Salmon Creek Temperature Total Maximum Daily Load

Water Quality Improvement Report and Implementation Plan

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Cover photo: Salmon Creek looking east from NW 36th Avenue Bridge

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Salmon Creek
Temperature
Total Maximum Daily Load

Water Quality Improvement Report and Implementation Plan

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Abstract

The Washington State Department of Ecology (Ecology) is required, under section 303(d) of the federal Clean Water Act and U.S. Environmental Protection Agency regulations, to develop and implement total maximum daily loads (TMDLs) for impaired waters. A TMDL is a plan to achieve pollution reductions necessary to bring an impaired water body into compliance with state water quality standards.

Monitoring data collected by Clark County in 1998-2002 indicate Salmon Creek does not meet Washington State water quality standards for temperature. These data resulted in the creek's inclusion on the 2004 303(d) list. Subsequent monitoring conducted by the county shows temperature impairments occur throughout the watershed.

This TMDL temperature assessment for the Salmon Creek watershed uses effective shade as a surrogate measure of heat flux to fulfill the requirements of section 303(d) for a temperature TMDL. Effective shade is defined as the fraction of incoming solar short wave radiation that is blocked by vegetation and topography from reaching the surface of the stream. Increasing effective shade will reduce water temperatures. In addition to describing the percentages of effective shade that can be achieved (called load allocations), the technical assessment recommends other management activities for compliance with state water quality standards for temperature.

Using the results of the technical assessment, Ecology worked with local stakeholders to develop an implementation plan that describes what will be done to improve water temperature in the Salmon Creek watershed. The plan explains the roles and authorities of cleanup partners, along with the programs or other means through which these partners will address these water quality issues. The plan prioritizes specific actions to improve water quality and to achieve Washington State water quality standards for temperature.

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Executive Summary

Introduction

Monitoring data collected by Clark County in 1998-2002 indicate Salmon Creek does not meet Washington State water quality criteria for temperature. These data resulted in the creek's inclusion on the 2004 303(d) list. Subsequent monitoring by the county showed temperatures not meeting (above) criteria throughout the watershed. Therefore, the Washington State Department of Ecology (Ecology) initiated a total maximum daily load (TMDL) assessment for the Salmon Creek watershed in late 2008.

What is a total maximum daily load (TMDL)?

The federal Clean Water Act requires that a TMDL be developed for each of the water bodies on the 303(d) list. The 303(d) list is a list of water bodies, which the Clean Water Act requires states to prepare, that do not meet state water quality standards. The TMDL assessment identifies pollution problems in the watershed, and then specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology, with the assistance of local governments, agencies, and the community then develops a plan that describes actions to control the pollution and a monitoring plan to assess the effectiveness of the water quality improvement activities. The water quality improvement report consists of the TMDL assessment and implementation strategy or plan.

Watershed description

The Salmon Creek watershed is located in Clark County in southwestern Washington (Figure ES-1). The basin comprises a significant portion of the Salmon-Washougal Water Resource Inventory Area (WRIA) 28. The upper portions of the watershed are generally forested, while the lower drainage is primarily urban. The city of Vancouver lies just south of lower Salmon Creek, and several small towns lie along the tributaries and central plains of the basin. The middle reaches contain a mixture of small towns, large and small-scale farms, pasture, and homes. The basin is highly urbanized near Vancouver, with many small subbasins heavily developed. These subbasins often experience problems with stormwater runoff, inadequate buffer vegetation, erosion, and sedimentation.

Washington State water quality standards are based on the designated beneficial uses of a water body and the criteria to achieve those uses. For the Salmon Creek watershed, the designated beneficial uses are the aquatic life uses of *core summer salmonid habitat* and *salmonid spawning, rearing, and migration*. Other non-aquatic life uses include *water supply* (domestic; industrial; and agricultural); *stock watering*; *fish and shellfish harvesting*; *wildlife habitat*; *recreation* (primary contact recreation; sport fishing; boating; and aesthetic enjoyment); and *commerce and navigation*.

Figure ES-1. Location of the Salmon Creek watershed.

The goal of this TMDL is to protect the designated uses by developing a plan to bring the watershed into compliance with state water quality standards for temperature.

What needs to be done in this watershed?

Currently there are no individual point pollution source discharges in the Salmon Creek watershed. There are three municipal stormwater general permits, however: a Phase 1 municipal permit for Clark County; a Phase 2 municipal permit for the city of Battle Ground; and a municipal permit for the Washington State Department of Transportation (WSDOT). Any new individual point source discharges would need to meet the seasonal numeric temperature water quality standards as described in Ecology (2010) and all portions of WAC 173-201A.

Load allocations for effective shade are prescribed to address temperature impairments in Salmon Creek and its tributaries. The load allocations are expected to re-establish mature riparian vegetation, eventually providing a functioning riparian zone and resulting in water temperatures equivalent to those that would occur under natural conditions.

Establishing mature riparian vegetation benefits stream temperatures directly through reduced solar radiation, and indirectly though an increase in channel complexity. These allocations will result in temperatures that are equivalent to the temperatures that would occur under natural conditions. At the point in time when mature riparian vegetation has been established, either the stream will have cooled to meet (or be cooler than) the numeric criterion, or the stream will have cooled to its natural temperature, which may be higher than the numeric criterion. In either case, the standard will be met, based on the natural conditions provision of the water quality standards, WAC 173-201A-070(2), which states:

"*Whenever the natural conditions of said waters are of a lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria*."

Determination of the amounts of effective riparian shade needed to restore water quality, called *load allocations*, is based on the estimated relationship between shade, channel width, and stream aspect at the assumed maximum 100-year riparian vegetation condition. For streams with a channel width less than seven meters (20 feet), shorter vegetation of 36.5 meters (119 feet) height, 85% canopy cover, and 3.6 meters (12 feet) overhanging vegetation, corresponding to 50-year vegetation values, provide the required shading. This is because the assumed overhanging vegetation will cover the stream**.**

Management actions that control other influences on stream temperature, such as sediment loading, groundwater inflows, and hyporheic exchange, are also recommended.

- 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. Projects that have the potential to increase ground water inflows to streams in the watershed should be encouraged.
- The hyporheic zone is defined as the region located beneath and adjacent to a streambed, where there is mixing of shallow groundwater and surface water. Hyporheic exchange flows are important to maintain the current temperature regime and reduce maximum daily instream temperatures. Management activities that help maintain hyporheic exchange flows

include (1) reducing upland and channel erosion and (2) avoiding sedimentation of fine materials in the stream substrate.

- Interim monitoring of water temperatures during summer is recommended, perhaps at five-year intervals. Continuously recording water temperature monitors should be deployed from June through October to capture the critical conditions.
- Interim monitoring of the composition and extent of riparian vegetation is also recommended (for example, by using photogrammetry or remote sensing methods, hemispherical photography, densiometers, or solar pathfinder instruments).
- Stormwater temperature monitoring of larger outfalls, especially those outfitted for continuous flow monitoring data, may be used to characterize potential heat risk to the stream and assist with future wasteload allocations, if necessary.

Implementation summary

An active group of stakeholders has been implementing cleanup activities in Salmon Creek since the U.S. Environmental Protection Agency approved a *Salmon Creek Bacteria and Turbidity TMDL* in 2001 (Howard, 2001). Many of the actions identified for the 2001 TMDL, including streambank restoration and riparian planting, will also improve stream temperatures in the watershed.

Stakeholders, including Clark County, Clark Public Utilities, Clark Conservation District, and others have already completed a number of riparian restoration projects and outreach and education activities. These agencies are committed to continuing restoration in the Salmon Creek watershed to achieve water quality standards. In addition, Clark County, the city of Battle Ground, and WSDOT will use best management practices (BMPs) associated with their stormwater permits to reduce the amount of runoff and increase groundwater recharge to minimize potential temperature impacts from stormwater entering Salmon Creek and its tributaries.

Why this matters

Temperature may be the most influential factor limiting the distribution and health of aquatic life, and can be greatly influenced by human activities. Water temperature influences what types of organisms can live in a water body. Cooler water can hold more dissolved oxygen that fish and other aquatic life need to breathe. Warmer water holds less dissolved oxygen. Threatened and endangered salmon need cold, clean water to survive. Certain temperatures are also required to protect spawning and incubation of salmonid species.

What is a Total Maximum Daily Load (TMDL)

Federal Clean Water Act requirements

The Clean Water Act (CWA) established a process to identify and clean up polluted waters. The act requires each state to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of (1) designated uses for protection, such as cold water biota and drinking water supply, and (2) criteria, usually numeric criteria, to achieve those uses.

The Water Quality Assessment and the 303(d) List

Every two years, states are required to prepare a list of water bodies that do not meet water quality standards. This list is called the Clean Water Act 303(d) list. In Washington State, this list is part of the Water Quality Assessment (WQA) process.

To develop the WQA, the Washington State Department of Ecology (Ecology) compiles its own water quality data along with data from local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data in this WQA are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the assessment. The list of waters that do not meet standards [the 303(d) list] is the Category 5 part of the larger assessment.

Category 1 – Meets standards for parameter(s) for which it has been tested.

Category 2 – Waters of concern.

Category 3 – Waters with no data or insufficient data available.

Category 4 – Polluted waters that do not require a TMDL because:

- 4a. – Have an approved TMDL being implemented.
- 4b. – Have a pollution-control program in place that should solve the problem.
- 4c. – Are impaired by a non-pollutant such as low water flow, dams, culverts.

Category 5 – Polluted waters that require a TMDL – the 303(d) list.

Further information is available at Ecology's Water Quality Assessment web site.

The Clean Water Act requires that a TMDL be developed for each of the water bodies on the 303(d) list. A TMDL is a numerical value representing the highest pollutant load a surface water body can receive and still meet water quality standards. Any amount of pollution over the TMDL level needs to be reduced or eliminated to achieve clean water.

TMDL process overview

Ecology uses the 303(d) list to prioritize and initiate TMDL studies across the state. The TMDL study identifies pollution problems in the watershed, and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology, with the assistance of local governments, tribes, agencies, and the community, develops a plan to control and reduce pollution sources, as well as a monitoring plan to assess effectiveness of the water quality improvement activities. This comprises the *water quality improvement report* (WQIR) *and implementation plan* (IP). The IP section identifies specific tasks, responsible parties, and timelines for reducing or eliminating pollution sources and achieving clean water.

After the public comment period, Ecology addresses the comments as appropriate. Then, Ecology submits the WQIR/IP to the U.S. Environmental Protection Agency (EPA) for approval.

Who should participate in this TMDL?

Load targets for nonpoint pollutant sources have been set in this TMDL and are described in Table 4. Because nonpoint pollution comes from diffuse sources, all upstream watershed areas have the potential to affect downstream water quality. Therefore, all potential nonpoint sources in the watershed must use the appropriate best management practices (BMPs) to reduce impacts to water quality. The area subject to the TMDL is shown in Figure 1.

Streamside landowners are the most important participants in reducing water temperatures in the Salmon Creek Watershed and meeting the nonpoint pollutant load targets. Governmental and private organizations that provide technical assistance and other support to these landowners are critical partners that need to work with the landowners to improve riparian shading of local waters. Regulatory agencies responsible for managing forestry practices and public lands are also essential participants. Specific agencies, organizations, and their role in reducing water temperatures are discussed in more detail in the implementation plan at the end of this document.

Clark County, and to a lesser extent, the city of Battle Ground, are the local governments affected by this TMDL. The Washington State Department of Transportation (WSDOT) is also affected. Currently, there are no individual permitted discrete (point) source dischargers in the watershed. Any new individual point source discharges would need to comply with the TMDL.

Figure 1. Map of the Salmon Creek watershed.

Elements the Clean Water Act requires in a TMDL

Loading capacity, allocations, seasonal variation, margin of safety, and reserve capacity

A water body's *loading capacity* is the amount of a given pollutant that a water body can receive and still meet water quality standards. The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with the standards.

The portion of the receiving water's loading capacity assigned to a particular source is a *wasteload* or *load* allocation. If the pollutant comes from a point source subject to a National Pollutant Discharge Elimination System (NPDES) permit, such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation*. If the pollutant comes from nonpoint sources not subject to an NPDES permit, such as general urban, residential, or farm runoff, the cumulative share is called a *load allocation*.

The TMDL must also consider *seasonal variations*, and include a *margin of safety* that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A *reserve capacity* for future pollutant sources is sometimes included as well.

Therefore, a TMDL is the sum of the wasteload and load allocations, any margin of safety, and any reserve capacity. The TMDL must be equal to or less than the loading capacity.

Surrogate measures

To provide more meaningful and measurable pollutant loading targets, this TMDL may also incorporate *surrogate measures* other than daily loads. EPA regulations [40 CFR 130.2(i)] allow other appropriate measures in a TMDL. See the Glossary section of this document for more information.

Potential surrogate measures for use in this TMDL are in the discussion that follows. The ultimate need for, and the selection of, a surrogate measure for use in setting allocations depends on how well the proposed surrogate measure matches the selected implementation strategy.

Water temperature increases as a result of increased heat flux loads. Heat loads to the stream are calculated in this TMDL in units of calories per square centimeter per day or watts per square meter (W/m^2). However, heat loads are of limited value in guiding management activities needed to solve identified water quality problems.

This *Salmon Creek Temperature TMDL* uses effective shade as a surrogate measure of heat flux from solar radiation. Effective shade is defined as the fraction of potential solar shortwave radiation that is blocked by vegetation and topography before it reaches the stream surface. The definition of effective shade allows direct translation of the solar radiation loading capacity.

