No. 17-269

In The
Supreme Court of the United States

STATE OF WASHINGTON,

Petitioner,

v.

UNITED STATES OF AMERICA, ET AL.

Respondents.

ON WRIT OF CERTIORARI
TO THE UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT

JOINT APPENDIX – VOLUME II OF III

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PETITION FOR CERTIORARI FILED AUGUST 17, 2017
CERTIORARI GRANTED JANUARY 12, 2018

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NOTE: The following documents were reprinted in the Petition Appendix.

JOINT APPENDIX

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Relevant Docket Entries

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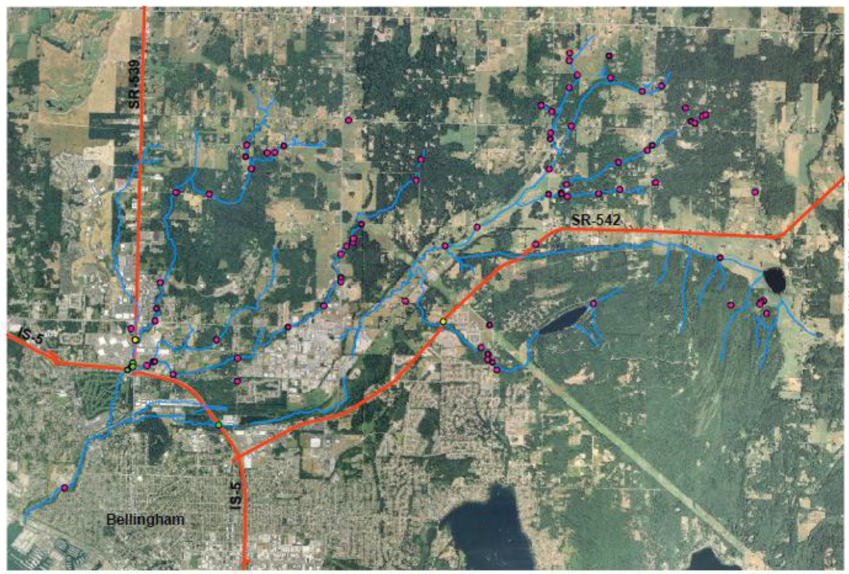
VOLUME 3 OF 3

Exhibits Admitted During Trial cont'd

Transcripts

Other Materials Including Pleadings From Original *U.S. v. Washington* Proceeding

Squalicum/Baker Creeks - WRIA 1



Fish Passage Barriers
- Non-State (80)
- State - Partial (6)
- State - Total (2)

Streams

State Highways

Data Sources:

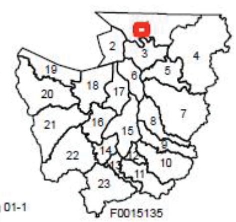
Fish Passage - Fish Passage and Diversion Screening Inventory (WDFW, 07/06/2009)

Streams - Washington State Watercourse Hydrography (DNR, 03/01/2006)

State Highways - State Routes of Washington State (WSDOT, 7/24/2006)

N W E S

0 0.5 1 1.5
Miles



State's Exhibit W-132
Page 000001
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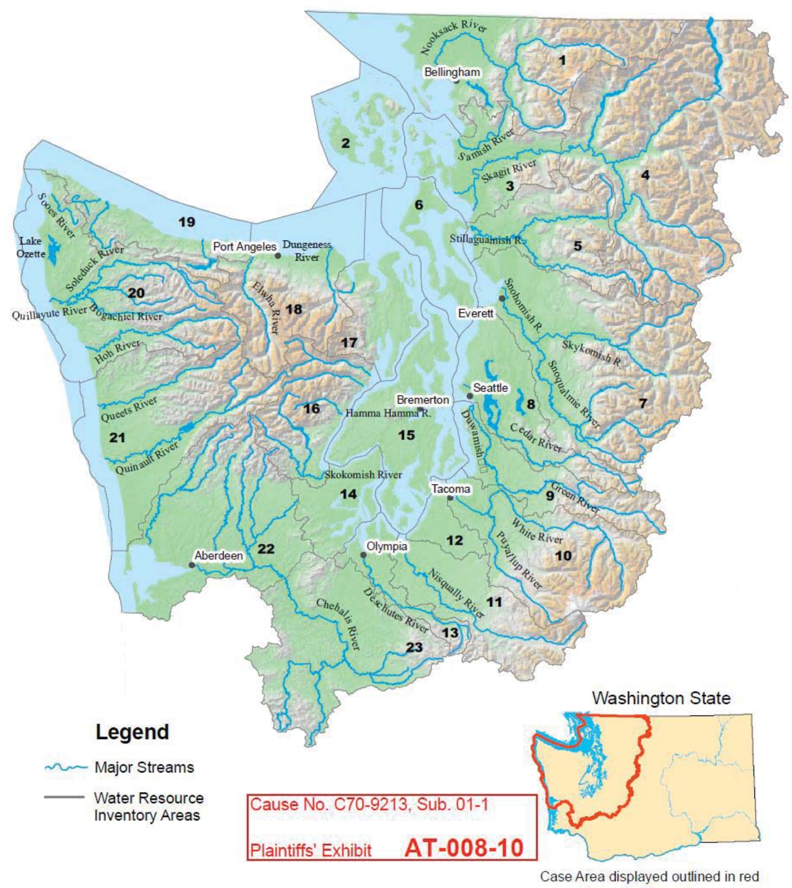
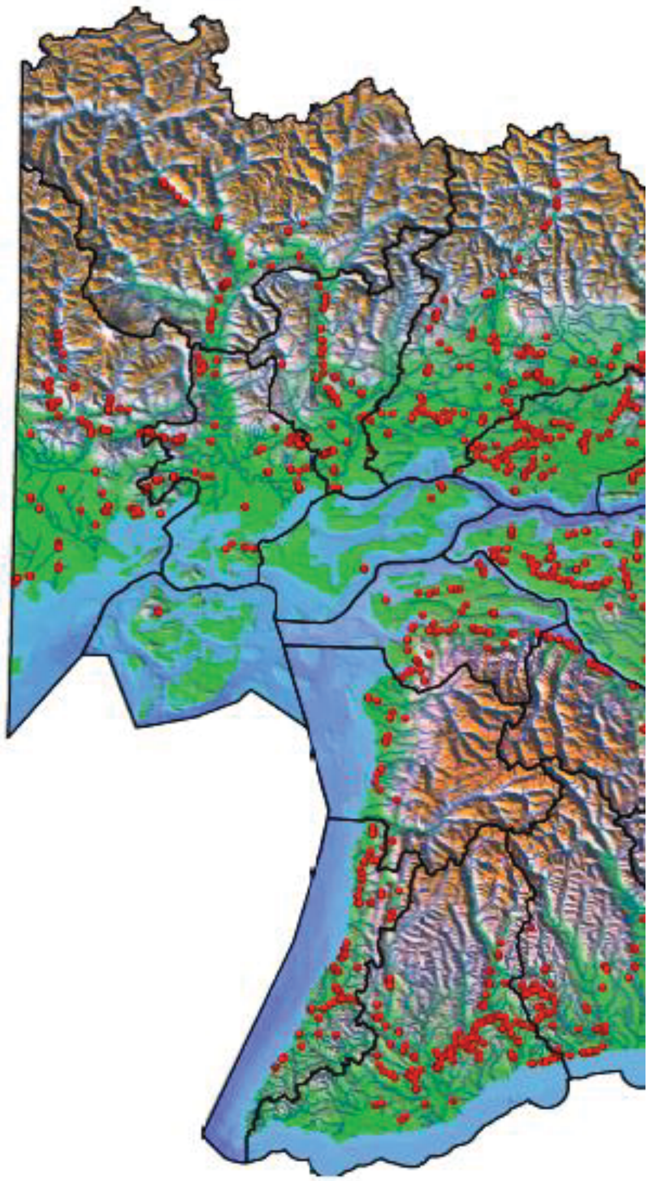
F0015135

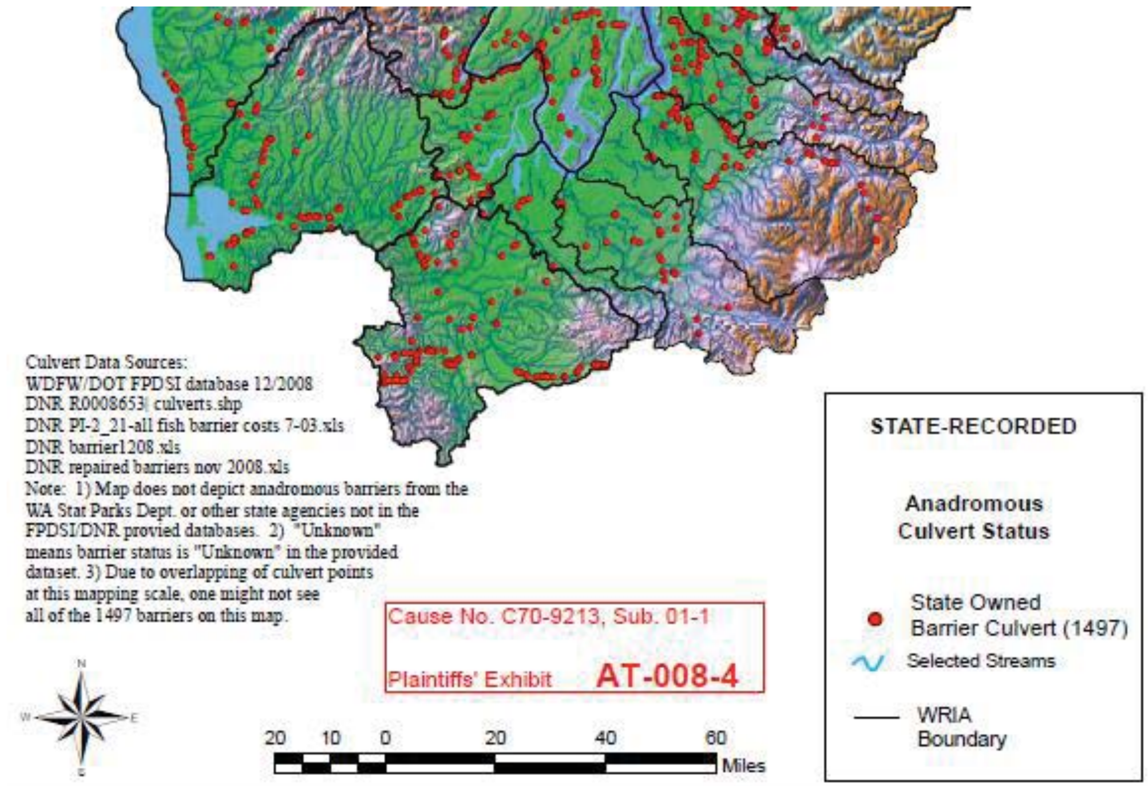

United States v Washington Case Area
Bellingham
Everett
Seattle
Tacoma
Olympia
Aberdeen
Cause No. C70-9213, Sub. 01-1
Plaintiffs' Exhibit
AT-008-9

Water Resource Inventory Areas 1 - 23



Washington State Barrier Culverts in U.S. v. WA. Case Area




Culvert Data Sources:
WDFW/DOT FPDSI database 12/2008
DNR R0008653| culverts.shp
DNR PI-2_21-all fish barrier costs 7-03.xls
DNR barrier1208.xls
DNR repaired barriers nov 2008.xls
Note: 1) Map does not depict anadromous barriers from the WA Stat Parks Dept. or other state agencies not in the FPDSI/DNR provied databases. 2) "Unknown" means barrier status is "Unknown" in the provided dataset. 3) Due to overlapping of culvert points at this mapping scale, one might not see all of the 1497 barriers on this map.
Cause No. C70-9213, Sub. 01-1
Plaintiffs' Exhibit AT-008-4
20 10 0 20 40 60 Miles
N
W
E
S
STATE-RECORDED
Anadromous Culvert Status
State Owned Barrier Culvert (1497)
Selected Streams
WRIA Boundary

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The Honorable Ricardo S. Martinez

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

UNITED STATES OF AMERICA, et al., Plaintiffs, v. STATE OF WASHINGTON, Defendant.	NO. C70-9213 Subproceeding No. 01-1 (Culverts) DECLARATION OF PAUL SEKULICH, PH.D., IN LIEU OF DIRECT TESTIMONY

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I, PAUL SEKULICH, Ph.D., declare as follows:

1. I am a fisheries biologist with over thirty years of professional experience in salmon habitat and fisheries issues in the State of Washington. My Curriculum Vitae is attached as Exhibit A.

2. I hold a Bachelor of Science in Fishery Biology from Colorado State University. After military service, I returned to that university and earned a Master of Science in Fishery Biology. In 1980, I completed the requirements for a Doctor of Philosophy degree in Forestry Science-Fisheries at

the University of Idaho. For my doctoral dissertation, I analyzed factors affecting the carrying capacity of Idaho forest streams for rearing juvenile chinook salmon. My dissertation has been cited by other state, tribal, and federal scientists studying salmon in Idaho.

3. I joined the Washington Department of Fisheries (WDF) in 1977. For two years, I worked as a Fish Biologist with progressively greater responsibility managing treaty Indian and non-Indian salmon net fisheries in Puget Sound. In 1979, I was promoted to Assistant Chief of the Harvest Management Division in the WDF Planning, Research, and Harvest Management Program. I held that position for over 11 years. I oversaw salmon fisheries management in Puget Sound. My staff and I worked through some difficult issues as we learned how to manage fisheries in accordance with court orders in *United States v. Washington*.

4. In 1991, I moved from salmon harvest management into salmon habitat work. I spent 12 years supervising the Environmental Restoration Division in what is now the Washington Department of Fish & Wildlife's (WDFW's) Habitat Program. My staff included environmental engineers, biologists and construction workers who specialized in salmonid habitat. We planned, constructed, and evaluated fish habitat projects across the state, and provided technical assistance to support state, local, and federal initiatives to maintain and restore wild salmonids and their habitat. More specifically, we planned and built fish habitat enhancement and restoration projects, inventoried and removed stream obstructions and unscreened water diversions,

inspected and maintained fishways and screened water diversions, developed and maintained a statewide fish passage and water diversion database, and conducted research.

5. I retired from state service in December 2002. I am still involved in salmonid habitat issues, however. Since April 2005 I have worked as a private contractor with WDFW and the Washington State Department of Transportation in matters involving fish passage and other environmental problems affecting salmonids in Washington State.

I. Fish Passage in Washington Before 1990

6. Under Washington State law, RCW Chapter 77.55, anyone who undertakes a construction project in state waters must obtain a hydraulic project approval (HPA) from WDFW. Under RCW 77.57.30, an obstruction in a stream must be provided with a fishway, or fish passage device, approved by WDFW. The HPA law has been on the books since 1943; the fish passage law has been around since the nineteenth century. Before 1990, however, WDFW and its predecessors had no formal program linking HPA applications with fish passage barriers. Staffing levels were sufficient to process HPA applications but not to promote the program. Field habitat biologists who noted fish passage barriers reported them to the Olympia office. Only the most obvious fish passage problems, such as "perched" culverts with large outfall drops, were recorded. Gradually, a database called "Unresolved Fish Passage Problems" was developed. Biologists also conducted yearly inspections of fishways they knew about, and kept a separate database to help them track the owners' compliance

with maintenance directives. Neither of these databases was comprehensive.

II. Systematic Culvert Inventories and Correction Projects Began in the Early 1990s

7. In 1990, WDFW began taking a more systematic approach to hydraulic project approvals and fish passage. Because highways cross streams and other water bodies, HPAs are usually required for highway construction and maintenance projects. State law also requires that highway culverts be passable to fish. It became apparent that we could be more efficient, and do a better job of protecting fish, if we put those two things together. My predecessors, and staff at the Washington State Department of Transportation (WSDOT), decided to incorporate fish passage into our planning on HPAs issued for WSDOT activities. As a result, the agencies executed a Memorandum of Understanding in 1990 (Exhibit B). Among other things, they agreed to conduct an inventory of fish passage barriers on WSDOT rights-of-way. The 1991 Washington Legislature appropriated funds for WSDOT to remove six known fish passage barriers, and to work with what is now WDFW to identify additional fish passage barriers and prioritize them for removal (Exhibit C). Later that year, WSDOT and the Washington Department of Fisheries executed a second agreement to perform a statewide fish passage inventory and develop plans to remove fish passage barriers (Exhibit D). Nearly two decades later, WDFW and WSDOT continue to work together to identify fish passage barriers in the state highway system, prioritize them for correction, and fix them.

8. In nearly every year beginning in 1992, WSDOT and WDFW have published progress reports describing their fish passage barrier inventory and correction work on state highways. I was involved in preparing those that were published before I retired in December 2002, eleven reports in all. The Tribes cited our first three reports in Paragraph 3.6 of their January 2001 Request For Determination that started this Subproceeding.

9. We knew that WSDOT culverts were not the only ones that block fish passage. During the early 1990s, WDFW also reached out to local governments to help them with fish passage problems on their roads. WDFW conducted or helped with culvert inventories in four counties within the *United States v. Washington* Case Area—Jefferson, Thurston, Skagit, and Kitsap—and fixed several high priority county culverts under a cost-sharing arrangement. WDFW also did other cooperative fish passage work with several other counties in Western Washington.

10. Because fish get the most benefits when all fish passage barriers in a watershed are fixed at the same time, WDFW sought to include nearby private fish passage barriers within the same construction project when it fixed state and county culverts. Our ability to do that was limited by financial and staffing resources, however.

11. As we gained experience in fish passage work during the early 1990s, we developed a plan for sequencing the work that is still used today by WDFW: (1) Find and evaluate the culverts that block fish passage; (2) Record the information in a database; (3) Prioritize the culverts for correction so as to get the

most "bang for the buck;" (4) "Scope" each correction project; that is, evaluate the site and possible fish passage solutions; (5) Design a suitable structure that will achieve fish passage; (6) Install it; and (7) After construction, monitor it to see whether it worked.

III. Finding, Prioritizing, and Fixing Culverts that Block Fish Passage

A. Inventory: Finding and Evaluating Culverts that Block Fish Passage

12. In accordance with the 1991 legislation about WSDOT culverts (Exhibit C) and the newly-executed agreements between WSDOT and WDF (Exhibits B and D), the Washington Department of Fisheries organized a new fish passage inventory section to conduct a systematic inventory on WSDOT rights-of-way. It started its work in 1991 under my supervision.

13. When the WSDOT culvert inventory got started in 1991, the Washington Departments of Fisheries and Wildlife were separate agencies. Fisheries was in charge of salmon. Wildlife was in charge of steelhead and most other fish that live in fresh water. Because Fisheries was conducting the culvert inventory, it looked only for barriers to salmon passage. At that time, streams with a gradient of more than 7% were considered too steep for salmon, so WDF did not look for culverts in streams steeper than that. In 1994, the two agencies merged into a single Washington Department of Fish and Wildlife (WDFW). After that, culvert inventories expanded to include all salmonids, not just anadromous salmon. First, in 1995, the inventories expanded to include steelhead by going to steeper stream gradients, up to

12%. Then, in 1998, when the Washington Forest Practices Board drafted new forest practices rules, the inventories expanded again to include nonanadromous, "resident" fish that live in steeper streams up to a 20% gradient.

14. As described in the first report that WDF and WSDOT published on the WSDOT culvert program (excerpts attached as Exhibit F), the culvert inventories started in the north central Puget Sound region. To decide the order in which the inventory crews would visit regions around the state, we looked at the number of road miles in each region, the number of expected stream crossings, the number of fish species present, and fish stock status. These inventories are "road-based." Using stream maps, highway maps, and their own eyes, two people in a truck drive the roads and look for streams and culverts, stopping when they arrive at a likely location. It can be dangerous when there is a lot of traffic and no shoulder. Crews clamber down to the stream to take measurements. It is slippery work, with plenty of blackberries, devil's club, and stinging nettles in the way. The crews record what they find in their field notes and move on to the next site, day after 10-hour day, in all kinds of weather.

15. Before 1998, inventory crews relied on subjective professional judgment to determine whether salmonids could get through a culvert. (See Exhibit F, Bates No. T1000011.) They considered site conditions such as hydraulic drop (e.g., whether the culvert was "perched" above the streambed), culvert slope, water depth, and velocity. "Professional judgment" is not easily taught, however, and my staff and I decided we needed to create a standardized

method that other people could be trained to use. We developed a standard fish passage barrier assessment protocol, and published it in 1998 in a manual entitled *Fish Passage Barrier Assessment and Prioritization Manual*. As updated in 2000, the WDFW culvert assessment manual is attached as Exhibit E. The WDFW protocol is now widely used throughout the Pacific Northwest. For more information about WDFW's fish passage barrier assessment manuals, please refer to the Declaration of Michael R. Barber.

16. The WDFW barrier assessment protocol has two parts: Level A and Level B. Level A is a basic assessment that can be done onsite. The inventory crew takes measurements of the culvert and the stream, and looks inside the culvert to see whether streambed material is present. Sometimes, this is enough for the crew to determine on the spot whether fish can get through the culvert. (See Exhibit E, pages 11-12, 14-17; Bates Nos. USFWS 000890 – USFWS 000891, USFWS 000893 – USFWS 000896.) The crew may use professional judgment to gauge whether the culvert blocks fish passage completely, or only partially. (See Exhibit E page 12, Bates No. USFWS 000891.) They make a rough estimate of the extent of impassability, assigning the designations full barrier (90-100%), two-thirds barrier (50-90%), one-third barrier (10-50%), or no barrier (0-10%).

17. If the results of the Level A analysis are inconclusive, the crew takes additional measurements for a Level B analysis. A Level B analysis calculates water velocity inside the culvert under certain conditions. If the calculated velocity exceeds the value for adult trout in Table 1 of Section 220-110-070 of the Washington Administration Code (Exhibit E

Appendix B, Bates No. USFWS 000985), the culvert is considered to be a barrier to fish passage.[1] The idea behind this method is that, if fish are not strong enough to swim upstream against fast-moving water inside the culvert, they will not be able to get through it, though some fish may still get through. WDFW crews used the Level A/Level B method to determine the passability of nearly all of the WSDOT culverts that the crews examined statewide.

18. If a culvert blocks fish passage, the next step is to determine how much fish habitat it blocks. When looking for culverts, the inventory crews perform basic habitat assessments. If the crew can tell right away that a culvert blocks fish passage, the crew makes a "threshold determination" of whether it blocks a significant amount of habitat. The crew walks 200 meters up- and downstream looking for natural fish passage barriers, such as natural waterfalls or sustained stream gradients exceeding 20%. If there are no natural fish barriers within 200 meters of the culvert, the crew concludes that the culvert blocks more than 200 meters of habitat. WDFW judges 200 meters to be significant, so the culvert is put on the list for further evaluation. (See Exhibit E page 36, Bates No. USFWS 000915.)

19. My staff and I developed methods for determining the amount and quality of fish habitat

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[1] For more about WAC 220-110-070, please refer to Paragraph 48 below, and to the Declaration of Robert Barnard, P.E.

blocked by culverts so that we could generate prioritized lists of culverts to be fixed. Once a culvert is determined to block more than 200 meters of habitat, it gets scheduled for a more in-depth habitat assessment under one of the methods described in the WDFW culvert assessment manual. (See Exhibit E pages 29-54, Appendix A Physical Habitat Survey Field Form, and Appendix F; Bates Nos. USFWS 000908 – USFWS 000933, USFWS 000978 – USFWS 000979, and USFWS 001013 – USFWS 001015.) Habitat assessment crews visit each culvert, walk the stream, take measurements, and record their observations. This work can be dangerous, tedious, and very physically demanding. Sometimes, landowners are unwilling to let the crews enter their land to do the work. Habitat information that the crews collect is recorded, along with other information, so that the culvert can be evaluated and compared with other culverts in the prioritization process described below.

B. Recording the Information in a Computer Database

20. Until the late 1990s, WDFW maintained several independent computer databases related to fish passage. As information from culvert inventories began accumulating and data technology improved, my staff and I knew we needed a centralized, standardized way to record it. In 1998, Brian Benson of WDFW developed such a database, now called the Fish Passage and Diversion Screening Inventory (FPDSI) database. It primarily supports WDFW's inventory efforts on WSDOT rights-of-way and

WDFW-owned lands,[2] and it has also been a repository for inventory information collected by recipients of culvert inventory grants. The database now has many thousands of entries. For information about the current status of the FPDSI, please refer to the Declaration of Michael R. Barber.

C. Deciding Which Culverts to Fix First Using the Fish Passage Priority Index

21. The collective wisdom of fisheries biologists is that efforts to protect and restore wild salmonid populations can best succeed if we schedule habitat and fish passage restoration projects in the most cost-effective manner so as to maximize fish benefits. How do we measure and compare the fish benefits from fixing blocking culverts? It seemed to me in the early 1990s that we needed a "common currency" that could be applied to every potential culvert project statewide. By incorporating many relevant factors into a single, standardized index number, we could develop a tool for comparing the relative benefits of correcting different fish passage barriers in different watersheds or within a single watershed. Values unique to a particular project, such as its connection to another project, could be incorporated as "value-added parameters" if desired, but would not be part of the index number itself.

22. I advanced the "single number concept" with the Priority Index (PI) methodology for fish

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[2] For information about culvert inventories on lands owned by the Washington Department of Fish and Wildlife, please refer to the Declaration of Michael R. Barber.

passage projects. My staff and I developed the Fish Passage Priority Index in 1991 as a way to implement the 1991 legislation that launched the WSDOT culvert program (Exhibit C). We first published it in the 1992 progress report on the WSDOT program (Exhibit F, Bates No. T1000015). It was later published in the 1998 and 2000 WDFW culvert assessment manuals. It is still widely used today.

23. The PI for each fish passage project is a numeric indicator giving each project's relative priority with respect to other projects. This *relativism* is crucial. The PI works because it provides a general, objective framework for overall prioritization. The PI incorporates a variety of factors, and no single factor for any individual species dominates.

24. The PI equation looks complex, but it is logical, and it works. Here it is:

$$PI = \sum_{\text{all species}} \sqrt[4]{[(BPH) \times MDC]}$$

Where:

PI = Fish Passage Priority Index number for a particular project, indicating the relative benefit of the project considering cost.

$\sum$ = A mathematical symbol indicating that individual values are to be summed. The overall project PI is the sum ($\Sigma_{\text{all species}}$) of individual PI values calculated for each species present in a stream (e.g., PI_{coho} is added to PI_{chum} to obtain $PI_{\text{all species}}$).

$\sqrt[4]{}$ = Quadratic root symbol. The quadratic root is used because otherwise the equation would generate an unwieldy range of gigantic numbers.

B = Proportion of passage improvement achieved from a particular culvert correction project—roughly reflects whether the culvert is a partial or total barrier to fish passage and gives greater weight to projects that would correct total barriers. See Paragraph 16 above for more.

P = Annual adult fish production potential per m^2 of habitat opened up if the culvert were fixed – gives greater weight to projects that have the potential to produce the most fish. Each species has its own "P."

H = Habitat gain in square meters (m^2) – the amount of habitat that would be opened up if the culvert were fixed – gives greater weight to projects that would open up more habitat.

M = Mobility Modifier – gives greater weight to projects that would open up habitat for anadromous species.

D = Species Condition Modifier – gives greater weight to less healthy species.

C = Cost Modifier – gives greater weight to less costly projects. Anything over $500,000 is considered to be a high cost project.

The P and H factors are discussed in greater detail below. For more detail about the other factors, see Exhibit E, pages 55-57 (Bates No. USFWS 000934 – USFWS 000936).

25. **The P Factor.** The P factor estimates the number of adult fish that could *potentially* be produced annually by the habitat made available by correction of the passage barrier. It is not intended to predict the number of fish that *would* be produced. My staff and I chose standard "P" values for each salmon species by examining the scientific literature that was available in the early 1990s. Most of it was based on research done in the 1970s and 1980s. (See Exhibit F, Bates Nos. T1000060 – T1000061.) We added "P" factors for steelhead and trout later in the 1990s after the merger of the Washington Departments of Fisheries and Wildlife. The following table shows the "P" factors for salmon and steelhead that are currently used in the Fish Passage Priority Index. (See Exhibit E, pages 55-56; Bates Nos. USFWS 000934 – USFWS 000935.)

Salmon and Steelhead "P" Factors Used in the Fish Passage Priority Index		
Species	**Type of Habitat**	**Methodology/Source**
Coho Salmon	Rearing	(0.5 coho smolts/m^2)(0.10 smolt to adult survival) = 0.05 coho adults/m^2 of rearing habitat
		See Exhibit F (Bates No. T1000060)
Chinook Salmon	Rearing	Spring/Summer Chinook: (0.5 spring/summer chinook smolts/m^2)(0.018 smolt/adult survival) = 0.009 spring/summer chinook adults/m^2 of rearing habitat

		Fall Chinook: (0.5 fall chinook smolts/m²)(0.015 smolt/adult survival) = 0.0075 fall chinook adults/m² of rearing habitat
		Spring/Summer and Fall Chinook are combined for a composite chinook production of 0.016 chinook adults/m² of rearing habitat
		See Exhibit F (Bates No. T1000060)
Chum Salmon	Spawning	(0.5 female/m² of spawning habitat)(2500 eggs/female)(0.10 egg to fry survival)(0.01 fry to adult survival) = 1.25 chum adults/m² of spawning habitat
		See Exhibit F (Bates No. T1000061)
Pink Salmon	Spawning	(0.5 female/m² of spawning habitat)(2500 eggs/female)(0.10 egg to fry survival)(0.01 fry to adult survival) = 1.25 pink adults/m² of spawning habitat
		See Exhibit F (Bates No. T1000061)
Sockeye Salmon	Spawning	(3500 eggs/redd)(0.0025 egg survival to adult) = (8.75 adults/redd)/2.9 m²/redd = 3 sockeye adults /m² of spawning habitat
		See Exhibit F (Bates No. T1000061)
Steelhead	Rearing	(0.06 smolts/m²)(0.035 smolt survival to adult) = 0.0021 steelhead adults/m² of rearing habitat
		See WDFW/WSDOT 1997 report to Legislature (app. XIII)

26. **The H Factor.** As described above in Paragraph 18, habitat assessment crews collect information about the habitat associated with each fish-blocking culvert. Habitat gain is expressed in square meters (m^2) of either spawning or rearing habitat. Spawning area is used for those species (chum, pink, and sockeye salmon) whose production is limited primarily by spawning habitat. Rearing area is used for those species (coho and chinook salmon, steelhead, and trout) whose production is limited primarily by rearing habitat. (See Exhibit E, pages 31-34 and Appendix E; Bates Nos. USFWS 000910 – USFWS 000913 and USFWS 001007 – USFWS 001012.) Spawning and rearing areas can be adjusted by a Habitat Quality Modifier, a subjective estimate of habitat quality to account for the decreased production potential of degraded streams. (See Exhibit E, pages 33, 38-39; Bates Nos. USFWS 000912, USFWS 000917 – USFWS 000918.) Data collected from habitat surveys are processed in a customized spreadsheet that generates a detailed report for each stream surveyed. (See Exhibit E, Appendix H; Bates Nos. USFWS 001019 – USFWS 001021.)

27. When fish species with similar freshwater life histories occupy the same habitat, they compete with each other, which tends to reduce the production of each species below what it would be without the competition. For example, coho and steelhead juveniles spend a lot of time in freshwater before heading to sea, and they compete for food and shelter. To adjust for that competition, my staff and I developed the species complex factor. It is used to reduce the habitat area (H) used in the Priority Index

formula. (See Exhibit E pages 39-40; Bates Nos. USFWS 000918 – USFWS 000919.)

28. Sometimes, there are multiple fish passage barriers on the same stream. But when we calculate a PI for a culvert, we assume it is the only barrier in the watershed because we don't know when the others might be fixed. So, when we calculate "H" for a culvert, we include all of the fish habitat upstream of the culvert, even though there may be other fish passage barrier culverts upstream.

D. Response to Tribal Use of the Fish Passage Priority Index

29. I understand that the Tribes in this Subproceeding have sought to use the "BPH" factors in the Fish Passage Priority Index to generate numbers of lost fish production and effects on fisheries from state-owned fish-blocking culverts. The PI was never intended to be used in that manner. We developed the PI solely as a tool to help decision-makers decide how to allocate limited funds when selecting fish passage projects. The PI uses standardized, generic production factors. That makes it a good tool for comparing the relative benefits of different projects, but a bad one for making predictions about fish production in particular streams. It is not an accurate method to predict actual salmon production upstream of fish-blocking culverts, or actual salmon harvest, and it is a misuse of the PI to use it for those purposes. The following paragraphs give some examples of why that is so.

30. **Double counting of habitat.** Sometimes, there are multiple state-owned fish passage barriers on the same stream. For each barrier, a

separate PI is calculated that assumes it is the only barrier in the watershed, as discussed above in paragraph 28. If there are four barriers in the watershed, and we add up the "potential" fish production from each one, we wind up counting some areas of the stream four times.

31. **Over-estimation of potential benefits.** Several factors may contribute to over-estimation of potential benefits of barrier correction. Among other things, these include:

- Presence of non-state-owned fish passage barrier culverts upstream or downstream of a state-owned barrier.
- Many areas upstream of partial blockages may already be fully seeded—that is, the fish are already getting past the partial barrier and spawning. Removing the barrier may not increase fish production.
- The "P" factors used in the PI are based on research from streams with shallow gradients, where fish production is highest. Fish production is less in streams with steeper gradients, such as we find on the Olympic Peninsula. Research by WDFW's Dave Seiler and others has shown that some watersheds are more productive than others.
- The "P" factors used in the PI assume that smolt-to-adult survival will be the same for every watershed in every year. That does not reflect reality. Many things affect the survival of young salmon as they grow to adulthood. For example, ocean conditions can have a huge

impact, as described in the Declaration of Jeffrey P. Koenings, Ph.D.

- The "P" factors used in the PI are based on standard production values for each species, but in particular stream systems the collective experience of biologists may suggest that lower values are more realistic. An example is sockeye salmon in Coal Creek, which flows into Lake Washington at Bellevue.

32. **Percent Passage Improvement ≠ Percent Fish Improvement.** As described above in Paragraph 16, crews conducting culvert inventories may make rough judgments about whether a culvert is a full or partial fish passage barrier. For partial barriers, they may estimate the extent of impassability, assigning the designations two-thirds barrier (50-90%), or one-third barrier (10-50%). The "B" factor in the PI equation, which represents proportion of passage improvement, relates to an approximate mid-point of those ranges. (See Exhibit E page 57, Bates No. USFWS 000936.) It is not intended to quantify the proportion of increased fish production that would result from a fish passage barrier correction, and I am aware of no evidence of a close correlation. The "B" factor is intended only to assist decision-makers in the prioritization model.

33. **Delay of fish use.** Sometimes, it can take years for salmon to find their way into newly-available habitat.

34. **Escapement goals.** Escapement goals—the number of fish that must get to the spawning grounds to sustain the run optimally—are based on the habitat available in the water-

shed. Fishery managers would need to increase escapement goals to account for the habitat opened up from fixing culverts. Fish needed for escapement would not be available for harvest.

35. **Habitat degradation.** The "P" factors used in the PI are based on high quality streams with ample fish habitat. Those numbers may not work for degraded streams or smaller streams. For example, WDFW research suggests that more sensitive species disappear from urban streams that get a lot of run-off from impervious streets and parking lots, and the only remaining salmonids are cutthroat trout or late-spawning chum salmon.

36. **Depressed stock status.** The "P" factors used in the PI are based on healthy fish stocks. For stocks in poor condition, such as those listed as threatened or endangered under the federal Endangered Species Act, there may not be enough spawners to use the stream habitat that is already available.

37. **Fisheries in Alaska and Canada.** Juvenile salmon from Washington rivers migrate to Canadian and Southeast Alaskan marine waters before reversing their migration and returning to Washington as adults. People fish for them in those waters, reducing the number that return to Washington. It is hoped that the new 2009-2018 chinook annex that has been negotiated under the Pacific Salmon Treaty will allow more Washington-origin chinook to return to Washington.

38. **Density Dependent Mortality.** Because of crowding and competition for food and shelter, increasing the production of juvenile fish can

decrease their freshwater or marine survival. The result may be little or no net increase in adult production even if we increase the juvenile production because we unblocked a culvert.

39. **Lack of full harvest.** Even where more salmon are produced when a fish passage barrier is removed, fishermen may be unable to catch them all because of factors such as:

- Low market prices for fish may make fishing uneconomical.
- Fisheries may be constrained to protect weak stocks mixed in with healthier stocks.
- Bad weather may keep fishermen home.
- Fish may arrive while fisheries are closed.
- Fishing opportunity is subject to court orders and state/tribal negotiations.

E. Scoping, Design, Construction, and Post-Construction Monitoring

40. For WSDOT culverts, the Fish Passage Priority Index formula typically generates PI numbers that range from 1 to 62. Other types of structures, such as dams, may generate higher numbers. In general, the higher a culvert's PI number, the higher the priority to fix the culvert. PI numbers are a valuable tool that decision-makers can use to compare culverts, but they do not in themselves dictate the order in which culverts are fixed. Assigning a PI number is just an initial step in deciding what to do about a fish passage barrier culvert. WDFW and WSDOT use a scoping process to make decisions about fish passage projects. In the

scoping process, biologists, engineers, and others consider practical factors such as construction feasibility or the presence of other blocking culverts. Challenging geology may be a reason to conduct a repair at an easier site first. Sometimes, culvert repair projects are selected so as to match costs with available funds. Projects may be spread around regionally to avoid overwhelming staff in one area, or concentrated in one area to be efficient. The aim is to get the greatest benefit from the resources available.

41. For more information about the scoping process and project inspection and monitoring, please refer to the Declaration of Michael R. Barber. For more information about culvert design, please refer to the Declaration of Robert Barnard, P.E.

IV. Fish Passage in Washington Since the Late 1990s

42. Beginning in the late 1990s, the whole environmental community recognized the importance of fish passage. This recognition translated to legislative attention, emphasis on resolving fish passage problems on all state-owned lands, and efforts to bring WDFW technical expertise to the public. For a description of what WDFW has done to address fish passage problems on its own lands, please refer to the Declaration of Michael R. Barber. Please refer to the Declarations of Michael R. Barber and Robert Barnard, P.E., for information about the work that WDFW has done to publish technical manuals and provide training and technical assistance to the public.

43. During the late 1990s, the Washington State Legislature enacted several key bills that

addressed fish passage and other environmental issues. A 1997 enactment directed WSDOT and WDFW to convene a Fish Passage Task Force with Tribes, local governments, businesses, and environmental groups. I co-chaired that Task Force with Paul Wagner from WSDOT. We presented a report to the legislature in December 1997 with recommendations for better coordination, training, funding, and permit streamlining for fish passage projects.

44. The Legislature adopted some of our recommendations in 1998, along with other salmon recovery measures. Most of the legislation is currently codified in Chapters 77.85 and 77.95 of the Revised Code of Washington. Please refer to the Declaration of Jeffrey P. Koenings, Ph.D., for more about salmon recovery efforts in Washington.

45. The 1998 legislation recognized the wisdom of targeting salmon recovery dollars where they could do the most good. To that end, the Legislature directed the Washington Conservation Commission, in consultation with Tribes and others, to invite the region's experts to identify habitat factors limiting salmon production in major watersheds across the state. (See 1998 Wash. Laws ch. 246, § 10, attached as Exhibit G.) Over a period of several years, the Conservation Commission published Salmon Habitat Limiting Factors Reports for all basins in Washington that produce salmon and steelhead. Fish passage was only one of many habitat factors examined. Others included floodplain conditions, riparian conditions, sediment conditions, woody debris conditions, pool habitat conditions, water temperature conditions, high flow conditions, low flow

conditions, and estuarine and nearshore habitat. The relative importance of those factors was different for each watershed. For some basins, such as the Lake Washington watershed, fish passage barrier culverts were found to be significant. For others, such as the Nisqually watershed, culverts were not identified as a significant limiting factor. The Conservation Commission's final summary report is attached as Exhibit H.

46. Another 1998 enactment authorized WSDOT to administer a fish passage grant program to assist state, local, tribal, and private groups to identify and remove fish passage barriers. (See 1998 Wash. Laws ch. 249, § 16, attached as Exhibit I.) In 1999, the Legislature created the Salmon Recovery Funding Board (SRF Board) to oversee a coordinated process for allocating grant monies for salmon recovery projects statewide, with administrative support from the Interagency Committee for Outdoor Recreation (now the Recreation and Conservation Office). (See 1999 Wash. Laws 1st sp. Sess. ch. 13, attached as Exhibit J.) It ultimately took over the grant program for fish passage barriers. A review team reviews and ranks project proposals that come before the SRF Board. That team incorporated the WDFW Fish Passage Priority Index methodology into its ranking process for fish passage projects, and still uses it today.

V. WDFW Fish Passage Research and Adaptive Management

47. One of the reasons I stayed at WDFW for 25 years was the passion and dedication of my colleagues. Throughout my career, my staff and others

conducted scientific and engineering research to make things better for fish, including our fish passage program. It was always a team approach. Mike Barber, Brian Benson, Tom Burns, Larry Cowan, Susan Cierebiej, Eva Wilder, Greg Johnson, Jim Lenzi, Pat Schille, Eric Egbers, Pat Powers, Ken Bates, and Bob Barnard all contributed to the development of our fish passage and screening procedures. It was a trial-and-error effort that started with good, technically sound ideas, followed by implementation of the ideas, recognition of needed improvements, group discussions to devise improved methods, implementation of the improvements, and repeating this cycle over and over. Using research to improve the way we do things is sometimes called "adaptive management," and this was adaptive management at its best. It could not have been accomplished without the fine-tuned team approach we had.

48. As described above, Washington State law provides that anyone who undertakes a construction project in state waters must obtain a hydraulic project approval from WDFW. WDFW and its predecessors have adopted rules to implement that law. An example of our adaptive management approach is the rule-making we did in the early 1990s. The current hydraulic rules were adopted in 1994 after a two-year revision process in which the Tribes were invited to participate. (The pre- and post-1994 culvert rules are attached as Exhibit K.) The 1994 rules reflected state-of-the-art research when they were adopted. For the first time, they identified specific options for culvert installation, and formalized specific fish passage criteria for culverts, including culvert size and maximum water veloci-

ty. Ken Bates, then a WDFW engineer, developed the water velocity criteria based on research conducted during the 1980s on the swimming abilities of adult fish. As of 1994, little information was available about the swimming abilities of juvenile salmon, so we used a six-inch trout as the closest surrogate.

49. Since 1994, several state and federal agencies, including WDFW, have participated in studies of juvenile salmon swimming abilities at WDFW's Skookumchuck Hatchery near Tenino, Washington. In 1997, Pat Powers of WDFW conducted a study involving juvenile coho salmon, which showed better passage in smooth pipes. In 2005-06, Battelle conducted a study on juvenile coho salmon passage through culverts retrofitted with baffles (excerpts attached as Exhibit L). The results suggest that baffles may make it easier for juvenile fish to swim upstream, but that juvenile fish behavior is complex. Both studies were funded by WSDOT.

50. Perhaps the most innovative research of the past decade has focused on the stream simulation approach to culvert design. Stream simulation is conceptually different from prior methods. Please refer to the Declaration of Robert Barnard, P.E., for a description of the stream simulation method and research about it.

I declare under the penalty of perjury that the foregoing is true and correct.

Executed on this *19th* day of March, 2009, at Olympia, Washington.

s/Paul Sekulich,
PAUL SEKULICH, PH.D.

EXHIBITS TO THE DECLARATION OF PAUL SEKULICH, PH.D.

Exhibit A
Curriculum Vitae of Paul Sekulich, Ph.D.

Exhibit B
Memorandum of Understanding Between the Washington State Departments of Fisheries, Wildlife, and Transportation Concerning Compliance With the Hydraulic Code (1990) (Bates Nos. T1000033 – T100054)

Exhibit C
1991 Wash. Laws, 1st sp. Sess., ch. 15, § 22 (Bates Nos. F0008267 – F0008268)

Exhibit D
Interagency Agreement between the Washington Department of Fisheries and the Washington State Department of Transportation to Perform a Fish Passage Inventory Statewide & Work With DOT in Planning Projects and Developing Agreements to Remove Fish Barriers Within DOT Rights-of-Way (December 6, 1991) (Bates Nos. T1000056 – T1000058)

Exhibit E
Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual (Washington Department of Fish and Wildlife, August 2000) (Bates Nos. USFWS 000875 – USFWS 001032)

Exhibit F
Excerpts from *Fish Passage Program Progress Performance Report for the Biennium 1991-1993* (Washington Department of Fisheries/Washington Department of Transportation, December 1992) (Bates Nos. T1000001, T1000002, T1000005, T100007 – T1000013, T1000015, T1000016, T1000060, T1000061)

Exhibit G
1998 Wash. Laws ch. 246

Exhibit H
Carol J. Smith, Ph.D., *Salmon Habitat Limiting Factors in Washington State* (Washington State Conservation Commission, 2005) (Exhibit AT 769 in Plaintiff Tribes' Exhibits, Corrected and Amended List, August 8, 2007)

Exhibit I
1998 Wash. Laws ch. 249

Exhibit J
1999 Wash. Laws 1st sp. Sess. ch. 13

Exhibit K
Washington Administrative Code § 220-110-110 Culvert Installation (1990 edition), and Washington Administrative Code § 220-110-070 Water Crossing Structures (1995 edition)

Exhibit L
Excerpts from Pearson, et al., *Final Report: Research on the Upstream Passage of Juvenile Salmon through Culverts: Retrofit Baffles* (Battelle Memorial Institute, April 2006) (Bates Nos. 113709 – 113714)

The Honorable Ricardo S. Martinez

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

UNITED STATES OF AMERICA, et al., Plaintiff, v. STATE OF WASHINGTON, Defendant.	NO. C70-9213 Subproceeding No. 01-1 (Culverts) DECLARATION OF MICHAEL R. BARBER IN LIEU OF DIRECT TESTIMONY

TABLE OF CONTENTS

I, MICHAEL R. BARBER, declare as follows:

1. I am a Section Manager within the Habitat Program of the Washington Department of Fish and Wildlife (WDFW). I have held that position since December 2001. Among other things, I oversee WDFW's program to find and fix fish passage barriers on WDFW-owned lands. Under a contract with the Washington State Department of Transportation (WSDOT), I manage the WDFW work supporting WSDOT's fish passage program, supervise the preparation of the annual progress reports that describe the program, and update WSDOT's Ten-Year Plan of prioritized fish passage projects. I am also involved in budgeting and in developing fish passage assessment methods and training materials. My resumé is attached as Exhibit A.

2. I hold Bachelor and Master of Science degrees in Biology, both from Eastern Washington University. I earned my Master's degree in 1988. My

thesis examined the relationship between stream flow and fish habitat on Chamokane Creek in the Spokane Indian Reservation.

3. In 1985, I began working as a Fish Biologist with the Upper Columbia United Tribes Fisheries Center in Cheney, Washington. The Upper Columbia United Tribes is an intertribal organization of the Spokane, Kalispel, Coeur d'Alene, and Kootenai Tribes, and now the Colville Tribes as well. To assist the Northwest Power Planning Council in its policy development for the Upper Columbia River region, I directed a study to assess fishery improvement opportunities on the Pend Oreille River. For my master's thesis, I collected and analyzed habitat data for a study on the Spokane Indian Reservation. The results of both studies were published in technical reports and have been cited in others.

4. In September 1990, I joined the Washington Department of Fisheries[1] Habitat Program as a Fish Biologist. For about five years, I was involved in permitting decisions for construction projects and timber harvests. In 1995, I started working for Dr. Paul Sekulich on fish passage barrier projects. As described in the Declaration of Paul Sekulich, Ph.D., WDFW fixed culverts for several Western Washington counties during the mid-1990s. I was in charge of some of those projects, as well as some fish passage projects for WSDOT. I acted as

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[1] The Washington Department of Fisheries was a predecessor to the Washington Department of Fish and Wildlife.

Project Manager on about 18 fish passage construction projects from start to finish.

5. As described in Dr. Sekulich's declaration, WDFW has been conducting fish passage barrier inventories and habitat assessments for WSDOT since 1991. In 1999, I became the supervisor of the inventory crews, a responsibility that I still have, while continuing to serve as a Project Manager for fish passage construction projects. I was responsible for preparing the 1998 and 2000 versions of WDFW's *Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual*. (The 2000 version is attached as Exhibit E to the Declaration of Paul Sekulich, Ph.D.) I also served as a technical expert in the evaluation of fish passage grant applications for several grant programs described in the Declarations of Paul Sekulich, Ph.D., and Jeffrey P. Koenings, Ph.D.

I. Finding, Prioritizing, and Fixing Washington State Highway Culverts that Block Fish Passage

6. As described in the Declaration of Paul Sekulich, Ph.D., WDFW plans its fish passage work in a sequence: (1) find and evaluate the culverts that block fish passage; (2) record the information in a database; (3) prioritize the culverts for correction so as to get the most "bang for the buck;" (4) "scope" each correction project, that is, evaluate the site and possible fish passage solutions; (5) design a suitable structure that will achieve fish passage; (6) install it; and (7) after construction, monitor it to see

whether it worked. WDFW has been performing fish passage work for WSDOT since 1991 under a series of contracts. The 2007-09 contract is attached as Exhibit B.

A. Inventory: Finding and Evaluating WSDOT Culverts that Block Fish Passage

7. The Declaration of Paul Sekulich, Ph.D., describes how WDFW developed methods to find culverts that block fish passage and assess how much habitat they block. As Dr. Sekulich describes, WDFW began an inventory of culverts in the Washington State highway system in 1991. I have been supervising the inventory crews since 1999. At first, we had only one two-person crew, but we added a second in 2003. In 2007, they finished the fish passage barrier assessment part of the WSDOT culvert inventory, on more than 7,000 miles of highways statewide. It took 16 years to complete. It took that long in part because culvert assessment is hard work, as described in Dr. Sekulich's declaration, and in part because we got better at finding culverts when improved mapping and navigation technology became available, such as Global Positioning System devices. By the end of 2007, the inventory crews had found 3,185 WSDOT culverts in fish-bearing streams statewide. Of those, 1,859 were determined to be partial or complete fish passage barriers. The following table shows the results for the *United States v. Washington* Case Area:

Fish Passage Barrier Culverts Within WSDOT Rights-of-Way In the *United States v. Washington* Case Area				
Culverts that block > 200 meters of salmon and steelhead habitat	Culverts that block > 200 meters of nonanadromous fish habitat	Culverts that block ≤ 200 meters of fish habitat	Culverts that block an unknown amount of habitat	Total
807	122	279	7	1,215

8. If a culvert blocks fish passage, the next step is to determine how much habitat it blocks. If an initial assessment shows that the culvert blocks more than 200 meters of habitat, it gets put on the list for a more extensive habitat assessment under one of the methods described in WDFW's *Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual* (2000 version attached as Exhibit E to the Declaration of Paul Sekulich, Ph.D.). WDFW has scheduled its habitat assessment work by starting with the streams thought to have the most blocked habitat, so that the culverts suspected to be the highest priority to fix could be scheduled for correction as soon as possible. In July 2005, a two-person crew was formed to conduct habitat assessments full-time. After the two crews that were doing the culvert inventories described in Paragraph 7 finished their work, they were reassigned to habitat assessments. At this time, WDFW has three two-person crews conducting habitat assessments for the

WSDOT culverts that have been identified as fish passage barriers. They visit each culvert, walk the stream, and take measurements in accordance with WDFW protocols. We use the information they gather to generate prioritized lists of culverts to be fixed. As described in Dr. Sekulich's declaration, doing habitat assessments is strenuous and sometimes dangerous. Each crew walking the streams can complete about one mile per day. The young people who do this work are frequently away from home for days at a time. With three crews, we expect to complete all habitat assessments for the entire state highway system by mid-2015.

B. The Fish Passage and Diversion Screening Inventory Database

9. WDFW records the culvert inventory information it collects in a computer database now called the Fish Passage and Diversion Screening Inventory (FPDSI) database. Brian Benson of WDFW designed it in 1998 and has been maintaining and continuously updating it ever since. He set it up with internal links so that information can be easily retrieved and analyzed. It now contains over 36,000 entries, including nearly 20,000 for human-made structures in fish-bearing or potentially fish-bearing streams. Of those, approximately 58% are partial or complete fish passage barriers. The FPDSI contains data collected by WDFW and by recipients of culvert inventory grants. The FPDSI is not a comprehensive or complete inventory of fish passage barriers within the State of Washington, however. The Washington Department of Natural Resources and the United States Forest Service maintain their own separate databases with information from inventories they

have conducted, for example. WDFW does have some information about other inventories that local governments, Indian Tribes, and environmental groups have conducted, but only if that information has been voluntarily provided to WDFW.

10. **Data on Washington State Parks Culverts.** WDFW conducted a separate inventory of culverts at some Washington State Parks facilities in 2007 under a contract with the Washington State Parks and Recreation Commission. The following table shows the results of that inventory, as currently reflected in the FPDSI.

Fish Passage Barrier Culverts Within Washington State Parks Facilities in the *United States v. Washington* Case Area				
Culverts that block > 200 meters of salmon and steelhead habitat	Culverts that block > 200 meters of nonanadromous fish habitat	Culverts that block ≤ 200 meters of fish habitat	Culverts that block an unknown amount of habitat	Total
28	25	23	13	89

11. As of March 2009, the FPDSI contains 1375 records of WSDOT, WDFW, and State Parks fish passage barrier culverts within the *United States v. Washington* Case Area. For 393 of those culverts, WDFW has conducted habitat assessments to identify all additional human-made barriers between the known salmon access point and the first upstream

natural fish barrier. Within that group of 393, the FPDSI shows 42 anadromous fish passage barrier culverts in the Case Area that block more than 200 meters of habitat in streams with no other known anadromous barriers. A list is attached as Exhibit C.

