Willapa River Watershed Temperature Total Maximum Daily Load
(Water Cleanup Plan)

Submittal Report
and
Detailed Implementation Plan

August 2005
Publication Number 05-10-073

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Prepared by

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Water Quality Program

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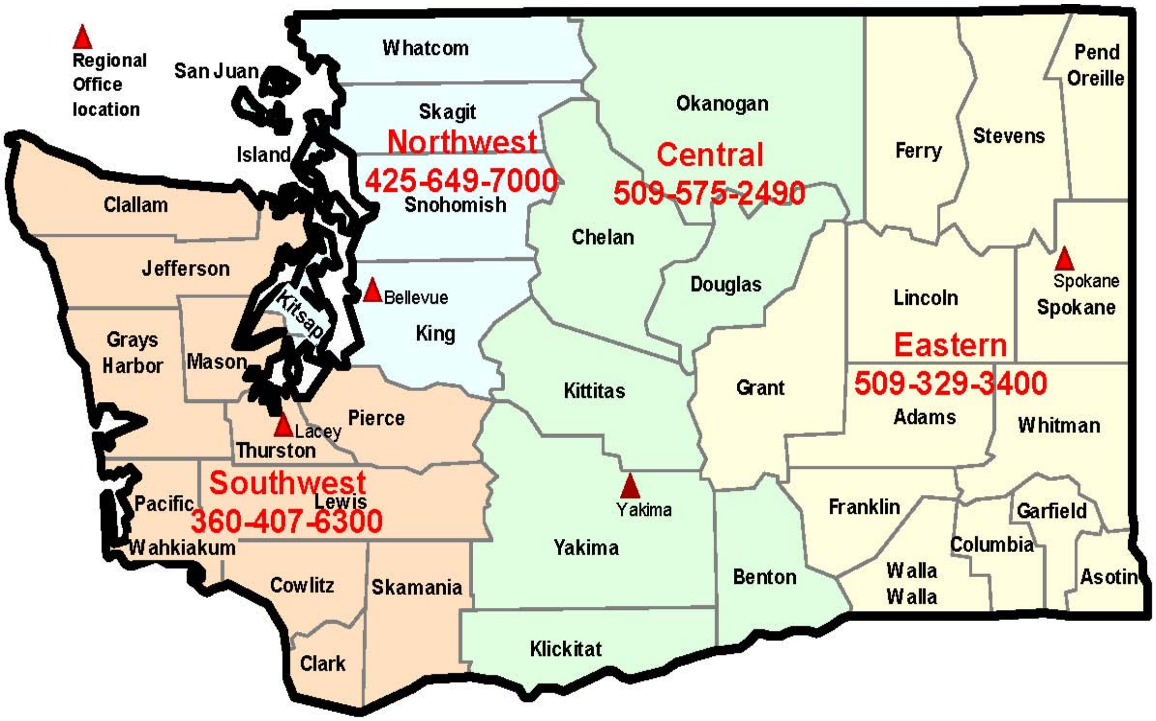

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Acknowledgements

This report incorporates necessary sections of a total maximum daily load (TMDL) submittal report as well as a detailed implementation (Cleanup) plan in order to streamline report completion and transition towards implementing the TMDL.

The original template for this report was provided by Ryan Anderson of Ecology's Central Region Office. This report incorporates some of the formatting, tables, and many relevant sections of "boilerplate language" taken directly from the *Little Klickitat Temperature TMDL Detailed Implementation (Cleanup) Plan* (2004) written by Ryan Anderson.

Thanks to Ryan for his contributions to this document.

Overview of Study and Cleanup Plan

This report summarizes results of a temperature total maximum daily load (TMDL) study conducted by the Washington State Department of Ecology (Ecology) in the Willapa River Watershed, and provides a detailed plan for restoring temperatures to meet state water quality standards. The technical basis for this cleanup plan is detailed in a separate report *Willapa River Watershed Temperature Total Maximum Daily Load Study* (Stohr, 2004). That report provides all the elements necessary for USEPA approval of the TMDLs addressed in this plan. The 2004 TMDL report characterizes water temperature conditions in the basin and recommends load and wasteload allocations (numerical limits) in order for heat sources to meet water quality standards for water temperature. By reference to the technical report elements required for TMDL approval, and by discussing an approach for water quality restoration having reasonable assurance of success, **t**his document serves as both the Submittal Report and Detailed Implementation (Cleanup) Plan for the project.

The Willapa Watershed includes the Willapa River and its tributaries located between the North and Palix Rivers in Pacific County of Washington State. From its headwaters to the mouth at the northeastern part of Willapa Bay, the watershed occupies approximately 384 square miles of public and private land. The lower elevation land along the mainstem and smaller tributaries is owned primarily by small landowners and is in agriculture or rural use. Land in the upper elevations and along the larger tributaries is dominated by private timber or Washington State Department of Natural Resources (DNR) forest land.

Two locations on the Willapa River and five tributary sites are listed on the 1996 and 1998 Washington State 303(d) lists or proposed for placement on the 2002/2004 303(d) list for elevated water temperatures. Fieldwork by Ecology provided data to detail temperature conditions throughout the watershed. Additional fieldwork, studies, surveys and data by others (e.g., USGS, US Army Corps of Engineers, USDA Natural Resources Conservation Service, US Meteorological Service weather data, the Weyerhaeuser Company) were used by Ecology in its technical study.

Temperature concerns in the Willapa watershed are also documented in studies and reports by local resource groups and others. Other studies and reports corroborate concerns about elevated temperatures in the Willapa River: two generations of a *WRIA 24 Salmon Recovery Strategy* (Willapa Bay Water Resources Coordinating Council, 2005); the *Willapa Headwaters Watershed Evaluation* (Weyerhaeuser, 1994); and a Washington State Conservation Commission *Salmon and Steelhead Habitat Limiting factors in the Willapa Basin* (WSCC, 1999) identify concerns about temperatures in the Willapa River system.

Effective shade is used as a surrogate measure of heat flux to fulfill the requirements of the Clean Water Act Section 303(d) for a total maximum daily load (TMDL) for temperature. Effective shade is defined as the fraction of incoming solar shortwave radiation above the vegetation and topography that is blocked from reaching the surface of the stream. The load allocations (goals for shade improvements) for this TMDL can be met through a series of land and water management practices presented in this temperature reduction (cleanup) plan. A range of shade increases, varying according to river location, are needed for the river to meet the state temperature standard of 64°F. The warmest segments (needing a 95 percent shade increase) are in the open mostly unshaded shoreline areas of the upper river mainstem. It could take more than 50 to 100 years to create enough added shade to reach the goals of this plan. However, areas in the uppermost part of the system that have riparian cover and lower temperatures are bound to recover more quickly.

Only one facility, the Forks Creek fish hatchery, affects temperatures in the upper Willapa River. The hatchery managers are determined to adapt the facility in order to comply with a wasteload allocation (maximum allowable heat discharge) set by this TMDL.

Ecology asked for input from primary affected interests in completing the temperature study plan, and later presented the TMDL study results and recommendations for cleanup strategies during five different community meetings. People were also invited to help write the required cleanup plan for water quality restoration. A local newspaper article announced the final public workshop, and Pacific County utilized a local mailing list of 300 addresses to invite citizens to attend. Only 25 local people showed up. From the public involvement efforts there is evidence that some landowners, notably several vocal residents in the upper watershed, are opposed to the TMDL study findings and recommendations from the Department of Ecology.

Another (larger) contingent responded with ambivalence toward the TMDL, yet there are growing numbers of people who have contacted the Conservation District for help in implementing the *BMP*s suggested in the TMDL. Immediately following the last public workshop where about seven of the twenty-five local attendees spoke against the TMDL, three other attendees asked how they could get help to implement *BMP*s on their own property. The restoration goals and strategies recommended in the TMDL align with other resource plans developed by other groups for the Willapa watershed. Those plans have broad local involvement and support. The people who have vocally opposed the TMDL mostly stated their opposition was due to Ecology's role in it. Many locals strongly object to Ecology's regulatory role and a perceived fear of regulation by the agency.

However, the *desired outcomes* of the TMDL and other restoration plans are expected to occur, as long as landowners are willing to implement *BMPs* and as long as financial assistance is available.

Progress towards goals will be measured by monitoring the rate of implementation of activities presented in this cleanup plan and by monitoring stream temperatures in the watershed.

In 1998 the Washington State Department of Ecology (Ecology) began an assessment of the 1996 and 1998 303(d) listings for temperature in the Willapa River. The listed segments are shown on Table 1. As a result of these listings a decision was made to complete a TMDL for temperature in the Willapa River. In 1998 a field study was performed. This study, *Willapa River Total Maximum Daily Load Study Data Summary Report* (Pickett, 2000) provided an overview of water quality conditions throughout the watershed. A focused follow-up investigation of temperature conditions also occurred during 2000 and 2001. The purpose of the investigation was to determine the conditions causing heat loading to surface waters in the Willapa River Watershed during the warmest weeks of the year (called the critical period).

The focused study area included all major tributaries to the Willapa River upstream of tidal influence (Figure 1). This 220 square mile area includes the South Fork Willapa River, the Wilson and Ward Creek drainages, and the Willapa mainstem upstream of the United States Geologic Services (USGS) gage near Camp One Rd. (RM 14.5).

Ecology used models and other information to calculate potential effective shade that could be provided by vegetation improvements and existing topography. Then, modeling predicted what effects would result on stream temperature achieving such potential effective shade conditions.

The study also analyzed the effect on temperature caused by the Washington State Department of Fish and Wildlife Fork Creek hatchery on Fork Creek.

The study showed there were stream segments that did not meet temperature standards, though the segments were not named on the 1996 or 1998 303(d) list. These segments are included in Table 2 as unlisted but impaired. This cleanup plan also provides direction to restore stream temperatures throughout the Willapa River Watershed.

The results of the investigation were published in a technical report titled *Willapa River Watershed Temperature TMDL* (Stohr, 2004). The report title page appears as Appendix E in this plan, and is also posted on the World Wide Web at **http://www/ecy/wa/gov/biblio/0403022.html**. The technical report discussed conditions in the watershed that affect stream temperature. Ecology predicted what stream temperatures could be if riparian area vegetation were restored. Existing vegetation and topography accounted for existing effective shade levels used in the study.

The technical report showed that only a very few sites in the uppermost parts of the watershed have enough shade to allow the river to meet the state water temperature standard of 18^{o}C (about 64^{o}Fahrenheit). Changes in land use practices during the last 100 to 150 years are believed to have disrupted the natural processes and hydrology including temperatures of the river and tributaries. Timber harvest practices, land clearing for settlement and agriculture, livestock grazing, and residential development are some activities that have altered the landscape leaving fewer shoreline trees and shade. Shade must be increased by as much as 95 percent depending on the river location in order for the river to achieve a maximum temperature of 64^{o}F. With the shade increases recommended, temperatures should decrease from 3 to 10^{o}F during the warmest time of the year (critical period), depending on the river location. It could take more than 100 years before new trees can fully correct water temperatures throughout the watershed. Areas in the uppermost part of the system that have riparian cover and lower temperatures are bound to recover more quickly than the 100 year estimate.