The “Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program” (EPA, 1998) includes the following guidance on the use of surrogate measures for TMDL development:

> *When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional “pollutant,” the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not.*

Because factors that affect water temperature are interrelated, the surrogate measure (effective shade) relies on restoring/protecting riparian vegetation to increase stream surface shade levels; reducing streambank erosion; stabilizing channels; reducing the near-stream disturbance zone width; and reducing the surface area of the stream exposed to radiant processes. Effective shade screens the water’s surface from direct rays of the sun.

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Why Ecology Conducted a TMDL Study in this Watershed

Background

Ecology completed a TMDL for fecal coliform bacteria and turbidity in the Salmon Creek watershed in 1995 (Cusimano and Giglio, 1995). Monitoring data collected by Clark County in 1998-2002 at one site in Salmon Creek (Station SMN010; NW 36th Avenue) indicate Salmon Creek does not meet the temperature criteria in the Washington State water quality standards. These data resulted in the creek's inclusion on the 2004 303(d) list.

Schnabel (2004) collected continuous temperature data at fifteen sites in Salmon Creek and its tributaries in 2003. From 2002-2009, Clark County conducted an intensive monitoring program on Salmon Creek and its tributaries, collecting monthly stream temperature, turbidity, pH, dissolved oxygen, conductivity, and fecal coliform bacteria data at eight sites in the watershed. Data from these studies indicate temperatures not meeting (exceeding) criteria occur throughout the watershed. Ecology initiated a TMDL assessment for the Salmon Creek watershed in late 2008. The assessment was conducted in accordance with the document, *Innovative Temperature Total Maximum Daily Load Pilot Study: Quality Assurance Project Plan* (Stohr, 2009). The goal of the *Salmon Creek Temperature TMDL* assessment is to establish load and wasteload allocations for the heat sources to meet water quality standards for surface water temperature in the study area.

During and after the technical assessment, Ecology worked with local stakeholders to identify and implement pollution controls based on the study findings.

Impairments addressed by this TMDL

Salmon Creek has one 303(d) listed impairment that will be addressed by this temperature TMDL (Table 1). The TMDL will protect the designated aquatic life uses of *core summer salmonid habitat* and *salmonid spawning, rearing, and migration*. Although only one location is included in Table 1, an additional 12 locations monitored by Clark County (Schnabel, 2004) demonstrate impairment and meet Ecology's quality assurance criteria for listing on the 303(d) list. These additional impaired, but not currently listed water bodies are detailed in Table 2. The uses will be protected by decreasing the loading of temperature in the water body.

Table 1. Study area water bodies on the 2008 303(d) list for temperature.

Water Body	Parameter	Listing ID	Township	Range	Section
Salmon Creek	Temperature	22047	03.0N	01.0E	20

Table 2. Impaired but not currently listed water bodies covered by this TMDL.

Site_id	Description	7-DAD MAX (C)	EIM_id	Town	Range	Section	Reach Code
SMN075	Salmon Cr at Risto Road (217)	19.6	SMN075	03N	03E	4	17090012005348
RCK010	Rock Cr at S.C. confluence	21.2	RCK010	03N	03E	4	17090012005749
SMN070	Salmon Cr at Risto Road (216)	20.5	SMN070	03N	03E	4	17090012005276
SMN060	Salmon Cr west of NE 167th Ave	23.7	SMN060	03N	02E	12	17090012005283
MOR010	Morgan Cr at 167th Ave	20.9	MOR010	03N	02E	12	17090012005701
SMN050	Salmon Cr at Caples Rd	22.5	SMN050	03N	02E	15	17090012005404
WDN020	Woodin (aka Weaver) Cr at NE 181st St	21.6	WDN020	03N	02E	10	17090012005798
SMN045	Salmon Cr at NE 156th St	22.9	SMN045	03N	02E	21	17090012005286
MIL010	Mill Cr upstreamm of S.C. Ave	19.0	MIL010	03N	01E	24	17090012005772
SMN030	Salmon Cr at NE 47th Ave	21.6	SMN030	03N	01E	24	17090012005391
SMN020	Salmon Cr at Klineline footbridge	22.3	SMN020	03N	01E	35	17090012005292
CGR020	Cougar Cr upstream of NW 119th St	16.8	CGR020	03N	01E	33	17090012005325

There are four other 303(d) listed segments in the watershed, but this report does not address them. In Salmon Creek, three segments are listed for low pH and one segment is listed for low dissolved oxygen. A recent Ecology report, *Salmon Creek Nonpoint Source Pollution Total Maximum Daily Load: Water Quality Effectiveness Monitoring Report* (Collyard, 2009), indicates the creek may be naturally low in pH and dissolved oxygen. Before conducting a TMDL for these parameters in Salmon Creek, Ecology will conduct a detailed study to determine if the listings are warranted.

Water Quality Standards and Numeric Targets

Designated beneficial uses

Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code (WAC; Ecology, 2006), include designated beneficial uses, water body classifications, and numeric and narrative water quality criteria for surface waters of the state.

The designated aquatic life uses for Salmon Creek and its tributaries include (WAC 173-201A-200):

- *Core summer salmonid habitat*. This use protects summer season (June 15 through September 15) salmonid spawning or emergence, or adult holding; summer rearing habitat by one or more salmonids; or foraging by adult and sub-adult native char. Other protected uses include spawning outside of the summer season, rearing, and migration by salmonids.
- *Salmonid spawning, rearing, and migration.* This use protects salmon or trout spawning and emergence that only occur outside of the summer season (September 16 – June 14). Other uses include rearing and migration by salmonids.

See Figure 2 for a map of designated uses for temperature in the Salmon Creek watershed.

Other non-aquatic life uses include water supply (domestic, industrial, and agricultural), stock watering, fish and shellfish harvesting, wildlife habitat, recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment), and commerce and navigation. Numeric criteria for specific water quality parameters are intended to protect these designated uses.

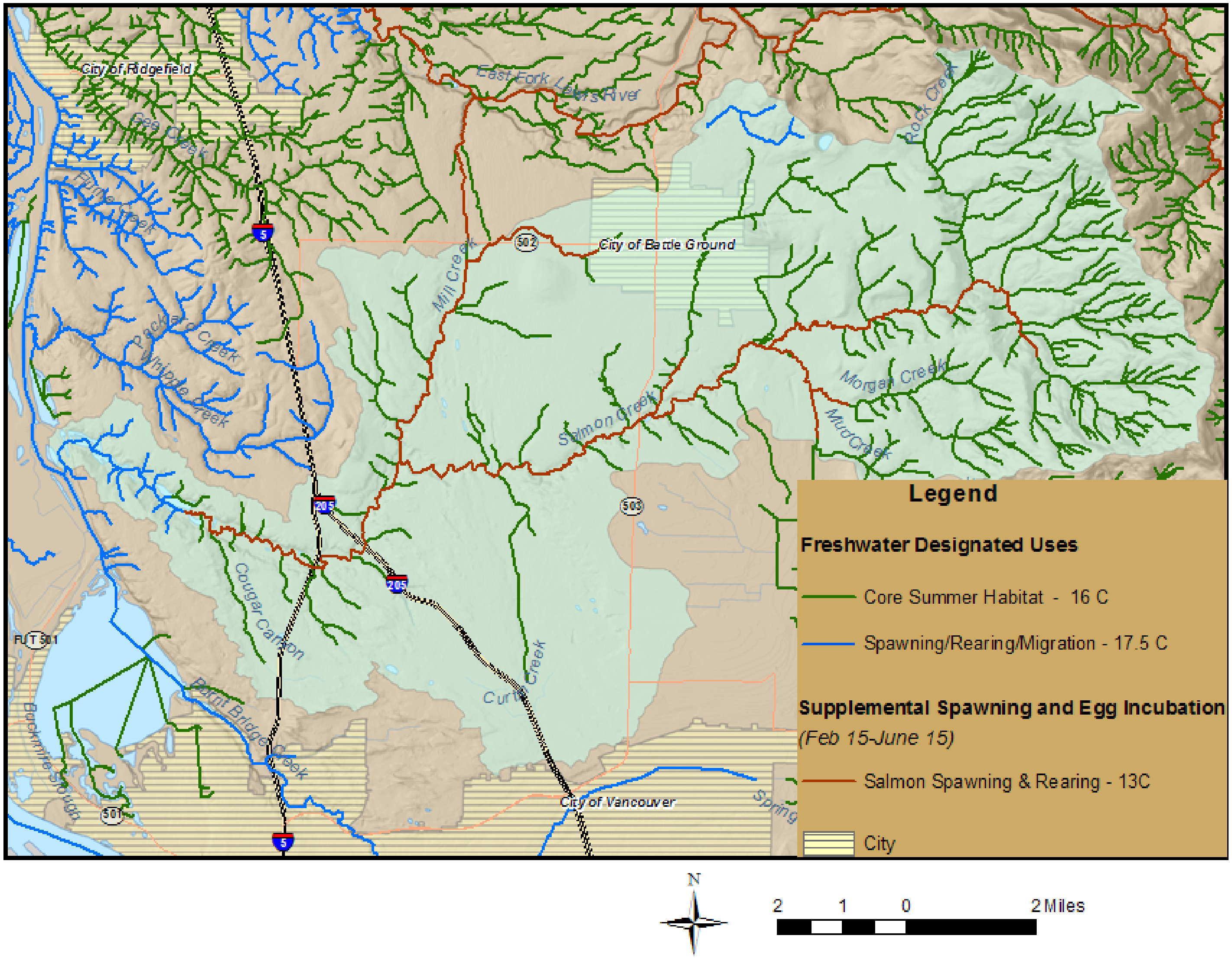

Figure 2. Designated uses for temperature in the Salmon Creek basin including supplemental spawning criteria f or Feb 15 – June 15.

Numeric temperature criteria

Temperature affects the physiology and behavior of fish and other aquatic life. Temperature may be the most influential factor limiting the distribution and health of aquatic life. Temperature can be greatly influenced by human activities.

Temperature levels fluctuate over the day and night in response to changes in climatic conditions and streamflows. Since the health of aquatic species is tied predominantly to the pattern of maximum temperatures, the criteria are expressed as the highest 7-day average of the daily maximum temperatures (7-DADMax) occurring in a water body.

In the Washington State water quality standards, aquatic life use categories are described using key species (salmon versus warm-water species) and life-stage conditions (spawning versus rearing) [WAC 173-201A-200; 2003 edition].

1. To protect the designated aquatic life uses of *core summer salmonid habitat,* the highest 7-DADMax temperature must not exceed 16°C (60.8°F) more than once every ten years on average.
2. To protect the designated aquatic life uses of *salmonid spawning, rearing, and migration,* and *salmonid rearing and migration only,* the highest 7-DADMax temperature must not exceed 17.5°C (63.5°F) more than once every ten years on average.

Washington State uses the criteria previously described to ensure that where a water body is naturally capable of providing full support for its designated aquatic life uses, that condition will be maintained. The standards recognize, however, that not all waters are naturally capable of staying below the fully protective temperature criteria. When a water body is naturally warmer than the previously-described criteria, the state provides a small allowance for additional warming due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.3°C (0.54°F) increase above the naturally higher (inferior) temperature condition.

In addition to the maximum criteria noted previously, compliance must also be assessed against criteria that limit the incremental amount of warming of otherwise cool waters due to human activities. When water is cooler than the criteria noted before, the allowable rate of warming up to, but not exceeding, the numeric criteria from human actions is restricted to: (1) incremental temperature increases resulting from individual point source activities must not, at any time, exceed 28/(T+7) as measured at the edge of a mixing zone boundary (where "T" represents the background temperature as measured at a point or points unaffected by the discharge), and (2) incremental temperature increases resulting from the combined effect of all nonpoint source activities in the water body must not at any time exceed 2.8°C (5.04°F).

Special consideration is also required to protect spawning and incubation of salmonid species. Where it has been determined that the temperature criteria established for a water body would likely not result in protective spawning and incubation temperatures, the following criterion applies: maximum 7-DADMax temperatures of 13°C (55.4°F) at the initiation of spawning for salmon and at fry emergence for salmon and trout.

Global climate change

Changes in climate are expected to affect both water quantity and quality in the Pacific Northwest (Casola et al., 2005). Salmon Creek and its tributaries are fed by stored groundwater, which is influenced by winter precipitation. Increases in air temperatures result in more precipitation falling as rain rather than snow and earlier melting of the winter snowpack. Changes to timing of precipitation or changes to quantities falling as snow or rain could affect summer streamflows.

Ten climate change models were used to predict the average rate of climatic warming in the Pacific Northwest (Mote et al., 2005). The average warming rate is expected to be in the range of 0.1-0.6°C (0.2-1.0°F) per decade, with a best estimate of 0.3°C (0.5°F) (Mote et al., 2005). Eight of the ten models predicted proportionately higher summer temperatures, with three indicating summer temperature increases at least two times higher than winter increases. Summer streamflows are also predicted to decrease as a consequence of global climate change (Hamlet and Lettenmaier, 1999).

The expected changes coming to our region's climate highlight the importance of protecting and restoring the mechanisms that help keep stream temperatures cool. Stream temperature improvements obtained by growing mature riparian vegetation corridors along streambanks, reducing channel widths, and enhancing summer baseflows may all help offset the changes expected from global climate change – keeping conditions from getting worse. It will take considerable time, however, to reverse those human actions that contribute to excess stream warming. The sooner such restoration actions begin and the more complete they are, the more effective we will be in offsetting some of the detrimental effects on our stream resources.

These efforts may not cause streams to meet the numeric temperature criteria everywhere or in all years. However, they will maximize the extent and frequency of healthy temperature conditions, creating long-term and crucial benefits for fish and other aquatic species. As global climate change progresses, the thermal regime of the stream itself will change due to reduced summer streamflows and increased air temperatures.