C. Prioritization and Scoping: Evaluating a Culvert Site and Choosing a Fish Passage Correction Option

12. Once a habitat assessment for a culvert has been completed and the data recorded, a Priority Index number (PI) can be calculated for the culvert. Please refer to the Declaration of Paul Sekulich, Ph.D., for a description of the Fish Passage Priority Index and how PIs are calculated. WDFW has calculated PIs for about 462 WSDOT barrier culverts statewide, including 341 within the *United States v. Washington* Case Area. Their PI numbers range from 1 to 62. In general, the higher a culvert's PI number, the higher the priority to fix the culvert. We did not wait to finish all the PI calculations before we started fixing WSDOT culverts, however. We have prioritized culverts for correction with whatever list we had at the time, focusing on those with higher PIs, especially if there were no other fish passage barriers in the watershed. As of early 2009, most WSDOT barriers with a PI greater than 20 and no other barriers in the watershed have been fixed.

13. PI numbers are a valuable tool that decision-makers can use to compare culverts, but they do not in themselves dictate the order in which culverts are fixed. Assigning a PI number is just an initial step in planning what to do about a fish passage barrier culvert. WDFW and WSDOT use a scoping

process to make decisions about fish passage projects. (See Exhibit B, Bates Nos. F0007042 – F0007043.)

14. Biologists get the scoping process started. First, they verify the information already collected about the culvert. A WDFW biologist visits the culvert and checks to see whether the information collected in the inventory and habitat assessment is correct and still current, filling in any data gaps. Next, the biologist confirms that habitat conditions and fish species expected to benefit are correctly reflected in the PI for the culvert. If not, the PI may be recalculated. Then, the biologist collects other information about the culvert, such as whether there are other human-made barriers in the watershed, and whether other habitat restoration efforts are occurring in the watershed. The biologist also considers the feasibility, likelihood of success, and potential cost of a project. The biologist summarizes this information and generates a map to show the location of additional human-made barriers located downstream and upstream of the barrier. An example, relating to two culverts on Anderson Creek under State Route (SR) 16 near Port Orchard, is attached as Exhibit D.

15. The biologist may either recommend that a project be put on "Hold" until other habitat problems in the watershed are corrected, or that a project go forward. For the Anderson Creek culverts described in Exhibit D, the biologist recommended that the project go forward because of high-quality habitat upstream, even though there are other fish passage barriers in the watershed. The next step in the scoping process is the assignment of a WDFW scoping engineer to develop conceptual designs for

barrier correction. To do that work, WDFW has eight environmental engineers statewide and two engineering aides who assist them. The engineer visits the site, takes measurements and photos, evaluates options, and prepares a written report with recommendations for fish passage solutions, which may include a rough cost estimate. An example, relating to the Anderson Creek culverts described in Exhibit D, is attached as Exhibit E. With current staffing, WDFW is able to prepare about 80 scoping reports per biennium for WSDOT.

16. Once the conceptual design options have been identified, WSDOT staff get involved, along with the WDFW Area Habitat Biologist assigned to the region where the culvert site is located. They meet with the WDFW scoping biologist and engineer in a "pre-scoping meeting." Together, the group selects a preferred design option. For example, Exhibit D shows that the preferred design option selected for the Anderson Creek culverts is replacement with a single stream simulation culvert estimated to cost $6.4 million.[2] Once a preferred design option has been selected, the project is eligible to be placed on the WSDOT Ten-Year Plan for fish passage barrier correction, which I prepare in coordination with the WSDOT Environmental Services Office. The Anderson Creek site described in Exhibits D and E, which has a PI of 38.6, has been placed on the Ten-Year Plan. WSDOT has requested $479,000 for engineering and design work during the 2009-11

[2] Please refer to the Declaration of Robert Barnard, P.E., for a discussion of the stream simulation culvert design method.

biennium, with construction possible during the 2011-13 biennium.

D. Design and Construction

17. During the 1990s, WDFW designed and constructed about 30 fish passage projects for WSDOT. I was the Project Manager on some of those projects. Today, WSDOT uses its own engineers to do the design and hires private contractors to do the construction. WDFW provides input at the "60% design" level, where major design elements are well established. WDFW reviews the design to make sure it is consistent with the preferred design option developed and agreed to during the scoping process. WDFW also has a role at the permitting stage, when it receives WSDOT's application for a hydraulic project approval (HPA) under RCW 77.55.021. WDFW may impose additional conditions for the protection of fish life, such as restrictions on the timing of construction.

E. Monitoring to See Whether the Fish Passage Project Worked

18. Immediately after WSDOT finishes a fish passage construction project, WDFW inspects it to verify that it was built as permitted and designed. WDFW also does that for fish passage projects on its own lands (described below). Among other things, WDFW determines whether the newly-built structure is passable to fish. For WSDOT culvert projects constructed with dedicated funds, under the "I-4 program,"[3] WDFW checks the culvert again after it

[3] Please refer to the Declaration of Paul J. Wagner for a description of the WSDOT I-4 program.

has been in place for one winter storm season to verify that it remains passable to fish.

19. For WSDOT culvert projects constructed under the "I-4 program," WDFW conducts fish spawner surveys in the stream before construction and one year after construction. The purpose is to verify that adult salmon are getting through the new structure and spawning upstream of it. WDFW does not check to see whether fish production actually increases after the culvert is fixed. The number of additional fish that might be produced from fixing a single culvert would not be detectable given the natural variability in run sizes due to ocean survival and other factors.

20. WDFW has four test sites where it conducts ongoing monitoring through annual spawner surveys. We want to know how different fish passage design methods compare with each other, so the four test sites represent four different design methods:

- Unnamed tributary to South Branch Big Creek (US 101, mile post 101.1 near Humptulips), to represent a hydraulic design option;
- Moose Creek, tributary to the North Fork Stillaguamish River (SR 530, mile post 44.0 west of Darrington), to represent a no slope design option;
- Fairchild Creek, tributary to Big Creek (US 101, mile post 105.6 near Humptulips), to represent a fishway retrofit design option; and
- Dogfish Creek, tributary to Liberty Bay (SR 307, mile post 0.07 near Poulsbo), to represent a stream simulation design option.

Please refer to the Declaration of Robert Barnard, P.E., for a description of these culvert design methods. The results of the annual surveys indicate that none of the projects are blocking fish passage, because we are not seeing a disproportionate number of adult fish or redds (salmon nests) downstream of the project sites.

II. Culverts on WDFW-Owned Lands

21. The Washington Department of Fish and Wildlife manages lands and roads of its own, which have culverts and, sometimes, fish passage problems. WDFW-owned lands include Wildlife Areas managed for wildlife habitat and public recreation, water access sites where people can launch boats to go fishing, and fish hatcheries. WDFW owns about 550,000 acres of land statewide, mostly in rural settings. That figure changes over time, as WDFW sometimes acquires or transfers lands.

22. In 1997, WDFW began an inventory of all fish passage and fish screening structures on its lands, including roads and culverts. I have been overseeing those inventories since 2001. They are complete within the *United States v. Washington* Case Area, but WDFW is still working on inventories and habitat assessments on its lands in the remainder of the state. WDFW has generally used the same inventory and prioritization methods on its own lands as it has on state highways, as described in WDFW's *Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual* (attached as Exhibit E to the Declaration of Paul Sekulich, Ph.D.). The principal difference is that WDFW has performed "stream-based" inventories on

its own lands, in contrast to the "road-based" inventories it has conducted for WSDOT. In a "stream-based" inventory, biologists or technicians walk the entire stream looking for fish passage barriers, whether they are associated with a road or not. My staff have found 73 culverts that currently block fish passage on WDFW lands within the *United States v. Washington* Case Area, as follows:

Fish Passage Barrier Culverts on WDFW Lands Within the *United States v. Washington* Case Area			
Culverts that block > 200 meters of salmon and steelhead habitat	Culverts that block > 200 meters of nonanadromous fish habitat	Culverts that block ≤ 200 meters of fish habitat	Total
51	3	19	73

23. As fish passage barriers are identified, WDFW begins developing plans to correct them through a scoping process like the one described above for WSDOT culverts. WDFW first collects information on the biology and physical characteristics of the site. WDFW engineers then develop correction options with cost estimates. As data for particular sites become available, recommended solutions are chosen and projects are moved forward for implementation through the state capital budget process.

24. WDFW's goal is to fix all fish passage barriers on its lands by July 1, 2016, provided funding is available. The WDFW Habitat Program Ten-Year Capital Plan as of December 2008, which includes

WDFW's proposed schedule for fish passage barrier correction on its lands, is attached as Exhibit F. As of January 2009, the average cost per correction is estimated at $230,000, in 2008 dollars.

25. WDFW is making progress in fixing its fish passage barriers, including those within the *United States v. Washington* Case Area. In 2008, WDFW fixed six culverts on the Stillwater Wildlife Area, near Carnation. Two were replaced with foot bridges, two were replaced with new culverts, and two were simply removed. WDFW also replaced one culvert on the Johns River Wildlife Area near Grays Harbor. During the 2009-2011 biennium, WDFW plans to remove or replace fish passage barrier culverts at 21 sites within the *United States v. Washington* Case Area—20 on the Cherry Valley Wildlife Area near Duvall, and one on the Johns River Wildlife Area near Grays Harbor. This work is expected to cost more than four million dollars. WDFW currently plans to correct an additional 27 barrier culverts in the Case Area, 15 of which block more than 200 meters of habitat, during the 2011-2013 biennium.

26. Culverts are not the only capital funding needs that WDFW has. Maintenance and infrastructure upgrades have been long delayed at many WDFW facilities. For example, improvements at WDFW hatcheries are needed to implement the recommendations of the Hatchery Scientific Review Group described in the Declaration of Jeffrey P. Koenings, Ph.D. A January 2009 capital budget presentation that WDFW's Capital Planning and Facilities Management group prepared for the Washington Fish and Wildlife Commission is

attached as Exhibit G. The total WDFW 2009-11 capital budget proposed by Governor Gregoire was $87 million, and that does not cover all needs.

III. Bringing WDFW Technical Expertise to the Public

27. In the late 1990s, WDFW began developing educational materials and conducting training to help others, such as federal, tribal, and local governments, conservation groups, and landowners, to find, prioritize, and correct non-state-owned fish passage barriers. As described in the Declaration of Paul Sekulich, Ph.D., WDFW developed a standard fish passage barrier assessment protocol and published it in 1998 in a manual entitled *Fish Passage Barrier Assessment and Prioritization Manual*. I was involved in that project. WDFW began providing training and follow-up technical assistance to Salmon Recovery Funding Board grant recipients and others so that they could conduct culvert inventories. As described above in Paragraph 9, WDFW developed a fish passage database to act as a centralized repository for the data collected by grant recipients.

28. WDFW revised the 1998 culvert barrier assessment manual in 2000, adding new sections on fishways, dams, and surface water diversion screens. The 2000 version is attached to the Declaration of Paul Sekulich, Ph.D., as Exhibit E. I was involved in preparing the 1998 and 2000 versions, and I have been supervising the preparation of a new revision that we expect to release in 2009. The 2009 version provides additional guidance and updated

methodology. The contents of each version of the manual are summarized in the table below.

Washington Department of Fish and Wildlife Fish Passage (and Surface Water Diversion Screening) Assessment and Prioritization Manuals			
Subject Covered	1998	2000	2009
Level A culvert evaluation[4]	√	√	√ updated
Level B culvert evaluation	√	√	√
Physical Survey (PS) habitat assessment method[5]	√	√ updated	√
Threshold Determination (TD) habitat assessment method	√	√	√
Expanded Threshold Determination (ETD) habitat assessment method	√	√	No
Reduced Sampling Full Survey (RSFS) habitat assessment method	No	√	√
Priority Index (PI)	√	√	√
Fish Passage and Diversion Screening Inventory (FPDSI) Database users manual[6]	√	√	No
WA state precipitation map (for Level B analysis)	No	√	√
% passability table for barrier culverts	No	No	√
Non-culvert road crossings	No	No	√
Dams	No	√	√ Expanded

Fishway	No	√	√ Expanded
Miscellaneous obstructions	No	No	√
Natural Barriers	No	√	√ Expanded
Surface water diversions (gravity & pump diversions)	No	√	√
Screening Priority Index (SPI)	No	√	√
Inventory process (guidance on how to develop an inventory)	No	√	√ Expanded
Quattro Pro habitat data entry spreadsheets presented	√	√	No
Excel habitat data entry spreadsheets presented[7]	No	√	√ updated
Expected species use[8]	√	√ updated	√
Fish bearing stream criteria[9]	√	√ updated	√ updated
Glossary of terms	No	No	√
List of recommended equipment for inventory	No	No	√

Instructions for measuring channel width (Appendix H from the *Design of Road Culverts for Fish Passage*, WDFW 2003)[10]	No	No	√
Basic Culvert Surveying Techniques	No	No	√
Pump Flow Chart (surface water diversions)	No	No	√

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[4] See Paragraph 16 of the Declaration of Paul Sekulich, Ph.D., for a discussion of the Level A analysis in the 2000 version of the manual. The 2009 revision updates the Level A flow chart by moving the water surface drop to the top of the chart and allowing the option of conducting a Level B analysis when culverts are not backwatered and the culvert slope is less than 1 percent.

[5] The 2000 revision added a discussion of pond and lake rearing habitat and included a "lake adjustment factor" to correct for over-estimation of rearing habitat in ponds and lakes. See page 38 in Exhibit E to the Declaration of Paul Sekulich, Ph.D. (Bates No. USFWS 000917).

[6] WDFW plans to develop a separate database users manual.

[7] See Appendix G of Exhibit E to the Declaration of Paul Sekulich, Ph.D. (Bates No. USFWS 001018). The 2009 revision updates the data entry spreadsheet to reflect terminology used in the 2009 manual (i.e. "OHW" changed to "SLW"; "downstream check" now called "fish access check"; "Barrier Site ID" changed to "Additional Feature Site ID"). Stream flow measurements are omitted in the 2009 version. Brook trout and brown trout are removed from the "Species Presence" section. WDFW has decided not to include them because they are exotic, non-native species.

29. WDFW has also developed a manual to provide guidance in the design of road culverts for fish passage. It was first published in 1999 and updated in 2003. The 2003 manual *Design of Road Culverts for Fish Passage* is attached as Exhibit B to the Declaration of Robert Barnard, P.E. WDFW expects to publish a new *Water Crossings Design Manual* in late 2010, which would replace the 2003 manual. WDFW has been providing technical assistance and training on the application of its culvert design manual since 1999.

30. Both of the WDFW fish passage technical assistance manuals, along with other technical guidance materials for fish passage and fish screens, are available to the public on the WDFW internet web site, http://wdfw.wa.gov/hab/engineer/habeng.htm.

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[8] Expected fish species use within different stream gradient strata table was updated in 2000 to reflect expected species passability (transport) through different gradient strata. The 2000 revision also added data for searun cutthroat trout and bull trout/Dolly Varden.

[9] Fish bearing stream criteria were updated in the 2000 and 2009 revisions, mainly to reflect changes in the Washington Forest Practices Board stream typing rules in Chapter 222-16 of the Washington Administrative Code.

[10] See pages 100-102 in Exhibit B to the Declaration of Robert Barnard, P.E. (Bates Nos. USFHWA/SUPP 002440 – USFHWA/SUPP 002442).

I declare under the penalty of perjury that the foregoing is true and correct.

Executed on this *27th* day of March, 2009, at Olympia, Washington.

s/Michael R. Barber
MICHAEL R. BARBER

EXHIBITS TO THE DECLARATION OF
MICHAEL R. BARBER

Exhibit A
Resumé of Michael R. Barber

Exhibit B
Interagency Agreement No. GCA5236 between the Washington State Department of Transportation and the Washington Department of Fish and Wildlife (June 2007) (Bates Nos. F00070366 – F0007044), and Supplement No. 1 (November 2007) (Bates Nos. F0007056 – F0007057)

Exhibit C
Table "WSDOT and WDFW barrier culverts unaffected by additional upstream or downstream barriers" (extracted by Brian Benson from the Fish Passage and Diversion Screening Inventory database on March 25, 2009)

Exhibit D
WSDOT Fish Passage Barrier Scoping Summary Report for SR 16, Milepost 28.10 (December 17, 2007), prepared by WDFW Scoping Biologist Susan Cierebiej

Exhibit E
WSDOT Culvert Scoping Report for SR 16, Milepost 28.10 (March 20, 2007), prepared by WDFW Engineer Bob Barnard (Bates No. CD F0008102, folder SR 16 MP 28.1)

Exhibit F
WDFW Habitat Program Ten-Year Capital Plan, December 2008 (Bates Nos. F0006886 – F0006888)

Exhibit G
WDFW 2009-2011 Ten-Year Capital Plan, Agency Request vs. Governor Proposed as of December 19, 2008—Commission Presentation January 9, 2009 (Bates Nos. F0009769 – F0009794)

The Honorable Ricardo S. Martinez

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

UNITED STATES OF AMERICA, et al., Plaintiffs, v. STATE OF WASHINGTON, Defendant.	NO. C70-9213 Subproceeding 01-1 (Culverts) ADDENDUM TO THE DECLARATION OF MICHAEL R. BARBER IN LIEU OF DIRECT TESTIMONY

I, MICHAEL R. BARBER, declare as follows:

31. On March 27, 2009, I executed a Declaration of Michael R. Barber in Lieu of Direct Testimony in *United States v. Washington* Subproceeding 01-1. In Paragraph 6, I summarized the fish passage work that the Washington Department of Fish and Wildlife (WDFW) has done for the Washington State Department of Transportation (WSDOT) under a series of contracts. In Paragraphs 21 through 26, I described the work that WDFW has done to identify fish passage barrier culverts on WDFW-owned lands, and WDFW's plans to fix them. I submit this Addendum to update that information. The paragraphs in this Addendum are numbered sequentially to follow those in my March 27,2009 Declaration.

32. In Paragraph 6 of my March 27, 2009 Declaration, I stated that WDFW has been performing fish passage work for WSDOT since 1991 under a series of contracts, and I attached a copy of the contract for the 2007-2009 biennium. In June 2009, WDFW and WSDOT executed a new contract for the 2009-2011 biennium. It took effect on July 1, 2009. A copy of the 2009-20l 1 contract is attached as Exhibit H.

33. In Paragraph 8 of my March 27, 2009 Declaration, I stated that WDFW expected to complete habitat assessments for fish passage barrier culverts in the entire state highway system by mid-2015. At this time, I estimate that, with three crews, WDFW will be able to complete habitat assessments for WSDOT fish passage barriers in the *United States v. Washington* Case Area by January 2013. At this time, it is difficult to make a reliable estimate of the completion date for habitat assessments in Eastern Washington. Our very rough estimate is that WDFW will be able to complete all habitat assessments for the entire state highway system by August 2017.

34. In Paragraph 22 of my March 27,2009 Declaration, I stated that my staff had found 73 culverts that block fish passage on WDFW lands within the *United States v. Washington* Case Area. My staff has now determined that two of those 73 culverts are not in fish-bearing streams. The following table shows the current status of culverts that block fish passage on WDFW lands within the Case Area.

Fish Passage Barrier Culverts on WDFW Lands Within the *United States v. Washington* Case Area			
Culverts that block > 200 meters of salmon and steelhead habitat	Culverts that block > 200 meters of nonanadromous fish habitat	Culverts that block ≤ 200 meters of fish habitat	Total
51	3	17	71

35. When I prepared my March 27, 2009 Declaration, the 2009 Washington legislative session was still underway, and the Washington Legislature had not yet enacted a capital budget for the 2009-2011 biennium. The Legislature has now done that. The Legislature appropriated less for culvert repair on WDFW-owned lands than WDFW requested. Attached as Exhibit I is a char comparing the capital funds that WDFW requested, the capital budget that Governor Gregoire proposed, and the 2009-2011 capital budget that the Legislature enacted for WDFW.

36. In Paragraph 24 of my March 27, 2009 Declaration, I referred to the WDFW Habitat Program Ten-Year Capital Plan as of December 2008, which I attached as Exhibit F. I have now revised the ten-year plan to reflect WDFW's capital budget for 2009-2011. The culvert projects that WDFW had planed to conduct on its lands during the 2009-2011 biennium have been postponed to later biennia. The WDFW Habitat Program Ten-Year Capital Plan as of July 2009 is attached as Exhibit J.

I declare under the penalty of perjury that the foregoing is true and correct.

Executed on this *6th* day of July, 2009, at Olympia, Washington.

s/Michael R. Barber
MICHAEL R. BARBER

EXHIBITS TO THE ADDENDEUM TO THE DECLARATION OF MICHAEL R. BARBER

Exhibit H
Interagency Agreement No. GCA6019 between the Washington State Department of Transportation and the Washington Department of Fish and Wildlife (June 2009) (Bates Nos. F0014545 - F0014555)

Exhibit I
WDFW 2009-2011 Capital Budget (Bates No. F0014982)

Exhibit J
WDFW Habitat Program Ten-Year Capital Plan, April 2009 (Bates No. F0014558)

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Exhibit C. WSDOT and WDFW barrier culverts
barriers. These culverts represent barriers to
of potential habitat gain within

Site ID	Road	Stream	Tributary To	WRIA
990148	US 101	Fisher Cr	Queets R	21.0018
990400	US 101	Steamboat Cr	Pacific Ocean	20.0574
990178	US 101	Harlow Cr	Queets R	21.0134
982712		Hurd Cr	Dungeness R	18.0028
990606	SR 542	Chain-up Cr	NF Nooksack R	1
993679	US 101	unnamed	Hoquaim R	22
990187	SR 542	Hedrick Cr	Nooksack R	1.0463
990450	SR 106	Twanoh Falls Cr	Hood Canal	14.0134
994799	US 12	unnamed	Chehalis R	22.0542
990385	SR 108	Skookum Cr	Skookum Inlet	14.002
990151	SR 530	Fortson Cr	NF Stillaguamish R	5.0254
990731	US 101	unnamed	Stevens Cr	22.0064A
991066	SR 8	unnamed pond	Wildcat Cr	22
991606	US 101	Schaerer Cr	Hood Canal	16.0326
990395	SR 3	Spring Cr	Hood Canal	15.0364
991244	SR 106	unnamed	Skokomish R	16.0002
990246	SR 530	Little French Cr	Fortson Cr	5.0253
997787	SR 109	unnamed	Pacific Ocean	21.0727
992344	SR 9	unnamed	Black Slough	1
991559	SR 302	unnamed	North Bay	15.0001
991266	SR 109	unnamed	Pacific Ocean	21
991271	SR 109	unnamed	Pacific Ocean	21.0716
993702	US 101	unnamed	WF Hoquiam R	22
991716	SR 203	unnamed	Snoqualmie R	07.0219A
991690	US 101	unnamed	Stevens Cr	22

unaffected by additional upstream or downstream anadromous salmon that have >200 lineal meters WRIA's 1-23 as of March 25, 2009.

PI	Survey Date	Spawning Area (m^2)	Rearing Area (m^2)	Lineal Gain (m)	Owner
29	1/30/2007	9836	12568	5132	WSDOT
27.53	4/4/1996	25322	26208	7434	WSDOT
25.68	4/12/1995	16231	16925	5525	WSDOT
19.23	9/18/2008	103	1967	717	WDFW
17.41	11/18/2005	370	491	276	WSDOT
17.35	4/18/2002	0	4450	323	WSDOT
16.63	3/10/1992	159	576	551	WSDOT
16.37	11/17/2008	4104	3193	3059	WSDOT
16.04	11/26/2005	1494	3548	3293	WSDOT
15.9	6/18/2007	811	1537	490	WSDOT
15.37	3/21/2006	860	1391	1030	WSDOT
14.44	11/15/1996	485	3052	1162	WSDOT
14.17	5/22/2002	0	4339	418	WSDOT
13.4	12/2/2003	542	580	250	WSDOT
13.37	7/7/2000	1094	1578	1441	WSDOT
13.03	12/16/1993	405	678	437	WSDOT
12.47	12/20/1995	1137	821	996	WSDOT
12.26	10/25/2007	658	2389	1937	WSDOT
11.83	8/23/2005	0	1053	665	WSDOT
11.44	1/27/1994	232	576	483	WSDOT
11.36	5/17/1995	599	548	482	WSDOT
11.07	1/21/1993	1239	1482	816	WSDOT
11.02	12/7/2005	15	1098	1037	WSDOT
10.96	9/8/1995	320	725	421	WSDOT
10.83	10/13/2008	33	2848	972	WSDOT

Site ID	Road	Stream	Tributary To	WRIA
991265	SR 109	unnamed	Pacific Ocean	21.0764
991731	SR 112	unnamed	Green Cr	19
990957	US 12	unnamed	Higgins Slough	22
991063	SR 8	unnamed	Cloquallum Cr	22
991261	US 101	unnamed	Pacific Ocean	20.0000A
990656	SR 510	unnamed	McAllister Cr	11.0328
990084	SR 7	Coal Cr	Roundtop Cr	11.0168
991647	US 101	unnamed	Hoh R	20
993698	US 101	Unnamed	WF Hoquiam R	22
991574	US 101	unnamed	Dowans Cr	20.0248A
991516	SR 16	unnamed	Burley Cr	15
991911	US 12	unnamed	Higgins Slough	22
991239	SR 302	unnamed	Case Inlet	15
995521	SR 116	unnamed	Port Townsend Bay	17
990921	SR 109	unnamed	Grays Harbor	22
991592	US 101	Hell Roaring Cr	Hoh R	20.0441
991910	US 12	unnamed	Higgins Slough	22

PI	Survey Date	Spawning Area (m^2)	Rearing Area (m^2)	Lineal Gain (m)	Owner
10.52	5/18/1995	0	1948	500	WSDOT
9.81	9/19/1995	287	305	418	WSDOT
9.67	5/28/2008	323	421	858	WSDOT
9.5	5/15/2002	0	656	234	WSDOT
9.19	6/9/1994	242	572	277	WSDOT
9.18	3/28/1997	0	1790	1449	WSDOT
8.86	7/7/1995	484	1394	1101	WSDOT
8.72	2/4/1997	158	578	853	WSDOT
8.62	10/15/2008	20	122	240	WSDOT
8.24	2/5/1997	268	1585	677	WSDOT
8.04	9/8/1994	186	308	817	WSDOT
7.82	6/2/1995	226	378	300	WSDOT
5.01	10/13/2004		63		WSDOT
4.71	12/11/2007	34	49	240	WSDOT
4.23	10/15/2008	0	190	366	WSDOT
3.01	5/15/2008	156	361	466	WSDOT
1.52	6/27/2002	26	133	200	WSDOT

The Honorable Ricardo S. Martinez

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

UNITED STATES OF AMERICA, et al., Plaintiffs, v. STATE OF WASHINGTON, Defendant.	NO. C70-9213 Subproceeding No. 01-1 (Culverts) DECLARATION OF JEFF CARPENTER, P.E. IN LIEU OF DIRECT TESTIMONY

Table of Contents

I, Jeff Carpenter, P.E., declare as follows:

1. I am a citizen of the United States, over the age of 18 years, and I am competent to testify as a witness. The statements in this declaration are based on my personal knowledge and upon my review of official public records.

INTRODUCTION

2. I am the Project Control and Reporting Director for the Washington State Department of Transportation (WSDOT). In my current position, I am required to have knowledge of WSDOT's budget in terms of revenue and expenditures. I have held my current position since February 2008, and on several occasions I have been asked to make budget presentations to members of the Legislature and legislative staff. During those presentations, I explained WSDOT's revenue sources and its expenditures.

3. Serving as the Director, I monitor the funding and expenditures for all capital projects, approve all changes to scope, schedule, and budget of projects, and provide project progress reports to WSDOT executives and external customers. I regularly work with WSDOT's Systems Analysis and Program Development Office to provide feedback on proposed changes to projects. I also assist in the preparation and assessment of projects within the biennial budget request to the Legislature.

4. Prior to this position, I worked for 17 years in managerial positions at WSDOT varying from the assistant design project engineer for the Olympic Region to the Project Director responsible for

overseeing the design and construction of bridge projects with budgets of hundreds of millions of dollars. Through these positions I gained experience with WSDOT's revenue sources and budget limitations from the project level to the agency-wide programmatic level.

5. The exhibits attached to this declaration are true and correct copies of records kept in the ordinary course of official public business, or are accurate summaries of voluminous public data. As the Director, I am one of the custodians of public records within my section.

GENERAL FACTORS AFFECTING WSDOT CULVERT REMEDIATION

6. There are three broad factors that affect how quickly WSDOT is able to implement its plans to remediate culverts that block or impede fish passage. These factors are a) funding, b) the availability of qualified contractors/work forces, and c) the "fish window" for performing construction work in a particular stream. This declaration will focus on the WSDOT budget and the funding for culvert remediation.

7. The State of Washington has recognized the impact of the transportation infrastructure on the environment for many years. This includes the impact on fish caused by culverts that impair or block the passage of fish. Years before this lawsuit was filed, WSDOT had established a budget line item specifically targeting culvert remediation. This budget item has been included as a permanent line item within the environmental retrofit category referred to as the I-4 budget since 1991. WSDOT has

been and continues to be a leader in the nation among transportation agencies in dedicating efforts to remediate transportation impacts on fish.

8. The WSDOT budget currently is experiencing significant shortfalls in available funds, as are other government functions. The revenue dedicated to transportation needs that is generated from State sources (primarily the State gas tax and various licensing fees) for FY 2009-2011 is currently projected to be $965 million less than what is necessary to fund the anticipated obligations of WSDOT. The severe revenue shortfall will compel the Legislature and WSDOT to make significant cuts to a wide variety of programs. As discussed in more detail below, one source of funding for culvert remediation by WSDOT is through a portion of its environmental budget known as the I-4 budget. The Governor has proposed $17.9 million for culvert remediation in the FY 09-11 I-4 budget. This would constitute an increase for that budget at a time when many other programs are being reduced or eliminated.

WSDOT REVENUE AND DISTRIBUTION

9. The combined total of all WSDOT revenue sources, both state and federal, for FY 09-11 is $5.271 billion. WSDOT's expenditures (its "budget") are divided between the operating and capital budgets. Attached as Exhibit A, is a chart summarizing the organization of the WSDOT budget.

10. The overwhelming majority of the budget (more than 85%) is dedicated to specific obligations by law, and WSDOT has no discretion to vary the percentage of its budget that is so dedicated.

For example, the state Legislature frequently identifies specific projects to be built with gas tax revenue as it did with the 5 cents per gallon “Nickel” tax and the 9.5 cent per gallon Transportation Partnership Act (TPA) tax. WSDOT cannot spend the revenue from those taxes on any projects other than those that have been specified by the Legislature.

11. The revenue from the state’s 37.5 cents per gallon gas tax is the primary source of transportation money raised by the state. The anticipated amount of revenue from the gas tax is down from previous years’ receipts because less gasoline is being consumed. Even if the State were to receive more revenue from this source than is anticipated, the gas tax is insufficient to pay for all of the demands placed on the transportation system.

12. Funding from the federal government will account for 16% of WSDOT’ s revenue in FY 09-11. 60% of the funding received from the federal government comes with specific restrictions on use of the funds and is unavailable for culvert remediation. Most federal funding for Washington State capital highway projects arises from the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). This is a federal trust fund. As its name implies, the Act seeks to address transportation safety issues on all projects and the scope of work and designs are prepared with safety in mind. These funds are unavailable for repairing culverts. The SAFETEA -LU trust fund will be exhausted in 2009. It is unclear how major safety projects will be funded in the future.

13. Another example of restricted federal funding came in early 2009 as part of the American Recovery and Reinvestment Act (ARRA). The federal government conditioned the release of ARRA funding to only projects which were "shovel ready." That term is generally defined as a project which has the design and environmental permitting complete, all right of way purchased and is able to be advertised for bid within 360 days of disbursement of the funds. Because of the "shovel ready" requirement, projects requiring extensive environmental permitting (such as culvert remediation) are unlikely to meet the federal stimulus requirements. Projects that include replacement of fish passage barriers have historically required at least two years to reach bid advertisement. This amount of time is needed because of the time required for property acquisition and environmental permitting. WSDOT does not have culvert projects that would qualify for ARRA funds.[1]

14. The amount of funding available to WSDOT for FY 09-11 that does not come with a specific mandate for how the money must be spent is approximately $600 million. Although these funds are not mandated for specific projects, WSDOT is required to spend the funds in accordance with legislative

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[1] In a situation where WSDOT has a highway construction project that will also remediate a culvert and the construction project qualifies for ARRA funds, then it would be possible that some ARRA funding would be used for culverts.

priorities for the broader mission of WSDOT. These priorities are defined for WSDOT through the budgeting process.

15. The funds that are not restricted to specific projects or activities must be used to fund the following broad categories of WSDOT responsibilities: maintaining the condition of the pavement for 20,250 lane miles of roadway; safety and preservation of 3,600 bridges and elevated structures on the state system; maintaining the facilities of the existing infrastructure; snow and ice removal; paying for the electrical system to light the roadways at night and to operate traffic control devices; environmental retrofit; congestion relief; and unanticipated emergencies.

16. WSDOT assists the Legislature by prioritizing projects according to the policies of improving safety, maintaining the current infrastructure, and making improvements to the system. Every biennium, WSDOT submits a list of projects and activities prioritized according *[sic]* the policies described above and to the category of highway needs with a recommended investment amount for each category. The Legislature ultimately determines the prioritization for any funds that are not mandated for specific projects and activities.

17. There have never been sufficient funds to pay for all of the activities and projects on the prioritization lists submitted to the Legislature by WSDOT. The activities and projects are performed in the order of the priority established by the Legislature. WSDOT will work as deeply down the priority lists as the available funding allows. With the legislative session still underway, it is unknown how

much will be funded and what changes to prioritization the Legislature will make.

18. The prioritization of the non-dedicated funds is a zero-sum budget exercise. That is, if funding is used for a particular purpose, that necessarily means that other needs will have less funding or may have to be eliminated. Currently many critical statewide transportation activities are significantly underfunded or have been postponed. For example, there are numerous major maintenance projects that are being deferred due to lack of available funds such as a growing list of steel bridge painting (currently 55 bridges - $170 million), aging pavements not being addressed (currently 550 lane miles - projected to be over 1,500 by the end of 2011), bridge deck rehabilitations (60 bridge decks - $70 million), and bridge deck replacements (35 bridges - $547 million).

19. More worrisome is the fact that important safety projects are being deferred due to lack of funding. For example, SR 101 near Shelton needs additional rumble strips and SR 195 near Cheney has a potentially dangerous at-grade intersection. SR 9, SR 291, and SR 302 also have pressing safety projects for which there is no available funding.

INCREASING CONSTRUCTION COSTS AND DECREASING REVENUE

20. Much of WSDOT's current revenue problems are the result of two trends-increasing construction costs and decreasing revenue. During the last five years inflation for transportation related construction increased by 60%. This rate of inflation results in a significant reduction in the purchasing

power of transportation funds. The increase in inflation was the result of a high demand for construction materials and oil-based products, such as asphalt and oil used for repaving projects. High oil prices also eventually led to a significant reduction in the number of miles driven by motorists with a corresponding reduction in the amount of gas tax collected. Since the gas tax is not indexed to inflation, WSDOT's gas tax revenues are in a constant state of decline compared to WSDOT's costs. During the past year, both the federal and state governments reduced their budget appropriations for transportation agencies in order to align with these reduced revenues.

THE MAINTENANCE ACCOUNTABILITY PROGRAM

21. In 1998, the Legislature established a Maintenance Accountability Program (MAP) for WSDOT. The MAP program establishes specific performance goals for WSDOT. The background and requirements of the MAP program can be reviewed at http://www.wsdot.wa.gov/maintenance/pdf/MAP_Manual2008.pdf. The Legislature uses the MAP program to determine whether additional funding is needed to meet the maintenance and operation objectives set by the Legislature.

22. Due primarily to declining revenue, WSDOT is unable to meet most targeted service levels in an acceptable fashion. Exhibit B is WSDOT's MAP report card from 2004 - 2008. There is currently an $85 million backlog of maintenance projects. The affects of deferred maintenance are captured by the

attached photograph of a bridge in Washington. Exhibit C.

IMPROVEMENT AND REMEDIATION PROJECTS

23. Improvement projects are aimed at correcting specific deficiencies within the transportation system or network such as high accident locations and particularly congested corridors. The budget designations for the four improvement programs are I-1 (Safety), I-2 (Mobility), I-3 (Economic Initiatives) and I-4 (environmental retrofit). As noted above, the I-4 budget is one of the sources for funding culvert remediation.

- **I-1 (Mobility).** Generally, mobility projects are projects which are designed to reduce congestion problems. At present, no gas tax revenue is available for new mobility projects. As a result, congestion relief projects such as corridor extensions for SR 509 and SR 167 are indefinitely postponed.

- **I-2 (Safety).** WSDOT is focused on implementing a plan called Washington's Highway Safety Plan/Target Zero which has a goal of achieving zero highway fatalities accompanied by significant reductions in serious collisions within twenty years. The projected amounts available for safety projects will decrease from $244 million in FY 07-09 to $150 million in FY09-11.

- **I-3 (Economic Initiatives).** This is an evolving category of transportation need and there is a great deal of interest in determining how transportation investments can create job growth in Washington State. Despite the growing demand and timeliness of economic initiatives, WSDOT anticipates that it will be requesting no funding for this category of programs over the next 10 years. The I-3 budget represents an entire category of funding that has essentially been prioritized out of existence.

- **I-4 (Environmental Retrofits).** As explained in the Declaration of Paul Wagner, when the I-4 budget was created in the early 1990s, the fish passage barrier retrofit program was the first program that attempted to address environmental conditions by providing a dedicated funding source. Since the inception of the I-4 category, WSDOT has added several other dedicated funding programs to the I-4 environmental retrofits category: chronic environmental deficiencies (CED), stormwater, noise barriers, and habitat connectivity.

24. In addition to the fish passage retrofit barrier program, both the chronic environmental deficiencies (CED) program and the stormwater retrofit program provide benefits to fish survival. Chronic environmental deficiencies are locations along the state highway system where recent, frequent, and chronic maintenance needs are causing impacts to fish and fish habitat. An example of a CED is erosion of a road prism from a stream close to state highway. To address this safety problem, formerly WSDOT would fill the area with large rock or other material. However, that practice could damage aquatic habitat. Through the CED retrofit program,

WSDOT is often replacing this material with rough woody structures and incorporating other biologically-sensitive techniques to stabilize the road prism and to aid stream habitat. These techniques are designed to address long-term habitat needs of salmon and other organisms while eliminating the need for repetitive maintenance.

CULVERT REMEDIATION

25. WSDOT-owned culverts that are fish passage barriers are remediated through two different funding structures. First, fish barriers can be remediated as part of a capital construction project when the barriers fall within the boundaries of a highway construction project. This funding comes from the capital construction budget. Second, fish passage barriers can be addressed with funding from the WSDOT I-4 budget. Exhibit D shows the history of funding for the I-4 budget. The chart also illustrates the amount requested by WSDOT and the amount appropriated by the Legislature.[2]

26. Exhibits E and F chart the number of blocking culverts that have been repaired through construction projects and through the I-4 budget. Exhibit G is a chart showing the potential lineal habitat gained through barrier corrections through 2008.

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[2] The amount spent on culvert remediation in the course of a capital construction project is not tracked separately within the construction budget. For example, there would be a total budget for concrete but the amount of concrete used for the culvert work would not be segregated.

27. As the purchasing power of available revenue for new preservation and improvement in the Highway Construction Program has declined by between 35% and 45% over the last several years, WSDOT recommended increases in the funding for fish barrier inventory and replacement. At the same time, WSDOT increased the reach of the I-4 program by creating the Chronic Environmental Deficiency program. Habitat improvements for fish and investments in this category are on the increase at locations such as the Snoqualmie River at Fall City, the Hoh River south of Forks, the Sauk River near Darrington, the Nooksack River and Red Cabin Creek on US 20 near Rockport.

28. WSDOT also implemented the stormwater retrofit program within I-4 to improve the quality of water and reduce the velocity of water that was running off state highways into fish bearing streams. The WSDOT has also begun building a habitat connectivity program for wildlife with its' first project about to go construction and another ready to start design.

29. The FY 09-11 budget for I-4 has not been finalized at the time this declaration has been submitted. The Governor has proposed $17.9 million for the fish barriers in the I-4 budget. The Senate and House have both proposed $15.07 million for fish barriers in the I-4 budget. The budget reconciliation process will resolve this discrepancy, and I am assuming that the final budget will be somewhere within the range defined by these proposals.

30. The current budget proposals and projected budgets for I-4 and specifically for fish

passage barriers is attached. Exhibit H. Based on current revenue projections the future budgets for I-4 and for fish barriers is predicted to decline along with the rest of the transportation budget. The effect of the zero-sum situation can be seen within the budget projections for I-4. Historically, the line item for fish barriers has been 30% of the I-4 budget. Budget projections show fish barriers increasing to 50% of the I-4 budget. This increase is coming at the expense of the other environmental efforts of WSDOT in the I-4 budget.

CONCLUSION

31. WSDOT receives a limited amount of money to operate, improve, and maintain the State's transportation system. The vast majority of funding comes to the agency with specific restrictions on how the money can be spent. As described above, the demands on remaining funds dramatically exceed the amount that is available. The prioritization of scarce resources is done carefully and represents a delicate balance of competing interests.

32. Increasing the funding for culvert remediation would necessarily mean other important projects would be shorted to an even greater degree. WSDOT is dedicated to reducing the impact of the transportation system on salmon, but salmon is only one of the many important demands that the agency is required to fulfill. Within the limits of available resources, WSDOT is doing the best it can to fix culverts that are barriers to fish passage.

I declare under penalty of perjury that the foregoing is true and correct.

DATED the *3rd* day of *April* 2009.

s/Jeff Carpenter
JEFF CARPENTER, P.E.

EXHIBITS TO THE DECLARATION OF JEFF CARPENTER, P.E.

Exhibit A

Chart -- Governor's Proposed FY 2009-11 Operating and Capital Budgets for WSDOT

Exhibit B

WSDOT's MAP report card from 2004 - 2008.

Exhibit C

Photograph of bridge - deferred maintenance

Exhibit D

I-4 Budget History of Funding

Exhibit E

Chart -- "WSDOT Barrier Corrections Numbers Per Year"

Exhibit F

Chart -- "Cumulative View of WSDOT Barrier Corrections"

Exhibit G

Chart -- Potential Lineal Habitat Gain 1991 - 2008

Exhibit H

Current budget proposals and projected budgets for I-4 and specifically for fish passage barriers

The Honorable Ricardo S. Martinez

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

UNITED STATES OF AMERICA, et al., Plaintiffs,	NO. C70-9213 Subproceeding No. 01-1 (Culverts)
v.	
STATE OF WASHINGTON, Defendant.	ADDENDUM TO THE DECLARATION OF JEFF CARPENTER, P.E. IN LIEU OF DIRECT TESTIMONY

I, Jeff Carpenter, P.E., declare as follows:

INTRODUCTION

33. On April 3, 2009, I executed the Declaration of Jeff Carpenter, P.E., in Lieu of Direct Testimony in *United States v. Washington* Subproceeding 01-1. I submit this Addendum to update information.

34. In paragraph 26 of my April 3, 2009 declaration, I referenced and attached as Exhibits E and F charts showing the number of blocking culverts repaired through construction projects and through the I-4 program and the total number of corrections. Since that time, it was determined that the total number of fish passage barriers corrections was 225. Exhibits E and F attached to this Addendum have been amended accordingly and reflect the correct numbers. Paragraph 26 also referenced Exhibit G, a chart showing the potential lineal habitat gained through barrier corrections through 2008. This chart

has also been corrected to accurately reflect the correct amounts and is attached to this Addendum as Exhibit G.

I declare under penalty of perjury that the foregoing is true and correct.

DATED the 22 day of September 2009.

s/Jeff Carpenter
JEFF CARPENTER, P.E.

EXHIBITS TO THE ADDENDUM DECLARATION OF JEFF CARPENTER, P.E.

Exhibit E

Chart -- WSDOT Barrier Corrections Numbers Per Year

Exhibit F

Chart -- Cumulative View of WSDOT Barrier Corrections

Exhibit G

Chart -- Potential Lineal Habitat Gain 1991 - 2008

The Honorable Ricardo S. Martinez

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

UNITED STATES OF AMERICA, et al., Plaintiffs, v. STATE OF WASHINGTON, Defendant.	NO. C70-9213 Subproceeding No. 01-1 (Culverts) DECLARATION OF PAUL J. WAGNER IN LIEU OF DIRECT TESTIMONY

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I, PAUL J. WAGNER, declare as follows:

I. Summary

1. I am the manager of the Washington State Department of Transportation (WSDOT) fish passage barrier correction program. For many years, WSDOT has recognized the need to provide fish passage at stream crossings. WSDOT has worked to correct fish passage barriers as part of highway improvement projects and through a separate dedicated-fund fish passage correction program. I

manage the dedicated-fund program and will describe it in this declaration, and my branch provides support to WSDOT regions in their work with transportation project development. Please refer to the Declaration of Allison Hanson for information about fish passage barrier corrections that occur as part of larger highway improvement projects. Through its dedicated-fund program, WSDOT has invested over $47 million dollars for the inventory, prioritization, and correction of high priority fish passage barriers since 1991, when concentrated efforts began. Those efforts, along with the correction of fish passage barriers in connection with highway improvement projects, have provided 232 barrier corrections and improved fish access to more than 754 miles of stream habitat in Washington State.

II. Witness Qualifications and Experience

2. I am the Biology Branch Manager in WSDOT's Environmental Services Office, a position I have held since 1993. I am the senior agency lead for implementing and complying with federal and state regulations related to biological resources, with an emphasis on fish passage, wildlife habitat connectivity, endangered species, wetlands, streams, and other aquatic habitats. I am responsible for four WSDOT programs, which include 25 full-time employees and about 16 seasonal positions. One of these programs, the Stream Restoration Program, includes WSDOT's dedicated-fund fish passage barrier correction program. I work with several national forums and work groups as part of the National Academies of Sciences, and other organizations, addressing the ecological effects of roads. I currently chair the International Conference

on Ecology and Transportation. I interact with many professionals involved with transportation and ecology in the United States and other countries, and I have spoken at educational seminars in the United States and Canada. I have over 20 years of experience as a professional biologist. My resumé is attached as Exhibit A.

3. I hold a Bachelor of Science degree in Natural History, which is a double major in Biology and Geology, from Juniata College in Pennsylvania. I started my career working on government projects related to endangered species conservation and wildlife studies. I joined WSDOT in 1990 as a biologist and was promoted to my current position as Biology Branch Manager in 1993.

4. The Biology Branch is a part of WSDOT's Environmental Services Office. That office coordinates WSDOT's agency-wide efforts to address environmental issues in its programs and projects, including fish passage, air quality, wetlands, stormwater management, hazardous materials, erosion control, wildlife migration, and historical and cultural preservation. WSDOT has about 250 full-time employees statewide who focus on environmental services. Many of them are biologists with substantial field experience. WSDOT's environmental efforts have received national recognition from the Federal Highway Administration, the National Association of Environmental Professionals, the American Council of Engineering Companies, and other organizations. For example, in 2003, FHWA presented WSDOT and its partners, including the Nisqually and Squaxin Island Tribes, with an Environmental Excellence Award for the Indian Creek Stormwater Treatment

Facility near I-5 in Olympia. My team and I have received several awards from the Federal Highway Administration, including a 2002 award for a fish passage project. A list of those awards is included in Exhibit A.

III. History of Washington State Highway Culvert Design

5. In my work as the WSDOT Biology Branch Manager, I have become generally familiar with culvert function and the history of culverts in the Washington State highway system. I have also spoken with Matthew J. Witecki, the WSDOT Chief Hydraulic Engineer, who is intimately familiar with culvert design methods. I have examined the declaration that Mr. Witecki filed in this Subproceeding in 2006 (Doc. No. 18553/288, filed August 14, 2006). The following paragraphs are based on my personal knowledge and what I learned from Mr. Witecki.

6. According to WSDOT's transportation data office, there are 7,044 centerline miles in the state highway system, managed by WSDOT. While these are some of the most well-known roads, they are only a small portion of those in the state. There are 83,432 miles of road under the jurisdiction of cities, counties, and others. Many Washington State highway culverts were installed decades ago. WSDOT used standard engineering methods when it installed them, but some culverts designed according to those methods are now considered to be partial or complete barriers to fish passage. In part, that is because fish passage criteria have evolved over time, and designs once thought to be passable are now known to block

fish passage under some circumstances, as described in the Declaration of Robert Barnard, P.E. Another reason that some culverts are now fish passage barriers is that streams are dynamic systems, and conditions at stream crossings can change and cause a passable culvert to become a barrier. Sometimes that happens slowly, over a long period of time, and sometimes it is triggered by certain high flow events. Culverts can become partial or complete barriers to fish passage when they do not adequately respond to change.

7. Culverts can impede fish passage because of excessive drops at the outfall ("perching"), excessive velocity inside the culvert, or inadequate water depth. Changes in the watershed can cause those conditions. In many Western Washington watersheds, forests have given way to suburban landscapes where falling rain meets roof, street, or parking lot instead of spongy soil. Those changes can increase the intensity of runoff entering a stream, which can increase water velocity in culverts. That can lead to scouring of the stream bed at culvert outfalls, high water velocity during high flows, and shallow water depths within or downstream of the culvert during periods of low flows. All of those conditions can block fish movement. Culverts can also become fish barriers due to structural failure or debris blockage.

8. Attached as Exhibit B are photos of several WSDOT-owned culverts which exemplify scour, velocity, and low flow problems. In my professional opinion, these culverts would not have been considered fish barriers when they were originally permitted and built.

9. Dating back to at least the 1960s, WSDOT has relied on a Federal Highway Administration (FHWA) publication entitled Hydraulic Engineering Circular #10 (HEC #10). The earliest version of HEC #10 in WSDOT's library is dated March 1965 (attached as Exhibit C). WSDOT used the procedures identified in the then-current version of HEC #10 as the basis for Chapter Three of the WSDOT *Hydraulics Manual* – "Culvert Design"—which relates to the use of hydraulic criteria for sizing culverts. The WSDOT manual contains the same culvert sizing charts and guidance originally set forth in HEC #10. It is my understanding that the protocols and techniques set forth in HEC #10 are generally accepted as the industry standard for the design of road culverts for hydraulic purposes.

10. Virtually all of the WSDOT culverts now identified as barriers to fish passage were designed according to the FHWA design standards promulgated in HEC #10. At no time has FHWA notified WSDOT that the federal design standards failed to provide fish passage or that culverts designed pursuant to the standards might violate treaty fishing rights.

11. In the early 1990s, the Washington Department of Fisheries (WDF) notified WSDOT that, in some circumstances, culverts designed according to the guidelines in HEC #10 failed to provide for adequate fish passage. A number of interagency meetings took place, and ultimately, WSDOT found WDF's position compelling and adopted the WDF fish passage culvert design standards as they were developed.

12. In 1999 and 2003, the Washington Department of Fish and Wildlife (WDFW) published new culvert design guidelines specifically intended to accommodate fish passage. A copy of the 2003 WDFW manual *Design of Road Culverts for Fish Passage* is attached to the Declaration of Robert Barnard, P.E. WSDOT has modified its *Hydraulics Manual* and training materials to reflect the WDFW's fish-friendly design methods. Attached as Exhibit D are excerpts from the current WSDOT *Hydraulics Manual*. Chapter Seven addresses fish passage.

13. In July 2007, the Federal Highway Administration published *Design for Fish Passage at Roadway-Stream Crossings: Synthesis Report*. It describes the state-of-the-art practice for fish passage, referencing Washington State for some leading examples. Excerpts of that report are provided as Exhibit E to the Declaration of Robert Barnard, P.E. I understand that FHWA has been working on a new Hydraulic Engineering Circular that would describe culvert design standards to accommodate fish passage. It is still in development and has not yet been published, but it is expected to reflect the information in the 2007 synthesis report.

IV. How WSDOT's Fish Passage Barrier Correction Programs Began

14. Before 1991, WSDOT corrected fish passage barriers when they were encountered as part of projects to improve highway safety and mobility, or when the culvert required work due to structural problems. No formalized fish barrier inventory

process existed. Professional judgment as part of permitting highway projects largely guided determinations of fish passability and the design of passage corrections. This meant corrections had to wait until a transportation need coincided with the location of a fish barrier, and a construction project was implemented that could include the barrier correction. This approach remains the only approach used by almost every other state in the country.

15. As described in the Declaration of Paul Sekulich, Ph.D., Washington State recognized that more needed to be done to address fish passage barriers. In December 1990, WSDOT entered into a Memorandum of Understanding ("MOU") with what is now known as the Washington Department of Fish and Wildlife (WDFW). The 1990 MOU is provided as Exhibit B to Dr. Sekulich's declaration. It sets out the agencies' process for working together to implement state laws for the protection of fish, including fish passage. As described in the Declaration of Allison Hanson and the exhibits accompanying it, the MOU has been updated several times. The current version was executed in 2008.

16. WSDOT's program for identifying and correcting fish passage barriers began in 1991, when the Washington State Legislature directed it to correct six known fish barriers during the 1991-1993 biennium. The 1991 legislation is attached as Exhibit C to the Declaration of Paul Sekulich, Ph.D. For the first time, WSDOT developed projects whose sole objective was to address environmental needs. The

amounts of $105,000 and $280,000, respectively, were allocated for the two years of the biennium for inventory and correction of fish passage barriers. In 1993, these "stand-alone" or "dedicated" fish passage projects formally became a separate program now referred to as the Environmental Retrofit Program, or "I-4" Program.

17. The stand-alone fish passage correction projects of the early 1990s led to the creation of a separate WSDOT program, with separate funds, to address a variety of environmental problems in the state highway system. Today, the I-4 Program has expanded to include stormwater treatment, stream habitat improvement, highway noise attenuation, and wildlife habitat connectivity, as well as fish passage.

18. To my knowledge, WSDOT's "stand-alone" fish passage correction program was the first among transportation agencies in North America to define transportation projects based on an environmental need. Oregon has since implemented a fish passage program modeled after WSDOT's, but otherwise it remains a unique approach.

V. The Current WSDOT Fish Passage Barrier Correction "I-4" Dedicated Fund Program

A. Introduction

19. WSDOT's fish passage barrier correction program is managed through close cooperation and partnership with WDFW. Before correcting a culvert,

WSDOT obtains information about the culvert which has been collected by WDFW. The program has three main areas of work: Inventory, prioritization, and correction. WDFW's share of that work is described in the Declarations of Paul Sekulich, Ph.D., and Michael R. Barber. I will describe WSDOT's share.