Table 1. Conversion Table Between degrees C (Celsius) and degrees F (Fahrenheit)

Degrees C	Degrees F
0	32
5	41
10	50
12	53.6
15	59
17	62.6
19	66.2
21	69.8
23	73.4
25	77
27	80.6
29	84.2
30	86

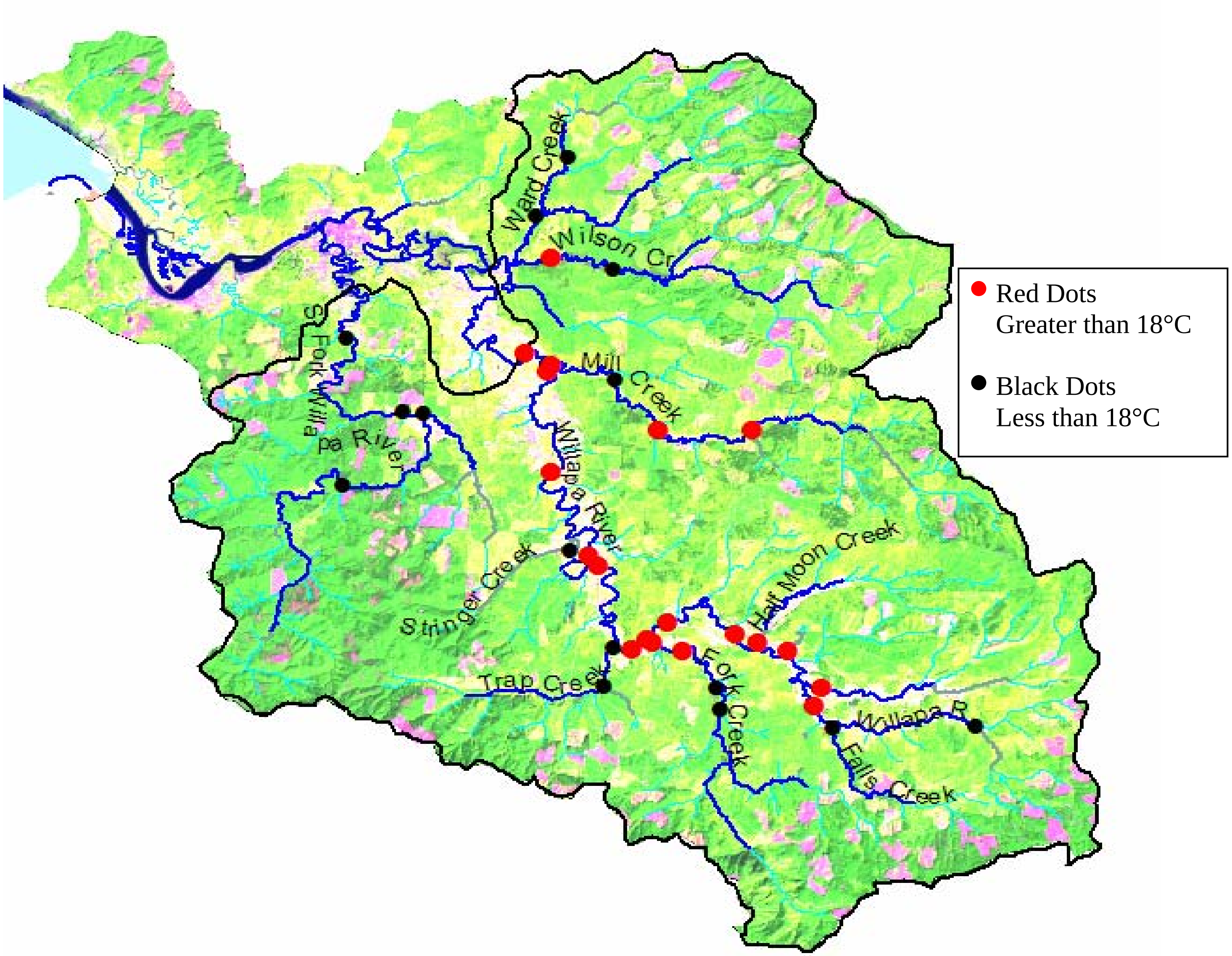

Figure 1. Willapa Watershed Temperature Monitoring Locations

Applicable Water Quality Criteria

The TMDL is designed to address impairments of characteristic uses caused by high temperatures. The characteristic uses designated for protection in Willapa River basin streams are as follows (Chapter 173-201A WAC):

"Characteristic uses. Characteristic uses shall include, but not be limited to, the following:

i. Water supply (domestic, industrial, agricultural).

ii. Stock watering.

iii. Fish and shellfish:

Salmonid migration, rearing, spawning, and harvesting.

Other fish migration, rearing, spawning, and harvesting.

Clam and mussel rearing, spawning, and harvesting.

Crayfish rearing, spawning, and harvesting.

iv. Wildlife habitat.

v. Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).

vi. Commerce and navigation."

The state water quality standards describe criteria for temperature for the protection of characteristic uses. Streams in the Willapa River basin are designated as Class A. The temperature criteria for Class A waters are as follows:

> *"Temperature shall not exceed 18.0°C…due to human activities. When natural conditions exceed 18.0°C…, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C."*

Water Quality and Resource Impairments

The 1998 303(d) listings for temperature in the Willapa River watershed (Table 2) are confirmed by data collected by Ecology during 2001. Temperatures higher than the water quality standard of 18°C were observed in 2001 throughout the watershed at numerous locations (Tables 2 and 3). Because the locations where temperature exceeds the water quality standard are spread throughout the watershed, this TMDL was developed to address water temperature in perennial streams in the entire watershed.

Table 2. 1996, 1998, and Proposed 2002/2004 303(d) Listings for Temperature in the Willapa River Watershed

Name	T	R	S	New Waterbody ID	Old Waterbody ID	96 List	98 List	Proposed 2002 List
Fork Creek	*12N*	*7E*	*6*	*MO06ZS*	*WA-24-2037*	*Yes*	*Yes*	*Yes* (Category 5)
Willapa River	*14N*	*08E*	*83*	*YN05JR*	*WA-24-2020*	*Yes*	*Yes*	*Yes* (Category 5)
Willapa River	*12N*	*07E*	*04*	*YN05JR*	*WA-24-2030*	*Yes*	*Yes*	*Yes* (Category 5)
Unlisted but Impaired Locations								
Half Moon Creek	*12N*	*07W*	*04*	*HR47WD*		*No*	*No*	*Yes (*Category5*)*
Mill Creek	*13N*	*08W*	*02*	*WQ10DO*	----	*No*	*No*	*Yes (*Category 2*)*
Fern Creek	*12N*	*07W*	*02*	*CO94AN*	----	*No*	*No*	*Yes (*Category 5*)*
Wilson Creek	*13N*	*08W*	*02*	*RX96AH*	----	*No*	*No*	*Yes (Category 2)*

T, R, and S are an abbreviation for Township, Section, and Range. The table contains the Township, Section, and Range of each water body that is documented as impaired. Class 5 means the "water body is impaired"; Class 2 is a water of concern.

Table 3. Highest daily maximum temperatures in the Willapa River and its tributaries during 2001, sorted in decreasing order of temperature. (Data above the bold line show values greater than the water quality standard of 18°C.)

Station ID (2001)	Station Name	Latitude (decimal degrees NAD27)	Longitude (decimal degrees NAD27)	Highest Daily Maximum Temperatures during 2001 (°C)	Highest 7-day Averages of Daily Maximum Temperatures During 2001 (°C)
2	Willapa R abv Mill Creek	46.6447	-123.6424	23.99	23.08
1	Willapa R at Camp One Road	46.6504	-123.6523	23.45	22.54
4	Willapa R at Oxbow Road	46.5855	-123.6216	22.18	21.19
3	Willapa R at SR 6 nr Menlo	46.6120	-123.6393	22.12	21.32
6	Willapa R at SR 6 nr Holcomb	46.5820	-123.6177	21.77	20.75
8	Willapa R abv Trap Creek	46.5555	-123.6024	20.73	19.87
13	Willapa R abv Half Moon Creek	46.5563	-123.5369	20.69	19.76
10	Willapa abv Fork Ck at Doyle Road	46.5645	-123.5871	19.93	19.29
12	Half Moon Creek near mouth	46.5591	-123.5492	19.84	18.64
11	Willapa R at Lebam	46.5612	-123.5590	19.60	18.67
14	Fern Creek at Elk Prairie Road	46.5449	-123.5219	19.26	18.40
15	Willapa R at Swiss Picnic Campg.	46.5387	-123.5243	19.14	18.23
9	Fork Creek near mouth	46.5585	-123.5957	19.02	18.10
20	Mill Creek at 5th bridge RM 4.7	46.6266	-123.5950	18.81	18.00
18	Mill Creek at 1st bridge RM 0.2	46.6471	-123.6412	18.64	17.95
21	Mill Creek at 7th bridge RM 7.6	46.6278	-123.5559	18.60	17.84
9a	Fork Creek abv State Hatchery	46.5578	-123.5935	18.43	17.65
29	Wilson Creek at 1st Weyco bridge	46.6814	-123.6430	18.33	17.66
9b	**Fork Creek at 1st bridge RM 1.0**	**46.5551**	**-123.5805**	**18.25**	**17.45**
30	Wilson Creek at 3rd Weyco bridge	46.6786	-123.6181	17.91	17.61
9c	Fork Creek RM 3	46.5438	-123.5669	17.58	16.78
27b	Ward Creek blw Fairchild Creek	46.6947	-123.6510	17.46	16.73
19	Mill Creek at 4th bridge RM 2.4	46.6428	-123.6151	17.38	16.81
16	Falls Creek abv Retreat Center	46.5321	-123.5170	17.27	16.54
7	Trap Creek above Hwy 6	46.5558	-123.6104	17.05	16.39
7a	Trap Creek at B-line bridge	46.5433	-123.6143	16.81	16.17
22	South Fork at Golf Course	46.6529	-123.7283	16.80	16.16
27	Ward Creek at Flow Site RM 3.2	46.7145	-123.6392	16.63	16.02
23	South Fork blw Rue at 1999 bridge	46.6296	-123.7035	16.42	15.68
25	Upper South Fork RM 11	46.6052	-123.7270	16.37	15.82
5	Stringer Creek at Highland Road	46.5869	-123.6303	15.94	15.31
9d	Fork Creek at A-400 bridge RM 4	46.5365	-123.5649	15.93	15.39
17	Willapa R below Patton Creek	46.5343	-123.4571	15.75	15.07
24	Rue Creek near mouth	46.6297	-123.6948	15.56	15.04

Seasonal Variation

The federal Clean Water Act Section 303(d)(1) requires that TMDLs "be established at the level necessary to implement the applicable water quality standards with seasonal variations." The current regulation also states that determination of "TMDLs shall take into account critical conditions for streamflow, loading, and water quality parameters" [40 CFR 130.7(c)(1)]. Finally, Section 303(d)(1)(D) also suggests consideration of normal conditions, flows, and dissipative capacity.

Existing conditions for stream temperatures in the Willapa River watershed reflect seasonal variation. Cooler temperatures occur in the winter, while warmer temperatures are observed in the summer. The highest temperatures typically occur from mid-July through mid-August. This timeframe is used as the critical period for development of the TMDL.

Seasonal estimates for streamflow, solar flux, and climatic variables for the TMDL are taken into account to develop critical conditions for the TMDL model. The critical period for evaluation of solar flux and effective shade was assumed to be August 1 because it is the mid-point of the period when water temperatures are typically at their seasonal peak. Critical streamflows for the TMDL were evaluated as the lowest seven-day average flows with a two-year recurrence interval (7Q2) and ten-year recurrence interval (7Q10) for the months of July and August. The 7Q2 streamflow was assumed to represent conditions that would occur during a typical climatic year, and the 7Q10 streamflow was assumed to represent a reasonable worst-case climatic year.

Figure 2 shows the major flow of heat energy across the water surface or streambed of a typical water body. Heat transfers between the water and streambed through conduction and with physical movement of the water.