Ecology is writing this TMDL to meet Washington State's water quality standards based on current and historic patterns of climate. Changes in stream temperature associated with global climate change may require further modifications to the human-source allocations at some time in the future. However, the best way to preserve our aquatic resources and to minimize future disturbance to human industry would be to begin now to protect as much of the thermal health of our streams as possible.

Watershed Description

Geographic setting

The Salmon Creek watershed is located in Clark County in southwestern Washington. The basin comprises a significant portion of the Salmon-Washougal Water Resource Inventory Area (WRIA) 28. Salmon Creek flows from the foothills of the Cascade Mountains west to Lake River, which in turn flows into the Columbia River. The Cascade foothills are generally forested, while the lower drainage is primarily urban. The city of Vancouver lies just south of lower Salmon Creek, and several small towns lie along the tributaries and central plains of the basin. The middle reaches contain a mixture of small towns, large and small-scale farms, pasture, and homes.

Six major tributaries flow into Salmon Creek: Rock Creek and Morgan Creek to the east, Weaver Creek (also called Woodin) and Curtin Creek (also called Glenwood) in the middle, and Mill Creek and Cougar Creek to the west.

Land use

The Salmon Creek basin is primarily rural-residential and is characterized by gently rolling hills and alluvial flood plains. Forestry, agriculture, commercial, and industrial activities have been significant uses within the basin (Wille, 1990). However, recent trends suggest forestry and agriculture activities have significantly declined over the last decade (Globalwise Inc., 2007). The basin is highly urbanized near Vancouver, with many small subbasins already heavily developed. These subbasins often experience problems with stormwater runoff, inadequate buffer vegetation, erosion, and sedimentation.

WRIA 28 primarily consists of continental sediments from the late Miocene, Pliocene, and Pleistocene eras. Eight hydrologic units make up three major subbasins. The youngest subbasin consists of unconsolidated sedimentary rock. The next oldest subbasin consists of sedimentary rock known as the Troutdale aquifer. The third subbasin includes older rocks from marine sediments, basalt, volcanic breccia, and volcaniclastic sediment. During the late Pleistocene era, the Missoula floods deposited large quantities of sediments over the Troutdale Formation.

Climate

Salmon Creek resides in the West Coast Marine Climate Region that includes the Pacific coast from southeastern Alaska to northern California (city of Vancouver, 2002). The Columbia River and Pacific Ocean, 110 kilometers (70 miles) to the west, moderate temperatures lending to a maritime climate. As a result, Vancouver experiences mild, cool, wet winters, and relatively dry, warm summers. The Willapa Range to the west and the relatively taller Cascade Range to the east influence the climate as well. In Clark County, the average air temperatures range from 65°F to 40°F during the summer and winter, respectively. Severe temperature extremes are not common. Average annual rainfall for Vancouver is 41.3 inches (Wade, 2001).

Point sources of pollution

Municipal stormwater permits are held by Clark County, the city of Battle Ground, and WSDOT. There are no individual industrial or municipal wastewater NPDES-permitted point source discharges to Salmon Creek or its tributaries. The city of Battle Ground currently pipes its wastewater to Clark County's Salmon Creek Wastewater Treatment Plant, near the mouth of Salmon Creek, where it is processed and then discharged to the Columbia River. Battle Ground is also exploring the possibility of constructing its own wastewater treatment facility near the city. WSDOT is responsible for stormwater generated from the Interstate 5 highway corridor, which crosses Salmon Creek at RM 5.

Goals and Objectives

Project goals

The goal of the *Salmon Creek Temperature TMDL* study is to protect the designated aquatic life uses of core summer salmonid habitat as well as salmonid spawning, rearing, and migration in the Salmon Creek watershed. This project determined effective shade targets for the watershed and developed an implementation plan to achieve those targets. The project also defined the process for setting wasteload allocations for point sources of pollution.

Study objectives

- Use soils and LIDAR data specific to the Salmon Creek basin to determine system-potential vegetation characteristics.
- Generate effective-shade, load-allocation curves that are based on system-potential vegetation specific to the Salmon Creek basin.
- Produce an efficient, low-cost temperature TMDL that relies on shade curves to define the shade needed for meeting water quality standards. Ecology's previous practice of conducting site-specific temperature modeling for each temperature TMDL was time-consuming and expensive. The result of that work was nearly always to recommend full system-potential shade.
- Allow temperature TMDLs to be developed much faster and allow TMDL implementation measures to be put in place more quickly than under the traditional TMDL approach.

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TMDL Analysis

Analytical approach

Almost all temperature TMDL analyses in Washington State have resulted in load-allocation targets that are equal to system-potential shade (mature riparian vegetation along the entire length of the stream) in order to not exceed the 7-DADMax temperature standard more often than one time in ten years. Exceptions to this have been higher elevation areas in the Cascade Range (Stohr and Leskie, 2000) and areas with a very high inflow of ground water (Brock and Stohr, 2002). Even in these cases, the majority of the study area had load-allocation targets that were at system-potential vegetation.

The assumption for Salmon Creek is that during hot weather (90 percentile air temperatures) and low-flow (7Q10) conditions, stream temperatures would be above 16°C. This is because of the lowland location of Salmon Creek and existing continuous water temperature data (Schnabel, 2004) show temperature exceedances well above the temperature criteria. Thus there is a need for system-potential shade and the associated channel improvements that come with restoring the riparian area.

Analysis in this TMDL focused on determining system-potential vegetation and shade goals for the Salmon Creek basin using soils and LIDAR data. This allowed emphasis to be placed on restoration activities sooner, rather than on determining specific water temperatures associated with system-potential vegetation.

Information and data from sources outside of Ecology

Two sources of information were particularly applicable to this project.

Clark County

Clark County (Schnabel, 2004) collected continuous temperature data in Salmon Creek and its tributaries in 2003. Data collection followed procedures documented in the Quality Assurance Project Plan (Schnabel, 2003). Figure 3 shows that at 12 of 15 stations, daily maximum stream temperature exceeded 64°F (17.8°C) on at least 35 days during summer 2003, and that at nine stations daily maximum stream temperatures exceeded 64°F on 55 or more days. Two stations, Curtin Creek and Tenny Creek, never exceeded the current state criterion of 61°F (16.0°C) during the deployment period. A third station, Cougar Creek, recorded temperatures near the 61°F criterion for most of the summer and exceeded it for a period during late July. It is notable that the two coldest sites are located in urban areas with considerable stormwater input.

Clark County concluded that:

- Elevated stream temperatures in the Salmon Creek watershed are more significant and widespread than previously determined and should be considered a limiting factor for salmonid rearing in Salmon Creek.

- Twelve of 15 stations sampled regularly exceeded thresholds for detrimental thermal impacts to rearing salmonids.
- Increasing riparian canopy cover, improving cold-water refugia through increased channel complexity (pools), and limiting the influence of ponds will likely contribute to lower stream temperatures.
- Decreasing tributary temperatures and increasing summer streamflow will likely provide the most immediate thermal benefits in the mainstem, while increasing riparian canopy cover along the mainstem will provide benefits in the long-term.

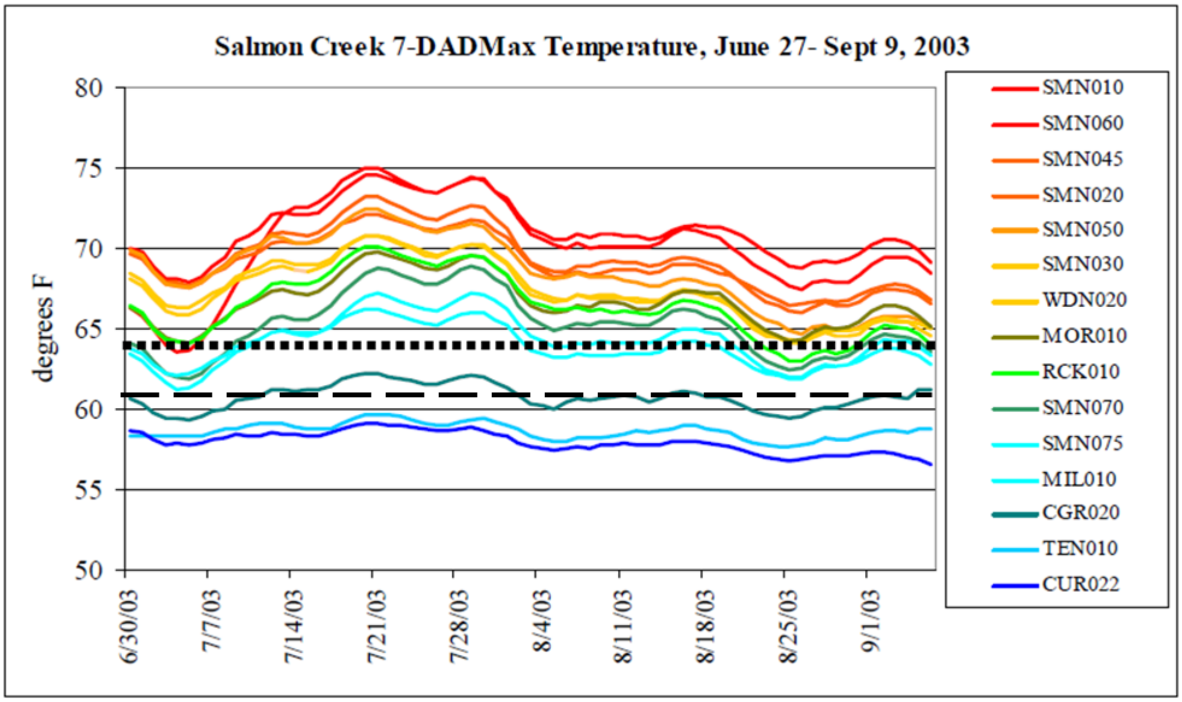

Figure 3. Time-series plot of 7-DADMax temperatures in Salmon Creek, summer 2003.
(Schnabel, 2004.) Dotted line at 64°F (17.8°C) and the dashed line at 61°F (16°C) are the current numeric water quality criteria in the basin.

Data from this Clark County project show that temperatures above state criteria are widespread and that the typical Western Washington seasonal pattern of the highest temperatures occurring in July and August holds true for this watershed.

Lower Columbia Fish Recovery Board

The Lower Columbia Fish Recovery Board commissioned a habitat assessment that included seven reaches in the Salmon Creek watershed (R2 Resource Consultants, 2004). Habitat surveys followed U.S. Geological Survey (USGS) Level 2 protocols (U.S. Forest Service, 2001). Data were collected on channel morphology, large woody debris, substrate, bank stability, and riparian vegetation and cover.

Channel width measurements taken during the 2004 habitat assessment of the Salmon Creek basin showed that the Salmon Creek active channel width ranged from 4.0 m (13 ft) to 27 m (89 ft) at the widest portion near the confluence with Lake River. The document further reports anticipated stream temperature conditions under current and potential riparian vegetation using a View to Sky (VTS) model (sections 5-15 and 5-16). Mature vegetation for this evaluation was assumed to be 46 m (150 ft) tall trees growing at the edge of the active channel width.

Estimated 7-DADMax temperature under current riparian conditions and normal summer weather patterns for Salmon Creek and Lake River ranged between 18.4°C and 21.8°C. Assuming mature forest timber stands could develop, the 7-DADMax reference was projected to approach 17.2°C to 19.5°C.

Similar analysis for upper reaches in Salmon Creek showed that temperature reductions ranging from 1.2°C to 2.5°C could be expected for the upper reaches, which would reduce their water temperatures to 16.6°C to 18.2°C.

Data from this project show that stream temperature decreases are expected with the addition of riparian vegetation. The expected stream temperature reduction of 1.2°C to 2.5°C (3.9°F to 8.2°F) is consistent with reductions calculated in other TMDL projects in Washington State.

Ecology's Shade model

Ecology's Shade model (Ecology, 2003) was used to generate effective-shade, load-allocation targets for this project. The Shade model was originally developed by the Oregon Department of Environmental Quality (ODEQ) and enhanced with shade calculation methods described in Chen (1996) and Chen et al. (1998a and 1998b).

Data required by the Shade model include stream orientation, topographic shade angles, time of year, sun position, latitude, channel width, and riparian vegetation characteristics (height, type, density). The model calculates solar radiation attenuation through the canopy and outputs percent shade for each stream reach by hour of the day for a specific day of the year.

The Shade model has been used to establish effective-shade load allocations in the following EPA-approved TMDL projects in Washington State:

- Willapa River basin
- Wind River basin
- Little Klickitat River basin
- Walla Walla River basin
- South Prairie Creek
- Stillaguamish River basin
- Wenatchee River basin
- Lower Skagit River tributaries
- Totten/Eld Inlets tributaries
- Bear-Evans Creek
- Snoqualmie River basin

- Upper Naches River watershed
- Tucannon-Pataha Creeks

The Shade model continues to be Ecology's primary method of developing effective-shade load allocations for temperature TMDL projects.

Loading capacity

Potential near-stream vegetation cover and effective shade

System-potential effective shade is the natural maximum level of shade that a given stream is capable of attaining with the growth of "system-potential mature riparian vegetation." This is defined as *that vegetation which can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes.*

Tree heights are specific to an area and dependent on several variables including soils, climate, elevation, and hydrologic processes. Geographic Information Systems (GIS) soils datasets are often linked to an index with values of 50- or 100-year tree heights, which the soils in the area can support. The 100-year values are considered to be system-potential mature vegetation. Both the Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) and the Washington State Department of Natural Resources (DNR) provide soils coverage for the state of Washington with site index heights. Both GIS soils datasets generally report 50-year site index values for lands west of the Cascade Range crest and 100-year site index values for lands east of the Cascade Range. One hundred-year values for western Washington are reported in the NRCS Soil Survey documents and often in the digital forest and woodland production database tables.