B. Inventory: Finding and Evaluating Culverts that Block Fish Passage

20. WSDOT funds staff at WDFW to inventory and prioritize fish barriers for correction. This effort has grown significantly over time as our understanding of the problem has increased. Since 1991, WSDOT has invested about $9 million for fish passage barrier inventory and prioritization. In the 2007-09 biennium, the funding for this work was over two million dollars. The 2007-09 funding agreement between WSDOT and WDFW is provided as Exhibit B to the Declaration of Michael R. Barber.

21. As explained in the Declaration of Paul Sekulich, Ph.D., the inventory has undergone several expansions. The first inventory focused only on salmon, in streams up to a 7% gradient, which was understood to be the extent of salmon use. The search for barriers in that inventory was completed statewide in May 1994. At that point, WDF had inspected 1,333 highway culverts at fish-bearing stream crossings and identified 340 barriers (either partial or complete) statewide.

22. As a result of the merger of WDF with the Washington Department of Wildlife, in 1995

WDFW expanded the scope of the fish passage program to include streams up to a 12% gradient, as steelhead and resident trout could swim up this steeper gradient. This constituted a significant increase in survey area, and the survey was expanded for the 12% gradient. Although the expanded survey was not yet complete, by June 1997, WDFW had inspected 1585 highway culverts at fish-bearing stream crossings and identified 509 barriers (either partial or complete) statewide.

23. In 1998 WDFW expanded the scope yet again to include streams up to a 20% gradient, in response to new rules of the Washington Forest Practices Board. WSDOT funded additional survey crews, but the scale of this expansion meant it would take over ten years – until fall of 2007 – before the statewide inventory would be complete.

24. The June 2008 *WSDOT Fish Passage Inventory Progress Performance Report* (attached as Exhibit E) shows that, since 1991, inventory crews have inventoried all 7,044 miles of the state highway system, inspecting 6,469 stream crossings, 3,185 of which were found to be fish-bearing streams. As of March 25, 2009, WDFW records show a statewide total for WSDOT of 1,878 fish passage barriers. Of those, 1,482 have at least 200 meters of fish habitat upstream. That is more than five times the quantity identified in 1994 when the survey was initially thought to be complete for salmon. The following table shows the current status in the *United States v. Washington* Case Area:

Fish Passage Barrier Culverts Within WSDOT Rights-of-Way In the *United States v. Washington* Case Area				
Culverts that block > 200 meters of salmon and steelhead habitat	Culverts that block > 200 meters of nonanadromous fish habitat	Culverts that block ≤ 200 meters of fish habitat	Culverts that block an unknown amount of habitat	Total
807	122	279	7	1,215

25. When WDFW inspects a culvert, it may determine whether the culvert is a partial or complete barrier to fish passage. For further explanation of WDFW's distinctions between a partial and complete barrier, see ¶ 16 of the Declaration of Paul Sekulich, Ph.D. Approximately 50% of the WSDOT fish passage barrier culverts statewide, as well as in the *United States v. Washington* Case Area, are considered partial barriers. They may impede fish of a certain size, for part of the year, or at certain stream flows. Partial barriers are still identified as fish passage barriers in WSDOT's program. A photograph of a partial barrier to fish passage is attached as Exhibit F.

26. If a culvert blocks fish passage, the next step is to determine how much habitat it blocks. If an initial assessment shows that the culvert blocks more than 200 meters of habitat, it gets put on the list for a more extensive habitat assessment under one of the methods described in WDFW's *Fish Passage Barrier*

and Surface Water Diversion Screening Assessment and Prioritization Manual (2000 version attached as Exhibit E to the Declaration of Paul Sekulich, Ph.D.). As described in the Declaration of Michael R. Barber, the habitat assessment process is labor intensive and still underway. WDFW currently has three crews working full time on these surveys. WDFW has conducted habitat assessments on approximately 34% of the WSDOT fish passage barrier culverts that block more than 200 meters of habitat in the *United States v. Washington* Case Area. WDFW's current projection for the completion of the habitat surveys is 2013 in the *United States v. Washington* Case Area and 2015 statewide.

C. Using the Fish Passage Priority Index to Decide Which Culverts to Fix First

27. To decide the order in which to fix the identified barriers, WSDOT uses several pieces of information. One of them is the Priority Index number assigned to the culvert by WDFW. For an explanation of the development of the Fish Passage Priority Index and how WDFW calculates Priority Index (PI) numbers, please refer to ¶¶ 21-28 of the Declaration of Paul Sekulich, Ph.D. Prioritization is an important part of the WSDOT program because the scale of the fish passage problem is large, corrections are expensive, and WSDOT wants to use its limited resources to provide the best benefit to fish.

28. The PI does incorporate a project cost variable, with projects grouped into three categories: less than $100,000, $100,000 to $500,000, and over $500,000. In the 1990s, that was a useful distinction for WSDOT. For the last several biennia, however, the

vast majority of the WSDOT correction projects have cost more than $500,000, so the cost variable generally has little or no influence on the PI calculation for WSDOT culverts today.

29. The value of the PI is most greatly influenced by the number of fish species present and the amount of fish habitat upstream of the culvert. Because habitat assessments have not been completed for all WSDOT fish passage barrier culverts, PIs have not been calculated for every fish barrier. In the absence of complete habitat assessment information, it is possible to create a Surrogate PI (SPI) using Geographic Information Systems (GIS) data. WDFW sometimes uses surrogate PIs to decide where to focus habitat assessment efforts before identifying projects for scoping. But the PI is considered more accurate and is used to help form the basis of programming decisions.

D. Scoping and Planning Fish Passage Barrier Corrections

30. Once fish passage barriers are identified and assigned Priority Index numbers, barriers with higher PIs undergo preliminary evaluation, or "scoping," to develop an agreed design concept to fix the culvert, with an estimated cost. Scoping starts several years before the completion of a detailed design. The scoping process begins when WDFW provides one or more conceptual designs to WSDOT that will meet fish passage needs at a particular site. Please refer to the Declaration of Michael R. Barber for a description of the initial scoping that WDFW conducts. An on-site "pre-scoping" meeting is then held to evaluate the specifics of the site, and to discuss

possible solutions. Attendees may include Tribes, local agencies, WDFW, and WSDOT. Cost estimates are developed for the correction design options. The final decision about which option to pursue is determined by agreement between WSDOT and WDFW.

31. WSDOT and WDFW have developed a stepwise process to help coordinate scoping and development of I-4 fish passage barrier corrections. A flow chart that depicts the I-4 scoping process is attached as Exhibit G.

32. When projects have been scoped, they can be proposed for funding and included for design and construction in WSDOT's Ten-Year Plan. Although culvert PIs are a key factor that informs the decision of how to sequence barrier corrections in the I-4 Program, the PI is not the sole factor considered. As described in the Declarations of Paul Sekulich, Ph.D., and Michael R. Barber, other factors are important, as well. The presence or absence of other barriers in the watershed carries weight, for example. Most WSDOT barriers with a PI greater than 20 and no other barriers in the watershed have already been fixed. The opportunities to work with other entities to fix several culverts or habitat problems at once can elevate a culvert's priority. For efficiency, WSDOT may fix several state highway culverts in a single project even though some may have low PIs. Constructability challenges, such as difficulty with right of way, access, or construction detours, can delay a project. For example, WSDOT must sometimes get permission to use city streets as a detour route while a culvert is constructed. Just today, I learned that, for two culvert projects that WSDOT expected to

construct in 2009, the City of Poulsbo has authorized WSDOT to use its streets as a detour route only if the work is done in 2010. Sometimes, projects are programmed to fit available funds. Some very high cost projects are delayed because they exceed the biennial budget. An example is the SR 3 crossing of Chico Creek, a Tributary of Dyes inlet in Kitsap County, which would require four bridges and is estimated to cost over $29 million to correct.

E. Designing, Constructing, and Paying For A Structure That Restores Fish Passage

33. Fish passage corrections in the I-4 Program are designed according to the guidance in the manual *Design of Road Culverts for Fish Passage*, which WDFW published in 2003 (Exhibit B to the Declaration of Robert Barnard, P.E.). Since 1992, WSDOT has fixed more than 70 high-priority fish passage barriers under the I-4 dedicated-fund program. WSDOT and WDFW publish annual reports describing the program and its newest completed projects. The most recent report, issued in June 2008, is attached as Exhibit E. Please see the Declaration of Jeff Carpenter for a description of the financial underpinnings of the program.

34. Approaches to fish passage design have evolved since the first I-4 corrections were constructed in the early 1990s, reflecting the advances in our understanding about the biological needs of fish as well as our experience over time with correction methods. WSDOT uses all three culvert design methods described in the WDFW culvert design manual: the hydraulic, no-slope, and stream simulation methods. Please see the Declaration of

Robert Barnard, P.E., for a description of these methods.

35. The hydraulic design method was the principal method used in the early years of WSDOT's I-4 Program. Today, WSDOT uses it primarily to retrofit existing culverts to improve passage without replacing the culvert with a new structure. Exhibit H includes photos of WSDOT culverts retrofitted with weirs or baffles. Weirs cause water to back up, while baffles interrupt its flow. Both devices slow the water velocity, which makes it easier for fish to get through. Because there are no expenses for excavation, new structure placement, or traffic control, such retrofits are economical to construct, but they can collect debris, become damaged, and require regular maintenance. For those reasons, their use has diminished in WSDOT's I-4 Program. Today, the hydraulic option is generally considered only where there are site-specific limitations, such as adjacent developed properties or very deep roadway fill, or where the cost for another type of correction would be many millions of dollars.

36. The cost of fixing a culvert using the hydraulic design option varies greatly depending on the situation. In the early 1990s, some hydraulic culverts were installed for under $50,000. In 2007, however, a hydraulic correction was constructed on SR 92 at Catherine Creek for $377,749.

37. In its current I-4 Program, WSDOT most often corrects fish passage barriers by replacing a barrier culvert with a new culvert designed under the no-slope or stream simulation methods. The Declaration of Robert Barnard, P.E., describes these

design methods. They provide a more natural and a wider span for high flows than does the hydraulic method, and they also allow for some channel movement. They provide fish passage by approximating natural stream conditions within the culvert. No-slope and stream simulation culverts also need less maintenance than hydraulic retrofit structures.

38. No-slope culverts have been a good option for WSDOT. They provide fish passage for all species at all flows, they require less maintenance than weirs and baffles, and they are generally less expensive than stream simulation culverts. No-slope culverts must be at least 1.25 times as wide as the channel bed, and WSDOT often designs them wider than that. State Route 112, along the Strait of Juan de Fuca west of Port Angeles, offers some examples of recent no-slope installations:

Recent No-Slope Culvert Installations on State Route 112			
Mile Post	**Stream**	**Year Constructed**	**Cost**
24.91	Unnamed tributary to Pysht River	2006	$647,773
32.02	Jim Creek	2004	$870,000
54.35	Bear Creek	2006	$666,151

The Jim Creek culvert is depicted in Exhibit H.

39. In some cases, the most expensive part of a culvert replacement project is excavation and traffic control, not the cost of the actual structure. In those cases, the stream simulation culvert design option is often selected even if it would cost a little more than a no-slope culvert. As described in the Declaration of Robert Barnard, P.E., WDFW's stream simulation design method is nationally recognized as the state of the art for culvert design. It provides passage for all fish species at all relevant flows, and allows for other ecological functions associated with streams. Most of the culvert corrections that WSDOT and WDFW are currently scoping use stream simulation designs. Examples of recent stream simulation installations are on SR 93 at Stevens Creek ($634,398, installed 2005), and a pair of culverts on SR 20 at Frazer Creek and Beaver Creek ($1,401,830, installed 2006).

40. WSDOT uses bridges when the stream simulation criteria would dictate a span of more than 20 feet. Bridges are also used for unconfined channels or highly dynamic stream systems. Bridges can provide benefits beyond fish passage, but they are also the most expensive fish passage barrier correction option. In 2004, a bridge was installed for fish passage on Tibbetts Creek under I-90 at a cost of $5,536,555. In 2005, a bridge was installed for fish passage on Skobob Creek on SR 106 at a cost of $1,731,000. Both bridges, and the culverts they replaced, are depicted in Exhibit I.

41. The cost of fish passage barrier correction projects has risen significantly over time. In the early 1990s, the I-4 Program started with projects that were more easily installed, and relied largely on retrofits of existing culverts. As the

program progressed, we have encountered more complex situations and relied on more extensive corrections, such as complete replacement. Inflation and rising materials costs have accelerated the increase in the cost of the program.

42. WSDOT has increasingly used full replacement for barrier culverts as the I-4 Program has matured. Of the 20 dedicated projects currently planned for design and/or construction in the 2009-2011 biennium, 17 are for stream simulation or bridge corrections. (See Exhibit J.)

43. The pace of WSDOT culvert corrections under the I-4 Program is affected by some non-monetary factors that WSDOT cannot control. One of those is state and federal regulatory agencies' seasonal timing restrictions for performing construction work in fish-bearing streams. For example WDFW currently allows construction work in Jimmycomelately Creek, a salmon-bearing stream in Clallam County, only during the month of August.

VI. WSDOT's Leadership in Fish Passage

44. When the WSDOT I-4 fish passage barrier correction program began in 1991, WSDOT had one Biologist in the Headquarters Design Office coordinating the work. Today, WSDOT has three Biologists and two Hydrologists in the Headquarters Environmental Services Office involved in this work. They work with WSDOT regional design offices and with WDFW staff in Olympia and regional offices.

45. WSDOT has supported research to increase our understanding of how best to provide fish passage at stream crossings and help reduce

transportation related effects to fish. Exhibit K lists research projects funded by WSDOT that were related to fish passage and fish protection. Two of those research projects are described in ¶ 49 of the Declaration of Paul Sekulich, Ph.D.

46. WSDOT's fish passage barrier retrofit program is among the most extensive efforts to address fish passage in the country and it is unique in several ways. Many states began to consider fish passage needs at their road crossings only in the last five years or so. Some are just beginning to inventory their culverts, using methods developed by WDFW and WSDOT as the basis for their inventory.

47. Washington has constructed more crossings specifically to accommodate fish passage than any other state in the United States. This was noted recently at page 18 of *Report 615: Evaluation of the use and Effectiveness of Wildlife Crossings*, published by the Transportation Research Board of the National Academies in 2008 (excerpts attached as Exhibit L).

48. In February 2006, FHWA hosted a Fish Passage Summit in Denver, Colorado. Representatives from many states attended, including staff from WSDOT and WDFW. Jon Peterson of my staff attended, and Robert Barnard of WDFW was one of the speakers. The efforts of several states were presented, which were modeled after parts of the Washington programs for inventory and correction. Many programs involved a less thorough inventory, less rigorous corrections standards, and no stand-alone or dedicated programs like WSDOT's I-4 Program, however.

49. The FHWA report *Design for Fish Passage at Roadway-Stream Crossings: Synthesis Report*, published in 2007, compiles information on the state of the practice for fish passage. The guidance developed in Washington for barrier inventory, as well as design of Stream Simulation and No Slope Culverts, are cited among the leading examples. Excerpts from this report are provided as Exhibit E to the Declaration of Robert Barnard, P.E.

VII. Conclusion

50. WSDOT has been proactive in addressing the need for fish passage. Through WSDOT's dedicated (I-4) fish passage program alone, the State of Washington has invested over $47 million for fish passage barrier inventory, prioritization, and correction since 1991. It has invested still more through other types of transportation projects. As depicted in Exhibits M and N, WSDOT has implemented 232 fish passage corrections, including 72 stand-alone corrections, improving access to over 754 lineal miles of stream habitat statewide. We have supported studies to improve our knowledge of fish passage and have revised our approaches to reflect new information. Our program is unique and nationally recognized for its leadership.

I declare under the penalty of perjury that the foregoing is true and correct.

Executed on this *2nd* day of April, 2009, at Olympia, Washington.

s/Paul J. Wagner
PAUL J. WAGNER

EXHIBITS TO THE DECLARATION OF PAUL J. WAGNER

Exhibit A
Resumé of Paul J. Wagner (Bates Nos. T1013589-93)

Exhibit B
Three photos of velocity, scour, and low flow at WSDOT culverts, with figures showing the cost of correcting these fish passage barriers (Bates Nos. T1013764-66)

Exhibit C
Capacity Charts for the Hydraulic Design of Highway Culverts, Hydraulic Engineering Circular No. 10 (Bureau of Public Roads, March 1965) (Bates Nos. T1013767-854)

Exhibit D
Excerpts from *Hydraulics Manual*, M 23-03.01 (Washington State Department of Transportation, June 2007) (Bates Nos. T1013855-63)

Exhibit E
Washington State Department of Fish and Wildlife/ Washington State Department of Transportation, *WSDOT Fish Passage Inventory Progress Performance Report* (June 2008) (Bates Nos. T1001862 – T1002020)

Exhibit F
Photo of a partial fish passage barrier culvert under SR 8 at Wildcat Creek (Bates No. 1013864)

Exhibit G
I-4 Flow Chart (Bates No. T1002021)

Exhibit H
Eight photographs showing one fish-blocking culvert, three hydraulic design culverts, two no-slope culverts, a stream simulation culvert, and a bridge (Bates Nos. T1013865-72)

Exhibit I
Five pages of before-and-after photos of WSDOT fish passage barrier correction projects (Bates Nos. T1013873-77)

Exhibit J
Fish Passage Pre-Scoping List (January 7, 2009) (Bates No. T1013878)

Exhibit K
List of environmental research projects that WSDOT has sponsored (Bates Nos. T1013879-81)

Exhibit L
National Highway Cooperative Research Program 615: Evaluation of the Use and Effectiveness of Wildlife Crossings (Transportation Research Board of the National Academies, 2008), Cover page and Chapter 2 (Bates Nos. T1013882-97)

Exhibit M
Chart of WSDOT Barrier Corrections Numbers Per Year

Exhibit N
Chart of Cumulative View of WSDOT Barrier Corrections

The Honorable Ricardo S. Martinez

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

UNITED STATES OF AMERICA, et al., Plaintiffs, v. STATE OF WASHINGTON, Defendant.	NO. C70-9213 Subproceeding No. 01-1 (Culverts) ADDENDUM TO THE DECLARATION OF PAUL J. WAGNER IN LIEU OF DIRECT TESTIMONY

I, PAUL J. WAGNER, declare as follows:

51. On April 2, 2009, I executed the Declaration of Paul J. Wagner in Lieu of Direct Testimony in *United Statse [sic] v. Washington* Subproceeding 01-1. I submit this Addendum to update information.

52. In paragraph 1 of my April 2, 2009 declaration, I stated that 232 barrier corrections had been completed since 1991 which improved access to more than 754 miles of stream habitat. Since that time, my staff determined that the correct number of corrections of fish passage barriers to be 225 with improved access of over 699 miles of stream habitat.

53. In paragraph 24 of my April 2, 2009 declaration, I referenced and attached as Exhibit E the 2008 *WSDOT Fish passage Inventory Progress Performance Report*. Since signing my declaration, the 2009 *WSDOT Fish Passage Inventory Progress Report*

was published and is attached to this Addendum as Exhibit O.

54. In paragraph 54, I stated that WSDOT has implemented 232 barrier corrections, including 72 stand-alone corrections, improving access to over 754 miles of stream habitat statewide. since that time, my staff determined that the correct number of corrections of fish passage barriers to be 225 (72 dedicated I-4 corrections and 153 corrections through other funding sources) improving access of over 699 miles of stream habitat. Exhibits M and N attached to this Addendum have been amended accordingly and reflect the correct numbers.

I declare under the penalty of perjury that the foregoing is true and correct.

Executed on this *22nd* day of July, 2009, at Olympia, Washington.

s/Paul J. Wagner
PAUL J. WAGNER

EXHIBITS TO THE ADDENDUM DECLARATION OF PAUL J. WAGNER

Exhibit M
Chart of WSDOT Barrier Corrections Numbers Per Year

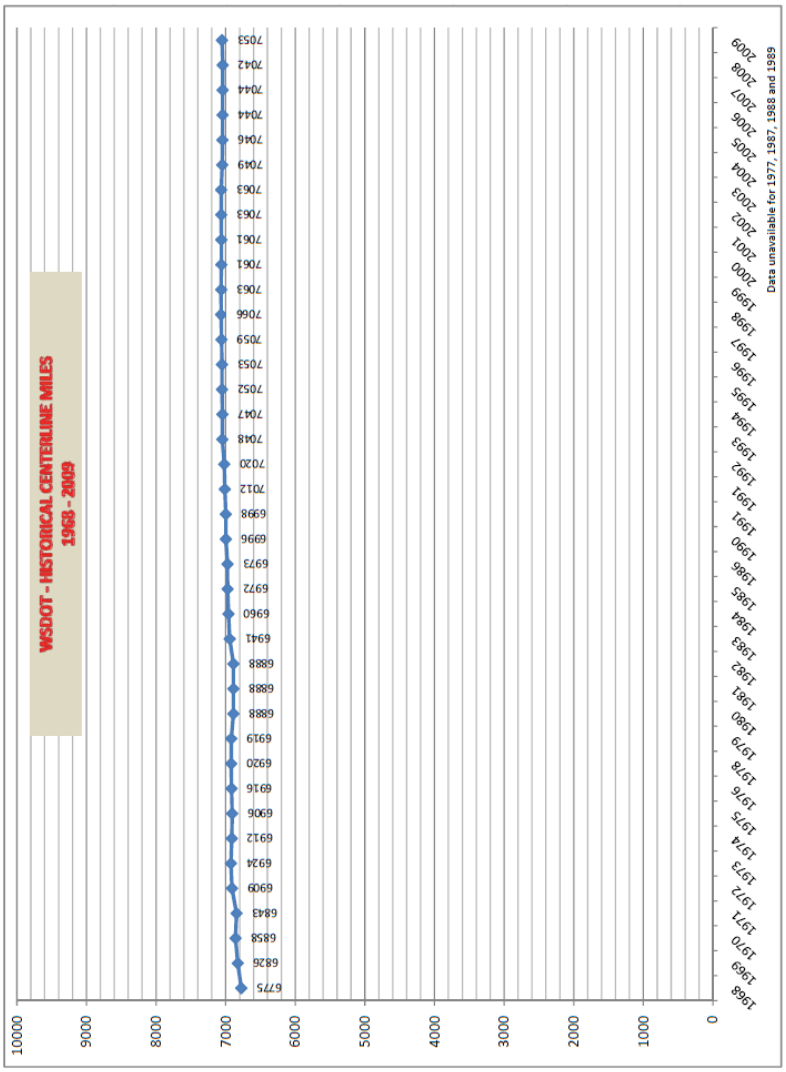
Exhibit N
Chart of Cumulative View of WSDOT Barrier Corrections

Exhibit O
Washington State Department of Fish and Wildlife/ Washington State Department of Transportation, *WSDOT Fish Passage Inventory Progress Performance Report* (July 2009) (Bates Nos. T1014085 – T1014252)

Case area summary of up and down stream barriers associated with the state owned barrier culverts used by Tyson Waldo to generate Table 1. Based on the revised list (315 of 348).		
Downstream	Upstream	Total
220	1370	1590

WRIA summary of the up and down stream barriers associated with the state owned barrier culverts (Base Culverts) used by Tyson Waldo to generate Table 1. Based on the revised list (315 of 348).			
WRIA	Base Culverts	DS Barriers	US Barriers
01	20	17	128
03	9	8	102
04	6	9	10
05	8	7	60
06	2		8
07	25	33	106
08	24	28	317
09	2	3	
10	9	11	65
11	3		16
13	1		14
14	10	4	41
15	44	30	162
16	12	6	8
17	19	17	78
18	9	10	39
19	15	2	77
20	27	11	22
21	16	1	9
22	44	12	85
23	10	11	23
Total	315	220	1370

WSDOT – Historical Center Line Miles
1868-2009



State's Exhibit W-188
Page 000001
Case No. 70-9213, Subproceeding 01-1

THE HONORABLE RICARDO S. MARTINEZ

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

UNITED STATES OF AMERICA, et al.,	NO. C70-9213
Plaintiff,	Subproceeding 01-1
vs.	
STATE OF WASHINGTON, at al. Defendant.	DECLARATION OF MIKE HENRY REGARDING PRE-FILED, WRITTEN DIRECT TESTIMONY

I, MIKE MCHENRY, declare as follows:

1. I was asked by counsel for Plaintiff Tribes in this sub-proceeding to testify as an expert witness on behalf of the Tribes.

2. As agreed to by the parties and ordered by the Court, my direct testimony is in writing. A true and complete copy is attached to this declaration.

Pursuant to 28 U.S.C. § 1746 I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge.

EXECUTED on this *10th* day of October, 2009 at *Pt. Angeles*, Washington.

s/Mike McHenry
MIKE MCHENRY

United States v. Washington
United States District Court
Western District of Washington
No C70-9213, Subproceeding 01-1 (Culverts)

Written Direct Testimony Of Mike McHenry
Habitat Program Manager
Lower Elwha Klallam Tribe
Witness For Plaintiff-Intervenor Tribes

Testimony Prepared March 27, 2009

Amended October 10, 2009

I. Introduction and Summary.

I have been asked to serve as a regional expert witness for the Washington treaty tribes on the culvert case. In that capacity I will provide my experiences in assessing watershed, habitat conditions and fish populations in Olympic Peninsula watersheds. Specifically, I will focus on the process of culvert inventory, assessments and restoration. I also provide examples of the ecological effects of culverts on stream habitat and fish populations based on my observations in watersheds of the Olympic Peninsula. The Olympic Peninsula contains watersheds that have significant potential to support anadromous fish. Many of these watersheds have been impacted by a variety of historic and ongoing land uses that have degraded and continue to limit those populations of anadromous fish important to Native American tribes. Those impacts include barriers caused by culverts under roads. The Lower Elwha Klallam Tribe operates a fisheries program with habitat assessment, monitoring and restoration capabilities. The Tribe uses a scientific process to identify and prioritize restoration projects at the watershed scale. As discussed below in Section IV below, the scientific literature recommends that restoration be conducted in a hierarchical fashion and at the watershed scale to achieve the maximum likelihood of success. The correction of human caused barriers is generally recognized as the second highest priority for restoring habitats used by Pacific salmon (following the protection of existing functional habitats). Specific methods are available to identify and prioritize culvert corrections and methods used by the Washington Department of Fish and Wildlife are widely accepted. However, problems associated with the accuracy of existing data bases used to identify streams and culvert locations likely result in underestimation of total habitat affected. Limitations in agency budgets have historically constrained barrier culvert corrections and have forced managers to implement cost-effectiveness measures to determine prioritization for culvert barrier corrections. The correction of culvert barriers is particularly important in the Pacific Northwest as there are literally thousands of barriers. Correction of barriers to salmon migration often results in a rapid response by colonizing salmon and has been shown to quickly result in increases in juvenile and adult salmon.

II. Qualifications.

I hold a Bachelor of Science degree from Humboldt State University (Fisheries 1983) and a Masters of Science degree from New Mexico State University (Wildlife Science 1986). I am currently employed by the Lower Elwha Klallam Tribe as the fisheries habitat program manager. In that capacity I am responsible for a number of activities, including: 1) reviewing and determining the effects of land use activities on treaty protected fish and wildlife resources, 2) assessing watershed, habitat and fish population conditions, 3) identifying, designing and implementing restoration actions that will improve resource conditions for fish and shellfish, 4) conducting long term monitoring and research on habitat and biological populations, 5) managing program personnel, budgets, and grants necessary to support the habitat program and 6) participating in watershed planning and other processes to advance protection and restoration of fish and wildlife resources. I have worked for the Tribe in this capacity since 1991. Previous to this position I was employed by the Northwest Indian Fisheries Commission, Idaho Department of Water Quality and the US Forest Service Intermountain Research Station in resource protection, fish population and fish habitat monitoring and research.

My background has given me broad experience in a number of areas pertinent to assessing the effects of watershed management on fish and their habitats including Pacific salmonids. I have twenty years of direct experience working in Olympic Peninsula watersheds that includes a variety of monitoring, assessment and research roles including the assessment, inventory and correction of fish passage barriers including those caused by culverts. I have conducted or have assisted with the inventories of culvert barriers on three Olympic Peninsula watersheds (Salt, Pysht, Clallam). I have also conducted numerous assessments at dozens of other watersheds in the states of Washington and Idaho. I have also been increasingly involved in management of watershed scale restoration efforts designed to improve fish habitats and watershed conditions. These projects include the correction of fish passage barriers by the replacement of barrier culverts with bridges and new passage structures that meet fish passage requirements. These barrier projects occurred in the Salt Creek, Deep Creek, East Twin River, Lyre River and the Pysht River watersheds. I am also intimately involved with planning for the removal of two dams on the Elwha River and the subsequent restoration of native salmonid populations in that river drainage.

III. Olympic Peninsula Habitat Overview.

The Olympic Peninsula contains numerous watersheds supporting diverse populations of Pacific salmon. The largest watersheds radiate off the core Olympic Mountains which rise from sea level to over 7,800' in height at Mount Olympus and include the Hoh, Queets, Quinault, Elwha and Sol Duc rivers. The headwaters of these rivers have been provided federal protection by Olympic National Park (and its predecessors), since prior to statehood. Because of this level of federal protection, large areas of the Olympic Peninsula have been largely spared from the effects of development. Not surprisingly the watersheds with the greatest levels of federal protection generally support the highest populations and greatest diversity of Pacific salmon (McHenry et al. 1996)[1]. The Elwha and Skokomish Rivers are generally thought to be an exception to this rule as construction of mainstem hydroelectric dams without fish passage facilities on these rivers has dramatically affected their ability to produce anadromous fish.

Dozens of other salmon bearing watersheds of various sizes can also be found on the Olympic Peninsula. These also were historically productive for Pacific salmon and include lesser known watersheds such as Pysht, Quilcene, Morse, Dickey, Hoko and Ozette to

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[1] McHenry, M.L., J. Licatowich and R. Hagaman. 1996. Status of Pacific Salmon and their habitats on the Olympic Peninsula, Washington. Lower Elwha Tribe, Fisheries Department, Port Angeles, Washington.

name a few. Many of these watersheds drain outside of the federally protected central Olympics and have historically had little or no protection from impacts associated with historic land uses such as logging, agricultural development, urban development, and road construction, including culverts. These activities have generally degraded the productive capacity of Olympic Peninsula watersheds to produce Pacific salmonids and can be referred to as cumulative effects. Historic overfishing, fluctuations in marine survival from large scale climatic shifts and in some cases hatchery practices are thought to be other contributors in the reduction of Olympic Peninsula salmon and steelhead populations (McHenry et al. 1996; Hard et al. 2007[2]; Myers et al 1998[3]).

Ironically, despite its reputation as a haven for Pacific salmon, the Olympic Peninsula, like other regions throughout the Pacific Northwest, has suffered dramatic decreases in salmon production during the last century (McHenry et al. 1996). Indeed many populations have either been locally extirpated, are listed as threatened under the Endangered Species Act (ESA), or have declined to remnant levels. For example, Chinook salmon from the Pysht River and

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[2] Hard, J.J., J.M. Myers, M.J. Ford, R.G. Cope, G.R. Pess, R.S. Waples, G.A. Winnans, B.A. Berejikian, F.W. Waknitz, P.B. Adams, P.A. Bisson, D.E. Campton, and R.R. Reisenbichler. 2007. Status review of Puget Sound steelhead (*Oncorhynchus mykiss*). NOAA Technical Memorandum NMFS-NWFSC-81.

[3] Myers, J., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-35.

Morse Creek are locally extirpated (McHenry et al. 1996), while steelhead populations in the Elwha and Dungeness Rivers (Hard et al. 2007) and sockeye salmon from the Ozette (Gustafson 2007[4]) are threatened and federally protected.

Watershed assessment or watershed analysis is a scientific tool used to assess landscape and land-use factors that affect rivers and their watersheds (Beechie et al. 2002[5]). Watershed assessments may utilize various methodologies but ultimately can identify the cause of habitat change or loss as well as identify needed habitat protection and restoration actions. Several watershed analyses have been completed on Olympic Peninsula watersheds. While the results vary somewhat between watersheds, there are themes that are similar and repeat with regards to habitat conditions that affect Pacific salmon on the Olympic Peninsula. These include a suite of common impacts resulting from historic logging practices (which is far and away the most widespread land use effecting *[sic]* Olympic Peninsula watersheds) and other land use activities that include:

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[4] Gustafson, R.G., T.C. Wainwright, G.A. Winans, F.W. Waknitz, L.T. Parker, and R.S. Waples. 2007. Status review of Sockeye salmon from Washington and Oregon. NOAA Technical Memorandum NMFS-NWFSC-33.

[5] Beechie, T. J., G. R. Pess, E. M. Beamer, G. Lucchetti, R. E. Bilby. 2002. Role of watershed assessments in recovery planning for salmon. Pages 194-225 /*in*/ Montgomery, D. R., S. Bolton, D. B. Booth. (Eds.) Restoration of Puget Sound Rivers. University of Washington Press, Seattle, WA.

- Increases in delivery of fine sediment to stream channels
- Increases in peak flow hydrology delivered to stream channels
- Reductions in woody debris loading delivered to stream channels from riparian forests for maintaining habitat forming processes.
- Loss of access to historically accessible habitats including from the installation of culverts at road crossings that have failed to adequately pass juvenile and/or adult fish at all stages of flow.

Depending upon the results of the individual watershed analysis in question, factors from other contributing land uses have also been identified that have further reduced habitat conditions for Pacific Salmon. These land use impacts are generally detrimental as they act to reduce life stage survival of Pacific salmon by degrading water quality, spawning and rearing habitat. For example, fine sediment is known to reduce the survival of developing salmon eggs during the incubation stage of their life history. When more than one of these factors occurs the effect may be magnified and is in referred to as a cumulative effect.

Human caused barriers, such as those caused by culverts at road crossings, directly affect the productivity of a given watershed's salmon population. Improperly designed, installed or poorly maintained culverts can create physical conditions which may inhibit or prevent the passage of both adult and juvenile salmon. Excessive outfall drops and excessive water velocities are typical mechanisms that may inhibit or prevent salmon migration to spawning and rearing habitats. Depending upon the location and severity of the blockage, a culvert barrier may completely eliminate access to salmon and cause local extirpation. In less severe cases (partial barriers) certain species or life histories may be excluded from historic spawning and rearing habitats.

Besides limiting access to habitats needed for salmon to complete their life histories, culverts may cause other undesirable impacts for fish and habitat forming processes that support them. Undersized culverts may prevent the natural transport of sediment and large wood necessary to support downstream habitats. During higher flows, culverts can "backwater" at their inlet because of insufficient transport capacity of the culvert itself. When this occurs stream velocity decreases and fluvially transported sediment and wood is typically deposited in the vicinity of the culvert inlet (Figure 1 & 2). This creates a maintenance problem; however the ecological implications to fish may be great. For example, Hammerquist Creek is a Pysht River floodplain tributary that has coho, steelhead and cutthroat trout spawning and rearing habitat. Hammerquist Creek drains through a small concrete culvert on State Highway 112 that is considered passable to fish. However it does not allow significant sediment passage (Figure 33 in Haggerty et al. 2006). Hammerquist Creek and its two associated wetlands provide overwinter habitat for thousands of coho juveniles that originate in other sections of the Pysht watershed. These fish access from the river during fall and winter high flows and exit as smolt in the spring. During some spring smolt outmigration periods, the creek may completely dry up as the creek disappears (sub-surface) through the large volume of sediments that have accumulated upstream of the culvert. In the 2005, local landowners documented the loss of more than 1000 coho pre- smolts (Figure 34 in Haggerty et al. 2006) and successfully moved another couple of thousand to the river from isolated holes in the creek and the wetlands outlets. In 2005-2006, additional fish losses because of upstream culvert stranding were documented on other Pysht River tributaries (Haggerty et al. 2006). Interestingly culverts are rarely thought of as barriers to downstream migration.

Culverts on roads or stream crossings high in the watershed may also plug and fail catastrophically. They may also route water on over steepened slopes and generate landslides. Regardless, the impacts of these culvert generated catastrophic events are transferred far downstream to habitats occupied by resident and anadromous fish. During my time working on the Olympic Peninsula I have witnessed dozens of such events in the Boundary Creek, East Twin River, Deep Creek, Calawah River, Sol Duc River, Hoh River and Clearwater Rivers.

Two state highways (101/112) directly bisect the Lower Elwha Klallam Tribe's usual and accustomed area and cross numerous streams through both bridges and various drainage structures including culverts and fishways (depending upon location). Topographic conditions on the Olympic Peninsula influenced the location where state highways were constructed. River valleys were often used because construction was relatively simple through low gradient river valleys. For example, Highway 112 is routed along portions of the mainstem Pysht, Clallam and Hoko Rivers where it encroaches on river, floodplain and riparian habitats and crosses tributaries at multiple locations. These crossings have created barriers for fish to access floodplain tributaries and wetlands that provide a critical overwintering habitat for species such as coho salmon (Figure 35 in Haggerty et al. 2006 & Figure 5). In contrast Highway 101 crosses many watersheds in the lower portions of their watershed, particularly on tributaries to the Strait of Juan de Fuca. On larger streams, bridges have been constructed that generally pass fish, but may cause other ecological problems. These may include interference with fluvial transport of wood and sediment and velocity impacts when bridge openings are undersized. On smaller streams culverts have been historically installed that if impassible may dramatically impact fish production of the entire watershed. Some examples I have personally observed include Chicken Coop (Figure 6), Colville (Figure 7) and Joe Creeks (Figure 8).

Despite the level of historic impacts that have contributed to degradation of stream and riparian habitats on the Olympic Peninsula, I have considerable optimism that these watersheds and their habitats may be recovered using a combined strategy of conservation easements and purchases to protect existing functional habitats, improved land use regulations to prevent further damages, active restoration to recover damaged habitats, and reductions in fishing mortality. The systematic correction of barrier culverts is an important place to focus restoration efforts. It is my professional opinion that the Olympic Peninsula represents one of the best geographic regions in Washington to recover salmon populations. The number of watersheds that have federally protected lands managed by the National Park Service and US Forest Service ensures that habitat forming processes will be protected across a large area. Much of the remaining areas are state and privately owned lands managed for timber production. Although these lands have historically been intensively harvested with little regard for watershed and ecosystem processes, significant improvements have occurred in the last two decades as forest practice regulations in Washington State improved under the Timber, Fish and Wildlife Agreement (TFW) and Forest and Fish Agreements (FFA). TFW (1987) and FFA (2000) were negotiated between the timber companies, state agencies, Tribes and environmental groups. The Lower Elwha Klallam Tribe is actively involved with several large timber companies to accelerate restoration of watersheds and recovery of salmon populations. Improved forest management combined with active restoration of habitats drives the Tribe's restoration of forested watersheds within its usual and accustomed area.

IV. Overview of LEKT Fisheries Program.

The Lower Elwha Klallam Tribe maintains a natural resources department that includes fisheries, water quality, wildlife management, and forestry responsibilities. The fisheries division is by far the largest program within the natural resources department and includes the following divisions: 1) fisheries and shellfish management, 2) hatchery production, 3) habitat management. Each division is supervised by a biologist and staffed with several technicians, who reports to the natural resource manager. The natural resources manager receives policy guidance from a fisheries committee composed of tribal members with interests in fishing, however ultimate responsibility for tribal policy decisions regarding fisheries issues lies with the Tribe's business council. Members of the business committee are directly elected by registered members of the Tribe.

Fisheries issues are of great importance to the Tribe as a whole. The Tribe and its ~800 members have struggled economically, and fisheries for salmon, marine fishes and shellfish provide incomes to many families. Subsistence fishing is also practiced by many tribal members. The conservation and restoration of salmon in particular are an important focus of the daily work performed in the Elwha fisheries office. Fisheries management actions are conducted with the long term sustainability and recovery of the salmon resource as a whole in mind. Hatchery supplementation actions are carefully evaluated to allow fishing opportunity while minimizing deleterious interactions with native stocks. Habitat management is conducted with an eye toward protecting existing functional habitats while restoring those degraded by human impacts. Each division in the fisheries department works collaboratively to achieve overall recovery goals by watershed and species. The Tribe also interacts with federal, state and private landowners to achieve restoration goals where possible.

The habitat management division uses watershed assessment and monitoring programs as a scientific tool to assess resource conditions and identify restoration opportunities and priorities (Beechie et al 2002). Our basic philosophy is to conduct watershed restoration systematically and at the watershed scale. In other words we attempt to treat all human caused problems over a wide an area as possible. Working within the hydrographic boundaries of individual watersheds is a rational way to break down restoration issues into discrete boundaries that coincide with physical and biological function. Watershed scale restoration also has the highest potential for succeeding (Wohl et al. 2005[6]). Restoration conducted at the scale of individual projects or at the individual stream reach may not result in the salmon recovery goals favored by the Tribe. This is not to say that the Tribe does not support or pursue individual projects. While whole watershed restoration is the "gold standard", the reality is that actually implementing the practice is exceedingly difficult and time consuming. In some watersheds a more opportunistic approach may be the only possible way for restoring habitat conditions in the short term.

Within an individual watershed we generally follow the recommendations of Roni et al (2002)[7] for

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[6] Wohl, E., P.L. Angermeier, B. Bledsoe, G.M. Kondolf, L. MacDonnell, D.M. Merritt, M.A. Palmer, N.L. Poff, and D. Tarboton. 2005. River restoration. Water Resources Research 41:1-12.

[7] Roni, P., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock, and G.R. Pess. 2002. A review of restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. North American Journal of Fisheries Management 22:1-20.

conducting hierarchical watershed restoration. Roni et al. 2002 noted that restoration of Pacific Northwest watershed should focus on the restoration of natural processes that create and maintain habitat as opposed to manipulating instream habitats. As such they recommended an approach that includes the following elements:

- Protect areas of high quality and functional habitat
- Reconnect isolated habitat areas isolated by human caused barriers
- Restore hydrologic, geologic and riparian processes
- Conduct instream habitat enhancement
- Conduct meaningful watershed scale monitoring

These principles are being applied to watershed scale restoration efforts by the Tribe in the following watersheds: Elwha River, Salt Creek, East Twin River, Deep Creek, and Pysht River. The tribe also has active watershed restoration in other watersheds such as Siebert Creek, Ennis Creek, Clallam River and Hoko River. These efforts to date have been more opportunistic and have not scaled up to the watershed scale as yet. Opportunistic restoration may include smaller scale projects with individual landowners in watersheds that lack a completed scientific analysis of watershed conditions.

The Tribe not only identifies restoration opportunities, but procures funding through competitive grants. The Tribe has successfully completed over 40 separate restoration projects with a combined value exceeding $10 million dollars since 1994. The Tribe employs a full time restoration crew composed of tribal members who implement restoration projects under the direction of the habitat manager. The habitat manager position is supported by federal and state funds received in support of the Forest and Fish Agreement (FFA).

V. LEKT Culvert Related Work.

The Lower Elwha Klallam Tribe has become increasingly involved with the inventory, assessment and correction of culverts within its usual and accustomed area. This has occurred because of the increased knowledge gained of our watersheds through scientific study and analysis. Studies such as those funded by and conducted by the Tribe on Salt Creek (McHenry et al. 2004)[8], state forest lands in the Clallam River (WDNR, Unpublished Data) and the Pysht River (Haggerty et al. 2005)[9] directly identified numerous barriers to historic fish habitats in those watersheds caused by culverts at road crossings. For example, the Salt Creek watershed analysis identified 28 culvert barriers that blocked access to one-half of the historically accessible habitat in the watershed (Figures 27 & 28 in McHenry et al. 2004). Individual site specific assessments at numerous locations have

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[8] McHenry, M., R. McCoy and M. Haggerty 2004. Salt Creek Watershed: Assessment of habitat conditions, fish populations and opportunities for restoration. Lower Elwha Klallam Tribe, Port Angeles, WA.

[9] Haggerty, M., M. McHenry and R. McCoy. 2006. Pysht River floodplain habitat Inventory and assessment. Pacific Salmon Commission, Vancouver, British Columbia, Canada.

further reinforced the need to systematically identify and correct these culvert barriers: they are ubiquitous throughout the tribe's usual and accustomed area. These include assessments conducted by other agencies such as WDFW's efforts to identify and prioritize barriers on state highways (www.wsdot.wa.gov/Environment/Biology/FP/fishpassage.htm).

Collectively these inventories provide useful information that partially describes the level of impacts from barrier culverts within the Tribe's usual and accustomed area (by individual landowner). Because many culverts on other ownerships or in other watershed have never been formally identified and surveyed, the Tribe considers the level of impacts described to date as conservative estimates. Comprehensive culvert inventories have not been completed on all county, city and private ownerships within the Tribe's usual and accustomed area.

The degree of impact that barrier culverts cause to anadromous salmon within an individual watershed is highly variable. On Ennis Creek culverts and a poorly maintained fishway on Highway 101 acts to limit access to well over half the historically accessible drainage area. Indeed the major tributary to Ennis Creek, White Creek, is completely inaccessible due to a blocking, perched culvert on Highway 101 (Figure 9 & 10). An unnamed tributary to the Pacific Ocean is completely blocked at its Highway 101 crossing at mile post 155 (Figure 11). In contrast, on Deep Creek, culvert barriers on Highway 112 and small tributaries limit access to only ~10% of historically accessible drainage area. In general I would characterize the total effects of culverts as variable depending upon watershed, with the greater impacts being to small watersheds and individual small tributaries. However, in combination with other ecological impacts, culvert effects are a significant negative cumulative effect for Olympic Peninsula salmon.

VI. Methods for Culvert Assessments.

There are multiple options for conducting culvert assessments and arguments can be made for or against various methodologies. In general, there are six basic questions that need to be answered when conducting a comprehensive assessment of barrier culverts. These include: 1) the location of the culvert within a given watershed's stream network, 2) the extent of the barrier (complete vs. partial), 3) the amount and quality of potential habitat affected, 4) the ecological effects of the culvert, 5) the physical characteristics and condition of the culvert, and 6) the presence or absence of fish in relation to potential barrier culverts. To locate stream crossings some surveys use existing maps available in Geographic Information Systems (GIS) to locate the intersection of road and stream networks. The tribe has used this approach to initially locate culverts in the Pysht River floodplain (Haggerty et al. 2005). These GIS based approaches to locating stream crossings at road and stream intersection tend to increase cost efficiencies as maps can be produced quickly in the office. Another approach is to simply walk the stream network until a culvert is encountered. This approach works well in watersheds that have extensive, old and poorly mapped road networks such as may be found in state and private industrial forest lands. However, it requires a large investment in field time by crews thus increasing inventory costs. The Tribe has used this approach to document culvert barriers in the Clallam River drainage (WDNR Unpublished Data).

A novel method involves the use of LIDAR (Light Detection and Ranging) Imaging, a remote sensing technique that can provide precise digital elevation (grid) models of the earth's surface. The Tribe used LIDAR data for Salt Creek and a combination of LIDAR and ground based GPS investigations on the Pysht River to locate, correct and classify stream layers for use in watershed analysis (McHenry et al. 2004; Haggerty et al. 2005). These techniques resulted in highly accurate maps of the stream habitats available in Salt Creek and the Pysht River floodplain (see Figures 3, 27, 28 in McHenry et al. 2004; Figures 7, 10, 24, 36 in Haggerty et al. 2005). This method resulted in a much greater network of stream habitats than existing hydrologic data layers based on traditional topographic surveys (USGS, WDNR). These maps provide the data upon which digital elevation models (DEMs) are generated. Due to hardware restrictions such as capacity and speed, large areas of coverage typically have reduced resolution. For example, generating and using a DEM of a large area such as the state of Washington, a grid width of 30 meters square is used to create the DEM. This grid resolution is derived from the existing topographic quadrangle which is 1:24,000 scale maps generated in the 1940's from aerial survey methods. In contrast, LIDAR generated maps produce grid cells of 2 m square. The level of accuracy afforded by this new technology has greatly improved remote mapping capabilities.

We compared the LIDAR imagery with existing stream and road data layers and ground surveys to identify habitats affected by fish passage barriers. Indeed, many of the habitats identified in the Pysht floodplain assessment were not known (not found on existing water type maps) until the LIDAR data was developed for the area. On the Pysht River, several stream/wetland complexes did not exist on existing water type or hydrology maps including: Spruce, Shop, Andis, Piling, 4500, and 4800 creeks. Other tributaries including Cabin, Razz and Lost Creek were either in incorrect positions or underestimated the stream length actually found on the ground. Not only were these habitats not well described, they were frequently blocked by culverts on state and privately owned roads. Culverts were estimated to represent barriers to nearly 53% of the total length of floodplain habitat. Additionally, culverts blocked access to a total of 74.9 acres of wetlands habitats in the Pysht floodplain, a critical habitat type for coho salmon (Haggerty et al. 2006). Based on these experiences I have concluded that because of inaccuracies in base hydrology maps it may be difficult to identify the total extent of the impacts caused by culverts. It is my professional opinion that the majority of culvert inventories that have been conducted to date, including those on state highways and forestlands, are conservative in their assessment of total impacts. These surveys are based only on data in existing hydrology layers, which to date has not been comprehensively corrected by LIDAR analysis or other means. Until the known population of streams, wetlands and other types of aquatic habitats are accurately defined, the likelihood of missing streams and blocking culverts remains high.

To assess effects of culverts on fish and associated habitat forming processes the Tribe has primarily used the WDFW assessment methodology (WDFW 2000[10]). This method provides a relatively rapid and repeatable, technique for assessing physical conditions at individual culvert sites. Parameters analyzed include culvert size (and size in relation to channel size), material, condition, slope, outfall drop, shape, and bottom materials. Additional data collected includes the characteristics of fill, and habitat conditions immediately downstream of the culvert. In my experience the level A analysis has resulted in a determination of the culvert's ability to completely pass fish, partially pass fish, or form a complete blockage to fish passage. In cases where the level A fails to produce a clear outcome in terms of fish passibility, a level B method that involves more detailed survey data collection in combination with hydrology modeling can be applied. Using the WDFW assessment methodology provides a standard methodology so that data can be readily shared between tribes and state agencies. We used the Level A method successfully on both the Pysht and Salt assessments to identify total and partial barriers to fish migration. Level A worked very well for these surveys as the majority of culverts encountered were clearly undersized, perched, lacked natural substrate, or set at excessive slopes. Additionally the majority of the culverts encountered were constructed of concrete

[10] Washington Department of Fish and Wildlife. 2000. Fish passage barrier and surface water diversion screening assessment and prioritization manual. Salmon Screening, Habitat Enhancement, and Restoration (SSHEAR) section, Olympia.

with smooth bottoms. Smooth concrete culverts may produce flow velocities that exceed sustained swimming speeds generated by juvenile fish. An assessment of this type takes approximately 3 hours per culvert by a two-person crew (excluding driving time) once the culvert is identified. The survey can be conducted by natural resource technicians with specific training using the method, but not necessarily requiring an advanced degree. In order to reduce subjectivity, the interpretation of the data collected and the assignment of culvert passibility should be done by either a biologist or hydraulic engineer (or preferably a team having both areas of expertise).

Once a stream barrier culvert has been located and identified, it is important to characterize the amount and quality of habitat blocked by the culvert in question. Habitat characterization is typically used to assign importance or prioritization to culvert corrections within a wider geographic area (watershed, region, state, province). Ideally all culvert corrections would be implemented over a reasonably short time period. However, budget limitations have traditionally limited comprehensive barrier corrections. As a result, habitat characterization is used to prioritize corrections: the culverts that block the greatest amount of high quality habitat areas are typically corrected first.

Similar to methods for locating culverts, there are multiple methods for assessing the amount of habitat and its quality above a given blocking culvert. The most accurate methods involve a direct survey of habitat by field crews. Under this methodology, crews would physically inventory stream characteristics upstream of barriers using any number of inventory methods. WDFW (2000) uses a system that measures attributes such as stream gradient, width, habitat type, stream bottom substrate and large woody debris. While this method is desirable in terms of producing highly accurate results of habitat conditions, it is also more expensive requiring the deployment of trained crews at considerable cost. Costs can be reduced by implementing habitat sub-sampling schemes or reducing the number of variables collected.

The Tribe has used both ground based surveys and estimates of habitat above barriers based upon physical models driven by watershed geomorphology. The later involves delineating stream network by dominant geomorphic drivers of habitat condition including gradient and valley confinement. This is a particularly good technique where accurate maps of the stream layers are available as derived from LIDAR. We used this technique in Salt Creek (McHenry et al. 2004) to estimate the length of stream, by gradient and confinement class, above a given blocking culvert. This provides a convenient means of prioritizing restoration treatments and corrections, particularly when budgets limit field survey time.

VII. Barrier Correction Successes.

The rapid responses of salmon when barriers of various types are eliminated are well documented in the fisheries literature. Probably the most spectacular example is from the Fraser River, British Columbia, where Pink and other salmon species were cut off from the majority of the watershed by a landslide in 1913. Following installation of fish passage facilities in 1940, pink salmon quickly re-colonized the upper watershed and established a large self-sustaining population within 20-30 years (Pess et al. 2007[11]). In recently de-glaciated habitats in Glacier National Park, Alaska, diverse populations of salmonids have established themselves within decades of glacial retreat (Milner and Bailey 1989[12]). In contrast where fish ladders have been installed or culvert barriers removed the response may be much more rapid. On the Cedar River, Washington, installation of a fish ladder on a low head dam allowed naturally migrating fish habitats from *[sic]* they had been excluded for over 100 years. Within 3 years the total density of juvenile salmon tripled in study reaches above the fish ladder as coho and other species colonized historic habitats (Kiffney et al. 2008[13]). Pess et al. (2003) found that culvert barrier removal projects on the Stillaguamish River, Washington opened 19 km of stream habitat for coho, chum, steelhead and cutthroat trout. Over 250 adult coho were observed spawning in the habitats above the former barrier culverts during two

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[11] Pess, G.R., T. Quinn, and K. Kloehn. 2007. The influence of population dynamics and landscape condition on Pacific salmon re-colonization. Proceedings from the International Association of Landscape Ecology World Congress, July 8-12, 2007.