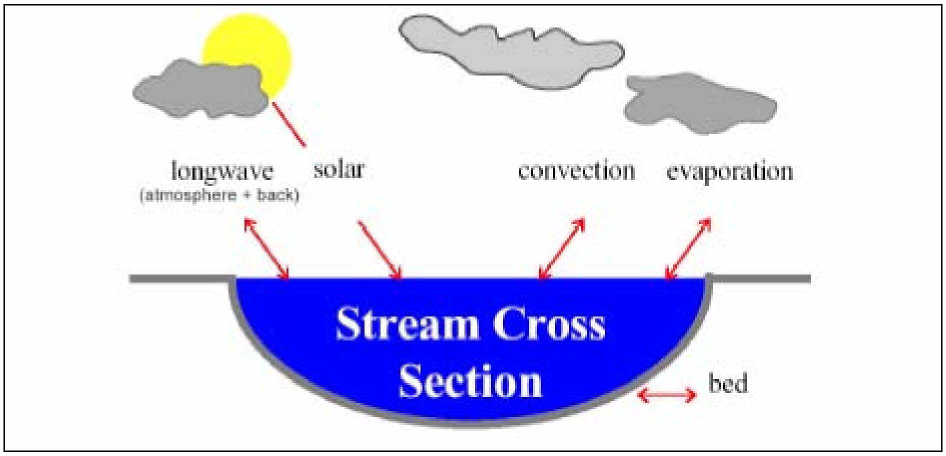

Figure 2. Surface heat exchange processes that affect water temperature

The TMDL Approach

The Clean Water Act mandates the Washington State Department of Ecology to develop total maximum daily load (TMDL) studies for water bodies that fail to meet water quality standards after technology-based water quality controls have been put into place. In 1997, Ecology signed a Memorandum of Agreement with the Environmental Protection Agency (EPA) assuring that TMDLs would be developed for all water bodies on the 1996 303(d) list. Additionally, Ecology agreed to develop submittal reports and detailed implementation plans (DIPs) to obtain EPA approval and to direct the implementation of these TMDLs.

Many existing regulations, agreements, and planning processes potentially affect stream improvements in the state of Washington, Pacific County, and the Willapa River Watershed. Actions taken pursuant to this TMDL report fall into three categories.

1) Voluntary stewardship actions that protect streambanks and increase shade.

2) Actions taken in accordance with a law, legal agreement, or existing planning process such as changes to the Fork Creek hatchery that reduce temperatures coming from the hatchery operations.

3) Activities to monitor restoration efforts and the resulting water quality improvements.

Stewardship activities will be completed as quickly as possible. Education about the benefits of land and water stewardship, coupled with the availability of cost share money, usually accelerates the rate of voluntary stewardship activity. Actions that are taken in accordance with an existing planning process, law, or legal agreement (if applicable) will be completed within the time frame prescribed by the planning document, law, or legal agreement. Complex monitoring programs are not necessary every year, but it is important to document management efforts and the environmental improvements they create.

According to common local knowledge, Willapa River water temperatures historically have been warm since trees were removed from the uplands and streambanks in the 1800s.

Consequently, there have been other planning processes in Pacific County that recommend stream habitat enhancement and protection measures similar to this plan. In fact, before the TMDL was ever thought of, habitat, streambank, and water quality protection programs were underway in Pacific County. The Pacific County Conservation District has been, and will continue to be the primary organization coordinating water quality restoration efforts in the Willapa watershed. The Willapa Bay Water Resources Coordinating Council also has an active advisory role in restoration plans.

The Willapa River Watershed Temperature TMDL and this cleanup plan are not new regulations. Rather, they describe conditions that cause water temperature problems, provide a list of organizations, people, and practices that can protect and enhance water temperatures in the Willapa River Watershed. Some actions related to this TMDL are voluntary, but others may be required by federal, state, county, or city laws. For example, the exclusion of livestock from vegetated stream banks is a voluntary stewardship action prescribed by this plan, but the degradation of water quality, whether by livestock grazing or any other action is not allowed according to state (Washington State Water Pollution Control Act RCW 90.48) and federal laws [Clean Water Act].

This plan pairs general examples of land use practices and best management practices (BMPs) with general land and waterway problems documented in the TMDL. The benefits of the riparian restoration practices recommended by this plan extend beyond temperature improvements. A Washington State Department of Ecology publication, titled *Riparian Restoration a Collection of Landowner's Perspectives* (Baldwin, Mangold, and Snouwaert, 2004), represents landowner viewpoints on the positive outcomes of riparian protection projects similar to the projects suggested by this plan.

The TMDL study generally recommends planting many more trees to create more shade.

Tree height and buffer width of somewhere between 100 feet (50 yrs. old) and 180 feet (100 years old) will actually work in the Willapa environment to cool the river enough to meet water quality standards (Stohr, 2004). Based on the TMDL recommendations for tree planting, it could take more than 100 years for new trees to mature to produce maximum potential effective shade to fully correct water temperatures throughout the watershed. Areas in the uppermost part of the system that have riparian cover and lower temperatures are bound to recover more quickly than the 100 year estimate.

This plan is not intended to foresee enough details to serve as technical guidance for individual restoration projects. It is a *guide* for general restoration activities and monitoring activities related to stream temperature improvements in the watershed. For specific land and stream restoration assistance, Ecology recommends that landowners and managers consult with professional staff from the Pacific County Conservation District, the Natural Resource Conservation Service, or other qualified natural resource professionals.

A long-term monitoring strategy is also a part of the implementation because of the long period of time that it takes for vegetation to establish and mature. The monitoring strategy will not only focus on changes in water temperature, but on changes in land-use techniques that will affect water temperature and the long-term health of the watershed.

Given the long period of time that it takes for vegetation to establish and mature, the monitoring will not only focus on changes in water temperature, but changes in land-use techniques that can affect the long-term health of the watershed as it relates to water temperature. In addition, monitoring is a critical component of this cleanup plan adaptive management strategy. The collection and analysis of information related to the health of the Willapa River Watershed can be used by local land managers and planners to direct activities in a manner that will protect and restore water quality.

Stream temperature improvements often necessitate a holistic look at the entire watershed. Many of the Willapa River characteristics that affect stream temperature can be affected by land and water use activities in the watershed. For example, wells pumping out of sources connected to the hyporheic zone, de-vegetating uplands, erosion from forest-road runoff, and sedimentation of streams can all affect the amount of and timing of flows in the river and tributaries. Many activities can have an effect on the amount of shade available to protect water temperature, as well as the amount of and timing of sediment entering the river. Plant species native to the riparian zone in the Willapa River Watershed are adapted to the natural hydrologic cycle of the area. Restoring an annual hydrograph condition that mimics the hydrograph conditions prior to land manipulation would most likely induce the quickest, most effective restoration of the riparian zone.

Overview of the Technical Analysis and Loading Capacity

The sensitivity of the water to temperature, or the upper limits that will still allow the river to meet water quality standards, is called the "loading capacity." The 2004 technical study used the calibrated QUAL2Kw model to determine loading capacity for streams in the Willapa watershed. A complete description of the loading capacity calculations, analytical framework, and calibration and verification of the modeling is presented in Stohr, 2004 (see Appendix F).

Loading capacity was determined based on prediction of water temperatures under typical and extreme flow and climate conditions combined with a range of effective shade conditions. The lowest seven-day average flow with a two-year recurrence interval (7Q2) was selected to represent a typical climatic year, and the lowest seven-day average flow with a ten-year recurrence interval (7Q10) was selected to represent a reasonable worst-case condition for the July-August period. Air temperature values for the 7Q2 condition were assumed to be represented by the average of the hottest weeks of 1997 and 1985 (Stohr, 2004). The air temperature for the 7Q10 condition was the average of the hottest weeks of 1996 and 1982 (Stohr, 2004).

The following scenarios for effective shade were evaluated for the 7Q2 and 7Q10 flow and climate conditions (Stohr. 2004):

- The effective shade that is produced by the current condition of riparian vegetation.

- Maximum potential effective shade from mature riparian vegetation that would naturally occur in the Willapa River watershed. The maximum potential shade is assumed to be that of a 100-year-old forest condition described in the USDA Soil Survey for Pacific County (USDA, 1986). Mature vegetation was represented by a tree height of 55 meters (about 180 feet), canopy density of 85 percent, and riparian vegetation width of 180 feet on each side of the stream.

- Maximum potential effective shade from mature red alder and 50-year site index conifer that would naturally occur in the Willapa River watershed. The maximum potential shade from vegetation was assumed to be represented by a tree height of 30.5 meters (about 100 feet), canopy density of 85 percent, and riparian vegetation width of 100 feet on each side of the stream.

Additional critical scenarios were evaluated to test the sensitivity of predicted water temperatures to changes in riparian microclimate, decreases in channel width, and reduction of tributary temperatures:

- **Microclimate.** Increases in vegetation height, density, and riparian zone width are expected to reduce air temperature. In order to evaluate the effect of this potential change in microclimate on water temperature, the daily maximum air temperature was reduced by 2°C for reaches modeled with a 100-year-old forest (Stohr, 2004).

The results of the model runs for the critical 7Q2 and 7Q10 conditions are presented in Figures 28 and 29 of the technical report (Stohr, 2004). The current condition in the Willapa watershed is expected to result in daily maximum water temperatures that are greater than 18°C in most of the evaluated reaches. Portions of the evaluated streams could be greater than the approximate threshold for lethality of 23°C under current riparian conditions.

Substantial reductions in water temperature are predicted for hypothetical conditions with mature riparian vegetation, improvements in riparian microclimate, and reduction of channel width. Potential reduced temperatures are predicted to be less than 18°C in most of the evaluated reaches and less than the threshold for lethality of 23°C in all of the streams that were evaluated. Further reductions are likely if all tributaries and channel complexity are restored.

- **Channel width.** Channel banks are expected to stabilize and become more resistant to erosion as the riparian vegetation along the stream matures. It is not expected that a large reduction in channel width will take place in this watershed. Although much of the Willapa River has channel widths that would be considered typical, there are some areas where large amounts of erosion have occurred and stream banks are very wide as seen from the aerial orthophotos. The sensitivity of predicted stream temperatures to reduction of channel width was tested by predicting stream temperatures that would be associated with a range of channel widths (calculated from an equation shown in Figure 15 of the technical report (Stohr, 2004). This simulation keeps most of the channel widths the same as the current channel, but reduces the wide areas where erosion of the banks has taken place.

- **Reduced tributary temperatures.** A scenario was evaluated with the assumption that the inflowing Mill Creek and Fork Creek tributaries did not exceed 18°C. Several tributary locations currently exceed daily maximum water temperatures of 18°C, but water temperatures may be reduced in the future if riparian vegetation is increased and other implementation activities occur.

The results of the model runs for the critical 7Q2 and 7Q10 conditions are presented in Figures 28 and 29 of the technical report (Stohr, 2004). The current condition in the Willapa watershed is expected to result in daily maximum water temperatures that are greater than 18°C in most of the evaluated reaches. Portions of the evaluated streams could be greater than the approximate threshold for lethality of 23°C under current riparian conditions.

Substantial reductions in water temperature are predicted for hypothetical conditions with mature riparian vegetation, improvements in riparian microclimate, and reduction of channel width. Potential reduced temperatures are predicted to be less than 18°C in most of the evaluated reaches and less than the threshold for lethality of 23°C in all of the streams that were evaluated Further reductions are likely if all tributaries and channel complexity are restored.

Pollution Sources Needing Management

Point Sources of Pollution

Hatchery Wasteload Allocations

The only facility in the Willapa River Watershed identified in the TMDL technical study that may affect stream temperature is the Forks Creek fish hatchery (Stohr, 2004).

Wasteload allocations (maximum allowable heat) for the National Pollutant Discharge Elimination System (NPDES) discharge from the hatchery were evaluated. The hatchery diverts water from Forks Creek approximately one mile upstream of the hatchery. The hatchery augments the creek water with well water and from a nearby smaller creek. The hatchery discharges effluent to Forks Creek a short distance upstream from the confluence with the mainstem Willapa River.

The state water quality standards contain the following provision for allowable increases in water temperature when natural conditions are less than 18°C in Class A waters:

"Incremental temperature increases resulting from point source activities shall not, at any time, exceed t=23/(T+5). For purposes hereof "t" represents the maximum permissible temperature increase measured at a mixing zone boundary; and T represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge."

When natural or system potential conditions are greater than 18°C then the following language applies:

"…When natural conditions exceed 18.0°C…, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C."

The flexibility for a 0.3°C increase applies only during the critical period when the study predicted that natural temperatures would exceed the standard of 18° C.

Figure 3 shows the water temperature upstream of the hatchery, the temperature below the hatchery, and the water quality temperature standard if the upstream temperature is used as a surrogate for background conditions. For most of the summer, the difference caused by hatchery effluent is within the water quality standard. There was a four-day period, August 8-12, 2001, when the temperature measured below the hatchery ranged from 0.12 - 0.45ºC warmer than the standard would allow. In general, a hatchery relies on having cold water for its fish.