For Salmon Creek, 50-year potential vegetation height was estimated based on the DNR soils polygon coverage (http://fortress.wa.gov/dnr/app1/dataweb/metadata/soils.htm) (Figure 4). DNR soils data were available for most of the Salmon Creek watershed. The mean site index tree height at 50 years for this area was 36.3 m (119 ft). The adjacent Burnt Bridge Creek watershed, located immediately south of Salmon Creek, has a 50-year potential tree height of 34.8 m (114 ft), and a 100-year potential tree height of 45.7 m (150 ft) based on the Clark County SSURGO database.

Current vegetation heights from LIDAR and field data confirmed that 36.3 m (119 ft) is a reasonable 50-year height and that trees larger than the 45.7 m (150 ft) system potential are rare in this watershed. Figure 5 shows the current heights of vegetation (and some structures) in the entire watershed, and Figure 6 shows the heights of vegetation growing within the Vancouver Urban Growth Area. The city portion has been processed to remove anything that is not vegetation.

Note that the height histograms for the city portion and for the entire watershed are similar. Although there is much land with little shading vegetation, there are significant areas with trees in the 9.5 to 30.5 m (31 to 100 ft) height category and lands with trees in the 30.0 to 45.7 m (101 to 150 ft) category.

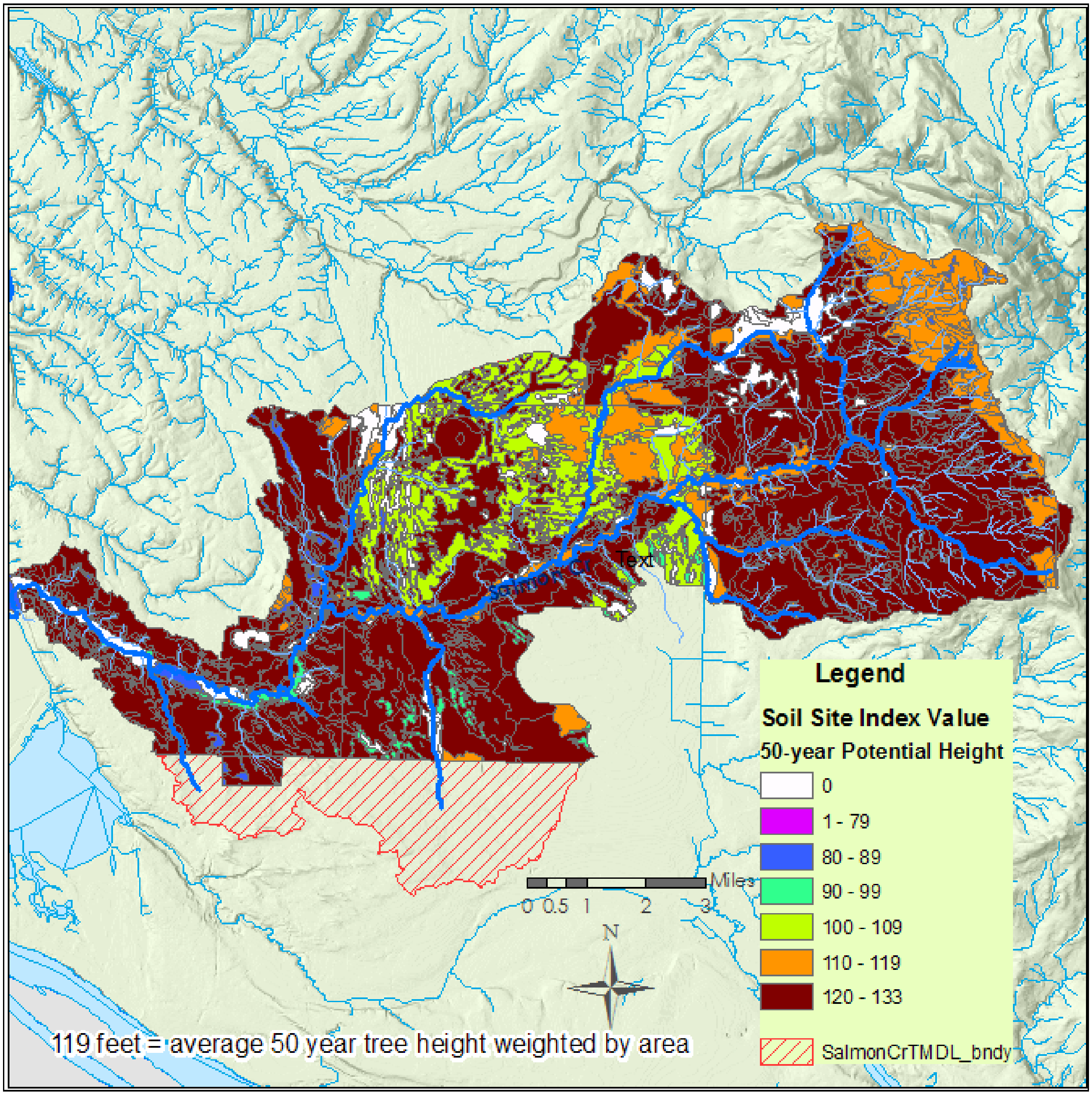

Figure 4. Fifty-year site index height for first major tree species based on soils (DNR soils).

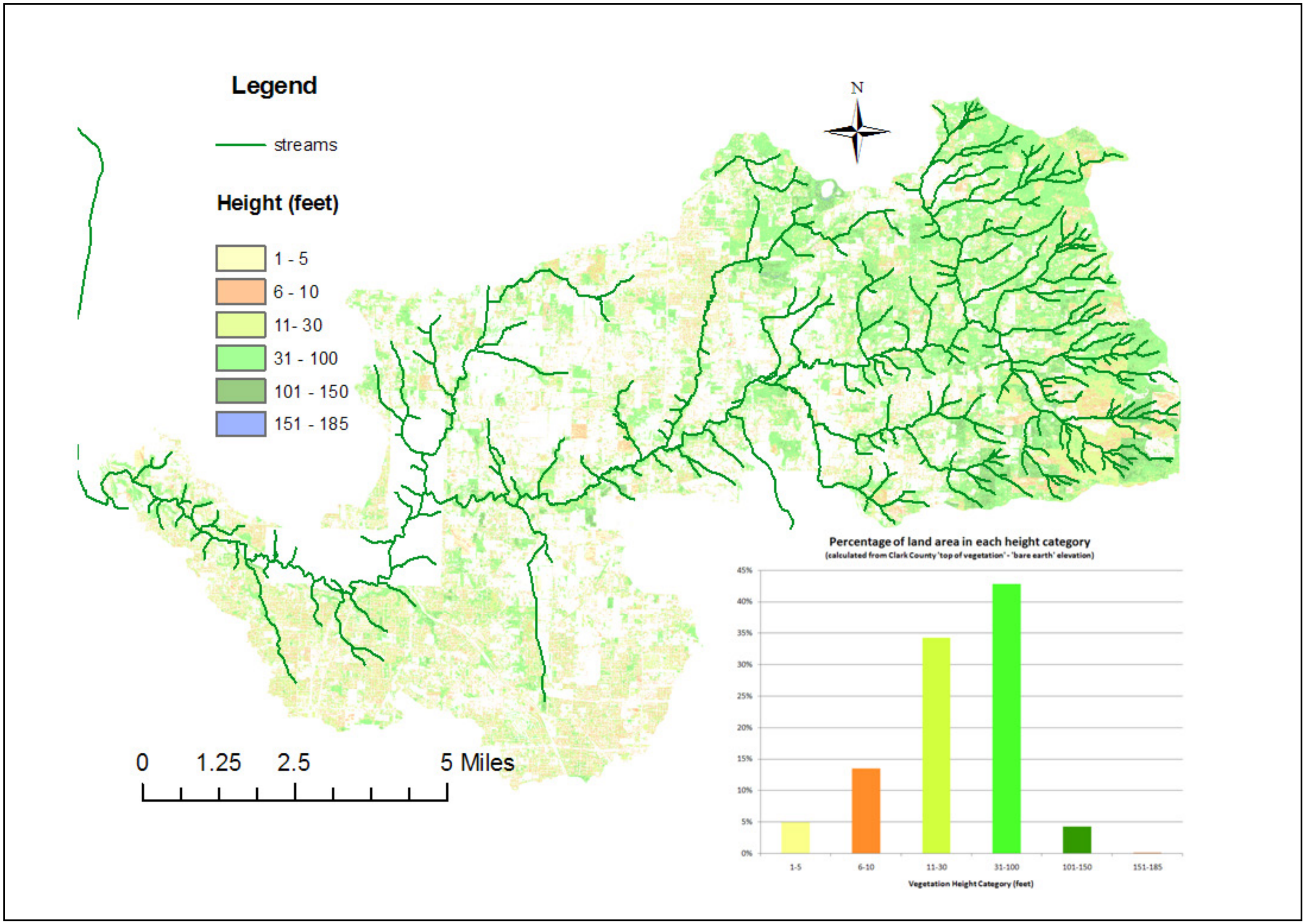

Figure 5. Current heights in the Salmon Creek watershed (LIDAR year 2002).

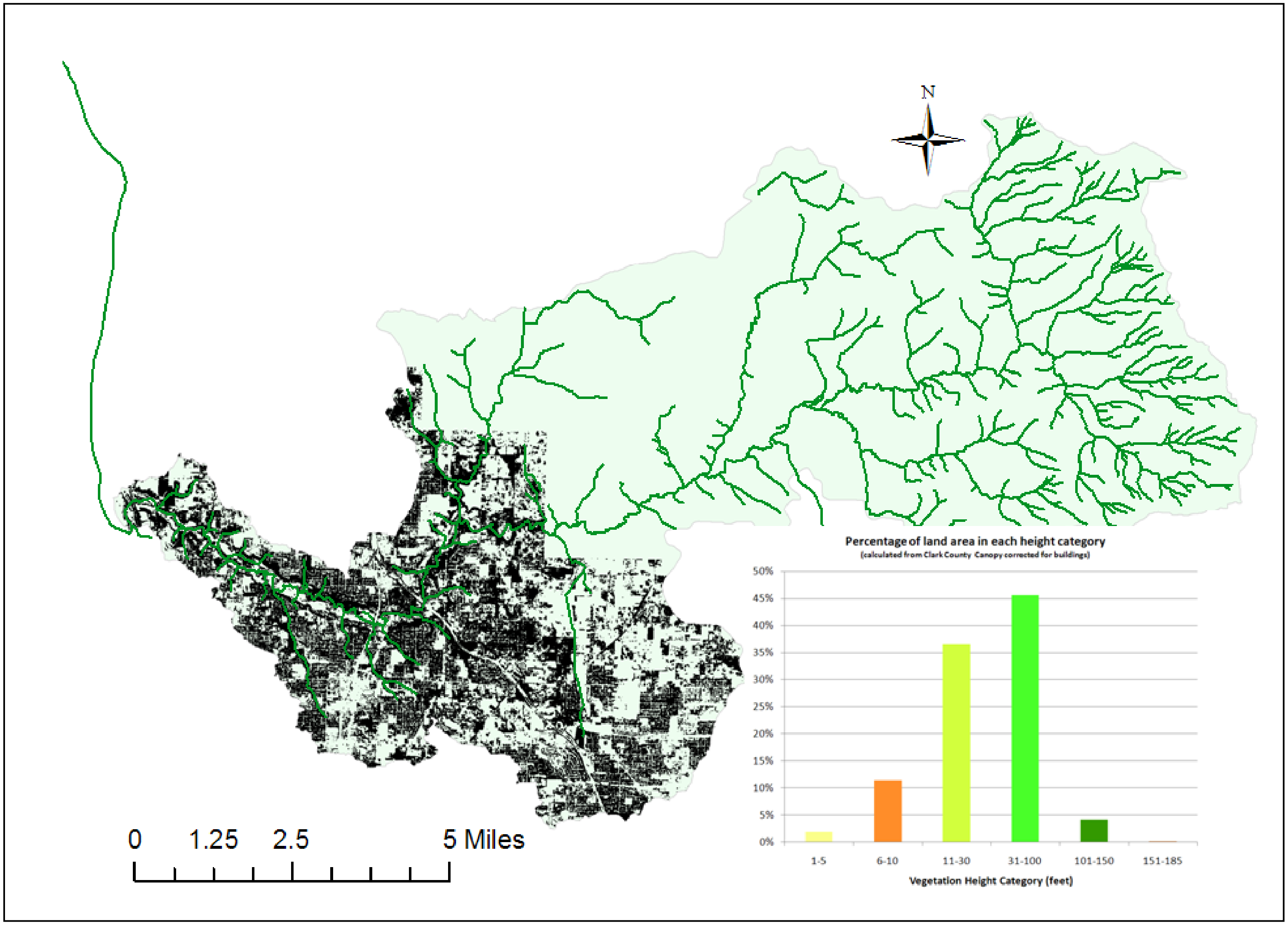

Figure 6. Heights in the lower watershed with buildings removed (LIDAR year 2002).

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Load and Wasteload Allocations

Wasteload allocations

Currently, there are no numeric wasteload allocations assigned to specific point discharges in this TMDL. There are no municipal wastewater treatment plants or other individual NPDES-permitted point source discharges in the Salmon Creek watershed. There are three municipal stormwater permits in this watershed. It is anticipated that stormwater runoff from the three sources will not be large enough to cause an exceedance in the state water quality criteria over the 7-day averaging period for water temperature. However, at this time insufficient data is available to definitely calculate this.

