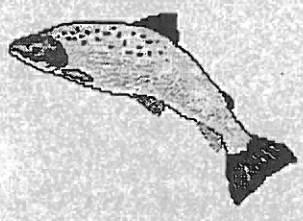
Second Substitute Senate Bill 5886

Fish Passage Task Force

Report to the Legislature



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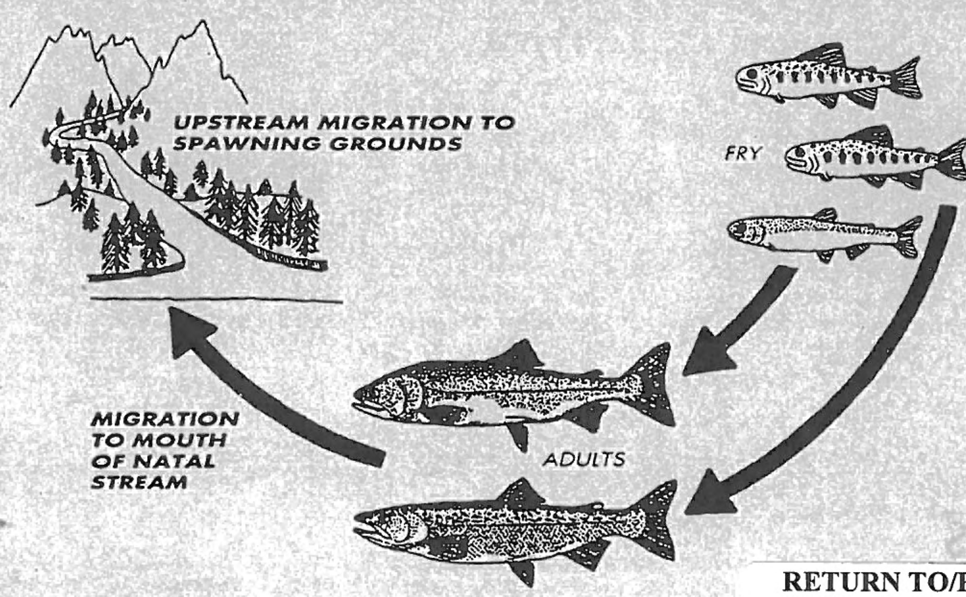

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EXECUTIVE SUMMARY

The Problem: Fish Barriers and Habitat Loss

The severe decline of Northwest wild salmon and trout populations has many well recognized causes, including over-harvest and habitat degradation. There is, however, one key factor in the wild salmonid equation that, until recently, has not received adequate attention and is not generally well understood. Over 100 years of road building and development have resulted in an estimated minimum 2,400 human-made barriers at road crossings. These structures block fish access to an estimated 3,000 linear miles of freshwater spawning and rearing habitat; this is equivalent to the loss of all habitat in a watershed the size of the Snohomish River system. Removal of these barriers offers a tremendous opportunity for habitat restoration and is a critical component in the effort to restore wild salmon and sea-run trout populations.

The Washington State Legislature recognized and addressed this fish passage barrier problem in 2SSB 5886 (1997), which directed a task force of representatives from state and local government, tribes, business, and environmental and regional fish enhancement groups to recommend how to develop a program to identify and remove fish barriers. As directed in this bill, this report summarizes the task force findings on the following: (1) coordination and priorities, (2) funding, and (3) legislative action needed.

What is Now Being Done for Fish Passage ?

The first step in the barrier removal process is identification and prioritization of known barriers. The Washington Department of Fish and Wildlife (WDFW), tribal governments, regional fisheries enhancement groups, and others have been inventorying fish barriers at road crossings for many years. However, because of limited resources and the massive scope of the problem (tens of thousands of road crossings statewide), only a fraction of the barriers have been identified and even fewer have had sufficient data collected to assess the habitat benefits necessary for establishing correction priorities. Data from these limited inventories suggest that up to 10 percent of the road crossings of fish bearing streams either partially restrict or totally block fish passage. All barriers do not have to be located before corrections can be initiated. Substantial progress has been made on correcting known barriers with an average rate of about 40-60 corrections annually in recent years.

One serious problem with the existing data on barriers is lack of standardized, agreed upon criteria for data collection and organization. This means that barrier data have been collected in different ways and placed in incompatible database formats used by various organizations. This prevents the easy exchange and broader use of barrier information. Another obstacle is the limited number of qualified staff and trained volunteers available to conduct the inventory work. Currently, WDFW conducts periodic workshops in fish passage design and inventory methods for state, county, and city engineers and volunteer organizations. Training workshops are also offered by other organizations such as Washington Trout. Here again, a coordinated approach is needed to improve consistency and efficiency.

Funding Barrier Corrections

It is estimated that state, federal, and local governments and private entities are spending $4 to $6 million annually to correct fish barriers at the rate of about 40 to 60 barriers each year. At this rate, it will take approximately 40 to 60 years to correct all the barriers believed to currently exist. Clearly, the creation of new barriers must be prevented and the rate of barrier correction must be accelerated if Washington's wild salmon and trout stocks are to recover.

The average cost of barrier correction on state and county roads is currently estimated at $100,000 per project with a range from a few thousand to several hundred thousand dollars. Based on this figure, the cost of resolving the 2,400 barriers believed to currently exist is $240 million.

The Washington State Department of Transportation (WSDOT) and WDFW have developed a successful model program for identification and removal of barriers on state highways. This program costs $2 million annually. WDFW uses a similar model in cooperation with various Washington counties. In this program, WDFW conducts county-wide inventories and counties are then eligible to have some of their barriers corrected by WDFW if they contribute 50 percent of the costs associated with the correction of high priority barriers. Indian tribes and regional fisheries enhancement groups are also actively correcting barriers using other funding sources.

Recommendations

As directed in 2SSB 5886, the task force makes the following recommendations on:

1. ***Coordination and Priorities***: Primary factors which need to be addressed in developing a more aggressive fish barrier correction effort in Washington include:

a. Need for Complete Inventories
Many barriers have been identified, but many more exist. Additional barrier inventories are needed to plan and effectively prioritize correction work on city, state, federal, private, and the remaining county roads. At least 90,000 road miles remain in these ownerships for which no barrier survey work has been done.

b. Need for Improved Watershed Coordination
Coordination of various inventory efforts is needed to allow data sharing and data consistency, and to promote efficiency in barrier correction efforts. Better coordination both at the watershed and state level can help promote partnerships and improved efficiency.

c. Lack of Stable Funding
Committed funds are needed to provide a base for expanding the current barrier correction work force, to cover design and construction costs, and to respond to various opportunities for matching funds and cooperative efforts.

d. Limited Work Force with Expertise
Trained individuals are needed to organize and conduct fish passage inventory, prioritization, correction design, and construction work. This expertise level is expanding slowly but needs to be greatly increased to address the magnitude of the problem, particularly for high risk projects requiring detailed design. Work force limitations present the most significant limiting factor at the current time. By increasing training opportunities for agency staff, project designers and local watershed restoration groups, existing human resources can help fill the gap.

2. ***Funding Mechanisms:*** The task force makes the following recommendations to expand existing efforts and accelerate fish barrier inventory, prioritization, and correction work:

a. Fish Passage Grant Program
Establish a grant program with a minimum of $4 million annually to make funding available to cities, counties, state, and private fish barrier owners to conduct barrier inventory, prioritization, and correction work. Funds would be dispensed through a competitive program that uses prioritizing criteria to encourage use of standardized inventory methods and ensure funds are directed to projects of high value.

Fund staff at WSDOT to help administer and coordinate the grant program (early implementation in FY '99 = $100,000).

b. Accelerated Barrier Correction

The increased funding would accelerate inventories, prioritization, and correction of all barriers to fish passage. This should include support for volunteer restoration groups working on low risk projects as well as for agency and jurisdictional efforts for higher risk corrections.

Any effort to fully address this problem will require a substantial and continued investment. To accomplish this within even a 24 year time frame, with an average rate of 100 barriers per year, would require an average investment of $10 million annually. This would consist of the $4 million grant program in addition to the present base funding level of $4 million, with an additional $2 million expected from increases in other funding sources. More rapid approaches to correct all barriers would require increased funding. Increases in funding should be incremental to allow for development of appropriate work force skills and accountable infrastructure.

1) Current agency budget requests include early implementation in FY '99 of $2 million targeted to address known priority barriers. A portion ($600,000) of this will also go to support barrier inventories in key areas to help fill data gaps.

2) Funding for the following bienniums should include a minimum of $4 million annually above present funding levels. This would support expanded retrofit design and construction and continued survey work to fill data gaps.

c. Expanded Training

Provide funding to expand staffing within WDFW (early implementation in FY '99 = $481,000). This will:

1) Develop standard, streamlined barrier identification and prioritization techniques.

2) Add an additional barrier identification and correction training team to improve outreach capacity. Train more people in barrier survey and correction techniques.

3) Build and maintain a state-wide data system capable of responding to accelerated data collection, storage, and retrieval needs.

3. ***Legislative Action Needed:*** The Task Force suggests legislative attention to the following issues to facilitate fulfillment of fish passage objectives:

a. **Provide for the long-term funding** and structure necessary to expand fish barrier correction efforts in a manageable and sustainable way (see Funding Mechanisms, above).

b. **Integrate fish passage in watershed analysis** and other watershed inventory and planning efforts by including barrier identification and prioritization. Make grant funds available for the increase in effort necessary for this work (see Funding Mechanisms, above).

c. **Streamline the permit process** by promoting accommodation of fish passage in Shoreline Master Programs and other land management programs (see page 11, below).

d. **Support the continued work of the fish passage** task force by encouraging additional work in the areas of:

   1) Expanding involvement of all interested stakeholders including federal agencies and improving integration with regional and watershed planning activities;

   2) Developing and promoting standards for barrier data collection and storage;

   3) Encouraging data sharing on barriers and consistency;

   4) Developing barrier correction grant criteria;

   5) Seeking additional means to expand fish passage restoration through new funding mechanisms and partnerships;

   6) Improving educational resources for those installing new culverts to ensure new barriers are not created.

I. MAGNITUDE OF THE FISH PASSAGE PROBLEM IN WASHINGTON

Salmon and resident fish constitute a valuable but declining resource to the state of Washington; they are an indicator of the region's environmental health. Once, as many as 30 million wild salmon and sea-run trout may have returned to the rivers and streams of Washington annually. At the time of Lewis and Clark, the Columbia River alone may have supported 16 million salmon. The key to this abundance was the ability of these fish to migrate to the sea, feed on its rich food resources, and return to spawn in the clean gravel and oxygen rich waters found in the state's 50,000 miles of streams. Unfortunately, by 1992 the "Washington State Salmon and Steelhead Stock Inventory" (SASSI) identified 135 salmon and steelhead stocks as being either extinct or in depressed or critical condition. In fact, less than 20% of the historic number of wild salmonids is present today. The SASSI report cited the loss of habitat as a major factor contributing to the severe decline of wild Northwest salmon and sea-run trout populations.

A. Lost Habitat

Any human-made structure that obstructs or restricts fish access to traditional freshwater habitat has the potential to destroy these populations of wild fish. As early as 1881, Washington residents recognized the need to preserve fish access to habitat and passed laws to prohibit the construction of human-made barriers. Despite these laws (Chapter 75.20.060, 75.20.061, 77.12.425 and 77.16.210 RCW [Appendix A]), thousands of miles of prime habitat have been lost to fish production due to improperly designed or poorly maintained water diversions and culverts.

In the last 10 years, the Washington Department of Fish and Wildlife (WDFW) has surveyed about 10 percent of the more than 100,000 miles of roads estimated to exist in Washington. From these data, WDFW estimates that there are a *minimum* of 2,400 fish barriers blocking access to more than 3,000 miles of habitat. This estimate should be viewed as conservative, because a recently completed survey of 7,000 miles of roadway managed by the Washington State Department of Transportation (WSDOT) found that 400 out of 4500 (or nearly 10 percent) of road crossings inspected need correction to provide fish passage.

B. Federal Listing

Currently, 15 Washington salmon and trout populations (known as Evolutionary Significant Units) are listed or are candidates for listing under the federal Endangered Species Act (ESA). These units, identified by federal agencies, are typically aggregates of several stocks identified in the SASSI report. Impacts to listed species and their habitat are regulated under the ESA by the federal government and may result in severe restrictions to development activities. Clearly, the prevention of new barriers and the repair of existing ones must play a key role in the recovery of these stocks.

C. Legislative Response

The 1997 Washington State Legislature emphasized the need to address fish passage through 2SSB Bill 5886 (Appendix B), which calls for the expedited identification and removal of human-made impediments to fish passage. In addition, this bill solicits recommendations for funding mechanisms to facilitate the process.

II. CURRENT SITUATION FOR ROAD CROSSINGS

A. Barrier Identification and Prioritization

1. *Finding Fish Barriers in the Transportation System*

Many types of structures in waterways can become barriers to fish. These include dams, water diversion screens, tidegates, railroad crossings, and other features. However, most barriers to fish passage are caused by road crossings, which are the focus of this report.

The WSDOT Transportation Data Office indicates that there are at least 80,000 miles of streets, roads, and highways in Washington. Ownership of these roads is shown in Table 1. In addition, the Department of Natural Resources (DNR) has estimated the total roads in the state through aerial photo interpretation, including forest roads and other unpaved roads, and determined the figure to be approximately 170,000 miles. Only a fraction of the road crossings in the state have been fully inventoried for fish passage barriers.

Table 1
Washington State Roadway Systems Mileage

Agency / Jurisdiction	Mileage
Local	
County Roads	41,094
City Streets	12,910
Port Districts	2
Office of the Council of Presidents (Colleges and Universities)	123
Total	54,129
State	
State Highways (WA Dept. of Transportation)	7,037
WA Dept. of Transportation Marine	3
WA Dept. of Fish and Wildlife	1929
WA Parks and Recreation Commission	655
WA Dept. of Social and Health Services	35
WA Dept. of Natural Resources	9,500
WA Dept. of Corrections	159
Total	19,318
Federal	
USDA Forest Service	5,453
USDI National Park Service	270
US Dept. of Energy	154
Bureau of Indian Affairs	902
Total	6,779
Grand Total	**80,226**

Source: Washington State Department of Transportation, Transportation Data Office, 1996 reporting.

Note: Roadway system mileage for private lands (railroads, timber holdings, agriculture, etc.) is not included in the totals given above.

The estimate of 2,400 barriers statewide was derived from expansion of inventories of county roads in three counties and the state highway system. Only a small portion of these barriers have been well documented. Common factors that create barriers include high water velocity, inadequate water depth, and large culvert outfall drops. With training and experience, identifying barriers is relatively quick, but there has not been a consistent approach to assessing the barrier status of road crossings. A more defined procedure is needed to ensure consistency if expanded capabilities are to be developed.

2. *Prioritization: Ensuring Fish Passage Dollars Are Spent Wisely*

Prioritization allows dollars to be spent effectively by directing correction of barriers yielding the highest benefits to fish. Considering that the average cost to correct a barrier beneath a public roadway is approximately $100,000, it is easy to understand why the accountability provided by inventory and prioritization efforts is necessary. Without adequate assessment of fish habitat gains, there may be no assurance that the effort was well spent.

The funds expended on inventories depend in large degree on the inventory objectives and the level of confidence expected from the result. For example, an inventory for a county could be in the form of a simple location list of all road crossings under that county's jurisdiction. However, if the objective is to determine the number of those crossings that are on fish bearing streams and that pose migration barriers to fish, the assessment becomes more involved. If the objective is also to determine which barriers need to be fixed and prioritize those barriers for order of correction, then the needed field work and assessment become much more complex. In fact, up to 10 times as much effort is required to collect information for prioritization as is required to find and record the barrier status of a crossing.

3. *Opportunities That Promote Efficiency*

Barriers have been identified by many different parties using different methods. Examples include the cooperative efforts between WDFW and WSDOT and counties that have generated prioritized databases for WSDOT and for Kitsap, Skagit, Thurston, and (soon) Jefferson counties. The data from these efforts are maintained in WDFW's Salmonid Screening, Habitat Enhancement and Restoration (SSHEAR) Division databases, along with other barrier information that has been reported (Appendix C).

A broad-based effort called the Watershed Recovery Inventory Project (WRIP), sponsored by WDFW, included workshops and surveys to solicit barrier and other information from inside and outside the agency. Part of this effort resulted in a database directory that can be accessed for contacts to obtain more detailed information (Appendix D). There are undoubtedly other efforts and databases that have not been included in the WDFW database or in the WRIP directory. Examples include the Washington Rivers Council database, Washington Trout, individual tribal databases, various basin and watershed plans and assessments (TFW, Conservation Districts, DNR, USFS, etc.), independent county and city inventories, and assessments by various interest groups, volunteers and private consulting firms.

Identifying and prioritizing fish barrier data offers a solid opportunity to build partnerships for watershed restoration. Restoring biological integrity to watersheds can be helped by standardizing data collection, creating means for data sharing, and looking for partnership opportunities that promote efficiency of effort.

As an example, WDFW conducts an outreach program with counties and other jurisdictions where inventory and survey work will be conducted at WDFW's expense, provided agreements are made to initiate barrier corrections. The inventory portion of this effort starts with an assessment of each crossing to determine if the waterway is fish bearing and whether the crossing constitutes a barrier. This phase typically takes a two-person crew about two months. The second phase involves determining the status of affected fish stocks and habitat measurements to determine the potential resource benefits that would result from barrier correction. Depending on the number of barriers and the habitat that must be measured, this phase can take another one or two years, followed by documentation in a report. With the investment of $150,000 to $250,000 to complete this effort, the product is a formally prioritized list that can be confidently used to spend dollars wisely in correction efforts. Following the existing model for jurisdiction-based surveys, this effort would address only road crossings on county roads. A comprehensive survey for all barriers within a county (not just limited to county-owned roads) would require a much more extensive effort.

4. *Present Outreach Involves Agencies, Volunteers, and Others*

Expanding the rate of barrier prioritization and correction means broadening the work force for culvert inventory and survey through training, while adopting standardized methods for data collection and reporting. WDFW has standardized forms that it recommends be used for reporting fish barriers so that data are reported in a consistent way (see Appendix E). It also conducts periodic workshops for state, county, and city engineers and for agency personnel that work with volunteer organizations. In addition, training workshops are now offered by other organizations such as the University of Washington and Washington Trout. These training efforts need to present more consistent information on measurements and criteria for locating and assessing barriers. Developing agreed-upon, consistent methods for barrier identification is an area where more work is needed.

B. Barrier Correction

1 *Overview: Streamlining the Process*

Correct culvert installation from the beginning is obviously the best approach. This is normally addressed through the hydraulic project approval (HPA) process. Guidelines for new culvert installation are included in WAC 220-110-070 (Appendix G). These are used as default standards, but project proponents are able to work with WDFW in developing and analyzing new design approaches to providing fish passage. Improved educational outreach would also help those installing new culverts to avoid creating new barriers.

Correcting existing barriers to fish passage is currently the responsibility of the barrier owner (Appendix A). Barrier correction can sometimes be as simple as debris removal, but retrofitting existing culverts to correct fish barriers requires site specific designs in most cases. Analysis is required to identify the conditions that block fish passage and assess viable options for correction.

Designs for barrier corrections require consideration of many factors. Different types of barriers may need to be addressed through different design and retrofit approaches. Constructability and ease of maintenance of these structures also need to be considered. In addition, changing basin conditions need to be anticipated and considered in the design.

Barrier correction work can be divided into high, moderate, and low risk projects. High risk projects require a high level of technical fish passage engineering and/or construction skills and involve significant resource and landowner implications should the project fail. Currently, high risk project work is limited by the number of technically competent design, construction, and project management fish passage experts available. WDFW, WSDOT, cities, and counties currently have varied degrees of ability to conduct high risk projects. Low risk projects are those that can be accomplished with readily available design and construction assistance, such as a simple culvert replacement or removal on a private drive. Moderate risk projects fall between high and low risk levels and require an intermediate level of fish passage correction design, construction, and project management.

Efforts have been made to streamline the permit process for fish barrier correction work. In 1995, the Washington State Legislature passed SSB 5155, which allows fish passage projects to be exempted from the Shoreline Management Act, provided the project is approved and has received an HPA from WDFW and the local government has determined that it is consistent with the local shoreline master program. The effectiveness of this legislation could be improved if the master programs acknowledged fish passage. The Department of Ecology is also working on streamlining the related process for permitting water quality modification. In some cases, additional local grading and filling permits may be required, which can add to project complexity.

2. *Opportunities that Promote Efficiency*

Barrier corrections are being done by many parties including state agencies, city and county programs, Regional Fisheries Enhancement Groups, Conservation Districts, Indian tribes, and others. These are largely independent efforts.

Since 1990, WSDOT and WDFW have co-managed a program to identify and correct barriers on the state highway system. Once barriers are identified and prioritized, design of barrier retrofits is accomplished through collaboration between engineers and biologists from both departments. So far, this program has corrected over 40 barriers in the state highway system, opening habitat capable of producing over 60,000 salmon annually.

The WDFW jurisdictional outreach program works with legal jurisdictions and private owners by providing technical assistance in design and cost sharing for retrofits in areas where barriers have been inventoried, surveyed, and prioritized. So far, this program has corrected about 100 barriers in the last decade in addition to the WSDOT program. Regional fisheries enhancement groups are also involved in correcting fish barriers and have reported corrections of 16 culverts in the last year.

3. *Expanding Funding and Spending Dollars Wisely*

Barrier correction is a very cost-effective means for habitat restoration. Investment up front can yield more than a fourfold benefit for every dollar spent. This estimate is based on assessment of the WSDOT program with correction taking 30 years and benefits estimated for 120 years. With this assumption $164 million in estimated benefits to potential production (actual value as food) could be derived from an investment of $37 million for barrier corrections. This should be considered conservative since recreational fishing benefits, all salmonid species and non-consumptive uses are not included.

Barrier correction costs can be quite variable. WDFW experience with county roads and WSDOT highways indicates typical costs average about $100,000 per retrofit. Projects involving smaller road crossings may be accomplished at a lower cost.

Existing barriers can also be corrected simultaneously with planned road project work. In this way, some design, mobilization, and other transactional costs can be saved. This is now being done with WSDOT projects. While this provides some cost-effective corrections, it does not generally coincide with the corrections that would provide the greatest habitat gain. Analysis of the WSDOT program indicated that it would take over 100 years to correct all the barriers if project work alone were relied on as a means for barrier correction. This compares to 50 years if road project work included fish passage barrier removal. Additional designated projects are required to effectively address fish passage barrier correction.

Fish passage projects are currently funded through several different sources. None of these funding mechanisms is adequate to address the scope of the problem on a state-wide basis. Corrections for barriers on the state highway system are funded through the transportation budget, where up to $2 million is included in construction funding ('97-'99) for barrier correction coincident with planned roadwork. The presence of fish barriers also plays a role in the prioritization of WSDOT projects, with those that would correct barriers receiving added weight in program prioritization. An additional amount up to $2 million ('97-'99) may be used for high priority barriers in the highway system where "stand alone" retrofit projects are developed.

Other jurisdictions accomplish barrier correction primarily through their own funding sources and by using cost share funds available through WDFW. Funding may also be available through habitat restoration projects.

4. *Outreach to Involve Volunteers and Others*

Design of culvert retrofits is a relatively new area of engineering, and required expertise is beginning to grow. Design assistance and review are now available through WDFW, but there is a need for expanded technical assistance in barrier correction design. Expanding expertise effectively expands the work force, so this is a critical area where gains can be made.

WDFW now conducts periodic workshops for state, county, and city engineers and for agency personnel who work with volunteer organizations. WDFW has developed resources for designers including a manual titled, "*Fishways Design Guidelines for Pacific Salmon*". In addition, training workshops are now offered by other organizations such as the University of Washington and Washington Trout. As with barrier identification, it is important that these training efforts present consistent information on measurements and criteria.

WSDOT is developing a pilot project for integrating watershed planning efforts with transportation planning in the Snohomish watershed. Fish passage is one of the key resource categories to be addressed. Efforts will be made to expand training and accelerate barrier identification and correction by training and utilizing stream restoration groups in barrier identification and survey.

III. ANTICIPATED FUTURE NEEDS

A. Coordination at the Watershed Level

Many players need to be involved to address the problem of fish passage barriers in Washington. These include Indian tribes, local stream enhancement groups, cities, counties, state agencies, and federal agencies. Large landholders such as timber companies, state forests, National Parks, and National Forests are particularly significant due to the large number of stream crossings present. Some of these parties have efforts underway to locate barriers on their roads, while others are just beginning. There is a need for greater coordination of efforts to make the best use of partnerships and yield greater environmental benefit. Barrier identification, prioritization, and correction should be a focal point of watershed planning. Integrating barrier identification with other stream studies can foster efficiency in data collection. Combining barrier removal with stream rehabilitation and restoration work or other watershed efforts can create synergistic benefits.

One such example of coordination at a watershed level has been occurring in Percival Creek in the greater Olympia area. Several cooperative fish passage projects have been completed, or are anticipated in the near future, in conjunction with a comprehensive fish barrier inventory conducted by WDFW. The inventory was conducted from 1995 to 1997. A major cooperative project between WSDOT and WDFW was completed in 1995 at the Highway 101 road crossing. A two-phase project was completed during 1994-96 at the Mottman Road crossing that involved design by WDFW, funding by the cities of Tumwater and Olympia, Capitol Auto Mall, and the South Sound Salmon Enhancement Group, and construction by South Sound Flyfishers and a private contractor. In 1997, WDFW replaced a barrier culvert at the Chapparrel Road crossing that was funded jointly by the city of Tumwater, WDFW, and the South Puget Sound Salmon Enhancement

Group.