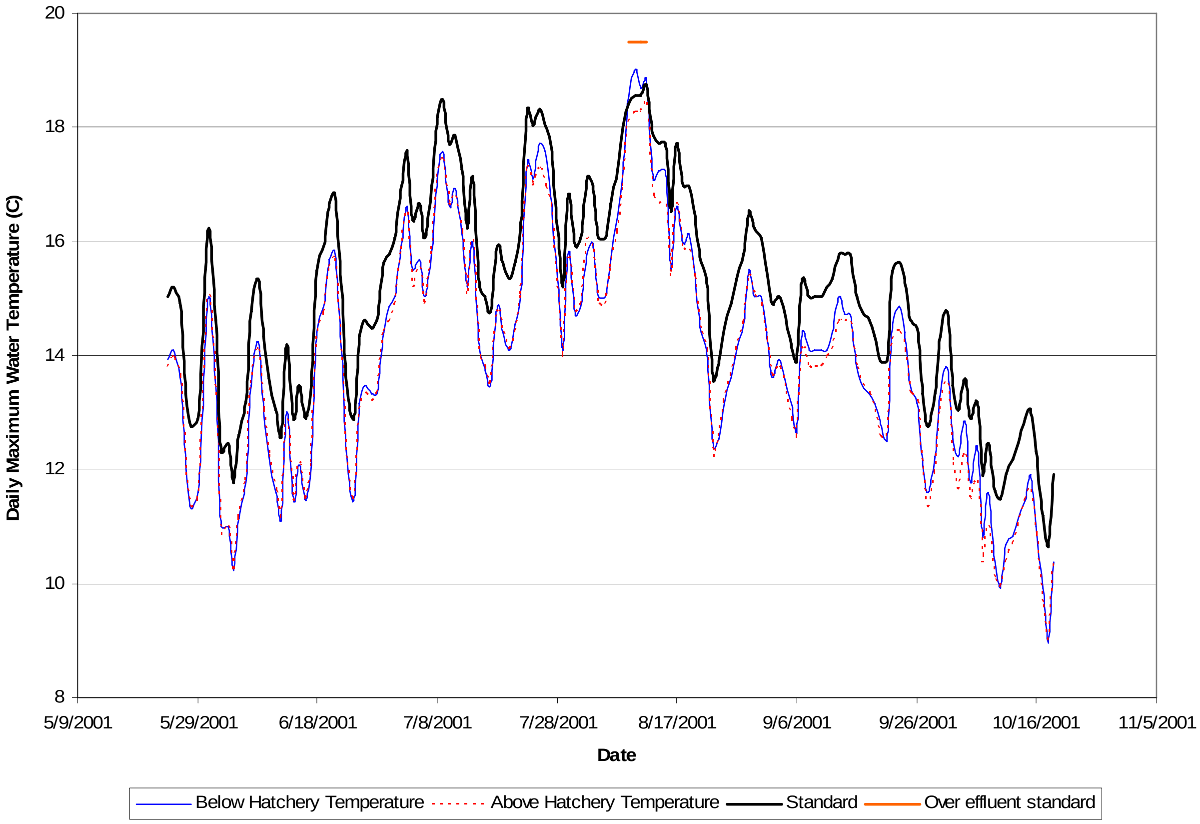

Figure 3. Forks Creek water temperatures immediately upstream and downstream of the hatchery

The federal Clean Water Act requires development of a wasteload allocation for the Forks Creek Fish Hatchery because water quality standards are not being met downstream of the hatchery discharge. The Forks Creek Hatchery does not have a mixing zone or dilution factor, so water quality standards need to be met at the end of the pipe (Greg Cloud, Ecology Southwest Regional Office permit manager, June 9, 2004).

The best estimate of background temperature immediately upstream of the hatchery after nonpoint controls are in place is 17.14°C (Stohr, 2004). To account for any variability in system potential estimates, effluent limits were calculated for a small range of system potential values. Maximum temperatures for NPDES effluent discharges (TNPDES) were calculated from the following mass balance equation for system potential upstream temperatures less than 18°C (Stohr, 2004, Table 10) as follows.

T_{NPDES} = 23/([system potential upstream temperature °C] +5°C) + [system potential upstream temperature°C

Maximum temperatures for NPDES effluent discharges (TNPDES) were calculated from the following mass balance equation for system potential upstream temperatures greater than or equal to 18°C:

T_{NPDES} = [system potential upstream temperature°C] +0.3°C

Table 4. Wasteload allocations for effluent temperature from the Forks Creek

Fish Hatchery NPDES discharge

System potential water temperature upstream of hatchery for 7Q10 critical condition (°C)	7Q10 flow upstream of hatchery	Allowable temperature change at edge of mixing zone (°C)	Allowable effluent temperature (°C)
17.4	**.1045 cms (3.69 cfs)**	**1.04**	**18.18**
18	.1045 cms (3.69 cfs)	0.3	18.3
19	.1045 cms (3.69 cfs)	0.3	19.3

Bold =best estimate of system potential water temperature and allowable effluent temperature for the forks Creek Fish Hatchery

The Hatchery Solution

Washington State Department of Fish and Wildlife have discussed options for reducing the heat caused by hatchery operations and believe the best option at the Forks Creek hatchery is to shade the concrete ponds. Other methods also considered include planting more trees adjacent to the stream and hatchery and supplementing hatchery influent with more (cooler) well water.

Because cold-water conditions are very important to the health of the fishery both inside the hatchery and the river system, the hatchery managers plan to make facility changes by 2008.

The discharge permit for the hatchery will be changed to include the wasteload allocations of this TMDL within one year after EPA approves the TMDL.

Nonpoint Sources of Pollution

Load Allocations for Effective Shade

The Willapa River Watershed Temperature TMDL concluded that the primary cause of elevated water temperatures is lower-than-potential levels of riparian shade. Ecology focused on the condition of effective shade because EPA considers it a reasonable surrogate for heat loading. Effective shade is used as a surrogate measure of heat flux (heating of the river caused by solar radiation) to fulfill the requirements of Section 303(d) for a TMDL. Effective shade is defined as the fraction of incoming solar short wave radiation above the topography and vegetation that is blocked from reaching the surface of the stream. In other words, topography and vegetation that blocks sunlight from reaching the stream create shade. The percentage of sunlight that these components effectively prevent from reaching the stream surface is called percent effective shade.

Effective shade is low in many parts of the Willapa River Watershed for various reasons. Disturbances from activities such as livestock grazing, logging, and road building have affected the amount and type of riparian vegetation along the river system.

Load Allocations

Load allocations for effective shade in the Willapa River watershed are as follows:

- For the mainstem Willapa River from a location approximately one mile above the Doyle Road bridge crossing to the headwaters, the load allocation for effective shade is the maximum potential effective shade that would be produced by naturally occurring 50-year-old riparian vegetation. Fifty-year-old vegetation is estimated to have a height of 100 feet and a density of 85 percent, and result in effective shade values ranging from 67 percent to 96 percent.

- For the mainstem Willapa River from a location approximately one mile above the Doyle Road bridge downstream to the USGS gage near Camp One Road, the load allocation for effective shade is the maximum potential effective shade that would occur from mature riparian vegetation. Mature riparian vegetation is estimated to have a height of 180 feet and a density of 85 percent, and result in effective shade values ranging from 57 percent to 86 percent.

- For all unmodeled perennial streams in the Willapa River watershed with bankfull widths less than 60 feet (18.3 m), the load allocation for effective shade is the maximum potential effective shade that would be produced by naturally occurring 50-year-old riparian vegetation. Fifty-year-old vegetation is estimated to have a height of 100 feet and a density of 85 percent.

- For all unmodeled perennial streams in the Willapa River watershed with bankfull widths greater than 60 feet (18.3 m), the load allocation for effective shade is the maximum potential effective shade that would occur from mature riparian vegetation. Mature riparian vegetation is estimated to have a height of 180 feet and a density of 85 percent.

Load allocations for effective shade are quantified in Appendix C for the modeled reaches of the mainstem Willapa River and Forks Creek.

For other perennial streams in the watershed, the load allocations for effective shade are represented in Figure 4 and Appendix E, based on the estimated relationship between shade, channel width, and stream aspect at the assumed maximum riparian vegetation condition (Stohr, 2004). Appendix E of Stohr, 2004 is included and labeled as Appendix C in this document.

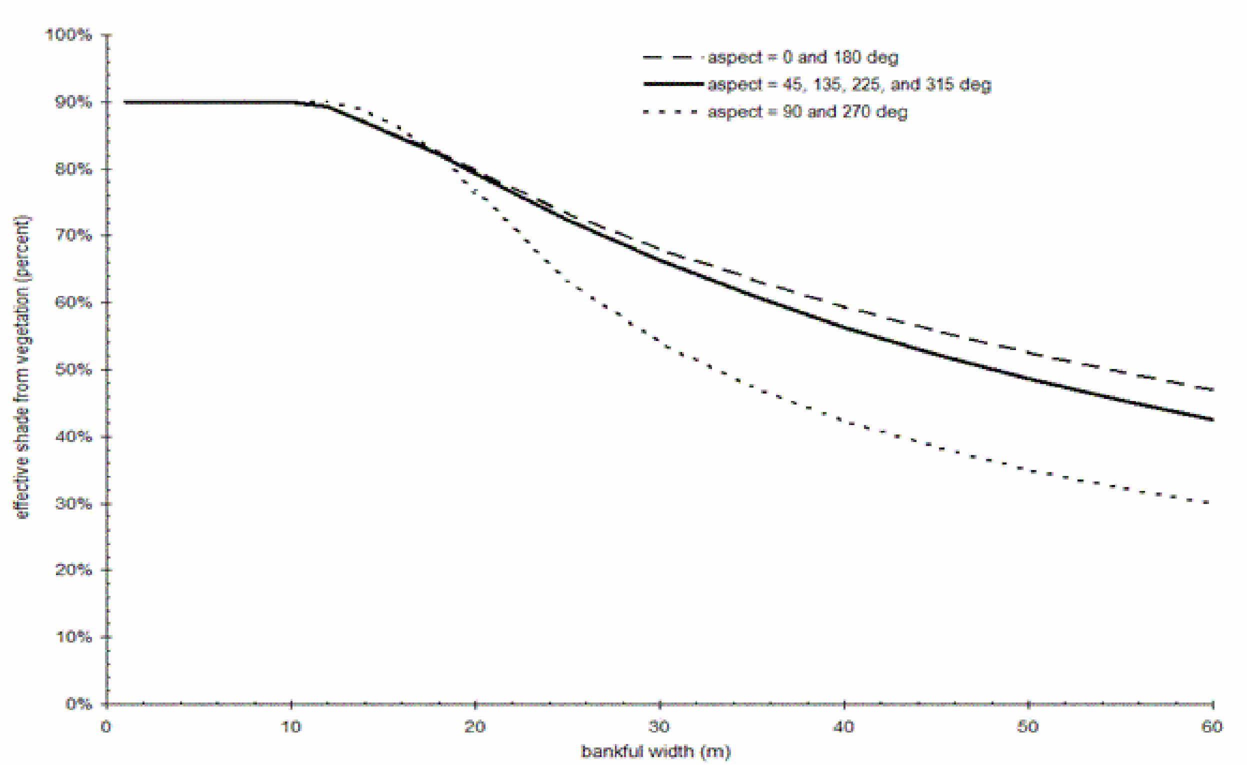

Figure 4. Load allocations for effective shade for various bankfull width and aspect of unmodeled perennial streams in the Willapa River watershed

- The South Fork Willapa River currently maintains cool water and does not exceed state standards. Management activities in this basin should take care to ensure that future activities maintain the existing riparian vegetation and shade levels. Current riparian vegetation and buffers are sufficient to maintain temperatures in this subbasin. Further harvest of existing riparian stands will negatively affect stream temperature.