[12] Milner, A.M., and R.G. Bailey. 1989. Salmonid colonization of new streams in Glacier Bay National Park, Alaska. Aquaculture and Fisheries Management 20:179-192.

[13] Kiffney, P.K., G.R. Pess, J.H. Anderson, P. Faulds, K. Burton, and S.C. Riley. 2008. Changes in fish communities following recolonization of the Cedar River, Washington by Pacific salmon after 103 years of local extirpation. River Research and Application.

consecutive spawning seasons after the project (Pess et al. 2003[14]).

Within the Lower Elwha Klallam Tribe's usual and accustomed area, barrier corrections have also resulted in rapid responses by colonizing populations. In Salt Creek, the Tribe in a cooperative project with the Department of Natural Resources (WDNR) removed a series of culvert barriers on an unnamed tributary (19.0010) during the summer of 2006. During the first rains that fall (October) adult coho salmon were observed passing through former barriers and spawning was documented above several of the barriers. I have made similar observations following barrier removal projects on Siebert Creek, where a box culvert and fish way were replaced by a bridge (Old Olympic Highway Crossing) and Susie Creek, a Lyre River tributary, where a culvert was replaced by a bridge (Highway 112 bridge replacement). Monitoring of adult escapement on both systems has indicated a positive increase for steelhead and coho salmon (Unpublished Data, Lower Elwha Klallam Tribe). On a South Fork Pysht River tributary (unnamed), the Tribe improved access to a forested wetland and pond complex above an impassible culvert barrier. Smolt production

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[14] Pess, G. R., T. J. Beechie, J. E. Williams, D. R. Whitall, J. I. Lange, J. R. Klochak. 2003. Chapter 8 - Watershed assessment techniques and the success of aquatic restoration activities. Pages 185-201 in Wissmar, R. C., P. A. Bisson. (Eds.) Strategies for Restoring River Ecosystems: Sources of Variability and Uncertainty in Natural and Managed Systems. American Fisheries Society, Bethesda, Maryland.

monitoring has shown a steady and dramatic increase in the number of coho salmon being produced from this system following restoration (Figure 12; Unpublished Data, Lower Elwha Klallam Tribe).

List of Figures

FISH PASSAGE PROGRAM
DEPARTMENT OF TRANSPORTATION INVENTORY
FINAL REPORT

Prepared for

THE WASHINGTON STATE LEGISLATURE
JUNE 1997

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Washington State Department of Transportation

[Original Page 1]

EXECUTIVE SUMMARY

It is recognized that wild salmon and trout are a symbol of the waterways of Washington, providing economic benefit to its citizens and indicating the health of streams and rivers. Economic advantages to local communities from salmonids are not abstract considering the dollars that change hands as a result of human interest in recreational and commercial fishing. In addition, vigorous populations of salmonids are important for healthy, functioning ecosystems because of the interdependence of vast numbers of flora and fauna. Many occupants of the aquatic and terrestrial ecosystems depend on salmonids for food. Most emphatically, endangered species including salmonids present imposing arguments to maintain and manage wild species on an integrated basis.

Fish passage at human made barriers such as road culverts is one of the most recurrent and correctable obstacles to healthy salmonid stocks in Washington. In some cases, many miles of quality salmonid spawning and rearing area have been blocked by a barrier culvert. State Laws subsequently recognize the importance of fish passage (Appendix I). These include RCW 75.20.060, titled "Fishways required at dams, obstructions-penalties, remedies for failure"; RCW 77.16.210, "Fishways to be provided and maintained"; RCW 75.20.061 titled "Director may modify inadequate fishways and fish guards"; and RCW 77.12.425, titled "Director may modify inadequate fishways and protective devices." Hence, fish passage at state highway culverts is important and timely and has been addressed by

Washington Department of fish and Wildlife (WDFW), Washington Department of Transportation (WSDOT), and the Washington State Legislature during the bienniums 1991-93, 1993-95, and 1995-97.

Comprehensive management of stream crossings at state highways requires fish passage inventory and barrier correction and is the topic of this report. Inventory of state owned culverts provides appropriate priorities using gains in usable habitat, sets protocol for repair, and provides a basis for budgeting. Long term planning is the cornerstone to successful funding, biological evaluation, design, project construction, and evaluation of results.

The WSDOT/WDFW strategy for inventory and correction of fish passage barriers is as follows:

- Reporting and documentation of state highway road culvert fish passage problems (inventory).
- Verification of significant stream reaches up to and above barrier culverts, quantification and qualification of blocked habitat, and prioritization of barriers for correction based on benefit evaluation (called priority indexing).
- Engineering evaluation and conceptual design.
- Final design and construction of fish passage facilities on high priority barriers (highest priority index) with dedicated barrier correction funding.
- Identification and correction of fish migration barriers concurrent with WSDOT safety and mobility road projects.
- Fish use evaluation.

[Original Page 2]

The WSDOT inventory has been an evolving project confounded by the merger of the former Fisheries and Wildlife departments; numerous adjustments to inventorying, physical surveying, and prioritizing methodologies; and the conversion to new and more effective database software. When the effort began with the former Department of Fisheries only salmon streams were the target of inventory efforts. Since the merger on July 1, 1994, the issue of fish passage has broadened to include anadromous and resident trout. Through investigation and expertise of habitat biologists it has been determined to be of extreme value to allow trout populations the mobility to intermix to maintain heterozygosity. It is equally important to enable trout to access smaller tributary streams and headwater habitats where adult spawning and juvenile rearing occur. In addition, it has been documented trout occupy stream gradients much steeper than those thought to be occupied by salmon. Hence, acceptable stream gradients were increased from 7% to 12%. Many stream sections containing barrier culverts in resident trout waters were subsequently added to the inventory, although most of the sections inventoried early in the process were not redone.

To date, WDFW has completed all of the road culvert segment and has inspected a total of 1,585 fish bearing stream crossings (culverts) on state routes throughout all six WSDOT Districts (see Figure 1). WDFW has identified 509 barrier culverts for further evaluation. Of those, 268 barrier culverts required correction to provide significant fish habitat gains. Sub-sampling resurveys to document omissions and errors estimated that another 95 barriers would require correction if the most current methodology were applied to the entire state complex.

Surveys, habitat assessments, and downstream verification of fish passage up to identified barriers have been completed on 193 streams. Sixteen of the streams surveyed did not provide a significant amount of habitat gain above the barrier culvert to justify barrier resolution. Another 91 steams were found to have a significant reach of habitat (>200 m downstream and upstream of the barrier), through a threshold determination (TD) habitat assessment, to justify barrier resolution. A total potential spawning and rearing area of 1,619,839 m^2 (249 linear miles) is currently blocked by WSDOT culverts on the 177 surveyed streams requiring barrier resolution; this is enough wetted stream area to produce 200,000 adult salmonid annually. These estimates would all increase when considering the additional 186 barriers that did not have full habitat assessments.

Working together, WDFW and WSDOT have resolved 17 barrier culverts since 1991 using WSDOT dedicated funding, and another 23 resolved through safety and mobility projects. Total habitat gained for the dedicated projects alone was 216,000 m^2, or roughly enough stream area to produce 27,000 salmon annually, not including the numerous other salmonids that have benefited from these gains. Planning is underway for resolution of at least seven more barriers during the 1997-99 biennium using dedicated funds, and to resolve all barriers in the next two to three decades. Meeting this objective will require the majority of projects to be evaluated concurrent with safety and mobility road projects and the remainder corrected as independent fish passage projects. Estimated cost is about $40 million, with resultant benefits exceeding $160 million.

[Original Page 3]

BACKGROUND

Alarming declines in salmonids in Washington during the 1980's and 1990's have caused extreme concern among fish managers, commercial and sport fishing interests, environmentalists, Native Americans, and legislatures. Overfishing, hydropower development, habitat degradation, and oceanic events such as El Niño are most often referred to as the causes. One habitat-related cause for weakening of salmonid production which can be easily resolved is human-made barriers to fish migrations caused by improper placement of road culverts. Increasing numbers of roads and resulting culverts are a common product of a growing human population in Washington. Culverts often pose immediate or eventual migration barriers to fish due to design which does not allow passage, or design that fails to consider the hydrology of watersheds, resulting in a culvert placement that eventually becomes a barrier. Changes in hydrology of streams can be natural or can result from watershed-related activities such as logging, road construction, paving, or fires. These factors can cause a passable culvert to become a barrier once stream bed scour from changes in hydrology occurs below the culvert.

A common misconception is that only adult salmon are affected by culvert barriers, as they return from the ocean to native rivers and streams to spawn. Life history studies on salmonids reveal culverts can also limit adult resident trout production and juvenile salmonid production by blocking them from important rearing areas such as swamps, ponds, marshes, or small streams. These areas have great significance to salmonid production. Research documents the upstream movement of young salmonids into areas such as this, especially during the colder months. Young salmonids do not have the swimming power of adults and are easily blocked from these areas by improperly installed culverts. Another misconception is that streams which dry in the summer have no value to salmonids; this is also not the case. Chum, pink, and sockeye salmon use these areas for spawning, and juvenile coho and chinook salmon for rearing during the high flow months.

This report documents agreements and subsequent efforts to inventory and correct fish passage problems at Washington State highway culverts. It examines Washington Department of Transportation and Washington Department of fish and Wildlife activities pursuant of inventory and correction of fish passage barriers for the bienniums 1991-93, 1993-95, and 1995-97 and provides a prioritized list for future work. It is an update to the Fish Passage Program Progress Performance Reports for the bienniums 1991-93, and 1993-95 (Burns - et. al., 1992, Bates - et. al. 1995). Many methodologies for this inventory were developed in previous bienniums, discussed in the last reports, and will be referred to in this document. In some cases revisions to the original methodology occurred this biennium and are discussed herein.

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length of usable stream above the culvert, surveys divide the stream into habitat types: pools, riffles, rapids and ponds. This is done by sampling 30-meter sections every 161 meters (one-tenth mile) or a 60-meter sample every 322 meters in streams estimated to be greater than one mile in length. Within sample areas, habitat types (riffle, pool, rapid and pond) are delineated and measured. streambed substrate composition (percentage of boulder, rubble, gravel and sand) within each type is estimated, and the stream gradient is measured. The samples result in an estimated ratio of habitat types which is then applied to the total stream length to obtain total riffle, pool, rapid and pond areas. These areas are then used to calculate spawning and rearing areas (see below). Any artificial barriers to salmonid passage are also documented. Appendix VIII contains a detailed description of the current physical habitat survey methodology.

For survey methods (1, 2, and 3) used between January 1992 and July 1995, a stream gradient > 7% continuing for 160 m or more was considered to be a gradient barrier. After July 1995 (method 4), this was increased to a gradient > 12% which continues for more 160 m. Since the end point of a physical survey may be controlled by a gradient barrier, then sampling to a higher gradient will result in more habitat being measured.

Physical habitat survey data are used to estimate habitat gains in terms of fish production potential. Habitat gain is expressed in square meters (m^2) of either spawning or rearing habitat. These values are key variables in the Pl. Spawning area is used for those species (chum, pink, and sockeye salmon) whose production is limited by spawning habitat. Rearing area is used for those species (coho and chinook salmon, steelhead, cutthroat, rainbow, bull, brook, and brown trout) whose production is limited by rearing habitat. Physical survey data were processed in a customized spreadsheet which generated a detailed summary report (Appendix X). The report documents the total habitat gain per species, habitat measurements for each reach and the total survey, information describing the quality of the stream habitat, and basic information on the survey.

In the original survey format (method 1), spawning area was defined as total riffle area. However, since spawning occurs mainly in late fall/early winter, when flows are at or near Ordinary High Water (OHW), and habitat types other than riffles may be used for spawning, so this method can result in an underestimation of spawning area. The revised physical survey methods (2, 3, and 4) define spawning area as the sum of the areas of each habitat type at OHW, multiplied by the habitat type's gravel percentage. The OHW line is defined as the point where "the presence and action of waters are so common and usual and so long continued in ordinary years, as to mark upon the soil or vegetation a character distinct from that of the abutting upland" (WAC 220-110-020, 1994). Widths at OHW are determined during the survey using the bank vegetation line, and other hydrologic evidence.

Since some salmonids remain in smaller tributaries year-round, their production is limited by the amount of rearing habitat available during the lowest stream flows of the year. Physical surveys are conducted throughout the year so measurements may not reflect low flow conditions. Calculating rearing habitat based on measured wetted area (methods 1 and 2) may overestimate available rearing habitat. Methods three and four incorporate the 60 day low flow methodology for calculating rearing habitat. Sixty-day low flow is defined as the lowest average flow occurring over any period of 60 consecutive days during the year, and is calculated for each stream using a regional constant formulated

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WSDOT ROAD PROJECTS AND BARRIER REMOVAL PLANNING

During the 1993-95 biennium, it was recognized that long-term planning between WSDOT and WDFW should include not only funding for dedicated, independent fish passage projects, but also

- close communication and coordination between the two agencies
- identification and correction of barriers in conjunction with road work, and
- long-term commitment by the legislature

Since the WSDOT inventory began, WDFW has developed a system to document highway barrier culverts statewide in order to recommend a prioritized list of fish passage projects to be completed using dedicated funding. However, with ongoing WSDOT road construction projects, it was recognized a more efficient use of state funding would be to repair fish passage problems in conjunction with WSDOT mobility, preservation/ improvement, flood control projects, as well as other jobs WSDOT might undertake which would lead to mobilization of heavy equipment in the vicinity of fish barriers. Given the number of barriers identified by the Phase I inventory, it was estimated it would take over 100 years to reach complete barrier resolution using dedicated funding only. The repair of culverts in conjunction with road projects, however, could allow complete barrier resolution in two to three decades. This approach would lead to a decrease in project costs by reducing the expense of mobilizing equipment, and a more timely increase in fish production and harvest opportunity which would enhance project benefits.

WSDOT has agreed to notify WDFW about upcoming road construction projects. If this notification occurs before the construction plans are engineered, a field crew will re-inventory all stream crossings located within the highway miles of the road project. Since WDFW and WSDOT have agreed on this approach, the inventory team has received numerous calls from WSDOT requesting comments on fish passage needs at road projects. WDFW has evaluated road projects on the following state routes; 4, 14, 18, 20, 97, 101,142, 164, 401, 504, 522, 530, 542, and 706.

All stream crossings are documented and every WSDOT culvert is evaluated for fish passage before a road project is engineered. A threshold determination (TD) is conducted upstream and downstream of each barrier culvert. Threshold determinations are conducted to verify a significant reach (≥ 200 m) of fish habitat available upstream and downstream of the barrier culvert, in order to meet the threshold criteria for barrier resolution. The TD evaluation requires a surveyor to walk (measuring the distance with a metric belt chain) a minimum of 200 m upstream and downstream of the culvert and document habitat quality. The stream gradient is measured every 50 m, species observations are made, human-made and natural barriers are documented, and habitat quality is noted. A WDFW TD form (Appendix XII) is used when collecting this data.

If a barrier culvert within the road project meets the threshold criteria (has a significant reach of habitat upstream and downstream), then it will be recommended for barrier correction, or culvert replacement, to be completed during the road project. Sometimes an undersized or failing culvert may be recommended for replacement for easier maintenance. Table III lists the barrier culverts that were or are planned to be replaced or corrected through road project recommendations. Barrier culverts WDFW

BRIEFING DOCUMENT
FISH PASSAGE
A KEY TO FISH HEALTH
4/8/97

WHY HAVE FISH PASSAGE?

1. Limited fish access to stream, lake, and river habitats because of poor road culvert construction, filling, diking, irrigation systems, and dams causes significant impacts to fish populations. Fish need habitat but if they cannot reach spawning and rearing areas, then the full potential of the habitat is not achieved and depressed and even healthy fish stocks decline to levels that cannot support utilization objectives and even to levels of extinction.

2. State law requires fish passage. At least as early as 1881, fish passage was recognized as a need in Washington and expressed in the Code of Washington. The most recent legal requirements are embodied in RCW 75.20.060 and 77.16.210.

3. Road crossings are a particularly insidious deterrent to fish passage because the average observer views water running through a culvert as an effective passage medium. In fact, road crossings block about 3,000 miles of spawning and rearing areas in Washington. This results from about 25% of the road culverts that are in noncompliance with fish passage statutes. Even when these culverts are provided with fish passage structures, there is about 25% noncompliance for maintenance needed to ensure effective passage. For facilities other than road culverts, the picture is not as clear, but based on

eastern Washington estimates noncompliance is expected to exceed 10%.

4. It is difficult to find categories of facility owners that do not share some responsibility for fish passage problems. For example, roughly about 10% of barrier culverts involve state roads, 40% county/municipal roads, and the remainder federal and private roads.

HOW HAS FISH PASSAGE BEEN ADDRESSED?

1. In the 1980's, WDFW created a fish passage unit that

a) maintains databases on fishways and barriers,

b) inventories road culvert barriers and associated habitat,

c) regularly inspects fishways and sends maintenance notices to owners,

d) serves as a core of technical fish passage experts,

e) conducts workshops, and

f) conducts specialized, high-risk construction projects to fix barriers using mobile, interdisciplinary teams of biologists, construction personnel, and environmental engineers. This complements the efforts of volunteers and Regional Enhancement Groups that concentrate on lower risk projects.

2. In the 1990's, WDFW emphasized partnerships with jurisdictions to promote fish passage in a cost-efficient manner.

a) WDFW and the Washington State Department of Transportation (DOT) entered three interagency agreements in the 1990's that involve barrier inventory work and barrier correction on state roads using dedicated fish passage funds. WDFW constructs many of the projects pursuant to reimbursable contracts. To accelerate the process, DOT also accommodates fish passage concurrent with safety and mobility road work using road funds. This approach became apparent when it was estimated that it would take more than 100 years to correct all barriers at state highway culverts with independent fish passage projects alone. Alternatively, a carefully designed blend of this effort with fish passage work on mobility and safety road projects could significantly reduce this time span. This improves cost efficiency because mobilization and some work efforts at the culvert sites would not have to be duplicated and because benefits of restored fish production would not be delayed nearly as long. In fact, it has been estimated that every dollar spent on fish passage work will return a minimum of four dollars in fish benefits, even when not considering non-consumptive values. It is expected that the prioritization of all state road barriers will be completed by the end of the 1995-7 biennium and that barriers on DOT roads can be corrected within two to three decades.

b) There is a recent global MOU with the Washington State associations of Counties and Cities and other state agencies that sets the framework for cooperative arrangements between WDFW and individual counties and cities.

c) The WDFW/DOT approach has been extended to a limited number of individual counties and, to a lesser extent, cities. In exchange for WDFW conducting the inventory of barrier culverts on county roads, the county is expected to provide at least half the funds for cooperative barrier resolution projects that WDFW builds. These arrangements are not intended to be open-ended, but rather as a "jump-start" to allow cities and counties opportunity to learn how to address fish passage and to budget for future barrier correction. The intent is for these authorities to independently correct barriers after working with WDFW on several projects. This program is in varying stages of completion with Kitsap, Skagit, and Thurston counties. Jefferson County has agreed to this arrangement beginning the 1997-9 biennium, although funding is not yet secured for even the inventory phase. Snohomish, King, Clallam, and Pierce counties and the cities of Olympia and Tumwater have also made sincere efforts at addressing fish passage.

WHAT'S IN THE FUTURE?

1. There is a need to accelerate fish passage on county and city roads, which are estimated to include about 1000 barriers. If the WDFW/DOT model is followed, it is estimated that road culvert inventories and habitat assessments to prioritize barriers for order of correction will cost about $8 million spread over two to three decades. If barrier correction incorporates a blend of dedicated fish passage projects (e.g., 200) and projects in conjunction with road work (e.g., 800), then correction of all barriers would cost about $100 million, again spread over two to three decades. This time period coincides with that for correction of barriers on DOT roads and includes cost efficiencies derived from interagency cooperation and integration of fish passage with road work.

2. There is a need to promote fish passage through the direct, personal involvement of people that work and live within watersheds. This is particularly important for barriers on private lands which are not addressed in the aforementioned jurisdictional approach and that are typically of lower risk than jurisdictional road crossings. WDFW enlists volunteers and coordinates the efforts of Regional Enhancement Groups in

programs that involve hands-on salmonid restoration efforts. For fish passage efforts, this involves Volunteer Technical Specialists and environmental engineers in WDFW well versed on fish barrier inventory, prioritization, and correction. These specialists can, in turn, train and develop this effort within the volunteers and Regional Enhancement Groups. This approach is designed to accelerate fish passage efforts through a network of local partnerships and a well-informed, active constituency operating on a watershed approach that interfaces well with the jurisdictional approach.

Table 1a. 315 Base Culverts with partial, total, and unknown barriers downstream.

	Zero Downstream Barriers	*One Downstream Barrier*	*Two Downstream Barriers*	*More than Two Downstream Barriers*	*Total*
Base Culverts	178	86	29	22	315
Percentage of Base Culverts	56.51%	27.30%	9.21%	6.98%	100.00%
Downstream Barriers Associated with Base Culverts	0	86	58	94	238
Percentage of Downstream Culverts	0.00%	36.13%	24.37%	39.50%	100.00%

Table 1a classifies the 315 state owned culverted barrier sites that Brian Benson has identified in rebuttal to Tyson Waldo by their number of associated downstream barriers. Four classes are used: zero downstream barriers, one downstream barrier, two downstream barriers, and more than two downstream barriers. The purpose is to show that the 315 state owned culverted barrier sites are impacted by downstream culverts to varying degrees. Of the 220 downstream barriers, 14 are downstream of more than one state owned culvert, and as a result there are 238 instances where the 220 downstream barriers are impacting the 315 state owned culverted barrier sites.

Cause No. C70-9213, Sub. 01-1

Plaintiffs' Exhibit **AT-285**

Table 2a. 315 Base Culverts with partial, total, and unknown barriers upstream.

	Zero Upstream Barrier	*One Upstream Barrier*	*Two Upstream Barriers*	*More than Two Upstream Barriers*	*All Upstream Barriers*
Base Culverts	120	63	31	101	315
Percentage of Base Culverts	38.10%	20.00%	9.84%	32.06%	100.00%
Upstream Barriers Associated with Base Culverts	0	63	62	1245	1370
Percentage of Upstream Barriers	0.00%	4.60%	4.53%	90.88%	100.00%

Cause No. C70-9213, Sub. 01-1

Plaintiffs' Exhibit **AT-288**

JOINT STATEMENT

REGARDING THE BIOLOGY, STATUS, MANAGEMENT, AND HARVEST OF THE SALMON AND STEELHEAD RESOURCES

OF THE PUGET SOUND AND OLYMPIC PENINSULAR DRAINAGE AREAS OF WESTERN WASHINGTON

Prepared for Use In

UNITED STATES, et al vs. STATE OF WASHINGTON, et al

CIVIL NO. 9213

UNITED STATES DISTRICT COURT WESTERN DISTRICT OF WASHINGTON

Prepared by

Washington Department of Fisheries

U. S. Fish and Wildlife Service

Washington Department of Game

May 14, 1973

JOINT STATEMENT

This Joint Statement has been prepared by and under the direct supervision of, and has been reviewed by, each of the undersigned. Except as may otherwise be stated in said Statement the facts, opinions and conclusions set forth herein are those to which each of us would testify as an expert witness in the case for which the Joint Statement has been prepared.

s/J E Lasater
J. E. Lasater, Assistant Director
Washington Department of Fisheries

s/James L Heckman
James L. Heckman, Manager
Northwest Fisheries Program
Bureau of Sport Fisheries & Wildlife
Fish and Wildlife Service

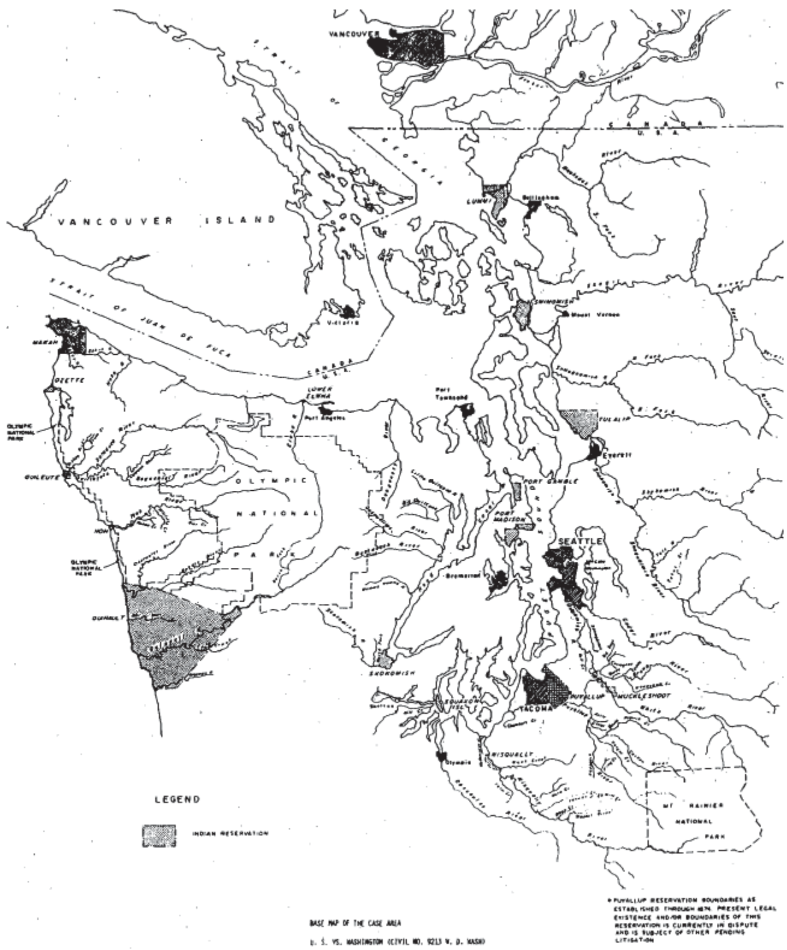
s/Cliff Millenbach
Clifford J. Millenbach
Chief, Fisheries Management
Washington Department of Game

May 14, 1973
Date

PREFACE

This report has been prepared for the purpose of presenting certain basic fisheries information for use in *U. S. v. Washington*, Civil No. 9213, U. S. District Court, Western District of Washington. That action is concerned with the treaty-secured fishing rights of certain Indians. The case is limited to the consideration of those rights as they apply in off-reservation waters of Western Washington exclusive of the Columbia River drainage area and in adjacent offshore waters. The case is concerned primarily with the rights of the Tribes which are parties to that case as they apply to the taking of salmon and steelhead at those Tribes' usual and accustomed fishing places within the aforementioned area (see map p. ii).

Accordingly, this report is limited to a discussion of the salmon and steelhead resources within the U. S. portion of the Puget Sound watershed, the watersheds of the Olympic Peninsula north of the Grays Harbor watershed and the offshore water adjacent to those areas (including those fish which are within any of such waters but are native to outside areas). As used in this report (except where the context clearly indicates otherwise) the term "Puget Sound" includes the Strait of Juan de Fuca and all saltwater areas inland therefrom, and all terms and discussions which would otherwise have a broader or more general scope - such as "fishery resource," "anadromous fish," "salmonids," "total catch," "hatcheries," "freshwater areas," etc. - are to be construed as being limited to the aforementioned geographical area and species to which this report is confined. Other terms commonly used in reference to Pacific salmon and steelhead are defined in the glossary.



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Glossary of Terms

1. Anadromous fish - Species that are hatched in freshwater, mature in saltwater, and return to freshwater to spawn.
2. Brood year - The year during which a particular year class of fish was spawned.
3. Commercial fisheries - Those fisheries engaged in for the purpose of selling the product.
4. Competitive fisheries - Fishing operations where two or more specific gear types (e.g., sport and commercial) or two or more distinct categories of fishermen compete in the harvest of the same stock of fish or shellfish or compete physically on the same fishing grounds. Fishing by one or more types of gear which interferes with the success of the other(s).
5. Cycle - The life span of a fish from its incubation through its act of spawning.

[6]. Environment - The tota1 of all external factors that affect fish. Not to be confused with *habitat*, which refers to the place where a fish is found.

7. Escapement - See spawning escapement
8. Fishery - The resource, its location, and the act of harvesting.
9. Food fish - Those species of fish designated by the Washington Legislature which may be taken from public waters for commercial sale.
10. Game fish - Those species of fish designated by the Washington Legislature which may be taken from public waters solely for personal use or recreational purposes.

11. Gear efficiency - Comparative capability of various types of fishing gear to harvest a specific stock of fish.
12. Habitat - Area which supplies oxygen, food, shelter, and space necessary for a fish's existence.
13. Harvest - The taking and possession of fish by man. Also used to designate the quantity so taken.
14. Harvestable supply - The number of fish which can be harvested from a definable population without impairing the long-run supply.
15. Indian fisheries - Those fisheries that are engaged in by Indians under claim of right arising from their status as Indians.
16. Jacks - Precocious salmon or steelhead, predominantly males, which have matured one or more years prior to the norm.
17. Landings - The quantity of fish harvested at a particular place at a particular time. When used without qualification it refers to commercial landings.
18. Limited entry - A means of controlling the level of fisherman participation in a definable fishery.
19. Management - Application of programs to maintain, enhance, and harvest fish stocks.
20. Marine - Saltwater areas, i.e., oceans or sounds - not freshwater.
21. Mature stocks - Fish of spawning age.
22. Migration - The seasonal mass movement (often annual) of fish from one place to another,

such as from freshwater to saltwater, or upstream to spawn.

23. Milling - Delay or random movement of fish, most commonly exhibited in estuary areas prior to migrating into streams to spawn.

24. Out-migrants - Young of a specific brood year moving seaward (from freshwater or estuaries) to take up marine water residence.

25. Overharvest (overfishing) - Taking of such quantities from a definable population of fish so that it is no longer capable of reproducing at its optimum rate.

26. Race - An identifiable group of fish of a given species, with unique life history or behavioral characteristics which include time of river entry as adults or distinct time and place of spawning.

27. Recruitment - Addition of new fish to fishable population by growth from among smaller size categories.

28. Run - Most often referred to as the total number of fish in a population enroute to its stream of origin.

29. Salmon and steelhead age classes -

    Fry - Newly hatched fish up to a month of age

    Fingerlings - Fry remaining in freshwater up to the age of one year from the time they are spawned

    Yearlings - Fingerlings entering their second year of freshwater residence up to the start of their seaward migration

Smolts - Fingerlings or yearlings on their seaward migration

30. Salmon preserve - Areas in Washington principally closed to commercial salmon fishing. Personal use hook and l1ne fishing is allowed.

31. Salmon species - (Note: Some earlier statutory definitions included steelhead within this term. Taxonomically, it is a member of the trout family.)

    Chinook - Also called spring, king, tyee, or blackmouth (Oncorhynchus tshawytscha)

    Coho - Also called silver, silverside, or hooknose (Oncorhynchus kisutch)

    Pink - Also called humpback or humpy (Oncorhynchus gorbuscha)

    Chum - Also called dog or keta (Oncorhynchus keta)

    Sockeye - Also called red or blueback (Oncorhynchus nerka)

32. Seed stock - The spawning adult fish which will produce the next generation or cycle. Usually refers to a specific number of adults needed to produce the maximum number of progeny and returning adults several years later.

33. Spawning escapement - Number of anadromous fish that return from the ocean to freshwater streams and spawn.

34. Sport fisheries - Fisheries which are managed or engaged in for recreational purposes or

personal use, the catch of which cannot lawfully be sold.

35. Steelhead - Salmo gairdnerii, anadromous rainbow trout.

36. Stocks - All or part of a fish population distinguished by place of origin, which may vary from a river tributary to a larger geographic area (river, state, country, hemisphere, etc.).

37. Surplus - The number of fish from a definable population escaping the fisheries and that are in excess of reproductive needs.

38. Underharvest (underfishing) - Harvesting fish below the level that would sustain reproduction of a fish population at its optimum rate.

I. THE FISHERY RESOURCE

§ 1 The Fishery Resource

§ 1.1 General Life History of Washington Salmon and Steelhead

1.1.0 Life History Characteristics Common to Salmon and Steelhead

In the fish family Salmonidae two genera, Salmo and Oncorhynchus, include species of particular importance to the Pacific Northwest. Among the various species of the genus Salmo the rainbow trout (Salmo gairdnerii) has an anadromous variety called steelhead. The genus Oncorhynchus includes all of the species of salmon. Those native to North America are:

1. Oncorhynchus tschawytscha - chinook, also called spring, king, tyee, or blackmouth salmon
2. Oncorhynchus kisutch - coho, also called silver salmon
3. Oncorhynchus gorbuscha - pink, also called humpback salmon
4. Oncorhynchus keta - chum, a1so called dog salmon
5. Oncorhynchus nerka - sockeye, also called red or blueback salmon

These five salmon species and steelhead are native to Washington State waters. Salmon and steelhead are anadromous fish; that is, they spend most of their lives in saltwater but, when approaching maturity, return to freshwater to spawn (Tab1e 1). They generally return to spawn in the stream in which they were reared naturally or released after being reared in an artificial environment. On reaching the freshwater spawning area, the female excavates a nest or "redd." She then lays a portion of her eggs which are fertilized by the accompanying male. The female then moves slightly upstream and begins excavating another depression. This gravel movement causes the first eggs deposited to be covered. The process is continued until all eggs are deposited and covered. It is important to note that the redd is dug in the stream (riffle area) where there is good inter-gravel movement of water to supply the eggs with oxygen and to carry away waste material during the incubation period. Once the spawning act is completed, all species of salmon die. This is in contrast to steelhead, which may survive the rigors of spawning.

Salmon and steelhead eggs develop and hatch while within the redd. When first hatched they are known as yolk-fry and remain in the gravel until the yolk material is totally absorbed. Egg incubation, hatching, and larval development require from 90 to 150 days, depending on water temperatures. Free-swimming fry emerge from the gravel in early spring. Juvenile salmon and steelhead spend various lengths of time in freshwater (see following sections on general life histories), then migrate downstream to saltwater. In the marine environment they feed heavily, exhibiting rapid growth until they return to freshwater on their spawning migration. Feeding activity of salmon generally ceases or diminishes as they near or enter their natal stream during the spawning migration. In contrast, steelhead do not cease their feeding activity. Degree of maturity at commencement of spawning migration varies among and within species, some having viable gonads on entry into freshwater, others after several months of freshwater residence (Tables 1-17 for general life histories and timing of freshwater life phases).

1.1.1 General Life History of Chinook Salmon

There are three important races of chinook salmon, Oncorhynchus tschawytscha, native to Washington State. These are the spring, summer, and fall chinook. This nomenclature is based upon their time of re-entry into freshwater. There are some distinct differences in the life history of these races, including the length of time the adults spend in freshwater during their spawning migration, the time of year when spawning occurs, the area in which spawning occurs, and the length of time juveniles spend in freshwater (Table 1).

Spring chinook tend to have the longest freshwater residency, both as adults and juveniles. As the name implies, they enter freshwater in the spring and yet do not spawn until August or September. They tend to migrate a longer distance in freshwater than the fall fish and utilize the spawning areas farthest upstream. Spring chinook juveniles tend to leave the freshwater habitat and migrate into the marine environment during their second year of freshwater residency as opposed to the fall chinook juvenile outmigration which occurs during the first year of freshwater residency.

Chinook salmon spawn principally in the mainstream areas of rivers and their larger tributaries. Spring chinook adults spend from 3 to 6 months in freshwater and spawn during late summer or early fall. The mature fall chinook adults spend up to 30 to 60 days in freshwater and spawn in the fall and early winter months. The adult freshwater residence of the summer chinook varies between these two extremes.

The juveniles of these races spend from 2 months to l year in freshwater before beginning their seaward migration, the spring chinook delaying the greatest length of time. The seaward migration during spring and early summer takes from 30 to 120 days.

Little is known about the life history of the summer chinook other than they enter freshwater during the summer months as adults and spawn in areas somewhat separate from spring and fall chinook.

Individuals of this species spend from 1 to 5 years in saltwater, with the average being 3 years. The maturing adults most commonly return to spawn during their fourth year. The annual average weight of chinook in the Puget Sound net fishery varies between 18 and 25 pounds.

1.1.2 General Life History of Coho Salmon

Coho salmon, Oncorhynchus kisutch, spawn in numerous small coastal streams and in the smaller tributaries of the larger rivers. The mature adults enter freshwater principally during September-November spend 30 to 60 days in freshwater, and spawn in the late fall and early winter. Juvenile coho salmon quite consistently spend a year in freshwater and will begin seaward migration during their second spring and summer of life. The seaward migration takes 30 to 120 days during the spring and summer months. The juveniles usually spend two summers and one winter in the marine environment, feeding and maturing to return as adults to spawn during their third year of life (Table 1). The annual average weight of coho in the Puget Sound net fishery varies between 8 and 10 pounds.

1.1.3 General Life History of Pink Salmon

Pink salmon, Oncorhynchus gorbuscha, have a rigid 2-year life cycle. Washington streams have populations of spawning adults in odd years only. The mature adults enter freshwater principally during August and September, spend 30 to 60 days in freshwater, and spawn during the early fall. Spawning occurs generally in the lower portion of the drainages and, in some instances, takes place in stream mouth areas where varying degrees of salinity are experienced. The fry begin their downstream migration immediately upon emergence from the gravel and may spend from 3 to 4 months in marine shoreline areas. The mature adults return on odd-numbered years to the original spawning grounds, always during their second year of life (Table 1). The annual average weight of pink salmon in the Puget Sound net fishery varies between 5 and 6 pounds.

1.1.4 General Life History of Chum Salmon

Adult chum salmon, Oncorhynchus keta, spend less than 30 days in freshwater on their spawning migration. Coastal and Puget Sound rivers receive spawning runs of chum salmon from September generally through December, though fish enter some streams such as the Nisqually River as late as March. As in the case of pink salmon, chum salmon frequently spawn in the lower reaches of the river system and near tidal areas. This species has been observed to spawn in tidal areas remote from any obvious surface freshwater streams. The fry begin their migration to saltwater immediately after emergence from the gravel. The juveniles may spend 3 to 4 months in shoreline areas in the saltwater. The adults spend 3 to 5 years in the ocean and return to spawn, normally during their third or fourth year of life (Table 1). The annual average weight of chum salmon in the Puget Sound net fishery varies between 10 and 12 pounds.

1.1.5 General Life History of Sockeye Salmon

Sockeye salmon, Oncorhynchus nerka, with few exceptions, enter rivers fed by lakes and usually spawn in tributary streams of those lakes but may spawn below the lakes in the outlet river. They also spawn on gravel beaches where subsurface upwelling occurs within the lakes. The adult spawning migration occurs during the summer and early fall months. One outstanding exception to this timing occurs in the Quinault River. These sockeye enter freshwater from January through July, with the peak of the run occurring during the last of May and the first of June.

The adult sockeye reside in the lake or stream until spawning occurs from September through December. On hatching in the following spring, the young enter the lakes where they spend usually one, frequently two, and occasionally three years feeding upon minute invertebrates. The seaward migration from the lakes usually occurs between March and May. Sockeye reside in the marine environment from 2 to 4 years. Mature fish return to spawn during their third to sixth year of life, but the fourth year is the predominant age class (Table 1). The annual average weight of sockeye salmon in the Puget Sound net fishery varies between 5 and 7 pounds.

1.1.6 General Life History of Steelhead Trout

Steel head trout, Salmo gairdnerii, may enter the larger river systems of Western Washington during all months of the year. Two “races” of steelhead occur in Washington. Winter-run fish are found in almost all streams west of the Cascade Mountains which empty into saltwater. Summer-run fish occur in the Columbia River and its tributaries above Bonneville Dam and in about 20 percent of the major steelhead streams of Western Washington. Winter-runs move upstream from November to June and spawn in the early spring. Summer-run fish generally travel upstream during June, July, August, and September, but may be found as early as February in some streams. Summer runs lay over in deep pools until the following spring, at which time they too spawn. The spawning season for steelhead extends from February through June, usually peaking in March and April.

The eggs hatch and the fry emerge after 50 to 110 days in the gravel. Juvenile steel head normally spend 2 years in freshwater before migrating to sea. Seaward migration occurs principally from April through mid-May. The adults spend from 1 to 3 years in saltwater before returning to spawn for the first time, usually at the age of 4 years (Table 1).

The frequency of survival beyond the first spawning is low and is a function of energy expended in freshwater migration, as well as number of spawnings. Because of the extremely low survival, repeat spawners are considered of only minor significance in management of the species. Just as in salmon hatchery egg taking operations, the adult winter steelhead are usually sacrificed. Except for a rare encounter of 8 and 9-year old fish, steelhead do not exceed the age of 7 years. The annual average weight of steelhead in the Puget Sound area sport fishery varies between 8 and 10 pounds.

1.1.7 Timing of Freshwater Life Phases - Salmon and Steelhead

The freshwater adult activity and juvenile development timing has been determined for the five salmon species and steelhead. The precise timing of upstream migration is influenced by a variety of factors, including maturity, water flow, and temperature. These timing data are shown by major river basins in Tables 2 through 17.

§ 1.2 Freshwater Habitat Areas

1.2.0 General Effects of Man's Activities

Early explorers' observations confirm that salmon and steelhead at one time used all streams open to them in the Pacific Northwest. They were the mainstay of a large population of Indians inhabiting the area. Due to man's activities, subsequent to the settlement of the area by non-Indians, and to other environmental changes, sections of streams or entire streams have been removed from salmon and steelhead production. However, all of the principal drainages of the Puget Sound and coastal areas are still utilized to some extent by spawning populations of salmon and steelhead. These drainages are shown in Figures 1 through 5.

1.2.1 Categories of Freshwater Habitat

In the Puget Sound area the types of fish production habitat vary a great deal. The types of production habitat are generally categorized into (1) the major rivers, (2) tributaries to the major rivers, and (3) the smaller independent streams running directly into saltwater. A further breakdown in stream classification separates each of the three basic categories into mountain, middle valley-lower valley, and lowland stream areas. Each offers somewhat different environmental conditions to which the individual species of salmon and steelhead have successfully adapted.

1.2.2 Major Rivers

Most of the major streams entering saltwater originate in mountain glacier fields, as do some of their larger tributaries. They provide a relatively stable water supply year-round from the snow packs, and periodic rainfall. As they move seaward, different types of aquatic environment are presented, ranging from cold, swift-flowing, high elevation streams, to the warmer, meandering lowland valley rivers. Spawning and rearing conditions vary considerably within these larger streams. Their upper reaches are generally characterized by having stream bottoms with large rocks and boulders, relatively short riffles and/or patch gravel spawning areas, and numerous shallow to moderately deep pools. Stream side cover usually consists of dense stands of timber. Basic productivity is usually lower than in the streams below due primarily to the lower water temperature and the fact that less nutrients are contained in the water. Fish utilization in the upper reaches of these major streams is governed primarily by stream size and accessibility. These sections receive mainly chinook salmon. However, many are also utilized by good numbers of coho and a few pink salmon.

The middle and lower valley areas offer numerous long and broad riffles, many channel split gravel bars, and extensive spawning habitat. Bottom material is generally smaller than that found in the upper reaches, and with the decrease in stream gradient more sand and silt is usually present. Long, and often very deep pools provide protection as well as excellent feeding zones for fish. Stream side cover is generally sparse, ranging from intermittent sections of timber in the upper valleys, to bare stream banks as the river courses through cleared farm land, small communities, and often through urbanized areas near the river's mouth. The diversified spawning habitats that are present in these sections of major rivers make them highly suitable for use by a number of salmon species. Chinook, pink, and chum salmon represent the predominant spawners, and if sockeye are indigenous to the system, they too will utilize this broad and varied habitat.

1.2.3 Tributaries

Tributaries to the major rivers also vary greatly in the type of aquatic habitat they offer. Again, this is dependent to a great deal on elevation and gradient, ranging from the high elevation mountain streams to the low valley type streams. In either case these streams range in size from those just a few feet wide to those nearly equal to the major rivers into which they drain. At higher elevations such streams are generally cold and swift-flowing, offering intermittent riffle and patch type spawning gravel. Stream side cover is usually dense in the higher elevation streams, as it is in the as yet undeveloped lower elevation areas. Middle and lower valley tributaries are generally more productive, being warmer and containing more nutrients. They tend to have a good pool-riffle balance and provide considerable, generally smaller sized gravel, spawning area.

The tributaries are generally shorter and accessibility more limited than the river mainstreams. In total, they usually provide a major portion of the available spawning habitat. Many of these smaller streams have greatly reduced flows in the summer. They are the major spawning habitat for coho salmon and steelhead and are used to a great extent by pink and chum salmon. The larger tributaries also receive good numbers of chinook salmon.

1.2.4 Independent Streams

The independent streams draining directly into saltwater offer production habitat similar to the lower to middle valley river tributaries. Stream gradients are generally moderate, with gravel riffles abundant. Most of these streams flow through second or third growth timber and immediate bank cover consisting of dense deciduous growth for much of the streams' length. Many of the smaller streams experience reduced flows in the summer months. These streams are generally warmer and highly productive. Virtually all of the independent streams that are accessible produce good-to-excellent numbers of coho salmon and steelhead. The lowland areas are excellent producers of chum salmon, and some of the larger streams accommodate chinook.

1.2.5 Specific Rivers Having Indian Fisheries

Brief descriptions of some of the river systems on which the principal current Indian fisheries are located are set out in Appendix I.

§ 1.3 Comparative Abundance

In nearly all annals and journals of early Pacific Northwest explorers, the writers remarked again and again on the prevalance *[sic]* of salmon as native food.

According to observations made by Hudson Bay Company fur trappers, the Lewis and Clark expedition, and earlier by Captain James Cook, salmon and steel head apparently used all freshwater streams open to them.

With the invention of the tin can during the mid-1800's, the salmon fishing industry began an intensive exploitation of the species which has continued to the present. Catches of all species of salmon in Puget Sound, e.g., have ranged from a high of over 39 million fish in 1913 to a low of just over a million fish in 1944. The largest single-producing stream to Puget Sound fishermen is the Fraser River located in Canada. The Fraser River system produces exceptionally large numbers of sockeye and pink salmon. A slide occurring in 1913 (due to railroad construction) blocked a significant portion of the sockeye spawning grounds. Catches of this species declined drastically and have not yet fully recovered from this disaster. The average annual catch of about 3.3 million sockeye in the period 1950-1971 was only

36 percent of the average catch for the years 1894-1913. The 1959-1971 catch of Fraser River pink salmon has averaged about 4.5 million fish, or about 20 percent of the potential catches from the estimated capability of the system.

Other species of salmon destined for Puget Sound watersheds have not declined to the degree observed for sockeye and pinks in the Fraser River. The natural freshwater habitat, although depreciated and reduced in area by watershed alteration, pollution, and other man-made activities, continues to produce an economically valuable resource. With contributions from artificial propagation stations, a variety of fisheries are active in pursuit of harvestable quantities of salmon and steelhead.

Extensive commercial exploitation of salmon began in the mid- to late l800's. Statewide salmon and steelhead commercial catch records have been kept by the U. S. Bureau of Fisheries since 1891 (Tables 18-22). The Washington Department of Fisheries has compiled annual records of the statewide salmon catch since 1935 (Table 23). Beginning in 1946, these records have included salmon sport catches. Estimates of the statewide steelhead sport catch have been made by the Washington Department of Game since 1946 (Table 24).

Since the earliest time of record keeping the accuracy of commercial salmon catch data has become increasingly reliable. Improved communications and staffing by the management agencies and their recognition of the importance of accurate catch records has improved the reliability of these data. In the case of steelhead, the Washington Department of

Game has not gathered commercial landing data, and until 1964 the Washington Department of Fisheries collected it only incidental to collection of salmon catch data. Since 1964 the Department of Fisheries has ceased collection of steelhead data except on the Columbia River. As a result there is no reliable data on the commercial take of steelhead for the coastal and Puget Sound areas since 1964.

Catch records are available from the earliest days of the fishery, but these cannot be directly used to assess the run sizes since some species were fished preferentially and escapements were not estimated. While some races of salmon are extinct, none of the species are endangered and all support various fisheries. The most significant change over the years is that the salmon fisheries have moved farther outward from the river mouths so that, generally, fewer numbers are arriving at the river. There are exceptions to this, particularly for some runs augmented by artificial propagation. Following is a partial resumé of the relative statewide catches of salmon and steelhead by Washington fishermen during the years 1935-1970 (Tables 18-24).

1. Chinook salmon catches ranged from a high of 13.7 million pounds in 1941 to a low of 4.6 million pounds in 1960. The catches remained relatively stable from 1935 to 1955 with an average annual catch of 10.4 million pounds. The chinook landings decreased from 1955 to 1960. Between 1960 and 1967 they remained relatively stable with an average annual catch of 5.7 million pounds. The chinook landings increased from 1968 to 1970 (Figure 6).

2. Coho salmon catches have ranged from a high of 17.4 million pounds in 1952 and 1970 to a low of 2.9 million pounds in 1960. The landings have fluctuated greatly during this period showing no trends. The average annual catch for the last 10 years of this time period was 10.1 million pounds (Figure 6).

3. Pink salmon catches have ranged from a high of 54 million pounds in 1947 to a low of 4.6 million pounds in 1965. The landings decreased from 1935 to 1943 and then sharply increased until 1947. Catches of pink salmon decreased between 1947 and 1970 (Figure 6).

4. Chum salmon catches have ranged from a high of 15.2 million pounds in 1946 to a low of 2 million pounds in 1961 and 1965. The catches declined during the last 20 years of the time period (Figure 6).

5. Sockeye salmon catches have ranged from a high of 35.1 million pounds in 1954 to a low of 1.4 million pounds in 1947. Between 1948 and 1970 the landings were relatively stable with an annual average catch of 10.2 million pounds (Figure 6).

6. Between 1947 and 1971, the catch of winter steelhead by anglers increased. It ranged from a high of 249 thousand fish in the 1965-66 season to a low of 23 thousand in 1947-48. Landings in the Puget Sound and coastal area Indian fisheries since 1945 have ranged from 21 thousand pounds in 1951 to 360 thousand pounds in 1963.

§ 1.4 Environmental Needs of Salmon and Steelhead

1.4.0 Introduction

The dependence of salmon and steelhead on suitable freshwater environment places them in direct competition with other multiple uses of the water. To determine the effect of man-made changes in the environment, requirements of anadromous fish in freshwater must be known.

Salmon and steelhead indigenous to Washington State waters are adapted to a variety of specific habitat conditions essential to their continued production. Although specific requirements by each species may vary slightly, generally their needs are quite similar. These include, but are not limited to, (1) access to and from the sea, (2) an adequate supply of good-quality water, (3) a sufficient amount of suitable gravel for spawning and egg incubation, (4) an ample supply of food, and (5) sufficient shelter.

These are the basic requirements and a detailed description of each is covered below. It is important to remember that alteration of even one of these essential, finely-balanced requirements will affect the production potential.

1.4.1 Access to and from the Sea

Anadromous fish must have free access to and from the sea. To protect the spawning and rearing environment while not providing free access for the adults or unhindered outmigration for the Juveniles would, of course, be pointless. Since adult salmon, and to some degree adult steelhead, do not feed heavily in freshwater, they must sustain themselves on their storage of energy once they leave the marine environment. Thus, it becomes important to assure their upstream passage without delay which would cause them abnormal expenditure of energy. Such delay in their migratory timing can be as catastrophic as a total block.

1.4.2 Adequate Water Supply

An adequate water supply in itself involves a number of characteristics, each of which presents rather narrow limitations on the production capabilities of a stream. Generally, an optimum volume of well-oxygenated water moving over the natural stream bed provides the necessary space and conditions for fish spawning, egg incubation, rearing, food production, and protection. The timing of the freshwater life phases of these fish is directly affected by the seasonal flow patterns. Successful fish production is also dependent upon optimum water temperatures. The temperature range most favorable to salmon and steelhead through all life phases is 50 to 60 degrees Fahrenheit. Again, the seasonal pattern and its, ranges dictate the production capability of the aquatic environment.

Water quality also presents very narrow limits with respect to aquatic productivity. The water chemistry provides certain nutrients that are picked up naturally as the stream flows seaward. Also the water must be free of pollutants that might reduce or eliminate basic food production or cause direct adverse effects to fish.

1.4.3 Adequate Spawning - Egg Incubation Areas

The stream bed of a river must contain a sufficient amount of suitable gravel riffles for spawning and incubation of deposited eggs. These riffle areas often serve to separate use by the various species of fish. The physical condition of these riffle areas, which can limit the capacity of spawning, include gravel size, amount of sand or silt in the gravel, degree of gravel compaction, and depth/velocity conditions of water flowing over the riffle. To facilitate production, these riffles must remain relatively free of silt overburden and must provide adequate flow through the gravel itself. Each of the aforementioned characteristics serves to restrict what species and number of fish will utilize the riffles, as well as to limit the overall production potential.

1.4.4 Ample Food Supply

The first requirement for an adequate food supply for fish is that the water offer the basic nutrient productivity gaged by the natural minerals, acidity, temperature patterns, and amount of dissolved oxygen. Relative to this basic productivity is the aquatic insect supply, a primary food. Insect production falls into seasonal patterns which are closely allied to the timing of the fish's freshwater juvenile residency.

1.4.5 Shelter

In order that the fish migration, spawning, and juvenile rearing life history phases take place without undue losses, protective cover is vital. Natural fish production streams usually ·provide a good pool-riffle balance, with the pools offering deep and, most often, shaded protection. Additional cover is normally provided by stream bank vegetation, wind-felled logs in or over the stream, and by large boulders which create eddies and shaded zones.

§ 1.5 Habitat Condition Trends Affecting Today's Fishery Resources

1.5.0 Introduction

Over the years, there has been a gradual deterioration and loss of natural fish production habitat in Washington State streams. Although there are many individual factors contributing to this, the general trend toward reduced production habitat is more the result of a combination of activities performed by man--activities which alter and destroy one or more habitat conditions required for successful fish production. Generally, these factors can be categorized under the broad headings of watershed alterations, water storage dams, industrial developments, stream channel alterations, and residential developments.