To complete the fish passage effort in the Percival drainage, remaining projects are planned by city of Olympia (Mottman Road crossing at Black Lake Ditch), city of Tumwater (Sapp Road crossing on Percival Creek), and Thurston County/WDFW (Fairview Road crossings at two tributaries of Black Lake). In addition, local volunteers have added habitat restoration work at various locations in the Percival drainage. This sort of coordinated, comprehensive effort obviously accelerates the fish passage effort and addresses other watershed issues in the solution.

In addition to coordinating barrier corrections, monitoring efforts need to be expanded to ensure that the projects function properly. The results of monitoring should complete a feedback loop to the database where barrier data are kept so status updates can be made.

B. Guidance Documents for Watershed Planning

Barrier identification and prioritization can be greatly accelerated by expanding the base of expertise. Presently, there are many different efforts underway to assess streams and watersheds. Additional benefits can be leveraged by incorporating barrier identification into these studies. To best take advantage of the efforts of all those involved in barrier identification and prioritization, consistent methods need to be used. This provides a good opportunity to utilize watershed groups and watershed planning efforts to help coordinate barrier identification and prioritization.

WDFW has developed a relatively simple and efficient method for identifying, evaluating, and recording fish barriers (Appendix E), to facilitate inventory processes in a manner consistent with state regulations that incorporate the swimming capabilities of fish. It provides the base of information necessary to evaluate the magnitude of the problem and develop barrier correction plans. Appendix F takes the assessment one step further by providing a comprehensive approach to prioritization once the barriers are identified. These resources are included in this report as a recommended starting point for promoting consistent methods.

There is a need to coordinate and centralize data collection for fish barrier identification. This will make the information more available and promote better coordination of barrier correction efforts. Ideally, this information would be spatially based, compatible with existing and foreseeable GIS uses, and accessible to many different users. To help ensure that data collection efforts and resultant data are compatible, those collecting barrier information, whether as part of basin studies and watershed analyses or as a specific fish passage effort, should follow agreed-upon criteria for barrier identification and submit the information for inclusion in a centralized database. Presently, WDFW manages the most extensive database of this type. There is a constant need to keep this information current with updates of new barriers or corrections of known barriers. In its supplemental budget request, WDFW asked for an additional FTE for expanded database development. This capacity may need to be expanded in the future.

There is a need to recognize the needs and capabilities of fish barrier correction efforts. The most current guidance document that relates these features to the physical process of installing road crossing structures resides in the WAC 220-110-070 (Appendix G). This document provides a reliable standard that represents the current level of technical knowledge. Other added benefits of application of this document to on-the-ground work are at least partial re-establishment of rearing and spawning habitat in or near the crossing itself and a decreased probability of damage to the crossing structure and adjacent land during flood events.

C. Investing in Barrier Removal - Fish Passage Grant Concept

Additional funding and improved coordination of existing efforts are needed to expand the identification and prioritization of fish barriers. For county-owned roadways alone, less than 20 percent of the 41,000 road miles have undergone a comprehensive barrier analysis, despite cooperative arrangements with WDFW and independent county actions. The Department of Natural Resources (DNR) estimates that 17,000 culverts on State Trust land need assessment to determine barrier status. Obviously, the inventory effort needs to accelerate concurrently with barrier correction efforts to provide accountability and ensure a cost-effective approach. Currently, there is no reliable source of funds to inventory fish barriers at road crossings or other locations.

WDFW's conservative estimate of the number of barriers that need correction is 2,400. An average cost for correction of barriers on state highways and county roads is $100,000 per barrier. This yields a total correction cost of $240,000,000. This does not include costs associated with surveys for barriers or for maintenance costs associated with keeping the retrofitted culverts functioning. It is clear that substantial funding is needed to adequately address the correction of fish barriers in Washington. This should be pursued through several avenues.

One solution would involve a grant program to provide funding assistance to inventory, prioritize, and correct fish barriers. Funds would be dispensed through a competitive grant program or other means using prioritizing criteria (Appendix H). This program would help expand fish barrier assessment by offering funds to parties with identified needs. The program would be available to cities, counties, and others and would award funding on a prioritized basis, factoring in the number of crossings to be evaluated, the number and status of affected fish stocks, and the degree of partnerships involved. This program would also be an integral part of the barrier correction effort by offering funds to parties with identified passage barriers. Funds would be awarded according to priorities that factor in quantity of habitat to be gained, cost-effectiveness of corrections, benefit for declining salmon stocks, and other factors (Appendix H).

The grant program would be intended to expediently direct funds to priority needs. This can provide an opportunity to leverage funds by seeking contributions from other sources and by offering grants to applicants with matching funds available. The magnitude of the problem of fish barriers points to the need for long term funding.

Federal funding under the Intramodal Surface Transportation Efficiency Act (ISTEA) includes enhancement funds which could be used for environmental improvements such as fish passage correction. Policies and guidance are being redrafted at the federal level so this would be an opportune time to promote this use.

Other possible long term funding options could include a gas tax component, motor vehicle excise tax, or creation of new revenue sources such as an excise tax on culverts. In addition, general funds or other non-road related sources could be considered. Some grant and partnership funding sources may be available through federal and state agencies and other parties. A list of these have been identified by the task force and will be explored in the future.

To ensure efficient expenditure of grants, the program could be administered by WSDOT, while WDFW should provide necessary technical assistance to address data collection, database management, and barrier correction. The Fish Passage Task Force is prepared to develop the grant program prior to FY '99. This would complement the supplemental budget packages that WSDOT and WDFW have submitted for that fiscal year. Included in those packages are $2 million for grants, $100,000 for WSDOT grants administration, and $481,000 for WDFW technical assistance for FY '99. The grant proposal allocates $600,000 for expanding inventory work and $1,400,000 for barrier correction. The Fish Passage Task Force grant program would be administered over the next year (FY '99) with the anticipation that it be continued and expanded in the future.

D. Options Considered (Table 2)

Various scenarios ranging from an extremely aggressive schedule that would identify and correct all barriers within 8 years to the current rate of correction that would correct all barriers in 40 to 60 years were evaluated (Table 2). The current rate is obviously too slow to avoid the decline of more salmonid stocks. Failings of the most aggressive correction schedules were tied to shortage of trained technical personnel (in all sectors) and/or existing infrastructure to effectively inventory and correct more than 100 barriers per year. A key component to any plan to increase barrier correction must be increased training and technical support for survey and retrofit design. Partnerships with interested organizations and contracting survey or design work should be investigated.

The magnitude of the effort required to inventory and fix 150 barriers each year is estimated to be equivalent to adding an average WSDOT Region office (personnel and infrastructure). Assuming that a phase-in period will be required to expand the existing effort effectively and develop an aggressive grant program, the recommended option would correct an average of 100 barriers per year for 24 years. It would utilize a full inventory and prioritization approach to allow barriers that provide the highest benefits to fish to be corrected first. This approach would provide a realistic correction rate and ensure that dollars are spent to complete the high benefit projects early in the correction effort. Low risk projects that are not design intensive could be accelerated more by utilizing resources available through volunteer restoration groups.

E. Outreach to Improve Programs and Engage the Public

Even with a consistent methodology for inventory and prioritization such as shown in Appendices E and F, there is a need to have staff available to train and guide grant applicants to avoid difficulties in the start-up period. In its supplemental request, WDFW is requesting one FTE for database building and maintenance and two FTEs for inventory/prioritization training to fill this need. Such an outreach approach will reinforce a consistent methodology, promote sharing of information, and minimize the frustration that often accompanies well meaning efforts that are not compatible with each other.

Overall, perhaps the most limiting factor in barrier correction is getting the right technical expertise to those who need it. Expanded training and technical assistance in the field of fish passage design are vital. Part of the training effort should focus on other trainers (i.e., a "train the trainers" approach). An example would include further training of the Volunteer Technical Specialists (VTSs) charged with assisting volunteer groups. The VTSs could then not only assist volunteer groups in fish passage corrections but also act as a regional "on call" team to assess barriers for passability. This would enhance overall public awareness on this issue, stimulate information sharing, and further promote the use of the grant program. In its supplemental request, WDFW is requesting 3 FTEs for technical design assistance and training to fill this need.

TABLE 2. Fish passage barrier identification, prioritization, and correction options. [1]

Option Combination			Annual Corrections Completed	Annual Funds Required (millions)		Factors to Consider	
Correction	Prioritization	Inventory		Total	Grants Program	Benefit Stream (New Projects)	Viability
8 years	few barriers	4 years	300	$30	$24	even over time	non viable (inadequate technical human resources and infastructure for all work)
8 years	some barriers	8 years	300	$30	$24	some front loading	non viable (inadequate technical human resources and infastructure for prioritization and correction)
16 years	few barriers	4 years	150	$15	$9	even over time	non viable (inadequate technical human resources and infastructure for inventory and prioritization and correction in early years)
16 years	some barriers	8 years	150	$15	$9	some front loading	high risk (inadequate technical human resources and infastructure for prioritization and correction in early years)
16 years	all barriers	16 years	150	$15	$9	maximum front loading	moderate risk (inadequate technical human resources and infastructure for correction in early years)
24 years	few barriers	4 years	100	$10	$4	even over time	non viable (inadequate technical human resources and infastructure for inventory and prioritization)
24 years	some barriers	8 years	100	$10	$4	some front loading	moderate risk (inadequate technical human resources and infastructure for prioritization)
24 years	all barriers	16 years	100	$10	$4	maximum front loading	low risk (technical human resources and infrastructure available for all phases of work)
(Current) 40-60 years	(Current) some barriers	(Current) ?? years	40-60	$4-6	none	some front loading	current technical human resources and infrastructure sufficient

Heavy shading represents options with a high probability of cost inefficiency and/or project failure for **high-risk projects**.
Light shading represents options with a moderate probability of cost inefficiency and/or project failure for **high-risk projects**.
No shading represents options with a low probability of cost inefficiency and/or project failure for **high-risk projects**.

NOTE: **High-risk projects** are those requiring a high level of technical fish passage engineering and/or construction skills and that involve significant safety issues and significant resource and landowner implications should the project fail.

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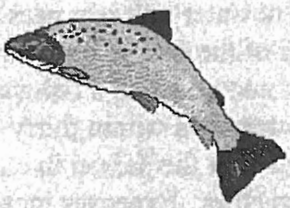
[1] Options were developed assuming 2,400 barriers need correction at an average cost of $100,000. The estimates for annual corrections completed and annual funds required are averaged over the whole time period, with an expectation that numbers would be lower than average early in the time period and higher than average later. There is also an assumption that fish passage work will be conducted in conjunction with road work as well as dedicated projects and an assumption of funding for administrative oversight and technical assistance.



APPENDIX A
FISH PASSAGE LAWS

FISH PASSAGE LAWS

RCW 75.20.060 Fishways required in dams, obstructions, - Penalties, remedies for failure.
A dam or other obstruction across or in a stream shall be provided with a durable and efficient fishway approved by the director. Plans and specifications shall be provided to the department prior to the director's approval. The fishway shall be maintained in an effective condition and continuously supplied with sufficient water to freely pass fish. It is unlawful for the owner, manager, agent, or person in charge of the dam or obstruction to fail to comply with this section.

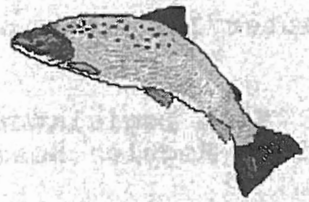
If a person fails to construct and maintain a fishway or to remove the dam or obstruction in a manner satisfactory to the director, then within thirty days after written notice to comply has been served upon the owner, his agent, or the person in charge, the director may construct a fishway or remove the dam or obstruction. Expenses incurred by the department constitute the value of a lien upon the dam and upon the personal property of the person owning the dam. Notice of the lien shall be filed and recorded in the office of the county auditor of the county in which the dam or obstruction is situated. The lien may be foreclosed in an action brought in the name of the state.

If, within thirty days after notice to construct a fishway or remove a dam or obstruction, the owner, his agent, or the person in charge fails to do so , the dam or obstruction is a public nuisance and the director may take possession of the dam or obstruction and destroy it. No liability shall attach for the destruction. (1983 1st ex.s. c 46 § 72; 1955 c 12 § 75.20.060. Prior: 1949 c 112 § 47; Rem. Supp. 1949 § 5780-321.)

RCW 75.20.061 Director may modify inadequate fishways and fish guards.
If the director determines that a fishway or fish guard described in RCW 75.20.040 and 75.20.060 and in existence on September 1, 1963, is inadequate, in addition to other authority granted in this chapter, the director may remove, relocate, reconstruct, or modify the device, without cost to the owner. The director shall not materially modify the amount of flow of water through the device. After the department has completed the improvements, the fishways and fish guards shall be operated and maintained at the expense of the owner in accordance with RCW 75.20.040 and 75.20.060. (1983 1st ex.s. c 46 § 73; 1963 c 153 § 1.)

RCW 77.16.210 Fishways to be provide and maintained.
Persons or government agencies managing, controlling, or owning a dam or other obstruction across a river or stream shall construct, maintain, and repair durable fishways and fish protective devices that allow the free passage of game fish around the obstruction. The fishways and fish protective devices shall be provided with sufficient water to insure the free passage of fish. (1980 c 78 § 88; 1955 c 36 § 77.16.020. Prior: 1947 c 275 § 60; Rem. Supp. 1947 § 5992-69.)

RCW 77.12.425 Director may modify inadequate fishways and protective devices.
The director may authorize removal, relocation, reconstruction, or other modification of an inadequate fishway or fish protective device required by RCW 77.16.210 and 77.16.220 which device was in existence on September 1, 1963, without cost to the owner for materials and labor. The modification may not materially alter the amount of water flowing through the fishway or fish protective device. Following modification, the fishway or fish protective device shall be maintained at the expense of the person or governmental agency owning the obstruction or water diversion device. (1980 c 78 § 90; 1963 c 152 § 1. Formerly RCW 77.16.221.)



APPENDIX B
SECOND SUBSTITUTE SENATE BILL 5886

CERTIFICATION OF ENROLLMENT

SECOND SUBSTITUTE SENATE BILL 5886

Chapter 389, Laws of 1997

55th Legislature
1997 Regular Session

FISHERIES ENHANCEMENT AND HABITAT RESTORATION

EFFECTIVE DATE: 7/27/97

Passed by the Senate April 26, 1997
YEAS 44 NAYS 0

BRAD OWEN
President of the Senate

Passed by the House April 25, 1997
YEAS 97 NAYS 0

CLYDE BALLARD
Speaker of the House of Representatives

Approved May 15, 1997

GARY LOCKE
Governor of the State of Washington

CERTIFICATE

I, Mike O'Connell, Secretary of the Senate of the State of Washington, do hereby certify that the attached is **SECOND SUBSTITUTE SENATE BILL 5886** as passed by the Senate and the House of Representatives on the dates hereon set forth.

MIKE O'CONNELL
Secretary

FILED

May 15, 1997 - 4:39 p.m.

Secretary of State
State of Washington

SECOND SUBSTITUTE SENATE BILL 5886

AS RECOMMENDED BY CONFERENCE COMMITTEE

Passed Legislature - 1997 Regular Session

State of Washington **55th Legislature** **1997 Regular Session**

By Senate Committee on Ways & Means (originally sponsored by Senators Strannigan, Swecker, Jacobsen and Oke)

Read first time 03/10/97.

AN ACT Relating to the regional fisheries enhancement program; amending RCW 75.50.080 and 75.50.160; adding new sections to chapter 75.50 RCW; and creating new sections.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF WASHINGTON:

NEW SECTION. **Sec. 1.** (1) The legislature finds that:

(a) Currently, many of the salmon stocks on the Washington coast and in Puget Sound are severely depressed and may soon be listed under the federal endangered species act.

(b) Immediate action is needed to reverse the severe decline of this resource and ensure its very survival.

(c) The cooperation and participation of private landowners is crucial in efforts to restore and enhance salmon populations.

(d) Regional fisheries enhancement groups have been exceptionally successful in their efforts to work with private landowners to restore and enhance salmon habitat on private lands.

(e) State funding for regional fisheries enhancement groups has been declining and is a significant limitation to current fisheries enhancement and habitat restoration efforts.

(f) Therefore, a stable funding source is essential to the success of the regional enhancement groups and their efforts to work cooperatively with private landowners to restore salmon resources.

(2) The legislature further finds that:

(a) The increasing population and continued development throughout the state, and the transportation system needed to serve this growth, have exacerbated problems associated with culverts, creating barriers to fish passage.

(b) These barriers obstruct habitat and have resulted in reduced production and survival of anadromous and resident fish at a time when salmonid stocks continue to decline.

(c) Current state laws do not appropriately direct resources for the correction of fish passage obstructions related to transportation facilities.

(d) Current fish passage management efforts related to transportation projects lack necessary coordination on a watershed, regional, and state-wide basis, have inadequate funding, and fail to maximize use of available resources.

(e) Therefore, the legislature finds that the department of transportation and the department of fish and wildlife should work with state, tribal, local government, and volunteer entities to develop a coordinated, watershed-based fish passage barrier removal program.

NEW SECTION. **Sec. 2.** A new section is added to chapter 75.50 RCW to read as follows:

The department may provide start-up funds to regional fisheries enhancement groups for costs associated with any enhancement project. The regional fisheries enhancement group advisory board and the department shall develop guidelines for providing funds to the regional fisheries enhancement groups.

NEW SECTION. **Sec. 3.** A new section is added to chapter 75.50 RCW to read as follows:

The regional fisheries enhancement salmonid recovery account is created in the state treasury. All receipts from federal sources and moneys from state sources specified by law must be deposited into the account. Moneys in the account may be spent only after appropriation. Expenditures from the account may be used for the sole purpose of fisheries enhancement and habitat restoration by regional fisheries enhancement groups.

NEW SECTION. **Sec. 4.** The regional fisheries enhancement group advisory board shall conduct a study of federal, state, and local permitting requirements for fisheries enhancement and habitat restoration projects. The study shall identify redundant, conflicting, or duplicative permitting requirements and rules, and shall make recommendations for streamlining and improving the permitting process. The results of the study shall be reported to the senate natural resources and parks committee and the house of representatives natural resources committee by November 1, 1997.

Sec. 5. RCW 75.50.080 and 1993 sp.s. c 2 s 47 are each amended to read as follows:

Regional fisheries enhancement groups, consistent with the long-term regional policy statements developed under RCW 75.50.020, shall seek to:

(1) Enhance the salmon and steelhead resources of the state;

(2) Maximize volunteer efforts and private donations to improve the salmon and steelhead resources for all citizens;

(3) Assist the department in achieving the goal to double the state-wide salmon and steelhead catch by the year 2000 ((~~under chapter 214, Laws of 1988~~)); and

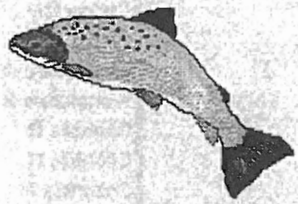
(4) Develop projects designed to supplement the fishery enhancement capability of the department.

Sec. 6. RCW 75.50.160 and 1995 c 367 s 2 are each amended to read as follows:

The ((~~department's habitat division shall work with~~)) department and the department of transportation shall convene a fish passage barrier removal task force. The task force shall consist of one representative each from the department, the department of transportation, the department of ecology, tribes, cities, counties, ((~~and~~)) a business organization, an environmental organization, regional fisheries enhancement groups, and other interested entities as deemed appropriate by the cochairs. The persons representing the department and the department of transportation shall serve as cochairs of the task force and shall appoint members to the task force. The task force shall make recommendations to ((~~develop a~~)) expand the program in RCW 75.50.170 to identify and expedite the removal of human-made or caused impediments to anadromous fish passage in the most efficient manner practical. Program recommendations shall include a funding mechanism and other necessary mechanisms to coordinate and prioritize state, tribal, local, and volunteer efforts within each water resource inventory area. A priority shall be given to projects that immediately increase access to available and improved spawning and rearing habitat for depressed, threatened, and endangered stocks. The department or the department of transportation may contract with cities and counties to assist in the identification and removal of impediments to anadromous fish passage.

A report on the ((~~progress of impediment identification and removal and the need for~~)) recommendations to develop a program to identify and remove fish passage barriers and any additional legislative action needed to implement the program shall be submitted to the ((~~senate and the house of representatives natural resources~~)) appropriate standing committees of the legislature no later than ((~~January 1, 1996~~)) December 1, 1997.

Passed the Senate April 26, 1997.
Passed the House April 25, 1997.
Approved by the Governor May 15, 1997.
Filed in Office of Secretary of State May 15, 1997.



APPENDIX C
WDFW FISH BARRIER DATABASES

List of Fish Passage Barriers by WRIA
Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
		Anderson Cr	L Roosevelt	WSDOT
		Bear Cr	L Roosevelt	WSDOT
		Empire Cr	L Roosevelt	WSDOT
		Jack Cr	L Roosevelt	WSDOT
		Lime Cr	L Roosevelt	WSDOT
		St Peter's Cr	Curlew Cr	WSDOT
		Tronsen Cr	Wenatchee R	WSDOT
		Tronsen Cr	Wenatchee R	WSDOT
		Tronsen Cr	Wenatchee R	WSDOT
		X-Trib	Chehalis R	WSDOT
		X-Trib	Chehalis R	WSDOT
		X-Trib	Columbia R	WSDOT
		X-Trib	Colville R	WSDOT
		X-Trib	Hoko R	WSDOT
		X-Trib	Hood Canal	WSDOT
		X-Trib	L Washington	WSDOT
		X-Trib	Nisqually R	WSDOT
		X-Trib	Pacific Ocean	WSDOT
		X-Trib	Pacific Ocean	WSDOT
		X-Trib	Pacific Ocean	WSDOT
		X-Trib	Pacific Ocean	WSDOT
		X-Trib	Pacific Ocean	WSDOT
		X-Trib	Pacific Ocean	WSDOT
		X-Trib	Sanpoil R	WSDOT
		X-Trib	Straits	WSDOT
		X-Trib	Yakima R	WSDOT
		X-Trib Clallam R	Straits	WSDOT
		X-Trib North Cr	L Washington	WSDOT
		X-Trib Quinalt	Quinault R	WSDOT
		X-trib Clallam	Clallam R	WSDOT
		X-trib Pysht River	Pysht R	WSDOT
		X-trib pysht	Straits	WSDOT
	0.1000	N Nanamkin Cr	Sanpoil R	WSDOT
00.0003	11.1000	Saar Cr.	Sumas R.	UFPP
00.0019	1.8000	Goodwin Ditch	Sumas R.	UFPP
00.0019A	1.1000	X-trib. to Goodwin Ditch	Goodwin Ditch	UFPP
00.0020	0.8000	Dale Cr.	Sumas R.	UFPP
01.0045	6.6000	California Cr.	Drayton Harbor	UFPP
01.0071	0.4000	X-trib. to California Cr.	California Cr.	UFPP
01.0089	0.0000	Terrell Cr.	Birch Bay	UFPP
01.0089	8.7000	Terrell Cr.	Birch Bay	UFPP
01.0104	0.0000	Lummi R.	Lummi Bay	UFPP
01.0107	0.0000	X-trib. to Lummi R. trib		UFPP
01.0116	3.8000	Schell Ditch	Lummi R.	UFPP
01.0116	3.9000	Schell Ditch	Lummi R.	UFPP
01.0116	4.2000	Schell Ditch	Lummi R.	UFPP
01.0116	4.7000	Schell Ditch	Lummi R.	UFPP
01.0124	0.0000	Silver Cr.	X-slough to Nooksack R.	UFPP
01.0163	0.0000	Ten Mile Cr.	Nooksack R.	UFPP
01.0165		Deer Cr	Nooksack R	WSDOT
01.0165	0.0000	Deer Cr.	Ten Mile Cr.	UFPP
01.0165	5.6000	Deer Cr.	Ten Mile Cr.	UFPP
01.0172	1.2000	X-trib. to Deer Cr.	Deer Cr.	UFPP
01.0172	1.5000	X-trib. to Deer Cr.	Deer Cr.	UFPP
01.0181	0.0000	Fourmile Cr.	Ten Mile Cr.	UFPP
01.0184	0.1000	X-trib. to Ten Mile Cr.	Ten Mile Cr.	UFPP
01.0184	0.2000	X-trib. to Ten Mile Cr.	Ten Mile Cr.	UFPP
01.0191A	0.1000	X-trib. to Ten Mile Cr.	Ten Mile Cr.	UFPP

The need for repair has been verified for those barriers listed from the Thurston County Inventory and WSDOT databases. Repair requirements have not been identified for those barriers listed from the UFPP (Unresolved Fish Passage Problems) database.