Margin of Safety

A margin of safety (MOS) was considered while setting the load allocation goals for shade improvements. The MOS accounts for uncertainty about pollutant loading and water body response (Stohr, 2004). For this TMDL, the MOS was addressed by using critical climatic conditions in the modeling analysis. The margin of safety in this TMDL is implicit because of the following:

- The 90th percentile of the highest seven-day averages of daily maximum air temperatures for each year of record at the Raymond weather station represents a reasonable worst-case condition for prediction of water temperatures in the Willapa watershed. Typical conditions were represented by the median of the highest seven-day averages of daily maximum air temperatures for each year of record.

- The lowest seven-day average flows during July-August with recurrence intervals of ten years (7Q10) were used to evaluate reasonable worst-case conditions. Typical conditions were evaluated using the lowest seven-day average flows during July-August with recurrence intervals of two years (7Q2)

- Model uncertainty for prediction of maximum daily water temperature was assessed by estimating the root-mean-square error (RMSE) of model predictions compared with observed temperatures during model validation. The average RMSE for model calibration and verification was 0.5°C.

Responsibilities for Pollution Reduction

This section describes specific agency and public commitments needed to reach water quality standards.

The effects of restoration practices by a few will be compounded by like efforts of others. For example, the success of shade devices at the hatchery will be much more effective if the upstream (hatchery influent) is also cooler. By working collaboratively, the hatchery managers and upstream landowners would most likely lower temperatures at the mouth of Forks Creek more than if the parties only worked apart.

Likewise, greater temperature reductions can be expected in a larger river segment where owners of contiguous land collaborate on shade projects. This might be a factor in future project funding decisions. When choosing funding priorities for different sites, the grantor might consider opportunities to leverage the benefit of adjacent work with a proposed project.

Point Sources

The Forks Creek fish hatchery operators recognize the need for reducing hatchery influence on the water temperatures. They plan to construct or install shade features and possibly other controls by 2008. The hatchery plans to continue operating in a manner that complies with state and federal law. In this case, the operators are responsible for following the conditions set in their discharge permit. Ecology is committed to updating their permit which will include a compliance schedule that directs the hatchery to meet the temperature targets set by this TMDL. Ecology plans to issue an individual facility permit with a temperature discharge limit that matches the wasteload allocation of this TMDL, within one year following EPA approval of this TMDL submittal.

Nonpoint Sources

Effective Shade

Realistically, individual landowners hold the responsibility for implementing this portion of the plan. There are programs available for helping the landowners restore the riparian vegetation on their property.

Landowners need to plant trees for shade. Assistance may be obtained from federal programs like the Conservation Reserve Enhancement Program, the Continuous Conservation Reserve Program, or the Wetlands Reserve Program. In addition, landowners should check in with the Natural Resource Conservation Service (NRCS) and Pacific County Conservation District periodically because these organizations sometimes have funds and assistance available for restoration projects that would help implement this TMDL. Table 4 below lists pollution sources, possible causes, remedies, and people affecting water quality restoration.

The Pacific Conservation District (CD) currently has a grant from the Department of Ecology to help landowners implement best management practices that help implement this TMDL. They have been valuable partners on this project, and it is expected that they will continue to provide valuable implementation actions for this TMDL.

Not all the work of the CD that benefits the TMDL can be accounted for in this report, but several projects installed just during the past three years are expected to help lower river temperatures. The CD has helped install best management practices on five separate properties, improved many miles of shoreline and more than 75 acres by planting trees. The CD is currently utilizing grants from the Conservation Reserve Enhancement Program as well as Department of Ecology's Water Quality Financial Assistance Program. Direct landowners are also investing via their cost-share in the stewardship projects.

Other Actions Besides Shade

In addition to load allocations for effective shade in the study area, the following management activities are recommended for compliance with the water quality standards throughout the watershed:

- For privately-owned forest land, the riparian vegetation prescriptions in the Forests and Fish Report are recommended for all perennial streams. Load allocations are included in this TMDL for forest lands in the Willapa River watershed in accordance with the section of the Forests and Fish Report entitled "TMDLs produced prior to 2009 in mixed use watersheds."

- For areas that are not managed in accordance with either the Forest Plan or the Forest and Fish Report (such as private non-forest areas), voluntary programs to increase riparian vegetation should be developed (for example, riparian buffers or conservation easements sponsored under the U.S. Department of Agriculture Natural Resources Conservation Service's Conservation Reserve Enhancement Program.)

- Instream flows and water withdrawals are managed through regulatory avenues separate from TMDLs. However, stream temperature is related to the amount of instream flow, and increases in flow generally result in decreases in maximum temperatures.

- Future projects that have the potential to increase groundwater or surface water inflows to streams in the watershed should be encouraged and have the potential to decrease stream temperatures.

- Management activities that would reduce the loading of sediment to the surface waters from upland areas and channel erosion are also recommended.

- Hyporheic exchange flows and groundwater discharges are important to maintain the current temperature regime and reduce maximum daily instream temperatures. Factors that influence hyporheic exchange flow include the vertical hydraulic gradient between surface and subsurface waters as well as the hydraulic conductivity of the streambed sediments. Activities that reduce the hydraulic conductivity of streambed sediments could increase stream temperatures. Management activities should reduce upland and channel erosion and avoid sedimentation of fine materials in the stream substrate.

Management activities that increase the amount of large woody debris in the Willapa River system will assist in pool forming processes and will help to reduce flow velocities that wash out spawning gravels and contribute to channel downcutting.

Table 5. Pollution sources with possible explanations, possible causes, possible remedies, and parties responsible for restoration work

Pollution Source	Explanation	Possible Causes	Possible Remedies	Possible Stewards
Low stream-side shade	Too few mature trees or brush near thalweg of river allows more solar heating of river water	Erosion in riparian areas slows growth of new trees, and allows non-native species to displace native plants	Protect riparian area from un-natural disturbances Where possible, make changes upstream to stabilize hydrograph (improve absorption of soils in forested areas; increasing vegetation and changing forest management practices to reduce soil compaction can help here)	Landowners, Natural Resource Agencies, (Pacific CD, NRCS, WBWRCC) Private Timber Companies, Highway managers
		Grazing of cattle along riverbank for long periods may deter growth of new trees, especially in areas where mature trees were removed from the riparian zone for one reason or the other	Control access of livestock to the riparian area via fencing or controlled crossings	Landowners Cattle Managers Resource Agencies
		Historic timber practices and farming practices cleared vegetation out of riparian zone	Increase riparian area plantings, large timberland tract management should Follow Forest and Fish Agreement Rules and monitor effectiveness of riparian restoration	Landowners Private Timber Companies Resource Agencies
			Take advantage of federal and state programs that promote riparian area conservation	Landowners, Resource Agencies
Increased channel width: depth ratio	River and tributaries wider and shallower than they would be in ideal conditions	Sediment deposition and movement causes river to be shallower and wider	Reduce sediment erosion from uplands	Landowners Private Timber Companies Highway Managers
	Shallow rivers in summer experience accelerated heating		Improve maintenance of earthen roads	Landowners, Private Timber Companies

Pollution Source	Explanation	Possible Causes	Possible Remedies	Possible Stewards
	Widening of channel causes remaining trees to be farther from shade, thus reducing shade ability to be effective		Reduce sediment from overland runoff of logged and grazed areas Reduce sediment from other sources such as construction sites, stormwater run-off, and cropland run-off	Landowners Timber Companies Highway Managers
Low summer instream flows	Low flow levels during the hottest time of the year result in more rapid heating of water	Changed hydrograph	Restore watershed features that retain moisture in the upper portions of watershed throughout the year For example: Wetlands and naturally occurring ponds Treed hill slopes with vegetated soil generally retain more moisture than un-vegetated slopes, increase absorption by reducing upland soil compaction	Landowners Timber Companies Resource Management Agencies
		Loss of stream connectivity with hyporheic zone due to channel straightening or sediment input	Increase streams' connection to hyporheic zone	Resource Management Agencies
Bank Stability	Some stream banks in an effort to protect public or private property may be armored with rip-rap or other material	Bank armoring can create bed scour and erosion of other banks by displacing stream energy to areas it should not be	Replace antiquated bank stabilization structures with river/neighbor friendly bank protection methods	Resource Agencies Highway Managers Landowners
			Reduce stream energy by increasing natural storage of the watershed such as is suggested under low summer time flow area of table	All the above
		Uncontrolled livestock access to streams can de-vegetate and destabilize stream banks	Use BMPs to prevent livestock from damaging stream banks	Landowners

Management Activities, Roles, and Schedules

Activities

As stated previously, actions taken pursuant to this TMDL fall into three categories: voluntary stewardship actions, actions that are taken in accordance with a law or legal agreement, and monitoring activities. Activities that are, or could be, contributing towards achieving the goals of this TMDL are identified in Table 5.

Stewardship Activities

- These are the activities that are undertaken to help improve overall stream health and lower stream temperatures during the critical period.
- Plant native riparian vegetation near streams. Consult with conservation district staff or other experts to determine what native riparian zone vegetation is best for the land.
- Fence livestock away from as much of the riparian zone as possible, or use grazing and watering methods that minimize livestock contact with surface and ground water. Consult with conservation district staff, NRCS staff or Washington State University Cooperative Extension grazing experts for help with this.
- Locate roads away from the riparian zones.
- Convert irrigation systems to more efficient systems wherever practical.
- Allow woody debris to stabilize streambeds and stream banks as possible, practical, and as would naturally occur.
- Re-vegetate, and where appropriate re-shape, stream banks.
- Develop farm plans that address temperature as part of their water quality component.
- When possible, use reduced-till or lower-impact farming and livestock grazing practices that reduce runoff rates during rapid snowmelt and rain runoff. Not only does this protect cropland soils, but also by creating a more natural runoff rate, it keeps stream banks stable and minimizes flood damage in the near stream disturbance zone.
- Provide off channel water sources for livestock.
- Close non-essential roads near streams.

Actions that are taken in accordance with a law or legal agreement

These actions can include but are not limited to:

- Compliance with Forests and Fish rules, for forest managers on private lands.
- Elimination of illegal water diversions if there are any.
- Protection of existing riparian vegetation (especially trees).
- Prevention of entry of sediment into the river, where sediment laden water results from other activities.
- Installing temperature controls to meet NPDES permit limits at the hatchery (e.g., shading of holding ponds).

Monitoring

Principally, the Department of Ecology and possibly others like the Pacific Conservation District or Pacific County government as funding allows, will conduct most of the monitoring related to the TMDL. Monitoring is discussed in further detail later in the document.

Table 6. Management roles, activities, and schedules

Entity	Responsibilities to be met	Year									Beyond 10 Years
		1	2	3	4	5	6	7	8	9	
CMER	Monitoring of Forests and Fish rules in support of adaptive management	X	X	X	X	X	X	X	X	X	X
DNR	Administration and enforcement of Forests and Fish rules	X	X	X	X	X	X	X	X	X	X
Homeowners with riverfront property	Avoid actions that will cause stream bank destabilization or erosion, or will otherwise add sediment to area waterways or decrease shading of the riparian area	X	X	X	X	X	X	X	X	X	X
Irrigators and irrigation entities (districts and companies)	Implement BMPs to conserve water and provide in stream flow	X	X	X	X	X	X	X	X	X	X
PCCD, NRCS and Ecology	Continue to fund agricultural BMP implementation	X	X	X	X	X	X	X	X	X	X
PCCD, NRCS	Extend outreach efforts and technical assistance to all agricultural producers (irrigators, livestock managers, others) in the watershed	X	X	X	X	X	X	X	X	X	X
Pacific County CD	Continue to monitor water quality of the watershed's surface waters	X	X	X	X	X	X	X	X	X	X
Pacific County Government	Administration of Critical Area Ordinances and Shoreline Master Programs	X	X	X	X	X	X	X	X	X	X
Private and state timber owners	Implement forest management practices as required by Forests and Fish rules	X	X	X	X	X	X	X	X	X	X
Livestock Managers	Implement livestock management BMPs to prevent stream bank de-vegetation and erosion	X	X	X	X	X	X	X	X	X	X
Forks Creek	Design and install features that		design	install							

Entity	Responsibilities to be met	Year									Beyond 10 Years
		1	2	3	4	5	6	7	8	9	
Hatchery	create shade at the hatchery										
Dept. of Ecology	Implement RCW 90.48 (Water Pollution Control Act), issue changed hatchery discharge permit, coordinate monitoring of improvements, coordinate adaptive management by all entities	X	X	X	X	X	X	X	X	X	X

Measuring Progress toward Goals

Monitoring

It could take more than 50 to 100 years to create enough added shade to reach the goals of this plan. Areas in the uppermost part of the system that have riparian cover and lower temperatures are bound to recover more quickly, however.

