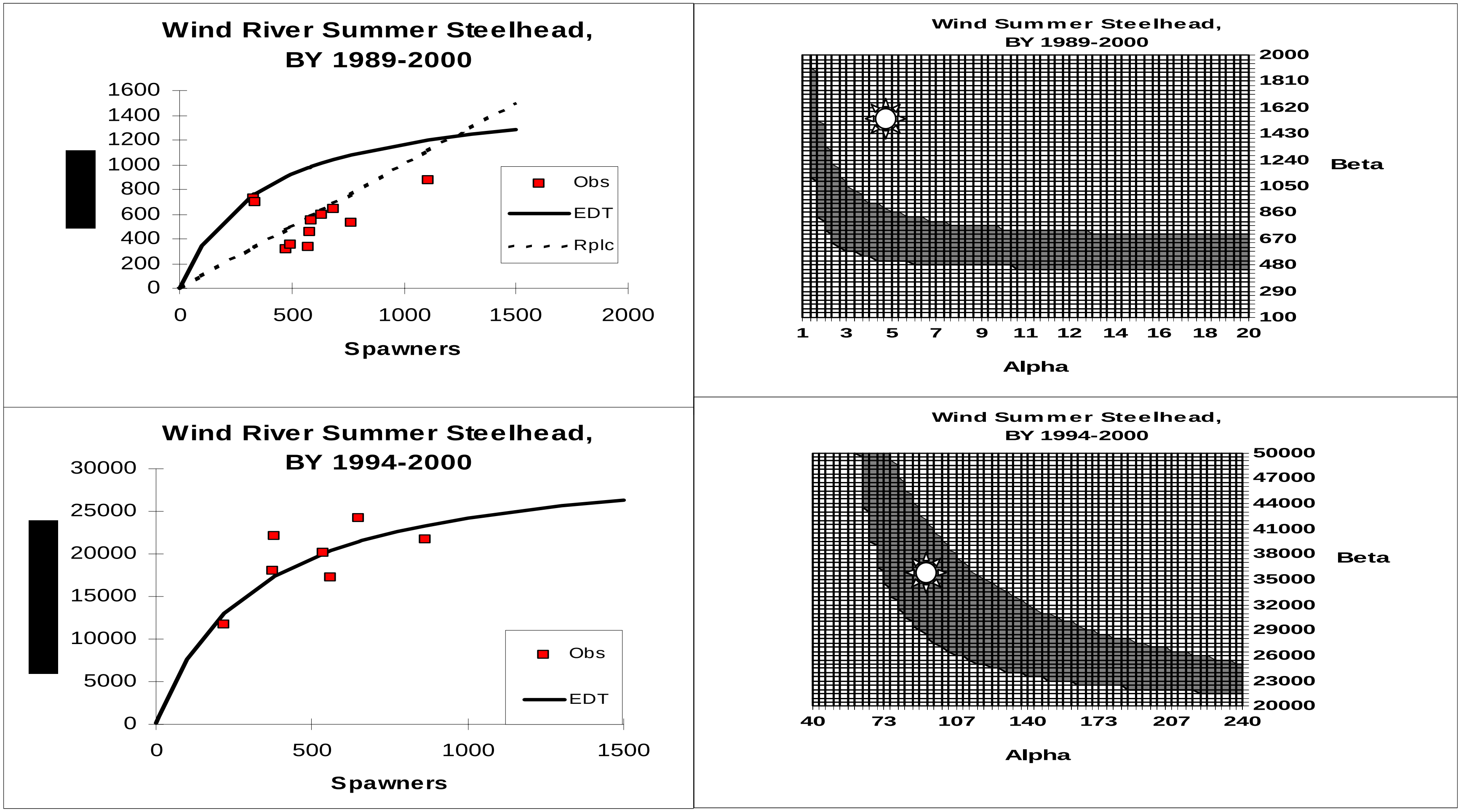

Figure 2. Comparison of EDT estimates of the Beverton-Holt spawner curve (solid line) with observed data (red squares) and the 95% confidence region determined by maximum likelihood analysis (dark grey pattern) compared to the EDT (α, β) point estimate (white sun).