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
01.0192	0.1000	Whiskey Cr.	Nooksack R.	UFPP
01.0196	0.0000	Snyder Ditch	Nooksack R.	UFPP
01.0202	3.4000	Duffner Ditch	Bertrand Cr.	UFPP
01.0202B	2.8000	X-trib. to 01.0202	Duffner Ditch	UFPP
01.0206	0.6000	X-trib. to Bertrand Cr.	Bertrand Cr.	UFPP
01.0206B	0.1000	X-trib. to Bertrand trib.	Bertrand Cr.	UFPP
01.0212	1.0000	Bender Ditch	Fishtrap Cr.	UFPP
01.0212	2.0000	Bender Ditch	Fishtrap Cr.	UFPP
01.0220	0.4000	Elder Ditch	X-trib. to Nooksack R.	UFPP
01.0262	0.0000	Jones Cr.	S.R. Nooksack R.	UFPP
01.0337	0.3000	X-trib. to Nooksack R.	Nooksack R.	UFPP
01.0339	7.2000	M.F. Nooksack R.	Nooksack R.	UFPP
01.0347	0.1000	X-trib. to M.F. Nooksack	M.F. Nooksack R.	UFPP
01.0347	0.2000	X-trib. to M.F. Nooksack	M.F. Nooksack R.	UFPP
01.0348	0.0000	X-trib. M.F. Nooksack trb	M.F. Nooksack R.	UFPP
01.0352	0.0000	Bear Cr.	M.F. Nooksack R.	UFPP
01.0392	1.6000	Kenny Cr.	N.F. Nooksack R.	UFPP
01.0393A	0.0000	X-trib. to N.F. Nooksack	N.F. Nooksack R.	UFPP
01.0406	0.1000	Kendall Cr.	N.F. Nooksack R.	UFPP
01.0407		X-Trib Kendall Cr	Nooksack R	WSDOT
01.0463		Hedrick Cr	Nooksack R	WSDOT
01.0550	0.0000	X-trib. to Bellingham Bay	Bellingham Bay	UFPP
01.0552	0.0000	Squalicum Cr.	Bellingham Bay	UFPP
01.0553	0.1000	X-trib. to Squalicum Cr.	Squalicum Cr.	UFPP
01.0554		Baker Cr	Squalicum Cr	WSDOT
01.0554	1.3700	Baker Cr.	X-trib. to Squalicum Cr.	UFPP
01.0554	2.0700	Baker Cr.	X-trib. to Squalicum Cr.	UFPP
01.0555	0.0000	X-trib. to Baker Cr.	Baker Cr.	UFPP
01.0555	0.5800	X-trib. to Baker Cr.	Baker Cr.	UFPP
01.0555	0.8400	X-trib. to Baker Cr.	Baker Cr.	UFPP
01.0559	0.1000	L. Squalicum Cr.	Squalicum Cr.	UFPP
01.0560		Toad Cr	Bellingham Bay	WSDOT
01.0560	0.1000	Toad Cr.	Squalicum Cr.	UFPP
01.0560	0.6300	Toad Cr.	Squalicum Cr.	UFPP
01.0560	0.6900	Toad Cr.	Squalicum Cr.	UFPP
01.0560	0.7600	Toad Cr.	Squalicum Cr.	UFPP
01.0566	0.1000	Whatcom Cr.	Bellingham Bay	UFPP
01.0566	1.0000	Whatcom Cr.	Bellingham Bay	UFPP
01.0622	0.0000	Padden Cr.	Bellingham Bay	UFPP
01.0654	0.7000	X-trib. to Colony Cr.	Colony Cr.	UFPP
01.XXXX		X-Trib	NF Nooksack R	WSDOT
01.XXXX		X-Trib	NF Nooksack R	WSDOT
03.0010	0.0000	Thomas Cr.	Samish R.	UFPP
03.0017X	0.0000	X-trib.	Friday Cr.	UFPP
03.0019	0.0000	Butler Cr.	Friday Cr.	UFPP
03.0019	4.3000	Butler Cr.	Friday Cr.	UFPP
03.0023	3.8000	Reed Lake Outlet	Silver Cr.	UFPP
03.0023A	0.0000	X-trib. to Silver Cr.	Silver Cr.	UFPP
03.0023A	0.0500	X-trib. to Silver Cr.	Silver Cr.	UFPP
03.0036		Barnes Cr	Samish Lake	WSDOT
03.0053B	0.0000	X-trib.		UFPP
03.0054	0.0000	Parson Cr.	Samish R.	UFPP
03.0061	0.2000	X-trib. to Samish R.	Samish R.	UFPP
03.0061	0.2500	X-trib. to Samish R.	Samish R.	UFPP
03.0063	0.1000	X-trib. to Samish R.	Samish R.	UFPP
03.0068	0.4000	X-trib. to Samish R.	Samish R.	UFPP
03.0078	0.3000	N.P. (Haner) Cr.	Samish R.	UFPP
03.0096	0.0000	No Name Cr.	Padilla Bay	UFPP

The need for repair has been verified for those barriers listed from the Thurston County Inventory and WSDOT databases. Repair requirements have not been identified for those barriers listed from the UFPP (Unresolved Fish Passage Problems) database.

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
03.0102	0.0000	Indian Slough	Padilla Bay	UFPP
03.0176 X	0.0000	X-trib. to Skagit R.	Skagit R.	UFPP
03.0182	0.0000	Milltown Cr.	Fisher Cr.	UFPP
03.0182	1.8500	Milltown Cr.	Fisher Cr.	UFPP
03.0182	1.8700	Milltown Cr.	Fisher Cr.	UFPP
03.0183	0.1000	X-trib. to Milltown Cr.	Milltown Cr.	UFPP
03.0183	0.7000	X-trib. to Milltown Cr.	Milltown Cr.	UFPP
03.0183	0.8000	X-trib. to Milltown Cr.	Milltown Cr.	UFPP
03.0183	1.2000	X-trib. to Milltown Cr.	Milltown Cr.	UFPP
03.0196	0.1000	X-trib. to Fisher Cr.	Fisher Cr.	UFPP
03.0196	0.6800	X-trib. to Fisher Cr.	Fisher Cr.	UFPP
03.0233	0.0600	Little Day Cr.	Turner Cr.	UFPP
03.0239	4.7000	Walker Cr.	E.F. Nookachamps Cr.	UFPP
03.0254	0.5000	Shiloh Cr.	W.F. Nookachamps Creek	UFPP
03.0256	0.6000	Otter Pond Cr.	W.F. Nookachamps Cr.	UFPP
03.0259	0.6000	X-trib. to Lake Cr.	Lake Cr.	UFPP
03.0266	1.9000	Brickyard Cr.	Skagit R.	UFPP
03.0266	2.0000	Brickyard Cr.	Skagit R.	UFPP
03.0266 A*	1.4000	X trib. to Brickyard Cr.	Brickyard Cr.	UFPP
03.0266 A*	1.5000	X-trib. to Brickyard Cr.	Brickyard Cr.	UFPP
03.0268	1.7000	Red Cr.	Hansen Cr.	UFPP
03.0268	1.9000	Red Cr.	Hansen Cr.	UFPP
03.0277A		X-Trib	Skagit R	WSDOT
03.0279	0.0000	Coal Cr.	Skiyou Slough (Skagit R.)	UFPP
03.0280	0.0000	Wiseman Cr.	Skagit R.	UFPP
03.0293B	0.4800	X-trib.		UFPP
03.0332	3.0000	Jones Cr.	Skagit R.	UFPP
03.0332X	0.0000	Pipeline Cr.		UFPP
03.0339A	0.1000	X-trib. to Mannser Cr.	Mannser Cr.	UFPP
03.0342	0.0000	X-trib. to Mannser Cr.	Mannser Cr.	UFPP
03.1345		Sutter Cr	Skagit R	WSDOT
03.1774A	0.2000	Cub Cr	Bacon Cr	WSDOT
03.2966	5.4000	Maddox Cr.		UFPP
03.2970	0.0000	X-trib. to Skagit R.	Skagit R.	UFPP
03.XXXX		X-Trib	Skagit R	WSDOT
04.0339 X	0.2600	X-trib. to Sauk R.	Sauk R.	UFPP
04.0373	0.1000	X-trib. to Skagit R.	Skagit R.	UFPP
04.0377	8.0000	Grandy Cr.	Skagit R.0	UFPP
04.0381	0.0000	X-trib. to Grandy Cr.	Grandy Cr.	UFPP
04.0434A	0.0000	Lornezan Cr.	Skagit R.	UFPP
04.0434A	0.8000	Lornezan Cr.	Skagit R.	UFPP
04.0644	0.2000	X-trib. to Skagit R.	Skagit R.	UFPP
04.0645	0.1000	X-trib. to Skagit R.	Skagit R.	UFPP
04.0646	0.7000	Hooper Cr.	Skagit R.	UFPP
04.0659	0.3100	Aldon Cr.	Skagit R.	UFPP
04.0661	0.1000	Miller Cr.	Skagit R.	UFPP
04.0673H	0.4000	Tiny Kisutch		UFPP
04.0675	0.5400	X-trib. to Sauk R.	Sauk R.	UFPP
04.1064		X-Trib	Skagit R	WSDOT
04.1069	0.3000	Prairie Cr.	Sauk R.	UFPP
04.1071	0.6000	Gravel Cr.	Sauk R.	UFPP
04.1088	0.0000	Unnamed (Turner's Corner)	X-trib. to Sauk R.	UFPP
04.1088	1.0000	Unnamed (Turner's Corner)	X-trib. to Sauk R.	UFPP
04.1112	0.1000	Murphy Cr.	Sauk R.	UFPP
04.1113	0.0500	Goodman Cr.	Sauk R.	UFPP
04.1114	0.3000	Dutch Cr.	Sauk R.	UFPP
04.1143	0.2900	Owl Cr.	Whitechuck R.	UFPP
04.1412	0.0000	Jordan Cr.	Cascade R.0	UFPP

List of Fish Passage Barriers by WRIA
Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
04.1433B	0.2500	X-trib. to Cascade R.	Cascade R.	UFPP
04.1751	0.2000	X-trib. Diobsud Cr. trib.	X-trib. to Diobsud Cr.	UFPP
04.1773	0.8000	X-trib. to Diobsud Cr.	Diobsud Cr.	UFPP
05.0012	0.0000	Cont. of S. Douglas Sl.	Old Stillaguamish R.	UFPP
05.0021		W F Church Cr	Church Cr	WSDOT
05.0036	6.0000	Portage Cr.	Stillaguamish R.	UFPP
05.0060	0.0000	X-trib.		UFPP
05.0064	0.5000	X-trib. to Pilchuck Cr.	Pilchuck Cr.	UFPP
05.0065		X-Trib	Pilchuck Cr	WSDOT
05.0065	0.9000	X-trib. to Pilchuck Cr.	Pilchuck Cr.	UFPP
05.0073	0.6000	X-trib. to Pilchuck Cr.	Pilchuck Cr.	UFPP
05.0137		X-Trib	Stillaguamish R	WSDOT
05.0138	0.0000	X-trib. to Stillaguamish	Stillaguamish R.	UFPP
05.0140	1.4000	Rock Cr.		UFPP
05.0145		X-Trib	NF Stillaguamish R	WSDOT
05.0145	0.9000	Trafton Cr.	N.F. Stillaguamish R.	UFPP
05.0145	1.0000	Trafton Cr.	N.F. Stillaguamish R.	UFPP
05.0145	1.1000	Trafton Cr.	N.F. Stillaguamish R.	UFPP
05.0147		X-Trib	NF Stillaguamish R	WSDOT
05.0148		X-Trib	NF Stillaguamish R	WSDOT
05.0150		X-Trib	NF Stillaguamish R	WSDOT
05.0150	0.0400	X-trib. to N.F. Stilly	N.F. Stillaguamish R.	UFPP
05.0151X		X-Trib	NF Stillaguamish R	WSDOT
05.0151X		X-Trib	NF Stillaguamish R	WSDOT
05.0152		Ryan Falls Cr	Stillaguamish R	WSDOT
05.0166	0.0000	X-trib. to N.F. Stilly	N.F. Stillaguamish R.	UFPP
05.0172A	0.6000	X-trib.		UFPP
05.0213X		X-Trib	Fry Cr (NF Stilly)	WSDOT
05.0217 X	0.1500	X-trib. to Montague Cr.	Montague Cr.	UFPP
05.0217X		X-Trib	Montaque Cr (NF Stilly)	WSDOT
05.0254		Fortson Cr	Stillaguamish R	WSDOT
05.0257		Old Moose Cr	NF Stilliguamish R	WSDOT
05.0257A	0.1000	X-trib. (L. Fish Cr.)	Moose Cr.	UFPP
05.0337	0.6000	X-trib. to Jim Cr.	Jim Cr.	UFPP
05.0338D	0.0000	X-trib.		UFPP
05.0396A	0.0000	X-trib. S.F. Stilly trib.	X-trib. S.F. Stilly R.	UFPP
05.0422A	0.1000	X-trib.	S.F. Stillaguamish R.	UFPP
05.0425	0.0000	Dazzling Howie Cr.	S.F. Stillaguamish R.	UFPP
05.0427A	0.0000	X-trib. to S.F. Stilly	S.F. Stillaguamish R.	UFPP
05.0433A	0.1000	X-trib. (Fish Crew Cr.)	S.F. Stillaguamish R.	UFPP
05.0433B	0.1000	X-trib. (Tiny Cr.)	S.F. Stillaguamish R.	UFPP
05.0434B	0.4000	X-trib. (Big Four Cr.)	S.F. Stillaguamish R.	UFPP
07.0058	0.0000	M.F. Quiliceda Cr.	Quilceda Cr.	UFPP
07.0059	0.0000	X-trib. to M.F. Quilceda	M.F. Quilceda Cr.	UFPP
07.0140	4.1000	Panther Cr.	Dubuque Cr.	UFPP
07.0184 A	0.5000	X-Trib. French Cr.	French Cr.	UFPP
07.0203	0.2700	X-trib. to French Cr.	French Cr.	UFPP
07.0205	1.3000	X-trib. to French Cr.	French Cr.	UFPP
07.0212		Anderson Cr	Snohomish R	WSDOT
07.0214		Elliott Cr	Snohomish R	WSDOT
07.0214	0.3000	Elliott Cr.	X-Side Channel Snohomish	UFPP
07.0219A		X-Trib	Snoqualmie R	WSDOT
07.0276 A	0.4000	X-trib. Snoqualmie trib.	X-trib. to Snoqualmie R.	UFPP
07.0276 A	0.4500	X-trib. Snoqualmie trib.	X-tribl to Snoqualmie R.	UFPP
07.0286A	0.3000	X-trib. to Harris Cr.	Harris Cr.	UFPP
07.0393		Lake Cr	Raging R	WSDOT
07.0396		Deep Cr	Raging R	WSDOT
07.0440	0.4000	Tokul Cr.	Snoqualmie R.	UFPP

The need for repair has been verified for those barriers listed from the Thurston County Inventory and WSDOT databases. Repair requirements have not been identified for those barriers listed from the UFPP (Unresolved Fish Passage Problems) database.

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
07.0508		Talapus Cr	SF Snoqualmie R	WSDOT
07.0508		Talupus Cr	SF Snoqualmie R	WSDOT
07.0939	0.3000	Wagley's Cr.	Skykomish R.	UFPP
07.0964	0.7000	X-trib. to Skykomish R.	Skykomish R.	UFPP
07.XXXX		X-Trib	SF Snoqualmie R	WSDOT
08.0000 A	0.0000	X-trib. to Lake Sammamish	Lake Sammamish	UFPP
08.0000 B	0.0000	X-trib. to Lk. Washington	Lake Washington	UFPP
08.0011		Deer / Willow Cr	Puget Sound	WSDOT
08.0011	0.6000	Willow Cr.	Puget Sound	UFPP
08.0011	0.6200	Willow Cr.	Puget Sound	UFPP
08.0011	0.8000	Willow Cr.	Puget Sound	UFPP
08.0011	0.9500	Willow Cr.	Puget Sound	UFPP
08.0011	1.2000	Willow Cr.	Puget Sound	UFPP
08.0011	1.2500	Willow Cr.	Puget Sound	UFPP
08.0011	1.5500	Willow Cr.	Puget Sound	UFPP
08.0011	1.5800	Willow Cr.	Puget Sound	UFPP
08.0017	0.0000	Boeing Cr.	Puget Sound	UFPP
08.0030	1.5000	Thornton Cr.	Lake Washington	UFPP
08.0030	1.8000	Thornton Cr.	Lake Washington	UFPP
08.0030	2.1000	Thornton Cr.	Lake Washington	UFPP
08.0030	2.3000	Thornton Cr.	Lake Washington	UFPP
08.0031	0.0000	X-trib. to Thornton Cr.	Thornton Cr.	UFPP
08.0031	0.4000	X-trib. to Thornton Cr.	Thornton Cr.	UFPP
08.0033		Maple Leaf Cr	L Washington	WSDOT
08.0039	0.0000	L. Brook Cr.	Thornton Cr.	UFPP
08.0049	1.5000	McAleer Cr.	Lake Washington	UFPP
08.0049	2.7000	McAleer Cr.	Lake Washington	UFPP
08.0049	5.0000	McAleer / Hall Cr.	Lake Washington	UFPP
08.0049	5.1000	McAleer / Hall Cr.	Lake Washington	UFPP
08.0049	5.8000	McAleer / Hall Cr.	Lake Washington	UFPP
08.0049 A	0.0000	X-trib. to McAleer Cr.	McAleer Cr.	UFPP
08.0049 B	0.0000	X-trib. to McAleer Cr.	McAleer Cr.	UFPP
08.0049 C	0.1000	X-trib. to McAleer Cr.	McAleer Cr.	UFPP
08.0050	0.0000	X-trib. to McAleer Cr.	McAleer CR.	UFPP
08.0052		Lyon Cr	L Washington	WSDOT
08.0052	1.3800	Lyon Cr.	Lake Washington	UFPP
08.0052	1.7000	Lyon Cr.	Lake Washington	UFPP
08.0052	1.8200	Lyon Cr.	Lake Washington	UFPP
08.0052	1.9100	Lyon Cr.	Lake Washington	UFPP
08.0052	2.0300	Lyon Cr.	Lake Washington	UFPP
08.0052	2.0600	Lyon Cr.	Lake Washington	UFPP
08.0052	2.1800	Lyon Cr.	Lake Washington	UFPP
08.0052	2.2500	Lyon Cr.	Lake Washington	UFPP
08.0052	2.4100	Lyon Cr.	Lake Washington	UFPP
08.0052	2.4700	Lyon Cr.	Lake Washington	UFPP
08.0052	2.5800	Lyon Cr.	Lake Washington	UFPP
08.0052	2.8000	Lyon Cr.	Lake Washington	UFPP
08.0052	3.0000	Lyon Cr.	Lake Washington	UFPP
08.0052	3.1900	Lyon Cr.	Lake Washington	UFPP
08.0052	3.2400	Lyon Cr.	Lake Washington	UFPP
08.0052 A	0.0000	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0052 B	0.2000	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0052 C	0.3000	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0052 D	0.4000	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0053		X-Trib	Lyon Cr	WSDOT
08.0053	0.0000	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0053	0.3000	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0053	0.3300	X-trib. to Lyon Cr.	Lyon Cr.	UFPP

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Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
08.0053	0.4100	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0053	0.4500	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0053	0.9200	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0053	1.3400	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0053	1.3800	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0053	1.4200	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0053	1.4600	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0054	0.2400	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0054	0.3600	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0055	0.0100	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0055	0.1700	X-trib. to Lyon Cr.	Lyon Cr.	UFPP
08.0056	0.0100	X-trib. to Lk. Washington	Lake Washington	UFPP
08.0056	0.1000	X-trib. to Lk. Washington	Lake Washington	UFPP
08.0056	0.1100	X-trib. to Lk. Washington	Lake Washington	UFPP
08.0057 A	0.0000	X-trib. to Sammamish R.	Sammamish R.	UFPP
08.0061	2.3000	Scriber Lake Cr.	Swamp Cr.	UFPP
08.0070 B*	0.0000	X-trib. to North Cr.	North Cr.	UFPP
08.0091 *	0.2000	X-trib. to Sammamish R.	Sammamish R.	UFPP
08.0102 A*	0.1000	NF X-trib to Sammamish R.	X-trib. to Sammamish R.	UFPP
08.0102 A*	0.3000	X-trib. to Sammamish R.	Sammamish R.	UFPP
08.0104	0.0000	Peters Cr.	Sammamish R.	UFPP
08.0105 A*	0.0000	X-trib. to Bear Cr.	Bear Cr.	UFPP
08.0106	6.9000	Evans Cr.	Bear Cr.	UFPP
08.0108	0.5000	X-trib. to Evans Cr.	Evans Cr.	UFPP
08.0110	0.9000	Rutherford Cr.	Evans Cr.	UFPP
08.0110	1.3000	Rutherford Cr.	Evans Cr.	UFPP
08.0110	1.7000	Rutherford Cr.	Evans Cr.	UFPP
08.0113	0.0100	X-trib. to Evans Cr.	Evans Cr.	UFPP
08.0129 *	0.6000	Seidel Cr.	Bear Cr.	UFPP
08.0129 *	0.8000	Seidel Cr.	Bear Cr.	UFPP
08.0129 *	2.0000	Seidel Cr.	Bear Cr.	UFPP
08.0131	0.8800	Struve Cr.	Bear Cr.	UFPP
08.0131	0.9500	Struve Cr.	Bear Cr.	UFPP
08.0132	0.9000	Colin Cr.	Bear Cr.	UFPP
08.0143	0.1000	X-trib. L. Sammamish	Lake Sammamish	UFPP
08.0152	0.1000	X-trib. to Lake Sammamish	Lake Sammamish	UFPP
08.0169		Tibbets Cr	L Washington	WSDOT
08.0172		X-Trib	L Washington	WSDOT
08.0178		Halder Cr	Issaquah Cr	WSDOT
08.0178 A	0.2000	X-trib. to Issaquah Cr.	Issaquah Cr.	UFPP
08.0178 B	0.0000	X-trib. to Issaquah Cr.	Issaquah Cr.	UFPP
08.0178 C	0.0000	X-trib. to Holder Cr.	Holder Cr.	UFPP
08.0183	5.8000	E.F.Issaquah Cr.	Issaquah Cr.	UFPP
08.0206	0.0000	X-trib. to Issaquah Cr.	Issaquah Cr.	UFPP
08.0206	0.1000	Nudist Camp Cr.	Issaquah Cr.	UFPP
08.0215	0.3000	X-trib. to Issaquah Cr.	Issaquah Cr.	UFPP
08.0218A		X-Trib Carey Cr	Issaquah Cr	WSDOT
08.0230	2.3000	Juanita Cr.	Lake Washington	UFPP
08.0235	0.4000	X-trib. to Juanita Cr.	Juanita Cr.	UFPP
08.0238	0.2500	X-trib. to Juanita Cr.	Juanita Cr.	UFPP
08.0238	0.3500	X-trib. to Juanita Cr.	Juanita Cr.	UFPP
08.0242	0.0000	Forbes Cr.		UFPP
08.0242	1.8000	Forbes Cr.		UFPP
08.0252	1.0000	Yarrow Cr.		UFPP
08.0252	1.2000	Yarrow Cr.		UFPP
08.0252	2.0000	Yarrow Cr.	Lake Washington	UFPP
08.0253	0.2000	Cochran Cr.		UFPP
08.0253	0.5000	Cochran Cr.		UFPP

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
08.0257		Goff Cr	L Washington	WSDOT
08.0257	0.0000	Goff Cr.		UFPP
08.0260	0.0000	Kelsey Cr.		UFPP
08.0299	21.5000	Cedar R.		UFPP
08.0299	21.8000	Cedar R.		UFPP
08.0302	0.1000	Maplewood Cr.		UFPP
08.0302	0.4000	Maplewood Cr.		UFPP
08.0302	0.5000	Maplewood Cr.		UFPP
08.0326		X-Trib Downs Cr	Cedar R	WSDOT
08.0328	0.0000	Peterson Cr.		UFPP
09.0020	0.0000	X-trib. to Springbrook Cr		UFPP
09.0089	2.5000	X-trib. to Jenkins Cr.		UFPP
09.0114	0.0000	N.F. Newaukum Cr.		UFPP
09.0362	0.0000	Salmon Cr.		UFPP
09.0362	0.1500	Salmon Cr.		UFPP
09.0371	1.6000	Miller Cr.	Puget Sound	UFPP
09.0377	0.5000	Des Moines (Bow Lake)	Duwamish R	WSDOT
10.0017	3.3000	Wapato Cr.		UFPP
10.0022	1.9000	Clear Cr.		UFPP
10.0023	0.0000	Swan Cr.		UFPP
10.0033	0.7000	Jovita Cr.		UFPP
10.0050		X-Trib	Puyallup R	WSDOT
10.0057	0.7000	Boise Cr.		UFPP
10.0057 A*	0.0000	X-trib. to Boise Cr.		UFPP
10.0073 A*	0.0000	X-trib. to Scatter Cr.		UFPP
11.0001A	0.5000	Little Red Salmon Cr.	Nisqually R.	UFPP
11.0136	0.1100	X-trib. to Alder Lake	Alder Lake	UFPP
11.0168		Coal Cr	Nisqually R	WSDOT
11.0328		X-Trib	McAllister Cr	WSDOT
11.0330		Eaton Cr	Lk St. Clair	Thurston Co. Inventory
11.XXXX		X-Trib	Alder Lake	WSDOT
11.XXXX		X-Trib	Mineral Lake	WSDOT
11.XXXX		X-Trib	Round Top Cr	WSDOT
11.XXXX		X-Trib	Summit Cr	WSDOT
11.XXXX		X-Trib Nisqually R	Nisqually R	WSDOT
11.XXXX	0.0410	X-Trib	Round Top Cr	WSDOT
11.XXXX	0.1050	X-Trib	Alder Lake	WSDOT
12.0007	5.9000	Clover Cr.		UFPP
12.0010	0.3000	Ponce De Leon Cr.		UFPP
12.0012	0.0000	Spanaway Cr.		UFPP
13.0008	0.0600	X-trib. to Woodland Cr.		UFPP
13.0010		X-Trib	Woodland Cr	Thurston Co. Inventory
13.0010	0.5500	X-trib. to Woodland Cr.	Woodland Cr.	UFPP
13.0010	0.6100	X-trib. to Woodland Cr.	Woodland Cr.	UFPP
13.0010A	0.0400	X-trib. to Woodland Cr.	Woodland Cr.	UFPP
13.0013B	0.1500	X-trib. to Woodard Cr.	Woodard Cr.	UFPP
13.0013x		X-Trib	Woodard Cr	Thurston Co. Inventory
13.0013x		X-Trib	Woodard Cr	Thurston Co. Inventory
13.0018		X-Trib	Budd Inlet	Thurston Co. Inventory
13.0018	0.6000	X-trib. to Budd Inlet	Budd Inlet	UFPP
13.0018	0.8400	X-trib. to Budd Inlet	Budd Inlet	UFPP
13.0021		Adams Cr	Budd Inlet	Thurston Co. Inventory
13.0021	0.4000	Adams Cr.	Budd Inlet	UFPP
13.0021	0.9000	Adams Cr.	Budd Inlet	UFPP
13.0022		Ellis Cr	Budd Inlet	Thurston Co. Inventory
13.0022		Ellis Cr	Budd Inlet	Thurston Co. Inventory
13.0022	0.9000	Ellis Cr.	Budd Inlet	UFPP
13.0023	0.5000	X-trib. to Ellis Cr.	Ellis Cr.	UFPP