1.5.1 Effects of Watershed Alteration

The most significant watershed alteration within the State over the past has resulted from extensive logging operations. Logging and road building frequently result in serious degradation of water quality. Even in the uppermost reaches of some watersheds, aquatic environments have been degraded as a result of logging or log road building practices that did not consider the total impact on the ecosystem. The most obvious and most adverse impact of improper logging on water quality is the increased sediment load caused by erosion of soils from the surface of logged-over areas and from roads. Sediment loads seriously reduce natural propagation by fish by silting of spawning gravels and the smothering of eggs and fry. Often these spawning areas are rendered useless for extended periods of time.

Logging of all trees to the water's edge and removal of other stream-side vegetation expose the stream to the full impact of the sun's heat (solar radiation), causing temperature increases that are damaging to the fishery resource. Conditions of heavy siltation, poor water quality, and unnaturally high temperatures often encroach over stream areas some distance below the actual logging operations. As a result, both spawning and rearing habitats suffer.

In addition, improper logging operations leave organic debris in and adjacent to stream channels. This debris and slash often result in damming the streams, creating virtual barriers to anadromous fish migration. As these organic materials decompose, measurable increases in dissolved chemicals and plant nutrients occur in the streams which cause the growth of bacterial slimes and algae. Increased plant activity also causes a reduction of dissolved oxygen in the intra-gravel waters of the spawning beds as well as in the rearing pools.

Extensively cleared watershed areas tend to exhibit a much different run-off pattern. There is usually a greatly intensified momentary run-off associated with any heavy rainfall. Due to lack of natural water retention, unnatural low flows will also occur in the late summer. Directly associated is extensive erosion of stream bed and stream bank areas often leading to a total destruction of the fish-production capacity of the streams.

Another habitat alteration which has caused extensive damage to salmon and steelhead runs has been irrigation. The heaviest impact of irrigation is the removal of water from the stream during the critical low-flow summer months. Irrigation through water removal during the summer rearing months often reduces the rearing capacity of the stream. This occurs directly if the return water is at temperatures too high to support salmonid fishes, or indirectly by reducing the remaining volume of flow to a point where solar radiation will heat the water, causing the stream to become unsuitable for salmon and steelhead during the summer months. Irrigation may also cause an enrichment of the stream by returning water over-enriched with fertilizers which may cause an aquatic plant bloom. Such plant blooms may subsequently cause a critical lack of oxygen due to the decomposition of the added organic load in the stream. This water may also contain harmful pesticides and herbicides.

The diversion of water, and consequently juvenile fish, from the stream by unscreened ditches or pumps is a particularly critical problem during the spring and summer outmigration periods. Today, most irrigation districts make extensive use of mechanical screens. However, the magnitude of water removal is such that not all diversions are screened.

1.5.2 Effects of Water Storage Projects

The most dramatic change, often causing a complete loss of the salmon and steelhead environment on stream systems in Washington State, is the series of dams which has been completed in the last 40 years. A number of Washington's major rivers, plus many of the larger tributaries, have been adversely affected by the placement of water storage dams. Whether they are for the purpose of domestic and industrial water supply, electrical power, or flood control makes little difference. They all impose a number of habitat alterations, most being detrimental to fish production. Several obvious changes in the river environment are known to affect salmon migration. For instance, timing and pattern of upstream migration is associated with the river discharge. Since flood control and hydroelectric dams reduce and prolong the average discharge during high run-off periods when salmon or steelhead are migrating upstream, this can seriously delay the spawning migration. Migration and spawning of adult salmon and steelhead are known to be dependent on energy stores accumulated during ocean residence, and any undue energy expenditure or inefficient utilization of energy during migration can prevent successful completion of the spawning act.

Unless located above natural fish-passage barriers, these projects interrupt and usually block fish migration, preventing adults from reaching their natural spawning grounds. Collection of migrating adult salmon and steelhead for transportation over dams causes many problems, but most importantly it causes another delay in their upstream migration. Short delays of only a few days are known to reduce the productivity of some runs.

Dams not only cause environmental changes in downstream areas but also create reservoirs that can have serious adverse effects on upstream habitat. It is obvious that reservoirs represent a radical departure from the natural migratory environment and that the altered ve1ocities, temperatures, depths, and other factors might interfere with upstream migration. Reduced velocities in reservoirs result in increased heating of the surface water during the summer. Changes in water temperature affect the rate of energy uti1ization, swimming ability, and disease susceptibility of these fish.

Dams can produce a multitude of environmental changes that affect spawning efficiency, the survival of incubating eggs, and the emergence of newly-hatched fry. Successful spawning and egg incubation can occur only within certain ranges of environmental conditions.

The most obvious effect of a dam on a spawning stream is the destruction of spawning beds by creation of the reservoir itself. Alterations of the normal discharge cycle can also reduce the availability of preferred spawning velocities and depths. Another less obvious effect on egg mortality is fluctuating temperatures that do not follow the natural order due to sporadic discharges from the reservoir. Abnormal temperatures during the incubation period may cause a high rate of egg mortality and may cause premature or delayed hatching and emergence. Reductions in flow can reduce the subsurface flow that supplies oxygen to incubating eggs and removal of metabolic waste products. Velocity changes resulting from sporadic or extended discharges can alter the gravel composition of spawning areas and lead to increased silt deposition that would reduce the percolation flow to incubating eggs.

One major effect of dams on downstream migrating juvenile salmon and steelhead is the direct mortalities incurred in passage over spillways and through turbines. Another problem is the passage of the juveniles on their seaward migration through long, slow-moving reservoirs. The temperature regime of the reservoir may alter the behavior of the young fish, and the reduction in water velocity may result in delaying the juveniles beyond the normal migratory period. The reduced velocities in the reservoir create a more favorable environment for predators, therefore causing increased predation on the young salmon and steelhead.

1.5.3 Effects of Industrial Developments

Industrially-oriented developments have served to restrict, and sometimes eliminate, fish-production habitat in many Washington State streams. Water supply systems, usually developed for both industrial and domestic purposes, often reduce the amount of available water required for fish production and nearly always alter natural streamflow patterns and/or water quality characteristics. Such conditions are usually prevalent in the upper valleys and mountainous regions where spawning and rearing life phases of fish are affected.

In the more heavily populated and industrialized areas, major rivers and/or their estuaries, and sometimes even small tributaries or independent drainages, suffer from water pollution. This may exist as periodic intensive pollution of permanent low-grade reduction of water quality. Both domestic and industrial pollution can reduce or eliminate natural rearing habitats thus producing less food and generally causing conditions that sustain fewer fish. Not only can some industrial wastes be toxic to the fish, but the decomposition of sewage can reduce the dissolved oxygen to a point where it will adversely affect salmon and steelhead. Detection of pollution-caused kills of anadromous fish is difficult, but it contributes significantly to mortality of both adult and juvenile fish. It can ruin the habitat of these fish and prevent them from entering important spawning and rearing areas.

1.5.4 Effects of Channel Alteration Projects

Channel straightening and channel relocation projects serve as two of the major problems affecting Washington State's fish production streams. For many years, stream dredging and channelization have been carried out with little attention to the possible long-term effect of these operations on anadromous fish. These projects are generally associated with flood control activities conducted on the major rivers, as well as on many of their larger tributaries.

The channelization of streams eliminates the pools and riffles of a natural stream, thereby eliminating necessary cover and feeding areas for rearing and migrating fish. It may also destroy spawning beds by altering the flow of the stream, making it into a straight raceway. Dredging gravel from stream beds for use, in road building and other uses destroys not only the spawning areas but may also destroy eggs and fry that are already in the gravel. Both dredging and channelization produce large amounts of silt which are deposited downstream, and may ruin downstream spawning areas.

1 .5.5 Effects of Residential Developments

Still another major factor affecting fish production habitat is the trend toward suburban housing development. This consists of anything from summer cabins to large community projects. They are often located adjacent to tributaries of the major rivers and are frequently situated directly on some of the best fish-production habitats that exist in Washington. The overriding effect of such projects is the elimination of natural stream and stream-side cover. Segments of the watershed are essentially paved with gutters, and run-off water from roofs, driveways, and streets is channeled directly into the stream. Often large quantities of additional water are imported into these areas, only to be released as an added supply, one that is somewhat different in quality from the natural run-off. The results are changes in stream run-off patterns; increased flooding and, hence, increased stream bank and stream bottom scouring; and, particularly during the summer months, a deterioration to some degree of the existing water quality. Secondary effects associated with such developments include culvert and bridge installations, stream bed modification, and a disruption of natural fish behavior due to the fact that there simply is more activity conducted in and around the stream proper. The result is a tendency for discontinued use by major segments of fish populations that would normally inhabit these waters, and a greatly reduced spawning and rearing capacity of the stream.

§ 1.6. Ocean Migration of Puget Sound and Washington Coastal Salmon and Steelhead

It is intriguing and important to the fisheries management biologist to examine the vast amount of ocean migration data which have been obtained through various tagging and fin-marking studies carried on by fisheries agencies, both Federal and State, over the years. Ocean movements are generally known for all species and well established for some stocks. While studies of marine migrations have been directed entirely to salmon species, incidental data on steelhead has begun to disclose definite patterns of ocean residency. It is immediately obvious that salmon and steelhead do not recognize state or even international boundaries and that a complex intermingling occurs between stocks from Washington, British Columbia, Oregon, California, Alaska, and Idaho (Figures 7-9).

1.6.1 Chinook Salmon - General

For administrative purposes of the Washington Department of Fisheries, chinook salmon stocks of Washington are basically divided into three management areas: (1) Columbia River, (2) coastal, and (3) Puget Sound. Fraser River salmon stocks constitute a fourth group of major importance to Washington fishermen specifically, and U. S. fishermen in general while the Columbia River is a major producer of chinook and other salmon taken in the case area, coverage of their distribution in the ocean catch is not herein discussed in detail.

1.6.2 Washington Coastal Chinook Stocks

The chinook-producing streams tributary to Grays Harbor and Willapa Bay, plus the rivers draining the northern Olympic Peninsula and emptying directly into the Pacific Ocean, constitute one major chinook-producing "group." The Olympic Peninsula stream data are projected from studies on Grays Harbor and Willapa Bay stocks. In this area, a dominant northward movement is apparent with various marking experiments indicating that over 75 percent of the ocean catch occurs off British Columbia and Southeastern Alaska (Figure 7). The ocean availability of these fish appears to be considerably lower than for lower Columbia River fall runs, however, and the percentage of the runs escaping the ocean fisheries is greater. Returning fish make important contributions to the commercial net, river sport, and Indian fisheries.

1.6.3 Puget Sound Chinook Stocks

Puget Sound chinook exhibit the typical northward migrations shown by other stocks of the species, although a minor segment disperses southward (Figure 7). The magnitude of this latter group diminishes rapidly from north to south along the Washington coast, becoming quite minor off the Columbia River mouth. The prevailing ocean migration pattern results in an ocean catch distribution of about 90 percent of the total ocean catch occurring off British Columbia and Southeastern Alaska and only about 10 percent off the Washington coast. On return from their ocean residency most of the U. S. Puget Sound stocks enter through the Strait of Juan de Fuca; however, a portion of some, such as those destined for the Bellingham and Samish Bay areas, it is believed to return through Johnstone Strait. From the standpoint of Washington salmon fisheries, these stocks have two important "positive" features. First, sizable numbers remain in "inside" waters for appreciable periods and these immature, feeding fish make important contributions to the sport fisheries. South of the Tacoma Narrows area they are the dominant component of the 2-year-old chinook sport catch, while older fish bolster the sport fisheries throughout Puget Sound. Others are taken in the Strait of Juan de Fuca, in the San Juan Islands, and in the Strait of Georgia (Canada) sport fishery.

Second, the immature Puget Sound fish that do move seaward are definitely less available to the ocean fisheries than several other major stocks, such as lower Columbia River fall-run chinook. Experiments have shown that in the ocean they are taken mainly as maturing 4-year-old fish. Consequently, a greater percentage of the run returns to Puget Sound for exploitation by the commercial net, sport, and Indian fisheries.

1.6.4 Fraser River Chinook Stocks

Chinook produced in the Fraser River system and other large rivers draining Southern British Columbia show similarities to Puget Sound fish. A typical northward movement is evident, with the bulk of the ocean harvest occurring off British Columbia and Southeastern Alaska (Figure 7). A lesser segment moves southward to enter the Washington ocean catches. The availability of the fish and ages at capture also appear to be roughly comparable to

U. S. Puget Sound stocks. Substantial numbers of immature, feeding chinook remain in inside waters for extended periods of time and enter the sport fisheries. Salmon produced in British Columbia streams appear to be the dominant stock in the Strait of Georgia and San Juan Islands sport fisheries. Sizable numbers are also taken in the Strait of Juan de Fuca and the northern portion of inner Puget Sound. Returning adults are the dominant stocks in the Canadian net fisheries of Georgia Strait and the Fraser River and the San Juan Islands-Point Roberts fisheries of Washington.

An interesting picture is presented by examining the freshwater recoveries of immature chinook tagged in several important Puget Sound sport fishing areas. The recovery areas include the Fraser and Columbia River systems plus nine Puget Sound drainage areas (Figure 10). It is evident that the success of fishing in any given marine area is dependent on the production from many river systems; or, perhaps more meaningful, the production from each drainage, resulting from both natural and artificial means, is important to many specific fisheries. Thus, if the potential of any given river is physically impaired by power dams, water pollution, or watershed damage, the impact on the stocks and subsequent harvest can be much more extensive and far-reaching than commonly presumed.

1.6.5 Chinook Salmon - Overall

Through a general understanding of each major chinook stock in regard to population size, ocean migration, and availability factors, it is possible to estimate the river origins of major stocks contributing to each definable Washington fishery. In Figure 11, the stocks are shown in order of their importance. For example, off Sekiu and Pillar Point on an average season basis, Columbia River fish are the largest single contributor to the catch, followed in order by Puget Sound, Fraser River, Washington coastal, and Oregon coastal fish. Many other stocks are often present but are not considered to be of major significance to the local fishery. During certain periods of time, this picture does not always hold true, but research studies enable the manager to define catches by specific time intervals for many of the fisheries involved. These data are based upon the digested outcome of literally hundreds of different investigations.

1.6.6 Washington Coastal Coho Salmon Stocks

Coho produced in Grays Harbor and Willapa Bay tributaries differ markedly from their nearby Columbia River counterparts. The results of studies from these drainages have been projected by the Washington Department of Fisheries to depict the marine migration patterns of the Peninsula coastal streams. Their primary dispersion occurs to the north (Columbia River coho primarily disperse southward), with the ocean harvest being mainly in the fisheries operating off central and northern Washington (Figure 8). In addition to those taken in the Washington troll fishery, sizable numbers move off Vancouver Island and are exploited by the Canadian troll fleet. Others enter the outer portion of the Strait of Juan de Fuca, contributing to the Canadian and U. S. net fisheries in that area and to the Washington sport fisheries. Returning adults enter the landings of the Indian and river sport fisheries. The harvest of "jacks" reaches significant proportions only in the river angler's creel. The movements of coho produced in Washington coastal streams north of Grays Harbor have not been carefully studied, but the limited evidence available points to significant ocean movements both to the north and south.

1.6.7 Puget Sound Coho Salmon Stocks

Puget Sound coho exhibit the typical north and south migrations in the ocean, with their abundance declining steadily from south to north along the west coast of Vancouver Island and from north to south along the Washington coast line (Figure 8). Apparently, relatively few of these fish move south of the Columbia River or north of Vancouver Island. As a result of this migration pattern, the ocean catch distribution is divided about equally between the fisheries off Washington and British Columbia. These stocks also contribute materially to the Washington and Canadian net fisheries operating in the Strait of Juan de Fuca and to Washington's Straits sport fishery and net and sport fisheries of inner Puget Sound.

Puget Sound coho differ markedly from coastal stocks discussed previously in that sizable numbers remain in Puget Sound and never migrate to the open sea. These resident, feeding fish form the backbone of the sport fishery, with drainages nearest the available foraging (and fishing) areas often being the main contributors to the catch.

1.6.8 British Columbia Coho Salmon Stocks

Coho produced in British Columbia streams are known to be of importance to several Washington fisheries. Fish from the west coast of Vancouver Island and the Strait of Georgia drainages, particularly the Fraser River, move south off the Washington coast and contribute to the troll and sport fisheries (Figure 8). Their abundance, however, diminishes rapidly from north to south. Fish from the Strait of Georgia tributaries make substantial additions to the net fisheries of the Strait of Juan de Fuca and San Juan Islands. Resident coho of the type noted in Puget Sound appear to be the dominant constituent of the San Juan Islands sport catch.

1.6.9 Coho Salmon - Overall

It is possible to estimate, with a reasonable degree of accuracy, the major coho stocks contributing to Washington's salmon fisheries on an annual basis (Figure 12). In contrast to chinook, the major stocks of coho are much more likely to originate in drainage systems near each definable fishery. This phenomenon is produced by several interrelated factors. Since coho, on the average, spend considerably less time in the marine environment due to their younger age at maturity, their distance of migration tends to be much less than chinook. They also commonly show random dispersions both to the north and south in contrast to the predominantly northward movements of chinook. Lastly, and probably most important, their "catchability" or susceptibility to hook-and-line gear does not diminish as rapidly as fall-run chinook as they mature and approach their streams of origin.

1.6.10 Pink Salmon

Pink salmon taken in the ocean fisheries originate from Canadian streams (mainly the Fraser) and Puget Sound tributaries. Migrations are both north and south with the primary diffusion northward. Catch distribution is shifted northward and favors the Canadian fishery off the west coast of Vancouver Island as the pinks return to spawn. They are also taken in the Strait of Juan de Fuca by net and sport fisheries of both countries. Significant portions of the pink salmon runs occasionally migrate toward spawning grounds in both Canada and the United States through Johnstone Strait and the Gulf of Georgia. When this occurs, a sizable catch is made in these areas by Canadian net fisheries. Both commercial and Indian net fisheries take considerable quantities of pinks as this species nears or enters natal streams.

1.6.11 Chum Salmon

Chum salmon of all origins have declined drastically over the past two decades. Few of this species are caught in the ocean fisheries and their migration patterns are not fully known or understood. Feeding and migration studies conducted in the Gulf of Alaska by the Federal Government indicate the presence of many feeding chum salmon in this area. Results of tagging studies to date indicate that chum salmon of Washington origin are not a major component of the chum salmon populations in the Gulf of Alaska.

2.6.12 Sockeye Salmon

By far the major river system contributing to fisheries for sockeye is the Fraser River. Sockeye exhibit a northerly movement, and upon their spawning migration, increasing numbers are taken by Canadian trollers off the West Coast of Vancouver

Island. The bulk of the harvest is by Washington and Canadian net fishermen in the Strait of Juan de Fuca and the San Juan Islands as the fish near the mouth of the Fraser. A significant segment of Fraser-bound sockeye migrates through Johnstone Strait and enters the Fraser without first entering U. S. waters. Canadian net fisheries take almost the entire harvestable portion of this segment.

Lake Washington sockeye exhibit the same northerly movement as Fraser stocks, but evidence of similar migrations through Johnstone Strait has not been found. Thus, the major portion of this run is assumed to enter Puget Sound by way of the Strait of Juan de Fuca. The entry of the Lake Washington portion of this run coincides with the entry of the early Fraser River portion.

1.6.13 Steelhead

Knowledge of the ocean phase of the steelhead's life history is relatively limited. Some information has become available incidental to high seas salmon investigations, which indicates that Washington State steelhead spend at least a part of their ocean residency in the Alaskan gyre.[1] Figure 9 shows the ocean areas inhabited by Washington, Oregon, and California steelhead stocks. Steelhead from Canadian and Alaskan streams commingle in the ocean with the southern stocks.

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[1] A gyre is an ocean eddy which, in the north Pacific, rotates over a large area in a counter-clockwise direction. Salmon and steelhead are believed to swim generally downstream with this current.

§ 1.7 Inshore Migration of Salmon and Steelhead

1.7.1 Migration Routes of Salmon within Puget Sound

Figures 13-17 show the approximate average pattern of migration in Puget Sound for each of the five species of salmon. As a group, these figures illustrate the geographic intermingling of all species, some of which have representative stocks from virtually all Puget Sound streams. The complexity of regulating the Puget Sound marine area fisheries is further appreciated through this illustration. This is particularly true for chinook, coho, and chum salmon.

1.7.2 General Migration Timing of Salmon within Puget Sound

The general timing of outmigration (from freshwater to marine feeding grounds) of salmonid juveniles has been previously discussed in Sections 1.1.0-1.1.7. The general timing of adults entering freshwater is also presented in those sections. It is the purpose of this narrative to present more specific run-timing data where available.

The management areas (fishing areas and preserves) established and used by the Washington Department of Fisheries in regulating the Puget Sound commercial salmon net fisheries are shown in Figure 18. Commercial salmon fishing is generally prohibited in the salmon preserves. The combined "catch area" designations which were used in developing the run-timing curves are shown in Figure 19. These run-timing curves (Figures 20-24) have been developed from daily commercial catch data collected over a number of years, and have been smoothed by 5-day averages. Except for chinook, these figures represent the average timing of the run passage through each specific catch area. Commercial net fishing has not been permitted during the early portion of the chinook run and, therefore, run-timing data are not available as such. However, occasional test fishing has established that this timing curve is generally bell-shaped.

The spring chinook run is the first salmon species to enter Puget Sound through the Strait of Juan de Fuca on its migration toward freshwater. This run is closely followed by summer and fall chinook and sockeye salmon during June, July, and August. Coho begin entering Puget Sound during the latter part of August and continue throughout September and October. During odd-numbered years, pink salmon enter between the chinook and coho runs. Chum salmon enter from September through December with the peak occurring during October and November.

The above description is general. The latter part of one run usually overlaps the beginning of the following run. If low water conditions exist in the natal stream, these runs may delay at the stream mouth in such a manner that there is little timing difference even between the peaks of the different runs. There are many exceptions to the rule. These runs are made up of segments bound for all major rivers in Puget Sound. Individual run segments may vary depending on genetic and environmental factors.

1.7.3 General Migration Timing of Salmon and Steelhead in Coastal and Puget Sound Rivers

The same type of data used to develop the curves introduced in the preceding section have been developed over a number of years for some Indian river fisheries, principally those on the reservations. Records of off-reservation landings are incomplete. Figure 25 shows the general location of these fisheries, both in Washington coastal and Puget Sound drainages. Figures 26 through 34 provide timing curves of steelhead and Figures 35 through 41 provide timing curves of chinook, coho, and chum salmon, and where present, pinks and sockeye as they pass through several of these Indian river net fisheries.

As can be seen from these figures, a general statement concerning timing of river entry cannot be made. Each river must be looked at individually. Moreover, run-timing varies from year to year depending on weather and run-off conditions. In marine fishing areas, the different salmon runs follow a general migration timing pattern, but as they approach or enter the natal stream they tend to develop a timing which is unique to that particular run and river.

§ 1.8 Natural and Artificial Propagation

1.8.0 Introduction

Artificial propagation programs and efforts are discussed more extensively in Part II of this report. This section is limited to a brief summary of the relative extent of the contribution of such propagation to the total resource available to Washington Puget Sound and coastal areas.

In reviewing all figures which denote the percentage of natural versus artificial production harvested in the various fisheries, it must be remembered that these figures represent averages. As the level of artificial production rises and the level of natural production fluctuates due to environmental changes, these figures also change, usually on an annual basis. In cases where the timing of the runs bound for a hatchery is slightly different than the natural run-timing, the contribution to a fishery may also fluctuate greatly on a weekly or even a daily basis.

1.8.1 Chinook Salmon

The Washington Department of Fisheries estimated that 40 percent of the total fall chinook catch in Washington coastal and Puget Sound fisheries can be attributed to hatchery production. In the case of fall chinook which enter the Strait of Juan de Fuca and Puget Sound net fisheries, both United States and Canadian, 40 percent are estimated to be of Fraser River stock and 60 percent from Puget Sound streams. Thirty-six percent of this latter figure are estimated to be of hatchery origin.

Spring and summer chinook result almost entirely from natural production, although major strides are being made in the artificial production of spring chinook. Artificial means of production are just beginning to be adapted to summer chinook.

1.8.2 Coho Salmon

Coho salmon also have been successfully adapted to artificial production. Therefore, as with chinook, the percentage of annual harvest which can be attributed to natural production fluctuates greatly, depending upon the success of the natural spawn and the level of the hatchery releases into each specific river. Daily and weekly fluctuations also occur because of the differences in migration timing between natural and artificially produced stocks. Due to the more rigid 3-year life cycle of the coho and the freshwater rearing phase of these fish, the annual natural production of coho tends to fluctuate more than does the fall chinook production.

Of those coho taken in the Puget Sound net fisheries, 20 percent are estimated to be of hatchery origin. On a weekly basis, these percentages may be in excess of 90 percent or as low as 0 percent, depending upon the timing and production level of each specific hatchery, the origin of the fish, and levels of natural production.

1.8.3 Pink, Chum, and Sockeye Salmon

Except for limited success with chum and pink salmon at specific hatcheries, these three species have not yet been successfully adapted to artificial production to the degree chinook and coho have. Therefore, the total production for these three species can be essentially attributed to natural production. There are presently no widely employed means of supplementing the natural production of these species as there is with chinook or coho. If an area does not receive an adequate spawning escapement, or if man-made or natural environmental stresses cause poor survival of these species, there presently is no way of replacing this loss by artificial means.

Although the means of propagating these fish artificially within a hatchery has not been extensively developed to date, some progress is being made in the field of developing artificial spawning channels. An artificial spawning channel is basically a man-made stream in which optimum spawning conditions have been developed. Water flow, turbidity, predation, and gravel size are controlled so that adverse man-made and naturally occurring environmental phenomenon (floods, freezing, drought) rarely affect the survival of the spawn from egg to emerging fry. These channels have been successfully developed at limited locations for sockeye (Baker River), chinook and coho (Columbia River), chum (Vancouver Island, British Columbia), and pinks (Fraser River).

The Department of Fisheries is presently developing a chum and pink egg incubation channel at the Skagit Hatchery with plans to develop these channels in other locations also. These channels differ from the artificial spawning channel described above in that the eggs and sperm are taken artificially. The fertilized eggs are then placed in incubation trays rather than in the gravel. Plans also call for short-term feeding prior to release.

1.8.4 Steelhead

Steelhead hatchery operations form an important part of the management program in Washington. Their importance will increase with continued water development and diversion, environmental deterioration, and the reduction in suitable spawning areas as well as increased recreational demands. Similar to coho, the steelhead production in the natural environment is controlled greatly by the quantity and quality of stream discharge during the annual low flow periods. In the case of steelhead it is particularly critical since they most commonly spend two years in freshwater before migrating to sea. A large portion of the Game Department's scientific investigations on steelhead has been directed toward improving the use of the hatcheries as a management tool. Game Department records indicate that good survival (8-10 percent) from smolt to adult has been experienced at some facilities.

In recent years the use of rearing ponds has proven biologically and economically feasible and is being employed increasingly in the steelhead management program.

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II. MANAGEMENT OF THE RESOURCE

§ 2 Management of the Resource

§ 2.0 Introduction

Fisheries management means maintaining and enhancing the fishery resources and the aquatic environment and establishing controls on the harvest. In this part we will consider fisheries management programs in terms of their objectives, methods of accomplishment, and the activities of various management entities.

§ 2.1 Management Objectives

2.1.0 Introduction

Fisheries management takes into consideration both the resource itself and the objectives and needs of the societies which control and seek to utilize it. The anadromous fishery resource is both perishable and renewable. Thus, while an over-harvest could imperil its renewability, an under-harvest during the limited time it is available would result in an irreplaceable waste of the resource. Fisheries management seeks to avoid both of these adverse results and to maintain the stocks at a level which will permit the optimum yield from one fish cycle to another. But the "optimum yield" of the different types of fisheries must be considered in broader terms than just the quantity of fish product obtained. Because in today's society fish resources serve broader needs of man than nourishment. The commercial, sport, and Indian fisheries are managed for different use objectives and user interests. Accordingly, the objectives of fisheries management vary in accordance with the purposes and constituency for which the particular fishery is being managed.

Commercial fisheries are managed to achieve a maximum sustained yield in terms of food and economic profit whereas sport fisheries are managed to achieve a maximum sustained recreational experience and a high yield of personal use food and "trophy" product. The Indian tribes have as their primary use objectives the fostering of Indian economic well-being, the preservation of their cultural heritage and way of life, and the provision of a significant element of Indian diet.

2.1.1 Commercial Fisheries Management

Managing the fishery for maximum sustained profit requires, among other things, that the harvest occurs near the time when the available "crop" has attained maximum bulk and quality. These do not necessarily coincide in time and place. Thus the proper time for commercial harvest corresponds most nearly to the relatively brief period of time when the fish are full-grown and returning to or entering their natal stream to spawn. Net fishery seasons permit the efficient taking of mature or nearly mature fish for commercial purposes during this time period only.

2.1.2 Sport Fisheries Management

Managing for maximum sustained recreation requires providing ample opportunities for fishing. Long seasons, economically and geographically accessible waters, and high catches per individual effort all increase recreational yield. Angling is the accepted method of recreational fishing for salmon and steelhead. It involves catching the feeding fish with baited hooks or lures. Generally, salmon are taken in the marine areas and steelhead in freshwater streams.

Feeding and growing salmon in the ocean and Puget Sound are of greatest recreational value because they are vulnerable to sport gear over a long period. On the spawning migration route from their saltwater feeding areas, full-grown salmon are available to anglers for only a short period of time. Feeding activity of these latter fish diminishes or ceases as they complete their saltwater migration. The efficiency of angling gear is then measurably decreased. In some Puget Sound areas where salmon are in or approaching their natal estuary, the catch rate is commonly one-tenth that of the ocean fishery.

In contrast to salmon, steelhead actively feed throughout their entire spawning migration route and are readily available to sport gear in freshwater areas. They are not generally taken by sport gear in saltwater.

2.1.3 Indian Fisheries Management

Management for Indian objectives is closer to commercial management than to sport inasmuch as pursuit of an economic livelihood and the efficient procurement of a food supply are major purposes. In addition, salmon and steelhead have special significance in the religious, cultural, and mores of the Indian people. Because of traditions, treaty provisions, and location of Indian communities, the Indian fisheries are largely place-oriented. Management for Indian fishery objectives must take this factor into consideration.

§ 2.2 Management Methods

2.2.0 Introduction

Fishery management methods are related to the life history characteristics of the resource discussed in Part I of this report. The life histories of salmon and steelhead are cyclic. The harvest today, particularly with respect to salmon, can occur in a number of locations on their migration and at several phases of their life progression. During a substantial part of this migration and development, fish of different species, races, and river systems are intermingled to both known and unknown extents. These facets of the anadromous salmonid fisheries make the task of management a complex and difficult one--one in which forecasts of constantly changing variables play a key role.

While there are a number of managers and policies governing the management of salmon and steelhead, the methods or techniques employed by each are essentially the same. All managers are faced with a growing demand on the resource coupled with a serious deterioration of the natural habitat.

2.2.1 Assessment of the Freshwater Habitat

In the management of salmon and steelhead, an assessment of the resource must be made. One of the first steps in assessing the existing or potential level of the resource is to evaluate the freshwater habitat condition. A survey of spawning, rearing, and migration habitat, and water quality on each watershed is needed. Examples of information collected on surveys of salmon and steelhead habitat include type of surrounding terrain, type and amount of stream bank cover, stream gradient, fish migration blocks, stream bottom composition, and pool-riffle profiles. The relative measures of potential spawning and rearing area available in each stream are determined from these surveys. These basic data also are used to evaluate fish or habitat losses that may result from water development projects.

2.2.2 Assessment of Fish Stocks

The run size is determined by adding the total catch to the total escapement; however, this method of measuring run size can only be completed after catch and escapement have been analyzed. Estimations of run size must be made before and during the fishing season to assure an adequate escapement for spawning purposes, and to alert the fishermen to the need to increase or decrease their gear for that season. Several methods of estimating run size are used so that the information may be applied to current regulations. One of these is to relate spawning ground counts--either total or index--and hatchery plants to the subsequent catches and escapement. Run size is also estimated by tagging a representative segment of the population and, .through recovery programs in the ensuing fisheries, determining the tagged-to-untagged ratio. Relating catch-per-unit of effort to past years' data can also provide gross estimates of run size during the fishing season. Measurement of numbers of juveniles in streams and estuaries gives some idea of mortality rates and a gross estimate of size of the returning adult run.

2.2.3 Habitat Protection and Improvement

Habitat protection, rehabilitation, and enhancement are major efforts in the management of salmon and steelhead. Habitat protection is concerned mainly with the prevention of loss or reduction in production potential in spawning and rearing streams. One of the most important means of habitat protection is setting restrictions on any project that will use, divert, obstruct, or change the natural flow or bed of any river or stream. Habitat rehabilitation involves restoring production potential in streams that have been altered by man or nature. It includes clearing log jams and debris from streams, stabilizing stream banks, and desilting of spawning areas. Providing access to spawning and rearing areas by either laddering or removing natural blocks to migrating fish is an example of habitat enhancement. Protection and restoration of freshwater migration routes and estuarine rearing areas are increasingly important tasks facing fishery managers.

2.2.4 Artificial Propagation

The first Pacific salmon hatchery was established by the Federal Government on the McCloud River (a tributary to the Sacramento River) in 1872. Since that time hatcheries proliferated throughout the coastal states as their effectiveness as a tool in fishery management was recognized by the State and Federal fishery agencies. Hatcheries are not generally considered to be a substitute for natural production except where water development projects have entirely precluded the production from the natural habitat. Instead they are a means of supplementing and rehabilitating natural production.

The greatest success in hatchery operations has been with coho and fall chinook salmon and steelhead. These represent the bulk of the total artificial production. Recent research has led to development of techniques which indicate that other species may be successfully produced artificially. Hatcheries specifically operated for spring chinook have been increasingly successful. In addition to hatcheries, artificial spawning channels and natural rearing ponds have become important management tools.

2.2.5 Regulating the Harvest

2.2.5.0 Purposes of Regulation

Most fishery harvest regulations rest on two fundamental precepts. The first is that stocks of fish should be protected since they are exhaustible and can be destroyed. The second precept is that as fish grow older they grow larger--up to a certain age--and it is desirable to protect the young and allow them to become older so that the harvest can take advantage of growth.

Under the present complex harvest scheme there are three main purposes of regulation:

1. To preserve the fish stocks--salmon and steelhead are extremely valuable and vulnerable, and regulations are necessary just to maintain a stock;
2. To attain the maximum sustained yield;
3. To provide an orderly fishery--today more people want to fish than are needed to harvest the resource.

To accomplish this all the runs and races that spawn in the multitude of streams of the Puget Sound and coastal area should be recognized and defined. Each stream has one or more of five salmon species plus steelhead, and many rivers have several races of one species. In order to regulate effectively, it is desirable to have:

1. Accurate catch and escapement statistics on all races;
2. A forecast of run size;
3. Estimates of the number of spawners that can be accommodated in the streams used by each one of the units of stock;
4. Information on the number of units of gear, their efficiency, and the amount of fishing that is needed in order to make the catch.

Limitations on the harvest to assure run survival can be grouped into two major categories--those designed to protect selected portions of a stock of fish and those designed to limit the size of the take.

2.2.5.1 Protecting Selected Portions of Fish Stocks

Included in the broad category of protecting selected portions of a stock are four approaches: (1) net restrictions; (2) closed areas; (3) closed seasons; and (4) size and weight limits.

1. Net restrictions. Examples of restrictions on nets in the salmon fishery include mesh size, either maximum or minimum, of purse seines, gill nets, and reef nets.
2. Closed areas. Selected areas are closed to fishing for a number of different reasons, only a few of which pertain to protecting selected portions of a stock. The usual selective closure in the salmon fishery is to assure protection to a weak run in a vulnerable position, such as a milling or holding area, migration obstructions, areas of concentrated passage, or the spawning

ground. Closed areas are relatively easy to administer and, as a result, are popular with those who must enforce the regulations. Salmon preserves are examples of areas closed to commercial fisheries to protect mature salmon in vulnerable positions near their home streams. Generally, sport fishing, being less efficient, is not excluded from such areas.

3. Closed seasons. Limitations in fishing time may be particularly effective in adjusting the fishing pressure on selected portions of a stock. These may take the form of long-term closures in which fishing is not permitted on a specific stock, or short-term closures which adjust the number of days fished during a week. In the former, e.g., summer chinook of Skagit River origin are protected from commercial harvest by a closed season in Skagit Bay during time of passage in this location. This may be followed by a commercial fishery for fall chinook which may be limited to 2 or 3 days per week in the same area. Closed time can be ineffective or harmful if applied without sufficient knowledge of the stocks of fish. Incorrectly used, it may permit overfishing of some stocks and underfishing of others.

4. Size and weight limits. Size and weight limits on salmon and steelhead are applied to the commercial troll fishery and to the sport fishery to protect the immature fish. Size limits are also applied to the gill net, reef net, and purse seine fisheries in conjunction with mesh size regulations.

2.2.5.2 Methods of Limiting Size of Catch

Three methods of limiting the total catch are: (1) by catch quota; (2) by limitation of number of fishing units; and (3) by limiting the efficiency of gear.

1. Limitation by quota. Limitation by quota is used only in a very few special situations in salmon management. The quota system is only used when there is a fairly sophisticated knowledge of the size of the run and the proportion that should be taken. The quota system is sometimes used in salmon fisheries management when a run of fish is to be divided between different groups of fishermen. Bag and possession limits are examples of quotas.

2. Limitation of number of fishing units. The limitation of total units of commercial fishing gear through limiting the number of persons who may participate has not been a popular method of regulation in North America. The chief argument in favor of limited entry is that it will allow the application of improved fishing methods which result in greater efficiency and lower cost. License limitation has not yet been accepted by the legislature. Limitation of number of units of gear that an individual may use is a common regulation.

3. Limitation of efficiency of gear. One of the most common regulatory techniques is to limit the efficiency of the gear. This is done in a number of different ways. Almost all of the methods described earlier to protect certain portions of the stock can be used to limit efficiency (or reduce efficiency as a side effect). In addition,

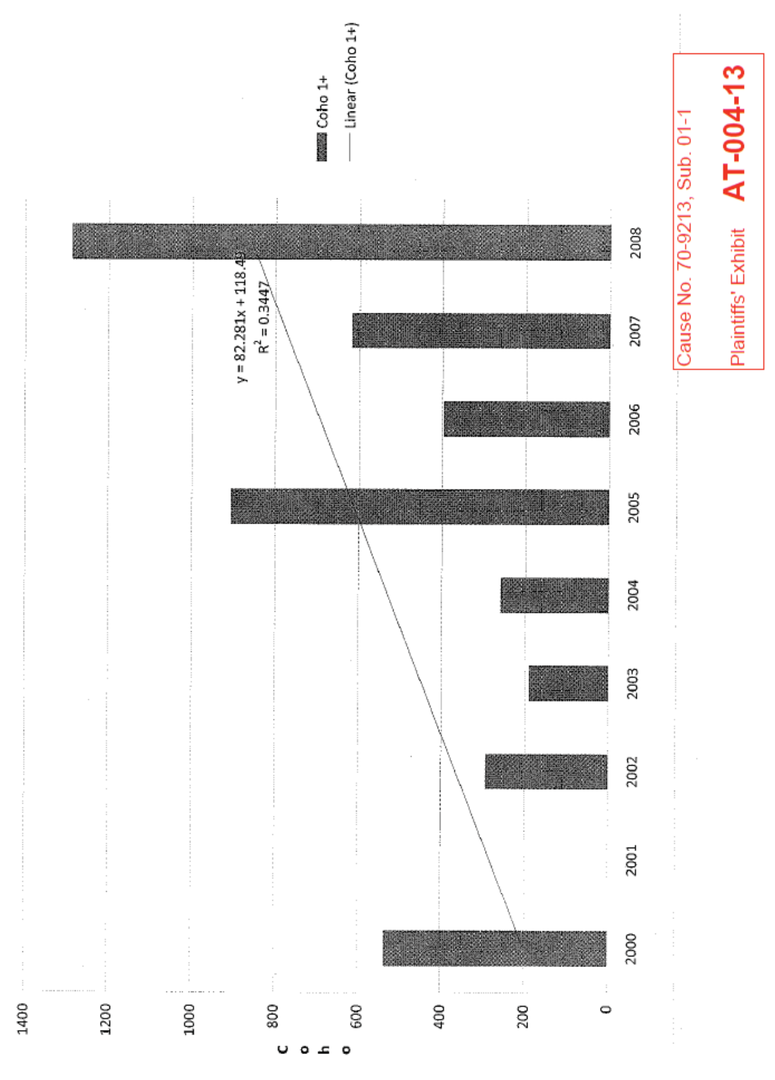
efficiency can be reduced by limiting the type of gear, the amount of net, the type of material, or the size of the boat.

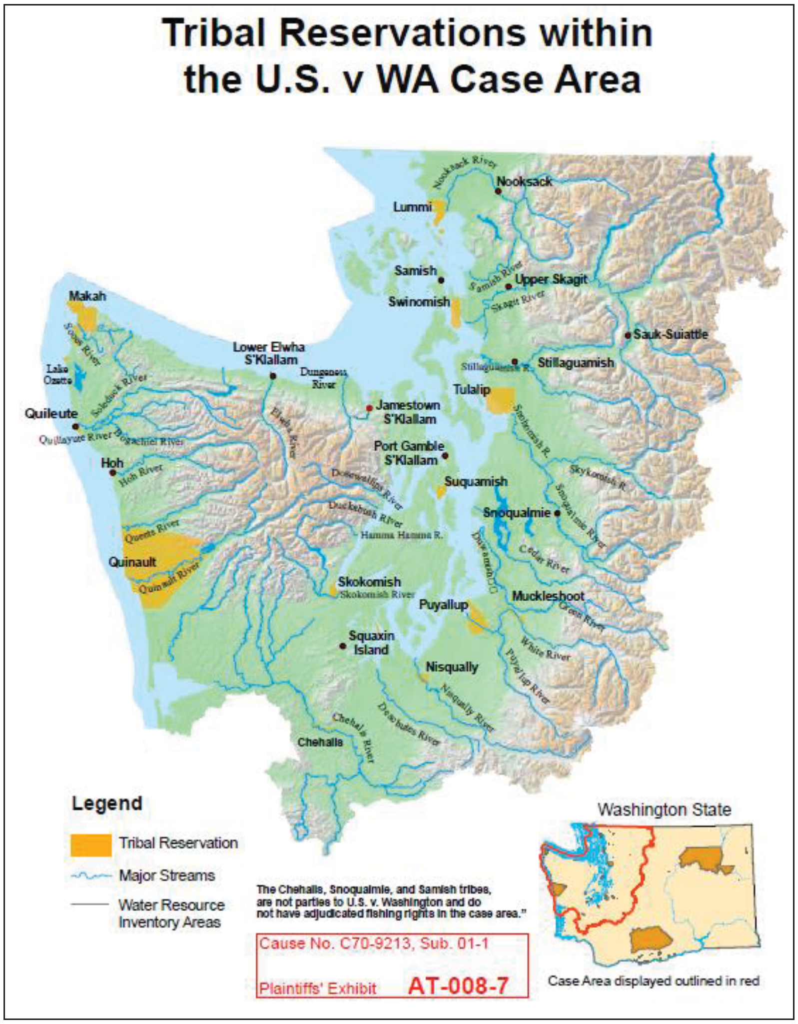
2.2.5.3 Regulations to Decrease Gear Efficiency

Regulations aimed at decreasing gear efficiency almost automatically restrict technological developments. State laws in Washington, for example, prohibit the use of monofilament nylon nets, electronic fish finders, or airplanes for spotting, although all are of demonstrable help in increasing the efficiency of salmon fishermen. Restriction of gear efficiency has social implications. The pressure for reduction of gear efficiency evolves sometimes from conflict between owners of different kinds of gear as to who should be allowed to fish. Often the result is that the most efficient gear is banned. Fixed gear is usually the first to go under this kind of social legislation. Examples of this in the history of the Northwest are the elimination of fish wheels and traps on the Columbia River and traps in Puget Sound and Alaska.

Much of the difficulty in controlling the harvest results from the fact that, until the fish has actually been legally caught, the individual fisherman has no property rights and it is not under his control. The root of the problem is that an individual fisherman has no incentive to maximize the yield from given stocks of fish. If he does not catch them, someone else does, so he cannot save them for the future. Although the need for management and the methods used depend on biological analyses, the actual techniques, like the ultimate objectives, involve political and economical considerations.

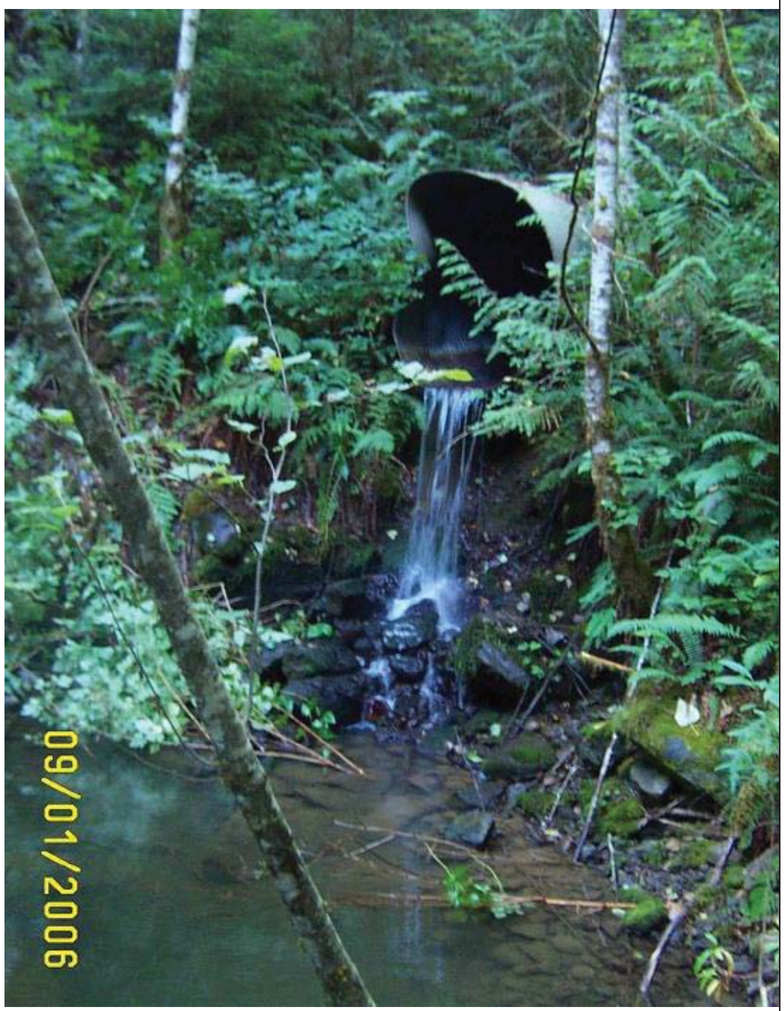
E3000 Pond Smolt Production




Tribal Reservations within
the U.S. v WA Case Area
Nooksack
Lummi
Samish
Upper Skagit
Swinomish
Makah
Sauk-Suiattle
Lower Elwha
S'Klallam
Stillaguamish
Tulalip
Jamestown
S'Klallam
Quileute
Port Gamble
S'Klallam
Hoh
Suquamish
Snoqualmie
Quinault
Skokomish
Muckleshoot
Puyallup
Squaxin
Island
Nisqually
Chehalis
Nooksack River
Samish River
Skagit River
Lake Ozette
Dungeness River
Elwha River
Quillayute River
Hoh River
Queets River
Quinault River
Skokomish River
Hamma Hamma R.
Snohomish R.
Skykomish R.
Snoqualmie River
Cedar River
Green River
White River
Puyallup River
Nisqually River
Deschutes River
Chehalis River
Legend
Tribal Reservation
Major Streams
Water Resource
Inventory Areas
The Chehalis, Snoqualmie, and Samish tribes,
are not parties to U.S. v. Washington and do
not have adjudicated fishing rights in the case area."
Cause No. C70-9213, Sub. 01-1
Plaintiffs' Exhibit AT-008-7
Washington State
Case Area displayed outlined in red

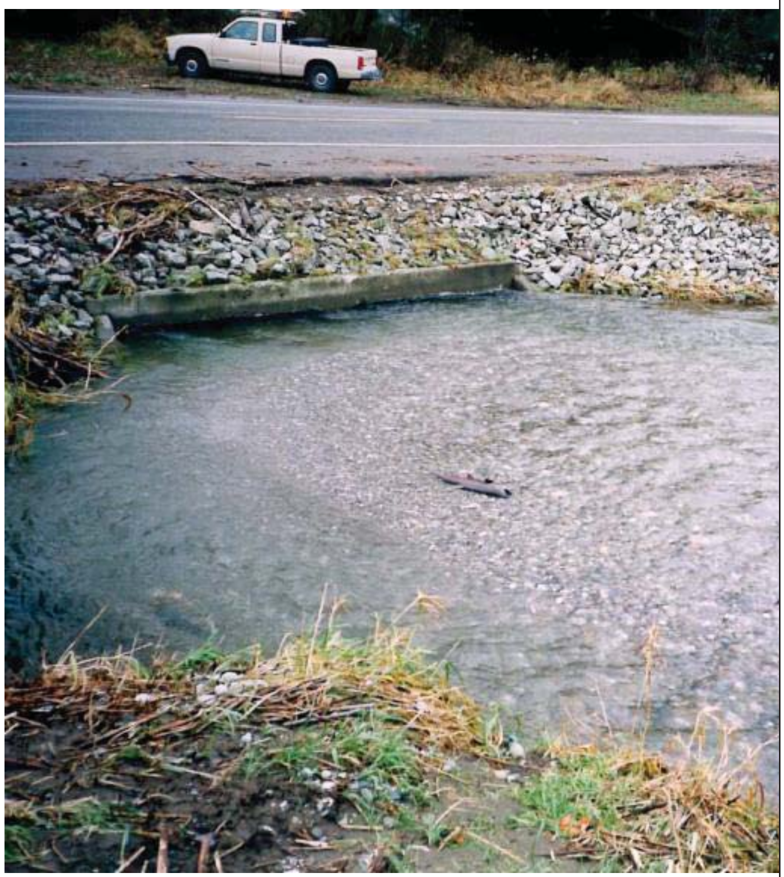
Attachment A: Washington Department Of Fish And Wildlife Illustration Entitled Pacific Salmon Lifecycle

Attachment D: Photograph Of A Culvert On A Tributary To The Nooksack River (Bates No. 02-002315)



Attachment E: Photograph Of A Culvert Showing Elimination Of Rearing Habitat With In *[sic]* A Culvert (Bates No. 02-002366)

Attachment G: Photograph Of Culvert At Red Cabin Creek Filled With Sediment Prior To Dredging (Bates No. 02-002180)



Attachment J: Photograph Or *[sic]* Culvert At Red Cabin Creek After Dredging (Bates No. 02-002281)

Attachment K: Photograph Of Culvert At Red Cabin Creek Showing Dead Adult Salmon (Bates No. 02-002194)

Attachment L: Photograph Of Culvert At Red Cabin Creek Showing Dead Adult And Juvenile Salmon (Bates No. 02-002204)

120-Year Salmonid Benefit:Cost Analysis
WSDOT Fish Passage Program
Four Options
Sekulich 5/29/01

Background

1. References
WDFW Habitat Program SSHEAR Section. WSDOT Fish Passage Inventory, Fish Barrier Corrections and Project Evaluation, April 2001. 21 pp.

WDFW 1995 Fisheries Statistical Report. 80 pp.

WDFW Washington State Sport Catch Report 1995. 81 pp.

2. Barriers
856 barriers left to correct (number changes with reinventory and corrections)

1997-2000: 46 barriers corrected (21 dedicated projects, 25 "tagalong" projects)

1991-2000: $164 K per correction with an assumption that future projects will average $250 K in 2001 dollars

1991-2000: For 30 dedicated correction projects that have a Priority Index (PI) and a stream length opened, an average of 6,445 linear meters were opened, resulting in a potential production of 3,202 adult equivalent (AE) salmonids (resident and anadromous combined) per project on an annual basis. This translates to 0.5 AE salmonids per linear meter.

3. Future Correction Options - assuming all barriers will be corrected
Option 1: The correction rate that was existing when the WSDOT/WDFW passage program was solidified in the 91-3 biennium– 7.1 corrections/yr for 120 years

Option 2: The correction rate resulting from the average number of corrections in 1997-2000– 11.5 corrections/yr for 74 years

Option 3: The 20-year correction plan– 42.8 corrections/yr for 20 years

Option 4: The 16-year correction plan– 53.5 corrections/yr for 16 years

Cause No. C70-9213, Sub. 01-1
Plaintiffs' Exhibit **AT-104**

Potential Harvest and Values

Retail Values per AE

Species	1995 Commercial Values ($$/AE)	2001 Commercial Values (rounded $$/AE) (4% annual inflation)	2001 Recreational Values (rounded $$/AE) (minimum estimate)
Chinook	28.72	36	36
Chum	8.38	11	11
Pink	1.57	2	2
Coho	10.61	13	13
Sockeye	19.84	25	25
Steelhead	22.13	28	28
Others (including resident salmonids)		19 (average)	19 (average)

"Potential" Harvest Rates (1995 = 2001 and later)

Species	Commercial			Recreational		
	Commercial (000)	Adjusted Commercial for WA stocks (000)	Harvest Rate (assuming 50% overall for anadromous & 20% for resident)	Recreational (000)	Adjusted Recreational for WA stocks (000)	Harvest Rate (assuming 50% overall for anadromous & 20% for resident)
Chinook	163	163	30%	100	100	20%
Chum	766	766	49%	14	14	1%
Pink	2743	549 (assumed 20% of total commercial)	40%	216	137 (assumed 25% of commercial)	10%
Coho	465	465	35%	177	177	15%
Sockeye	416	83 (assumed 20% of total commercial)	40%	minimal	21 (assumed 25% of commercial)	10%
Steelhead	??	95 (assumed = recreational)	25%	95	95	25%
Others (mostly resident salmonids)		minimal assumed	0			20% (average of chinook, coho, & steelhead

Other Assumptions and Information

1. Benefits are considered conservative because ecosystem values not included (e.g., spawners), socio-political values not included (e.g., non-consumptive use, tribal ceremonial), sport values set at commercial values, spin-off values not included (e.g., benefits to other industries if stocks not listed under ESA). This is partially tempered recognizing that future projects will open less habitat than those already corrected.