Figure 4 contains the two longest steelhead datasets from the Washougal and Kalama Rivers. Both summer and winter steelhead are passed above Kalama Falls Hatchery (KFH). Since the exact spawning and rearing distribution of both races is unknown, a generic EDT steelhead population was modeled. Both wild and hatchery steelhead have been passed above KFH. The relative fitness of hatchery steelhead in the Kalama River is less than wild steelhead (Leider et al. 1990 and Hulett et al. 1996). Specific brood year data was used to reduce the effectiveness of hatchery spawners when available, otherwise the average reproductive success was used. The eruption of Mt. St. Helens, resulted in high stray rates into the Kalama River; therefore the returns influenced by this event were not used in this analysis (Leider 1989). Due to the hatchery program, escapements of hatchery and wild steelhead approached equilibrium levels and the spawner-recruit data are not very informative about the productivity of the stock. The EDT estimate of performance is slightly outside this 95% confidence region. In reviewing the EDT outputs, the survival of juvenile steelhead overwintering in the mainstem was reduced due to estimates of bed scour in these canyon reaches. This pattern was observed in other basins with larger canyons and a monitoring program for bed scour using TFW protocols should be established to address this uncertainty (WFPB 1997).

The Washougal River summer steelhead population has been monitored by snorkeling from the 1950's to the early 1970's and monitoring was re-initiated in 1985. Recently, these snorkel counts were standardized and population estimates were made using PCE from snorkeling. During the course of the data collection, the ocean regime has cycled through productive and unproductive periods (Hare and Francis 1994) and the data is highly variable. The EDT point estimate falls within the 95% contour.

Most fall chinook populations are associated with a hatchery program. Due to the potential uncertainties and lack of specific data, only three fall chinook populations were identified for comparison with the EDT model. Tule populations on the Coweeman and EF Lewis are shown in Figure 5. As mentioned above these populations are monitored using a PCE of live and dead counts and index reaches are expanded to estimate the entire population. To estimate ocean harvest, these stocks were assumed to have interception and maturity rates similar to the Cowlitz Hatchery CWT groups. Given these assumptions, there is an unknown amount of measurement error in the spawner-recruit data. When the EDT fit is plotted against both populations the fit is reasonable. The point estimate for the Coweeman population is within the 95% confidence region, while the EF Lewis estimate is not. The MLE of capacity in the EF Lewis River was over 100,000 adults which not feasible for this small basin.

Lewis River fall chinook are classified as a bright population. This population has a different life history pattern than the typical tule population. The Lewis River bright stock was modeled with extended freshwater rearing and higher smolt to adult survival due to their larger outmigration size. As with other populations, the spawner-recruit data is highly variable and the BH model had a poor fit to the data. The EDT fit to the data was through the middle of the scatter plot and point estimate is within the 95% confidence region (Figure 6).

The Grays River chum salmon dataset was the only one available for this species for a comparison with the EDT model because other datasets are too recent or other counts represent an unknown and potentially varying portion of the escapement. Similar to the tule spawner-recruit dataset, this dataset has an unknown amount of measurement error. There were no stock specific estimates of harvest and the recruits in this dataset are post harvest recruits. The original

MLE were unrealistic and two data points with the lowest escapement were eliminated from the dataset to obtain a realistic convergence. The BH curve from EDT provides a reasonable estimate of chum performance and the point estimate falls within the 95% confidence region (Figure 6).

Summary

Overall EDT model passed the criteria that salmon performance is consistent with observed data. Estimates of spawner-recruit performance as measured by the BH model were similar between the MLE fit to observed data and the EDT estimate based on the quantity and quality of available habitat when recruits were measured as smolts. All three point estimates from the EDT model were within the 95% confidence region from the observed data. When recruits were measured as adults the MLE of the BH parameters were some times realistic and sometimes unrealistic due to high variability in datasets and the lack of data at low spawning densities. For the remaining nine adult datasets, five EDT point estimates were within the 95% confidence region, two under estimated performance, one over estimated performance, and the EF Lewis was off due to lack of a realistic MLE of the BH parameters from the observed data. Population monitoring should be expanded to add additional stocks to assess risk and check the reasonableness of the EDT model. Some current spawning ground survey programs should be improved to increase the accuracy and precision of the population estimates.