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
13.0024		X-Trib	Ellis Cr	Thurston Co. Inventory
13.0026		Indian Cr	Moxlie Cr	Thurston Co. Inventory
13.0026	0.4300	Indian Cr	Moxlie Cr	WSDOT
13.0026	0.4800	Indian Cr.	Moxlie Cr.	UFPP
13.0026	0.6800	Indian Cr.	Moxlie Cr.	UFPP
13.0026	0.9800	Indian Cr.	Moxlie Cr.	UFPP
13.0026	1.2300	Indian Cr.	Moxlie Cr.	UFPP
13.0026	1.4300	Indian Cr.	Moxlie Cr.	UFPP
13.0026	1.4600	Indian Cr.	Moxlie Cr.	UFPP
13.0028x		X-Trib	Deschutes R	Thurston Co. Inventory
13.0029		Percival Cr	Capitol Lk	Thurston Co. Inventory
13.0030		Black Lk Ditch	Capitol Lk	Thurston Co. Inventory
13.0040		X-Trib	Offut Lk	Thurston Co. Inventory
13.0132		X-Trib	Budd Inlet	Thurston Co. Inventory
13.0132	0.0000	X-trib. (Butler Cove Cr.)	Budd Inlet	UFPP
13.0137		X-Trib	Eld Inlet	Thurston Co. Inventory
13.0137		X-Trib	Eld Inlet	Thurston Co. Inventory
13.0139		Swift Cr	McLane cr	Thurston Co. Inventory
13.0139		Swift Cr.	Mclane Cr.	Thurston Co. Inventory
13.0139	3.8000	Swift Cr.	McLane Cr.	UFPP
13.0139 X	0.3400	X-trib. to Swift Cr.	Swift Cr.	UFPP
13.0139 Z	0.0100	X-trib. to Swift Cr. trib	X-trib. to Swift Cr.	UFPP
13.0139x		X-Trib	Swift Cr	Thurston Co. Inventory
13.0143	1.6000	Beatty Cr.	McLane Cr.	UFPP
14.0000x		X-Trib	Eld Inlet	Thurston Co. Inventory
14.0001 A	0.9000	X-trib. to Perry Cr.	Perry Cr.	UFPP
14.0001 X	0.0200	X-trib. to Perry Cr. trib	X-trib. to Perry Cr.	UFPP
14.0002	0.2000	X-trib. to Perry Cr.	Perry Cr.	UFPP
14.0006		X-Trib	Eld Inlet	Thurston Co. Inventory
14.0009A	1.1600	Holiday Valley Cr.	Schneider Cr.	UFPP
14.0012	9.2700	Kennedy Cr.	Totten Inlet	UFPP
14.0012 X	0.1100	X-trib. to Kennedy Cr.	Kennedy Cr.	UFPP
14.0012B	0.4000	Fiscus Cr.	Kennedy Cr.	UFPP
14.0014			Kennedy Cr	Thurston Co. Inventory
14.0014 B	0.1000	X-trib. to Summit Lake	Summit Lake (Kennedy Cr.)	UFPP
14.0014 B	0.1500	X-trib. to Summit Lake	Summit Lake (Kennedy Cr.)	UFPP
14.0014x		X-Trib	Summit Lk	Thurston Co. Inventory
14.0015		X-Trib	Kennedy Cr	Thurston Co. Inventory
14.0015		X-Trib	Kennedy Cr	WSDOT
14.0018		X-Trib	Kennedy Cr	Thurston Co. Inventory
14.0018	0.7200	X-trib. to Kennedy Cr.	Kennedy Cr.	UFPP
14.0020A		X-Trib Skookum Cr	Skookum Inlet	WSDOT
14.0023		McDonald Cr	Skookum Cr	WSDOT
14.0036C	0.3000	X-trib. to Coffee Cr.	Coffee Cr.	UFPP
14.0051	4.1000	Cranberry Cr.	Oakland Bay	UFPP
14.0051B	0.1000	X-trib. to Cranberry Cr.	Oakland Bay	UFPP
14.0067	0.5000	Malaney Cr.	Oakland	UFPP
14.0084	0.2000	Keller Cr.	Pickering Passage	UFPP
14.0095	0.1000	X-trib. to Sherwood Cr.	Sherwood Cr.	UFPP
14.1200A	0.2600	X-trib. to Sauk R.	Sauk R.	UFPP
14.XXXX		X-Trib	Kennedy Cr	WSDOT
14.XXXX		X-Trib	Kennedy Cr	WSDOT
14.XXXX		X-Trib	Kennedy Cr	WSDOT
14.XXXX		X-Trib	Kennedy Cr	WSDOT
14.XXXX		X-Trib (Madrona Beach)	Puget Sound	WSDOT
14.XXXX	0.0000	X-Trib	Perry Cr	WSDOT
14.XXXX	0.0440	X-Trib	Kennedy Cr	WSDOT
15.0001		X-Trib Coulter Cr	Coulter Cr	WSDOT

The need for repair has been verified for those barriers listed from the Thurston County Inventory and WSDOT databases. Repair requirements have not been identified for those barriers listed from the UFPP (Unresolved Fish Passage Problems) database.

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
15.0011 A	0.1300	X-trib. to North Bay		UFPP
15.0016	1.0000	X-Trib. Rocky Cr.	Rocky Cr.	UFPP
15.0029	0.1000	Knackstedt Cr.	Case Inlet	UFPP
15.0048	4.7000	Minter Cr.	Henderson Bay	UFPP
15.0052	1.4000	Huge Cr.	Minter Cr.	UFPP
15.0056	3.7000	Burley Cr.	Henderson Bay	UFPP
15.0057	0.1000	Little Bear Cr.	Burley Cr.	UFPP
15.0057	0.4000	Little Bear Cr.	Burley Cr.	UFPP
15.0057	0.9000	Little Bear Cr.	Burley Cr.	UFPP
15.0057	0.9500	Little Bear Cr.	Burley Cr.	UFPP
15.0057	1.1000	Little Bear Cr.	Burley Cr.	UFPP
15.0057	1.4000	Little Bear Cr.	Burley Cr.	UFPP
15.0057A	0.0000	X-Trib. to L. Bear Cr.	Bear Creek	UFPP
15.0058		X-Trib Burley Cr	Henderson Bay	WSDOT
15.0063	0.1000	X-trib. to Henderson Bay		UFPP
15.0068	0.0000	X-trib. to Henderson Bay		UFPP
15.0070	0.3000	Mark Dickson Cr.		UFPP
15.0070	0.3500	Mark Dickson Cr.		UFPP
15.0070	0.4000	Mark Dickson Cr.		UFPP
15.0070	0.4300	Mark Dickson Cr.		UFPP
15.0070A	0.0000	Trib. to Mark Dickson Cr.		UFPP
15.0070A	0.1000	Trib. to Mark Dickson Cr.		UFPP
15.0080	0.2400	Carr Cr.		UFPP
15.0105	0.0000	Sunnycove Cr.		UFPP
15.0116	0.0000	Fragaria Cr.	Colvos Passage	UFPP
15.0129	2.0000	Judd Cr.		UFPP
15.0187	0.2000	X-trib. to Curley Cr.	Curley Cr.	UFPP
15.0201	0.9000	Wilson Cr.	Sinclair Inlet	UFPP
15.0208	0.0000	X-trib. to Sinclair Inlet	Sinclair Inlet	UFPP
15.0209		Ross Cr	Sinclair Inlet	WSDOT
15.0210	0.1700	X-trib. to Ross Cr.	Ross Cr.	UFPP
15.0210	0.2600	Mc Cormick Cr	Ross Cr	WSDOT
15.0210	0.4200	X-trib. to Ross Cr.	Ross Cr.	UFPP
15.0210	0.5100	X-trib. to Ross Cr.	Ross Cr.	UFPP
15.0210	1.8400	X-trib. to Ross Cr.	Ross Cr.	UFPP
15.0216	2.3000	Gorst Cr.	Sinclair Inlet	UFPP
15.0216	3.5000	Gorst Cr	Sinclair Inlet	WSDOT
15.0216	3.6000	Gorst Cr.	Sinclair Inlet	UFPP
15.0217	0.0100	X-trib. to Gorst Cr.	Gorst Cr.	UFPP
15.0218	0.1000	Jarstad Cr.	Gorst Cr.	UFPP
15.0221	0.1000	Heins Cr.	Gorst Cr.	UFPP
15.0221	0.3000	Heins Cr.	Gorst Cr.	UFPP
15.0229	4.4500	Wildcat Cr.	Chico Cr.	UFPP
15.0230	1.7000	Kitsap Cr.	Chico Cr.	UFPP
15.0245	0.1000	Koch Cr.	Dyes Inlet	UFPP
15.0246	0.4900	Strawberry Cr.	Dyes Inlet	UFPP
15.0246	0.8300	Strawberry Cr.	Dyes Inlet	UFPP
15.0246	1.6700	Strawberry Cr.	Dyes Inlet	UFPP
15.0247	0.0700	X-Trib	Strawberry Cr	WSDOT
15.0247	0.1400	X-trib. to Strawberry Cr.	Strawberry Cr.	UFPP
15.0247	0.4000	X-trib. Strawberry Cr.	Strawberry Cr.	UFPP
15.0249	3.1000	Clear Cr.	Dyes Inlet	UFPP
15.0250	2.2000	W.F. Clear Cr.	Clear Cr.	UFPP
15.0254	0.5000	X-trib. to Clear Cr.	Clear Cr.	UFPP
15.0255	0.3000	Barker Cr.	Dyes Inlet	UFPP
15.0255	0.8500	Barker Cr.	Dyes Inlet	UFPP
15.0255 B	1.8500	Hoot Cr.	Barker Cr.	UFPP
15.0266	0.7500	Illahee Cr.	Port Orchard Bay	UFPP

The need for repair has been verified for those barriers listed from the Thurston County Inventory and WSDOT databases. Repair requirements have not been identified for those barriers listed from the UFPP (Unresolved Fish Passage Problems) database.

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
15.0269	0.1000	X-trib. Burke Bay	Burke Bay	UFPP
15.0273	0.7100	Steele Cr.	Port Orchard Bay	UFPP
15.0273	0.8000	Steele Cr.	Port Orchard Bay	UFPP
15.0274	0.1500	X-trib. to Steele Cr.	Steele Cr.	UFPP
15.0274	0.1900	X-trib. to Steele Cr.	Steele Cr.	UFPP
15.0274	0.2100	X-trib. to Steele Cr.	Steele Cr.	UFPP
15.0274	0.2500	X-trib. to Steele Cr.	Steele Cr.	UFPP
15.0275	0.4000	X-trib. to Steele Cr.	Steele Cr.	UFPP
15.0275	0.8000	X-trib. to Steele Cr.	Steele Cr.	UFPP
15.0280	0.2000	Big Scandia Cr.	Liberty Bay	UFPP
15.0282		X-Trib	Liberty Bay	WSDOT
15.0282	0.0100	S.F. Johnson Cr.	Johnson Cr.	UFPP
15.0282	0.0800	S.F. Johnson Cr.	Johnson Cr.	UFPP
15.0283		Johnson Cr	Liberty Bay	WSDOT
15.0285		Dogfish Cr	Liberty Bay	WSDOT
15.0285	0.8000	Dogfish Cr.	Liberty Bay	UFPP
15.0285	1.3500	Dogfish Cr.	Liberty Bay	UFPP
15.0285A	0.2000	X-trib. to Dogfish Cr.	Dogfish Cr.	UFPP
15.0285A	0.2500	X-trib. to Dogfish Cr.	Dogfish Cr.	UFPP
15.0285A	0.8000	X-trib. to Dogfish Cr.	Dogfish Cr.	UFPP
15.0286	1.0700	X-trib. to Dogfish Cr.	Dogfish Cr.	UFPP
15.0286	1.1000	X-trib. to Dogfish Cr.	Dogfish Cr.	UFPP
15.0286A	0.8000	X-trib. to Dogfish Cr.	Dogfish Cr.	UFPP
15.0287	0.1000	X-trib. Dogfish Cr. trib.	Dogfish Cr.	UFPP
15.0287	0.1100	X-trib. Dogfish Cr. trib.	Dogfish Cr.	UFPP
15.0287	0.1500	X-trib. Dogfish Cr. trib.	Dogfish Cr.	UFPP
15.0290	0.9000	X-trib. to Liberty Bay	Liberty Bay	UFPP
15.0291	0.0200	X-trib. to Liberty Bay	Liberty Bay	UFPP
15.0291	0.1700	X-Trib	Liberty Bay	WSDOT
15.0310	0.4000	X-trib. to Puget Sound	Puget Sound	UFPP
15.0348	0.0100	Jake's Cr.	Hood Canal	UFPP
15.0350	0.5000	Little Boston Cr.	Port Gamble Bay	UFPP
15.0352	0.1000	Middle Cr.	Port Gamble	UFPP
15.0364	0.1000	Spring Cr.	Hood Canal	UFPP
15.0364	0.2000	Spring Cr	Hood Canal	WSDOT
15.0368		X-Trib Hood Canal	Hood Canal	WSDOT
15.0368	0.5000	X-trib. to Kinman Cr.	Kinman Cr.	UFPP
15.0368	0.5100	X-trib. to Kinman Cr.	Kinman Cr.	UFPP
15.0368	1.1000	X-trib. to Hood Canal	Hood Canal	UFPP
15.0369	0.8000	Jump Off Joe Cr.	Hood Canal	UFPP
15.0377	0.2000	Little Anderson Cr.	Hood Canal	UFPP
15.0381	0.1000	X-Trib. L. Anderson Cr.	Little Anderson	UFPP
15.0387	0.3000	Johnson Cr.	Hood Canal	UFPP
15.0387	0.5300	Johnson Cr.	Hood Canal	UFPP
15.0387	0.8600	Johnson Cr.	Hood Canal	UFPP
15.0387	0.9100	Johnson Cr.	Hood Canal	UFPP
15.0420	8.2000	Dewatto R.	Hood Canal	UFPP
15.0423	0.1000	Dewatto R.	Hood Canal	UFPP
15.0434	0.2000	X-trib. Dewatto R.	Dewatto River	UFPP
15.0447	0.2000	X-trib. to Tahuya R.	Tahuya R.	UFPP
15.0459	0.6000	Erdman Lake Outlet	Tahuya R.	UFPP
15.0486	0.1000	X-trib. to Hood Canal	Hood Canal	UFPP
15.0487	0.1000	X-trib. to Hood Canal	Hood Canal	UFPP
15.0503		X-TribUnion River	Hood Canal	WSDOT
15.0510	0.2000	Bear Cr.	Union River	UFPP
15.XXXX		X-Trib	Case Inlet	WSDOT
16.0000 A*	0.1000	X-trib. to Hood Canal	Hood Canal	UFPP
16.0000 B	0.0000	X-trib. to Hood Canal	Hood Canal	UFPP

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
16.0000 B*	0.0300	X-trib. to Hood Canal	Hood Canal	UFPP
16.0002		X-Trib	Skokomish R	WSDOT
16.0004		Skobob Cr	Hood Canal	WSDOT
16.XXXX		X-Trib	Hood Canal	WSDOT
17.0000 A*	0.0000	X-trib. to Sequim Bay	Sequim Bay	UFPP
17.0011	0.1000	Indian Cr.	Quilicene Bay	UFPP
17.0078	0.1000	X-trib. to Leland Cr.	Leland Creek	UFPP
17.0089	0.1000	Ripley Cr.	Little Quilicene River	UFPP
17.0118	0.1000	Rice Lake Outlet	Donovan Creek	UFPP
17.0129	4.3000	Tarboo Cr.	Dabob Bay	UFPP
17.0129A	0.1000	X-trib. to WF Tarboo Cr.	Tarboo Creek	UFPP
17.0130	0.6000	X-trib. to Tarboo Cr.	Tarboo Creek	UFPP
17.0133	1.2000	E.Branch/E.F. Tarboo Cr.	East Fork Tarboo Cr.	UFPP
17.0170	1.0000	Thorndyke Cr.	Hood Canal	UFPP
17.0171	0.2000	X-trib to Thorndyke Cr.	Thorndyke Creek	UFPP
17.0195		X-Trib	Ludlow Cr	WSDOT
17.0195	3.2000	X-trib. to Ludlow Cr.	Ludlow Cr.	UFPP
17.0195 X	0.0200	X-trib. Ludlow Cr. trib.	X-trib.to Ludlow Cr.	UFPP
17.0200 A	0.0200	X-trib. (L. Goose Cr.)	Oak Bay	UFPP
17.0200 A	0.4000	X-trib. (L. Goose Cr.0	Oak Bay	UFPP
17.0203C	0.0200	X-trib. to Chimacum Cr.	Chimacum Cr.	UFPP
17.0206	0.0000	X-trib. to E. Chimacum Cr	Chimacum Cr.	UFPP
17.0213	0.7000	Barnhouse Cr.	Chimicum Creek	UFPP
17.0270		Contractors Cr	Straits	WSDOT
17.0270	0.3000	Contractor's Cr.	Discovery Bay	UFPP
17.0272	1.6000	Eagle Cr.	Discovery Bay	UFPP
17.0278		Chicken Coop Cr	Straits	WSDOT
17.0300	0.0500	X-trib. to Sequim Bay	Sequim Bay	UFPP
18.0038	0.2000	Canyon Cr.	Dungeness R.	UFPP
18.0183	1.4000	Bagley Cr.	Strait of Juan de Fuca	UFPP
18.0183	1.5000	Bagley Cr.	Strait of Juan de Fuca	UFPP
18.0235		White Cr	Straits	WSDOT
18.0245		Peabody Cr	Straits	WSDOT
18.0245	0.3000	Peabody Cr.	Port Angeles Harbor	UFPP
18.0245	0.5100	Peabody Cr.	Port Angeles Harbor	UFPP
18.0245	0.8400	Peabody Cr	Port Angeles Harbor	UFPP
18.0245	1.3000	Peabody Cr.	Port Angeles Harbor	UFPP
18.0249		Valley Cr	Straits	WSDOT
18.0249	0.0000	Valley Cr.	Port Angeles Harbor	UFPP
18.0265		Dry Cr	Straits	WSDOT
19.0001		Coville Cr	Straits	WSDOT
19.0003		X-Trib Straits	Colville Cr (Straits)	WSDOT
19.0009	0.0000	X-trib. to Salt Cr.	Strait of Juan de Fuca	UFPP
19.0012		X-Trib Salt Cr	Straits	WSDOT
19.0012	1.2900	X-trib. to Salt Cr.	Salt Cr.	UFPP
19.0020		Whiskey Cr	Straits	WSDOT
19.0026		Field Cr	Straits	WSDOT
19.0032		Nelson Cr	Straits	WSDOT
19.0083	1.9000	Sadie Cr.	East Twin River	UFPP
19.0109		Joe Cr	Straits	WSDOT
19.0110	1.3000	Jim Cr.	Strait of Juan de Fuca	UFPP
19.0112		X-Trib	Straits	WSDOT
19.0114A		X-Trib	Pysht R	WSDOT
19.0174	0.1000	Rights Cr.	Hoko River	UFPP
20.0098	0.1000	X-trib. to Dickey River		UFPP
20.0118A	0.0000	X-Trib. to Gunderson Cr.		UFPP
20.0140	0.1000	X-trib. to W.F. Dickey R.		UFPP
20.0144	18.4000	Saddlehorn Cr.	W.F.Dickey River	UFPP

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
20.0144I	18.4000	Saddlehorn Cr.	Dickey River	UFPP
20.0145	0.7000	Pseudo Springs	M.F. Dickey River	UFPP
20.0145A	2.0000	Mel's Cr.	M.F. Dickey River	UFPP
20.0145B	2.1000	Tomahack Cr.	M.F. Dickey River	UFPP
20.0145B	2.3000	Tomahack Cr.	M.F. Dickey River	UFPP
20.0154	1.3000	X-trib. to Ponds Cr.	Ponds Creek	UFPP
20.0154E	1.3000	Quickwater Cr.	Ponds Cr.	UFPP
20.0154F	1.5000	Slowwater Cr.	Ponds Cr.	UFPP
20.0155	1.6000	Thunder Cr.	Ponds Cr.	UFPP
20.0157A	2.5000	Labrador Cr.	Ponds Cr.	UFPP
20.0157B	0.5000	X-trib. to WD-153L-02	WD-153L-02	UFPP
20.0157E	2.8500	Mix Cr.	Ponds Cr.	UFPP
20.0158	0.7000	X-trib. to Ponds Cr.	Ponds Cr.	UFPP
20.0159C	3.3000	Circle Cr.	Ponds Cr.	UFPP
20.0160	0.6000	Haehule Cr.	Ponds Cr.	UFPP
20.0177 A*	0.0000	X-trib. to N.F. Calawah R		UFPP
20.0305	0.4000	Tassel Cr.		UFPP
20.0325		X-trib Beaver Cr	Soleduck R	WSDOT
20.0422 B	0.2300	X-Trib. to Hoh R.		UFPP
20.0430 A	0.1000	X-Trib. to Nolan Cr.		UFPP
20.0440		Lost Cr	Hoh R	WSDOT
20.0449 B	0.6000	Alder Forks Cr.	Alder Cr.	UFPP
20.0449 C*	0.5000	X-trib. to Alder Forks Cr		UFPP
20.0458	0.6000	Lindner Cr.	Hoh R.	UFPP
20.0470	0.2000	Canyon Cr.		UFPP
20.0505	0.1000	East Twin Cr.		UFPP
20.0506	0.1000	West Twin Cr.		UFPP
20.0511	0.1000	Snider Cr.		UFPP
20.0574		Steamboat Cr	Pacific Ocean	WSDOT
20.0574 X	1.1200	X-trib. to Steamboat Cr.	Steamboat Cr.	UFPP
20.0576		X-Trib	Pacific Ocean	WSDOT
20.XXXX		X-Trib	Bogachiel R	WSDOT
20.XXXX		X-Trib	Pacific Ocean	WSDOT
20.XXXX		X-Trib	Pacific Ocean	WSDOT
20.XXXX		X-Trib Bogachiel	Bogachiel R	WSDOT
20.XXXX		X-Trib Bogachiel	Bogachiel R	WSDOT
20.XXXX		X-Trib Dowans Cr	Bogachiel R	WSDOT
20.XXXX		X-Trib Hell Roaring Cr	Bogachiel R	WSDOT
20.XXXX		X-Trib Hell Roaring Cr	Hoh R	WSDOT
20.XXXX		X-Trib Old Joe Slough	Hoh R	WSDOT
20.XXXX		X-Trib Old Joe Slough	Hoh R	WSDOT
21.0011		X-Trib	Pacific Ocean	WSDOT
21.0024	0.0500	Donkey Cr.		UFPP
21.0042	0.0000	Iska Cr.		UFPP
21.0160 A	0.1000	X-trib. to Tacoma Cr.		UFPP
21.0456		McCalla Cr	Quinault R	WSDOT
21.0460	0.1000	Higley Cr.		UFPP
21.0460 A	0.1000	Mill Cr.	Lake Quinault	UFPP
21.0463	0.1000	McCormick Cr.		UFPP
21.0464	0.1000	Slide Cr.		UFPP
21.0715		X-Trib	Pacific Ocean	WSDOT
21.0716		X-Trib	Pacific Ocean	WSDOT
21.0728		X-Trib	Pacific Ocean	WSDOT
21.XXXX		X-Trib	Pacific Ocean	WSDOT
21.XXXX		X-Trib	Pacific Ocean	WSDOT
21.XXXX		X-Trib Crane	Raft R	WSDOT
22.0042	8.6000	Big Cr.		UFPP
22.0058	0.2000	S.F. Big Cr.		UFPP