Ecology does not consider stormwater discharges as significant direct sources of thermal pollution during the summer critical period. However, stormwater runoff could potentially contribute to thermal loadings during summer rainstorms that are normally infrequent and of short duration. Precipitation that occurs earlier or later in the year that runs off or across heated surfaces can be initially quite warm. However, runoff cools rapidly during long rain events and is not expected to cause greater than a 0.3^{o} increase of the seven-day average daily maximum temperature as identified by state water quality standards. Although thermal loadings from permitted stormwater are of minimal size, all NPDES-permitted discharges must be provided wasteload allocations.

A categorical wasteload allocation for municipal stormwater permittees is established in this TMDL and is as follows:

- The cumulative stormwater discharge from all permitted sources may not cause the 7DADMax temperature in receiving waters to increase more than 0.3 degrees during the June – September critical period.

The following procedure documents how numeric wasteload allocations will be calculated for any future individual NPDES permitted facilities. The same method will be used to calculate numeric limits for stormwater outfalls, if any are determined to have sufficient sustained discharge quantities during June through September.

Any new individual point source discharges would need to comply with all portions of WAC 173-201A and be able to meet the water quality discharge criteria as described in *Procedures to Implement the State's Temperature Standards through NPDES Permits* (Ecology, 2010). Calculation of effluent temperature limits is thoroughly discussed in Appendix 1. The mass balance equation referred to in Appendix 1 (section 1.B.) as the "default equation" is Ecology's standard method to calculate effluent temperature limits in a temperature TMDL. Although this mass balance equation applies when water temperature is warmer than the numeric criteria, effluent limits derived using this equation generally meet both the threshold and incremental warming criteria.

February 15 – June 15

$$TNPDES = [13.0ºC-0.3ºC] + [\text{chronic dilution factor}] \times 0.3ºC.$$

June 16 – February 14

$$TNPDES = [16.0ºC-0.3ºC] + [\text{chronic dilution factor}] \times 0.3ºC.$$

where:

TNPDES is the maximum effluent temperature allowable under the NPDES permit.
13.0 and 16.0 are the seasonal numeric standards for the receiving water.

Effluent discharges from point sources are also regulated under the permit to meet:

1. Incremental warming restrictions established in the standards when background water temperatures are cooler than the numeric criteria. (Appendix 1.C.)
2. Restrictions to avoid instantaneous lethality to fish and other aquatic life. (Appendix 1.D.)

The purpose of these restrictions is to ensure that sources prevent unreasonable warming of the background receiving water from an effluent discharge that may impact the aquatic life uses or impact the general temperature regime of the watershed. The water quality standards at WAC 173-201A-200(1)(c) (i) – (vii) contain these restrictions and other notes on implementation of the temperature threshold criteria.

Current stormwater program and monitoring

Thermal loading from municipal stormwater discharges can increase the temperature of small receiving waters at certain times of the year. Runoff from late spring or early fall rainfall onto heated pavements may be quite warm initially, but that runoff cools rapidly during long rain events and is not expected to warm receiving waters to cause a 0.3°C increase of the 7-day average criteria. Wasteload allocations are necessary for this source of pollutant loading, but it is expected that implementation of the NPDES permit-mandated stormwater control program will achieve compliance with targets for temperature.

Clark County has a very complete stormwater program in place. They have located all outfalls and are conducting water quality and flow monitoring. The program inventories and maps storm sewer infrastructure built in the course of development and public capital improvement projects. The inventory includes all stormwater infrastructures inside of and outside of the county's municipal separate storm sewer system MS4 (Clark County, 2010). Three new stormwater characterization monitoring stations were installed during 2009 and the first part of 2010, one of which is located in Cougar Creek, a Salmon Creek tributary. Several stormwater treatment and flow control BMPs are also currently being tested for effectiveness in the Salmon Creek watershed. BMPs are being installed to restrict delivery of pollutants to the stream.

Screening level monitoring is initially necessary to identify which discharges contribute the largest stormwater flows during the June-September period. Additionally, evaluation of the three characterization monitoring stations should provide a set of flow data that would typically be produced by runoff from different landuse types. If results from these initial monitoring studies show that the size of the stormwater discharges to the stream warrant further study, subsequent water temperature monitoring of the discharge and receiving water would be performed using an Ecology approved Quality Assurance Project Plan (QAPP).

This further study would involve monitoring the larger stormwater discharges for contributions of heat to the stream. This may involve adding continuous temperature monitors to those discharges. The same default equations used to calculate TNPDES for other point sources, shown previously, can be applied to stormwater discharges and used to verify that these are meeting the wasteload allocation. Smaller discharges, those with flows less than 1% of the receiving water flow, are considered to have negligible individual impact on stream temperature. Monitoring is necessary to determine if the cumulative impact of multiple discharges to a stream reach raises stream temperature.

Timing of potential stormwater point source impacts

The highest water temperatures in Western Washington typically occur in the months of July and August. These water temperatures are caused by a combination of weather conditions and lower summertime stream flows. Table 3 shows that average precipitation is extremely low during the hottest months of July and August and thus generation of stormwater flow in large enough quantity to impact stream temperature is also extremely low.

Table 3. Air temperature and rainfall averages for Clark County WA reported by the Western Regional Climate Center.

VANCOUVER 4 NNE, WASHINGTON (458773); Period of Record Monthly Climate Summary; Period of Record : 5/ 1/1898 to 12/30/2008

	Jan	Feb	Mar	Apr	May	**Jun**	**Jul**	**Aug**	**Sep**	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	44.8	49.9	55.3	61.3	67.4	**72.6**	**79**	**79.2**	**73.9**	63.6	52.4	45.8	62.1
Average Min. Temperature (F)	32.5	34.3	37.3	40.6	45.6	**50.5**	**53.7**	**53.4**	**49.1**	43.3	38	34.2	42.7
Average Total Precipitation (in.)	5.76	4.4	3.76	2.7	2.24	**1.65**	**0.62**	**0.86**	**1.8**	3.19	6.01	6.46	39.46
Average Total Snowfall (in.)	3.8	1.3	0.3	0	0	0	0	0	0	0	0.1	1	6.5
Average Snow Depth (in.)	0	0	0	0	0	0	0	0	0	0	0	0	0

Percent of possible observations for period of record.
Max. Temp.: 99.4% Min. Temp.: 99.4% Precipitation: 99.5% Snowfall: 92.7% Snow Depth: 92.6%
Check Station Metadata or Metadata graphics for more detail about data completeness.

Stormwater is also not a likely heat source during the months of November to May. These months are typically much cooler and also typically have higher stream flow (Figure 7). Storms producing rainfall do not occur on the hottest days. Therefore it is expected that storm generated flow will occur during periods that are cool enough to not impact stream temperature.

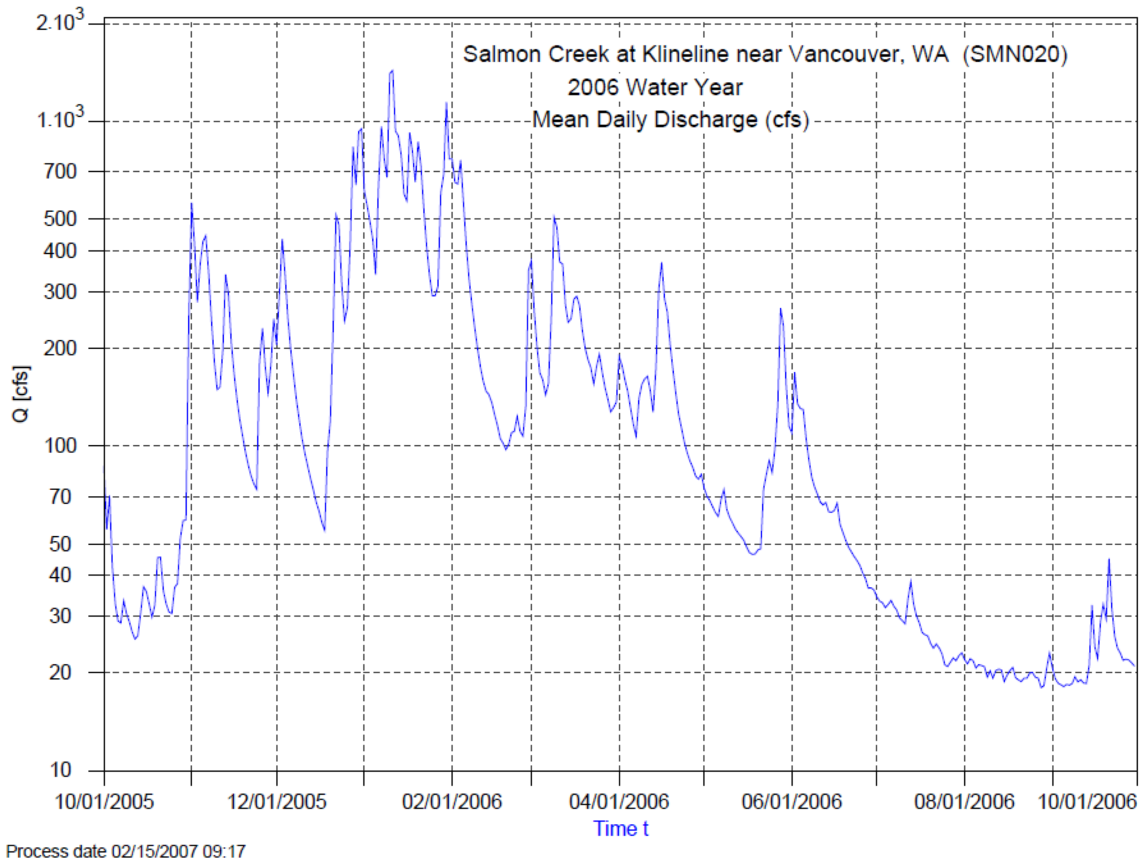

Figure 7. Example streamflow for Salmon Creek from station SMN020, water year 2006.
More data and other stations available at www.co.clark.wa.us/water-resources/monitoring/flow.html

In the Salmon Creek basin, June and September are the most likely months for stormwater to have an impact on water temperatures that could potentially exceed water quality criteria. In most watersheds, June streamflows are large enough to make it difficult for stormwater quantities to affect temperature. However, Salmon Creek has a supplemental temperature criterion of 13°C in place from February 15 to June 15. There is a potential for June stormwater to be warmer than this lower numeric criterion, but it is unlikely that prolonged rainfall will occur during these times to cause the applicable 7-day average criteria to be exceeded.

September streamflows are typically some of the lowest of the year and rainfall is also typically low (Table 3), but early fall rainstorms could cause increased temperatures. Whether stormwater runoff is affecting stream temperature by 0.3°C would be determined using stream flow and stormwater flow volumes and the temperature difference between them. The standards also allow for a 1 in 10 year exception (e.g., they need to be met in 9 of 10 years).

Load allocations

Load allocations for effective shade are represented in Figure 8 and Table 4, based on the estimated relationship between shade, channel width, and stream aspect at the assumed maximum 100 year riparian vegetation condition. Effective shade corresponding to system-potential vegetation (100 year) was estimated assuming that riparian vegetation at mature stages has an average height of 45.7 m (150 ft), an 85% canopy cover, and a 4.6 m (15 ft) overhang.

Figure 8 shows that the amount of shade decreases as the width of the channel increases. For streams with a channel width less than 7 m (20 ft), shorter vegetation of 36.5 m (119 ft) height, 85% canopy cover, and 3.6 m (12 ft) overhanging vegetation (corresponding to 50-year vegetation values) provides the required shading. This is because the assumed overhanging vegetation will cover the stream. Topographic shade in Figure 8 was assumed equal to zero.

The load allocations are expected to re-establish mature riparian vegetation. Establishing mature riparian vegetation benefits stream temperatures directly through reduced solar radiation and indirectly through an increase in channel complexity. A natural, fully-functioning channel would be expected to have more sinuosity and braiding, more woody debris, reduced bank erosion, and better interaction with subsurface water and the flood plain.

These allocations will result in water temperatures that are equivalent to the temperatures that would occur under natural conditions. At that point in time, either the stream will have cooled to meet or be cooler than the numeric criterion, or the stream will have cooled to its natural temperature, which may be higher than the numeric criterion. In either case, the standard will be met, based on the natural conditions provision of the water quality standards, WAC 173-201A-070(2), which states: "*Whenever the natural conditions of said waters are of a lower quality than the criteria assigned, the natural conditions shall constitute the water quality criteria*."