Ecology will hold responsibility to determine when temperatures meet water quality standards. Interim monitoring responsibilities may be taken up by other organizations such as the Pacific CD or County Government. Currently the Department. of Ecology ambient monitoring program monitors one site near the USGS flow gage at Camp One Road. They expect to add at least one other location upstream in 2005. Monitoring includes water temperature monitoring, but it can also include riparian shade monitoring, flow monitoring, tracking the length of riparian zone restored, and tracking other implementation activities.

The technical study (Stohr, 2004) also recommends ongoing monitoring to include:

> Continuously-recording water temperature monitors should be deployed from July through September to capture the critical conditions. The following locations are suggested for a minimal sampling program:
>
> - Willapa River at Camp One Road (site of USGS flow station)
> - Fork Creek above the hatchery
> - Willapa River near Oxbow
> - Willapa River at Lebam or at Swiss Picnic Campground
> - South Fork Willapa near drinking water withdrawal
>
> Mature riparian vegetation requires many years to become established. Interim monitoring of summer water temperatures is recommended, such as at five-year intervals. Interim monitoring of the composition and extent of riparian vegetation is also recommended (e.g., by using photogrammetry or remote sensing methods.) Measurement of effective shade at the stream center in various segments, for comparison with the load allocations, could be done using hemispherical photography, angular canopy densiometers, solar pathfinder instruments, or the more-common spherical densitometers. Monitoring implementation activities by keeping a record of miles/acres

of stream in restoration will also provide valuable information on riparian restoration progress.

As noted earlier, the implementation goal of this project is to decrease stream temperatures in the Willapa River Watershed by increasing riparian vegetation's contribution to effective shade. Progress toward many of the TMDL goals can be measured using the milestones in Table 7.

Different implementation schedules will be used for different types of activities. Actions that are taken in accordance with a law or legal agreement will be completed within the timeframe prescribed in the law or legal agreement. Riparian stewardship actions will be completed along with monitoring for temperature (water and air). Annual collection of data is ideal for establishing long-term baselines, but at a minimum, effectiveness monitoring should be conducted every five years. Detailed effectiveness monitoring should be collected every ten years. It would be preferable that local advisory and technical resource agencies partner to conduct ongoing monitoring, evaluate results and recommend ways to adapt, if necessary, to maintain temperature reduction trends. The Pacific CD and Willapa Bay Water Resources Coordinating Council are the most likely groups to lead that work.

Ecology is the entity ultimately responsible for determining compliance with targets. Ecology will meet with the Pacific County Conservation District and other involved organizations (such as the Willapa Bay Water Resources Coordinating Council) at least every other year to review current monitoring data and discuss project progress toward targets until goals are met. If this workgroup believes progress towards goals is inadequate, then adaptive management may be considered and employed.

Table 7. Activities and Timelines for Monitoring the Willapa River Watershed Temperature TMDL

Action No.	Description	Measurement Method	Goal	When Monitored
1 Education				
	a. Educational events	Number of education activities and area covered	Educational activities each year	Annually
	b. Create, publish and distribute educational publications regarding river protection and restoration	Amount of material distributed	Every other year	Bi -annually
2 Riparian Vegetation				
	a. Plant new vegetation along stream banks	Total number of plants and miles of riparian zone planted	Plant as much native riparian vegetation as possible	Ongoing
	b. Protect riparian vegetation plantings	Percentage plants that survived	% plant survival first and fifth years	Ongoing
	c. Increased stream shading	Measure compared to baseline established in the technical report	Increased number each time assessed	Every 10 years, or as data available
3 Reduced Stream Temperature				
		Compare stream temperature to baseline*	Data show reduction in stream temperature	At least every 5 to 10 years

*The baseline stream temperature is based on all of the previously collected data spatially and temporally relevant to new data.

Effectiveness Monitoring Plan

Effectiveness monitoring evaluates whether the management activities achieved the desired effect or goal. Success may be measured against baseline conditions, or desired future conditions. This type of monitoring addresses the effectiveness of a particular project against water quality standards or a desired outcome. For example, it would try to answer the question: did trees planted along the stream actually lower the water temperature? This type of monitoring is designed to assess both the specific effects of individual management actions and may help with a review the overall cumulative effect of nonpoint source management programs statewide.

Monitoring is a valuable part of the implementation strategy. It serves to track and evaluate the effectiveness of implementation measures.

Procedure 1: Track Stream Temperature

Stream temperature should be monitored for attainment of standards and the results evaluated at five year intervals and as consistent with timelines established in the state Forest and Fish Rules. Ideally, temperature monitoring with in-stream thermistors and data loggers should occur every five years during the critical period.

Temperature monitoring results should be compared to previous years' monitoring results, state water quality standards, the predicted temperatures under natural conditions presented in the technical report, and to the results of monitoring as described by Procedure 2 below.

Procedure 2: Monitor Physical Parameters Known to Affect Stream Temperatures

Parameters that may be monitored include shade, active channel zone widths, width to depth ratio, sediment (bedload, suspended sediment, and turbidity), air temperature, and flow. Baselines for many of these parameters were determined during the technical study. Surveys should be conducted in at least five to ten-year intervals. Aerial photos may be used to determine completeness over all reaches of concern.

Tracking of natural events that might influence stream temperature over time should also be undertaken. Forest fire effects can definitely affect stream temperatures. Floods can change the channel of the river. All of these things should be tracked. Weather records are kept by the national weather service and can be used as guides for evaluating temperature conditions in the watershed.

Procedure 3: Track Implementation

Implementation of riparian restoration activities and instream flow restoration should also be tracked, as well as implementation of existing regulations.

The conservation district should keep track of projects in the Willapa River Watershed that could result in improved temperature conditions in the watershed. Additionally, Ecology should keep track of projects related to the hatchery and its permit, and stream flow improvements.

Individual projects should be tracked and monitored for their effectiveness of establishing shade, bank stabilization, water conservation, and other possible criteria. In the end, watershed recovery depends on the completion of several finished and sustainable projects.

Cost is another parameter that is important to track as part of implementation. The cost of watershed restoration projects to landowners, local, state, and federal government agencies is worth tracking. The information could be used to evaluate the estimated cost for future water quality protection costs in the watershed, or it could be used by planners in other watersheds.

Adaptive Management

If planned implementation activities are not producing expected results, Ecology or other entities may choose or be mandated to perform additional studies to identify the significant sources of heat input to the river system. If the causes can be determined and the remedies are required by law or legal agreement, then additional implementation measures may be needed. If the causes cannot be determined, or if the causes are found to be naturally occurring, then the TMDL targets may need to be revised. For non-federal forested areas, the agreements in the Forests and Fish Report incorporate adaptive management as needed to meet the allocations in this report. Re-evaluation of this TMDL is anticipated to occur at five to ten-year intervals. If progress toward cooler water temperatures cannot be detected, then the TMDL may be modified as a result.

As mentioned in the monitoring section, natural occurrences of fire and flood can affect hydrology and riparian vegetation. Keeping track of these occurrences is important for assessing the effectiveness of implementation and for setting schedules.

Reasonable Assurances

Current Implementation Efforts

As mentioned before, Ecology believes that the following activities are already supporting this TMDL and add to the assurance that surface water temperatures in the Willapa River Watershed will meet conditions provided by state water quality standards. This assumes that the below described activities are continued and maintained.

Past and ongoing activities by the Pacific County CD, Washington State Department of Fish and Wildlife, NRCS, and landowners that already support the goals of this TMDL. The NRCS promotes and administers the Conservation Reserve Enhancement Program (CREP) and the Continuous Conservation Reserve Program (CCRP). These programs are available to landowners as incentive to protect and enhance riparian zones. Since 2001 the PCCD has helped implement three (Cuttle, Ash, Fern Creek) restoration projects using CREP. In 2001, the Department of Ecology granted the Pacific County Conservation District a Centennial Clean Water Fund Grant to assist with development, outreach, and implementation of this TMDL. They have already conducted valuable monitoring, outreach activities, and sponsored two projects (Turner, Burkhalter) with funds from this grant.

Timber harvesting activities by state and private forest landowners are conducted according to the Forest Practices Rules and the Forest and Fish (F&F) Agreement, which includes provisions for monitoring rule effectiveness and for adaptive management of the rules. Although it is anticipated these rules will result in greater protection of water quality than afforded by previous timber harvesting regulations, there is not yet any information available with which F&F can be evaluated. Long-term monitoring of this TMDL will provide information needed to direct future management of the Forests and Fish Agreement implementation in the Willapa River Watershed as it related to water quality protection.

Ecology’s NPDES program is working with the hatchery to develop a compliance schedule for this TMDL. The hatchery managers are already making plans for facility improvements that will lower temperatures in both the hatchery and receiving water.

Supporting Regulations, Legal Agreements, and Enforcement

Several laws, regulations, legal agreements, and land management plans support the efforts of this DIP by guiding riparian area activities on lands under a variety of property ownership. These include Forest and Fish Rules (covers activities on private and state-owned forested lands); county ordinances; the Shorelines Management Act (covers shorelands within 200 feet of rivers, on non-federal lands); the Washington Water Code (covers water use throughout the basin); and Washington State water quality laws and regulations (covers water quality in all water bodies in the basin). Washington's Water Pollution Control Act (Chapter 90.48 RCW) provides broad authority to issue permits and regulations, and prohibits all discharges of pollutants to water. The act declares that it is the policy of the state to maintain the highest possible standards to ensure the purity of all waters of the state and to require the use of all known, available, and reasonable means to prevent and control water pollution. The act defines waters of the state and pollution, and it authorizes the Department of Ecology to control and prevent pollution, to make and enforce rules, including water quality standards. Compliance with existing laws and legal agreements will preclude enforcement or other legal action by appropriate organizations. Where compliance is not forthcoming, then education, outreach, technical and financial assistance, and procedures described by a Memorandum of Agreement (MOA) between the Washington State Department of Ecology, Washington State Conservation Commission and Pacific County Conservation District will be used to the maximum extent prior to initiating any enforcement actions.

Ecology and the Pacific CD and the Conservation Commission entered into the *Agricultural Compliance Memorandum of Agreement* in 1989. The agreement defines a consistent series of steps that coordinate Ecology's water pollution control responsibilities with the conservation district programs that provide technical assistance to landowners and farm operators. The steps are:

1. Ecology receives an agricultural complaint, then verifies whether the complaint is valid.

2. If a pollution problem is verified, the farm is referred to the local conservation district for assistance. If the problem is an immediate or substantial threat, Ecology requires immediate corrective action.

3. Usually, the farmer, working with the conservation district, has up to six months to develop a farm plan and an additional 18 months to implement the plan.

4. If the farmer chooses not to work cooperatively with Ecology or the conservation district, Ecology will take appropriate action, which may include formal enforcement

Public Involvement

Throughout the TMDL project, the public had various opportunities to comment and to be involved. Ecology invited the affected community to become involved in the development of the study design and quality assurance project plan (QAPP), the Technical Report, and this TMDL Submittal and Detailed Implementation Plan Report. A sample of specific activities includes:

- Request for input to study plan development in April 2001.
- Project status reports at three meetings of the North Pacific County Infrastructure Action Team (NPCIAT).
- Presentation of plans for synoptic flow survey fieldwork during meetings of the NPCIAT and Pacific CD in May 2001.
- Presentation of contractor's report *Aerial Surveys in the Willapa River Basin* at meetings of the NPCIAT and the Pacific CD Board of Supervisors in May 2002.
- Presentation of preliminary study findings to meetings of the Pacific CD and Willapa Bay Water Resources Coordinating Council in Spring and Summer 2004.
- News Release of final study findings circulated for media interest, and report by local newspaper *Willapa Harbor Herald* in September 2004.
- February 5, 2005 Public workshop advertised by the Pacific County government to about 300 households in the area affected by the TMDL. Workshop convened at Lebam school in middle part of upper watershed.