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
22.0064 A	0.0500	X-trib. to Stevens Cr.	Stevens Cr.	UFPP
22.0064A		X-Trib	Stevens Cr	WSDOT
22.0181	0.1000	X-trib. to Davis Cr.	Davis Cr.	UFPP
22.0225	0.5500	Big Cr.		UFPP
22.0252		X-Trib	Chehalis R	WSDOT
22.0254		X-Trib	Chehalis R	WSDOT
22.0471A	0.0000	X-trib. to E.F. Satsop R.		UFPP
23.0190 B	0.6000	X-trib. to Chehalis R.		UFPP
23.0543 A	0.1000	X-trib. to Porter Cr.	Porter Cr.	UFPP
23.0663		X-Trib	Black R	Thurston Co. Inventory
23.0672		X-Trib	Beaver Cr	Thurston Co. Inventory
23.0689B	2.2000	Lehman Cr.	Black R.	UFPP
23.0689xx		X-Trib	Lehman Cr	Thurston Co. Inventory
23.0690x		Pants Cr	Stony Cr	Thurston Co. Inventory
23.0693		X-Trib	Black Lk.	Thurston Co. Inventory
23.0694		Fish Pond Cr	Black Lk	Thurston Co. Inventory
23.0697		X-Trib	Independence Cr	Thurston Co. Inventory
23.0697	4.6000	X-trib. to Independence	Independence Cr.	UFPP
23.0704		XX-Trib	Independence Cr.	Thurston Co. Inventory
23.0716x		X-Trib	Scatter Cr	Thurston Co. Inventory
23.0720	0.2500	X-trib. to Scatter Cr.		UFPP
23.0721	0.0000	X-trib. to Scatter Cr.		UFPP
23.0731 X	0.3500	X-trib. to Dry Cr.	Dry Cr.	UFPP
23.0731x		X-Trib	Dry Cr	Thurston Co. Inventory
23.0888A	0.3000	X-trib. to M.F. Newaukum	M.F. Newaukum R.	UFPP
23.0915 A*	5.0000	X-trib. to Kearney Cr.		UFPP
23.0930	3.7000	Mill Creek	Chehalis R.	UFPP
23.1269		X-Trib	John's R	WSDOT
23.XXXX		X-Trib Chehalis	Chehalis R	WSDOT
24		X-Trib	SF Naselle R	WSDOT
24		X-Trib	Salmon Cr	WSDOT
24.0060		Butte Cr	Willapa R	WSDOT
24.0261	2.5000	X-trib. to Willapa R.		UFPP
24.0334	0.1500	X-trib. to Willapa R.	Willapa R.	UFPP
24.0338 A	0.6000	X-trib. to Willapa R.	Willapa R.	UFPP
24.0345	0.1500	X-trib. to Willapa R.	Willapa R.	UFPP
24.0345 A	0.2300	X-trib. to Willapa R.	Willapa R.	UFPP
24.0376	1.1000	Fern Cr.	Willapa R.	UFPP
24.0581		Johnson Cr	Naselle R	WSDOT
24.0584 A	0.0100	X-trib. S.F. Naselle trib		UFPP
24.0584 A	0.0400	X-trib. to SF Naselle R.		UFPP
24.0587	0.0000	X-trib. to S.F. Naselle R		UFPP
24.0587	1.0000	X-trib. to S.F. Naselle R		UFPP
24.0598		Cement Cr	SF Naselle	WSDOT
24.0600	0.0000	Burnam Cr.		UFPP
24.0672		X-Trib Willapa Refuge	Willapa Bay	WSDOT
24.0672	0.4000	X-trib. to Willapa Refuge		UFPP
24.0672	0.4500	X-trib. to Willapa Refuge		UFPP
24.0672	0.4800	X-trib. to Willapa Refuge		UFPP
24.0673		X-Trib	Willapa	WSDOT
24.0684		X-Trib	Willapa	WSDOT
24.XXXX		X-Trib	Columbia R	WSDOT
24.XXXX		X-Trib	Columbia R	WSDOT
24.XXXX		X-Trib	Willapa	WSDOT
24.XXXX		X-Trib	Willapa Bay	WSDOT
24.XXXX		X-Trib	Willapa Bay	WSDOT
24.XXXX	0.5000	X-trib.		UFPP
25		X-Trib Grays River	Grays R	WSDOT

The need for repair has been verified for those barriers listed from the Thurston County Inventory and WSDOT databases. Repair requirements have not been identified for those barriers listed from the UFPP (Unresolved Fish Passage Problems) database.

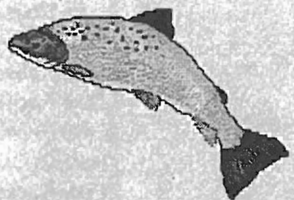
WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
25.0093 A*	0.0000	X-trib. to Grays R.		UFPP
25.0093A		X-Trib	Grays R	WSDOT
25.0236 A*	0.0000	X-trib. to Elochoman R.		UFPP
25.0236 B*	0.0000	X-trib. to Elochoman R.		UFPP
25.0236 C*	0.0000	X-trib. to Elochoman R.		UFPP
25.0236 D*	0.0000	X-trib. to Elochoman R.		UFPP
25.0236 E*	0.0000	X-trib. to Elochoman R.		UFPP
25.0253	0.0000	Clear Cr.		UFPP
25.0253	0.1000	Clear Cr.		UFPP
25.0255	0.1000	Rock Cr.		UFPP
25.0281		Birnie Cr	Columbia R	WSDOT
25.0281		Birnie Cr	Columbia R	WSDOT
25.0281	0.2000	Birnie Cr.		UFPP
25.0429 C*	0.0000	X-trib. to Stillwater Cr.		UFPP
26		X-Trib (a)	Cowlitz R	WSDOT
26		X-Trib Stillwater Cr	Stillwater Cr	WSDOT
26.0000	0.0100	Cascade Cr.	Green River	UFPP
26.0002 A*	0.0000	X-trib. to Cowlitz R.		UFPP
26.0030	0.0000	Cline Cr.		UFPP
26.0195	0.0000	Monahan Cr.		UFPP
26.0214A		X-Trib N F Toutle	Toutle R	WSDOT
26.0236	0.1000	Rock Cr.		UFPP
26.0239	1.2200	Outlet Cr.	Toutle River	UFPP
26.0239	1.2400	Outlet Cr.	Toutle River	UFPP
26.0239	2.0000	Outlet Cr.	Toutle River	UFPP
26.0254KA	0.4500	X-trib. Johnson Cr. trib.	Johnson Cr. trib.	UFPP
26.0261	0.1200	Brownell Cr.	S.F. Toutle R.	UFPP
26.0262	0.0300	Jordan Cr.	Brownell Cr.	UFPP
26.0262	0.7000	Jordan Cr.	Brownell Cr.	UFPP
26.0262 B	0.1000	X-trib. to Jordan Cr.	Jordan Cr.	UFPP
26.0262 C	0.1000	X-trib. to Jordan Cr.	Jordan Cr.	UFPP
26.0314 C*	0.0000	Hatchet Springs	North Fork Toutle	UFPP
26.0325 C	0.2000	X-trib. to Beaver Cr.	Beaver Cr.	UFPP
26.0353 B	3.5000	X-trib. to Elk Cr.	Elk Cr.	UFPP
26.0353 C	0.5000	X-trib. to Elk Cr.	Elk Cr.	UFPP
26.0429A		X-Trib Stillwater Cr	Stillwater Cr	WSDOT
26.0457	0.2000	Ferrier Cr.		UFPP
26.0475		Foster Cr	Cowlitz R	WSDOT
26.0527	3.5800	Blue Creek	Cowlitz River	UFPP
26.XXXX		X-Trib	EF Tilton R	WSDOT
26.XXXX		X-Trib	EF Tilton R	WSDOT
27		X-Trib	NF Lewis R	WSDOT
27.0139A		X-Trib Schoolhouse Cr	Columbia R	WSDOT
27.0142		Bybee Cr	Columbia R	WSDOT
27.0168B		X-Trib	NF Lewis R	WSDOT
27.0222		X-Trib Rock Cr	EF Lewis R	WSDOT
27.0222A	0.7200	X-trib. to Rock Cr.	Rock Cr.	UFPP
27.0222A	0.7400	X-trib. to Rock Cr.	Rock Cr.	UFPP
27.0222A	0.7900	X-trib. to Rock Cr.	Rock Cr.	UFPP
27.0222A	0.8200	X-trib. to Rock Cr.	Rock Cr.	UFPP
27.0222A	1.0200	X-trib. to Rock Cr.	Rock Cr.	UFPP
27.0222A	1.1000	X-trib. to Rock Cr.	Rock Cr.	UFPP
27.0222A	1.2100	X-trib. to Rock Cr.	Rock Cr.	UFPP
27.0222A	1.2500	X-trib. to Rock Cr.	Rock Cr.	UFPP
27.0339	14.4000	Cedar Cr.	Lewis R.	UFPP
27.0373	0.0000	Chelatchie Cr.	Cedar Cr.	UFPP
27.0392		Colvin Cr	NF Lewis R	WSDOT
27.0476 B	0.1000	X-trib. to Dog Cr.	Dog Cr.	UFPP

Excluding Fishways

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
27.XXXX		Dog Cr	Yale Resevoir	WSDOT
27.XXXX		X-Trib Dog Cr	Lewis R	WSDOT
28.0229	0.5000	Winkler Cr.	Washougal R.	UFPP
28.0231	0.1000	Canyon Cr.	Washougal R.	UFPP
28.0295	0.1000	Hardy Cr.		UFPP
28.0296	0.0500	Duncan Cr.		UFPP
28.0298	0.2000	Woodward Cr.		UFPP
28.0303		Hardy Cr	Columbia R	WSDOT
29.0128 *	0.0000	Collins Cr.		UFPP
30.0019	0.1000	Simmons Cr.		UFPP
30.0069		Bowman Cr	Klickitat R	WSDOT
30.0623	0.0000	Little Corral Cr.		UFPP
30.XXXX		X-Trib	Butler Cr	WSDOT
30.XXXX		X-Trib	Little Klickitat R	WSDOT
30.XXXX		X-Trib	Little Klickitat R	WSDOT
30.XXXX		X-Trib	Little Klickitat R	WSDOT
30.XXXX		X-Trib	Little Klickitat R	WSDOT
31.0354		Pine Cr	Columbia R	WSDOT
35.1018		L Almata Cr	Snake R	WSDOT
37		X-Trib	Yakima R	WSDOT
37.0002 A	0.1000	X-trib. to Yakima R.		UFPP
37.0002 B	0.0000	X-trib. to Yakima R.		UFPP
37.0002 C	0.0000	X-trib. to Yakima R.		UFPP
37.0196		X-Trib	Yakima R	WSDOT
37.XXXX		X-Trib	Satus Cr	WSDOT
37.XXXX		X-Trib	Satus Cr	WSDOT
38.0251		Hause Cr	Tieton R	WSDOT
38.1019	0.1000	Wash Cr	American R	WSDOT
38.1041		Survey Cr	American R	WSDOT
39.1157		Swauk Cr	Yakima R	WSDOT
39.1157	15.2000	Swauk Cr.	Yakima R.	UFPP
39.1713		Silver Cr	Yakima R	WSDOT
39.1713	0.0000	Silver Cr.	Yakima R.	UFPP
39.XXXX		X-Trib	SF Snoqualmie R	WSDOT
41.0000	26.0000	S.F. Lower Crab Cr.		UFPP
41.0000	28.5000	Mainstem Lower Crab Cr.		UFPP
41.0000	30.5000	Mainstem Lower Crab Cr.		UFPP
41.0002	22.0000	N.F. Lower Crab Cr.		UFPP
41.0012	22.0000	S.F. Lower Crab Cr.		UFPP
41.2151		Sand Hollow Cr	Columbia R	WSDOT
41.2151	2.1500	Sand Hollow Cr.		UFPP
41.2151	2.2500	Sand Hollow Cr.		UFPP
41.XXXX		X-Trib (Baird Springs)	Columbia R	WSDOT
43.0852		Sheep Cr	Upper Crab Cr	WSDOT
45.0700 A	1.5000	Skinney Cr.	Wenatchee R.	UFPP
45.XXXX		Skinney Cr	Wenatchee R	WSDOT
45.XXXX		Skinney Cr	Wenatchee R	WSDOT
45.XXXX		Skinney Cr	Wenatchee R	WSDOT
48.0307		Beaver Cr	Methow R	WSDOT
48.1400		L Boulder Cr	Methow R	WSDOT
49.XXXX		First Cr	Lake Chelan	WSDOT
50.0065	1.0000	Foster Cr.		UFPP
52.0238		NF O'Brien Cr	Sanpoil R	WSDOT
52.0238		NF O'Brien Cr	Sanpoil R	WSDOT
52.0239		O'Brien Cr	Sanpoil R	WSDOT
55.0051	20.3000	Deadman Cr.	Little Spokane R.	UFPP
55.0051	20.5000	Deadman Cr.	Little Spokane R.	UFPP
55.0147	0.0000	Burping Brook	Deadman Cr.	UFPP

The need for repair has been verified for those barriers listed from the Thurston County Inventory and WSDOT databases. Repair requirements have not been identified for those barriers listed from the UFPP (Unresolved Fish Passage Problems) database.

WRIA	RIVER MILE	STREAM	TRIBUTARY TO	DATA SOURCE
58.0134		Alder Cr	L Roosevelt	WSDOT
58.0134	4.3500	Alder Cr. (S. Fork)	Lake Roosevelt	UFPP
58.0134	4.6900	Alder Cr. (S. Fork)	Lake Roosevelt	UFPP
58.0134	6.1600	Alder Cr. (S. Fork)	Lake Roosevelt	UFPP
58.0146	2.2700	Hunters Cr.	Lake Roosevelt	UFPP
58.0146	3.2800	Hunters Cr.	Lake Roosevelt	UFPP
58.0146	3.8900	Hunters Cr.	Lake Roosevelt	UFPP
58.0146	4.8600	Hunters Cr.	Lake Roosevelt	UFPP
58.0146	5.5000	Hunters Cr.	Lake Roosevelt	UFPP
58.0146	8.5600	Hunters Creek	Lake Roosevelt	UFPP
58.0146 X	1.8900	N.F. Hunters Cr.	Hunters Cr.	UFPP
58.0170		Hunters Cr	Lake Roosevelt	WSDOT
60.0009		Deadman Cr	Kettle R	WSDOT
60.0056		Matsen Cr	Kettle R	WSDOT
60.0056	0.0600	Matsen Cr.	Kettle R.	UFPP
60.0056	0.5500	Matsen Cr.	Kettle R.	UFPP
60.0060		Doyle Cr	Kettle R Arm	WSDOT
62.		Ione Millpond	Pend Oreille R	WSDOT
62.0224		Sweet Cr	Pend Oreille R	WSDOT

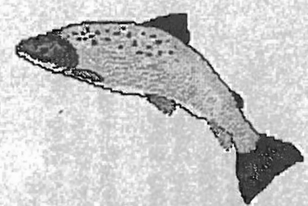


APPENDIX D
WATERSHED RECOVERY INVENTORY PROJECT DATABASE DIRECTORY

Watershed Recovery Inventory Project (direct or indirect fish passage implications)

Data Directory *DRAFT*

Database Name	Description	Area Coverage (Describe)	Last Update	Organization
SSHIAP	Stream habitat data inventory			NWIFC
Pt Angeles Watershed	Wetlands, hydro, geo, landuse/cover, etc	Statewide Watersheds	1994	Clallam Co Plan
Dungeness/Sequim Wet	Wetlands, hydro, geo, landuse/cover, etc	Clallam Co	1994	Clallam Co Plan
Landslide Haz/Erosion Haz	Landslide hazards with slopes of 40% +	Clallam Co	1994	Clallam Co Plan
Transportation	Roads, RR's, & other transport types.	Regional		DNR/FP
StreamNet	Stocking, harvest,returns, presence of salmonids	Statewide	1997	WDFW
SaSI	Inventory, escapement info.	Statewide	1997	WDFW
Steelhead Trout Res. Inv. Data	Stocking, harvest, spawning escape info.	Coast & sound & part. Col. R.	1997	WDFW
Stream and Lake Fish Database	Species by sample site, chem, bio data.	Statewide	1995	WDFW
Wildlife Area Inventory	Create multi-layer db for WDFW-lands	Regional		WDFW
Watershed Analysis Tech Rpt	Reports on fish habitat, channel cond, etc	Statewide	1994	WDFW
DWAIN	Turbidity measurements & water qual	Statewide	1994	DOH
Wetland Mitigation Sites	Sites built by DOT.	Statewide	1993	DOT
Trips Database	Traffic vol, hazard info, road invent, etc	Statewide	1994	DOT
GAP	Survey data for nongame wildlife.	Statewide	1994	UW/Coop F & W Unit
Dungeness R. Hab. Info	Spawning location, trap location, etc.	Lo 10 miles of Dungenss R. Basin		Jamestown Klallam Tribe
Pendine Water Qual db	Surface water & thermal info.	SF Nooksack R.	1995	Nooksack Indian Tribal Council
Flood Control	Flood prevention, monitoring, etc	Nooksack River	1994	Nooksack Indian Tribal Council
Ambient Monitoring Program	Stream data, ref pt data habitat, LOD, etc	Statewide	1993	NWIFC
TFW & fisheries	Habitat monitoring in S Hood Canal drain	Skokomish R. Basin	1993	Skokomish Tribal Council
Salmon Summit Project	Activity affecting water bodies & anad fish	BLM lands	1994	BLM Wenatchee Dist
108 GIS Theme Layers	db info on fisheries, biophyiscal, etc.	Cascade Crest East		Eastside Ecosys Mgmt Project
Stream Mgmt, Analysis, ...	Data from USFS Region 6 level I&II invent	Streams w/in Nat'l Forests		USFS Region 6
NOAA Tech Memo of Report	Reports that deal with Puget Sound.	Sound, Hood Canal, St of Juan de Fuca	1985	NOAA
Pit Tag db	Fish passage info thru hydro projects.	Col R basin, Snake R	1994	Pac States Marine Fisheries Comm
Gravity Fish Screens	Irrigation diversions w/ "foodfish" (salmon)	E. WA and Columbia R.	1997	WDFW/SSHEAR
Fishways	Fish passage	Statewide	1997	WDFW/SSHEAR
Barrier Culverts	Fish passage	Statewide	1997	WDFW/SSHEAR
Barrier Culverts	Fish passage	Statewide (WSDOT roads)	1997	WDFW/SSHEAR
Barrier Culverts	Fish passage	Thurston County (County roads)	1997	WDFW/SSHEAR
Off-Channel Habitat	Fish habitat	North Puget Sound	1997	WDFW/SSHEAR
Off-Channel Habitat	Fish habitat	North Coast	1997	WDFW/SSHEAR
Fish Screen Projects(pending)	Capital budget screens on irrigation diversions	E. WA and Columbia R.	1997	WDFW/SSHEAR
Fish Pass/Hab Projects(pending)	Fish passage/fish habitat	Statewide	1997	WDFW/SSHEAR
Pump Station Fish Screens	Pump Diversion Inventory & Screen Status	Columbia/Snake/Okanogan Rivers	1997	WDFW/SSHEAR



APPENDIX E
GUIDANCE DOCUMENT - BARRIER RECORD/ASSESSMENT

Culvert Fish Passage and Inventory: Level 1 Analysis
Washington Department of Fish and Wildlife

Introduction

Recent awareness and interest in salmonid population levels in the Pacific Northwest has focused attention on fish passage barriers. Culverts comprise a significant number of barriers and are receiving increased attention from a variety of concerned groups and agencies. An integral part of resolving culvert barriers is the process of culvert inventory and barrier analysis. This paper describes an initial level (Level 1) of barrier inventory and analysis. Identification of a culvert as a barrier is defined as not meeting criteria set out in the Washington Administrative Code (WAC) 220-110-070, section 3 - permanent culvert installation. The intent is to make a conservative definition of passability based on capabilities of the weakest fish of a given species and size. The process will give a "yes" , "no" or "unknown" answer on whether a culvert is a barrier. In reality the culverts that are identified as barriers may have varying degrees of passability depending on fish species, size and condition, flow level, debris maintenance and channel conditions. More detailed analysis of these culverts and prioritizing remedies are beyond the scope of this paper.

Barrier culvert determination is a step-wise process of data collection and analysis. The field process and analysis rationale is outlined below. A two person field team is recommended as a minimum. The first step is to collect sufficient data at the site for a complete Level 1 analysis. Next a series of questions are asked to eliminate culverts from further analysis that obviously do or do not meet the intent of the WAC. The remaining culverts go through a basic hydraulic analysis that can be learned with minimal training. Analysis beyond Level 1 requires significant training in open channel hydraulics and fish passage engineering.

Procedure Outline:

1. Locate culvert and record Positional Information

2. Determine and record whether or not the stream is fish bearing.
   a. If "NOT", additional data collection is optional.
   b. If "YES or UNKNOWN", continue with evaluation.

3. Collect and record descriptive information and physical measurents per Figure 1.

4. Analysis - Level 1A
   a. If the outfall drop is > 1 foot the culvert **is a barrier**.
   b. If the outfall drop is < 1 foot and there is a gradient break inside the culvert, **an analysis beyond Level 1 is required.**
   c. If the outfall drop is < 1 foot and there is not a gradient break inside the culvert

answer the following questions:

i. Is the culvert placed at a slope $\leq$ 0.5% ?
ii. Is there natural streambed material throughout the culvert?
iii. Is the culvert countersunk at least 20% at the outlet?
iv. Is the culvert width (span) at the bed at least as wide as the average stream width (@OHW)?

d. If the answer to **all** the questions in 4c is **"Yes"**, the culvert is **not a barrier**.
e. If the answer to **any** of the questions in 4c is **"No"**, conduct a Level 1B analysis.

5. Analysis - Level 1B
   a. Calculate culvert barrel water depth, velocity, and hydraulic drop and compare to criteria in WAC 220-110-070 for all fish requiring passage.
   b. Conclusion of analysis, barrier status:
      i. Yes (includes partial barriers)
      ii. No
      iii. Unknown (includes all culverts with conditions that prevent analysis using normal depth hydraulic calculations)

Field Inspection - Level 1A Analysis

It is recommended that all the data listed in Figure 1 be collected at all culverts in the inventory. Once the culvert has been located and identified, the outfall drop is measured. If the drop (water surface differential from the downstream end of the culvert to the plunge pool) is greater than a foot the culvert is a barrier based on WAC criteria[1]. If a barrier is identified no additional Level 1 analysis is necessary.

Several situations result in hydraulic conditions that can not be analyzed at Level 1. These include gradient breaks inside the culvert, debris collections within or at the inlet of the culvert, excessive streambed material in the barrel, plunging flow onto exposed debris at the outlet, and baffles or weirs in the culvert. If these conditions exist a fish passage expert should be consulted.

If the outfall drop is less than one foot and the conditions above are not present, the following four questions are asked. If they can be answered affirmatively the culvert is not a barrier. Otherwise Level 1B hydraulic analysis is required.

1. Is the culvert placed at a slope $\leq$ 0.5%?
2. Is there natural streambed material throughout the culvert?
3. Is the culvert countersunk at least 20% below the streambed at the outlet?
4. Is the culvert width (span) at the bed at least as wide as average ordinary high water

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[1] Outfall drop is equal to or greater than the hydraulic drop used in the WAC. An outfall drop of one foot or more always indicates a hydraulic drop greater than one foot.

(OHW) width?

These questions are not the actual WAC criteria, but they conservatively represent passage conditions which the WAC is intended to create. OHW is averaged from a minimum of three measurements taken beyond the influence of the culvert. These measurements should include both pool and riffle sections if they are present.

The data required for further analysis include culvert shape, dimensions and materials, culvert elevations, water elevation in the channel immediately below the culvert, water depth in the culvert, and channel cross section at the control point downstream of the culvert. Depending on the purpose of the inspection and the needs of the landowner, additional information about the culvert, road or stream may be collected. These data may be pertinent to detailed passage analysis, flooding, safety and maintenance, or other issues. The additional data may eliminate the need for a return visit, but are not required for a Level 1 analysis.

Culvert shape - round, square, rectangular, elliptical, pipe arch, bottomless arch, etc.

Culvert dimensions - total length and cross section (diameter, span, rise).

Culvert materials - concrete, wood, plastic, smooth steel, corrugated metal (identify dimensions of corrugations) etc.

Culvert elevations - Measure upstream and downstream end elevations, preferably the inverts (bottom) if exposed or remove bed material to expose the invert. Record any changes in grade within the culvert.

Water surface elevation - The downstream water surface elevation is measured immediately below the culvert along a relatively calm stream margin. Measuring a high water mark will be useful if the stream is gaged, but other hydraulic calculations of high water elevations are beyond the scope of Level 1 analysis.

Water depth - Measure inside the culvert away from the influence of inlet and outlet conditions. If the culvert is too small to admit the data collector, measure as far in from the downstream end as can be reached.

Channel control cross section - The channel control point is the channel feature that controls the water depth immediately downstream of the culvert. Typically this is the head of the first riffle below the culvert, particularly when there is a plunge out of the culvert. The location of the control is usually 10-25 feet downstream of the culvert. The cross section should include all grade breaks in the section (top of banks, toe of banks, gravel bars, islands, thalweg). A minimum of 5 points should be measured, including elevation and distance from a reference point on one bank. In large or complex channels more than 5 points will be required.