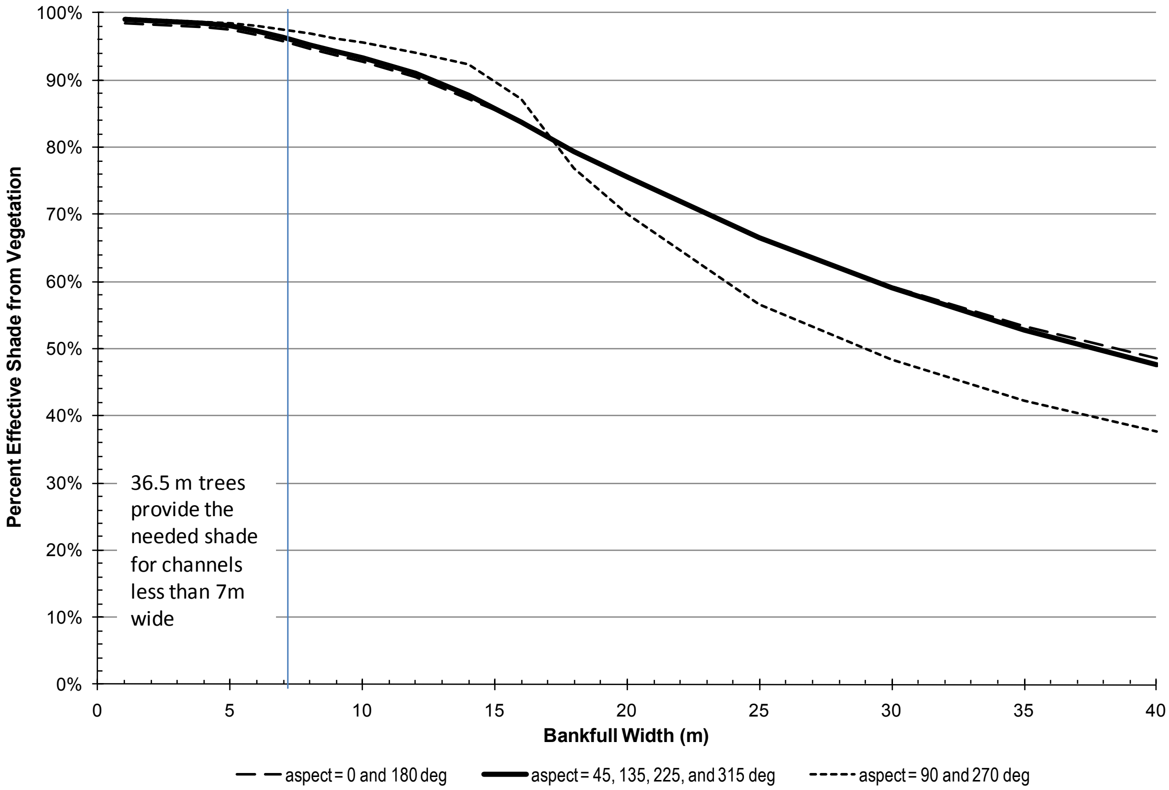

Figure 8. Load allocations for effective shade in Salmon Creek and its tributaries by bankfull width (meters) and aspect assuming a riparian vegetation height of 46 meters (150 feet), a canopy density of 85%, and an overhang of 4.6 meters (15 feet).

Table 4. Effective-shade load allocation at the condition of system-potential riparian vegetation and channel.

Bankfull width (meters)	Effective shade from vegetation (percent) at the stream center at various stream aspects (degrees from N)			Daily average global solar short-wave radiation (W/m2) at the stream center at various stream aspects (degrees from N)		
	0 and 180 deg aspect	45, 135, 225, and 315 deg aspect	90 and 270 deg aspect	0 and 180 deg aspect	45, 135, 225, and 315 deg aspect	90 and 270 deg aspect
1	98.5%	99.0%	99.2%	5	3	3
2	98.3%	98.8%	99.0%	5	4	3
3	98.1%	98.6%	98.9%	6	4	3
4	97.9%	98.5%	98.7%	6	5	4
5	97.6%	98.1%	98.5%	8	6	5
6	96.8%	97.3%	98.0%	10	8	6
7	95.8%	96.4%	97.5%	13	11	8
8	94.7%	95.3%	96.9%	16	14	10
9	93.6%	94.3%	96.3%	20	18	11
10	92.7%	93.4%	95.6%	22	20	14
12	90.4%	91.0%	94.1%	30	28	18
14	87.2%	87.7%	92.3%	39	38	24
16	83.9%	83.8%	87.1%	49	50	40
18	79.5%	79.4%	76.9%	63	63	71
20	75.4%	75.5%	70.0%	75	75	92
25	66.3%	66.5%	56.6%	103	103	133
30	59.3%	59.1%	48.4%	125	126	159
35	53.3%	52.9%	42.3%	143	145	177
40	48.5%	47.6%	37.7%	158	161	191

Establishing mature riparian vegetation is expected to have a secondary benefit by improving microclimate conditions, especially cooler air temperatures under the canopy. Management actions that control other influences on stream temperature, such as sediment loading, groundwater inflows, and hyporheic exchange, are also recommended.

- 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. Projects that have the potential to increase groundwater inflows to streams in the watershed should be encouraged.

- The hyporheic zone is defined as the region located beneath and adjacent to a streambed, where there is mixing of shallow ground water and surface water. Hyporheic exchange flows are important to maintain the current temperature regime and to reduce maximum daily instream temperatures. Management activities that help maintain hyporheic exchange flows include (1) reducing upland and channel erosion and (2) avoiding sedimentation of fine materials in the stream substrate.

- Interim monitoring of water temperatures during summer is recommended, perhaps at five-year intervals. Continuously-recording water temperature monitors should be deployed from July through September to capture the critical conditions.

- Interim monitoring of the composition and extent of riparian vegetation is also recommended. For example, this could be done by using photogrammetry or remote sensing methods, hemispherical photography, densiometers, or solar pathfinder instruments.

Using a shade curve to determine site-specific load allocation

Although the goal in this TMDL is to establish mature vegetation along the entire length of Salmon Creek and its tributaries, there may be times when it is desirable to know the shade load allocation at a specific site.

Figure 9 shows an example shade curve to use as a reference for these instructions. The specific shade curve for this basin is Figure 8 of this report. Shade curves are based on the estimated relationship between riparian shade, channel width, and stream aspect at the assumed maximum riparian vegetation condition. These are the steps to determine the shade prescription for a specific stream location.

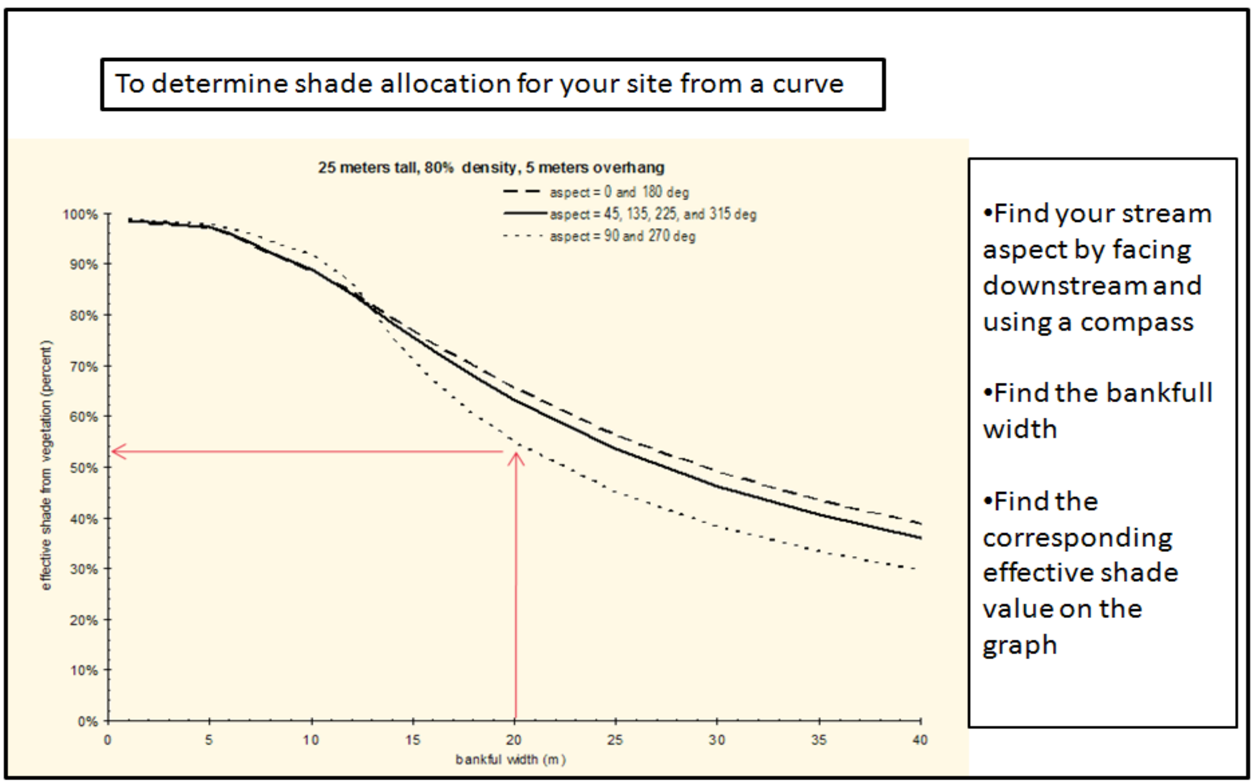

Figure 9. Example of how to use a shade curve.

1. Determine the stream aspect by facing downstream and using a compass to determine the general direction of streamflow in degrees.

   The categories are:

   - Stream aspect = 0º and 180º (North and South).
   - Stream aspect = 45º, 135º, 225º, and 315º (NE, SE, SW, and NW).
   - Stream aspect = 90º and 270º (East and West).

   For example: You are standing in the middle of the stream (when the stream can be safely waded) facing downstream holding a compass in your hand. You read your compass and get 50º. Of the three aspect lines on the shade curve, the 45° line is the closest to your 50° reading and will be used to determine effective shade.

2. Determine the bankfull width of the stream (in meters) at your location.

3. Look at the shade load-allocation curve (or table). Find the correct aspect line for your stream, find the bankfull width for your stream, follow the graph straight up from the corresponding bankfull width until you "hit" the correct aspect line, and follow the graph directly to the left. You will find your corresponding effective shade.

The effective-shade value derived from the graph is the estimated site-potential (or maximum) riparian shade target for restoration efforts. Local site conditions may preclude the site-potential vegetation from reaching the estimated effective shade.

Seasonal variation

Clean Water Act Section 303(d)(1) requires that TMDLs *"be established at levels necessary to implement the applicable water quality standards with seasonal variations."* Existing conditions for stream temperatures throughout the Salmon Creek watershed reflect seasonal variation. Cooler temperatures occur in the winter, while warmer temperatures are observed in the summer. The highest water temperatures typically occur from July through August (Schnabel, 2004). This timeframe was used as the critical period for development of this TMDL.

Seasonal estimates for streamflow, solar flux, and climatic variables were considered in developing critical conditions for TMDL model assumptions. 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.

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Margin of Safety

The margin of safety accounts for uncertainty about pollutant loading and water body response. In this TMDL, the margin of safety is implicit and is addressed by using critical conditions in the analysis.

During July and August of 2003, monitored stream temperatures did not meet (exceeded) the numeric standard throughout the basin. Based on weather data from 1996 – 2009, the year 2003 was a typical year. We assume that during critical low-flow and high-temperature conditions, these water temperatures would be higher. The Lower Columbia Fish Recovery Board (2004) also concluded that water temperatures under normal summer conditions and with mature vegetation would exceed the current numeric water quality criteria.

Therefore:

- The load allocations are set to the effective shade provided by full mature riparian vegetation, which are the maximum values achievable in the Salmon Creek watershed.
- Wasteload allocations are based on the seasonal criteria and discharges in compliance with these targets will not contribute to violation of water quality standards.

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Reasonable Assurance

When establishing a TMDL, reductions of a particular pollutant are allocated among the pollutant sources (both point and nonpoint) in the water body. TMDLs (and related implementation plans) must show "reasonable assurance" that these sources will be reduced to their allocated amount. Education, outreach, technical and financial assistance, permit administration, and enforcement will all be used to ensure that the goals of this TMDL are met.

The goal of the *Salmon Creek Water Quality Improvement Report* for temperature is to help the waters of the basin meet the state's water quality standards. The following rationale helps provide reasonable assurance that the Salmon Creek nonpoint source TMDL goals will be met throughout the watershed by 2110. Many segments of Salmon Creek and its tributaries have a channel width less than 7 m (20 ft). These segments should achieve cooler temperatures much sooner than 2110.

Ecology believes that the following activities already support this TMDL and add to the assurance that temperature in the Salmon Creek watershed will meet conditions provided by Washington State water quality standards. This assumes that the activities described below are continued and maintained.

There is considerable local interest and involvement toward resolving the water quality problems in the watershed. An active group of stakeholders has been implementing cleanup activities in Salmon Creek since EPA approved the *Salmon Creek Bacteria and Turbidity TMDL* in 2001 (Howard, 2001). Many of the actions identified for the 2001 TMDL, including streambank restoration and riparian planting, will also improve temperatures in the watershed. Stakeholders, including Clark County Clean Water Program, Clark Public Utilities, and Clark Conservation District, have already completed a number of riparian restoration projects and outreach and education activities. These agencies are committed to continuing restoration in the Salmon Creek watershed to achieve water quality standards.

While Ecology is authorized under Chapter 90.48 RCW to impose strict requirements or issue enforcement actions to achieve compliance with state water quality standards, it is the goal of all participants in the *Salmon Creek Temperature TMDL* process to achieve clean water through cooperative efforts.

Specific actions relative to implementation of the *Salmon Creek Temperature TMDL* are described in the following implementation plan. An important component of the plan is inclusion of an adaptive management process to assess whether the actions identified as necessary to solve the identified pollution problems are the correct ones and whether they are working. Adaptive management allows us to fine-tune our actions to make them more effective, and to try new strategies if we have evidence that a new approach could help us to achieve compliance.

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Implementation Plan

Introduction

This *implementation plan* was developed jointly by Ecology and TMDL stakeholders (Cleanup Partners). It describes what will be done to improve water quality. It explains the roles and authorities of the Cleanup Partners and other organizations with jurisdiction, authority, or direct responsibility for cleanup, along with the programs or other means through which they will address these water quality issues. It prioritizes specific actions planned to improve water quality and achieve water quality standards. It expands on the recommendations made earlier in this document.

Typically, Ecology produces an implementation strategy, which is submitted with the technical analysis to EPA for approval of the TMDL. Then, following EPA's approval, Ecology and interested and responsible parties develop a water quality implementation plan. However, this section of this water quality improvement report serves as both the implementation *strategy* and the implementation *plan*.