Input from a February 5, 2005 workshop in Lebam helped guide the writing of this report. A summary of the dialog from the final workshop occurs in Appendix B.

During the entire TMDL implementation period, monitoring data and status reports will be available for public review. Periodic updates will be provided to area media and other interested parties.

Funding Opportunities

Inevitably, watershed protection results in costs to landowners in the watershed. There are numerous existing and potential funding sources in the Willapa River Watershed that can ease this burden include the following.

- The Natural Resources Conservation Service often provides cost-share funding to agricultural producers for farm plan implementation and conservation improvements on farms via its Environmental Quality Incentives Program (EQIP) and their Conservation Reserve Enhancement Program (CREP). Additionally, the EQIP program can now fund forest road improvements, giving priority to fish passage improvements.
- The Pacific County Conservation District provides cost-share funding for agricultural improvements.
- Ecology funds water quality facilities and activities through its water quality grants program.

- State Salmon Recovery Funding Board awards funds to help improve habitat and temperature conditions in alignment with this TMDL.

Currently, the Pacific County Conservation District is funding staff and project needs related to this TMDL with a Centennial Clean Water Fund grant.

Potential funding sources include resources offered through the Centennial Clean Water Fund and the state 319 grants and loan program. Additionally, there are other sources of funding available for salmon habitat, salmon restoration efforts and associated projects that support actions that could increase riparian shade and instream flows. The CD and WBWRCC are also implementing parallel projects recommended in other reports, including:

- The WBWRCC's *WRIA 24 Salmon Recovery Strategy* (2003, updated draft 2005) document which corroborates the importance of water quality protection strategies on the Willapa.

- *The Willapa Fisheries Recovery Strategy* (first discussion draft February 1996)

- *Salmon and Steelhead Habitat Limiting Factors in the Willapa Basin (1999)* by the state Conservation Commission initially identified hot temperatures in the Willapa as a risk to fisheries.

The conservation district has applied for other financial support for projects in the Willapa River Watershed. There are many other funding sources available. The Environmental Finance Center at Boise State University sponsors an internet web site that inventories funding sources. It can be found at http://sspa.boisestate.edu/efc.

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USDA, 1986. *USDA Soil Survey for Pacific County*

Washington State Conservation Commission, 1999. *Salmon and Steelhead Habitat Limiting Factors in the Willapa Basin*

Weyerhaeuser, 1994. *Willapa Headwaters Watershed Evaluation*

Willapa Bay Water Resources Coordinating Council, 2005. *WRIA 24 Salmon Recovery Strategy*

Electronic Resources

Boise State Environmental Finance Center http://sspa.boisestate.edu/efc .

Riparian Restoration a Landowners Perspective http://www.ecy.wa.gov/biblio/0410068.html

Willapa River Watershed Temperature Total Maximum Daily Load Study http://www.ecy.wa.gov/biblio/0403024.html

Willapa River Total Maximum Daily Load Study Data Summary Report **http://www.ecy.wa.gov/biblio/0003005.html**

Appendix A
List of Acronyms

303(d) list - List of water bodies that do not meet Washington State water quality standards

BMP - Best management practices

CFS - Cubic feet per second

CMER - Cooperative Monitoring Evaluation and Research Committee

DIP - Detailed Implementation Plan

DNR - Department of Natural Resources

EPA - Environmental Protection Agency

LA - Load allocation (for river and tributaries)

MOA - Memorandum of Agreement

RCW - Revised Code of Washington

NRCS - Natural Resource Conservation Service

PCCD - Pacific County Conservation District

SIS - Summary Implementation Strategy

SRF - State Revolving Fund

TMDL - Total maximum daily load

WBWRCC - Willapa Bay Water Resources Coordinating Council

WLA - Waste load allocation (for Forks Creek Hatchery)

Appendix B
Responsiveness Summary

Summary of Ecology's response to public comments provided during the detailed implementation plan development process

Date
Addressee Name
Address
City/Town

Dear _(participants at February 5, 2005 temperature TMDL workshop)_:

Hello again. Here is the summary we promised to mail you from the water quality workshop held in Lebam on Feb. 5. Thank you for taking the time to attend the meeting and give us your thoughts about temperature conditions in the Willapa River. We appreciate your interest and views.

As we consider what to do next with this temperature total maximum daily load effort (also known as a water cleanup plan), we heard the following statements ***from you and your neighbors***:

- Landowners living along the Willapa River value their property and are good stewards of the land. Many of you plan to, or have already planted trees to stabilize the river bank and create shade. Many want their land to stay in the family and be passed on to future generations.
- Summer temperatures have always been warm as trees were removed along the stream bank in the late 1800s.
- High summer temperatures are due more to the natural hydrology of the river and low flows than to the absence of trees.
- Landowners along the river are having a hard time making a living off their land. Planting trees will take away land needed to make a living.
- If warm temperatures are a problem, why was the river full of salmon last fall?
- If Ecology wants more landowners to plant trees, bring "sacks of money", and pay them for the use of the land.

More of the workshop statements and some answers to questions that people asked Ecology can be found in the enclosed materials. It is clear that many people see no need to reduce temperatures in the river. We believe that existing conditions in the river can be improved. Rather than waiting for temperatures to get worse , early actions, no matter how large or how small, can make a difference in future temperatures. More shade will help the Willapa River.

You should also be aware that Ecology has an obligation to the U.S. Environmental Protection Agency to develop a Summary Implementation Strategy as part of this TMDL effort. Simply stated, this strategy identifies "who should be involved" and "what should to be implemented." While we can independently develop the implementation plan, our preference is to have the participation of local groups and citizens in this effort. Please let me know if you would like to participate.

If you want a deeper answer to some key questions raised at the workshop or want to learn more about the TMDL process, check out the enclosed materials. You can also read the final Willapa River Temperature TMDL study report on the Internet at: http://www.ecy.wa..gov/biblio/0403024. The video shown at the meeting of the infrared flight results can be viewed online at http://www.ecy.wa.gov/apps/watersheds/temperature/index.html.

Thanks again for your input, interest, and help with Willapa River temperature issues.

Sincerely,

Dave Rountry
Water Cleanup Coordinator
Water Quality Program, Southwest Regional Office

Enclosures

Enclosure #1.

SPECIFIC WORKSHOP QUESTIONS DESERVING BETTER EXPLANATION:

Here are some specific questions asked by residents, and more thoughtful answers than what Ecology provided during the February 5 workshop in Lebam.

What do you want us to do?

Local knowledge and experience in the watershed is essential. Ecology wants your suggestions for how to lower river temperatures and improve habitat in ways that make sense to you. Ecology does not have all the answers. We have a few recommendations in the study report. Our top suggestion is to plant more trees in places where it makes sense. Local knowledge and landowner observations should be considered along with the most recent scientific information obtained. Some conditions can't be completely explained by science or sight alone.

Could one row of trees be enough?

One row along the bank could help a lot, but each row planted helps make the stand more resilient to damage from river undercutting or wind. A denser stand of trees will also help create a greater cooling effect. The technical study showed that besides giving more shade to prevent the river from getting warmer, the cooling effect of the recommended plant canopy will lower air temperature under the canopy by about 2 more degrees, which will in turn help lower water temperature further.

Because the natural environment is so complex, the scientific power of the technical study has limits. Instead of stating shade conditions required to meet the state water quality standards, the study suggests *a range* of potential shade conditions that are possible given the specific soil and climate conditions along the river. The unshaded sections are hotter, while some shorelines are well shaded and cooler. The study *generally* recommends that a tree height and buffer width of somewhere between 100 ft. (50 years old) and 180 ft. (100 years old) will actually work to achieve a temperature of about 64 degrees Fahrenheit (equates to maximum state temperature standard of 18 degrees Celsius) in the warmest period of the year. However, a narrower buffer will provide shade and help cool the river – not as much as a wider buffer but every bit helps.

Was the study limited to just a few months of field observations/sampling?

No. The study included water and air temperatures, and flow sampling data from several years. Several studies and reports (1996 to the present) by local workgroups and Pacific County also show temperature problems and low dissolved oxygen levels in the Willapa River which limit the long-term survival of salmon. (Oxygen levels generally increase in colder water so more shade is expected to also improve oxygen levels for fish.)

Were the low summer flows also considered in the technical study and the resulting shade recommendations?

Yes**.** River flows were sampled at five places using continuous measurement devices throughout the study period of May 2001 to October 2001, and flows were also measured approximately monthly at a total of twenty nine more places throughout the study period. We also utilized temperature and flow data collected in 1998. Several years of flow data from the USGS gauge (Old Willapa) were also used in the study.

Isn't the real cause of temperature problems the low flows rather than lack of shade? How well do low flows correlate to the extremes in river temperatures?

Flow and shade are both important. Is one more important than the other? It depends on the river. In the case of the Willapa River, flow is important, but shade is probably more important. On the Willapa, if one could increase the lowest flows by 50 percent, we think that water temperatures would decrease by 3-4°F. However, we think that water temperatures will decrease from 3°F-10°F, depending on location along the river, with more trees. So, in the long run, we think that trees are more important than flow.

The lowest flows during the 2002 field study occurred in September, yet water temperatures were cooler then, compared to higher temperatures in August. Temperatures were actually cooler-than-normal during the period of the aerial infrared imagery part of the study. Due to heavy rains before the flight, flows peaked on August 22 and volumes then were 200 percent higher than a normal year. Yet in many places temperatures were still too high.

The river was full of salmon last season. If there were more fish, what would you do with them?

Of course fish returns vary each year depending on the species, their migration patterns, habitat, ocean survival, harvest, and the many ways humans affect them. Long-term survival of salmon is dependant on protecting them during the worst as well as best of conditions. (We buy insurance to protect ourselves from the worst risks possible even though the risk may be for just one day of the year.)

Many people believe that salmon populations are still way below historic levels when there were canneries at the mouth of the Willapa and when more added-value commerce in the community profited from the salmon resource. The February 1996 Willapa Fisheries Recovery Strategy evaluated local conditions, such as ecological, economic and social factors that are affected by the fisheries resource. Given the general decline of economic conditions believed to result from a loss of timber and fisheries jobs, the 1996 Strategy looked at the benefits that could occur from an increase of fisheries businesses in the community. Could the community be helped by more fish and the chance to use or profit from them? That seems to be the goal of other local salmon recovery workgroups and their plans.

How can you say that landowners won't be forced to plant trees and protect the river? Can you guarantee that the river cleanup plan won't become mandatory?

The answer is "No" to both. We cannot give any guarantee that the river cleanup plan won't be mandatory or that the Washington State Legislature or some other legal action through the federal or state court systems will not direct us to engage in mandatory compliance. Until that time comes however, we are confident that voluntary compliance is the best approach to follow. For the Willapa River, this means that our efforts should be directed toward creating and maintaining an adequate and healthy riparian area, along both sides of the river. Establishing this is critical to the health of the river system.

Our experience with the legislature and/or court system tells us that the best way to avoid formal enforcement is to demonstrate that corrective actions are being implemented and that headway is being made toward meeting the intended purpose and goals. Clearly, there is no comparison between action and in-action. Voluntary efforts are already underway in the watershed and this shows us that residents are interested in helping work on the problem. However, more work needs to be done. Reducing summer river temperatures in the Willapa is dependent upon creating effective shade. We know that this will not happen overnight as it takes trees take time to grown and mature. The quicker this happens, the quicker a reduction of stream temperature during the critical summer period can occur so that current temperature standards can be met.