2. Costs are considered liberal because tagalong efficiencies were not considered.

3. Annual harvest benefit = $12,365 commercial + $7,166 recreational = $19,500 approx. (see attached table for AE production and benefits per correction)

4. Social discount rate set at 0

5. Annual inspection and maintenance cost to keep corrected barriers passable = 1% of correction cost (i.e., $2.5 K per year)

Option Analysis

<u>Option 1</u>
Benefit = 856 barriers (60-year mean correction) ($19,500) = $1,001,520,000 (today's dollars)
Cost = 856 barriers [($250,000) + (60-year mean correction)($2,500)] = $342,400,000 (today's dollars)
B:C = 2.93

<u>Option 2</u>
Benefit = 856 barriers (37-year mean correction + 46 years) ($19,500) = $1,385,436,000 (today's dollars)
Cost = 856 barriers [($250,000) + (37-year mean correction + 46 years)($2,500)] = $391,620,000 (today's dollars)
B:C = 3.54

<u>Option 3</u>
Benefit = 856 barriers (10-year mean correction + 100 years) ($19,500) = $1,836,120,000 (today's dollars)
Cost = 856 barriers [($250,000) + (10-year mean correction + 100 years)($2,500)] = $449,400,000 (today's dollars)
B:C = 4.09

<u>Option 4</u>
Benefit = 856 barriers (8-year mean correction + 104 years) ($19,500) = $1,869,504,000 (today's dollars)
Cost = 856 barriers [($250,000) + (8-year mean correction + 104 years)($2,500)] = $453,680,000 (today's dollars)
B:C = 4.12

Memorandum of Agreement
Between
Washington State Department of Fish and Wildlife and Washington State Department of Transportation
Concerning
CONSTRUCTION OF PROJECTS IN STATE WATERS
(Chapter RCW 77.55. RCW and Chapter 220-110 WAC)
June, 2002

CONTENTS

Appendix C: Fish Passage

Include, in the project definition (scoping), a recommended conceptual design approach to remove a barrier to fish passage for projects scheduled for construction where a fish passage barrier has been inventoried, evaluated and prioritized. The barrier must be identified on the Subprogram I4 deficiency list six-year plan. The recommended conceptual design approach will be a joint effort between the WDFW SSHEAR Program and WSDOT region environmental/hydraulics offices. Barrier correction may be included in the project as per the following, which is derived from the subprogram I4 programming instructions:

Paving project (subprogram P1): The purpose of these projects is to preserve the roadway, and fish barriers are typically not fixed in these projects. The program does allow for minor, spot safety improvements, with a dollar limit of $25,000. Low cost barriers could be fixed under this allowance, at the discretion of WSDOT.

Safety (subprogram I2) and Mobility (I1) projects: The purpose of these projects is to eliminate safety deficiencies, primarily high accident corridors and locations (HACs & HALs), and increase capacity, respectively. Fish barriers can be fixed in I2 and I1 projects in one of two ways:

If the safety or mobility project requires work on a culvert that is a barrier and the culvert work necessitates an HPA, then WSDOT is required to fix the barrier.

If there is a barrier culvert within the limits of the safety or mobility project, but the project does not require work on the culvert, WSDOT may fix the barrier on a case-by-case exception basis.

When using its discretion in these cases, WSDOT will consider the priority of the barrier and the relative cost of the fix. WSDOT does not want to divert large sums of funding away from the intended purpose of these subprograms, which necessitates the case-by-case review.

The above does not address all funding subprograms, only the common ones.

The highest priority fish passage barriers are fixed as stand-alone projects funded by subprogram I4 (environmental retrofit).

WSDOT will install and maintain all culverts, fishways, and bridges to provide unrestricted fish access, per RCW 77.55.060. Design will be based on the latest version of the Fish **Passage Design at Road Culverts** manual or its successor. In addition to fish passage, passage for other aquatic and terrestrial species will be considered and addressed to the extent possible when designing crossing structures.

WSDOT will not be required to maintain fish passage facilities off their right-of-ways which they do not own. However, WSDOT will provide funding to apply corrective measures and maintenance where it has been shown, that the barrier resulted from a WSDOT action or facility.

WSDOT/WDFW will continue to participate in the statewide inventory of fish passage barriers in WSDOT right-of-ways. The inventory will include a recommended course of action to correct fish passage problems on high priority projects. Additionally, personnel will note instances where other wildlife species movement is disrupted by WSDOT crossing structures. Passage problems related to other wildlife species will be discussed with the local AHB when maintenance or replacement projects occur. This inventory will be reviewed and upgraded annually .

The participating agencies agree to establish priorities for correcting identified fish passage barriers using WDFW priority index as a guideline using the following criteria:

- Fish Species Presence and Stock Condition as documented in federal threatened or endangered species listings and Washington State Salmon and Steelhead Stock Inventory (SASSI) reports).
- Fish production increase as a result of the project.

Table 1c. Ownership of Downstream Barriers Associated with Base Culverts.

	Partial Barrier	*Total Barrier*	*Unknown Barrier*	*All Barriers*
State Owned Downstream Barriers	13 (9 culverts/4 dams)	11 (10 dams/ 1 misc. barrier)	0	24
Non-State Owned Downstream Barriers on Forestland to be repaired by 2016	2 (culverts)	2 (culverts)	2 (culverts)	6
Non-State Owned Downstream Barriers not on Forestland	137 (107 culverts/17 dams/3 misc. barrier)	52 (40 culverts/6 dams/6 misc. barriers)	1(culvert)	190

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Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
991036		1	I-5	255.15	Squalicum Cr	Bellingham Bay	01.0552	PI	58.2	0.124	4
991803	991036		SR 542	2.4	Toad Lk Cr	Squalicum Cr	01.0560	PI	13.41	0.248	2.1
990133			SR 8	6.3	EF Wildcat Cr	Wildcat Cr	22.0503A	PI	52.71	0.372	8
102 L062		7	SR 202	0.1	Little Bear Cr	Sammamish R	08.0080	PI	52.7	0.496	5.6
102 L020	102 L062		SR 524	12.44	Great Dane Cr	Little Bear Cr	08.0084	PI	39.58	0.62	3.5
990316	102 L062		SR 9	1.16	Cutthroat Cr	Little Bear Cr	08.0083	PI	22.56	0.744	2.55
102 L012	102 L062		SR 9	0.17	Howell Cr	Little Bear Cr	08.0082	PI	9.88	0.868	3.05
996916	102 L062		SR 522	12.86	unnamed	Little Bear Cr	08	PI	8.98	0.992	1.3
994430	102 L062		SR 522	14.25	Howell Cr	Little Bear Cr	08.0082	PI	8.39	1.116	3.05
996913	102 L062		SR 522	13.66	unnamed	Little Bear Cr	08	PI	8.08	1.24	1.3
996880	102 L062		SR 522 ROW	12.86	unnamed	Little Bear Cr	08	PI	6.89	1.364	2.1
990021			US 101	253.85	Bagley Cr	Strait of Juan De Fuca	18.0183	PI	48.12	1.488	
15.0229 0.10		3	SR 3	40.96	Chico Cr	Dyes Inlet	15.0229	PI	48	1.612	7.3
991907	15.0229 0.10		SR 3 ROW Access Rd	40.97	unnamed	Chico Cr	15.0240	PI	16.26	1.736	1
996796	15.0229 0.10		SR 3 on-ramp	40.99	unnamed	Chico Cr	15.0240	PI	12.86	1.86	1.35
996794	15.0229 0.10		SR 3 SB off-ramp	41.08	unnamed	Chico Cr	15.0240	PI	8.43	1.984	1.75
08.0183 1.60			I-90	18.83	EF Issaquah Cr	Issaquah Cr	08.0183	PI	46.85	2.108	5.29
22.0507 0.10			SR 8	5	MF Wildcat Cr	EF Wildcat Cr	22.0507	PI	39.37	2.232	5.5
996343		1	SR 162	19.7	Spiketon Cr	S Prairie Cr	10.0449	PI	39.37	2.356	5.1
105 R033018B	996343		SR 165	19.76	Spiketon Cr	S Prairie Cr	10.0449	PI	29.59	2.48	2.6
990017		1	SR 16	28.1	Anderson Cr	Sinclair Inlet	15.0211	PI	38.6	2.604	3.79
996753	990017		SR 16	28.1	Anderson Cr	Sinclair Inlet	15.0211	PI	32.33	2.728	3.75
991049			SR 507	36.35	Lacamas Cr	Muck Cr	11.0022	PI	37.62	2.852	4.23
991210			SR 99	6.86	WF Hylebos Cr	Hylebos Cr	10.0014	PI	37.46	2.976	2.61
18.0173 2.40			US 101	256.1	Siebert Cr	Strait of Juan de Fuca	18.0173	SPI	37.1	3.1	9
990430		2	SR 522	2.86	Thornton Cr	Lk Washington	08.0030	SPI	36.92	3.224	3
994562	990430		I-5	174.71	Thornton Cr	Lk Washington	08.0030	PI	18.09	3.348	1.28
996915	990430		SR 523	1.24	unnamed	Thornton Cr	08	SPI	16.02	3.472	1.5
990241		3	US 101	292.52	Leland Cr	L Quilcene R	17.0077	PI	36.68	3.596	3.43
990896	990241		US 101	290.35	unnamed	Leland Cr	17.0080	PI	19.76	3.72	2.09
995502	990241		US 101	291.79	unnamed	Leland Cr	17.0079	PI	13.05	3.844	0.85
995499	990241		US 101	289.36	unnamed	Leland Cr	17	PI	6.76	3.968	1.5
01.0228 4.80			SR 542	6.55	Anderson Cr	Nooksack R	01.0228	SPI	36.16	4.092	5
05.0018 2.00		3	SR 532	6.14	Church Cr	Stillaguamish R	05.0018	PI	36.1	4.216	6.45
996073	05.0018 2.00		I-5	214.74	unnamed	Freedom Cr	05	SPI	6.94	4.34	1.3
996071	05.0018 2.00		I-5	214.73	unnamed	Freedom Cr	05	SPI	6.81	4.464	1.6
996077	05.0018 2.00		I-5	214.38	Freedom Cr	Church Cr	05.0185	SPI	5.78	4.588	0.8
102 N183		1	SR 96	0.47	North Cr	Sammamish R	08.0070	PI	35.58	4.712	2.09
102 N192	102 N183		SR 99	54.23	North Cr	Sammamish R	08.0070	PI	21.31	4.836	2.35
992798			I-90	13.83	Lewis Cr	Lk Sammamish	08.0162	PI	35.14	4.96	4.18
991944		3	SR 16 Off Ext 15 EB	15.21	McCormick Cr	Henderson Bay	15.0065	PI	34.69	5.084	2.3
991942	991944		SR 16	15.02	unnamed	McCormick Cr	15.0066	PI	24.47	5.208	2.05
991941	991944		SR 16	14.86	McCormick Cr	Henderson Bay	15.0065	PI	21.42	5.332	2.3
991939	991944		SR 16	14.63	unnamed	McCormick Cr	15	PI	21.29	5.456	2.47
995978			SR 20	12.96	Crockett Lk	Keystone Harbor	06.0053	PI	34.35	5.58	8
115 MC218		1	SR 106	19.57	unnamed	Hood Canal	14.0124	SPI	32.84	5.704	2.2
991795	115 MC218		SR 3	23.94	unnamed	Hood Canal	14	SPI	4.92	5.828	1
990366			SR 160	2.29	Salmonberry Cr	Long Lk	15.0188	PI	32.51	5.952	1.8
990624		5	SR 532	9.75	Secret Cr	Pilchuck Cr	05.0065	PI	31.55	6.076	3.1
991979	990624		I-5	213.29	unnamed	unnamed	05.0065C	PI	12.24	6.2	1.5
992182	990624		I-5	213.27	unnamed	unnamed to Pilchuck Cr	05.0065C	PI	12.24	6.324	1.5
992181	990624		I-5	213.27	unnamed	unnamed to Pilchuck Cr	05.0065B	PI	7.94	6.448	1.5
992175	990624		I-5	213.66	Secret Cr	Pilchuck Cr	05.0065	PI	6.02	6.572	0.95
LP66	990624		I-5	213.86	unnamed	unnamed	05	SPI	3.14	6.696	0.8
990219			US 101	267.18	Johnson Cr	Sequim Bay	17.0301	PI	31.46	6.82	2.78
990429			SR 548	4.67	Terrell Cr	Birch Bay	01.0089	PI	31.43	6.944	9
18.0234 1.10			US 101	250	Ennis Cr	Strait of Juan de Fuca	18.0234	PI	31.33	7.068	
990075			US 101	271.98	Chicken Coop Cr	Sequim Bay	17.0278	PI	30.9	7.192	2.51
991211		4	SR 167	10	Milwaukee Canal	White R	10.0032	SPI	30.08	7.316	3.8
105 R050320a	991211		SR 167 NB ext 8	12.05	Jovita Cr	Milwaukee Canal	10.0033	PI	22.4	7.44	3
996288	991211		SR 167 Ext 8 NB	11.72	unnamed	Milwaukee Canal	10	SPI	21.03	7.564	1
105 R050320b	991211		SR 167 off ext 8	10.67	Milwaukee Canal	White R	10.0034	SPI	8.79	7.688	4.1
996290	991211		SR 167	11.37	unnamed	Milwaukee Canal	10	SPI	2.88	7.812	3.3
105 R042117a			SR 164	8.24	Pussywillow Cr	White R	10.0048	PI	29.74	7.936	6.2
991958			SR 305	7.28	Kiebeal Cr	Agate Passage	15.0296	PI	29.48	8.06	3.38

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment
34827	34827	2.08	21007	21007	1.25	98138	98138	2.03	1	
0	34827	2.08	0	21007	1.25	0	98138	2.03	2	
21924	56751	3.39	26044	47051	2.81	70277	168415	3.48	3	
46169	102920	6.15	33024	80075	4.78	100496	268911	5.56	4	OHW = toe width
0	102920	6.15	0	80075	4.78	0	268911	5.56	5	
0	102920	6.15	0	80075	4.78	0	268911	5.56	6	
0	102920	6.15	0	80075	4.78	0	268911	5.56	7	
0	102920	6.15	0	80075	4.78	0	268911	5.56	8	
0	102920	6.15	0	80075	4.78	0	268911	5.56	9	
0	102920	6.15	0	80075	4.78	0	268911	5.56	10	
0	102920	6.15	0	80075	4.78	0	268911	5.56	11	
10450	113370	6.78	11942	92017	5.49	22028	290939	6.01	12	no OHW data
35048	148418	8.87	60475	152492	9.11	265684	556623	11.5	13	
0	148418	8.87	0	152492	9.11	0	556623	11.5	14	
0	148418	8.87	0	152492	9.11	0	556623	11.5	15	
0	148418	8.87	0	152492	9.11	0	556623	11.5	16	
12900	161318	9.64	25294	177786	10.62	39818	596441	12.33	17	
30005	191323	11.43	20778	198564	11.86	79247	675688	13.96	18	
8603	199926	11.95	6859	205423	12.27	9205	684893	14.15	19	
0	199926	11.95	0	205423	12.27	0	684893	14.15	20	
9295	209221	12.5	9488	214911	12.83	49945	734838	15.19	21	
0	209221	12.5	0	214911	12.83	0	734838	15.19	22	
24287	233508	13.95	8206	223117	13.32	82900	817738	16.9	23	
3364	236872	14.15	2798	225915	13.49	19503	837241	17.3	24	
42000	278872	16.67	189000	414915	24.77	378000	1215241	25.11	25	
11909	290781	17.38	17864	432779	25.84	35727	1250968	25.86	26	
0	290781	17.38	0	432779	25.84	0	1250968	25.86	27	
0	290781	17.38	0	432779	25.84	0	1250968	25.86	28	
23068	313849	18.76	6708	439487	26.24	67554	1318522	27.25	29	
0	313849	18.76	0	439487	26.24	0	1318522	27.25	30	
0	313849	18.76	0	439487	26.24	0	1318522	27.25	31	
0	313849	18.76	0	439487	26.24	0	1318522	27.25	32	
16044	329893	19.72	40110	479597	28.64	80220	1398742	28.91	33	
27681	357574	21.37	28396	507993	30.33	100818	1499560	30.99	34	
0	357574	21.37	0	507993	30.33	0	1499560	30.99	35	
0	357574	21.37	0	507993	30.33	0	1499560	30.99	36	
0	357574	21.37	0	507993	30.33	0	1499560	30.99	37	
3976	361550	21.61	2999	510992	30.51	4502	1504062	31.08	38	
0	361550	21.61	0	510992	30.51	0	1504062	31.08	39	
3956	365506	21.85	3986	514978	30.75	6663	1510725	31.22	40	
4851	370357	22.14	2021	516999	30.87	9074	1519799	31.41	41	
0	370357	22.14	0	516999	30.87	0	1519799	31.41	42	
0	370357	22.14	0	516999	30.87	0	1519799	31.41	43	
0	370357	22.14	0	516999	30.87	0	1519799	31.41	44	
5857	376214	22.49	738	517737	30.91	110033	1629832	33.68	45	
3697	379911	22.71	4066	521803	31.16	8133	1637965	33.85	46	
0	379911	22.71	0	521803	31.16	0	1637965	33.85	47	
9210	389121	23.26	6700	528503	31.56	40963	1678928	34.7	48	
4570	393691	23.53	2089	530592	31.68	8657	1687585	34.88	49	
0	393691	23.53	0	530592	31.68	0	1687585	34.88	50	
0	393691	23.53	0	530592	31.68	0	1687585	34.88	51	
0	393691	23.53	0	530592	31.68	0	1687585	34.88	52	
0	393691	23.53	0	530592	31.68	0	1687585	34.88	53	
0	393691	23.53	0	530592	31.68	0	1687585	34.88	54	
7252	400943	23.96	6227	536819	32.05	18912	1706497	35.27	55	
11313	412256	24.64	2767	539586	32.22	52518	1759015	36.35	56	
8950	421206	25.17	13853	553439	33.05	33438	1792453	37.04	57	no OHW data
6092	427298	25.54	3383	556822	33.25	5607	1798060	37.16	58	
9005	436303	26.08	15210	572032	34.16	30419	1828479	37.79	59	
0	436303	26.08	0	572032	34.16	0	1828479	37.79	60	
0	436303	26.08	0	572032	34.16	0	1828479	37.79	61	
0	436303	26.08	0	572032	34.16	0	1828479	37.79	62	
0	436303	26.08	0	572032	34.16	0	1828479	37.79	63	
15048	451351	26.96	2161	574193	34.28	30202	1858681	38.41	64	
3767	455118	27.14	1027	575220	34.35	8345	1867026	38.58	65	

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
994325			SR 305	2.44	unnamed	Murden Cove	15.0321	PI	29.44	8.184	2.91
990148			US 101	147.49	Fisher Cr	Queets R	21.0018	PI	29	8.308	5.3
115 MC093			US 101	346.95	Coffee Cr	Goldsborough Cr	14.0036	PI	28.97	8.432	8.5
990022		4	I-5	256.28	Baker Cr	Squalicum Cr	01.0553	PI	28.66	8.556	3.3
990015	990022		SR 539	0.3	Spring Cr	Baker Cr	01.0556	PI	30.61	8.68	2.4
992003	990022		I-5 NB on-ramp	256	Baker Cr	Squalicum Cr	01.0553	PI	25.69	8.804	3.3
992987	990022		SR 539	0.04	SF Baker Cr	Baker Cr	01.0554	PI	19.56	8.928	2.7
991973	990022		SR 539	0.3	Baker Cr	Squalicum Cr	01.0553	PI	7.17	9.052	3.3
996508			SR 3	38.41	unnamed	Puget Sound	15.0226	SPI	28.58	9.176	2.7
990199		1	I-5	105.85	Indian Cr	Moxlie Cr	13.0026	PI	28.26	9.3	2.53
990200	990199		I-5	105.83	Indian Cr	Moxlie Cr	13.0026	PI	19.33	9.424	2.53
990233			SR 92	2.73	Little Pilchuck Cr	Pilchuck R	07.0146	PI	28.18	9.548	6
991842			SR 900	15.86	Green Cr	May Cr	08.0288	PI	28.17	9.672	1.75
990123			SR 307	0.49	Dogfish Cr	Liberty Bay	15.0285	PI	27.97	9.796	2.9
995326			SR 96	5.29	Thomas Cr	Marshland Sl	07.0108	PI	27.62	9.92	1.9
990400			US 101	162.8	Steamboat Cr	Pacific Ocean	20.0574	PI	27.53	10.044	7.31
990345		1	SR 302SP PURDY	15.8	Purdy Cr	Burley Lagoon	15.0060	PI	27.43	10.168	4.5
15.0060 0.10	990345		SR 302 ROW	16.09	Purdy Cr	Burley Lagoon	15.0060	PI	29.99	10.292	6.5
996921			SR 202	4.17	unnamed	Sammamish R	08	PI	27.3	10.416	1.95
990270			SR 16	27.1	unnamed	Ross Cr	15.0210	PI	26.45	10.54	2.55
994320		1	SR 305	0.38	unnamed	Eagle Harbor	15.0324	PI	26.26	10.664	2.83
994324	994320		SR 305	0.73	unnamed	Eagle Harbor	15.0324	PI	21.41	10.788	1.8
990032		1	US 101	102.14	unnamed	S Branch Big Cr	22.0059	PI	25.82	10.912	2.75
990729	990032		US 101	100.9	unnamed	unnamed to S Branch Big Cr	22	PI	17.97	11.036	1.7
990178			US 101	146.85	Harlow Cr	Queets R	21.0134	PI	25.68	11.16	3
990297			SR 7	41.17	Muck Cr	Nisqually R	11.0018	PI	24.61	11.284	6.4
08.0077 0.20		3	SR 527	6.57	Penny Cr	North Cr	08.0077	PI	24.56	11.408	3.5
993091	08.0077 0.20		I-5	187.64	unnamed	Silver Lk	08	PI	13.24	11.532	1.55
930252	08.0077 0.20		I-5	187.93	unnamed	Penny Cr	08	PI	12.93	11.656	1.83
993124	08.0077 0.20		I-5 ROW	187.89	unnamed	Silver Lk	08	PI	10.91	11.78	3.3
990709			SR 305	9.6	unnamed	Liberty Bay	15.0291	PI	24.15	11.904	
990167			SR 520	7.9	WF Goff Cr	Goff Cr	08	SPI	23.8	12.028	2.35
990173		3	SR 18	22.16	Holder Cr	Issaquah Cr	08.0178	PI	23.5	12.152	7.15
995971	990173		SR 18	22.82	unnamed	Holder Cr	08.0220	PI	17.18	12.276	2.15
995973	990173		SR 18	23.45	unnamed	unnamed	08	PI	9.59	12.4	2.15
995974	990173		SR 18	23.55	unnamed	unnamed	08	PI	5.53	12.524	1.75
105 R021121a			SR 162	11.04	Card Cr	Carbon R	10	PI	23.48	12.648	2.85
991246			SR 106	13.5	Twanoh Falls Cr	Hood Canal	14.0132	SPI	22.97	12.772	2.3
991750			SR 531	2.61	Fish Cr	Portage Cr	05.0038	PI	22.94	12.896	375
994389		2	SR 11	20.25	Padden Cr	Bellingham Bay	01.0622	PI	22.72	13.02	2.95
994386	994389		SR 11	21.08	Padden Cr	Bellingham Bay	01.0622	PI	18.85	13.144	3.45
994233	994389		I-5	250.55	Padden Cr	Bellingham Bay	01.0622	PI	14.29	13.268	3.55
03.0181 0.50			I-5	219.41	Fisher Cr	Carpenter Cr	03.0181	PI	22.39	13.392	3
996928		2	SR 522	9.6	unnamed	Sammamish R	08	PI	22.19	13.516	1.2
996178	996928		SR 527	1.37	unnamed	Sammamish R	08	PI	19.4	13.64	1.1
991187	996928		SR 527	0.58	unnamed	Sammamish R	08	PI	18.39	13.764	0.95
994234		7	SR 520 WB on-ramp	5.95	Yarrow Cr	Lk Washington	08.0252	PI	22.08	13.888	2.5
992385	994234		I-405	15.09	Yarrow Cr	Lk Washington	08.0252	PI	28.47	14.012	2.5
991736	994234		SR 520	6.04	Yarrow Cr	Lk Washington	08.0252	PI	23.18	14.136	2.75
994227	994234		SR 520 WB on-ramp	5.95	Yarrow Cr	Lk Washington	08.0252	PI	23.18	14.26	17
994449	994234		SR 520 EB off-ramp	6.03	Yarrow Cr	Lk Washington	08.0252	PI	23.12	14.384	2.2
994238	994234		SR 520 WB off-ramp	6.27	Yarrow Cr	Lk Washington	08.0252	PI	22.7	14.508	1.95
994704	994234		SR 520 Maint. Yard	6.4	unnamed	Yarrow Cr	08	PI	6.58	14.632	1.75
994705	994234		SR 520	6.44	unnamed	Yarrow Cr	08	PI	5.24	14.756	1.6
996622			SR 410	31.48	unnamed	White R	10	SPI	22.08	14.88	3.4
990092			SR 112	57.61	Coville Cr	Strait of Juan de Fuca	19.0001	PI	22.03	15.004	3.8
991122			SR 9	48	Gribble Cr	WF Nookachamps Cr	03.0227	PI	21.92	15.128	2.38
991621			SR 542	24.9	High Cr	Kendall Cr	01.0407	PI	21.37	15.252	3.2
991120		7	SR 9	42.36	Lake Cr	Big Lk	03.0227	PI	21.21	15.376	4.8
990091	991120		SR 9	41.04	Norway Park Cr	Lk Mc Murray	03.0265	PI	13.32	15.5	2.05
990641	991120		SR 9	40.09	unnamed	Lk McMurray	03	PI	13.3	15.624	1.6
NC158	991120		SR 9	39.16	unnamed	Lk McMurray	03	PI	12.67	15.748	1.2
NC160	991120		SR 9	39.69	unnamed	Lk McMurray	03	PI	9.22	15.872	1.3
NC166	991120		SR 9	40.77	unnamed	Lk McMurray	03	PI	6.75	15.996	1.3
NC170	991120		SR 9	39.87	unnamed	unnamed	03	PI	5.46	16.12	1.5
NC164	991120		SR 9	41.93	unnamed	Lake Cr	03	PI	4.86	16.244	0.88

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment
2356	456476	27.28	3799	579019	34.57	3715	1870741	38.66	66	
5132	461608	27.59	9836	588855	35.16	12568	1883309	38.92	67	
21444	483052	28.87	11069	599924	35.82	52066	1935375	40	68	
18331	501383	29.97	5641	605565	36.16	29032	1964407	40.6	69	
0	501383	29.97	0	605565	36.16	0	1964407	40.6	70	
0	501383	29.97	0	605565	36.16	0	1964407	40.6	71	
0	501383	29.97	0	605565	36.16	0	1964407	40.6	72	
0	501383	29.97	0	605565	36.16	0	1964407	40.6	73	
2916	504299	30.14	3936	609501	36.39	7873	1972280	40.76	74	
5026	509325	30.44	1624	611125	36.49	18204	1990484	41.14	75	
0	509325	30.44	0	611125	36.49	0	1990484	41.14	76	
46553	555878	33.22	15280	626405	37.4	185241	2175725	44.96	77	
2155	558033	33.35	995	627400	37.46	50198	2225923	46	78	
7891	565924	33.82	1211	628611	37.53	6798	2232721	46.14	79	
2225	568149	33.96	1725	630336	37.64	4378	2237099	46.23	80	
7434	575583	34.4	25322	655658	39.15	26208	2263307	46.77	81	
10436	586019	35.02	9523	665181	39.72	216787	2480094	51.25	82	
0	586019	35.02	0	665181	39.72	0	2480094	51.25	83	
3014	589033	35.2	1779	666960	39.82	8321	2488415	51.43	84	
4778	593811	35.49	2891	669851	40	12226	2500641	51.68	85	
1873	595684	35.6	1059	670910	40.06	9715	2510356	51.88	86	
0	595684	35.6	0	670910	40.06	0	2510356	51.88	87	
7870	603554	36.07	2643	673553	40.22	19327	2529683	52.28	88	
0	603554	36.07	0	673553	40.22	0	2529683	52.28	89	
5525	609079	36.4	16231	689784	41.19	16925	2546608	52.63	90	
8388	617467	36.9	2516	692300	41.34	31441	2578049	53.28	91	
13458	630925	37.71	3462	695762	41.54	39288	2617337	54.09	92	
0	630925	37.71	0	695762	41.54	0	2617337	54.09	93	
0	630925	37.71	0	695762	41.54	0	2617337	54.09	94	
0	630925	37.71	0	695762	41.54	0	2617337	54.09	95	
2803	633728	37.88	2135	697897	41.67	7364	2624701	54.24	96	no OHW data
1580	635308	37.97	1856	699753	41.78	3713	2628414	54.32	97	
14636	649944	38.85	22651	722404	43.13	25225	2653639	54.84	98	
0	649944	38.85	0	722404	43.13	0	2653639	54.84	99	
0	649944	38.85	0	722404	43.13	0	2653639	54.84	100	
0	649944	38.85	0	722404	43.13	0	2653639	54.84	101	
2908	652852	39.02	651	723055	43.17	6148	2659787	54.97	102	
3350	656202	39.22	3852	726907	43.4	7705	2667492	55.13	103	
1252	657454	39.29	0	726907	43.4	32069	2699561	55.79	104	
4213	661667	39.55	2198	729105	43.53	5292	2704853	55.9	105	
0	661667	39.55	0	729105	43.53	0	2704853	55.9	106	
0	661667	39.55	0	729105	43.53	0	2704853	55.9	107	
27780	689447	41.21	14059	743164	44.37	47853	2752706	56.89	108	
2642	692089	41.36	632	743796	44.41	10659	2763365	57.11	109	
0	692089	41.36	0	743796	44.41	0	2763365	57.11	110	
0	692089	41.36	0	743796	44.41	0	2763365	57.11	111	
5754	697843	41.71	1682	745478	44.51	13826	2777191	57.39	112	
0	697843	41.71	0	745478	44.51	0	2777191	57.39	113	
0	697843	41.71	0	745478	44.51	0	2777191	57.39	114	
0	697843	41.71	0	745478	44.51	0	2777191	57.39	115	
0	697843	41.71	0	745478	44.51	0	2777191	57.39	116	
0	697843	41.71	0	745478	44.51	0	2777191	57.39	117	
0	697843	41.71	0	745478	44.51	0	2777191	57.39	118	
0	697843	41.71	0	745478	44.51	0	2777191	57.39	119	
14116	711959	42.55	23997	769475	45.94	47994	2825185	58.39	120	
15710	727669	43.49	7729	777204	46.41	26640	2851825	58.94	121	
4291	731960	43.75	1743	778947	46.51	18551	2870376	59.32	122	
3882	735842	43.98	5286	784233	46.83	10279	2880655	59.53	123	
16453	752295	44.96	7588	791821	47.28	42252	2922907	60.4	124	
0	752295	44.96	0	791821	47.28	0	2922907	60.4	125	
0	752295	44.96	0	791821	47.28	0	2922907	60.4	126	
0	752295	44.96	0	791821	47.28	0	2922907	60.4	127	
0	752295	44.96	0	791821	47.28	0	2922907	60.4	128	
0	752295	44.96	0	791821	47.28	0	2922907	60.4	129	
0	752295	44.96	0	791821	47.28	0	2922907	60.4	130	
0	752295	44.96	0	791821	47.28	0	2922907	60.4	131	

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
991585			SR 3	34.27	unnamed	Gorst Cr	15.0217	SPI	21.18	16.368	2.3
990240			US 101	250.5	Lees Cr	Strait of Juan de Fuca	18.0232	PI	21.14	16.492	3.15
FR75		5	I-5	245.76	unnamed	Lake Cr	03.0042	PI	21.05	16.616	3.38
995256	FR75		I-5 SB exit 246	246.12	unnamed	unnamed	03.0043	PI	15.6	16.74	2.55
995255	FR75		I-5 SB exit 246	246.22	unnamed	unnamed to Lake Samish	03.0043	PI	14.7	16.864	3.8
995329	FR75		I-5	264.16	unnamed	unnamed	03.0043	PI	14.5	16.988	3.85
995248	FR75		I-5 Ext 246 NB	246	unnamed	unnamed to Lake Cr	03	PI	4.05	17.112	1.4
995247	FR75		I-5 Ext 246 NB	246	unnamed	unnamed to Lake Cr	03	PI	3.05	17.236	0.7
15.0280 1.00		2	SR 308	1.15	Big Scandia Cr	Liberty Bay	15.0280	PI	21	17.36	3.5
990235	15.0280 1.00		SR 308	0.94	Big Scandia Cr	Liberty Bay	15.0280	PI	23.62	17.484	2.05
996804	15.0280 1.00		SR 3	49.48	Big Scandia Cr	Liberty Bay	15.0280	PI	16.5	17.608	3.9
991999		1	SR 307	1.34	unnamed	Dogfish Cr	15.0286	PI	20.92	17.732	3.3
991572	991999		SR 307	1.45	unnamed	unnamed	15	ETD	16.41	17.856	2.85
992207			SR 104	22.95	Carpenter Cr	Appletree Cove	15.0309	PI	20.92	17.98	3.35
992641			SR 92	0.22	unnamed	Stevens Cr	07	SPI	20.71	18.104	90
990236			SR 18	27.84	Lake Cr	Raging R	07.0393	PI	20.65	18.228	3
990773			SR 8	9.1	unnamed	Mox Chehalis Cr	22	PI	20.63	18.352	2.5
15.0051 0.10		1	SR 302	11.36	Little Minter Cr	Minter Cr	15.0051	PI	20.47	18.476	3.7
15.0051 0.20	15.0051 0.10		SR 302	11.42	Little Minter Cr	Minter Cr	15.0051	PI	20.23	18.6	3.7
09.0377 2.12			SR 509/ 200th Ave	21.8	Des Moines Cr	Puget Sound	09.0377	PI	20.43	18.724	3.4
990304			SR 112	47.1	Nelson Cr	Lyre R	19.0032	ETD	20.42	18.848	1.8
992205			SR 104	22.47	Grovers Cr	Miller Bay	15.0299	SPI	20.39	18.972	1.3
991730			SR 112	25.6	unnamed	Pysht R	19	PI	20.31	19.096	4.73
992356			SR 9	77.94	unnamed	SF Nooksack R	01.0247	SPI	20.1	19.22	2.62
994484			US 101	303.01	Marple Cr	Jackson Cove	17.0001	PI	20.05	19.344	4.15
995759			SR 20	11.63	Kah Tai Sl	Port Townsend Bay	17	PI	20.03	19.468	551
991757		1	SR 6	46.5	unnamed	Chehalis R	23.0949	PI	19.91	19.592	5.5
991544	991757		SR 6	46.39	unnamed	Chehalis R	23.0949	PI	19.76	19.716	3.15
997670			SR 516	10.56	unnamed	Big Soos Cr	09	SPI	19.84	19.84	2.9
994791			US 12	9.04	unnamed	Wynoochee R	22	PI	19.53	19.964	2.55
997695			SR 169	9.95	Covington Cr	Lake Sawyer	09.0083	SPI	19.43	20.088	5.6
990214			SR 112	33.21	Joe Cr	Strait of Juan de Fuca	19.0109	PI	19.37	20.212	4.48
991000			SR 308	2.16	unnamed	Puget Sound	15.0278	PI	19.25	20.336	1.85
990269			US 101	184.66	May Cr	Bogachiel R	20.0247	PI	19.21	20.46	12.55
997225			SR 108	9.47	Kamilche Cr	Skookum Cr	14.0022	PI	19.11	20.584	4
990655			SR 522	6.63	unnamed	Lk Washington	08.0056	PI	18.94	20.708	1.5
15.0206 0.00			SR 166	2.54	unnamed	Sinclair Inlet	15.0206	SPI	18.62	20.832	1.9
991159			SR 530	24.65	Trafton Cr	NF Stillaguamish R	05.0137	PI	18.6	20.956	3.18
990253		2	SR 104	31.3	Lyon Cr	Lk Washington	08.0052	PI	18.56	21.08	2.5
990653	990253		SR 104	30.67	unnamed	Lyon Cr	08.0053	PI	11.38	21.204	4.91
990654	990253		SR 104	31.08	unnamed	Lyon Cr	08.0053	SPI	4.42	21.328	0.65
993116		1	I-5	180.63	Scriber Cr	Swamp Cr	08.0061	SPI	18.41	21.452	3.4
993103	993116		SR 524	3.89	Scriber Cr	Swamp Cr	08.0061	ETD	13.06	21.576	3.05
996712			US 12	31.61	unnamed	Cedar Cr	23	PI	18.38	21.7	1.85
994085			SR 303 off-ramp	6.77	Hoot Cr	Barker Cr	15.0256C	SPI	18.36	21.824	1.35
991739			SR 112	7.35	Olsen Cr	Strait of Juan de Fuca	19.0227	PI	18.18	21.948	5.1
996251			I-90	10.52	Sunset Cr	Richards Cr	08.0262	SPI	18.18	22.072	2.5
991855			SR 305	12.59	unnamed	SF Dogfish Cr	15	SPI	17.68	22.196	2.4
991991			SR 3	26.4	unnamed	Union R	15.0504	ETD	17.43	22.32	1.69
990606			SR 542	38.98	Chain-up Cr	NF Nooksack R	01	PI	17.41	22.444	3.6
990144			SR 112	48.49	Field Cr	Strait of Juan de Fuca	19.0026	PI	17.39	22.568	5.6
993679			US 101	90.73	unnamed	Hoquaim R	22	PI	17.35	22.692	0.75
996684			SR 112	17.14	unnamed	Clallam R	19	PI	17.22	22.816	1
991742			SR 305	9.88	Bjorgen Cr	Liberty Bay	15.0290	PI	17.21	22.94	3.36
993834			SR 99	52.7	Swamp Cr	Sammamish R	08.0059	PI	17.15	23.064	1.9
991797			SR 3	25.31	Sweetwater Cr	Hood Canal	15.0504	PI	16.96	23.188	25
998967		4	I-405	0.61	Gilliam Cr	Green R	09	SPI	16.94	23.312	2.6
996030	998967		I-5NB off to NB I-405	154.39	Gilliam Cr	Green R	09.0032	SPI	20.91	23.436	2.9
995857	998967		I-405 NB on-ramp	0.42	Gilliam Cr	Green R	09.0032	SPI	19.96	23.56	2.6
998964	998967		I-5 NB of-ramp	154.48	unnamed	unnamed	09	SPI	7.79	23.684	1.5
998886	998967		SR 518	2.27	unnamed	Gilliam Cr	09	PI	3.16	23.808	1.85
990481			US 101	249.4	White Cr	Ennis Cr	18.0235	PI	16.88	23.932	
990958			US 12	6.92	Higgins Sl	Chehalis R	22.0257	PI	16.72	24.056	1.54

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment	
1828	754123	45.07	2102	793923	47.4	4204	2927111	60.49	132		
11288	765411	45.75	10774	804697	48.08	14173	2941284	60.78	133		
3126	768537	45.93	1339	806036	48.13	4421	2945705	60.88	134		
0	768537	45.93	0	806036	48.13	0	2945705	60.88	135		
0	768537	45.93	0	806036	48.13	0	2945705	60.88	136		
0	768537	45.93	0	806036	48.13	0	2945705	60.88	137		
0	768537	45.93	0	806036	48.13	0	2945705	60.88	138		
0	768537	45.93	0	806036	48.13	0	2945705	60.88	139		
6430	774967	46.32	5016	811052	48.43	9257	2954962	61.07	140		
0	774967	46.32	0	811052	48.43	0	2954962	61.07	141		
0	774967	46.32	0	811052	48.43	0	2954962	61.07	142		
3372	778339	46.52	1605	812657	48.52	3834	2958796	61.15	143		
0	778339	46.52	0	812657	48.52	0	2958796	61.15	144	OHW = toe width	
2791	781130	46.69	1838	814495	48.63	3113	2961909	61.21	145		
200	781330	46.7	9000	823495	49.17	18000	2979909	61.58	146		
2168	783498	46.83	1597	825092	49.27	14558	2994467	61.88	147		
2481	785979	46.98	1179	826271	49.34	2311	2996778	61.93	148		
6102	792081	47.34	1867	828138	49.45	14863	3011641	62.24	149		
0	792081	47.34	0	828138	49.45	0	3011641	62.24	150		
1120	793201	47.41	129	828267	49.46	12590	3024231	62.5	151		
4684	797885	47.69	2243	830510	49.59	2334	3026565	62.55	152	OHW = toe width	
3453	801338	47.89	2244	832754	49.72	4489	3031054	62.64	153		
3347	804685	48.09	1644	834398	49.82	4003	3035057	62.72	154		
2355	807040	48.23	3085	837483	50.01	6170	3041227	62.85	155		
2755	809795	48.4	2943	840426	50.18	6506	3047733	62.98	156		
379	810174	48.42	0	840426	50.18	25886	3073619	63.52	157		
13052	823226	49.2	4904	845330	50.47	25869	3099488	64.05	158		
0	823226	49.2	0	845330	50.47	0	3099488	64.05	159		
3900	827126	49.44	5655	850985	50.81	11310	3110798	64.29	160		
2649	829775	49.59	110	851095	50.82	9326	3120124	64.48	161		
6028	835803	49.95	16878	867973	51.83	33757	3153881	65.18	162		
7158	842961	50.38	5262	873235	52.14	9506	3163387	65.37	163		
1576	844537	50.48	433	873668	52.17	1893	3165280	65.41	164		
12990	857527	51.25	22700	896368	53.52	23129	3188409	65.89	165		
2867	860394	51.42	549	896917	53.55	5611	3194020	66.01	166		
5185	865579	51.73	1758	898675	53.66	14807	3208827	66.31	167		
2360	867939	51.87	2242	900917	53.79	4484	3213311	66.4	168		
4520	872459	52.14	1308	902225	53.87	7332	3220643	66.55	169		
11365	883824	52.82	5010	907235	54.17	8303	3228946	66.73	170		
0	883824	52.82	0	907235	54.17	0	3228946	66.73	171		
0	883824	52.82	0	907235	54.17	0	3228946	66.73	172		
5072	888896	53.13	8622	915857	54.68	17245	3246190	67.09	173		
0	888896	53.13	0	915857	54.68	0	3246190	67.09	174	OHW = toe width	
1580	890476	53.22	833	916690	54.73	1702	3247892	67.12	175		
3006	893482	53.4	2029	918719	54.86	4058	3251950	67.2	176		
5827	899309	53.75	6485	925204	55.24	8049	3259999	67.37	177		
2078	901387	53.87	2598	927802	55.4	5195	3265194	67.48	178		
1456	902843	53.96	1747	929549	55.5	3494	3268688	67.55	179		
1815	904658	54.07	936	930485	55.56	2135	3270823	67.59	180	OHW = toe width	
276	904934	54.09	370	930855	55.58	491	3271314	67.61	181		
8926	913860	54.62	5140	935995	55.89	15945	3287259	67.93	182		
323	914183	54.64	0	935995	55.89	4450	3291709	68.03	183		
1429	915612	54.72	629	936624	55.92	1538	3293247	68.06	184		
1520	917132	54.81	2387	939011	56.07	1793	3295040	68.1	185		
2919	920051	54.99	414	939425	56.09	3171	3298211	68.16	186		
1096	921147	55.05	861	940286	56.14	1479	3299690	68.19	187		
2231	923378	55.19	2900	943186	56.32	5801	3305491	68.31	188		
0	923378	55.19	0	943186	56.32	0	3305491	68.31	189		
0	923378	55.19	0	943186	56.32	0	3305491	68.31	190		
0	923378	55.19	0	943186	56.32	0	3305491	68.31	191		
0	923378	55.19	0	943186	56.32	0	3305491	68.31	192		
2215	925593	55.32	4772	947958	56.6	5945	3311436	68.43	193	no OHW data	
1612	927205	55.42	439	948397	56.63	1132	3312568	68.46	194		

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
990187			SR 542	32	Hedrick Cr	Nooksack R	01.0463	PI	16.63	24.18	3.36
990972			SR 161	12.86	SF Muck Cr	Muck Cr	11.0028	SPI	16.57	24.304	4
101OWEN-02			US 2	21.75	unnamed	Skykomish R	07	PI	16.56	24.428	1.3
990292			I-5	105.52	Moslie Cr	Puget Sound	13.0027	SPI	16.5	24.552	4.9
990138			SR 109	28.1	Elk Cr	Pacific Ocean	21.0761	PI	16.48	24.676	7
996155			SR 548	11.19	unnamed	Drayton Harbor	01.0044	PI	16.46	24.8	2
990450			SR 106	12.3	Twanoh Falls Cr	Hood Canal	14.0134	PI	16.37	24.924	3.3
15.0246 0.96			SR 3	44.8	Strawberry Cr	Dyes Inlet	15.0246	PI	16.33	25.048	3.28
994086			SR 303 on-ramp	6.62	Hoot Cr	Barker Cr	15.0256C	SPI	16.26	25.172	1.75
990448			US 101	246.4	Tumwater Cr	Port Angeles Harbor	18.0256	PI	16.25	25.296	9.83
991059			SR 531	8.71	MF Quilceda Cr	Quilceda Cr	07	PI	16.23	25.42	3.3
991667			US 101	268.54	unnamed	Sequim Bay	17.0300	PI	16.22	25.544	1.2
992008			SR 308	1.33	Little Scandia Cr	Liberty Bay	15.0279	ETD	16.06	25.668	1.45
994799			US 12	26.87	unnamed	Chehalis R	22.0542	PI	16.04	25.792	2.86
991732			SR 112	29.12	Indian Cr	Strait of Juan De Fuca	19.0112	PI	15.98	25.916	3.3
07.0396 0.80			SR 18	25.67	Deep Cr	Raging R	07.0396	PI	15.93	26.04	3.8
990385			SR 108	5.54	Skookum Cr	Skookum Inlet	14.0020	PI	15.9	26.164	6.5
990708			SR 3	44.62	unnamed	Strawberry Cr	15.0247	PI	15.89	26.288	2
994128			SR 522	21.96	unnamed	Skykomish R	07.0814	PI	15.87	26.412	2.15
990139			SR 522	20.21	Elliott Cr	Snohomish R	07.0214	PI	15.78	26.536	1.91
20.0312 0.60			US 101	197.1	Swanson Cr	Soleduck R	20.0312	PI	15.75	26.66	4.7
990090			US 101	277.9	Contractors Cr	Discovery Bay	17.0270	PI	15.67	26.784	1.46
999626			SR 3	26.26	Mindy Cr	Union R	15	SPI	15.66	26.908	3
CD18			SR 20	105.42	Backus Cr	Skagit R	04.1407	SPI	15.46	27.032	2.4
991567			SR 160	4.5	unnamed	Curley Cr	15.0186	SPI	15.43	27.156	1.6
990326			US 101	248.1	Peabody Cr	Strait of Juan de Fuca	18.0245	PI	15.39	27.28	3.8
990151			SR 530	42.99	Fortson Cr	NF Stillaguamish R	05.0254	PI	15.37	27.404	2.42
991191			SR 516	0.41	Barnes Cr	Massey Cr	09.0380	SPI	14.81	27.528	2.1
994459			SR 520	4.48	unnamed	Lk Washington	08.0257	ETD	14.8	27.652	
18.0021 5.40			US 101	260.93	Matriotti Cr	Dungeness R	18.0021	PI	14.72	27.776	2
993704			US 101	99.46	unnamed	WF Hoquiam R	22	ETD	14.7	27.9	0.8
994301			I-5	81.77	China Cr	Chehalis R	23.0870	PI	14.61	28.024	5.7
105 K051518a		1	SR 302	16.15	Goodnough Cr	Henderson Bay	15.0063	SPI	14.52	28.148	2.5
105 K051618a	105 K051518a		SR 16	16.59	Goodnough Cr	Henderson Bay	15.0063	SPI	12.46	28.272	2
991272			SR 109	33.1	unnamed	Pacific Ocean	21.0728	PI	14.46	28.396	4.73
990731			US 101	111.34	unnamed	Stevens Cr	22.0064A	PI	14.44	28.52	3.6
990218			SR 3	50.94	MF Johnson Cr	Liberty Bay	15.0283	PI	14.43	28.644	1.83
991661			SR 112	53.5	Falls Cr	Salt Cr	19.0012	PI	14.4	28.768	1.7
990644			SR 530	31.01	unnamed	NF Stillaguamish R	05	ETD	14.38	28.892	
991756			SR 508	3.5	unnamed	SF Newaukum R	23	SPI	14.31	29.016	3.1
997651			SR 516	5.8	Springbrook Cr	Black R	09.0005	SPI	14.26	29.14	2.66
991262			US 101	163.13	unnamed	Pacific Ocean	20	PI	14.25	29.264	2.3
996803			SR 3	47.72	unnamed	Clear Cr	15.0254	PI	14.22	29.388	2.8
102 Q058		1	I-5	203.24	unnamed	WF Quilceda Cr	07.0049	SPI	14.2	29.512	2
995284	102 Q058		I-5	203.22	unnamed	WF Quilceda Cr	07.0051	SPI	5.59	29.636	1.2
991066			SR 8	3.72	unnamed pond	Wildcat Cr	22	PI	14.17	29.76	28.75
996783			SR 302	15.96	unnamed	Henderson Bay	15	SPI	14.02	29.884	1.7
991215			SR 162	4.82	Ball Cr	Puyallup R	10.0405	PI	14.01	30.008	3.8
FR73		1	I-5	243.91	unnamed	Samish Lk	03	SPI	13.92	30.132	1.6
995250	FR73		I-5 NB	243.96	unnamed	Samish Lk	03	SPI	14.27	30.256	2.1
996291			SR 162	13.64	unnamed	S Prairie Cr	10	SPI	13.82	30.38	1.9
990710			SR 104	16.56	unnamed	Port Gamble	15	ETD	13.81	30.504	1.5
990962			SR 121	4.04	Blooms Ditch	Black R	23.0684	PI	13.79	30.628	5.1
994788			US 12	3.76	unnamed	unnamed	22.0238	ETD	13.73	30.752	1.2
990554			US 101	209.32	Wisen Cr	Sol Duc R	20.0336	PI	13.7	30.876	6.13
996943			SR 305 ROW	12.16	SF Dogfish Cr	Dogfish Cr	15	SPI	13.7	31	0.91
996963			I-90 WB on-ramp	17	NF Issaquah Cr	Issaquah Cr	08.0181	PI	13.69	31.124	4
995000			US 2	45.47	unnamed	SF Skykomish R	07.1298	PI	13.66	31.248	3.2
995693			SR 507	30.61	Schorno Cr	Nisqually R	11.0055	SPI	13.65	31.372	3.3
991725		1	I-5	224.62	Maddox Cr	SF Skagit R	03.2966	PI	13.6	31.496	1.3
CR122	991725		I-5; Hanson Rd	225.24	Martha Washington Cr	Maddox Cr	03.2970	PI	9.82	31.62	2.9
997342			US 101	152.47	unnamed	Queets R	21	SPI	13.58	31.744	2.8
990699			US 101	307	unnamed	Hood Canal	16	PI	13.55	31.868	3.6
990924			SR 109	37.43	unnamed	Pacific Ocean	21.0713	SPI	13.48	31.992	2.5
991258			SR 112	29.71	Unnamed	Butler Cr	19	PI	13.48	32.116	2.46
980275			SR 105	38.1	unnamed	Johns R	22	PI	13.46	32.24	1.42
991535			US 12	29.19	unnamed	Chehalis R	23	PI	13.43	32.364	1.52