This implementation plan describes how temperature levels will be reduced to meet water quality standards. Mature vegetation resulting in effective shade should be achieved throughout the entire Salmon Creek watershed by 2110. Based upon work already underway and completed, many areas in the watershed will achieve cooler temperatures even sooner.

The technical analysis performed under this TMDL did not recommend buffer widths associated with the load allocations. Buffer widths are an important consideration of any temperature improvement effort. In the absence of specific recommendations, they should be based upon existing regulatory requirements. For Salmon Creek and its tributaries, these include: Clark County Code 40.240.880, *Special Areas Natural Resource Review Criteria* (Amended 2006) and Shoreline Master Program requirements; Washington State Forest Practices Act rules and the Forest Practice Board Manual (applies to private and state-owned timberlands); city of Battleground ordinances codified in Title 18 Environmental Protection requirements (applicable for portions of Mill and Woodin Creeks); and if federal, state, or private funding is involved, specific requirements associated with these respective programs.

The relationship between effective shade and mature vegetation is dependent upon the establishment of a sustainable plant community, such that the recommended tree heights capable of meeting the load allocations can be achieved and maintained. Sustainable buffers allow for recruitment and succession, and a mixed and heterogeneous plant community that provides for a healthy riparian corridor and habitat values. Buffers should be sufficient to accommodate wind throw and should adjoin wetlands to assure functions of the hyporheic zone, including the groundwater and nutrient relationships important to sustain desired streamside plant communities. Buffer widths should be sufficient to account for stream channel migration, as Salmon Creek and its tributaries will continue to physically move within the respective floodplains.

Streambank erosion and liberated sediment can also have an influence on temperatures in Salmon Creek and its tributaries. Dislodged soils can be carried downstream and contribute to stream-bed load. Soil particles can also fill interstitial spaces in the hyporheic zone, disrupting water/groundwater movement. By itself, loss of hyporheic exchange can lead to increased stream heating as cooler groundwater inflow becomes reduced.

Soil properties, including soil texture, organic matter content, aspect, moisture content, and structure all affect tree growth and management requirements. Vascular plant species vary by soil type and location. Replanting of riparian areas along Salmon Creek and its tributaries should consider native vegetation, including but not limited to Douglas fir; western red cedar; western hemlock; dogwood; red alder; black cottonwood; vine maple; salal; Oregon grape; wild cherry; and fern. Individuals should consult with staff from the Clark County/Washington State University Cooperative Extension, Clark Conservation District, Washington State Department of Natural Resources, or other local professionals already engaged in riparian restoration for recommendations on the appropriate species to plant.

Who needs to participate in implementation?

Key Cleanup Partners, agencies, and other groups that have influence, regulatory authority, involvement, or other controls will be incorporated into a coordinated effort to implement the TMDL. Additional agencies, local or environmental groups would be welcome to support or endorse the recommendations in this TMDL The initial Key Cleanup Partners participating in the development of this TMDL include the following:

City of Battle Ground

The city of Battle Ground was issued a Phase II NPDES Municipal Stormwater Permit in October 2010. Requirements and activities for the Phase II permit include stormwater capital improvements; water quality monitoring; public education and outreach; regulations and enforcement; and stormwater maintenance. The city of Battle Ground will use stormwater BMPs to reduce temperature impacts of stormwater and surface discharges entering Mill Creek and Woodin (Weaver) Creek, both tributaries to Salmon Creek.

Clark Conservation District

The Clark Conservation District (CCD) was formed in 1942 and is a legal sub-division of state government that administers programs to conserve natural resources. The CCD is self-governed by volunteers who establish priorities and set policy. These district supervisors are not paid, but direct the expertise of district employees working in partnership with the USDA Natural Resources Conservation Service. The CCD promotes conservation through BMPs and assists Clark County residents by providing land management workshops and outreach activities. The CCD works directly with landowners in the Salmon Creek watershed to develop conservation farm plans for individual properties.

At the time of publication, the CCD had received a grant (G1100183) from Ecology for a project titled "Salmon Creek Water Quality BMP Implementation." This grant provides technical and financial assistance to livestock owners along Salmon Creek and its tributaries. Funding was provided through the Centennial Clean Water Fund and riparian plantings are an eligible BMP under this funding agreement. The CCD will continue this program for the life of the grant (June 30, 2014 expiration).

Clark County

EPA rules require local governments to develop programs to control stormwater pollution. Ecology issued an NPDES Phase I Municipal Stormwater Permit to Clark County in January 2007, and revised it in June 2009 and October 2010. Clark County fulfills the requirements for the Municipal Stormwater permit, reducing pollutants to the maximum extent practicable and meeting Washington State requirements to use all known, available and reasonable treatment by performing its Stormwater Management Program.

The stormwater program's primary activities include watershed assessment; planning and building stormwater capital improvements; monitoring; public education and outreach; regulation of development projects; enforcement of county water quality rules; and stormwater system maintenance.

The county stormwater development regulations help maintain groundwater recharge and summer base flow by requiring that development projects use stormwater infiltration where feasible. Infiltration into ground water helps maintain the hydrologic regime of the watershed, similar to natural conditions.

Environmental regulations enforced by Clark County are a primary tool for protecting riparian forests. These include a Habitat Conservation Ordinance, a Wetland Protection Ordinance, the Clark County Shoreline Master Program, and State Environmental Policy Act (SEPA). These protections should allow riparian forests to attain shade levels proposed by the TMDL.

The county also conducts work to identify sites where riparian forest restoration projects are a priority under the Stormwater Needs Assessment Program. This, in turn, informs programs that acquire land or make improvements to county land to better target their actions.

In spring 2009, Clark County Community Planning began working with residents, businesses, and property owners to develop a sub-area plan for the Salmon Creek area. The plan will include a vision for the area and targeted projects that can be built in the next six years. The plan will include an environmental component to promote responsible development that protects, maintains and enhances sensitive areas, open space, parks, and public areas.

Clark Public Utilities

Clark Public Utilities (CPU) is a customer-owned utility providing electric and water service in Clark County. The agency currently provides water service to around 30,000 homes and businesses. To effectively protect the supply of high-quality drinking water, CPU strives to maintain or improve both the quality and quantity of water resources. The agency works with local property owners and government agencies to improve the water in Salmon Creek and its tributaries. Work in the watershed includes planting trees to add shade, stabilizing streambanks to improve shoreline habitat, and building fences on farms to keep livestock away from the stream.

At the time of publication, CPU had received a grant (G1100161) from Ecology for a project titled "Salmon Creek Riparian Restoration." This grant provides assistance to streamside landowners to plant trees and shrubs in the riparian corridor along Salmon Creek and its tributaries. Funding was provided through the federal Clean Water Act Section 319 Nonpoint Source Fund, and riparian plantings are an eligible BMP under this funding agreement. CPU will continue this program for the life of the grant (March 31, 2014 expiration).

Lower Columbia Fish Recovery Board

The Lower Columbia Fish Recovery Board (Board) is comprised of representatives from the legislature; city and county governments; the Cowlitz Tribe; private property owners; hydro-project operators; the environmental community; and concerned citizens. State law directs the Board to participate in the development and implementation of a regional fish recovery plan, assess the factors for decline of salmon and steelhead on a "stream-by-stream" basis, and implement the local government responsibilities for habitat restoration and preservation.

Salmon Creek Watershed Council

The Salmon Creek Watershed Council (SCWC) was formed in 2006 to provide a forum for residents of Clark County to participate and partner for "on the ground" restoration, water quality, and advocacy of the Salmon Creek Watershed. The SCWC has a board of directors drawn from Clark County citizens, Salmon Creek landowners, businesses, and public agencies that have an interest in restoring the Salmon Creek Watershed. Activities in the watershed include exotic species removal, tree planting, and education and outreach activities.

Washington State Department of Ecology

The Washington State Department of Ecology (Ecology) protects, preserves, and enhances Washington's environment and promotes the wise management of the state's air, land, and water. Ecology has been delegated authority under the Federal Clean Water Act by EPA to establish water quality standards, administer the NPDES program, and enforce water quality regulations. Enforcement activities fall under RCW Chapter 90.48, Water Pollution Control.

Ecology will lead the coordination effort to implement the *Salmon Creek Temperature TMDL*. In order to gauge the progress of the implementation plan, Ecology will convene meetings of the watershed partners in order to share information on the state of water quality in the watershed and status of implementation activities. Accomplishments; challenges; water quality data; regulatory changes; new and innovative concepts; planned activities; and funding sources will be discussed to evaluate the overall status of the TMDL.

Washington State Department of Fish and Wildlife

The Washington Department of Fish and Wildlife (DFW) serves Washington's citizens by protecting, restoring and enhancing fish and wildlife and their habitats, while providing sustainable fish and wildlife-related recreational and commercial opportunities. The DFW implements the Washington State Hydraulic Code (RCW 77.55), which requires approval of actions by landowners in waterways of the state. The DFW also participates with other state agencies in implementing the Forest and Fish Rules with regard to Road Maintenance and Abandonment Plans (RMAPs).

Washington State Department of Natural Resources

The Washington State Department of Natural Resources (DNR) is responsible for regulating and protecting forest land resources under the state Forest Practices Act, RCW 76.09. This act stipulates that "a viable forest products industry is of prime importance to the state's economy; that it is in the public interest for public and private commercial forest lands to be managed consistent with sound policies of natural resource protection; that coincident with maintenance of a viable forest products industry, it is important to afford protection to forest soils, fisheries, wildlife, water quantity and quality, air quality, recreation, and scenic beauty." Oversight of RCW 76.09 is accomplished by the Washington Forest Practice Board and rules found in Chapter 222, Washington Administrative Code and Forest Practices Board Manual. The Forest Practices Board Manual is an advisory technical supplement to the forest practices rules.

The state's forest practices rules were developed with the expectation that the stream buffers and harvest management prescriptions were stringent enough to meet state water quality standards for temperature and turbidity, and provide protection equal to what would be required under a TMDL. As part of the 1999 Forest and Fish Report agreement, new forest practices rules for roads were also established. These new road construction and maintenance standards are intended to provide better control of road-related sediments, provide better stream bank stability protection, and meet current BMPs.

In addition to its regulatory responsibilities, DNR is a major landowner in Washington State. There is approximately 5.6 million acres of "state lands". Much of this (3 million acres) is state trust land that provides revenue to help pay for construction of public schools, universities, and other state institutions, and funds services in many counties. Forest harvest of state lands must follow forest practice rules.

Washington State Department of Transportation

The Washington State Department of Transportation (SWDOT) implements their NPDES Municipal Stormwater Permit and Stormwater Management Program Plan (SWMPP) in all applicable Phase I and II coverage areas, and implements the Highway Runoff Manual statewide. Implementation of the permit includes, but is not limited to, the following:

- Discharge inventory and mapping.
- Illicit Discharge Detection and Elimination (IDDE).
- Stormwater design per the WSDOT Highway Runoff Manual (stormwater BMP design manual equivalent to Ecology's Stormwater Management Manuals).
- Water quality monitoring (at selected sites statewide per the Permit requirements).
- Stormwater BMP retrofit program.
- Highway maintenance program.

Between 1995 and 2009, WSDOT was regulated under Ecology's Phase 1 Municipal Stormwater permits. WSDOT's current permit was issued in February 2009 and modified in May 2010. WSDOT's Stormwater Management Program Plan (SWMMP) was updated in 2009.

Pollution sources and organizational actions, goals, and schedules

Activities to address pollution sources

To reduce temperatures in the Salmon Creek watershed, it will be necessary to restore system-potential shade to Salmon Creek and its tributaries. Organizations will explore options and opportunities to continue temperature reduction efforts through increased riparian shading as outlined in Table 5. Activities that maintain or increase the amount of flow in the creek, or that return riparian function or restore hydrologic function and hydraulic continuity, would also reduce stream temperatures.