Appendix C
Load Allocations for Effective Shade for the Willapa River watershed

Table C-1. Load Allocations for effective shade in the mainstem Willapa River

Distance from Patton Creek confluence to upstream segment boundary (Km)	Distance from Patton Creek confluence to downstream segment boundary (Km)	Load allocation for effective shade on August 1 (percent)	Load allocation for daily average shortwave solar radiation on August 1 (W/m2)	Percent effective shade increase required over current conditions	Landmark/ Tributary Name
0	0	96%	13	2.4%	
0.00	0.30	96%	13	0.5%	Patton Creek
0.30	0.61	93%	20	0.0%	
0.61	0.91	94%	18	0.0%	
0.91	1.22	94%	17	9.5%	
1.22	1.52	94%	19	59.3%	
1.52	1.83	94%	18	42.6%	
1.83	2.13	92%	24	75.6%	
2.13	2.44	93%	22	9.8%	
2.44	2.74	93%	22	37.9%	
2.74	3.05	93%	22	65.5%	
3.05	3.35	93%	22	58.4%	
3.35	3.66	92%	24	93.1%	
3.66	3.96	93%	21	33.7%	
3.96	4.27	91%	27	84.7%	
4.27	4.57	92%	25	21.5%	
4.57	4.88	92%	23	35.2%	
4.88	5.18	91%	26	5.1%	
5.18	5.49	91%	26	55.2%	
5.49	5.79	91%	28	95.3%	
5.79	6.10	92%	24	33.6%	
6.10	6.40	91%	28	72.7%	
6.40	6.71	91%	28	66.1%	Falls Creek
6.71	7.01	87%	41	61.7%	
7.01	7.32	86%	43	41.1%	
7.32	7.62	86%	43	0.0%	
7.62	7.92	88%	36	15.9%	
7.92	8.23	87%	40	61.9%	
8.23	8.53	87%	41	54.0%	
8.53	8.84	82%	56	70.0%	
8.84	9.14	82%	54	77.8%	Fern Creek
9.14	9.45	81%	58	55.8%	
9.45	9.75	77%	68	78.0%	
9.75	10.06	82%	56	69.0%	
10.06	10.36	81%	56	55.3%	

Distance from Patton Creek confluence to upstream segment boundary (Km)	Distance from Patton Creek confluence to downstream segment boundary (Km)	Load allocation for effective shade on August 1 (percent)	Load allocation for daily average shortwave solar radiation on August 1 (W/m2)	Percent effective shade increase required over current conditions	Landmark/ Tributary Name
10.36	10.67	81%	59	61.5%	
10.67	10.97	79%	64	48.3%	
10.97	11.28	79%	63	24.6%	
11.28	11.58	77%	68	60.8%	
11.58	11.89	79%	62	26.8%	
11.89	12.19	79%	62	16.8%	
12.19	12.50	80%	60	33.4%	
12.50	12.80	79%	63	62.6%	Half Moon Creek
12.80	13.11	81%	58	6.7%	
13.11	13.41	82%	55	12.4%	
13.41	13.72	76%	72	32.2%	
13.72	14.02	76%	73	66.8%	
14.02	14.33	67%	100	46.4%	
14.33	14.63	67%	99	51.2%	
14.63	14.94	75%	75	18.8%	
14.94	15.24	75%	77	38.1%	
15.24	15.54	74%	77	60.8%	
15.54	15.85	74%	78	63.1%	
15.85	16.15	75%	77	54.0%	
16.15	16.46	74%	79	17.4%	
16.46	16.76	73%	80	33.0%	
16.76	17.07	83%	51	56.1%	
17.07	17.37	78%	66	71.3%	
17.37	17.68	78%	66	70.3%	
17.68	17.98	76%	74	80.5%	
17.98	18.29	76%	74	83.9%	Doyle Road
18.29	18.59	86%	43	39.1%	
18.59	18.90	77%	71	47.5%	
18.90	19.20	77%	69	36.5%	
19.20	19.51	78%	65	34.5%	
19.51	19.81	68%	98	37.4%	Fork Creek
19.81	20.12	78%	67	13.4%	
20.12	20.42	68%	97	46.3%	
20.42	20.73	70%	92	39.9%	Trap Creek
20.73	21.03	67%	99	15.6%	
21.03	21.34	65%	104	75.5%	
21.34	21.64	66%	103	65.5%	
21.64	21.95	67%	101	41.4%	
21.95	22.25	78%	67	33.4%	
22.25	22.56	65%	105	52.9%	
22.56	22.86	67%	101	56.1%	
22.86	23.16	71%	89	40.6%	
23.16	23.47	68%	96	52.3%	
23.47	23.77	76%	73	68.5%	
23.77	24.08	74%	79	43.5%	

Distance from Patton Creek confluence to upstream segment boundary (Km)	Distance from Patton Creek confluence to downstream segment boundary (Km)	Load allocation for effective shade on August 1 (percent)	Load allocation for daily average shortwave solar radiation on August 1 (W/m2)	Percent effective shade increase required over current conditions	Landmark/ Tributary Name
24.08	24.38	76%	74	72.3%	
24.38	24.69	74%	78	80.1%	
24.69	24.99	70%	92	73.4%	
24.99	25.30	78%	65	82.6%	
25.30	25.60	68%	97	86.1%	
25.60	25.91	74%	78	93.8%	
25.91	26.21	57%	131	96.1%	
26.21	26.52	71%	88	81.1%	
26.52	26.82	80%	62	27.8%	
26.82	27.13	77%	69	21.2%	
27.13	27.43	75%	76	28.8%	Oxbow Cr.
27.43	27.74	77%	71	57.9%	
27.74	28.04	73%	81	75.5%	
28.04	28.35	76%	73	76.6%	
28.35	28.65	71%	88	71.3%	
28.65	28.96	74%	79	50.4%	
28.96	29.26	73%	82	42.7%	
29.26	29.57	72%	85	47.1%	
29.57	29.87	73%	80	60.0%	
29.87	30.18	69%	94	67.1%	
30.18	30.48	66%	101	79.7%	
30.48	30.78	67%	98	67.3%	
30.78	31.09	75%	76	54.1%	Stringer Cr.
31.09	31.39	74%	80	60.5%	
31.39	31.70	76%	73	71.9%	
31.70	32.00	68%	97	84.5%	
32.00	32.31	76%	71	66.9%	
32.31	32.61	73%	82	72.9%	
32.61	32.92	68%	97	77.0%	
32.92	33.22	65%	106	80.6%	
33.22	33.53	78%	66	67.2%	
33.53	33.83	69%	93	64.0%	
33.83	34.14	71%	89	58.0%	
34.14	34.44	65%	106	82.3%	
34.44	34.75	73%	80	66.2%	
34.75	35.05	82%	54	64.8%	
35.05	35.36	73%	81	32.0%	
35.36	35.66	72%	85	65.1%	
35.66	35.97	77%	69	78.7%	Rt 6 crossing near Menlo
35.97	36.27	79%	64	41.4%	
36.27	36.58	73%	82	32.7%	
36.58	36.88	70%	92	35.2%	
36.88	37.19	72%	84	25.9%	
37.19	37.49	70%	90	23.9%	

Distance from Patton Creek confluence to upstream segment boundary (Km)	Distance from Patton Creek confluence to downstream segment boundary (Km)	Load allocation for effective shade on August 1 (percent)	Load allocation for daily average shortwave solar radiation on August 1 (W/m2)	Percent effective shade increase required over current conditions	Landmark/ Tributary Name
37.49	37.80	73%	81	60.8%	
37.80	38.10	64%	109	84.4%	
38.10	38.40	66%	102	92.3%	
38.40	38.71	72%	85	88.1%	
38.71	39.01	62%	114	57.4%	
39.01	39.32	66%	104	42.1%	
39.32	39.62	66%	101	95.6%	
39.62	39.93	58%	127	93.0%	
39.93	40.23	64%	110	57.2%	
40.23	40.54	64%	108	94.2%	
40.54	40.84	72%	85	72.0%	
40.84	41.15	65%	104	42.3%	
41.15	41.45	62%	116	89.9%	
41.45	41.76	65%	105	89.5%	Mill Creek
41.76	42.06	65%	107	87.8%	
42.06	42.37	58%	127	85.6%	
42.37	42.67	66%	102	76.2%	
42.67	42.98	62%	116	51.9%	
42.98	43.16	67%	98	40.2%	

The line separating River Miles 16.46 and 16.76 is the point on the mainstem where load allocations change from use of 50 year vegetation to 100 year vegetation.

Table C-2. Load Allocations for effective shade in the Fork Creek tributary to the Willapa River

Distance from boundary condition at A-400 road to upstream segment boundary (Km)	Distance from boundary condition at A-400 road to downstream segment boundary (Km)	Load allocation for effective shade on August 1 (percent)	Load allocation for daily average shortwave solar radiation on August 1 (W/m2)	Percent effective shade increase required over current conditions	Landmark
0	0	85.3%	45	31.1%	A-400 road
0.00	0.30	82.1%	54	23.5%	
0.30	0.61	79.1%	63	15.5%	
0.61	0.91	78.8%	64	14.7%	
0.91	1.22	79.9%	61	15.7%	
1.22	1.52	80.8%	58	5.2%	
1.52	1.83	81.6%	56	2.2%	
1.83	2.13	78.2%	66	17.1%	
2.13	2.44	77.8%	67	11.7%	
2.44	2.74	81.0%	57	21.5%	
2.74	3.05	80.0%	60	18.7%	
3.05	3.35	81.4%	56	21.0%	
3.35	3.66	78.7%	65	15.0%	
3.66	3.96	78.2%	66	21.6%	
3.96	4.27	81.4%	56	56.6%	Hatchery intake and dam
4.27	4.57	75.0%	76	33.6%	
4.57	4.88	78.0%	66	33.2%	
4.88	5.18	78.7%	64	25.1%	
5.18	5.49	76.9%	70	47.2%	
5.49	5.79	73.9%	79	53.0%	
5.79	6.10	75.7%	74	56.8%	Mouth at Km 6.16

Appendix D
Tracking Table for Implementation Activities

Tracking Table 1. Annual Progress This table is designed to track each year's progress of stream restoration along the main stem of the Willapa River. For tracking purposes, the stream has been divided into four reaches (0-10 miles, 10-25 miles, 25-35 miles, and 35-45 miles). The distance protected, enhanced, or restored within each reach should be recorded for each year in tenths of a mile. Each mile of stream has at least two miles of stream bank that could be enhanced, protected, or restored.

	Tenths of Mile Restored on Main Stem of Willapa River			
Year	Tenths of Mile Between River Mile 0 to 10	Tenths of Mile Between River Mile 10 to 25	Tenths of Mile Between River Mile 25 to 35	Tenths of Mile Between River Mile 35 to 45
2001 - 2005				
2006				
2007				
2008				
2009				
2010				
2011				
2012				
2013				
2014				
2015				

Tracking Table 2. Tributaries. This table is designed to track each year's progress of stream restoration along tributaries. The distance protected, enhanced, or restored within each area should be recorded for each year in tenths of a mile. Each mile of stream has at least two miles of stream bank that could be enhanced, protected, or restored.

Tenths of Stream Mile Restored on Tributaries			
	Headwaters Tributaries Enters main stem at 35-45 miles	Middle Tributaries Enters main stem at 10-35 miles	Lower Tributaries Enters main stem at 0-10 miles
2001-2005			
2006			
2007			
2008			
2009			
2010			
2011			
2012			
2013			
2014			
2015			

Below, a narrative description of projects implemented in each year of the TMDL should be provided to explain progress documented in the tables above.

2005

2006

2007

2008

2009

Appendix E
Forks Creek Hatchery Tracking Table

	Activities			
Year	Summer sampling of Effluent by Hatchery	Ecology Issue New Permit	Design Hatchery Controls	Install Hatchery Controls
2006	X	X		
2007	X		X	
2008	X			X
2009	X			
2010	X			

Appendix F
Willapa River Watershed Temperature TMDL Technical Study

by Anita Stohr
Department of Ecology Environmental Assessment Program

September 2004
Publication 04-03-24

The report forms the technical basis for the Willapa Temperature TMDL and is available on the Department of Ecology home page on the World Wide Web at:

http://www.ecy.wa.gov/biblio/0403024.html