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment
551	927756	55.45	159	948556	56.64	576	3313144	68.47	195	
12652	940408	56.21	25304	973860	58.15	50608	3363752	69.52	196	
3176	943584	56.4	266	974126	58.16	2814	3366566	69.57	197	
951	944535	56.45	2330	976456	58.3	4660	3371226	69.67	198	
5561	950096	56.78	2604	979060	58.46	14666	3385892	69.97	199	
3250	953346	56.98	0	979060	58.46	8258	3394150	70.14	200	
3059	956405	57.16	4104	983163	58.7	3193	3397343	70.21	201	
1998	958403	57.28	2014	985177	58.82	3525	3400868	70.28	202	
704	959107	57.32	616	985793	58.86	1232	3402100	70.31	203	
8928	968035	57.86	8760	994553	59.38	16969	3419069	70.66	204	
2838	970873	58.03	2869	997422	59.56	4833	3423902	70.76	205	
5065	975938	58.33	1390	998812	59.64	10417	3434319	70.97	206	
1524	977462	58.42	1034	999846	59.7	1579	3435898	71.01	207	OHW = toe width
3293	980755	58.62	1494	1001340	59.79	3548	3439446	71.08	208	
2567	983322	58.77	1126	1002466	59.86	3623	3443069	71.15	209	
3377	986699	58.97	2928	1005394	60.03	9493	3452562	71.35	210	
490	987189	59	811	1006205	60.08	1537	3454099	71.38	211	
705	987894	59.04	706	1006911	60.12	843	3454942	71.4	212	
1450	989344	59.13	1025	1007936	60.18	1615	3456557	71.43	213	
2294	991638	59.27	2058	1009994	60.31	4413	3460970	71.52	214	
6644	998282	59.66	2744	1012738	60.47	20009	3480979	71.94	215	
3787	1002069	59.89	1132	1013870	60.54	3597	3484576	72.01	216	
600	1002669	59.93	900	1014770	60.59	1800	3486376	72.05	217	
6414	1009083	60.31	7697	1022467	61.05	15394	3501770	72.37	218	
504	1009587	60.34	403	1022870	61.07	806	3502576	72.38	219	
2296	1011883	60.48	875	1023745	61.13	2033	3504609	72.43	220	
1030	1012913	60.54	860	1024605	61.18	1391	3506000	72.46	221	
818	1013731	60.59	859	1025464	61.23	1718	3507718	72.49	222	
2391	1016122	60.73	888	1026352	61.28	985	3508703	72.51	223	no OHW data
8075	1024197	61.21	1682	1028034	61.38	13787	3522490	72.8	224	
1144	1025341	61.28	44	1028078	61.39	856	3523346	72.81	225	OHW = toe width
8289	1033630	61.78	2842	1030920	61.56	14839	3538184	73.12	226	
2660	1036290	61.94	3325	1034245	61.75	6650	3544834	73.26	227	
0	1036290	61.94	0	1034245	61.75	0	3544834	73.26	228	
3972	1040262	62.17	5849	1040094	62.1	4665	3549499	73.35	229	
1162	1041424	62.24	485	1040579	62.13	3052	3552551	73.42	230	
252	1041676	62.26	156	1040735	62.14	348	3552899	73.42	231	
3557	1045233	62.47	1768	1042503	62.25	6904	3559803	73.57	232	
1296	1046529	62.55	51	1042554	62.25	285	3560088	73.57	233	no OHW data
1100	1047629	62.61	1705	1044259	62.35	3410	3563498	73.64	234	
4636	1052265	62.89	6142	1050401	62.72	12285	3575783	73.9	235	
1928	1054193	63.01	3087	1053488	62.9	4459	3580242	73.99	236	
817	1055010	63.06	865	1054353	62.95	1237	3581479	74.01	237	
562	1055572	63.09	562	1054915	62.99	1124	3582603	74.04	238	
0	1055572	63.09	0	1054915	62.99	0	3582603	74.04	239	
418	1055990	63.11	0	1054915	62.99	4339	3586942	74.13	240	
400	1056390	63.14	340	1055255	63.01	680	3587622	74.14	241	
2482	1058872	63.29	0	1055255	63.01	5060	3592682	74.25	242	
535	1059407	63.32	428	1055683	63.03	856	3593538	74.26	243	
0	1059407	63.32	0	1055683	63.03	0	3593538	74.26	244	
27106	1086513	64.94	25750	1081433	64.57	51501	3645039	75.33	245	
1617	1088130	65.03	533	1081966	64.6	1898	3646937	75.37	246	OHW = toe width
4939	1093069	65.33	481	1082447	64.63	11778	3658715	75.61	247	
1144	1094213	65.4	0	1082447	64.63	2859	3661574	75.67	248	OHW = toe width
3273	1097486	65.59	8239	1090686	65.12	6036	3667610	75.79	249	
681	1098167	65.63	310	1090996	65.14	620	3668230	75.81	250	
1380	1099547	65.72	670	1091666	65.18	2697	3670927	75.86	251	
1411	1100958	65.8	1117	1092783	65.25	2933	3673860	75.92	252	
2782	1103740	65.97	4590	1097373	65.52	9181	3683041	76.11	253	
6938	1110678	66.38	2398	1099771	65.67	7699	3690740	76.27	254	
0	1110678	66.38	0	1099771	65.67	0	3690740	76.27	255	
2290	1112968	66.52	3206	1102977	65.86	6412	3697152	76.41	256	
1115	1114083	66.59	2072	1105049	65.98	1207	3698359	76.43	257	
1305	1115388	66.66	1631	1106680	66.08	3262	3701621	76.5	258	
2262	1117650	66.8	1386	1108066	66.16	2824	3704445	76.56	259	
420	1118070	66.82	222	1108288	66.17	567	3705012	76.57	260	
3990	1122060	67.06	2159	1110447	66.3	2979	3707991	76.63	261	OHW = toe width

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
991606			US 101	315.19	Schaerer Cr	Hood Canal	16.0326	PI	13.4	32.488	7.95
990640			SR 530	35.24	unnamed	Montaque Cr	05.0217X	SPI	13.39	32.612	0.9
990395			SR 3	58.49	Spring Cr	Hood Canal	15.0364	PI	13.37	32.736	1.95
992632		1	SR 522	17.82	unnamed	Evans Cr	07.0211	PI	13.28	32.86	3.2
992371	992632		SR 522	17.48	unnamed	Evans Cr	07.0211	PI	6.11	32.984	8.59
993723			SR 8	1.27	unnamed	Cloquallum Cr	22	PI	13.28	33.108	3.1
991237			SR 108	5.5	unnamed	Skookum Cr	14	PI	13.13	33.232	3.45
997694			SR 169	8.29	unnamed	Rock Cr	09	SPI	13.13	33.356	3.4
991276			US 101	156.1	unnamed	Pacific Ocean	21	SPI	13.12	33.48	2.9
990205			SR 112	5.17	Jansen Cr	Strait of Juan de Fuca	19.0228	SPI	13.1	33.604	3.1
996168			SR 544	3.51	unnamed	Green Lk	01	SPI	13.07	33.728	2.5
991244			SR 106	2.95	unnamed	Skokomish R	16.0002	PI	13.03	33.852	1.4
996699			SR 300	2.36	unnamed	Union R	15	SPI	12.98	33.976	0.8
15.0201 0.90			SR 166	4.52	Olney Cr	Sinclair Inlet	15.0201	PI	12.94	34.1	2.8
990672			SR 7	14.72	unnamed	East Cr	11	SPI	12.94	34.224	2.1
991686			SR 112	56.5	unnamed	Coville Cr	19.0003	ETD	12.94	34.348	2.8
992350			SR 9	77.43	unnamed	unnamed	01	ETD	12.91	34.472	1
992196			SR 104	12.7	unnamed	Squamish Harbor	17.0185	PI	12.89	34.596	1.3
995108			US 2	12.94	unnamed	French Cr	07.0193	ETD	12.79	34.72	2.2
995917			SR 119	8.2	unnamed	Big Cr	16	SPI	12.79	34.844	2.9
990480			SR 112	49.48	Whiskey Cr	Strait of Juan de Fuca	19.0020	PI	12.73	34.968	4.7
991240			SR 3	58.21	unnamed	Hood Canal	15	ETD	12.72	35.092	0.8
991448			SR 9	67.33	NP Cr	Samish R	03.0078	PI	12.68	35.216	3.1
995497			US 101	283.57	unnamed	Snow Cr	17	SPI	12.67	35.34	2.5
990760			SR 6	41.22	Davis Cr	Chehalis R	23.1080	SPI	12.64	35.464	2.6
996142			SR 548	4.27	unnamed	Fingleson Cr	01	SPI	12.6	35.588	1.7
997157			US 101	356.48	unnamed	Schneider Cr	14	SPI	12.6	35.712	0.7
997365			SR 3	7.16	unnamed	Oakland Bay	14.0050	PI	12.59	35.836	1.36
162173			SR 104	4.25	unnamed	Barnhouse Cr	17.0213b3	PI	12.58	35.96	1.25
991672			SR 108	7.62	unnamed	Skookum Cr	14	PI	12.58	36.084	3.68
995470			I-405	2.31	unnamed	Springbrook Cr	09	SPI	12.57	36.208	2.7
991284			US 12	4.59	unnamed	Max Chuck Sl	22.0253	ETD	12.55	36.332	1.5
991756			SR 508	5.1	unnamed	SF Newaukum R	23	SPI	12.54	36.456	2.3
990082			SR 410	35.77	Clay Cr	White R	10.0103	PI	12.53	36.58	3.63
996748			SR 3	42.56	unnamed	Dyes Inlet	15.0244	SPI	12.52	36.704	4.2
990751			SR 6	33.56	unnamed	unnamed to Chehalis R	23	SPI	12.48	36.828	1.6
990246			SR 530	42.14	Little French Cr	Fortson Cr	05.0253	PI	12.47	36.952	4.27
991723			SR 900	20.34	unnamed	Tibbetts Cr	08.0171	PI	12.47	37.076	1.27
991113			SR 542	23.95	unnamed	High Cr	01	SPI	12.46	37.2	2.4
996925			SR 202	4.25	unnamed	Sammamish R	08	SPI	12.46	37.324	2.1
995931			US 101	305.59	unnamed	Hood Canal	16	SPI	12.43	37.448	1.9
990650			US 101	154.9	unnamed	Pacific Ocean	21	SPI	12.38	37.572	3
993898		3	I-405 ROW	29.67	Martha Cr	Swamp Cr	08	PI	12.36	37.696	1.6
993122	993898		SR 524/Filbert Rd	7.02	Martha Cr	Swamp Cr	08	PI	11.97	37.82	3.3
993121	993898		SR 524/Filbert Rd	7.07	Martha Cr	Swamp Cr	08	PI	11.76	37.944	3.33
993100	993898		SR 524	6.96	Martha Cr	Swamp Cr	08	PI	11.61	38.068	3.3
990681			SR 11	18.65	unnamed	Chuckanut Cr	01.0627	PI	12.35	38.192	1.36
990080			SR 532	6.68	unnamed	Church Cr	05.0020	SPI	12.34	38.316	0.9
991499			I-5	94.57	unnamed	Beaver Cr	23	ETD	12.31	38.44	1.48
997787			SR 109	33.87	unnamed	Pacific Ocean	21.0727	PI	12.26	38.564	3.5
991131			SR 20	112.9	unnamed	Skagit R	04	SPI	12.24	38.688	3.3
991252			US 101	335.02	unnamed	Hood Canal	16.0218	PI	12.24	38.812	4.2
994327			SR 305	8.94	unnamed	Liberty Bay	15.0293	SPI	12.24	38.936	1.75
990102			SR 410	38.49	Cyclone Cr	White R	10.0105	SPI	12.23	39.06	3
991270			SR 109	38.43	unnamed	Pacific Ocean	21.0715	PI	12.18	39.184	2.85
991473			SR 539	11.08	unnamed	unnamed to Bertrand Cr	01	SPI	12.16	39.308	2.2
994501		1	I-5 SB	244.2	Barnes Cr	Samish Lk	03.0036	PI	12.12	39.432	3
990025	994501		I-5	244.2	Barnes Cr	Samish Lk	03.0036	PI	11.7	39.556	3
997669			SR 18	15.14	unnamed	unnamed	09	SPI	12.12	39.68	1.9
992378			SR 522	19.26	Anderson Cr	Evans Cr	07.0212	ETD	12.06	39.804	2.42
991705			SR 542	21.45	unnamed	Kendall Cr	01	SPI	12.03	39.928	1
994969			SR 508	8.88	unnamed	SF Newaukum R	23	SPI	12.02	40.052	3.3
115 MC144			US 101	355.58	unnamed	Totten Inlet	14	PI	11.95	40.176	1.7
990941			SR 112	29.7	Butler Cr	Butler Cove	19	PI	11.94	40.3	2
996571			SR 113	8.35	unnamed	Pysht R	19	SPI	11.94	40.424	1.6
990745			SR 6	31	unnamed	Chehalis R	23	SPI	11.92	40.548	1.6
993724			SR 8	3.16	unnamed	Wildcat Cr	22	ETD	11.91	40.672	1.6

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment
250	1122310	67.08	542	1110980	68.34	580	3708571	78.64	262	
547	1122857	67.11	246	1111236	68.35	492	3709063	78.65	263	
1441	1124298	67.2	1094	1112329	68.42	1578	3710641	78.68	264	
1150	1125448	67.26	15	1112344	68.42	11520	3722161	78.92	265	
0	1125448	67.26	0	1112344	68.42	0	3722161	78.92	266	
767	1126215	67.31	3	1112347	68.42	1420	3723581	78.95	267	
2814	1129029	67.48	1642	1113989	68.52	3626	3727207	77.03	268	
2604	1131633	67.63	4427	1118416	68.78	8854	3736061	77.21	269	
644	1132277	67.67	934	1119350	68.84	1868	3737929	77.25	270	
5760	1138037	68.02	8928	1128278	67.37	17856	3755785	77.62	271	
3918	1141955	68.25	4898	1133176	67.66	9796	3765580	77.82	272	
437	1142392	68.28	405	1133581	67.69	676	3766256	77.83	273	
1269	1143661	68.35	508	1134089	67.72	1015	3767273	77.85	274	
2516	1146177	68.5	1713	1135802	67.82	4489	3771762	77.96	275	
1453	1147630	68.59	1526	1137328	67.91	3051	3774813	78.01	276	
2770	1150400	68.76	1049	1138377	67.97	3099	3777912	78.07	277	OHW = toe width
1400	1151800	68.84	127	1138504	67.98	1054	3778966	78.1	278	OHW = toe width
1822	1153622	68.95	91	1138595	67.98	2276	3781242	78.14	279	
5295	1158917	69.27	1978	1140573	68.1	5660	3786902	78.26	280	OHW = toe width
1107	1160024	69.33	1605	1142178	68.2	3210	3790112	78.33	281	
2724	1162748	69.49	6414	1148592	68.58	4409	3794521	78.42	282	
1689	1164437	69.6	815	1149407	68.63	1866	3796387	78.46	283	OHW = toe width
2101	1166538	69.72	3566	1152973	68.84	2042	3798429	78.5	284	
1316	1167854	69.8	1645	1154618	68.94	3290	3801719	78.57	285	
1469	1169323	69.89	1910	1156528	69.06	3819	3805538	78.65	286	
1640	1170963	69.99	1394	1157922	69.14	2788	3808326	78.7	287	
670	1171633	70.03	234	1158156	69.15	469	3808795	78.71	288	
661	1172294	70.06	248	1158404	69.17	1351	3810146	78.74	289	
963	1173257	70.12	686	1159090	69.21	1467	3811613	78.77	290	
2325	1175582	70.26	3549	1162639	69.42	1774	3813387	78.81	291	
1022	1176604	70.32	1380	1164019	69.5	2759	3816146	78.86	292	
1107	1177711	70.39	568	1164587	69.54	1393	3817539	78.89	293	OHW = toe width
3011	1180722	70.57	3462	1168049	69.74	6925	3824464	79.04	294	
668	1181390	70.61	421	1168470	69.77	1678	3826142	79.07	295	
1023	1182413	70.67	2148	1170618	69.9	4297	3830439	79.16	296	
1963	1184376	70.79	1570	1172188	69.99	3141	3833580	79.22	297	
996	1185372	70.85	1137	1173325	70.06	821	3834401	79.24	298	
650	1186022	70.89	890	1174215	70.11	1187	3835588	79.27	299	
1008	1187030	70.95	1210	1175425	70.18	2419	3838007	79.32	300	
973	1188003	71	1022	1176447	70.24	2043	3840050	79.36	301	
1121	1189124	71.07	1065	1177512	70.31	2130	3842180	79.4	302	
1496	1190620	71.16	2244	1179756	70.44	4488	3846668	79.5	303	
2817	1193437	71.33	2138	1181894	70.57	1825	3848493	79.53	304	
0	1193437	71.33	0	1181894	70.57	0	3848493	79.53	305	
0	1193437	71.33	0	1181894	70.57	0	3848493	79.53	306	
0	1193437	71.33	0	1181894	70.57	0	3848493	79.53	307	
1138	1194575	71.4	250	1182144	70.58	4842	3853335	79.63	308	
300	1194875	71.41	135	1182279	70.59	270	3853605	79.64	309	
483	1195358	71.44	37	1182316	70.59	545	3854150	79.65	310	OHW = toe width
1937	1197295	71.56	658	1182974	70.63	2389	3856539	79.7	311	
404	1197699	71.58	666	1183640	70.67	1333	3857872	79.73	312	
210	1197909	71.6	617	1184257	70.71	268	3858140	79.73	313	
2570	1200479	71.75	2249	1186506	70.85	4498	3862638	79.83	314	
7523	1208002	72.2	11284	1197790	71.52	22569	3885207	80.29	315	
3081	1211083	72.38	677	1198467	71.56	3593	3888800	80.37	316	
5550	1216633	72.71	6105	1204572	71.92	12210	3901010	80.62	317	
532	1217165	72.75	240	1204812	71.94	714	3901724	80.63	318	
0	1217165	72.75	0	1204812	71.94	0	3901724	80.63	319	
1137	1218302	72.81	1080	1205892	72	2160	3903884	80.68	320	
328	1218630	72.83	536	1206428	72.03	824	3904708	80.69	321	OHW = toe width
3129	1221759	73.02	1564	1207992	72.13	3129	3907837	80.76	322	
818	1222577	73.07	1350	1209342	72.21	2699	3910536	80.82	323	
749	1223326	73.11	99	1209441	72.21	437	3910973	80.82	324	
1351	1224677	73.2	864	1210305	72.27	1739	3912712	80.86	325	
299	1224976	73.21	239	1210544	72.28	478	3913190	80.87	326	
1632	1226608	73.31	1306	1211850	72.36	2611	3915801	80.92	327	
1393	1228001	73.39	253	1212103	72.37	1085	3916886	80.95	328	OHW = toe width

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
990744			SR 6	31.05	unnamed	Fronia Cr	23	SPI	11.9	40.796	3.2
995200			SR 202	23.22	unnamed	Skunk Cr	07	SPI	11.87	40.92	1.5
990711			SR 19	4.3	Swansonville Cr	EF Chimacum Cr	17.0205A	PI	11.86	41.044	1.1
992344			SR 9	76.91	unnamed	Black Sl	01	PI	11.83	41.168	3.6
102 M048			I-5 Service Rd	177.85	unnamed	McAleer Cr	08.0049	SPI	11.79	41.292	5.7
997684			SR 99	23.41	unnamed	Duwamish R	09	SPI	11.79	41.416	2.7
990927			SR 109	39.15	unnamed	Pacific Ocean	21.0711	PI	11.73	41.54	2.1
991867			SR 16	20.44	unnamed	Burley Cr	15	PI	11.66	41.664	1
992064		1	SR 161	33.79	unnamed	EF Hylebos Cr	10.0016	SPI	11.63	41.788	1.5
996277	992064		SR 18	0.29	unnamed	unnamed	10	SPI	6.36	41.912	3.7
996886			SR 908	5.4	unnamed	unnamed	08	SPI	11.61	42.036	3.3
991613			SR 3	57.87	unnamed	Hood Canal	15	SPI	11.59	42.16	1.2
990644			US 101	132.2	unnamed	Ten O Clock Cr	21	SPI	11.58	42.284	2.6
997681			SR 18	8	unnamed	Soosette Cr	09	SPI	11.57	42.408	2.1
997679			SR 509	25.69	Miller Cr	Puget Sound	09.0371	SPI	11.54	42.532	4.3
997706			I-5	104.13	unnamed	Deschutes R	13	SPI	11.53	42.656	1.9
996556			SR 112	25.2	unnamed	Pysht R	19	SPI	11.52	42.78	0.75
993695			US 101	93.49	unnamed	WF Hoquiam R	22	ETD	11.5	42.904	1.4
991660			SR 112	52.9	Nordstrom Cr	Salt Cr	19.0011	PI	11.46	43.028	3.7
991559			SR 302	0.9	unnamed	North Bay	15.0001	PI	11.44	43.152	0.92
991266			SR 109	33.4	unnamed	Pacific Ocean	21	PI	11.36	43.276	3.05
995491			US 101	281.72	unnamed	Discovery Bay	17	PI	11.35	43.4	2.05
996539			SR 112	51.53	Itsa Cr	Uptha Cr	19	SPI	11.3	43.524	1
995246		1	I-5 Ext 240 NB	240	unnamed	Friday Cr	03	SPI	11.24	43.648	1.4
995259	995246		I-5 Ext 240 SB	240	unnamed	Friday Cr	03	SPI	9.63	43.772	1.4
08.0070 A 0.25			I-405	26.46	Perry Cr	North Cr	08.0070 A	ETD	11.22	43.896	
991296			SR 508	15.85	unnamed	Kearney Cr	23	SPI	11.22	44.02	3
990688			SR 7	38.12	unnamed	South Cr	11	SPI	11.21	44.144	2.18
991151			SR 20	87.31	Eagle Cr	Skagit R	04	SPI	11.18	44.268	2.1
998967			SR 520	4.81	unnamed	Lk Washington	08	SPI	11.17	44.392	1.6
990732			US 101	93.79	unnamed	WF Hoquiam R	22	PI	11.16	44.516	1.6
993717			US 101	110.84	unnamed	Stevens Cr	22	PI	11.14	44.64	2.45
994410			I-90	23.13	Soderman Cr	Raging R	07.0390	ETD	11.14	44.764	4
997675			SR 509	14.23	unnamed	Poverty Bay	09.0384	SPI	11.14	44.888	1.7
996478			I-90	12.75	unnamed	Lk Sammamish	08	SPI	11.13	45.012	1.1
997184			SR 106	14.61	unnamed	Hood Canal	14.0130	SPI	11.13	45.136	1.51
990758			SR 6	35.85	unnamed	Chehalis R	23	SPI	11.11	45.26	1.3
991142			SR 20	69.06	unnamed	Coal Cr	03	SPI	11.1	45.384	1.3
991213			SR 164	9.06	Second Cr	White R	10.0050	PI	11.1	45.508	1.62
997920			SR 512	3.3	unnamed	Clover Cr	12.0015	SPI	11.08	45.632	2.3
991271			SR 109	36.38	unnamed	Pacific Ocean	21.0716	PI	11.07	45.756	2.38
992277			SR 508	4.26	unnamed	SF Newaukum R	23	SPI	11.07	45.88	1.62
990452			US 101	135.26	unnamed	Lunch Cr	21	SPI	11.04	46.004	3.5
995982			SR 9	10.61	Cemetery Cr	unnamed to Snohomish R	07.0118	SPI	11.03	46.128	2.5
993702			US 101	98.47	unnamed	WF Hoquiam R	22	PI	11.02	46.252	1.5
991589			US 101	178.3	unnamed	Hell Roaring Cr	20	PI	10.99	46.376	4.25
992062			SR 161	33.48	unnamed	Hylebos Cr	10.0006	SPI	10.98	46.5	1.5
991716			SR 203	13.6	unnamed	Snoqualmie R	07.0219A	PI	10.96	46.624	1.56
994415			I-90	14.71	unnamed	Lk Sammamish	08	SPI	10.95	46.748	1.56
997054			US 101	171.29	unnamed	Hoh R	20	SPI	10.95	46.872	2.38
997784			SR 109	30.26	unnamed	Pacific Ocean	21	SPI	10.94	46.996	1.5
993849			SR 99	51.45	unnamed	Swamp Cr	08	PI	10.93	47.12	2.2
991285			US 12	5.38	unnamed	Max Chuck Sl	22.0254	PI	10.89	47.244	1.53
996092		1	SR 530	25.88	unnamed	Trafton Cr	05.0148	SPI	10.88	47.368	0.6
990629	996092		SR 530	25.74	unnamed	Trafton Cr	05.0148	SPI	3.71	47.492	0.6
115 MC190			SR 106	14.72	Mulberg Cr	Hood Canal	14	PI	10.86	47.616	1
996573			SR 113	9.7	unnamed	Pysht R	19	SPI	10.85	47.74	0.75
991536			US 12	29.45	unnamed	Chehalis R	23	PI	10.83	47.864	1.52
991690			US 101	111.9	unnamed	Stevens Cr	22	PI	10.83	47.988	1.65
992846			SR 524	5.54	Golde Cr	Scriber Cr	08.0062	ETD	10.8	48.112	2.45
991054			SR 525	2.05	unnamed	Swamp Cr	08.0065	SPI	10.75	48.236	0.85
991289			SR 508	12.66	unnamed	SF Newaukum R	23	SPI	10.74	48.36	3.4
990920			SR 109	19.4	unnamed	Connor Cr	21	SPI	10.66	48.484	2.7
996008			SR 548	1.24	unnamed	California Cr	01.0079	PI	10.64	48.608	1.69
997107			US 101	202.71	unnamed	Sol Duc R	20	SPI	10.63	48.732	1.6
995891			SR 507	25.96	unnamed	Yelm Cr	11	SPI	10.56	48.856	2
995475			SR 161	14.89	unnamed	unnamed	11.0036	SPI	10.55	48.98	2.4
115 MC180			US 101	348.21	unnamed	Mill Cr	14	PI	10.54	49.104	1.3
991265			SR 109	26.1	unnamed	Pacific Ocean	21.0764	PI	10.52	49.228	1.3
997703			SR 507	18.9	unnamed	McIntosh Lk	13	SPI	10.52	49.352	1.8

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment
1752	1229753	73.5	2503	1214906	72.54	5606	3922492	81.06	329	
956	1230709	73.56	717	1215623	72.58	1434	3923926	81.09	330	
3178	1233887	73.75	1239	1216862	72.66	1986	3925912	81.13	331	
665	1234552	73.79	0	1216862	72.66	1053	3926965	81.15	332	
730	1235282	73.83	2080	1218942	72.78	4161	3931126	81.24	333	
717	1235999	73.87	968	1219910	72.84	1936	3933062	81.28	334	
871	1236870	73.92	1254	1221164	72.91	1840	3934902	81.32	335	
1096	1237966	73.98	497	1221661	72.94	454	3935356	81.33	336	
4801	1242767	74.28	3601	1225262	73.16	7202	3942558	81.48	337	
0	1242767	74.28	0	1225262	73.16	0	3942558	81.48	338	
966	1243733	74.33	1594	1226856	73.25	3188	3945746	81.54	339	
336	1244069	74.35	202	1227058	73.27	403	3946149	81.55	340	
585	1244654	74.39	760	1227818	73.31	1521	3947670	81.58	341	
855	1245509	74.44	898	1228716	73.37	1796	3949466	81.62	342	
2815	1248324	74.61	6052	1234768	73.73	12104	3961570	81.87	343	
1415	1249739	74.69	1344	1236112	73.81	2686	3964256	81.93	344	
245	1249984	74.71	92	1236204	73.81	186	3964442	81.93	345	
300	1250284	74.73	65	1236269	73.82	294	3964736	81.94	346	OHW = toe width
4855	1255139	75.02	5388	1241657	74.14	5648	3970384	82.05	347	
483	1255622	75.05	232	1241889	74.15	576	3970960	82.06	348	
482	1256104	75.07	599	1242488	74.19	548	3971508	82.08	349	
2014	1258118	75.19	1200	1243688	74.26	2337	3973845	82.12	350	
1638	1259756	75.29	819	1244507	74.31	1638	3975483	82.16	351	
1013	1260769	75.35	709	1245216	74.35	1418	3976901	82.19	352	
0	1260769	75.35	0	1245216	74.35	0	3976901	82.19	353	
885	1261654	75.41	444	1245660	74.38	1707	3978608	82.22	354	no OHW data
1603	1263257	75.5	2404	1248064	74.52	4809	3983417	82.32	355	
4381	1267638	75.76	4776	1252840	74.81	9551	3992968	82.52	356	
987	1268625	75.82	1036	1253876	74.87	2073	3995041	82.56	357	
1052	1269677	75.88	842	1254718	74.92	1683	3996724	82.6	358	
940	1270617	75.94	72	1254790	74.92	381	3997105	82.6	359	
404	1271021	75.97	110	1254900	74.93	324	3997429	82.61	360	
1075	1272096	76.03	994	1255894	74.99	1892	3999321	82.65	361	OHW = toe width
1808	1273904	76.14	1537	1257431	75.08	3074	4002395	82.71	362	
243	1274147	76.15	134	1257565	75.09	267	4002662	82.72	363	
1524	1275671	76.24	1150	1258715	75.16	2301	4004963	82.77	364	
500	1276171	76.27	325	1259040	75.18	650	4005613	82.78	365	
1899	1278070	76.39	1234	1260274	75.25	2469	4008082	82.83	366	
2376	1280446	76.53	409	1260683	75.27	1506	4009588	82.86	367	
1580	1282026	76.62	1817	1262500	75.38	3634	4013222	82.94	368	
816	1282842	76.67	1239	1263739	75.46	1482	4014704	82.97	369	
1385	1284227	76.75	1122	1264861	75.52	2244	4016948	83.01	370	
2892	1287119	76.93	5061	1269922	75.83	10122	4027070	83.22	371	
2050	1289169	77.05	2562	1272484	75.98	5125	4032195	83.33	372	
1037	1290206	77.11	15	1272499	75.98	1098	4033293	83.35	373	
4102	1294308	77.36	4979	1277478	76.28	6882	4040175	83.49	374	
3803	1298111	77.58	2852	1280330	76.45	5704	4045879	83.61	375	
421	1298532	77.61	320	1280650	76.47	725	4046604	83.63	376	
1236	1299768	77.68	958	1281608	76.52	1916	4048520	83.67	377	
1244	1301012	77.76	1462	1283070	76.61	2923	4051443	83.73	378	
956	1301968	77.82	717	1283787	76.65	1434	4052877	83.76	379	
620	1302588	77.85		1283787	76.65	554	4053431	83.77	380	
1338	1303926	77.93	144	1283931	76.66	473	4053904	83.78	381	
630	1304556	77.97	189	1284120	76.67	378	4054282	83.79	382	
0	1304556	77.97	0	1284120	76.67	0	4054282	83.79	383	
273	1304829	77.99	81	1284201	76.68	317	4054599	83.79	384	
1181	1306010	78.06	443	1284644	76.7	886	4055485	83.81	385	
2283	1308293	78.19	474	1285118	76.73	953	4056438	83.83	386	OHW = toe width
972	1309265	78.25	33	1285151	76.74	2848	4059286	83.89	387	
450	1309715	78.28	123	1285274	76.74	485	4059771	83.9	388	OHW = toe width
374	1310089	78.3	159	1285433	76.75	318	4060089	83.91	389	
586	1310675	78.34	996	1286429	76.81	1992	4062081	83.95	390	
962	1311637	78.39	1298	1287727	76.89	2597	4064678	84	391	
1574	1313211	78.49	345	1288072	76.91	471	4065149	84.01	392	
1194	1314405	78.56	955	1289027	76.97	1910	4067059	84.05	393	
8480	1322885	79.07	8480	1297507	77.47	16960	4084019	84.4	394	
4307	1327192	79.32	5168	1302675	77.78	10337	4094356	84.61	395	
445	1327637	79.35	190	1302865	77.79	473	4094829	84.62	396	
500	1328137	79.38	0	1302865	77.79	1948	4096777	84.66	397	
1415	1329552	79.46	1274	1304139	77.87	2547	4099324	84.72	398	

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
162192			SR 104	12.57	unnamed	Squamish Harbor	17	PI	10.5	49.476	2.25
990168			SR 3	32.1	Gorst Cr	Sinclair Inlet	15.0216	PI	10.49	49.6	1.7
991539			US 12	33.6	unnamed	Chehalis R	23	SPI	10.49	49.724	1.4
991751			SR 531	3.8	Cougar Cr	Fish Cr	05.0041	PI	10.49	49.848	2.1
CR2		1	SR 534	0.53	unnamed	Carpenter Cr	03	SPI	10.48	49.972	0.91
995265	CR2		SR 534	0.8	unnamed	Carpenter Cr	03	SPI	10.48	50.096	0.9
996156		1	SR 548	13.8	Cain Cr	Drayton Harbor	01.0001	SPI	10.45	50.22	2
995726	996156		I-5	275.33	Cain Cr	Boundary Bay	01.0001	SPI	9.53	50.344	2
990134			US 101	274.25	Eagle Cr	Strait of Juan de Fuca	17.0272	SPI	10.4	50.468	0.8
996371			US 101	338.37	unnamed	Skobob Cr	16	SPI	10.38	50.592	2
995743			SR 20	0.65	unnamed	Discovery Bay	17.0218	PI	10.36	50.716	1.43
993013			SR 3	46.09	unnamed	Clear Cr	15	ETD	10.35	50.84	1.65
990630			SR 530	27.46	unnamed	NF Stillaguamish R	05.0150	SPI	10.3	50.964	1.8
990717			US 101	169.45	unnamed	Hoh R	20	SPI	10.26	51.088	2.35
996714			US 12	32.69	unnamed	Cedar Cr	23	SPI	10.26	51.212	1.2
993725			SR 8	3.51	unnamed	Wildcat Cr	22	ETD	10.25	51.336	1
995529			SR 19	2.93	unnamed	Ludlow Cr	17	SPI	10.25	51.46	0.8
993714			US 101	107.42	Mopang Cr	Big Cr	22.0044	PI	10.24	51.584	2.2
990652			SR 530	43.34	unnamed	Fortson Ponds	05	SPI	10.22	51.708	0.9
990632		1	SR 530	26.68	unnamed	NF Stillaguamish R	05.0151X	SPI	10.21	51.832	1.5
990633	990632		SR 530	26.87	unnamed	NF Stillaguamish R	05.0151	SPI	10.17	51.956	2.2
991540			US 12	28.6	unnamed	Chehalis R	23	SPI	10.21	52.08	1.4
991575			US 101	181.2	unnamed	Dowans Cr	20	SPI	10.21	52.204	3.8
991447			SR 9	66.66	unnamed	Samish R	03	SPI	10.2	52.328	0.9
991538			US 12	33.42	unnamed	Chehalis R	23.0619	SPI	10.19	52.452	1.57
997081			US 101	183.11	unnamed	unnamed	20	SPI	10.19	52.576	1.8
991598			US 101	175.91	unnamed	Hoh R	20	SPI	10.12	52.7	2.25
991477			US 101	360.6	unnamed	Eld Inlet	14.0002A	PI	10.1	52.824	1.95
990244			SR 6	30.87	unnamed	Chehalis R	23	SPI	10.05	52.948	1.3
996153			SR 548	10.55	unnamed	California Cr	01.0047	SPI	10.03	53.072	1
995021			US 2	49.87	unnamed	SF Skykomish R	07	SPI	10.02	53.196	2.6
995770			SR 542	24.25	unnamed	High Cr	01	SPI	10.02	53.32	1.7
996272			SR 509	11.43	unnamed	Lakota Cr	10.0387	SPI	9.98	53.444	1.1
995474			SR 18	21.15	unnamed	Holder Cr	08	SPI	9.97	53.568	2
997363			SR 109	24.56	unnamed	Boone Cr	21	PI	9.93	53.692	2.6
GR23			SR 20	88.82	unnamed	Skagit R	04	SPI	9.93	53.816	1.1
991850			US 101	271.83	unnamed	Sequim Bay	17	ETD	9.91	53.94	0.9
991591			US 101	179.13	unnamed	Hell Roaring Cr	20	PI	9.88	54.064	4.4
992654			I-405	20.95	unnamed	Juanita Cr	08.0238	SPI	9.87	54.188	1.4
991202			SR 167	26.1	unnamed	Springbrook Cr	09	SPI	9.86	54.312	2.7
991731			SR 112	21.1	unnamed	Green Cr	19	PI	9.81	54.436	2.54
991106			SR 9	70.6	unnamed	Samish R	03	SPI	9.76	54.56	2.3
991245			SR 106	13.84	unnamed	Hood Canal	14.0131	SPI	9.72	54.684	1.91
996223			US 101	160.89	unnamed	Pacific Ocean	20	SPI	9.71	54.808	1.55
991728			SR 3	29.63	unnamed	Union R	15.0512	PI	9.7	54.932	4.15
997692			SR 169	7.25	unnamed	Rock Cr	09	SPI	9.7	55.056	1.7
999632			I-5	85.81	Unnamed	Dry Cr	23	SPI	9.7	55.18	1.8
105 R022221a			SR 410	41.42	unnamed	White R	10	SPI	9.67	55.304	2.2
990957			US 12	6.58	unnamed	Higgins Sl	22	PI	9.67	55.428	1.3
991192			SR 509	13.49	unnamed	Puget Sound	09.0385	SPI	9.67	55.552	1.8
995398			SR 9	69.88	unnamed	Samish R	03	SPI	9.66	55.676	1.2
995245		5	I-5 Ext 240 NB	240	unnamed	Friday Cr	03	SPI	9.65	55.8	1.5
995236	995245		I-5 Ext 240 SB	240	unnamed	Friday Cr	03	SPI	9.72	55.924	1
995232	995245		I-5 NB	240.95	unnamed	Friday Cr	03	SPI	8.71	56.048	1
995233	995245		I-5 Median	240.95	unnamed	Friday Cr	03	SPI	8.18	56.172	1
995235	995245		I-5 SB ROW	240.95	unnamed	Friday Cr	03	SPI	7.89	56.296	1
995234	995245		I-5 SB	240.95	unnamed	Friday Cr	03	SPI	7.33	56.42	1
995217			SR 98	6.49	unnamed	unnamed to Ebey Sl	07	SPI	9.61	56.544	0.7
JK2			SR 20	91.3	unnamed	Skagit R	04.0176X	SPI	9.61	56.668	2.6
997786			SR 109	31.93	unnamed	Moclips R	21	SPI	9.58	56.792	2.1
990276			US 101	123.05	McCalla Cr	Boulder Cr	21.0456	PI	9.57	56.916	2.65
996424			SR 112	31.46	unnamed	Jim Cr	19	SPI	9.54	57.04	1.2
991711			SR 20	94.1	unnamed	Skagit R	04.0650	SPI	9.51	57.164	3
991063			SR 8	0.1	unnamed	Cloquallum Cr	22	PI	9.5	57.288	5.05
990721			US 101	172.73	unnamed	Pins Cr	20	SPI	9.48	57.412	10
995019			SR 119	3.98	unnamed	Skokomish R	16	SPI	9.48	57.536	2.1
995152			SR 204	1.8	unnamed	Ebey Sl	07	SPI	9.47	57.66	2.2
990922			SR 109	35.73	unnamed	Pacific Ocean	21.0718	PI	9.46	57.784	2.12
997646			SR 181	7.3	unnamed	unnamed	09	SPI	9.46	57.908	9

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment	
932	1330484	79.52	469	1304606	77.9	1062	4100406	84.74	399		
1277	1331761	79.6	1498	1306106	77.99	894	4101300	84.76	400		
855	1332616	79.65	598	1306704	78.02	1197	4102497	84.78	401		
778	1333394	79.69	682	1307386	78.06	1400	4103897	84.81	402		
1437	1334831	79.78	654	1308040	78.1	1308	4105205	84.84	403		
0	1334831	79.78	0	1308040	78.1	0	4105205	84.84	404		
2687	1337518	79.94	2687	1310727	78.26	5374	4110579	84.95	405		
0	1337518	79.94	0	1310727	78.26	0	4110579	84.95	406		
2723	1340241	80.1	1089	1311816	78.33	2178	4112757	84.99	407		
123	1340364	80.11	123	1311939	78.33	246	4113003	85	408		
1208	1341572	80.18	342	1312281	78.36	1110	4114113	85.02	409		
407	1341979	80.21	0	1312281	78.36	2460	4116573	85.07	410	OHW = toe width	
498	1342477	80.24	448	1312729	78.38	896	4117469	85.09	411		
948	1343425	80.29	1114	1313843	78.45	2228	4119697	85.14	412		
1194	1344619	80.36	716	1314559	78.49	1433	4121130	85.17	413		
346	1344965	80.38	104	1314663	78.5	596	4121726	85.18	414	OHW = toe width	
607	1345572	80.42	243	1314906	78.51	486	4122212	85.19	415		
400	1345972	80.45	0	1314906	78.51	545	4122757	85.2	416		
949	1346921	80.5	427	1315333	78.54	854	4123611	85.22	417		
2150	1349071	80.63	1612	1316945	78.63	3225	4126836	85.29	418		
0	1349071	80.63	0	1316945	78.63	0	4126836	85.29	419		
780	1349851	80.68	546	1317491	78.67	1092	4127928	85.31	420		
871	1350722	80.73	1655	1319146	78.76	3310	4131238	85.38	421		
2532	1353254	80.88	1140	1320286	78.83	2279	4133517	85.42	422		
1029	1354283	80.94	808	1321094	78.88	1616	4135133	85.46	423		
600	1354883	80.98	540	1321634	78.91	1080	4136213	85.48	424		
462	1355345	81.01	520	1322154	78.94	1040	4137253	85.5	425		
331	1355676	81.03	266	1322420	78.96	350	4137603	85.51	426		
500	1356176	81.06	325	1322745	78.98	650	4138253	85.52	427		
361	1356537	81.08	180	1322925	78.99	361	4138614	85.53	428		
1167	1357704	81.15	1517	1324442	79.08	3034	4141648	85.59	429		
885	1358589	81.2	752	1325194	79.13	1504	4143152	85.62	430		
1368	1359957	81.28	752	1325946	79.17	1505	4144657	85.65	431		
1477	1361434	81.37	1477	1327423	79.26	2954	4147611	85.71	432		
1659	1363093	81.47	54	1327477	79.26	2090	4149701	85.76	433		
865	1363958	81.52	476	1327953	79.29	952	4150653	85.78	434		
1108	1365066	81.59	120	1328073	79.3	540	4151193	85.79	435	OHW = toe width	
3433	1368499	81.79	5514	1333587	79.63	6314	4157507	85.92	436		
1712	1370211	81.89	1198	1334785	79.7	2397	4159904	85.97	437		
1175	1371386	81.96	1586	1336371	79.79	3172	4163076	86.03	438		
418	1371804	81.99	287	1336658	79.81	305	4163381	86.04	439		
789	1372593	82.04	908	1337566	79.86	1815	4165196	86.08	440		
935	1373528	82.09	893	1338459	79.92	1786	4166982	86.11	441		
577	1374105	82.13	447	1338906	79.94	894	4167876	86.13	442		
915	1375020	82.18	810	1339716	79.99	1162	4169038	86.16	443		
1551	1376571	82.27	1318	1341034	80.07	2637	4171675	86.21	444		
1620	1378191	82.37	1458	1342492	80.16	2916	4174591	86.27	445		
909	1379100	82.43	1000	1343492	80.22	2000	4176591	86.31	446		
858	1379958	82.48	323	1343815	80.24	421	4177012	86.32	447		
971	1380929	82.53	874	1344689	80.29	1748	4178760	86.36	448		
647	1381576	82.57	388	1345077	80.31	776	4179536	86.37	449		
514	1382090	82.6	386	1345463	80.34	771	4180307	86.39	450		
0	1382090	82.6	0	1345463	80.34	0	4180307	86.39	451		
0	1382090	82.6	0	1345463	80.34	0	4180307	86.39	452		
0	1382090	82.6	0	1345463	80.34	0	4180307	86.39	453		
0	1382090	82.6	0	1345463	80.34	0	4180307	86.39	454		
0	1382090	82.6	0	1345463	80.34	0	4180307	86.39	455		
704	1382794	82.65	246	1345709	80.35	493	4180800	86.4	456		
631	1383425	82.68	820	1346529	80.4	1641	4182441	86.43	457		
804	1384229	82.73	844	1347373	80.45	1688	4184129	86.47	458		
861	1385090	82.78	763	1348136	80.5	1118	4185247	86.49	459		
758	1385848	82.83	455	1348591	80.52	910	4186157	86.51	460		
2103	1387951	82.95	3154	1351745	80.71	6309	4192466	86.64	461		
234	1388185	82.97	0	1351745	80.71	656	4193122	86.66	462		
4315	1392500	83.23	21575	1373320	82	43150	4236272	87.55	463		
1243	1393743	83.3	1305	1374625	82.08	2610	4238882	87.6	464		
370	1394113	83.32	407	1375032	82.1	814	4239696	87.62	465		
575	1394688	83.36	96	1375128	82.11	270	4239966	87.62	466		
200	1394888	83.37	900	1376028	82.16	1800	4241766	87.66	467		

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
996431			SR 112	34.2	unnamed	Deep Cr	19	SPI	9.43	58.032	1.2
996319		1	SR 20 ROW	46.14	unnamed	Campbell Lk	03	PI	9.41	58.156	1.23
996320	996319		SR 20	46.1	unnamed	Campbell Lk	03	PI	10.24	58.28	1.46
125 1806W34G			US 12	19.17	unnamed	Vance Cr	22	SPI	9.4	58.404	3.8
994066			SR 508	4.7	unnamed	SF Newaukum R	23	SPI	9.4	58.528	2.2
993673			US 101	84.15	unnamed	Grays Harbor	22	ETD	9.36	58.652	1.1
997210			SR 108	5.2	unnamed	unnamed to Skookum Cr	14	SPI	9.33	58.776	1
991154			SR 530	55.07	Hatchery Cr	Sauk R	04.1062	SPI	9.31	58.9	2.4
997693			SR 169	8.27	unnamed	Rock Cr	09	SPI	9.31	59.024	1.65
991250			US 101	335.93	unnamed	Hood Canal	16	SPI	9.27	59.148	2
991738			SR 112	51.6	Uptha Cr	Salt Cr	19	SPI	9.27	59.272	0.86
990046			SR 542	28.01	Bruce Cr	Nooksack R	01	SPI	9.26	59.396	1.8
995411			I-5	246.75	Chuckanut Cr	Puget Sound	01.0626	ETD	9.24	59.52	3
995760			US 101 ROW NB	284.87	unnamed	Snow Cr	17	SPI	9.24	59.644	1.8
996554			SR 112	24.26	unnamed	Pysht R	19	SPI	9.24	59.768	0.65
991851			SR 307	2.5	unnamed	Gamble Cr	15.0358	ETD	9.23	59.892	0.86
991835			SR 109	3.41	unnamed	Grays Harbor	22	ETD	9.21	60.016	
990294			SR 528	2.47	Munson Cr	Allen Cr	07.0073	SPI	9.2	60.14	2
991261			US 101	161.5	unnamed	Pacific Ocean	20.0000A	PI	9.19	60.264	3.96
990050			SR 16	22.7	Burley Cr	Henderson Bay	15.0056	SPI	9.18	60.388	1.7
990656			SR 510	5.64	unnamed	McAllister Cr	11.0028	PI	9.18	60.512	5.67
996555			SR 112	24.77	unnamed	Pysht R	19	SPI	9.18	60.636	0.75
991259			SR 112	12.26	unnamed	Hoko R	19.0148A	SPI	9.17	60.76	0.7
995994		2	SR 525	9.14	Clinton Cr	Puget Sound	06	PI	9.15	60.884	1.15
995986	995994		SR 525	9.54	Clinton Cr	Puget Sound	06	PI	6.48	61.008	1.1
995984	995994		SR 525	9.7	Clinton Cr	Puget Sound	06	PI	5.71	61.132	1.05
991614			US 101	322.83	unnamed	Hood Canal	16	PI	9.09	61.256	2.43
994471			US 101	256.9	unnamed	Siebert Cr	18	ETD	9.09	61.38	2.5
997066		1	US 101	117.38	unnamed	unnamed	20	SPI	9.08	61.504	0.92
997068	997066		US 101	177.58	unnamed	unnamed	20	SPI	6.05	61.628	0.65
993670			US 101	80.4	unnamed	Chehalis R	22	PI	9.07	61.752	2
991603			US 101	314.1	unnamed	Hood Canal	16.0331	ETD	9.06	61.876	5.34
991744			SR 3	52.21	Johnson Cr	Liberty Bay	15.0283	PI	9.06	62	0.86
991733			SR 113	0.9	unnamed	Beaver Cr	20	PI	9.04	62.124	2
991292			SR 508	5.46	unnamed	SF Newaukum R	23	SPI	9.03	62.248	3.1
990534			SR 6	40.53	unnamed	Chehalis R	23	SPI	9.02	62.372	1.6
993083			SR 522	11.31	unnamed	Sammamish R	08	SPI	9.02	62.496	4
990376			I-405	19.12	Forbes Cr	Juanita Bay	08.0242	SPI	8.96	62.62	3
990757			SR 6	35.42	unnamed	Chehalis R	23	SPI	8.96	62.744	2.8
993084		1	SR 527	2.78	unnamed	North R	08	ETD	8.93	62.868	2.3
993109	993084		I-405	26.87	unnamed	North Cr	08	ETD	9.33	62.992	1.95
996752			SR 16	21.58	unnamed	Burley Cr	15	SPI	8.93	63.116	2.2
997072			US 101	177.97	unnamed	unnamed	20	SPI	8.89	63.24	1.2
991612		1	SR 3	59.52	unnamed	Hood Canal	15.0361	SPI	8.88	63.364	1
996811	991612		SR 3	59.55	unnamed	unnamed	15.0362	SPI	8.77	63.488	1
990084			SR 7	11.56	Coal Cr	Roundtop Cr	11.0168	PI	8.86	63.612	2.68
991541			US 12	28.17	unnamed	Chehalis R	23	PI	8.86	63.736	1.8
991283			US 12	5.24	unnamed	Mox Chuck Sl	22	PI	8.82	63.86	
990749			SR 6	32	unnamed	Chehalis R	23	SPI	8.81	63.984	1.3
997161			US 101	357.4	unnamed	Schneider Cr	14	SPI	8.8	64.108	1.3
HC53			SR 9	59.08	unnamed	unnamed; Hansen Cr	03	SPI	8.8	64.232	0.9
990770			SR 8	6.1	unnamed	EF Wildcat Cr	22	PI	8.77	64.356	1.2
991290			SR 508	15.1	unnamed	Kearney Cr	23	SPI	8.75	64.48	2.2
997055			US 101	174.43	unnamed	Hoh R	20	SPI	8.75	64.604	1.2
990543			US 101	131.96	unnamed	Ten O Clock Cr	21	SPI	8.74	64.728	1.7
996270			SR 509	10.96	Lakota Cr	Puget Sound	10.0386	SPI	8.73	64.852	1.1
991647			US 101	175.45	unnamed	Hoh R	20	PI	8.72	64.976	1.77
991277			US 101	156.15	unnamed	Pacific Ocean	21	SPI	8.69	65.1	1.8
996801			SR 3	46.82	unnamed	Clear Cr	15	SPI	8.68	65.224	1
DM7			SR 20	116.25	unnamed	Skagit R	04	SPI	8.67	65.348	4
991293			SR 508	6.78	unnamed	SF Newaukum R	23	SPI	8.62	65.472	1
993698			US 101	95.46	Unnamed	WF Hoquiam R	22	PI	8.62	65.596	2
997349			US 101	158.26	unnamed	Pacific Ocean	21	SPI	8.62	65.72	2.6
997649			SR 516	2.98	unnamed	Green R	09.0043	SPI	8.61	65.844	2.45
990685			SR 542	15.08	unnamed	NF Nooksack R	01	SPI	8.57	65.968	1.5
997052			US 101	169.94	unnamed	Nolan Cr	20	PI	8.57	66.092	1.3
991214			SR 162	3.7	unnamed	Puyallup R	10.0399	SPI	8.56	66.216	1.7
991508			US 101	182.84	unnamed	Dowans Cr	20	SPI	8.56	66.34	3.75
991666			US 101	269.24	unnamed	Sequim Bay	17.0297	PI	8.54	66.464	2.05

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment
419	1398307	83.39	252	1378280	82.18	503	4242269	87.67	468	
672	1398979	83.43	38	1378318	82.18	631	4242900	87.68	469	
0	1398979	83.43	0	1378318	82.18	0	4242900	87.68	470	
2800	1398779	83.6	5320	1381638	82.5	10640	4253540	87.9	471	
533	1399312	83.63	586	1382224	82.53	1173	4254713	87.93	472	
2045	1401357	83.76	267	1382491	82.55	743	4255456	87.94	473	OHW = toe width
761	1402118	83.8	380	1382871	82.57	761	4256217	87.96	474	
351	1402469	83.82	421	1383292	82.6	842	4257059	87.98	475	
1357	1403826	83.9	1120	1384412	82.66	2239	4259298	88.02	476	
250	1404076	83.92	250	1384662	82.68	500	4259798	88.03	477	
1299	1405375	84	552	1385214	82.71	1104	4260902	88.06	478	
3153	1408528	84.18	2838	1388052	82.88	5675	4266577	88.17	479	
240	1408768	84.2	577	1388629	82.91	586	4267163	88.19	480	OHW = toe width
516	1409284	84.23	464	1389093	82.94	929	4268092	88.2	481	
714	1409998	84.27	232	1389325	82.96	464	4268556	88.21	482	
220	1410218	84.28	38	1389363	82.96	114	4268670	88.22	483	OHW = toe width
200	1410418	84.3	0	1389363	82.96	330	4269000	88.22	484	no OHW data
1090	1411508	84.36	1090	1390453	83.02	2180	4271180	88.27	485	
277	1411785	84.38	242	1390695	83.04	572	4271752	88.28	486	
1269	1413054	84.45	1078	1391773	83.1	2157	4273909	88.32	487	
1449	1414503	84.54	0	1391773	83.1	1790	4275699	88.36	488	
409	1414912	84.57	154	1391927	83.11	307	4276006	88.37	489	
1513	1416425	84.66	530	1392457	83.14	1059	4277065	88.39	490	
1367	1417792	84.74	248	1392705	83.16	755	4277820	88.41	491	
0	1417792	84.74	0	1392705	83.16	0	4277820	88.41	492	
0	1417792	84.74	0	1392705	83.16	0	4277820	88.41	493	
571	1418363	84.77	499	1393204	83.19	450	4278270	88.41	494	
914	1419277	84.83	58	1393262	83.19	527	4278797	88.43	495	OHW = toe width
730	1420007	84.87	336	1393598	83.21	672	4279469	88.44	496	
0	1420007	84.87	0	1393598	83.21	0	4279469	88.44	497	
219	1420226	84.88	4	1393602	83.21	729	4280198	88.45	498	
2265	1422491	85.02	4493	1398095	83.48	3940	4284138	88.54	499	OHW = toe width
1050	1423541	85.08	346	1398441	83.5	333	4284471	88.54	500	
363	1423904	85.1	265	1398706	83.52	224	4284695	88.55	501	
600	1424504	85.14	930	1399636	83.57	1860	4286555	88.59	502	
536	1425040	85.17	429	1400065	83.6	858	4287413	88.6	503	
1197	1426237	85.24	2394	1402459	83.74	4788	4292201	88.7	504	
1296	1427533	85.32	1944	1404403	83.86	3888	4296089	88.78	505	
700	1428233	85.36	980	1405383	83.91	1960	4298049	88.82	506	
616	1428849	85.4	182	1405565	83.92	338	4298387	88.83	507	OHW = toe width
0	1428849	85.4	0	1405565	83.92	0	4298387	88.83	508	OHW = toe width
580	1429429	85.43	638	1406203	83.96	1276	4299663	88.86	509	
779	1430208	85.48	468	1406671	83.99	935	4300598	88.88	510	
945	1431153	85.54	472	1407143	84.02	945	4301543	88.9	511	
0	1431153	85.54	0	1407143	84.02	0	4301543	88.9	512	
1101	1432254	85.6	484	1407627	84.05	1394	4302937	88.92	513	
1145	1433399	85.67	441	1408068	84.07	988	4303925	88.95	514	
691	1434090	85.71	110	1408178	84.08	391	4304316	88.95	515	no OHW data
600	1434690	85.75	390	1408568	84.1	780	4305096	88.97	516	
760	1435450	85.79	494	1409062	84.13	988	4306084	88.99	517	
791	1436241	85.84	356	1409418	84.16	712	4306796	89	518	
359	1436600	85.86	0	1409418	84.16	438	4307234	89.01	519	
810	1437410	85.91	891	1410309	84.21	1782	4309016	89.05	520	
320	1437730	85.93	192	1410501	84.22	384	4309400	89.06	521	
514	1438244	85.96	437	1410938	84.25	874	4310274	89.08	522	
1056	1439300	86.02	581	1411519	84.28	1162	4311436	89.1	523	
853	1440153	86.07	158	1411677	84.29	578	4312014	89.11	524	
200	1440353	86.09	180	1411857	84.3	360	4312374	89.12	525	
569	1440922	86.12	284	1412141	84.32	569	4312943	89.13	526	
725	1441647	86.16	1450	1413591	84.4	2900	4315843	89.19	527	
1680	1443327	86.26	840	1414431	84.45	1680	4317523	89.23	528	
240	1443567	86.28	20	1414451	84.46	122	4317645	89.23	529	
200	1443767	86.29	260	1414711	84.47	520	4318165	89.24	530	
448	1444215	86.32	549	1415260	84.5	1098	4319263	89.26	531	
805	1445020	86.36	604	1415864	84.54	1208	4320471	89.29	532	
802	1445822	86.41	908	1416772	84.59	693	4321164	89.3	533	
1285	1447107	86.49	1092	1417864	84.66	2184	4323348	89.35	534	
658	1447765	86.53	1234	1419098	84.73	2468	4325816	89.4	535	
861	1448626	86.58	598	1419696	84.77	839	4326655	89.41	536	