Hydraulic Analysis - Level 1B

The hydraulic analysis is the development of design flows, calculation of culvert barrel velocity and depth, and outlet hydraulic drop, followed by comparison to WAC 220-110-070 criteria. Determination of passability will depend on the specific velocity, depth and allowable hydraulic drop for the species and age of fish present as listed in Table 1 in the WAC. Most streams have resident trout present so they normally become the "design fish" that determines if the culvert is a barrier. Juvenile salmonids are not listed in Table 1 but may be the design fish. The criteria in the WAC are intended to allow a gravel bed to deposit in the culvert and to eliminate a hydraulic drop at the downstream end of the culvert, thus allowing juvenile passage. This deposition also partially restores rearing conditions in the culvert. Regardless of which design fish is selected, the field data will provide sufficient information for a Level 1 analysis.

Hydrology - The high design flow required by the WAC is the flow that is not exceeded more than 10% of the time (10% exceedance) during the months of fish migration. A variety of methods are available to determine this flow. If the stream is gaged a simple statistical analysis of the data is performed to develop a duration curve. If the stream is ungaged a variety of hydrologic models are available. Many of these require specific training and may be unreasonable for a Level 1 analysis. A simple acceptable model based on regional regressions of USGS gaged streams is described in Fish Passage Design Flows for Ungaged Catchments in Washington (Powers and Saunders, 1996). This model requires drainage area, precipitation and basin elevation to estimate the 10% exceedance flow. As with many simple models there can be significant error in the estimates (S.E. = 25-60%).

Velocity calculations - Level 1 velocity analysis involves calculation of normal depth at the high design flow. Manning's equation is typically used for this calculation and is available in inexpensive commercial software packages. There are also culvert charts that show normal velocity for culverts at various gradients. The inputs of culvert shape and dimensions are used to determine hydraulic radius of flow. The culvert material determines the hydraulic resistance to flow, or Manning's "n" value. Tables of "n" values for various culverts materials are found in most open channel hydraulics manuals and with commercial software. Culvert slope and design flow are the remaining data necessary for the velocity calculation.
The calculated velocity is compared to velocity limits in Table 1 for a given length of culvert to decide if the culvert is a barrier to the design fish.

Hydraulic Drop - Hydraulic drop is the difference in water surface elevation between two points. Fish barrier analysis is concerned with hydraulic drop over a short distance (plunging flow) that may require fish to leap. The drop generally occurs at the culvert outlet. Hydraulic drop is calculated by first adding the culvert water depth to the downstream invert elevation, then subtracting the downstream water surface elevation. Hydraulic drop does not necessarily equal the outfall drop measured for the field analysis.

Occasionally there is a drop inside the culvert where a pipe has been extended or where a connection has failed. A hydraulic drop inside the culvert requires adequate pool volume to dissipate the energy of the drop. This situation would be considered unknown passability and requires analysis beyond Level 1.

The maximum drop criteria in WAC Table 1 must be satisfied at all flows between the low flow and the high fish passage design flow. If the hydraulic drop measured during the inventory exceeds the criteria the culvert is considered a barrier. If the elevation difference between the downstream culvert invert and the streambed control thalweg exceeds the criteria the culvert is assumed a potential barrier at low flow. Further analysis of hydraulic drop would require site visits at several flows to develop a rating curve at the downstream control. The other option is to develop a hydraulic model of the outlet control, which is beyond the scope of a Level 1 analysis.

Minimum flow depth - Assuming the velocity and hydraulic drop limits are not exceeded, water depth in the culvert can be estimated with Manning's equation for any given flow. The WAC specifies that low flow is used to determine minimum depth. The specific design flow is that which is exceeded 95% of the time, or the 7-day low flow with a 2-year recurrence interval. However, there is no easily accessible model for determining low flows throughout Washington. If the stream is gaged a statistical analysis can be used to develop a duration curve that identifies this flow level. Another source is regional models developed by USGS or others for some streams in Washington. A third option is to measure the flow at the culvert during the low flow time of year, typically late August or September. Many small streams may be dry during this time, further confusing the analysis. If minimum depth is an apparent issue and no simple hydrology model is available, culvert passage would be classified as unknown and requires a detailed analysis. If there is a natural streambed throughout the culvert the minimum depth criteria is assumed to be met.

Figure 1. Table detailing the positional information, descriptive information and physical measurements.

Attribute	Value	Comment
POSITIONAL INFORMATION		
Site ID	Alpha - Numeric	Unique for each stream crossing
Sequencer	Numeric	Unique # for each culvert at crossing
GPS Co-ordinates	LAT/LON (decimal degrees) or STATE PLANE (1927)	
Date	MM/DD/YYYY	
Time	24 Hour	
Observer	Text	Agency/Names of survey crew
Road Name	Text	
Road Number		County or City assigned code

Attribute	Value	Comment
Stream Name	Text	Name of stream culvert is in
Tributary To	Text	Water body to which stream is tributary
WRIA	Text	Water resource inventory area number
Legal	1/4Sec, Sec, Twnshp, Rng	
Owner	Text	
FISH UTILIZATION		
Fish Bearing	Yes No Unknown	Mapped, Physical, Biological, or Other Physical or Biological Meets no criteria for "Yes" or "No"
Decision Criteria	Mapped, Physical, Biological, or Other	
DESCRIPTIVE INFORMATION AND PHYSICAL MEASUREMENTS		
Outfall Drop	Feet, measured to nearest 0.1	Distance from the water surface at the downstream end of the culvert to the water surface of the plunge pool
Interior Grade Break	Yes/No	Describe in comments.
Shape	RND BOX ARCH PIP ELL OTH	Round Box Bottomless Squash (pipe arch) Ellipse Other
Material	PCC CST CAL SPS SPA CPC PVC TMB MRY OTH	Precast concrete Corrugated steel Corrugated aluminum Structural plate steel Structural plate aluminum Cast in place concrete Plastic Timber Masonry Other
Coating	NON GAL BIT EPX FBG CON POL OTH	None Galvanized Bituminus Epoxy Fiberglass Concrete (use NON for PCC and CPC pipes) Polymeric Other
Span/Diameter	Feet, measured to nearest 0.1	For round pipes a single measurement suffices.
Rise (height)	Feet, measured to nearest 0.1	
Length	Feet, measured to nearest 1.0	

Attribute	Value	Comment
Corrugation	9x2.5, 6x1, 6x2, 5x1, 3x1, 2.66x0.5 , 0.75x0.75	Dimensions are width (peak to peak) by depth, measured in inches.
Skew	In degrees right or left.	Angle at which stream enters culvert. Right or left reference is facing upstream.
Culvert Elevation - Upstream	Feet, measured to nearest 0.1	Measure upstream end elevation, preferably the invert if exposed
Culvert Elevation - Downstream	Feet, measured to nearest 0.1	Measure downstream end elevation, preferably the invert if exposed
Water Depth Inside Culvert	Feet, measured to nearest 0.1	Measured inside the culvert away from the influence of inlet and outlet conditions
Slope	Percent	Slope of the culvert calculated using invert elevations and length.
Streambed Elevation approx. 50' downstream.	Feet, measured to nearest 0.1	Measure at head of riffle. Used to estimate natural stream gradient.
Streambed Elevation approx. 50' upstream.	Feet, measured to nearest 0.1	Measure at head of riffle. Used to estimate natural stream gradient.
Average Channel Width at OHW	Feet, measured to nearest 0.1	Used to evaluate culvert sizing problems
Channel Control Cross Section	Depths and distances in Feet, measured to nearest 0.1	Typically this is the head of the first riffle below the culvert, particularly when there is a plunge out of the culvert. The control location is usually 10-25 feet downstream of the culvert. The cross section involves at least 5 measurements and includes all grade breaks in the section.
Water Surface Elevation - DS Control	Feet, measured to nearest 0.1	The downstream water surface elevation measured at the streambed control thalweg.
Reference Point Location	Text, possibly GPS coordinates	Best to establish a reference point away from construction zone for culvert replacement.
Reference Point Datum	Feet, measured to nearest 0.1	Datum may be an established datum or a local assumed datum.
OTHER MEASUREMENTS/INFORMATION ARE OPTIONAL		

FISH PASSAGE DESIGN FLOWS FOR UNGAGED CATCHMENTS IN WASHINGTON

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Washington Department of FISH and WILDLIFE

LANDS AND RESTORATION SERVICES PROGRAM
Environmental Engineering Services

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Prepared in Cooperation with the Washington State Department of Transportation

Introduction

Successful upstream passage of adult and juvenile fish through artificial structures (channels, culverts, fishways) depends on the selection of appropriate passage design flows. It is recognized that fish passage through artificial structures cannot practically be provided at all flows. A high design flow is selected to be the upper limit of the range through which upstream fish passage criteria are satisfied. The limitation of passage above the passage design flow may be due to velocity, drop height or turbulence. Structural design flows are also important, especially in terms of passage of debris and bed material. WAC 220-110-070 (Water Crossing Structures) requires that the high flow design discharge be the flow that is not exceeded more than 10 percent of the time during the months of migration. This report provides regional regression equations for ungaged catchments to estimate this flow.

For gaged catchments the 10 percent exceedance flow for any month can be easily determined by developing a flow duration curve. For ungaged catchments, the two-year peak flood can be used to estimate this flow (Cummans, 1975). The two-year peak flow is often much higher (300 to 400 percent) than the 10 percent exceedence flow. Bates (1988), reviewed current agency criteria and developed two regression equations relating basin parameters to the 10 percent exceedence flow.

The U.S. Geological Survey (USGS) are in the process of updating regional regression equations for flood frequencies in Washington. This report utilizes the same regions and basin parameters to develop regression equations for the 10 percent exceedence flow for the months of January and May. These months were selected to represent the high fish passage design flow (Q_{FP}) for two periods when upstream passage has been observed (Peterson, 1982) and (Cederholm, 1982). January represents the month of highest flow when adult salmonids are passing upstream, and May represents the most critical month for upstream passage of juvenile salmonids. Other months are also important, but January and May represent the two extreme combinations for design considerations. Equations were developed for three regions of Western Washington (Figure 1). Data was also analyzed for Eastern Washington, but no correlation between design flows and basin parameters could be found.

Description of Regions

The state of Washington was divided into subsections based on their drainage flow characteristics. These regions were derived from "The Catalog of Information on Water Resources Data" (1972), "Water Resources Regions and Subregions for the National Assessment of Water and Related Land Resources" by the U.S. Water Resources Council (1970), "River Basins of the United States" by the Inter-Agency Committee on Water Resources, Subcommittee on Hydrology (1961), and State planning maps. The regions defined are those regularly employed by the U.S. Water Resources Council and USGS for water resources planning.

The Coastal Lowland Region (Region 1) includes parts of Clallam, Jefferson, Mason, Thurston, Pacific, Lewis, and all of Grays Harbor counties and consists of streams that drain directly into the Pacific Ocean.

The Puget Sound Region (Region 2) includes sections of Clallam, Jefferson, Mason, Thurston, Pierce, and all of King, Snohomish, Whatcom, and Skagit counties. Region two consists of streams that drain into the Puget Sound. In order to find the best correlation, the Region 2 data was divided into highland and lowland streams. The division was defined at gage elevations of 1000 feet. In addition, Region 2 had a high percentage of urbanized streams (defined arbitrarily as greater than 20 percent impervious surfaces). Separate regression equations were run for this data.

The Lower Columbia Region (Region 3) is based on rivers that flow west of the Cascade Mountain Range and drain into the Columbia River. This region includes Wahkiakum, Cowlitz, Clark, and sections of Skamania, Pacific, and Lewis Counties. Again the best correlation was found when the region was divided into highland and lowland subregions. Again, the classification was based on the gage elevation.

Region four (Eastern Washington) is defined as the rivers in counties east of the Cascade Mountain Range. As defined by the USGS and U.S. Water Resources Council, Eastern Washington is divided into six regions. Too few fluvial systems fit the required criteria however to analyze any one region as a whole. Therefore, it was necessary to condense all of Eastern Washington into one region. No correlation was found amongst the small, unrepresentative data pool gathered within this large, diverse region.

Methodology

To create a usable model for estimating fish passage design flows, a data selection process was necessary. Parameters selected required the drainage areas to be less than 50 square miles with at least five years of data compiled by the USGS for January and May. All selected data were reported by USGS as either fair, good or excellent. Sites where the measured data was reported poor or had large periods of estimation during the months of interest were excluded from the analysis. Certain sites were also rejected because of major upstream diversions, lakes or reservoirs acting as stream controls. Data was compiled from USGS Hydrodata (Daily Values) and USGS Open File Reports 84-144-A, 84-144-B, 84-145-A, and 84-145-B. Basin drainage areas were gathered from the USGS Hydrodata. Mean annual precipitation and precipitation intensity were gathered from the USGS Open File Reports. When figures were not available in the Open File Reports, values were determined by locating the latitudinal and longitudinal coordinates of the gage stations on plates 1 and 2. The 10 percent exceedence flow values were calculated using the Hydrodata software via the Weibul formula;

$$P = M/(N+1)$$

where N is the number of values and M is the ascendant number in the pool of values.

Regression Analysis

A least squares multiple regression analysis was run on a logarithmic transformation of the data. Drainage area and mean annual precipitation (precipitation intensity for Region 1) were the independent values. The independent variables used were those specified in the 1996 USGS report.

Reasonable correlations were found within the Western Washington regions. Correlation improved upon further division of the individual regions. Gage less than 1000 feet were classified lowland, gages more than 1000 feet were classified highland. Separate analyses were run for the high passage flows during January and May migration periods for each region/subregion defined. Percent standard error (Tasker 1978), was derived from the formula;

$$SE_{percent} = 100(e^{\text{mean squared}} - 1)^{1/2},$$

where the units of the mean are natural log units. A table was included in the paper by Tasker that allowed for simple derivation of standard error in percent from logarithmic units.

The user is reminded of the non-symmetrical nature of the log-normal distribution. The higher the calculated design flow, the greater probability that the upper design flow will fall higher than one standard error above the regression line and less than one standard error below the regression line. It is, however, correct to assume an equal probability within one standard error above or below the regression line when the calculated flow and the standard error are expressed in logarithmic (base 10) units. However, the imprecise nature of accurately predicting high passage design flows would more often than not influence the user to add the standard error, making the probability distribution somewhat unimportant. The above statement remains to maintain scientific accuracy.

Results and Applications

Table 1 is a summary of the regression equations that were developed. Region one stations were all lowland (elevation <1000 ft), Region 2 had lowland, highland (elevation > 1000 ft) and urbanized stations, and Region 3 has lowland and highland stations.

Computation of a fish passage design flow at an ungaged site is made as follows:

1. From the map showing hydrologic regions (Figure 1), select the region in which the site is located.

2. From Table 1 select the appropriate equation from the region, elevation or land use condition and month.

3. From a USGS topographic map measure the drainage area above the site, latitude and

longitude and estimate the basin parameters from plates 1 and 2.

4. Substitute the values determined from step three into the equation from step two and solve for the fish passage design flow.

5. Apply the percent standard error as appropriate. In most cases the standard error is added to the result because the high end of the passage flow is desired, but in some cases if depth is a concern it may be subtracted.

Example 1: X-Trib to Lake Creek (Lake Cavanaugh Road)

From Table 1: Region 2, Elev <1000 ft, January
A = 1.82 sq mi
Latitude: 48°22' Longitude: 122°11'
From Plate 2: P = 80 in/yr

$Q_{fp} = 0.125(A)^{.93}(P)^{1.15}$

$Q_{fp} = 0.125(1.82)^{.93}(80)^{1.15}$

Q_{fp} = 34 cfs, Standard Error is 48.6%

Q_{fp} = 18 to 50 cfs .... Answer

Example 2: S. Branch Big Creek (SR 101)

From Table 1: Region 1, May
A = 0.87 sq mi
Latitude: 47°09' Longitude: 123°53'
From Plate 1: $I_{24,2}$= 4.5 in/24 hours

$Q_{fp} = 2.25(A)^{.85}(I_{24,2})^{0.95}$

$Q_{fp} = 2.25(0.87)^{.85}(4.5)^{0.95}$

Q_{fp} = 8.3 cfs, Standard Error is 30.6%

Q_{fp} = 5.8 to 10.8 cfs.. Answer

Table 1. - Regional regression equations for fish passage design flows in Washington. Q_{fp}, fish passage design flow; A, drainage area, square miles; I, 2-year, 24-hour precipitation, in inches; P, mean annual precipitation, in inches.

	Equation	Constant a	Coefficients b	Coefficients c	Standard error of prediction (%)
REGION 1					
January	$Q_{fp}=aA^bI^c$	6.99	0.95	1.01	25.7
May	$Q_{fp}=aA^bI^c$	2.25	0.85	0.95	30.6
REGION 2					
Lowland Streams < 1000 feet Elevation					
January	$Q_{fp}=aA^bP^c$	.125	0.93	1.15	48.6
May	$Q_{fp}=aA^bP^c$	.001	1.09	2.07	75
Highland Streams > 1000 feet Elevation					
January	$Q_{fp}=aA^b$	141	0.72		59.8
May	$Q_{fp}=aA^bP^c$	3.25	0.76	0.48	56.9
Urban Streams > 20% Effective Impervious Area					
January	$Q_{fp}=aA^bP^c$	.052	0.96	1.28	40.7
May	$Q_{fp}=aA^bP^c$	.003	1.10	1.60	43.3
REGION 3					
Lowland Streams < 1000 feet Elevation					
January	$Q_{fp}=aA^bP^c$	.666	0.95	0.82	38.1
May	$Q_{fp}=aA^bP^c$	.014	0.87	1.42	38.1
Highland Streams > 1000 feet Elevation					
January	$Q_{fp}=aA^bP^c$	.278	1.41	0.55	59.8
May	$Q_{fp}=aA^bP^c$	3.478	0.85	0.38	28.2

Table 2. - Maximum and minimum values of basin characteristics and R squared values used in the regression analysis, by region and land type.

	Drainage Area (sq mi)	Mean Annual Precipitation (inches)	2-year 24-hour Precipitation (inches)	R^2
REGION 1				
Maximum	48	--	7.5	.91
Minimum	2.72	--	2.5	.84
REGION 2				
Lowland Streams < 1000 ft Elevation				
Maximum	48.6	160	--	.81
Minimum	1	28	--	.77
Highland Streams > 1000 ft Elevation				
Maximum	45.8	170	--	.68
Minimum	.19	60	--	.76
Urban Streams > 20% Effective Impervious Area				
Maximum	24.6	35	--	.74
Minimum	3.67	47	--	.76
REGION 3				
Lowland Streams < 1000 ft Elevation				
Maximum	40.8	130	--	.84
Minimum	3.29	56	--	.86
Highland Streams > 1000 ft Elevation				
Maximum	37.4	132	--	.73
Minimum	5.87	70	--	.81

Comparison to Existing Equations

The regional equations were compared to existing equations used to calculate fish passage design flows. On the average flows from the regional equations were in between flows from the other two equations. Area and precipitation values were selected to cover typical ranges, and are completely arbitrary. Q_2 was calculated using equations compiled in USGS Open File Report 74-336. The two equations ($Q_{fp} = .18Q_2 + 36$ and $Q_{fp} = .03A^{1.11}P^{1.40}$) are from Bates and Powers (1988). These two equations cover the entire Western Washington. Answers for the regional model used lowland elevations and January as the month of passage.

Table 3 - Comparison of regional equations to existing fish passage design flow equations. Standard error not included.

REGION Fig. 1	AREA sq mi	PRECIP in/yr	$.18Q_2 + 36$ cfs	$.03A^{1.11}P^{1.40}$ cfs	Regional Equation cfs
3	5	60	72	55	87
1	2	4 in/24 hrs	82	30	55
2	3	50	45	24	31
3	2	70	48	25	41
2	4	65	98	48	55

Limitations and Comments

The equations presented in this study can be used within certain limitations to predict fish passage design flows for Western Washington. With the exception of urbanized streams in region two, the relationships were determined from gaging-station data for natural-flow streams and should not be applied where artificial conditions have altered stream hydrology. These equations are not a substitute for hydrologic synthesis within a region, where flows are actually measured to develop a correlation to gaged data. Extrapolations beyond the limits of the basic data used in each region is not advised. Relationships can be used with the most confidence in lowland areas with runoff dominated by rainfall, and with least confidence in highland or desert areas with little rainfall. Many urbanized streams in Puget Sound have been modeled using continuous simulation models. Watershed basin plans may be available from local governments with data that should be used to generate flow duration curves for a specific stream location. For Eastern Washington, since no correlation was found it is recommended that the two year peak flood flow (USGS, 1996) be used as the high fish passage design flow.

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PROVISIONAL DATA
SUBJECT TO REVISION

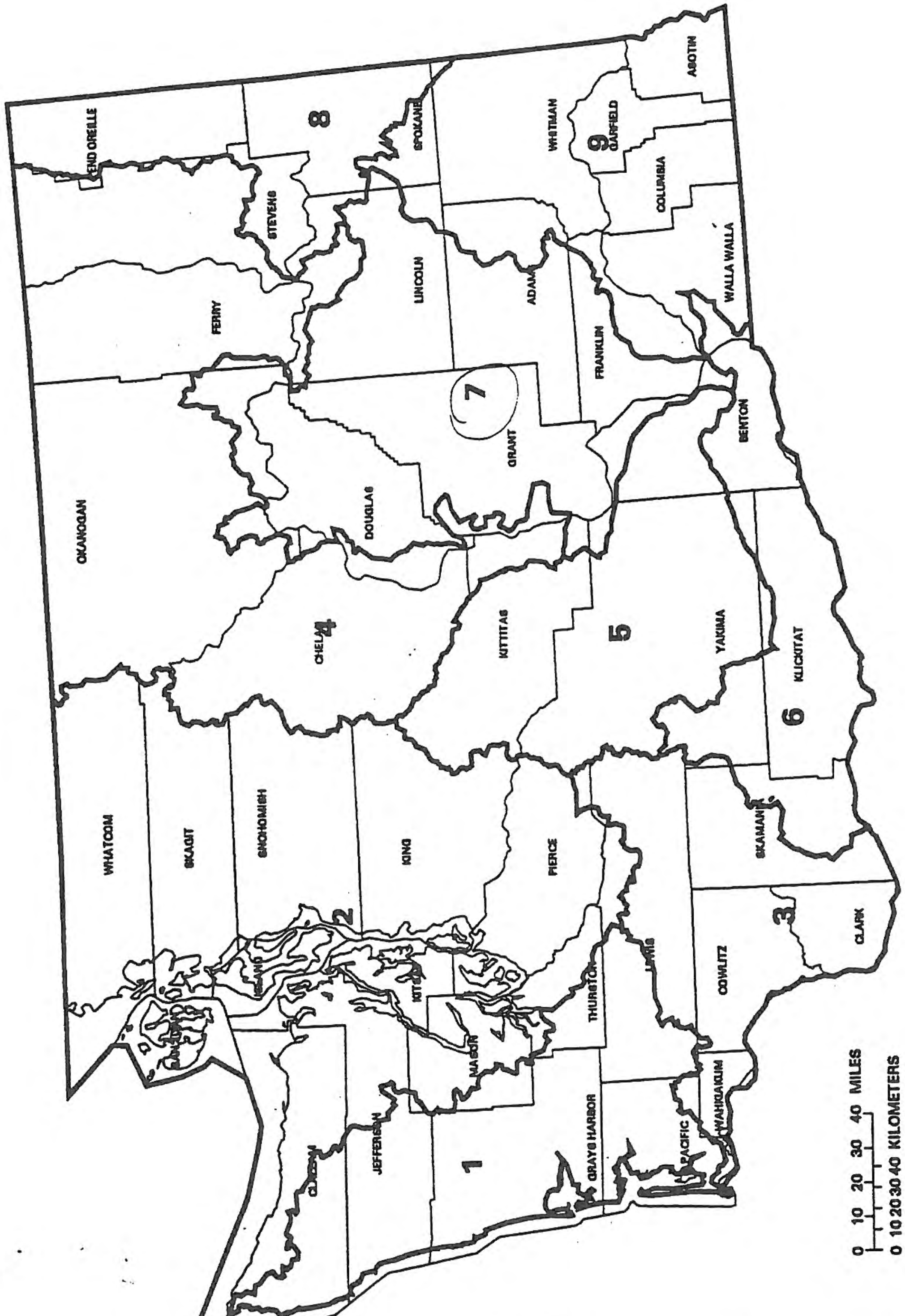

Figure 1 - Regions in Washington State used for development of regression equations (Source, USGS 1996)

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/fd03/flood/buccall/iftregions.eps regions.aml