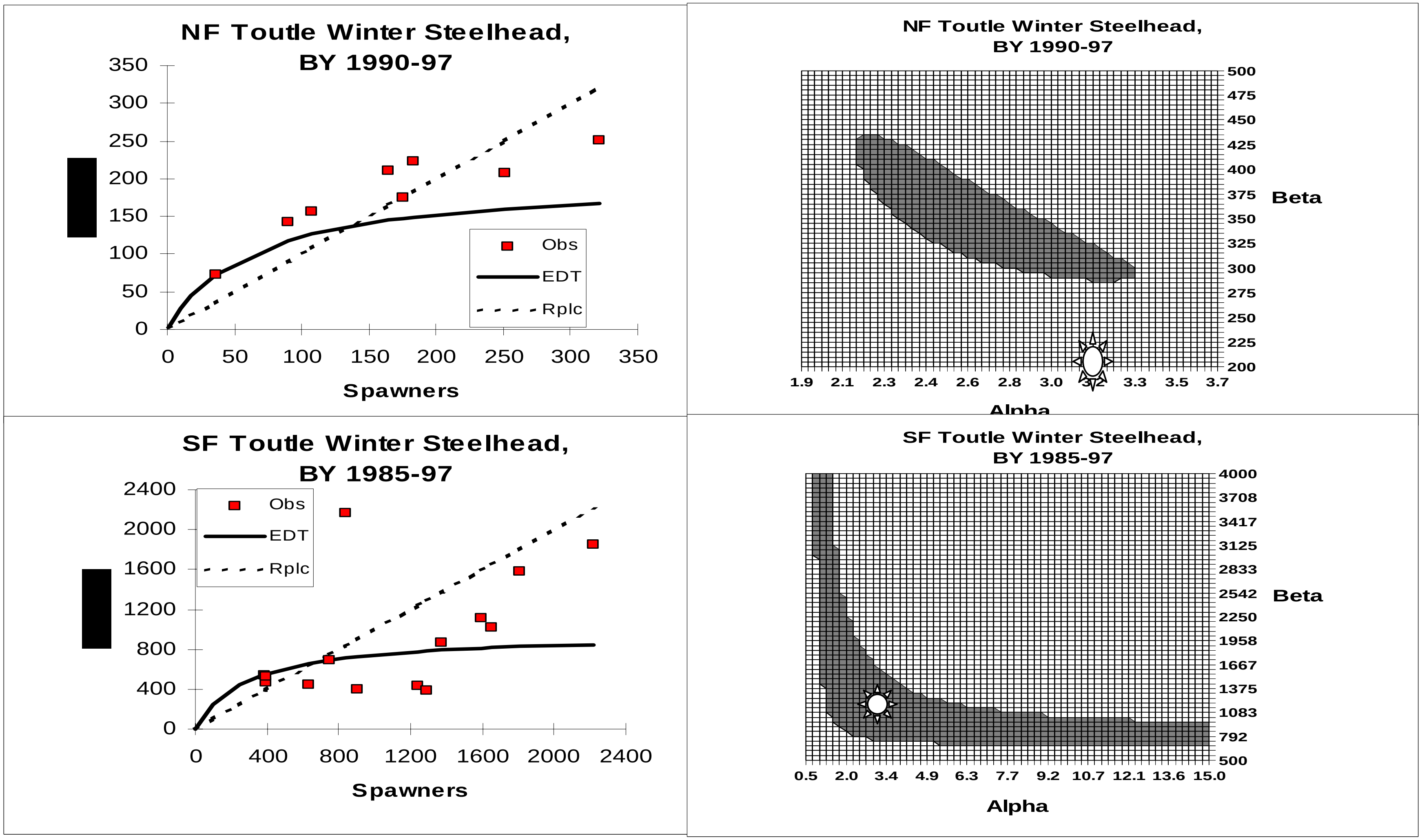

Figure 3. Comparison of EDT estimates of the Beverton-Holt spawner curve (solid line) with observed data (red squares) and the 95% confidence region determined by maximum likelihood analysis (dark grey pattern) compared to the EDT (α, β) point estimate (white sun).