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
997974			SR 161	32.9	unnamed	unnamed	10	SPI	8.53	66.588	1.4
991509			US 101	183.05	unnamed	Dowans Cr	20	SPI	8.51	66.712	3
997158			US 101	354.01	unnamed	unnamed	14	SPI	8.51	66.836	1.4
995007			US 101	316.19	unnamed	Hood Canal	16	SPI	8.5	66.96	2.2
DM5			SR 20	117.61	unnamed	Newhalem Ponds	04	SPI	8.5	67.084	6.8
991221			SR 6	43.61	unnamed	Chehalis R	23	SPI	8.46	67.208	2.9
996494			SR 169	18.48	unnamed	Cedar R	08	SPI	8.45	67.332	2
996528			SR 112	44.32	unnamed	Murdock Cr	19.0079	SPI	8.45	67.456	1.5
991239			SR 302	2.36	unnamed	Case Inlet	15	SPI	8.43	67.58	0.75
990577			SR 542	24.49	unnamed	High Cr	01	SPI	8.42	67.704	1.6
995409			SR 542	28.87	unnamed	NF Nooksack R	01	ETD	8.41	67.828	0.7
991016			SR 410	56.51	unnamed	White R	10	SPI	8.38	67.952	2.7
GR9			SR 20	87.7	Fish Cr	Skagit R	04	SPI	8.38	68.076	1.5
992345			SR 9	77.12	unnamed	Black Sl	01	ETD	8.37	68.2	1
990023			SR 542	28.74	Baptist Camp Cr	NF Nooksack R	01.0433	PI	8.36	68.324	2.1
990111			SR 104	25.7	Willow Cr	Puget Sound	08.0011	PI	8.36	68.448	1.8
990659			SR 112	6.95	unnamed	Strait of Juan de Fuca	19	SPI	8.36	68.572	1.85
994308			SR 20	94.47	unnamed	Skagit R	04.0654	ETD	8.33	68.696	2.1
997182			SR 106	11.57	unnamed	Hood Canal	14.0136	SPI	8.3	68.82	1.7
995963			SR 99	22.33	Riverton Cr	Duwamish R	09	SPI	8.29	68.944	1.6
997063			US 101	176.56	unnamed	Hoh R	20	SPI	8.29	69.068	0.8
101NORT-36			US 2	19.3	unnamed	Skykomish R	07.0663	PI	8.28	69.192	6
995138			SR 204	0.54	unnamed	Ebey Sl	07	SPI	8.28	69.316	1.7
991735		1	US 101	271.22	unnamed	Sequim Bay	17	PI	8.27	69.44	1.5
994478	991735		US 101 ROW	271.22	unnamed	Sequim Bay	17	PI	8.27	69.564	1.2
996432			SR 112	34.28	unnamed	Deep Cr	19	SPI	8.27	69.688	1
991205			SR 410	23.83	unnamed	Boise Cr	10	SPI	8.25	69.812	0.9
991574			US 101	181.46	unnamed	Dowans Cr	20.0248A	PI	8.24	69.936	2.4
997078			US 101	179.73	unnamed	Hell Roaring Cr	20	SPI	8.2	70.06	1.4
990423			SR 6	38.74	unnamed	Hope Cr	23	SPI	8.19	70.184	1.5
994984			I-90 WB	24.85	unnamed	Lake Cr	07	SPI	8.15	70.308	2
995150			SR 204	1.19	unnamed	Ebey Sl	07.0093	SPI	8.15	70.432	1.1
105 R072016a			SR 410	56.29	Dry Cr	White R	10	SPI	8.08	70.556	3
990603			SR 542	36.61	Lookout Cr	NF Nooksack R	01	SPI	8.07	70.68	4.3
991978			SR 104	5.75	unnamed	Chimacum Cr	17.0212	SPI	8.07	70.804	3.1
996003			SR 548	0.29	California Cr	Drayton Harbor	01.0082	SPI	8.07	70.928	1.5
991516			SR 16	20.36	unnamed	Burley Cr	15	PI	8.04	71.052	1.38
997224			SR 108	9.35	unnamed	unnamed to Skookum Cr	14	SPI	8.04	71.176	1
18.0283 2.00		1	US 101	238.36	Indian Cr	Elwah R	18.0283	SPI	8	71.3	9.5
995817	18.0283 2.00		US 101	236.36	unnamed	Indian Cr	18	SPI	7.7	71.424	1.22
992200			SR 104	17.82	unnamed	Port Gamble	15	SPI	8	71.548	0.8
996734			SR 3	25.15	unnamed	Hood Canal	15.0123	SPI	8	71.672	1.05
996887			SR 908	5.69	Peter's Cr	Sammamish R	08.0104	PI	7.98	71.796	2
990639			SR 530	34.3	unnamed	NF Stillaguamish R	05	SPI	7.96	71.92	0.6
997082			US 101	183.44	unnamed	Dowans Cr	20	SPI	7.95	72.044	1
994326			SR 305	3.73	unnamed	Manzanita Bay	15.0344	SPI	7.94	72.168	1.13
991515			US 101	187.79	unnamed	Bogachiel R	20	SPI	7.9	72.292	2.1
995023			US 2	52.7	unnamed	Tye R	07	SPI	7.87	72.416	1.5
996164			SR 546	2.01	unnamed	Fishtrap Cr	01.0214	SPI	7.85	72.54	2
991911			US 12	7.26	unnamed	Higgins Sl	22	PI	7.82	72.664	2.53
995777			SR 542	17.38	unnamed	NF Nooksack R	01	SPI	7.8	72.788	1.9
995430			SR 20 SPUR	50.48	unnamed	Fidalgo Bay	03	SPI	7.74	72.912	1.3
990738			SR 6	25.24	unnamed	Rock Cr	23	SPI	7.72	73.036	1.8
995295		7	I-5 NB ROW	141.17	unnamed	EF Hylebos Cr	10.0016	PI	7.71	73.16	1.8
992364	995295		I-5	143.6	unnamed	EF Hylebos Cr	10.0013	ETD	10.79	73.284	
995299	995295		I-5 Ext 143 NB	143	unnamed	Hylebos Cr	10.0013	ETD	8.58	73.408	1.4
995300	995295		I-5 Ext 143 NB	143	unnamed	Hylebos Cr	10.0013	ETD	8.58	73.532	1
995297	995295		I-5 On Ext 142 SB	142	unnamed	EF Hylebos Cr	10.0016	PI	7.16	73.656	2.6
995292	995295		I-5	141.49	unnamed	EF Hylebos Cr	10.0016	PI	7	73.78	2.17
995298	995295		SR 18	0.45	unnamed	EF Hylebos Cr	10.0016	PI	6.09	73.904	2.6
995293	995295		I-5 Ext 142 SB	142.15	unnamed	Hylebos Cr	10.0016	PI	4.55	74.028	1.6
991653			US 101	126.24	unnamed	Quinault R	21	PI	7.69	74.152	1.98
991533			US 12	23.3	unnamed	Chehalis R	22	ETD	7.66	74.276	1.45
995238		1	I-5 SB	241.03	unnamed	Friday Cr	03	SPI	7.66	74.4	1.2
995240	995238		I-5 Ext 240 SB	240	unnamed	Friday Cr	03	SPI	8.15	74.524	1.2
997687			SR 99	24.86	NF Hamm Cr	Duwamish R	09	SPI	7.65	74.648	2.3
991507			US 101	182.2	unnamed	Dowans Cr	20	SPI	7.61	74.772	3.7
997109			US 101	210.78	unnamed	Sol Duc R	20	SPI	7.57	74.896	4
991527			SR 302	5.5	unnamed	Rocky Bay	15	SPI	7.56	75.02	1.2

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment	
1485	1450111	86.67	1040	1420736	84.83	2079	4328734	89.46	537		
804	1450915	86.72	1206	1421942	84.9	2412	4331146	89.51	538		
415	1451330	86.74	290	1422232	84.92	581	4331727	89.52	539		
533	1451863	86.77	586	1422818	84.96	1173	4332900	89.54	540		
251	1452114	86.79	854	1423672	85.01	1707	4334607	89.58	541		
810	1452924	86.84	1174	1424846	85.08	2349	4336956	89.63	542		
669	1453593	86.88	669	1425515	85.12	1338	4338294	89.66	543		
341	1453934	86.9	256	1425771	85.13	512	4338806	89.67	544		
677	1454611	86.94	254	1426025	85.15	508	4339314	89.68	545		
1906	1456517	87.05	1525	1427550	85.24	3050	4342364	89.74	546		
300	1456817	87.07	56	1427606	85.24	188	4342552	89.74	547	OHW = toe width	
719	1457536	87.11	970	1428576	85.3	1941	4344493	89.78	548		
1480	1459016	87.2	1110	1429686	85.37	2220	4346713	89.83	549		
643	1459659	87.24	15	1429701	85.37	752	4347465	89.84	550	OHW = toe width	
512	1460171	87.27	344	1430045	85.39	810	4348275	89.86	551		
692	1460863	87.31	277	1430322	85.4	482	4348757	89.87	552		
801	1461664	87.36	741	1431063	85.45	1482	4350239	89.9	553		
1232	1462896	87.43	806	1431869	85.5	1555	4351794	89.93	554	OHW = toe width	
1970	1464866	87.55	1674	1433543	85.6	3349	4355143	90	555		
663	1465529	87.59	530	1434073	85.63	1061	4356204	90.03	556		
392	1465921	87.61	157	1434230	85.64	314	4356518	90.03	557		
1791	1467712	87.72	74	1434304	85.64	1449	4357967	90.06	558		
419	1468131	87.75	356	1434660	85.66	712	4358679	90.08	559		
317	1468448	87.77	0	1434660	85.66	609	4359288	90.09	560		
0	1468448	87.77	0	1434660	85.66	0	4359288	90.09	561		
200	1468648	87.78	100	1434760	85.67	200	4359488	90.09	562		
200	1468848	87.79	90	1434850	85.67	180	4359668	90.1	563		
677	1469525	87.83	268	1435118	85.69	1585	4361253	90.13	564		
320	1469845	87.85	224	1435342	85.7	448	4361701	90.14	565		
1671	1471516	87.95	1253	1436595	85.78	2506	4364207	90.19	566		
1233	1472749	88.02	1233	1437828	85.85	2466	4366673	90.24	567		
1209	1473958	88.09	665	1438493	85.89	1330	4368003	90.27	568		
3686	1477644	88.31	5529	1444022	86.22	11058	4379061	90.5	569		
2554	1480198	88.47	5491	1449513	86.55	10982	4390043	90.72	570		
1200	1481398	88.54	1860	1451373	86.66	3720	4393763	90.8	571		
1302	1482700	88.62	976	1452349	86.72	1953	4395716	90.84	572		
817	1483517	88.67	186	1452535	86.73	308	4396024	90.85	573		
1271	1484788	88.74	636	1453171	86.77	1271	4397295	90.87	574		
19948	1504736	89.93	94753	1547924	92.43	189506	4586801	94.79	575		
0	1504736	89.93	0	1547924	92.43	0	4586801	94.79	576		
1036	1505772	90	414	1548338	92.45	829	4587630	94.81	577		
593	1506365	90.03	312	1548650	92.47	623	4588253	94.82	578		
820	1507185	90.08	656	1549306	92.51	516	4588769	94.83	579		
980	1508165	90.14	294	1549599	92.53	588	4589357	94.84	580		
400	1508565	90.16	200	1549799	92.54	400	4589757	94.85	581		
791	1509356	90.21	447	1550246	92.56	894	4590651	94.87	582		
1310	1510666	90.29	1376	1551622	92.65	2751	4593402	94.93	583		
325	1510991	90.31	244	1551866	92.66	488	4593890	94.94	584		
3161	1514152	90.5	3161	1555027	92.85	6322	4600212	95.07	585		
300	1514452	90.51	226	1555253	92.86	378	4600590	95.08	586		
360	1514812	90.54	342	1555595	92.88	684	4601274	95.09	587		
551	1515363	90.57	358	1555953	92.9	716	4601990	95.1	588		
325	1515688	90.59	292	1556245	92.92	585	4602575	95.12	589		
1637	1517325	90.69	826	1557071	92.97	1522	4604097	95.15	590		
0	1517325	90.69	0	1557071	92.97	0	4604097	95.15	591	no OHW data	
0	1517325	90.69	0	1557071	92.97	0	4604097	95.15	592	OHW = toe width	
0	1517325	90.69	0	1557071	92.97	0	4604097	95.15	593	OHW = toe width	
0	1517325	90.69	0	1557071	92.97	0	4604097	95.15	594		
0	1517325	90.69	0	1557071	92.97	0	4604097	95.15	595		
0	1517325	90.69	0	1557071	92.97	0	4604097	95.15	596		
0	1517325	90.69	0	1557071	92.97	0	4604097	95.15	597		
278	1517603	90.7	94	1557165	92.98	117	4604214	95.15	598		
	1517603	90.7		1557165	92.98		4604214	95.15	599	OHW = toe width	
381	1517984	90.73	228	1557393	92.99	457	4604671	95.16	600		
0	1517984	90.73	0	1557393	92.99	0	4604671	95.16	601		
443	1518427	90.75	510	1557903	93.02	1019	4605690	95.18	602		
641	1519068	90.79	1186	1559089	93.09	2372	4608062	95.23	603		
550	1519618	90.82	1100	1560189	93.16	2200	4610262	95.28	604		
814	1520432	90.87	488	1560677	93.19	977	4611239	95.3	605		

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
105 R071916a			SR 410	48.29	Boundary Cr	White R	10.0250	PI	7.55	75.144	2.55
999410			I-405	6.31	Clover Cr	Lk Washington	08	SPI	7.55	75.268	0.9
991623			SR 104	31.73	unnamed	Lyon Cr	08	SPI	7.53	75.392	2.5
997235			SR 3	4.67	unnamed	Oakland Bay	14	SPI	7.5	75.516	1
991229			SR 702	4.53	unnamed	unnamed to Nisqually R	11.0058	SPI	7.48	75.64	3.4
991505			US 101	188.09	unnamed	Bogachiel R	20	SPI	7.46	75.764	1.8
996430			SR 112	34.12	unnamed	Deep Cr	19	SPI	7.46	75.888	2
996931			SR 308	0.3	Clear Cr	Puget Sound	15.0249	SPI	7.46	76.012	0.9
990410			SR 20	99.95	Sutter Cr	Skagit R	04.1345	PI	7.42	76.136	3.4
995753			SR 20	3.67	unnamed	Discovery Bay	17	PI	7.41	76.26	1.23
996032			I-405	7.62	Gypsy Cr	Lk Washington	08	SPI	7.4	76.384	1.4
991264			US 101	189.15	unnamed	Grader Cr	20	PI	7.39	76.508	1.06
992381			SR 522	19.38	unnamed	Anderson Cr	07	ETD	7.37	76.632	1.7
996366			US 101	334.4	unnamed	Hood Canal	16	SPI	7.35	76.756	1.4
997645			SR 515	3.97	Panther Cr	Springbrook Cr	09.0006	SPI	7.33	76.88	1.2
998977			I-405 SB	27.83	unnamed	North Cr	08	SPI	7.3	77.004	1.4
115 MC276			US 101	361.22	unnamed	Eld Inlet	14	SPI	7.29	77.128	0.8
991579			SR 19	6.82	unnamed	EF Chimacum Cr	17	SPI	7.26	77.252	0.95
994979			SR 508	16.5	unnamed	unnamed to Stowell Cr	23	SPI	7.26	77.376	4.3
990555			US 101	259.79	unnamed	Josun Ditch	18	ETD	7.24	77.5	1.5
996735			SR 3	26.13	unnamed	Union R	15	SPI	7.23	77.624	1.3
991670			SR 16	28.6	unnamed	Sinclair Inlet	15.0215	SPI	7.22	77.748	2.8
997780			SR 109	27.05	unnamed	Pacific Ocean	21	SPI	7.21	77.872	1.9
995916			SR 119	7.8	unnamed	Lk Cushman	16	SPI	7.2	77.996	2.4
990712			US 101	271.57	unnamed	Sequim Bay	17.0284	ETD	7.18	78.12	
990746			SR 6	31.26	Fronia Cr	Chehalis R	23.1145	SPI	7.17	78.244	1
995215			SR 96	5.96	unnamed	unnamed to Snohomish R	07.0123	SPI	7.17	78.368	1
990628			SR 530	26.29	unnamed	unnamed	05	SPI	7.14	78.492	0.6
105 R040517a			SR 162	19.11	unnamed	S Prairie Cr	10	SPI	7.11	78.616	2.3
991720			SR 203	4.37	unnamed	Snoqualmie R	07	SPI	7.1	78.74	2.1
997790			SR 109	36	unnamed	Pacific Ocean	21	SPI	7.07	78.864	1.25
997071			US 101	177.8	unnamed	unnamed	20	SPI	7.06	78.988	0.95
990756			SR 6	35.08	unnamed	Chehalis R	23	SPI	7.05	79.112	1.4
996006			SR 548	0.87	unnamed	California Cr	01	SPI	7.04	79.236	1.5
996163			SR 548	1.47	unnamed	Fishtrap Cr	01.0213	SPI	7.01	79.36	2
991615			US 101	317.45	unnamed	Hood Canal	16	SPI	6.98	79.484	0.9
997168			SR 106	7.71	unnamed	Hood Canal	14	SPI	6.98	79.608	0.75
991523			SR 302	2.48	unnamed	North Bay	15	SPI	6.96	79.732	0.92
997093			US 101	188.19	unnamed	Bogachiel R	20	SPI	6.96	79.856	0.67
995936			US 101	310.4	unnamed	Hood Canal	16	SPI	6.94	79.98	1.6
995086			SR 9	16.66	Hulbert Cr	Ebey Sl	07.0086	SPI	6.85	80.104	1.21
995181			SR 203	14.1	unnamed	Snoqualmie R	07	SPI	6.81	80.228	1.2
990997			SR 303	4.41	unnamed	Steele Cr	15	SPI	6.77	80.352	2.5
991827			SR 92	0.78	unnamed	Lake Stevens	07.0150	SPI	6.76	80.476	1.4
991225			SR 7	37.5	unnamed	South Cr	11.0032	SPI	6.72	80.6	1.8
996574			SR 113	9.81	unnamed	Pysht R	19	SPI	6.7	80.724	1.45
LP32			SR 9	38.69	unnamed	unnamed	05	SPI	6.7	80.848	1.5
996266			SR 509	9.18	unnamed	Puget Sound	10	SPI	6.67	80.972	1
370614			I-5	243.43	Unnamed	Lk Samish	03	ETD	6.64	81.096	4.7
994971			SR 508	11.27	unnamed	SF Newaukum R	23	SPI	6.61	81.22	1.7
991254			US 101	331.83	unnamed	Hood Canal	16	PI	6.6	81.344	
992360			SR 164	5.89	unnamed	White R	10	SPI	6.6	81.468	1.5
997660			SR 18	7.51	unnamed	Big Soos Cr	09	SPI	6.58	81.592	1.75
995141			SR 204	0.96	unnamed	Ebey Sl	07	SPI	6.54	81.716	1.1
990602			SR 542	34.49	unnamed	NF Nooksack R	01	SPI	6.52	81.84	1
995908			SR 119	2.76	Dow Cr	Lk Kokanee	16.0112	SPI	6.49	81.964	6.1
996619			SR 410	21.73	unnamed	LkTapps Canal	10	SPI	6.49	82.088	1.9
995214			SR 96	5.86	unnamed	unnamed to Snohomish R	07	SPI	6.48	82.212	0.9
101S-22			SR 202	22.56	unnamed	Snoqualmie R	07.0429	ETD	6.47	82.336	1.1
995485			US 101	276.22	unnamed	Discovery Bay	17	SPI	6.46	82.46	1.7
997681			SR 509	29.06	Lost Fork Hamm Cr	Duwamish R	09	SPI	6.46	82.584	1.1
991298			SR 105	40.5	unnamed	South Bay	22	PI	6.45	82.708	2
995481			US 101	266.59	unnamed	Johnson Cr	17	SPI	6.45	82.832	1.9
997371			SR 3	8.28	unnamed	Oakland Bay	14	SPI	6.45	82.956	1
990474			SR 410	25.19	Watercress Cr	Newaukum Cr	09	SPI	6.42	83.08	2.85
991149			SR 20	60.2	unnamed	Skagit R	03	SPI	6.42	83.204	0.9
991242			SR 3	57.23	unnamed	Kinman Cr	15	SPI	6.41	83.328	1

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment	
596	1521028	90.91	453	1561130	93.21	647	4611886	95.31	606		
1079	1522107	90.97	486	1561616	93.24	971	4612857	95.33	607		
2072	1524179	91.1	2590	1564206	93.4	5180	4618037	95.44	608		
326	1524505	91.12	163	1564369	93.41	326	4618363	95.44	609		
248	1524753	91.13	422	1564791	93.43	843	4619206	95.46	610		
790	1525543	91.18	711	1565502	93.47	1422	4620628	95.49	611		
200	1525743	91.19	200	1565702	93.49	400	4621028	95.5	612		
517	1526260	91.22	232	1565934	93.5	465	4621493	95.51	613		
497	1526757	91.25	123	1566057	93.51	579	4622072	95.52	614		
1027	1527784	91.31	216	1566273	93.52	335	4622407	95.53	615		
963	1528747	91.37	674	1566947	93.56	1348	4623755	95.55	616		
302	1529049	91.39	46	1566993	93.56	164	4623919	95.56	617		
603	1529652	91.42	160	1567153	93.57	318	4624237	95.56	618	OHW = toe width	
265	1529917	91.44	186	1567339	93.58	371	4624608	95.57	619		
1454	1531371	91.53	872	1568211	93.64	1745	4626353	95.61	620		
516	1531887	91.56	361	1568572	93.66	722	4627075	95.62	621		
1623	1533510	91.65	649	1569221	93.7	1298	4628373	95.65	622		
658	1534168	91.69	312	1569533	93.72	625	4628998	95.66	623		
2047	1536215	91.82	4401	1573934	93.98	8802	4637800	95.84	624		
1086	1537301	91.88	50	1573984	93.98	450	4638250	95.85	625	OHW = toe width	
944	1538245	91.94	614	1574598	94.02	1227	4639477	95.88	626		
1920	1540165	92.05	2688	1577286	94.18	5376	4644853	95.99	627		
861	1541026	92.1	818	1578104	94.23	1636	4646489	96.02	628		
1501	1542527	92.19	1801	1579905	94.33	3602	4650091	96.1	629		
896	1543423	92.25	83	1579988	94.34	198	4650289	96.1	630	no OHW data	
1767	1545190	92.35	884	1580872	94.39	1767	4652056	96.14	631		
1187	1546377	92.42	594	1581466	94.43	1187	4653243	96.16	632		
1269	1547646	92.5	380	1581846	94.45	761	4654004	96.18	633		
650	1548296	92.54	748	1582594	94.5	1495	4655499	96.21	634		
1008	1549304	92.6	1058	1583652	94.56	2117	4657616	96.25	635		
200	1549504	92.61	125	1583777	94.57	250	4657866	96.26	636		
392	1549896	92.63	186	1583963	94.58	372	4658238	96.27	637		
810	1550706	92.68	567	1584530	94.61	1134	4659372	96.29	638		
1097	1551803	92.75	823	1585353	94.66	1646	4661018	96.32	639		
2009	1553812	92.87	2009	1587362	94.78	4018	4665036	96.41	640		
1936	1555748	92.98	871	1588233	94.83	1742	4666778	96.44	641		
350	1556098	93	131	1588364	94.84	262	4667040	96.45	642		
509	1556607	93.03	234	1588598	94.85	468	4667508	96.46	643		
526	1557133	93.07	176	1588774	94.86	352	4667860	96.47	644		
670	1557803	93.11	536	1589310	94.9	1072	4668932	96.49	645		
700	1558503	93.15	424	1589734	94.92	847	4669779	96.51	646		
807	1559310	93.2	484	1590218	94.95	968	4670747	96.53	647		
800	1560110	93.24	1000	1591218	95.01	2000	4672747	96.57	648		
1161	1561271	93.31	812	1592030	95.06	1625	4674372	96.6	649		
3704	1564975	93.53	3334	1595364	95.26	6667	4681039	96.74	650		
207	1565182	93.55	150	1595514	95.27	300	4681339	96.74	651		
788	1565970	93.59	591	1596105	95.3	1182	4682521	96.77	652		
398	1566368	93.62	199	1596304	95.31	398	4682919	96.78	653		
850	1567218	93.67	394	1596698	95.34	570	4683489	96.79	654	OHW = toe width	
342	1567560	93.69	290	1596988	95.35	581	4684070	96.8	655		
364	1567924	93.71	58	1597046	95.36	129	4684199	96.8	656	no OHW data	
1785	1569709	93.82	1339	1598385	95.44	2678	4686877	96.86	657		
415	1570124	93.84	363	1598748	95.46	726	4687603	96.87	658		
928	1571052	93.9	510	1599258	95.49	1021	4688624	96.9	659		
200	1571252	93.91	100	1599358	95.5	200	4688824	96.9	660		
993	1572245	93.97	3028	1602386	95.68	6057	4694881	97.02	661		
280	1572525	93.99	266	1602652	95.69	532	4695413	97.04	662		
1092	1573617	94.05	492	1603144	95.72	983	4696396	97.06	663		
630	1574247	94.09	262	1603406	95.74	547	4696943	97.07	664	OHW = toe width	
2253	1576500	94.22	1915	1605321	95.85	3830	4700773	97.15	665		
355	1576855	94.24	196	1605517	95.86	391	4701164	97.15	666		
228	1577083	94.26	58	1605575	95.87	170	4701334	97.16	667		
1202	1578285	94.33	1142	1606717	95.94	2284	4703618	97.21	668		
260	1578545	94.35	130	1606847	95.94	260	4703878	97.21	669		
200	1578745	94.36	285	1607132	95.96	570	4704448	97.22	670		
201	1578946	94.37	90	1607222	95.97	181	4704629	97.23	671		
1815	1580761	94.48	908	1608130	96.02	1815	4706444	97.26	672		

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
995992			SR 525	11.99	unnamed	unnamed	06	SPI	6.41	83.452	1
991291			SR 508	17.06	unnamed	Stowell Cr	23	SPI	6.4	83.576	2.8
994967			SR 508	5.75	unnamed	SF Newaukum R	23	SPI	6.4	83.7	1.2
930023			SR 160	2.04	unnamed	Salmonberry Cr	15	SPI	6.38	83.824	3.1
994959			SR 508	1.85	unnamed	unnamed to Allen Cr	23	SPI	6.3	83.948	1.8
996076			I-5 Ext 210 NB	210.01	unnamed	Stillaguamish R	05	SPI	6.3	84.072	0.8
995137			SR 204	0.21	unnamed	unnamed to Ebey Sl	07	SPI	6.28	84.196	1
997781			SR 109	27.41	Spruce Cr	Pacific Ocean	21	SPI	6.27	84.32	2.3
993681		1	US 101	89.48	unnamed	Hoquiam R	22	PI	6.25	84.444	1.1
993674	993681		US 101	89.48	unnamed	Hoquiam R	22	PI	7.41	84.568	1.2
991595			US 101	178.03	unnamed	unnamed	20	SPI	6.23	84.692	0.9
994976			SR 508	15.42	unnamed	unnamed to Kearney Cr	23	SPI	6.23	84.816	4.2
101SA-06			SR 202	23.18	Skunk Cr	Mud Cr	07.0436	SPI	6.19	84.94	1.3
105 R032517a		1	SR 162	12.42	Rauch Cr	Carbon R	10	SPI	6.19	85.064	1.7
105 R032918d	105 R032517a		SR 162	12.44	Rauch Cr	Carbon R	10	SPI	6.1	85.188	1.7
991241			SR 3	50.85	SF Johnson Cr	Johnson Cr	15.0282	ETD	6.19	85.312	1.1
994954			SR 508	0.53	Allen Cr	Newaukum R	23.0883	SPI	6.1	85.436	3.4
996798			SR 3 SB on-ramp	39.13	unnamed	Dyes Inlet	15.0228	SPI	6.05	85.56	1.3
102 Q028			SR 9	24.44	unnamed	MF Quilceda Cr	07	SPI	6.04	85.684	2.2
996356			US 101	330.25	unnamed	Hood Canal	16	SPI	6.03	85.808	1.9
991176			SR 525	1.1	unnamed	Swamp Cr	08	SPI	6.01	85.932	7
991522			SR 302	2.1	unnamed	North Bay	15	SPI	5.99	86.056	0.8
991997		1	SR 307	0.98	unnamed	unnamed	15	ETD	5.99	86.18	0.33
991998	991997		SR 307	0.98	unnamed	unnamed	15	ETD	5.99	86.304	0.79
995242			I-5 Ext 218 NB	218	unnamed	unnamed	03.0184	SPI	5.96	86.428	1
990761			SR 6	41.7	unnamed	Chehalis R	23	SPI	5.95	86.552	1
996514			SR 169 ROW	18.06	unnamed	Cedar R	08	SPI	5.94	86.676	0.9
997368			SR 3	7.59	unnamed	Oakland Bay	14	SPI	5.91	86.8	0.7
991445			SR 20	85.63	unnamed	Skagit R	04.0434	SPI	5.9	86.924	1.4
991182			I-90	16.21	unnamed	Tibbetts Cr	08	SPI	5.88	87.048	1.8
991640			SR 542	27.21	unnamed	Nooksack R	01	SPI	5.87	87.172	1.1
101NORT-33			US 2	20.53	unnamed	Skykomish R	07	SPI	5.86	87.296	2
991839			SR 164	13.33	unnamed	Newaukum Cr	09	SPI	5.86	87.42	1.4
997685			SR 99	24.71	NF Hamm Cr	Duwamish R	09	SPI	5.86	87.544	1.6
997309			US 101	122.92	unnamed	McCalla Cr	21	SPI	5.83	87.668	1.5
NC69			SR 9	49	unnamed	WF Nookachamps Cr	03	SPI	5.8	87.792	1
995484			US 101	275.72	unnamed	Discovery Bay	17	SPI	5.79	87.916	0.77
991710			SR 20	93.84	unnamed	Skagit R	04.0649	ETD	5.78	88.04	1.3
995796			SR 11	18.47	unnamed	Chuckanut Cr	01	SPI	5.76	88.164	1.2
991633			US 12	5.62	unnamed	Mox Chuck Sl	22	ETD	5.71	88.288	0.7
996536			SR 112	49.62	EF Whiskey Cr	Whiskey Cr	19.0022	SPI	5.71	88.412	1.2
994119			SR 520	5.81	unnamed	Lk Washington	08	ETD	5.69	88.536	1.4
996383			SR 106	4.11	unnamed	Hood Canal	16	SPI	5.63	88.66	0.9
996115			SR 106	2.07	unnamed	unnamed to Skokomish R	16	ETD	5.62	88.784	1.75
993676			SR 16	20.2	unnamed	Burley Cr	15	SPI	5.61	88.908	0.96
990325			SR 202	13.22	Patterson Cr	Snoqualmie R	07.0376	SPI	5.56	89.032	1.6
996472			I-90	15.92	unnamed	unnamed	08	SPI	5.54	89.156	1.5
997691			SR 169	7.15	unnamed	Jones Lk	09	SPI	5.49	89.28	2
996116			SR 106	2.36	unnamed	unnamed to Skokomish R	16	SPI	5.48	89.404	1.2
996932			SR 308	2.57	unnamed	Liberty Bay	15.0277	SPI	5.48	89.528	1.1
995490			US 101	281.81	unnamed	Discovery Bay	17	SPI	5.47	89.652	1
996216			SR 99	49.01	unnamed	Lund's Gulch Cr	08	SPI	5.47	89.776	0.5
996492			SR 169	17.92	Unnamed	Cedar R	08	SPI	5.41	89.9	1
994955			SR 508	0.84	unnamed	Allen Cr	23	SPI	5.4	90.024	3
995020			US 2	48.94	unnamed	SF Skykomish R	07	SPI	5.36	90.148	1.1
996671			SR 410	53.01	unnamed	White R	10	SPI	5.29	90.272	2.1
994440		2	SR 522	16.54	unnamed	Crystal Lk	08	SPI	5.25	90.396	1.65
994123	994440		SR 524	14.52	unnamed	Crystal Lk	08	SPI	5.43	90.52	1
994124	994440		SR 524	14.38	Daniels Cr	Crystal Lk	08.0122A	SPI	5.31	90.644	1
995915			SR 119	7.02	unnamed	Lk Cushman	16	SPI	5.22	90.768	1.8
996765			SR 302	1.86	unnamed	North Bay	15	SPI	5.21	90.892	1
990584			SR 542	15.05	unnamed	Nooksack R	01	SPI	5.17	91.016	1.1
995632			SR 19	3.48	unnamed	Ludlow Cr	17	SPI	5.05	91.14	1
995084			SR 9	22.72	unnamed	Quilceda Cr	07	SPI	5.02	91.264	0.9
996205			SR 524 SP 3	0.3	Shelleberger Cr	Puget Sound	08.0010	SPI	5.02	91.388	0.9
995216			SR 96	6.09	unnamed	unnamed	07.0120	SPI	4.99	91.512	1.3

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment	
1000	1581761	94.54	500	1608630	96.06	1000	4707444	97.28	673		
1016	1582777	94.6	1422	1610052	96.13	2846	4710289	97.34	674		
515	1583292	94.63	309	1610361	96.15	618	4710907	97.36	675		
	1583292	94.63		1610361	96.15		4710907	97.36	676	OHW = toe width	
600	1583892	94.66	540	1610901	96.19	1080	4711987	97.38	677		
772	1584664	94.71	309	1611210	96.2	618	4712605	97.39	678		
200	1584864	94.72	100	1611310	96.21	200	4712805	97.39	679		
409	1585273	94.75	470	1611780	96.24	941	4713746	97.41	680		
498	1585771	94.78	9	1611789	96.24	224	4713970	97.42	681		
0	1585771	94.78	0	1611789	96.24	0	4713970	97.42	682		
250	1586021	94.79	112	1611901	96.25	225	4714195	97.42	683		
350	1586371	94.81	735	1612636	96.29	1470	4715665	97.45	684		
2864	1589235	94.98	1862	1614498	96.4	3723	4719388	97.53	685		
581	1589816	95.02	494	1614992	96.43	988	4720376	97.55	686		
0	1589816	95.02	0	1614992	96.43	0	4720376	97.55	687		
	1589816	95.02	30	1615022	96.43	147	4720523	97.55	688	OHW = toe width	
690	1590506	95.06	1173	1616195	96.5	2346	4722869	97.6	689		
207	1590713	95.07	134	1616329	96.51	269	4723138	97.61	690		
1974	1592687	95.19	2172	1618501	96.64	4343	4727481	97.7	691		
1378	1594065	95.27	1309	1619810	96.72	2618	4730099	97.75	692		
2008	1596073	95.39	7028	1626838	97.14	14056	4744155	98.04	693		
976	1597049	95.45	390	1627228	97.16	781	4744936	98.06	694		
480	1597529	95.48	362	1627590	97.18	287	4745223	98.06	695	OHW = toe width	
0	1597529	95.48	0	1627590	97.18	0	4745223	98.06	696	OHW = toe width	
2034	1599563	95.6	1017	1628607	97.24	2034	4747257	98.11	697		
757	1600320	95.65	378	1628985	97.27	757	4748014	98.12	698		
242	1600562	95.66	109	1629094	97.27	218	4748232	98.13	699		
800	1601362	95.71	280	1629374	97.29	560	4748792	98.14	700		
500	1601862	95.74	350	1629724	97.31	700	4749492	98.15	701		
600	1602462	95.77	540	1630264	97.34	1080	4750572	98.18	702		
740	1603202	95.82	407	1630671	97.37	814	4751386	98.19	703		
1503	1604705	95.91	1503	1632174	97.46	3006	4754392	98.25	704		
907	1605612	95.96	635	1632809	97.49	1270	4755662	98.28	705		
248	1605860	95.98	198	1633007	97.51	397	4756059	98.29	706		
800	1606660	96.03	600	1633607	97.54	1200	4757259	98.31	707		
763	1607423	96.07	382	1633989	97.56	763	4758022	98.33	708		
564	1607987	96.1	217	1634206	97.58	434	4758456	98.34	709		
426	1608413	96.13	380	1634586	97.6	459	4758915	98.35	710	OHW = toe width	
420	1608833	96.16	252	1634838	97.61	504	4759419	98.36	711		
624	1609457	96.19	0	1634838	97.61	147	4759566	98.36	712	OHW = toe width	
2257	1611714	96.33	1354	1636192	97.7	2708	4762274	98.42	713		
994	1612708	96.39	704	1636896	97.74	336	4762610	98.42	714	OHW = toe width	
250	1612958	96.4	112	1637008	97.74	225	4762835	98.43	715		
636	1613594	96.44	42	1637050	97.75	98	4762933	98.43	716	OHW = toe width	
235	1613829	96.45	112	1637162	97.75	223	4763156	98.44	717		
3075	1616904	96.64	2460	1639622	97.9	4920	4768076	98.54	718		
570	1617474	96.67	428	1640050	97.93	855	4768931	98.55	719		
1870	1619344	96.78	1870	1641920	98.04	3740	4772671	98.63	720		
100	1619444	96.79	60	1641980	98.04	120	4772791	98.63	721		
1087	1620531	96.85	598	1642578	98.08	1196	4773987	98.66	722		
1181	1621712	96.93	590	1643168	98.11	1181	4775168	98.68	723		
1107	1622819	96.99	277	1643445	98.13	554	4775722	98.7	724		
224	1623043	97	112	1643557	98.14	224	4775946	98.7	725		
480	1623523	97.03	720	1644277	98.18	1440	4777386	98.73	726		
225	1623748	97.05	124	1644401	98.19	248	4777634	98.73	727		
629	1624377	97.08	660	1645061	98.23	1321	4778955	98.76	728		
1497	1625874	97.17	1235	1646296	98.3	2470	4781425	98.81	729		
0	1625874	97.17	0	1646296	98.3	0	4781425	98.81	730		
0	1625874	97.17	0	1646296	98.3	0	4781425	98.81	731		
556	1626430	97.21	500	1646796	98.33	1001	4782426	98.83	732		
338	1626768	97.23	169	1646965	98.34	338	4782764	98.84	733		
228	1626996	97.24	126	1647091	98.35	251	4783015	98.85	734		
1654	1628650	97.34	827	1647918	98.4	1654	4784669	98.88	735		
1802	1630452	97.45	811	1648729	98.44	1622	4786291	98.91	736		
1135	1631587	97.52	511	1649240	98.47	1022	4787313	98.93	737		
265	1631852	97.53	172	1649412	98.48	344	4787657	98.94	738		

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
991288			SR 508	11.55	unnamed	SF Newaukum R	23	SPI	4.97	91.636	1.3
991610			US 101	324.31	unnamed	Hood Canal	16	ETD	4.97	91.76	1.45
990740			SR 6	26.36	unnamed	Rock Cr	23	SPI	4.96	91.884	1.4
996460			SR 524	14.28	Daniels Cr	Crystal Lk	08.0122A	SPI	4.89	92.008	1.1
991822			US 2	34.35	unnamed	Skykomish R	07	SPI	4.87	92.132	2.1
995062			US 2	52.39	unnamed	Tye R	07	ETD	4.86	92.256	1
994981			SR 508	16.99	unnamed	Stowell Cr	23	SPI	4.82	92.38	1.4
990412			SR 512	4.17	Swan Cr	Puyallup R	10	SPI	4.81	92.504	3.9
990883			US 101	137.35	Crane Cr	Raft R	21.0370	SPI	4.8	92.628	1.3
991127			SR 20	96.23	unnamed	Skagit R	04.0672	PI	4.8	92.752	1.8
NC163			SR 9	43.06	unnamed	Lake Cr	03	SPI	4.77	92.876	1.2
101NORT-32			US 2	20.53	unnamed	unnamed to Skykomish R	07	SPI	4.76	93	1.2
994463			SR 508	17.55	Stowell Cr	Kearney Cr	23.0916	SPI	4.76	93.124	2.4
990394			SR 167	21.64	Spring Brook Cr	Black R	09.0005	SPI	4.73	93.248	2
997097			US 101	191.12	Uncle John's Cr	Mill Cr	20	SPI	4.72	93.372	2.07
105 R033020A			SR 162	16.66	unnamed	S Prairie Cr	10	SPI	4.71	93.496	2
995521			SR 116	1.64	unnamed	Port Townsend Bay	17	PI	4.71	93.62	0.96
991126			SR 20	94.82	unnamed	Skagit R	04.0657	ETD	4.64	93.744	4.8
995432			SR 20	53.9	unnamed	Indian Sl	03.0108	SPI	4.6	93.868	2.2
995699			I-5	251.36	unnamed	Connelly Cr	01	PI	4.57	93.992	2.65
994406			I-405	3.06	Thunder Hills Cr	Unnamed	08	ETD	4.56	94.116	
994958			SR 508	1.66	unnamed	unnamed to Allen Cr	23	SPI	4.43	94.24	1.3
995538			I-5	71.34	unnamed	unnamed	23	SPI	4.38	94.364	1.9
992202			SR 104	19.39	unnamed	Port Gamble	15	ETD	4.37	94.488	0.7
996007			SR 548	1.14	unnamed	unnamed	01	SPI	4.36	94.612	1.6
997091			US 101	187.18	unnamed	Bogachiel R	20	SPI	4.34	94.736	1.2
991174			SR 202	19.69	unnamed	unnamed	07.0378	SPI	4.33	94.86	1.7
995087			SR 9	12.57	unnamed	unnamed	07	SPI	4.31	94.984	1.2
996742			SR 3	41.52	unnamed	Dyes Inlet	15.0241	SPI	4.31	95.108	1.4
990921			SR 109	2.71	unnamed	Grays Harbor	22	PI	4.23	95.232	0.7
996747			SR 3	42.21	unnamed	Dyes Inlet	15.0243	SPI	4.18	95.356	1.5
996275			SR 99	0.44	unnamed	Hylebos Cr	10	SPI	4.12	95.48	3.1
996079		1	SR 9	27.94	unnamed	unnamed	05	SPI	4.02	95.604	0.8
990255	996079		SR 9	27.25	unnamed	Portage Cr	05.0058	SPI	5.6	95.728	1.1
991590			US 101	178.63	unnamed	Hell Roaring Cr	20	PI	3.99	95.852	2
997397			SR 20	86.59	unnamed	Skagit R	04	SPI	3.95	95.976	0.75
996080			SR 9	33.2	Roth Cr	Stillaguamish R	05	SPI	3.91	96.1	1.5
991837			SR 164	10.21	unnamed	unnamed	10	SPI	3.8	96.224	1.2
990686			SR 7	32.4	unnamed	Silver Lk	11	SPI	3.76	96.348	1
995741			SR 19	8.12	unnamed	Chimacum Cr	17	SPI	3.72	96.472	1.35
997682			SR 509	29.2	Lost Fork Hamm Cr	Duwamish R	09	SPI	3.71	96.596	1.5
990736			SR 6	22.94	unnamed	Salmon Cr	23	SPI	3.67	96.72	1.7
996618			SR 410	17.26	Fennel Cr	Puyallup R	10.0406	SPI	3.64	96.844	1.2
997355			US 101	155.8	unnamed	Pacific Ocean	21	SPI	3.64	96.968	2
996745			SR 3	41.81	unnamed	Dyes Inlet	15	SPI	3.61	97.092	1
997098			US 101	190.06	unnamed	Mill Cr	20	SPI	3.6	97.216	0.7
991681			SR 167	23.94	unnamed	Springbrook Cr	09	SPI	3.44	97.34	1.8
995194			SR 202	16.79	unnamed	Patterson Cr	07	SPI	3.44	97.464	0.96
940081			SR 11	14.76	unnamed	Puget Sound (Wildcat Cove)	01	PI	3.37	97.588	1.3
996360			US 101	332.15	unnamed	Hood Canal	16	SPI	3.37	97.712	0.9
991593			US 101	180.2	unnamed	EF Hell Roaring Cr	20	PI	3.19	97.836	2.6
995167			SR 203	7.26	unnamed	Horseshoe Lk	07	SPI	3.19	97.96	1
997087			US 101	184.87	unnamed	Bogachiel R	20	SPI	3.17	98.084	1.8
997166			SR 106	7.64	unnamed	Hood Canal	14	SPI	3.11	98.208	2
996614			US 12	27.87	unnamed	Chehalis R	23	SPI	3.08	98.332	1.4
991592			US 101	179.57	Hell Roaring Cr	Hoh R	20.0441	PI	3.01	98.456	1.9
991608			US 101	324.1	unnamed	Hood Canal	16	ETD	2.66	98.58	1.02
990737			SR 6	23.49	unnamed	Rock Cr	23	SPI	2.64	98.704	1.1
991866			SR 16	19.54	unnamed	Burley Cr	15	ETD	2.58	98.828	1.1
997096			US 101	188.64	unnamed	Bogachiel R	20	SPI	2.46	98.952	1.45
996664			SR 410	48.94	unnamed	unnamed	10	SPI	2.44	99.076	1.4
997637			SR 169	4.77	unnamed	Green R	09	SPI	2.41	99.2	1.6
995774			SR 547	6.71	unnamed	Saar Cr	01	SPI	2.3	99.324	0.8
991565			US 101	221	unnamed	Lk Crescent	19	SPI	2.21	99.448	1
996602			I-405	21.94	Juanita Cr	Lk Washington	08.0230	SPI	1.9	99.572	2.5
991301			SR 105	31.38	unnamed	South Bay	22.1321	PI	1.78	99.696	6
994225			SR 20	96.12	unnamed	Skagit R	04.0671	ETD	1.68	99.82	1.6

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment
315	1632167	97.55	205	1649617	98.5	410	4788067	98.95	739	
400	1632567	97.57	192	1649809	98.51	380	4788427	98.96	740	OHW = toe width
358	1632925	97.6	250	1650059	98.52	501	4788928	98.97	741	
1158	1634083	97.66	637	1650696	98.56	1274	4790202	98.99	742	
693	1634776	97.71	728	1651424	98.6	1456	4791657	99.02	743	
907	1635683	97.76	229	1651653	98.62	652	4792309	99.04	744	OHW = toe width
651	1636334	97.8	456	1652109	98.65	911	4793220	99.06	745	
896	1637230	97.85	1747	1653856	98.75	3494	4796714	99.13	746	
2107	1639337	97.98	1370	1655226	98.83	2739	4799453	99.19	747	
476	1639813	98.01	937	1656163	98.89	1924	4801377	99.23	748	OHW = toe width
290	1640103	98.02	174	1656337	98.9	348	4801725	99.23	749	
200	1640303	98.04	120	1656457	98.91	240	4801965	99.24	750	
362	1640665	98.06	434	1656891	98.93	869	4802834	99.26	751	
422	1641087	98.08	422	1657313	98.96	844	4803678	99.27	752	
200	1641287	98.1	207	1657520	98.97	414	4804092	99.28	753	
803	1642090	98.14	803	1658323	99.02	1606	4805698	99.31	754	
240	1642330	98.16	34	1658357	99.02	49	4805747	99.32	755	
484	1642814	98.19	257	1658614	99.03	210	4805957	99.32	756	OHW = toe width
515	1643329	98.22	566	1659180	99.07	1133	4807090	99.34	757	
575	1643904	98.25	54	1659234	99.07	355	4807445	99.35	758	
794	1644698	98.3	567	1659801	99.11	684	4808129	99.36	759	no OHW data
500	1645198	98.33	325	1660126	99.12	650	4808779	99.38	760	
330	1645528	98.35	314	1660440	99.14	627	4809406	99.39	761	
531	1646059	98.38	407	1660847	99.17	153	4809559	99.39	762	OHW = toe width
1165	1647224	98.45	932	1661779	99.22	1864	4811423	99.43	763	
412	1647636	98.47	247	1662026	99.24	494	4811917	99.44	764	
1065	1648701	98.54	905	1662931	99.29	1810	4813727	99.48	765	
200	1648901	98.55	120	1663051	99.3	240	4813967	99.49	766	
1981	1650882	98.67	1386	1664437	99.38	2773	4816740	99.54	767	
366	1651248	98.69	0	1664437	99.38	190	4816930	99.55	768	
327	1651575	98.71	245	1664682	99.4	490	4817420	99.56	769	
314	1651889	98.73	486	1665168	99.43	973	4818393	99.58	770	
756	1652645	98.77	302	1665470	99.44	605	4818998	99.59	771	
0	1652645	98.77	0	1665470	99.44	0	4818998	99.59	772	
801	1653446	98.82	182	1665652	99.45	1118	4820116	99.61	773	
645	1654091	98.86	242	1665894	99.47	484	4820600	99.62	774	
400	1654491	98.88	300	1666194	99.49	600	4821200	99.64	775	
893	1655384	98.94	536	1666730	99.52	1072	4822272	99.66	776	
650	1656034	98.98	325	1667055	99.54	650	4822922	99.67	777	
339	1656373	99	229	1667284	99.55	458	4823380	99.68	778	
202	1656575	99.01	152	1667436	99.56	303	4823683	99.69	779	
1276	1657851	99.09	1084	1668520	99.63	2169	4825852	99.73	780	
500	1658351	99.12	300	1668820	99.64	600	4826452	99.74	781	
200	1658551	99.13	200	1669020	99.66	400	4826852	99.75	782	
541	1659092	99.16	270	1669290	99.67	541	4827393	99.76	783	
200	1659292	99.17	70	1669360	99.68	140	4827533	99.77	784	
400	1659692	99.2	360	1669720	99.7	720	4828253	99.78	785	
763	1660455	99.24	362	1670082	99.72	725	4828978	99.8	786	
213	1660668	99.25	120	1670202	99.73	73	4829051	99.8	787	
227	1660895	99.27	102	1670304	99.73	204	4829255	99.8	788	
316	1661211	99.29	0	1670304	99.73	459	4829714	99.81	789	
264	1661475	99.3	132	1670436	99.74	264	4829978	99.82	790	
451	1661926	99.33	406	1670842	99.76	812	4830790	99.83	791	
376	1662302	99.35	376	1671218	99.79	752	4831542	99.85	792	
971	1663273	99.41	680	1671898	99.83	1359	4832901	99.88	793	
466	1663739	99.44	156	1672054	99.84	361	4833262	99.88	794	
402	1664141	99.46	55	1672109	99.84	57	4833319	99.89	795	OHW = toe width
1077	1665218	99.53	592	1672701	99.88	1185	4834504	99.91	796	
	1665218	99.53		1672701	99.88		4834504	99.91	797	OHW = toe width
200	1665418	99.54	145	1672846	99.88	290	4834794	99.92	798	
384	1665802	99.56	269	1673115	99.9	538	4835332	99.93	799	
321	1666123	99.58	257	1673372	99.92	514	4835846	99.94	800	
415	1666538	99.6	166	1673538	99.93	332	4836178	99.94	801	
204	1666742	99.62	102	1673640	99.93	204	4836382	99.95	802	
549	1667291	99.65	686	1674326	99.97	1372	4837754	99.98	803	
620	1667911	99.69	0	1674326	99.97	233	4837987	99.98	804	
4401	1672312	99.95	110	1674436	99.98	87	4838074	99.98	805	OHW = toe width

Site ID	Primary Barrier	WSDOT US Barrier Count	Road	Mile Post	Stream	TribTo	WRIA	PI Type	PI	Cumulative % of Culverts	OHW Width (m)
991910			US 12	6.55	unnamed	Higgins Sl	22	PI	1.52	99.944	1.13
990741			SR 6	29	unnamed	Chehalis R	23	SPI	1.49	100.068	1.5
997588			SR 20	129.63	unnamed	Diablo Lk	04	SPI	1.36	100.192	0.75
997095			US 101	188.42	unnamed	Bogachiel R	20	SPI	0.99	100.316	0.67

Lineal Gain (m)	Sum of Lineal Gain	Cumulative % Lineal Gain	Spawning Area (m2)	Sum of Spawning Area	Cumulative % Spawning Area	Rearing Area (m2)	Sum of Rearing Area	Cumulative % Rearing Area	Sort#	Comment	
200	1672512	99.96	26	1674482	99.98	133	4638207	99.98	806	OHW = toe width	
245	1672757	99.98	164	1674646	99.99	368	4638575	99.99	807		
200	1672957	99.99	75	1674721	100	150	4638725	100	808		
200	1673157	100	67	1674788	100	134	4638859	100	809		