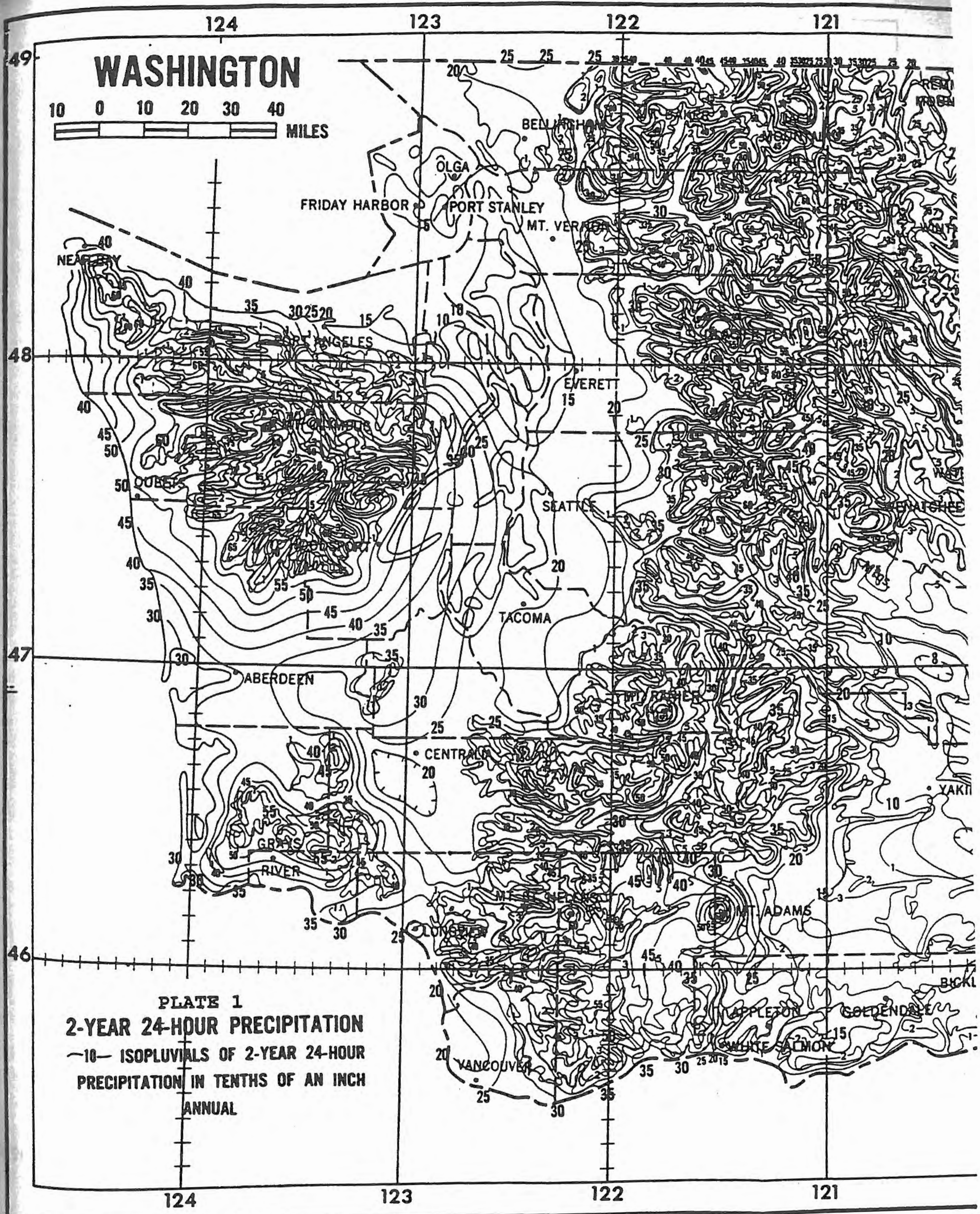


PLATE 1

2-YEAR 24-HOUR PRECIPITATION

—10— ISOPLUVIALS OF 2-YEAR 24-HOUR PRECIPITATION IN TENTHS OF AN INCH

ANNUAL

USDA-SCS-NATIONAL CARTOGRAPHIC CENTER, FT. WORTH, TX-1986

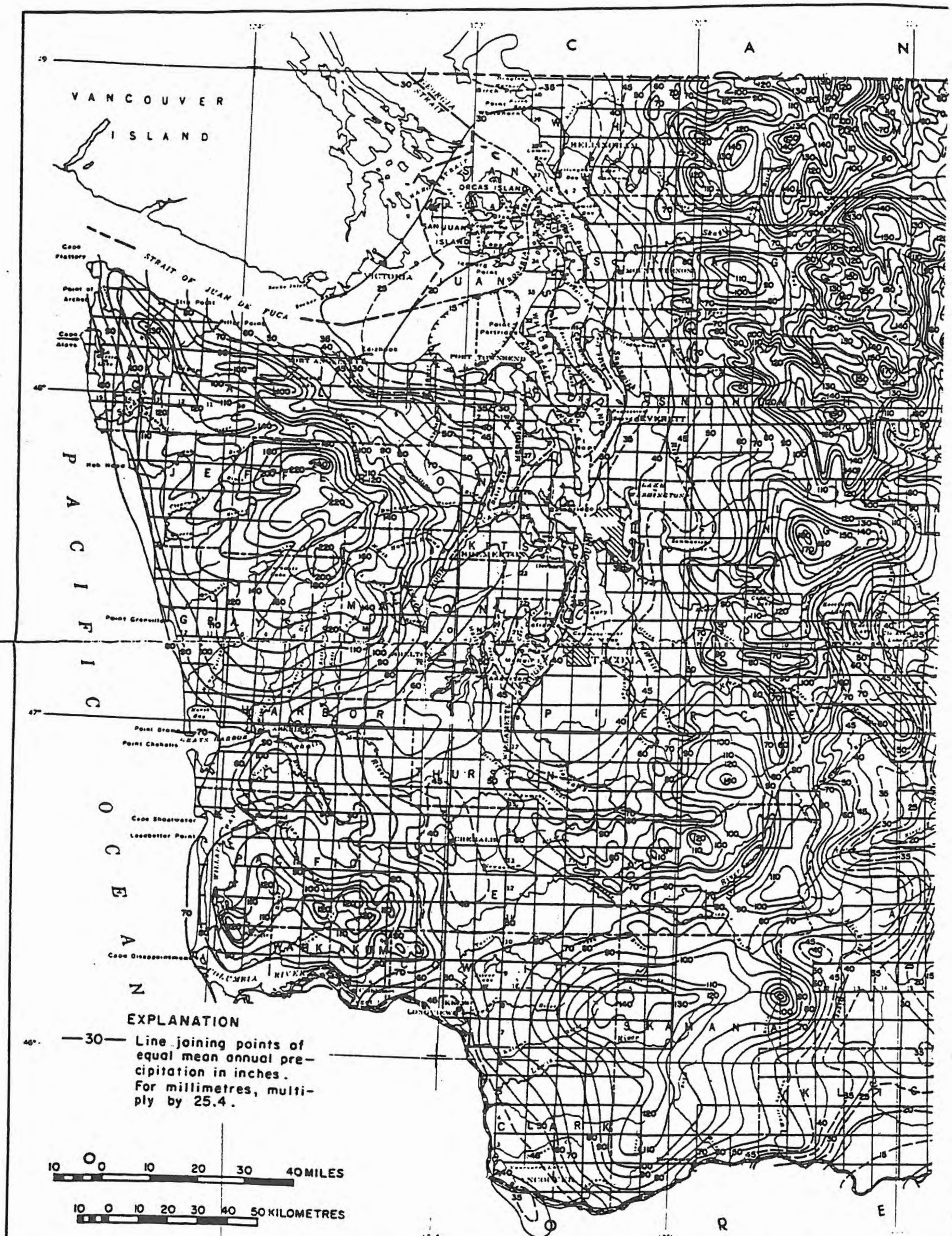
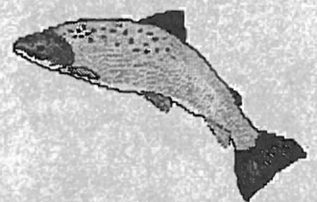


PLATE 2.-- Mean annual precipitation in Washington, 1930-57. From U.S. Weather Bureau (196



APPENDIX F
GUIDANCE DOCUMENT - BARRIER PRIORITIZATION

PRIORITIZATION

Data Analysis

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 Priority Index Model (described below) which is used to prioritize barrier correction. 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 habitat survey data were processed in a customized spreadsheet which generated a detailed report for each stream surveyed. The reports contain the total habitat gain per species, habitat measurements for each stream reach and the total survey, habitat quality information, and other fundamental survey data.

Spawning area was calculated as the sum of the areas of each habitat type, measured at ordinary high water, multiplied by the gravel percentage in each habitat type. Widths at ordinary high water are determined during the survey using the bank vegetation line and other hydrologic evidence.

Rearing area was calculated using a projected 60-day low flow. Sixty-day low flow is defined as the lowest average flow occurring over any period of 60 consecutive days during the year. The 60-day low flow methodology is described in detail in Appendix E. The entire stream area calculated using the 60-day low flow is considered rearing area. This methodology allows comparison of rearing areas regardless of the season in which the stream was surveyed.

Both the spawning and rearing areas can be adjusted by a Habitat Quality Modifier, which is a subjective estimate of habitat quality. It has a value which ranges in increments of ⅓ from zero to one. A separate modifier is assigned to each habitat type within each stream reach. This modifier serves to decrease the habitat areas in degraded streams to reflect the lower production potential.

Gains in spawning or rearing area are calculated for each species (potential presence) for each sample reach within a survey. Reach values are then subjected to an analysis of species interaction. Competition between species with similar freshwater life histories tends to reduce the production rate below single species production values. For example, optimum single species productivity for two species within the same complex (coho and steelhead) is estimated at 0.05 and 0.0021 adults/m^2 respectively. If the single species values are added, a total production value of 0.0521 is the result. To adjust for competition within species complexes, the species complex factor was developed to reduce multiple species production values below the simple total of individual values.

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Species Complex Factor (CF) = production value species 1 + 0.66 (production value species 2) + 0.33 (production value species 3) / production value species 1 + production value species 2 + production value species 3

In the case of coho and steelhead the species complex production value would be reduced from 0.0521 to 0.0514 or [*0.0521 x (0.05+0.66(0.0021)/0.05+0.0021)*].

In practice, the species complex factor is used to reduce the habitat area (H) used in the Priority Index formula. The habitat area value is adjusted on a reach by reach basis for each species present. In the case where coho and steelhead utilize the same stream reach the total rearing area available would be multiplied by the species complex factor [H = habitat gain (m^2) x *(0.05+0.66(0.0021)/0.05+0.0021)*]. The adjusted habitat values for each reach are summed and used to calculate single species PI values using the full single species adult production value. This is similar in effect to adjusting the adult production value. However, it is more sensitive to changes in species composition throughout a drainage.

Priority Index

The variety in costs, amounts of habitat gain, and species utilizing potential project sites throughout Washington State can make the characterization and prioritization of corrections to fish passage barriers complex. The WDFW Fish Passage Inventory process uses a Priority Index model to consolidate the many factors which affect a project's feasibility (expected passage improvement, production potential of the blocked stream, fish stock health, etc.) into a manageable framework for developing prioritized lists of projects. The result is a numeric indicator giving each project's relative priority that includes production benefits to both anadromous and resident salmonid species adjusted for sympatric species interactions (species complexes). The Priority Index (PI) for each barrier is calculated as follows:

$$PI = \sum_{all\ stocks} \sqrt[4]{[(BPH)\ x\ MDC]}$$

Where:

PI = Priority Index

- Relative project benefit considering cost.
- The PI is actually the sum ($\sum_{\text{all species}}$)of individual PI values, one of which is calculated for each species present in a stream (e.g., PI_{coho} is added to PI_{chum} to obtain $PI_{\text{all species}}$).
- The quadratic root in the equation is used because it provides a more manageable number and represents a geometric mean of factors used.

B = Proportion of passage improvement

- Proportion of fish run expected to gain access due to the project (passability after project minus passability before project); gives greater weight to projects providing a greater margin of improvement in passage.

P = Annual adult equivalent production potential per m^2

- Estimated number of adult salmonids that can potentially be produced by each m^2 of habitat annually.

- The values (adults/m^2) are species specific; chinook salmon = 0.016, chum salmon = 1.25, coho salmon = 0.05, pink salmon = 1.25, sockeye salmon = 3.00, steelhead = 0.0021, brook trout = 0.04, brown trout = 0.0019, bull trout = 0.0007, cutthroat trout = 0.037, and rainbow trout = 0.0048.

H = Habitat gain in m^2

- Measured/calculated from physical survey; gives greater weight to projects which will make greater amounts of habitat available.

- Spawning area values used for species complexes normally limited by spawning habitat (sockeye, chum, pink salmon) and rearing area values used for species complexes normally limited by rearing habitat [(coho, chinook, steelhead) and (cutthroat, rainbow, bull trout) and (brook and brown trout)].

- When more than one species within a species complex is present H is modified to reflect sympatric interactions among species with similar freshwater life histories. The result is a reduction of single species habitat area values when competing species coexist.

M = Mobility Modifier

- Accounts for benefits to each fish stock for increased mobility (access to habitat being evaluated); gives greater weight to projects that increase productivity of species that are highly mobile and subject to geographically diverse recreational and commercial fisheries by providing access to habitat currently limiting productivity.

- 2 = Highly mobile stock subject to geographically diverse recreational and commercial fisheries (anadromous species)

- 1 = Moderately mobile stock subject to local recreational fisheries (resident species)

- 0 = Increased mobility of stock would have negative or undesirable impacts on productivity or would be contrary to fish management policy. By default, exotic salmonid species such as brook trout, brown trout and Atlantic salmon will be assigned a 0 value unless they are the only salmonid species present in the system.

D = Species Condition Modifier

- Representation of status of species present; gives greater weight to less healthy species as listed in the Washington State Salmon and Steelhead Stock Inventory (SASSI) report. In the absence of a SASSI assignment, stock condition should be estimated using the best available information.

  3 = Condition of species considered critical.

  2 = Condition of species considered depressed or stock of concern.

  1 = species not meeting the conditions for 2 or 3.

C = Cost Modifier

- Representation of projected cost of project; gives greater weight to less costly projects.

  3 = incremental funds needed ≤ \$100,000...

  2 = incremental funds needed >\$100,000 and ≤\$500,000...

  1 = incremental funds needed >\$500,000...

- All barriers receive a cost modifier value of 2 until engineering evaluations are completed.

WASHINGTON STATE DEPARTMENT OF FISH AND WILDLIFE SALMONID SCREENING HABITAT ENHANCEMENT AND RESTORATION(SSHEAR) PROGRAM REVISED PHYSICAL SURVEY METHODS, EQUIPMENT, AND MATERIALS

May 30,1997

METHODS

Date, Stream Name, Tributary To, and Section Surveyed
The date, stream name, tributary to and WRIA number are noted prior to beginning the survey. The stream reach surveyed is identified as meters above the starting point (e.g. - Mouth to 1000 M upstream).

Survey Reaches Will Be Broken Out By Channel Morphology The stream to be surveyed will be broken out into reaches with similar gradient, bed form and channel size (break out at each significant tributary => 20% of parent stream flow). The following gradient breaks will be used as reach breaks.

REACH GRADIENT BREAKS	NORMAL UPPER LIMIT OF SPECIES USE
0 - 1 %	CHUM
1 - 3	"
3 - 5	PINK, COHO, SOCKEYE, SP CHIN
5 - 7	"
7 - 12	STEELHEAD and Trout Species

For gradient reach breaks a sample reach must have a sustained gradient for at least **160 meters (0.1 mile)**. The survey will be terminated when a sustained gradient greater than 12% is encountered for a distance of at least 160 meters or when a natural barrier in reached. Exceptions to the 12% gradient cutoff may be made if there is evidence of passability and valuable lower gradient habitat exists upstream.

Since you won't always know how long the stream continues at a particular gradient, it will be necessary to measure the first 160 meters by belt chain to verify the need to create a new reach when gradient changes are encountered. Sample frequency should continue uninterrupted across gradient reach breaks, to avoid unnecessary sampling should the gradient change prove to be less than 160 meters. This will be an exception to the way you will handle other types of reach breaks (bed form change, land use change etc), where a new sampling frequency will begin at the reach break point.

Changes in bed form that require a reach break would be any change which significantly effects pool:riffle:rapid ratio, substrate composition, or channel width. Changes in bed form need not be 0.1 mile long to qualify as a reach. An example would be a stream which has a significant sediment source (feeder bluff) at river mile 1 which provides good spawning gravel in riffle areas downstream but is boulder and bed rock (gravel poor) upstream from this point. In this case a reach break at river mile 1 would be necessary to keep from biasing your gravel composition assessments. If the sediment source were a sand bluff which shifted bed composition to a high percentage sand (low percentage spawning gravel) below river mile 1 and low sand (high percentage spawning gravel) above river mile 1 a reach break would also be required.

Other bed form shifts which could require a reach break would be a change from a forested high quality channel (high level of LWD) which emerges into a highly impacted dairy or cattle grazing reach of lower productivity (cattle waste, low LWD, or lack of stream bank vegetation and hiding cover).

As a rule of thumb a reach break should be made whenever a change in stream characteristic will effect one of the measured parameters used to calculate production potential (gradient, channel width, riffle area, pool area, bed composition or habitat quality modifier).

Sample Frequency Within A Sample Reach - Samples shall be taken within each sample reach to provide statistically valid estimates of measured criteria. A 20% sampling level will be achieved by taking habitat measurements in the first 60 meters of each 322 meter section walked on streams longer than one mile and the first 30 meters of each 161 meters on streams less than 1 mile. In cases where a reach break is caused by a gradient change the sample section will be located based upon the appropriate distance (322 M or 161 M) from the previous sample point regardless of the reach break location.

A Habitat Quality Modifier shall be assigned to each survey reach to identify productive capability of the habitat. The rating will be used as a multiplier of the square meter habitat number to obtain H in the Priority Index model (H= habitat quality modifier x habitat in square meters). This should be applied independently to spawning and rearing habitat. In some situations (sand bottom creeks) rearing habitat may be excellent but due to high fines spawning habitat may be of poor quality for example.

Good to Excellent	= 1	(Habitat is generally in its natural state with no major disturbances)
Fair	= 2/3	(Habitat shows significant signs of disturbance known to reduce productive capability)
Poor	= 1/3	(Habitat shows signs of major disturbance likely to cause major reductions in its production capabilities)
No Value	= 0	(Habitat severely disturbed production capabilities effectively with out value at this time)

Limiting Factor - If a habitat quality modifier other than 1 is assigned to a reach indicate why in this space. A simple note will suffice (dairy waste, unstable bed, lacking riparian vegetation, lacking in stream cover, irrigation return water, stream dry, high summer temperatures etc.

Survey All Potential Habitat Above A Barrier - We will eliminate the category "immediate habitat" and call all habitat above a barrier potential habitat. This will include habitat above secondary barriers upstream of subject barrier provided the barrier has a reasonable potential for correction. When secondary barriers are encountered their location should be entered into the "multiple barriers" space in your field data notebook as distance in meters above the primary barrier. This may be directly tied to the data base via the unresolved fish passage problem identification report which you are currently completing at each man made barrier located.

1) Stream length

a) A belt chain measuring in meters and using a 3 strand, biodegradable thread is worn, and the stream is walked from the downstream end of the survey area.

b) To determine total potential habitat available above a barrier, the survey is continued to a point when the gradient consistently exceeds 12% for a distance of at least one tenth of a mile or an anadromous barrier is reached.

c) **MULTIPLE BARRIERS** Frequently, additional man made or temporary (beaver dam, log jam) barriers exist which must be corrected to realize the potential habitat gain above the primary barrier. In this case, note the river mile of each additional barrier in the "multiple barrier" space on your survey form and identify your method of river mile identification (chain belt, stream catalogue, aerial photo, USGS quadrangle).

d) A fish passage barrier identification form should be filled out and submitted for each man made barrier encountered.

e) The multiple barrier river mile locations will appear as an additional field in our fish passage database.

2) Sample Frequency

a) Where the survey is predicted to be over 1.0 mile long, sample sections are 60 meters in length and taken at the beginning of each 0.2 mile (322 meters) section of stream.

b) Where the survey is predicted to be under 1.0 mile long, sample sections are 30 meters in length and taken at the beginning of each 0.1 mile (161 meters) section of stream. Note: Depending upon the location of the end of the survey, this rate of sampling will result in no less than 18.6% of the total stream length surveyed.

3) Pool:Riffle:Rapid Area

a) The length in meters of each pool, riffle and rapid within the sample section is recorded.

b) Two representative channel width measurements are taken to the nearest 0.1 meter 1) wetted width and 2) ordinary high water (OHW) width.

c) An average depth to the nearest 0.1 meter is taken at the cross section location of each wetted width measurement. No residual pool depth measurements will be taken.

d) Width measurements (wetted & OHW) are taken at the first two pool, riffle and rapid sections found within the sample section. Depth measurements for each wetted width are also taken. Ordinary high water mark depths will not be taken. A staff marked for metric lengths and meter tape are used.

e) The pool:riffle:rapid areas in M^2 for each reach is calculated using the following formula.

Total (pool) area = total reach length x **average wetted pool width**[1] x (sum of sampled pool lengths/total sample lengths).

1\ Calculated channel width based upon calculated 60 day summer low flow and measured channel cross section may be used to calculate rearing area. OHW width should be used to calculate spawning area. Wetted width can be used as a default to calculate rearing area in the event that the above information is not available, or the calculated 60 day summer low flow area is ambiguous. Methodology for the 60 day summer low flow calculation is per Ken Bates October 17, 1994 unpublished paper titled ESTIMATE OF POTENTIAL SUMMER HABITAT.

4) **Pool:Riffle:Rapid Ratio**

Pool:Riffle:Rapid areas for each survey reach shall be calculated as follows: sum all areas (pool + riffle + rapid) = Total reach area then: pool area/total reach area x 100 = % pool, and riffle area/total reach area X 100 = % riffle area and so on.

5) **Substrate Composition**

Substrate composition of riffle, pool and rapid areas will be visually estimated per existing methodology. Use attached "Suggested Methodology of Visually Estimating Gravel" to test visual estimate accuracy and calibrate among observers.

a) Estimates of percentages of bottom composition are made by visually observing substrate composition within riffle, pool and rapid areas in each sample area and estimating percent substrate composition in each category shown below for each sample pool, riffle, or rapid.

b) The following substrate categories shall be used to break out mean particle diameter size of substrate composition:

1) Boulder = >12 inches
2) Rubble = 3 to 12 inches
3) Gravel = 0.25 to 3 inches
4) Sand = <0.25 inches

Once all bottom composition estimates have been made for the sample reach, the mean substrate composition for the entire reach is calculated by summing the % composition for each substrate category (boulder, rubble, gravel, sand) and dividing by the sample number. Example: Mean Boulder composition = Sum of all boulder samples/ Total Sample Number.

6) **Spawning Area** - Spawning area for each habitat category (pool, riffle, rapid) will be calculated for each reach as follows: Total (pool) area x % gravel/100 x habitat quality modifier. Total spawning area for the reach shall be calculated as the sum of spawning area calculated for pool, riffle and rapid categories. Total spawning area for the stream system surveyed will be the sum of spawning area calculated for each reach.

7) **Rearing Area** - The sum of Pool, Riffle, Rapid area totals for each reach x the habitat quality modifier = total rearing area within the reach. The sum of all rearing area within reaches = total rearing area surveyed. Reaches with low quality rearing conditions, for example, a reach severely lacking in pool area the habitat quality modifier should be used to reduce the quantity of rearing area.

8) **Pond Habitat** Pond habitat has a different production value than stream habitat. For this reason ponds will be broken out as separate reaches and pond area measured and rated using the habitat quality modifier. A standard pond habitat production value of 3000 coho smolts/acre = .74 smolts/M^2 will be used. This base production level will be used for good to excellent habitat, in lesser quality pond systems the habitat quality modifier should be used to arrive at a production figure for the pond reach. Pond rearing area for each pond reach shall be calculated as total pond area x habitat quality modifier = total rearing area within the reach.

Pond habitat shall be defined as a zero gradient channel reach having a average width at least five times that of the average pool width and five times the average pool length in the downstream reach. In the event short, high quality riffles exist between a series of high quality rearing ponds, exceptions to reach lengths can be made (<.1 mile) to capture these high quality areas in the survey.

9) **Flow**

a) A flow measurement should be taken at the beginning of each survey (using a flow meter if possible) and periodically as proceeding upstream as flow conditions change such as tributary or groundwater input areas (using the chip method).

b) The three chip flow method or flow meter is used.

1) Measure flows at a culvert, sharp crested weir riffle area or other uniform cross section when possible.

2) The average width and average depth of the selected cross section is determined with at least 3 measurements of each.

3) Flow velocity measurements are taken using a flow meter or a stop watch and meter tape to time a chip traveling over the length of the sample riffle or a distance up to 10 meters immediately upstream of the cross section. A minimum of three flow velocities are recorded.

c) Flow in cubic feet per second (CFS) is calculated using the continuity equation Q = Flow Cross Section Area X Velocity.

10) Water temperature

a) Water temperature is normally taken at the same general time and location as the flow.

b) A hand-held mercury thermometer, calibrated for centigrade readings is used. Temperature is recorded to the nearest degree centigrade.

11) Gradient

a) Gradients are taken at a rate of at least one per sample section.

b) A hand or tripod mounted level and stadia rod is used.

c) Gradients are shot over as long a stream section as visibility allows, and back sights are taken where possible as a double check. Ribbon is tied at eye level for sightings when only one surveyor is working.

d) Mean gradient for each reach is calculated by summing all gradient samples taken in the reach and dividing by the sample number.

12) Comments

a) Principal stream features, road crossings, culvert sizes, etc., are noted (in meters from the beginning of the survey) as they are encountered.

b) The end of the survey and the reason for ending the survey are noted.

c) Notes are added to the "Comments" section of the database

d) All streams surveyed should be flowing at the time of the composition = Sum of all boulder samples/ Total Sample Number.