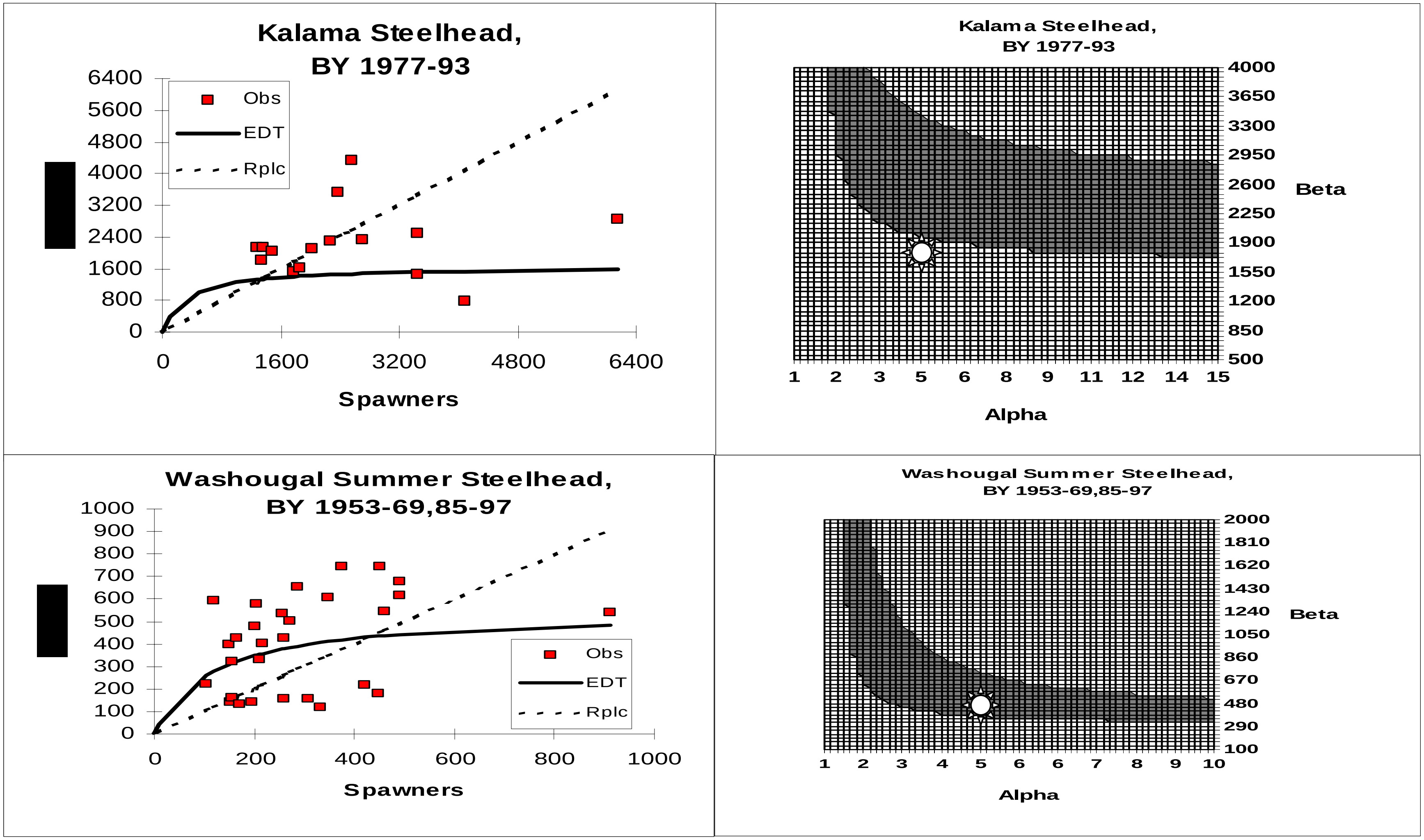

Figure 4. Comparison of EDT estimates of the Beverton-Holt spawner curve (solid line) with observed data (red squares) and the 95% confidence region determined by maximum likelihood analysis (dark grey pattern) compared to the EDT (α, β) point estimate (white sun).

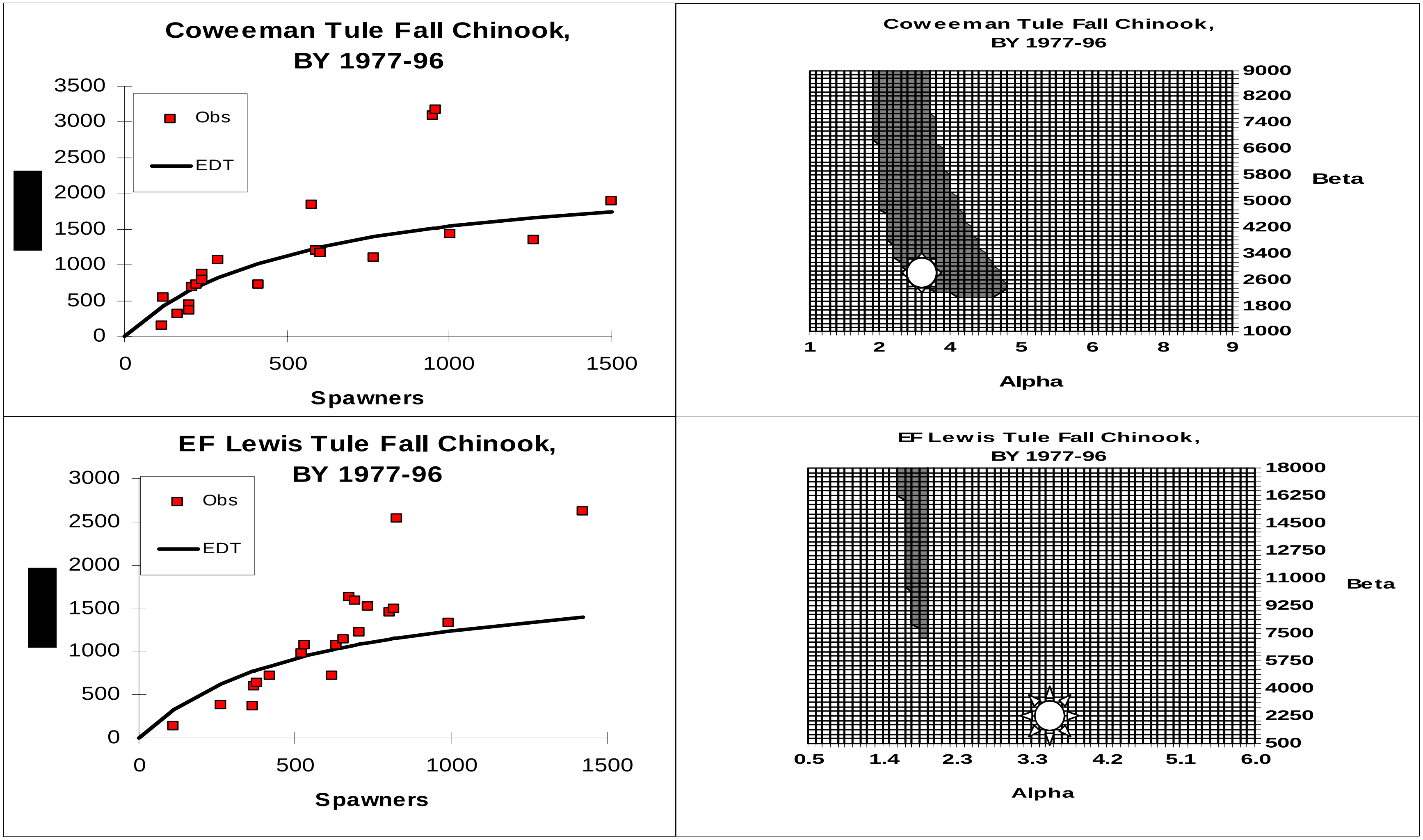

Figure 5. Comparison of EDT estimates of the Beverton-Holt spawner curve (solid line) with observed data (red squares) and the 95% confidence region determined by maximum likelihood analysis (dark grey pattern) compared to the EDT (α, β) point estimate (white sun).