6) **Spawning Area** - Spawning area for each habitat category (pool, riffle, rapid) will be calculated for each reach as follows: Total (pool) area x % gravel/100 x habitat quality modifier. Total spawning area for the reach shall be calculated as the sum of spawning area calculated for pool, riffle and rapid categories. Total spawning area for the stream system surveyed will be the sum of spawning area calculated for each reach.

7) **Rearing Area** - The sum of Pool, Riffle, Rapid area totals for each reach x the habitat quality modifier = total rearing area within the reach. The sum of all rearing area within reaches = total rearing area surveyed. Reaches with low quality rearing conditions, for example, a reach severely lacking in pool area the habitat quality modifier should be used to reduce the quantity of rearing area.

8) **Pond Habitat** Pond habitat has a different production value than stream habitat. For this reason ponds will be broken out as separate reaches and pond area measured and rated using the habitat quality modifier. A standard pond habitat production value of 3000 coho smolts/acre = .74 smolts/M^2 will be used. This base production level will be used for good to excellent habitat, in lesser quality pond systems the habitat quality modifier should be used to arrive at a production figure for the pond reach. Pond rearing area for each pond reach shall be calculated as total pond area x habitat quality modifier = total rearing area within the reach.

Pond habitat shall be defined as a zero gradient channel reach having a average width at least five times that of the average pool width and five times the average pool length in the downstream reach. In the event short, high quality riffles exist between a series of high quality rearing ponds, exceptions to reach lengths can be made (<.1 mile) to capture these high quality areas in the survey.

9) **Flow**

a) A flow measurement should be taken at the beginning of each survey (using a flow meter if possible) and periodically as proceeding upstream as flow conditions change such as tributary or groundwater input areas (using the chip method).

b) The three chip flow method or flow meter is used.

1) Measure flows at a culvert, sharp crested weir riffle area or other uniform cross section when possible.

2) The average width and average depth of the selected cross section is determined with at least 3 measurements of each.

3) Flow velocity measurements are taken using a flow meter or a stop watch and meter tape to time a chip traveling over the length of the sample riffle or a distance up to 10 meters immediately upstream of the cross section. A minimum of three flow velocities are recorded.

c) Flow in cubic feet per second (CFS) is calculated using the continuity equation Q = Flow Cross Section Area X Velocity.

10) Water temperature

a) Water temperature is normally taken at the same general time and location as the flow.

b) A hand-held mercury thermometer, calibrated for centigrade readings is used. Temperature is recorded to the nearest degree centigrade.

11) Gradient

a) Gradients are taken at a rate of at least one per sample section.

b) A hand or tripod mounted level and stadia rod is used.

c) Gradients are shot over as long a stream section as visibility allows, and back sights are taken where possible as a double check. Ribbon is tied at eye level for sightings when only one surveyor is working.

d) Mean gradient for each reach is calculated by summing all gradient samples taken in the reach and dividing by the sample number.

12) Comments

a) Principal stream features, road crossings, culvert sizes, etc., are noted (in meters from the beginning of the survey) as they are encountered.

b) The end of the survey and the reason for ending the survey are noted.

c) Notes are added to the "Comments" section of the database

d) All streams surveyed should be flowing at the time of the survey.

13) Canopy Composition - Visually estimate percent area shaded by the streams riparian canopy assuming full leaf out condition. Note major tree and shrub species within stream corridor. The estimate should represent the percent of wetted stream area that would be shaded during summer full leaf out conditions. One canopy composition estimate should be made for each reach. Periodic use of a densiometer is advised to calibrate survey observations and to train new survey teams.

14) Water Diversions - Other water uses are noted in the "Comments" section of the field notes as encountered (e.g. - privately owned pump drawing water from stream).

15) In Stream Cover - In stream cover density such as large woody debris (LWD), undercut banks, large boulders, close overhanging vegetation (etc) is visually estimated as high, medium or low. A low in stream cover rating should be reflected in the rearing habitat modifier rating. One estimate of instream cover density should be made for each reach.

16) Juvenile abundance

a) A subjective visual estimate of fry densities is noted by species if possible.

b) The density is denoted as either low, medium, or high.

c) One juvenile abundance estimate for each reach shall be made.

17) Blockage location

a) The location of the problem culvert or other blockage in question is recorded by belt chain measurement in meters above survey starting point (reference point) and converted to river mile using USGS Quadrangle map and map wheel if necessary.

b) Blockage location on tributaries shall be recorded as meters above the confluence with the parent stream.

18) Production Calculations shall be the sum or all rearing habitat within the survey which occurs within the gradient break reaches appropriate for the species of concern, where rearing habitat is limiting to production. In cases where spawning habitat is limiting (chum and pink salmon) production shall be based upon the sum of all spawning habitat within the survey which occurs within the gradient break reaches appropriate for the species of concern (eg 0 to 3% for chum salmon).

Equipment

1) **Belt chain**

2) **Meter tape or calibrated staff**

3) **Hand level**

4) **Stadia rod**

5) **Flow meter**

6) **Thermometer**

7) **Stop Watch**

8) **Densiometer**

9) **Computer and software (Quattro)**

Materials

1) **String for belt chain** (1991 Mallory cost = $5.15 per 2,743 meter roll)

2) **Surveyors ribbon** (1991 Mallory cost = $0.58 per roll)

Definitions Explanation of terms used in this survey format shall be as shown in attachments and in the Aquatic Habitat Inventory Glossary and Standard Methods produced by the Western Division American Fisheries Society unless otherwise defined herein. Use of the Rosgen stream classification system is recommended to identify channel form defined reach breaks.

October 17, 1994

ESTIMATE OF POTENTIAL SUMMER HABITAT

Objective

The objective of this study is to estimate, from channel characteristics which are measurable throughout the field season, the relative areas of summer low flow rearing habitat in streams across the state.

Method

This method for estimating relative potential aquatic habitat is based on regional estimates of 60-day low flow per unit watershed area (i.e., cubic feet per second per square mile) combined with channel characteristics measured in the physical survey.

The physical survey distinguishes four geomorphic stream features: riffles, rapids, pools, and ponds. These features are generally categorized into two habitat types: pools (i.e., pools and ponds), and riffles (i.e., all other habitat types). Pools are characterized by low gradients (<1%), reduced flow velocities, and often greater water depths than in surrounding areas. Ponds are pools which have average widths and lengths at least five times the average widths and lengths of pools in the downstream reach. Riffle habitat types are characterized by shallow, swift, turbulent flow over completely or partially submerged obstructions.

Regional stream gage data were used to generate regression equations of the form:

$$Q_{60} = (CA)/35.3 \qquad \text{(Eq. 1)}$$

where Q_{60} = 60-day low flow (cubic meters per second),
A = watershed area (square miles), and
C = a regional constant.

From this equation, Q_{60} can be estimated for each stream in the survey. In this preliminary study, Washington was divided into four hydrologic regions: 1) Olympic Peninsula/south coast, 2) Cascade (east Puget Sound), 3) Columbia/eastern Washington, and 5) Northern/North-eastern mountains. These divisions are based on evaluation of USGS analyses of low flow characteristics of streams in Washington rather than on direct statistical analysis of low flow data. Due to scarcity of 60-day low flow data, regression relationships for the Olympic/south coast and the Northern/north-eastern mountain regions were developed from 7-day low flow data and increased by a factor representing the regional relationship between 60-day low flow and 7-day low flow. The Cascade/east Puget Sound 60-day low flow values were interpolated from 30-day and 90-day low flow data. Regional constants are shown in Table 1.

Table 1. Regional constants for 60-day low flow per square mile of watershed area.

Region	Constant	Standard Error	R^2	Observations
Olympic/ coastal	0.49	0.023	0.36	168
Cascade/ east Puget	1.04	0.140	0.28	46
Columbia/ Eastern Wash.	0.12	0.021	0.22	17
Northern/ N-E mountains	0.097	0.011	0.22	70

Water surface area at 60-day low flow conditions was used to estimate relative potential habitat. Two hydraulic equations were used to estimate average flow geometry in the riffles:

$$Q = AV, \qquad \text{(Eq. 2)}$$

where Q = flow, in cubic meters per second,
A = cross-sectional area of flow, in square meters,
V = average velocity of flow, in meters per second;

and Manning's equation,

$$V = (1/n)R^{2/3}S^{1/2}, \qquad \text{(Eq. 3)}$$

where n = Manning's roughness factor,
R = the hydraulic radius (in m) = flow area/wetted perimeter,
S = the gradient.

Certain simplifying assumptions were made in order to estimate the low flow riffle area:

1) the riffles are wide in relation to their depth (i.e., width/depth > 10) during the period of measurement and at low flow;

2) the width/depth ratio (W/D) remains constant between the time of the stream survey and summer low-flow conditions,

3) the cross-sectional shape of the riffle bottom is approximately triangular, i.e., the depth increases gradually from the banks to the thalweg so that

$$A = (WD)/2 \qquad \text{(Eq. 4);}$$

4) the surface area of rapids changes, in response to changes in flow, by the same factor as that of the riffles;

5) the roughness factor, n, is approximately 0.1 under low-flow conditions.

By combining equations 2, 3, and 4, average 60-day low-flow riffle depth (D_{60}) and width (W_{60}) were calculated as

$$D_{60} = [(0.318Q_{60}D_s)/(S^{0.5}W_s)]^{0.375} \qquad \text{(Eq. 5)}$$

where D_s= the average riffle depth (in m) measured during the survey,
W_s= the average riffle width (in m) measured during the survey, and

$$W_{60} = (W_sD_{60})/D_s. \qquad \text{(Eq. 6)}$$

The ratio W_{60}/W_s is the factor used in calculating riffle and rapid surface areas at Q_{60}, i.e.,

$$A_{60}(\text{riffle}) = A_s(\text{riffle})*W_{60}/W_s, \text{ and} \qquad \text{(Eq. 7)}$$

$$A_{60}(\text{rapid}) = A_s(\text{rapid})*W_{60}/W_s. \qquad \text{(Eq. 8)}$$

Pool depth is assumed to change by an amount equal to the change in the riffle depth. Pool area is assumed to change by a factor equal to the ratio of the low-flow depth to twice the average measured depth, i.e.,

$$A_{60}(\text{pool}) = A_s(\text{pool})*[D_s(\text{pool})-(D_s-D_{60})]/D_s(\text{pool}). \qquad \text{(Eq. 9)}$$

Pond depth and surface area is assumed to be relatively insensitive to changes in flow. It is suggested that a factor of 1.0 be assigned to pond area, i.e.,

$$A_{60}(pond) = A_s(pond). \qquad (Eq.10)$$

Discussion

Individual stream systems may vary substantially in their low-flow characteristics from the regional averages developed for use in this habitat estimate. One particularly important aspect of streams which will cause them to deviate from regional low-flow estimates is contributions to base flow by springs; the habitat offered by these streams will be seriously underestimated by this method.

It is suggested that the physical survey of streams include a checklist designed to identify spring-fed systems. Indicators of spring-dominated hydrology include:

1) a relatively regular, rectangular cross-section, with minor variations in depth,

2) very low, flat floodplains, and

3) bank vegetation established along a distinct line, at a small distance above the water surface; moss on the exposed surfaces of rocks in the channel is a strong indicator of spring-fed flow.

The presence of these indicators could be noted in the physical survey on a scale of zero to three as: absent (0), slight (1), moderate (2), and pronounced (3).

The low-flow habitat factors estimated by this method should be increased according to the degree of spring influence, as identified in the physical survey, i.e.,

$$F_{sp} = 1.0 - \frac{(1-F)(3-N)}{3} \qquad Eq. 11$$

where F_{sp} = the low flow habitat factor, modified for spring influence,

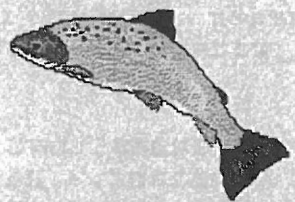
F = the previously calculated low flow habitat factor, and

N = the degree of indicators of spring influence identified during the physical survey.

Thus, where the indicators are identified as pronounced, the habitat factors will be 1.0; where no spring-fed indicators are evident the habitat factors will be as previously calculated.

Several other possibilities exist for the improvement of the estimates yielded by this method. For example, the regional low-flow constants (C) could be improved by subdividing the regions, by the inclusion of a larger number of stream gages, and by considering climatic and watershed factors such as precipitation and elevation.

Additionally, this method assumes that the resistance offered to flow by the streambed is constant. Resistance is represented by the roughness factor, n, in Manning's equation. Manning's n becomes highly variable when the average substrate particle is more than 10% of flow depth. The Manning's n assumed for this analysis (i.e., 0.1) would occur throughout a range of depths and substrate textures, for instance, at an average depth of 1 foot and an average particle size (by weight) of 6.2 inches, at an average depth of 8 inches and an average particle size of 4.5 inches, and at an average depth of 4 inches and an average particle size of 2.5 inches. The effect of assuming this constant value for Manning's n is that the low-flow surface areas of streams with fine-textured, smooth substrates may be overestimated. Thus, the hydraulic calculations could be refined by varying the roughness factor according to the substrate texture and the Q_{60}.



APPENDIX G
BARRIER CORRECTION

WAC 220-110-070
WATER CROSSING STRUCTURES

WAC 220-110-070 Water crossing structures. In fish bearing waters, bridges are preferred as water crossing structures by the department in order to ensure free and unimpeded fish passage for adult and juvenile fishes and preserve spawning and rearing habitat. Pier placement waterward of the ordinary high water line shall be avoided, where practicable. Other structures which may be approved, in descending order of preference, include: Temporary culverts, bottomless arch culverts, arch culverts, and round culverts. Corrugated metal culverts are generally preferred over smooth surfaced culverts. Culvert baffles and downstream control weirs are discouraged except to correct fish passage problems at existing structures.

An HPA is required for construction or structural work associated with any bridge structure waterward of or across the ordinary high water line of state waters. An HPA is also required for bridge painting and other maintenance where there is potential for wastage of paint, sandblasting material, sediments, or bridge parts into the water, or where the work, including equipment operation, occurs waterward of the ordinary high water line. Exemptions/5-year permits will be considered if an applicant submits a plan to adhere to practices that meet or exceed the provisions otherwise required by the department.

Water crossing structure projects shall incorporate mitigation measures as necessary to achieve no-net-loss of productive capacity of fish and shellfish habitat. The following technical provisions shall apply to water crossing structures:

(1) Bridge construction.

(a) Excavation for and placement of the foundation and superstructure shall be outside the ordinary high water line unless the construction site is separated from waters of the state by use of an approved dike, cofferdam, or similar structure.

(b) The bridge structure or stringers shall be placed in a manner to minimize damage to the bed.

(c) Alteration or disturbance of bank or bank vegetation shall be limited to that necessary to construct the project. All disturbed areas shall be revegetated or otherwise protected from erosion, within seven calendar days of completion of the project, using vegetation or other means. The banks shall be revegetated within one year with native or other approved woody species. Vegetative cuttings shall be planted at a maximum interval of three feet (on center), and maintained as necessary for three years to ensure eighty percent survival. Where proposed, planting densities and maintenance requirements for rooted stock will be determined on a site-specific basis. The requirement to plant woody vegetation may be waived for areas where the potential for natural revegetation is adequate, or where other engineering or safety factors preclude them.

(d) Removal of existing or temporary structures shall be accomplished so that the structure and associated material does not enter the watercourse.

(e) The bridge shall be constructed, according to the approved design, to pass the 100-year peak flow with consideration of debris likely to be encountered. Exception shall be granted if applicant provides hydrologic or other information that supports alternative design criteria.

(f) Wastewater from project activities and water removed from within the work area shall be routed to an area landward of the ordinary high water line to allow removal of fine sediment and other contaminants prior to being discharged to state waters.

(g) Structures containing concrete shall be sufficiently cured prior to contact with water to avoid leaching.

(h) Abutments, piers, piling, sills, approach fills, etc., shall not constrict the flow so as to cause any appreciable increase (not to exceed .2 feet) in backwater elevation (calculated at the 100-year flood) or channel wide scour and shall be aligned to cause the least effect on the hydraulics of the watercourse.

(i) Riprap materials used for structure protection shall be angular rock and the placement shall be installed according to an approved design to withstand the 100-year peak flow.

(2) Temporary culvert installation.

The allowable placement of temporary culverts and time limitations shall be determined by the department, based on the specific fish resources of concern at the proposed location of the culvert.

(a) Where fish passage is a concern, temporary culverts shall be installed according to an approved design to provide adequate fish passage. In these cases, the temporary culvert installation shall meet the fi passage design criteria in Table 1 in subsection (3) of this section.

(b) Where culverts are left in place during the period of September 30 to June 15, the culvert shall be designed to maintain structural integrity to the 100-year peak flow with consideration of the debris loading likely to be encountered.

(c) Where culverts are left in place during the period June 16 to September 30, the culvert shall be designed to maintain structural integrity at a peak flow expected to occur once in 100 years during the season of installation.

(d) Disturbance of the bed and banks shall be limited to that necessary to place the culvert and any required channel modification associated with it. Affected bed and bank areas outside the culvert shall be restored to preproject condition following installation of the culvert.

(e) The culvert shall be installed in the dry, or in isolation from stream flow by the installation of a bypass flume or culvert, or by pumping the stream flow around the work area. Exception may be granted if siltation or turbidity is reduced by installing the culvert in the flowing stream. The bypass reach shall be limited to the minimum distance necessary to complete the project. Fish stranded in the bypass reach shall be safely removed to the flowing stream.

(f) Wastewater, from project activities and dewatering, shall be routed to an area outside the ordinary high water line to allow removal of fine sediment and other contaminants prior to being discharged to state waters.

(g) Imported fill which will remain in the stream after culvert removal shall consist of clean rounded gravel ranging in size from one-quarter to three inches in diameter. The use of angular rock may be approved from June 16 to September 30, where rounded rock is unavailable. Angular rock shall be removed from the watercourse and the site restored to preproject conditions upon removal of the temporary culvert.

(h) The culvert and fill shall be removed, and the disturbed bed and bank areas shall be reshaped to preproject configuration. All disturbed areas shall be protected from erosion, within seven days of completion of the project, using vegetation or other means. The banks shall be revegetated within one year with native or other approved woody species. Vegetative cuttings shall be planted at a maximum interval of three feet (on center), and maintained as necessary for three years to ensure eighty percent survival. Where proposed, planting densities and maintenance requirements for rooted stock will be determined on a site-specific basis. The requirement to plant woody vegetation may be waived for areas where the potential for natural revegetation is adequate, or where other engineering or safety factors need to be considered.

(i) The temporary culvert shall be removed and the approaches shall be blocked to vehicular traffic prior to the expiration of the HPA.

(j) Temporary culverts may not be left in place for more than two years from the date of issuance of the HPA.

(3) Permanent culvert installation.

(a) In fish bearing waters or waters upstream of a fish passage barrier (which can reasonably be expected to be corrected, and if corrected, fish presence would be reestablished), culverts shall be designed and installed so as not to impede fish passage. Culverts shall only be approved for installation in spawning areas where full replacement of impacted habitat is provided by the applicant.

(b) To facilitate fish passage, culverts shall be designed to the following standards:

(i) Culverts may be approved for placement in small streams if placed on a flat gradient with the bottom of the culvert placed below the level of the streambed a minimum of twenty percent of the culvert diameter for round culverts, or twenty percent of the vertical rise for elliptical culverts (this depth consideration does not apply within bottomless culverts). Footings of bottomless culverts shall be buried sufficiently deep so they will not become exposed by scour within the culvert. The twenty percent placement below the streambed shall be measured at the culvert outlet. The culvert width at the bed, or footing width, shall be equal to or greater than the average width of the bed of the stream.

(ii) Where culvert placement is not feasible as described in (b)(i) of this subsection, the culvert design shall include the elements in (b)(ii)(A) through (E) of this subsection:

(A) Water depth at any location within culverts as installed and without a natural bed shall not be less than that identified in Table 1. The low flow design, to be used to determine the minimum depth of flow in the culvert, is the two-year seven-day low flow discharge for the subject basin or ninety-five percent exceedance flow for migration months of the fish species of concern. Where flow information is unavailable for the drainage in which the project will be conducted, calibrated flows from comparable gauged drainages may be used, or the depth may be determined using the installed no-flow condition.

(B) The high flow design discharge, used to determine maximum velocity in the culvert (see Table 1), is the flow that is not exceeded more than ten percent of the time during the months of adult fish migration. The two-year peak flood flow may be used where stream flow data are unavailable.

(C) The hydraulic drop is the abrupt drop in water surface measured at any point within or at the outlet of a culvert. The maximum hydraulic drop criteria must be satisfied at all flows between the low and high flow design criteria.

(D) The bottom of the culvert shall be placed below the natural channel grade a minimum of twenty percent of the culvert diameter for round culverts, or twenty percent of the vertical rise for elliptical culverts (this depth consideration does not apply within bottomless culverts). The downstream bed elevation, used for hydraulic calculations and culvert placement in relation to bed elevation, shall be taken at a point downstream at least four times the average width of the stream (this point need not exceed twenty-five feet from the downstream end of the culvert). The culvert capacity for flood design flow shall be determined by using the remaining capacity of the culvert.

Table 1
Fish Passage Design Criteria for Culvert Installation

Criteria	Adult Trout >6 in. (150mm)	Adult Pink, Chum Salmon	Adult Chinook, Coho, Sockeye, Steelhead
1. Velocity, Maximum (fps)			
Culvert Length (ft)			
a. 10 - 60	4.0	5.0	6.0
b. 60 - 100	4.0	4.0	5.0
c. 100 - 200	3.0	3.0	4.0
d. >200	2.0	2.0	3.0
2. Flow Depth Minimum (ft)	0.8	0.8	1.0
. Hydraulic Drop, Maximum (ft)	0.8	0.8	1.0

(E) Appropriate statistical or hydraulic methods must be applied for the determination of flows in (b)(ii)(A) and (B) of this subsection. These design flow criteria may be modified for specific proposals as necessary to address unusual fish passage requirements, where other approved methods of empirical analysis are provided, or where the fish passage provisions of other special facilities are approved by the department.

(F) Culvert design shall include consideration of flood capacity for current conditions and future changes likely to be encountered within the stream channel, and debris and bedload passage.

(c) Culverts shall be installed according to an approved design to maintain structural integrity to the 100-year peak flow with consideration of the debris loading likely to be encountered. Exception may be granted if the applicant provides justification for a different level or a design that routes that flow past the culvert without jeopardizing the culvert or associated fill.

(d) Disturbance of the bed and banks shall be limited to that necessary to place the culvert and any required channel modification associated with it. Affected bed and bank areas outside the culvert and associated fill shall be restored to preproject configuration following installation of the culvert, and the banks shall be revegetated within one year with native or other approved woody species. Vegetative cuttings shall be planted at a maximum interval of three feet (on center), and maintained as necessary for three years to ensure eighty percent survival. Where proposed, planting densities and maintenance requirements, for rooted stock will be determined on a site-specific basis. The requirement to plant woody vegetation may be waived for areas where the potential for natural revegetation is adequate, or where other engineering or safety factors preclude them.

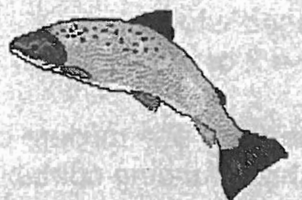
(e) Fill associated with the culvert installation shall be protected from erosion to the 100-year peak flow.

(f) Culverts shall be designed and installed to avoid inlet scouring and shall be designed in a manner to prevent erosion of streambanks downstream of the project.

(g) Where fish passage criteria are required, the culvert facility shall be maintained by the owner(s), such that fish passage design criteria in Table 1 are not exceeded. If the structure becomes a hindrance to fish passage, the owner shall be responsible for obtaining a HPA and providing prompt repair.

(h) The culvert shall be installed in the dry or in isolation from the stream flow by the installation of a bypass flume or culvert, or by pumping the stream flow around the work area. Exception may be granted if siltation or turbidity is reduced by installing the culvert in the flowing stream. The bypass reach shall be limited to the minimum distance necessary to complete the project. Fish stranded in the bypass reach shall be safely removed to the flowing stream.

(i) Wastewater, from project activities and dewatering, shall be routed to an area outside the ordinary high water line to allow removal of fine sediment and other contaminants prior to being discharged to state waters.



APPENDIX H
GRANT PROGRAM PRIORITIZATION

2SSB 5886
FISH PASSAGE
SCORING SYSTEM PROPOSAL

INVENTORY OF FISH PASSAGE BARRIERS (50% of first $1 million + 10% of remaining funds)

A = Estimated number of crossings in area to inventory
B = Estimated number of "depressed" stocks
    1 = none   2 = 1 stock   3 = 2 or more stocks
C = Mobility of stocks
    1 = primarily resident salmonids   2 = mixture of resident and anadromous salmonids
D = Coordinated efforts (partnerships, funding contributions)
    1 = small degree of coordination
    2 = significant coordination
    3 = part of a comprehensive, coordinated plan

PRIORITY = geometric mean of A, B, C, and D

CORRECTION OF BARRIERS (50% of first $1 million + 90% of remaining funds)

PI = Priority Index based on methodology in Thurston County Barrier Culvert Inventory (1997)

"VALUE ADDED" multipliers (1.1 for each multiplier)
- Coordinated effort
- Matching funds ≥ 50%
- Permitting assurances
- Part of comprehensive inventory
- Feasible design and logistics
- Maintenance assurances
- Post project evaluation assurances

NOTE: In the absence of a PI, then supporting information that addresses PI parameters must be provided to allow generation of a PI or a reasonable surrogate.