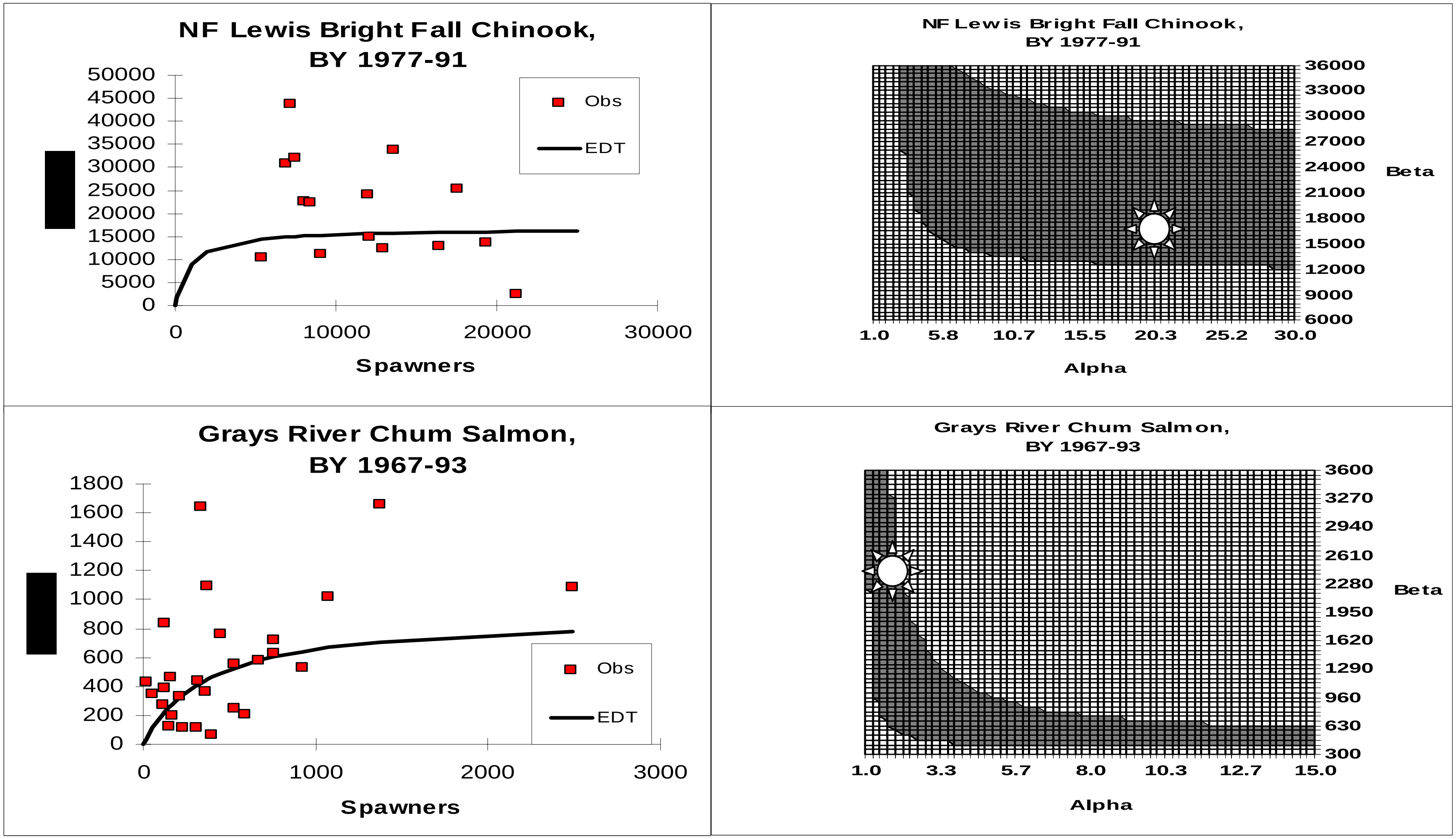

Figure 6. Comparison of EDT estimates of the Beverton-Holt spawner curve (solid line) with observed data (red squares) and the 95% confidence region determined by maximum likelihood analysis (dark grey pattern) compared to the EDT (α, β) point estimate (white sun).

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