Table 5. Cleanup Partners and Recommended Temperature Implementation Actions

Organization	Implementation Goal	Activity	Priority	Schedule
City of Battle Ground	Effective stormwater management that reduces MS4 pollutant discharges to the maximum extent practicable and meets state AKART requirements.	Implement the Stormwater Management Program under the Phase 2 Municipal Stormwater Permit.	1	Ongoing
	Ensure zoning or land use changes adjacent to Salmon Creek tributaries result in effective shade.	Implement the Clark County Shoreline Master Program (SMP).	4	Ongoing with SMP update planned for adoption in late 2011 or early 2012
	Enhance/protect riparian habitat along Salmon Creek tributaries.	Incorporate shade curve allocations in City sponsored riparian and streambank enhancement projects.	3	Dependent on available funding
	Restore riparian areas of Salmon Creek and tributaries needing effective shade.	Consider public or private funding for riparian and streambank enhancement projects.	5	Dependent on available funding
	Educate stream adjacent landowners on benefits of a healthy riparian corridor.	Coordinate with Cleanup Partners to distribute materials developed by other entities on the ecological benefits of healthy riparian corridors.	2	Ongoing

Table 5 cont'd

Organization	Implementation Goal	Activity	Priority	Schedule
Clark Conservation District	Enhance/protect riparian habitat along Salmon Creek and tributaries.	Provide assistance to landowners to incorporate shade curve allocations in riparian and streambank enhancement projects.	1	Ongoing
	Prioritize potential riparian projects	Inventory riparian areas of Salmon Creek	1	Dependent on available funding
	Eliminate agricultural impacts along Salmon Creek and tributaries.	Work with stream-adjacent agricultural producers to exclude livestock access from riparian areas.	2	Ongoing
	Educate stream adjacent landowners on benefits of a healthy riparian corridor.	Coordinate with Cleanup Partners to distribute materials developed by other entities on the ecological benefits of healthy riparian corridors.	3	As funding and educational materials become available.
	Restore riparian areas of Salmon Creek and tributaries needing effective shade.	Consider public or private funding for District sponsored riparian and streambank enhancement projects.	3	Ongoing by 2015
Clark County	Effective stormwater management that reduces MS4 pollutant discharges to the maximum extent practicable and meets state AKART requirements.	Implement the Stormwater Management Program under the Phase 1 Municipal Stormwater Permit.	1	Ongoing
	Assess riparian conditions to identify high priority restoration projects.	Conduct the Stormwater Needs Assessment Program.	1	Ongoing, dependant on available funding
	Complete projects to enhance or restore riparian forest.	Conduct the Stormwater Capital Improvement Program	1	Ongoing, dependant on available funding
	Protect, manage and restore riparian forest for shade goals through land acquisition and restoration.	Legacy Lands Program	1	Ongoing, dependant on available funding
	Protect and restore riparian forest.	Incorporate shade curve allocations in county sponsored riparian planting and enhancement projects.	1	Begin upon TMDL approval from EPA
	Preserve riparian forest.	Enforce Habitat Conservation rules, Chapter 40.440 CCC; Enforce Wetland Protection rules, Chapter 40.450 CCC; Apply SEPA under Chapter 40.570 CCC to non-exempt development projects.	1	Ongoing

Table 5 cont'd

Organization	Implementation Goal	Activity	Priority	Schedule
Clark County cont'd	Preserve and restore riparian forest.	Implement the Clark County Shoreline Master Program (SMP); Follow Clark County Comprehensive Plan.	1	Ongoing with SMP update planned for adoption in late 2011 or early 2012
Clark Public Utilities	Enhance/protect riparian habitat along Salmon Creek and tributaries.	Utility sponsored riparian and streambank enhancement projects.	1	Ongoing, as funding becomes available
	Educate stream adjacent landowners on benefits of a healthy riparian corridor.	Coordinate with Cleanup Partners to distribute materials developed by other entities on the ecological benefits of healthy riparian corridors.	2	As funding and educational materials become available
	Assess riparian conditions to identify high priority restoration projects.	Coordinate with Clark County and the Clark Conservation District with this assessment.	1	Ongoing
	Eliminate agricultural impacts along Salmon Creek and tributaries.	Coordinate with Clark Conservation District and work with stream-adjacent property owners on livestock exclusion in riparian areas.	2	Ongoing, dependent upon available funding
	Restore riparian areas of Salmon Creek and tributaries needing effective shade.	Consider public or private funding program opportunities for riparian and streambank enhancement projects.	1	Ongoing, dependent upon available funding
Lower Columbia Fish Recovery Board	Enhance/protect riparian habitat along Salmon Creek and tributaries.	Incorporate shade curve allocations in LCFRB sponsored riparian and streambank enhancement projects.	1	Begin upon TMDL approval from EPA
	Restore riparian areas of Salmon Creek and tributaries needing effective shade.	Consider public or private funding program opportunities for riparian and streambank enhancement projects.	1	Ongoing, dependent upon available funding
Salmon Creek Watershed Council	Enhance/protect riparian habitat along Salmon Creek and tributaries.	Incorporate shade curve allocations in Council sponsored riparian and streambank enhancement projects.	1	Ongoing

Table 5 cont'd

Organization	Implementation Goal	Activity	Priority	Schedule
Washington State Department of Ecology	Convene adaptive management process for Salmon Creek.	Schedule and facilitate adaptive management meetings.	5	Annually for three years and at three to five-year intervals
	Ensure critical areas or land use changes adjacent to Salmon Creek and tributaries result in effective shade.	Condition SEPA reviews and permit approvals on shade curve recommendations.	4	Begin upon TMDL approval from EPA
	Provide funding for Salmon Creek riparian projects improving effective shade.	Facilitate annual funding cycles; provide assistance with project development and funding application question.	1	Ongoing
	Eliminate non-regulated discharges to Salmon Creek and tributaries.	Issue and condition NPDES water quality permits.	2	Ongoing
	Eliminate illegal water withdrawals from Salmon Creek and tributaries.	Respond to complaints provided to Southwest Region Water Resources Program regarding suspected illegal water withdrawals.	3	Ongoing
	Compliance with Water Pollution Control Act (RCW 90.48).	Exercise enforcement authority where needed.	3	Ongoing
Washington State Department of Fish and Wildlife	Ensure land use changes adjacent to Salmon Creek and tributaries result in effective shade.	Acknowledge shade curve allocations in Hydraulic Project Approval reviews.	1	Ongoing
	Enhance/protect riparian habitat along Salmon Creek and tributaries	Incorporate shade curve allocations in Department sponsored riparian planting and streambank enhancement project	2	Ongoing
Washington State Department of Natural Resources	Ensure forest practice application approvals for private and state timberlands adjacent to Salmon Creek and tributaries result in effective shade.	Increased level of review and/or scrutiny of Salmon Creek adjacent harvests to ensure compliance with Forest Practice Rules (RCW 76.09 and WAC 222).	1	Ongoing
		Exercise enforcement authority where needed.		
Washington State Department of Transportation	Effective stormwater management that meets Municipal Stormwater General Permit requirements.	Implement all required elements under the Municipal Stormwater General Permit.	1	Ongoing

SEPA/Planning standard language

Cleanup Partners, including Ecology, will consider the goals for this TMDL and incorporate the major scientific principals during State Environmental Policy Act (SEPA) and other local land use planning reviews. The SEPA lead agencies and Cleanup Partner reviewers should consider the load allocations outlined in this TMDL as they consider environmental impacts and alternatives of proposed actions in the Salmon Creek watershed. Land-use planners and project managers should consider findings and actions in this TMDL to help prevent new land uses from violating water quality standards. Ecology recently published a focus sheet on how TMDLs play a role in SEPA impact analysis, threshold determinations, and mitigation (www.ecy.wa.gov/biblio/0806008.html). Additionally, the TMDL should be considered in the issuance of land use permits by local authorities.

Measuring Progress toward Goals

Evaluating progress is an important component for any monitoring program. Monitoring is important for keeping track of what activities have been done, determining the success or failure of actions, and evaluating if water quality standards are achieved. Monitoring should continue after water quality standards are obtained to ensure implementation measures continue to be effective and that water quality standards continue to be met.

Ecology's TMDL coordinator will work with the organizations outlined in this document to convene an advisory group from the Cleanup Partners to track implementation activities occurring in the watershed. Depending on Ecology's resources and current implementation tracking tools, the coordinator will consider using an Excel© spreadsheet, Ecology's TMDL Management Database, geographic information system (GIS) mapping, or other tool to track where implementation has occurred or is planned. Cleanup Partners will work together to monitor progress toward these goals, evaluate successes, obstacles, and changing needs, and make adjustments to the implementation strategy as needed.

Compliance with this TMDL will be based on meeting in the mainstem the designated aquatic life uses of *core summer salmonid habitat.* The highest 7-DADMax temperature must not exceed 16°C (60.8°F) more than once every ten years on average. For the Salmon Creek tributaries, compliance will be meeting the designated aquatic life uses of *salmonid spawning, rearing, and migration,* and *salmonid rearing and migration only*. The highest 7-DADMax temperature must not exceed 17.5°C (63.5°F) more than once every ten years on average. If the shade curve targets are not met, but the water quality standards are met, the purpose of this TMDL will be satisfied.

Compliance with assigned action items for municipal stormwater permittees constitutes compliance with the goals of this TMDL and assigned categorical WLA.

Performance measures and targets

The activities listed in Table 5 of this implementation plan need to be tracked to determine what activities were performed and where; whether the actions meet objectives and could be applied elsewhere; what practices should be considered for adaptive management, if necessary; whether resource limitations or some other factor are preventing some actions from occurring; and whether this implementation plan is adequate to meet water quality standards.

Each Cleanup Partner should track the progress they have made on implementation. Partners conducting riparian revegetation/restoration projects or installing best management practices (BMPs) are responsible for monitoring plant survival rates and performing maintenance of related improvements. Partners with enforcement authority are also responsible for following up on any enforcement actions they have taken to comply with this TMDL.

Significant implementation to restore riparian areas and plant trees is already occurring or is planned in the watershed. The implementation focus should be on tributaries first and the mainstem Salmon Creek second. Therefore, it is expected that streams in this TMDL study area will achieve water quality standards by 2110.

An interim target of calendar year 2035 has been established by Ecology for revegetating 50 percent of the stream segments that are less than 7m in width and 20 percent of the stream segments that are greater than 7m. The remainder of stream segments less than 7m will be revegetated by 2050. Other metrics can be considered as recommended through the Adaptive Management process.

Effectiveness monitoring plan

Effectiveness monitoring is performed to determine if the interim targets and overall water quality standards goal have been met after the measures described in the water quality implementation plan have been installed and are functioning properly. The relatively long period of time needed to establish mature vegetation throughout Salmon Creek and its tributaries will require interim monitoring to determine the progress being made.

Before either interim or effectiveness monitoring is performed, a quality assurance project plan (QAPP) will be prepared. The QAPP should follow Ecology guidelines (Lombard and Kirchmer, 2004), paying particular attention to consistency in sampling and analytical methods. Monitoring objectives should clearly be established to ensure that sampling results will meet those objectives. Monitoring personnel will consult with the original TMDL to determine critical parts of the implementation plan and to verify critical locations. A strategy should be developed as part of any water quality monitoring QAPP to verify that stormwater outfalls are not a significant heat source during the critical summer months. Separate QAPPs should be developed for the interim and effectiveness monitoring efforts as they should have different monitoring objectives.

Interim monitoring may be accomplished several ways, including as part of existing Cleanup Partner or other entity monitoring efforts; as part of an ad-hoc grant or loan monitoring request; or as a special project request through Ecology's Southwest Regional Office and performed by Ecology's Environmental Assessment Program. Interim monitoring is recommended every ten years. Continuous-recording temperature devices should be used and measurements made between July 1 and September 15 to capture critical conditions. At a minimum, a downstream location near NW 36th Avenue and an upstream location near Caples Road should be sampled.

Interim monitoring should also document physical changes in the Salmon Creek system. As streamside areas are revegetated and riparian canopy is reestablished, documentation of these improvements becomes important for the effective shade assessment.

To assess progress of TMDL implementation measures, an assessment or "report card" based upon a ten-year interval should be employed. This report card could suffice as a form of implementation monitoring. The report card should track the following: type and extent of existing vegetation; date and location of new vegetation planted since the last report card; plant survival rates; maintenance of improvements; areas where riparian erosion is occurring; degree of temperature improvement (if available); and percent effective-shade improvement (if available). A random approach to assess both revegetated reaches and maintenance of existing riparian areas, using a repeatable remote sensing approach, would also provide valuable information for inclusion in the report card. Utilizing the report card approach to assess other implementation measures besides riparian vegetation and condition, such as the actions identified in Table 5, is also recommended.

The report card can be used as part of the adaptive management process to manage riparian condition; identify where additional improvements are warranted; identify where vegetation is not growing as expected; deploy ad-hoc temperature measurement opportunities; and recommend alternative channel improvement measures in areas where erosion threatens planting projects. Individual stormwater permit holders will be responsible for meeting the requirements of their permits, independent of the report card.

Effectiveness monitoring will be performed to compare the results from BMP implementation against attainment of water quality standards. Information from the ten-year report cards will be compiled and evaluated. Water quality monitoring in Salmon Creek and tributaries will be performed such that comparisons with the initial 303(d) listing information can be made. Spatial resolution for continuous temperature loggers should be at a fairly dense level. A minimum of 10-15 stations is reasonable and cost-effective. If the results from the effectiveness monitoring show that water quality standards are now being met, this information should be provided to Ecology through the Water Quality Assessment process.

Adaptive management

Natural systems are complex and dynamic. The way a system will respond to human management activities is often unknown and can only be described in terms of probabilities or possibilities. Adaptive management involves reviewing implementation monitoring data, evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings. In the case of TMDLs, Ecology uses adaptive management to assess whether the actions identified as necessary to solve the identified pollution problems are the correct ones and whether they are working. As we implement these actions, the system will respond, and it will also change. Adaptive management allows us to fine-tune our actions to make them more effective, and to try new strategies if we have evidence that a new approach could help us to achieve compliance.

Ecology will use adaptive management when water monitoring data show that the TMDL targets are not being met or implementation activities are not producing the desired result. In that event, further analysis of monitoring data and pollution sources would likely identify additional controls that could be implemented to gain the desired pollution reductions. Data gaps will be identified which, when filled, may lead to new information about other potential pollution sources. Further source identification activities and control measures will follow. While adaptive management primarily focuses on necessary adjustments or revisions to implementation actions, it will also be used to draw attention to and/or enhance measures that are working and achieving the desired results.

The advisory group of Cleanup Partners will meet every year initially for the first three years and at three to five-year intervals following federal approval of the TMDL. This effort will focus on the review of results from recommended implementation efforts. Documented failure to meet water quality standards for temperature will require the development of additional controls and source identification procedures.

A feedback loop (Figure 10) consisting of the following steps shows how the adaptive management process works:

Step 1. The activities in the water quality implementation plan are put into practice.
Step 2. Programs and BMPs are evaluated for technical adequacy of design and installation.
Step 3. The effectiveness of the activities is evaluated by assessing new monitoring data and comparing it to the data used to set the TMDL targets.
- Step 3a. If the goals and objectives are achieved, the implementation efforts are adequate as designed, installed, and maintained. Project success and accomplishments should be publicized and reported to continue project implementation and increase public support.
- Step 3b. If not, then BMPs and the implementation plan will be modified or new actions identified. The new or modified activities are then applied as in Step 1.

It is ultimately Ecology's responsibility to assure that implementation is being actively pursued and water standards are achieved. Adaptive management is critical for project success.

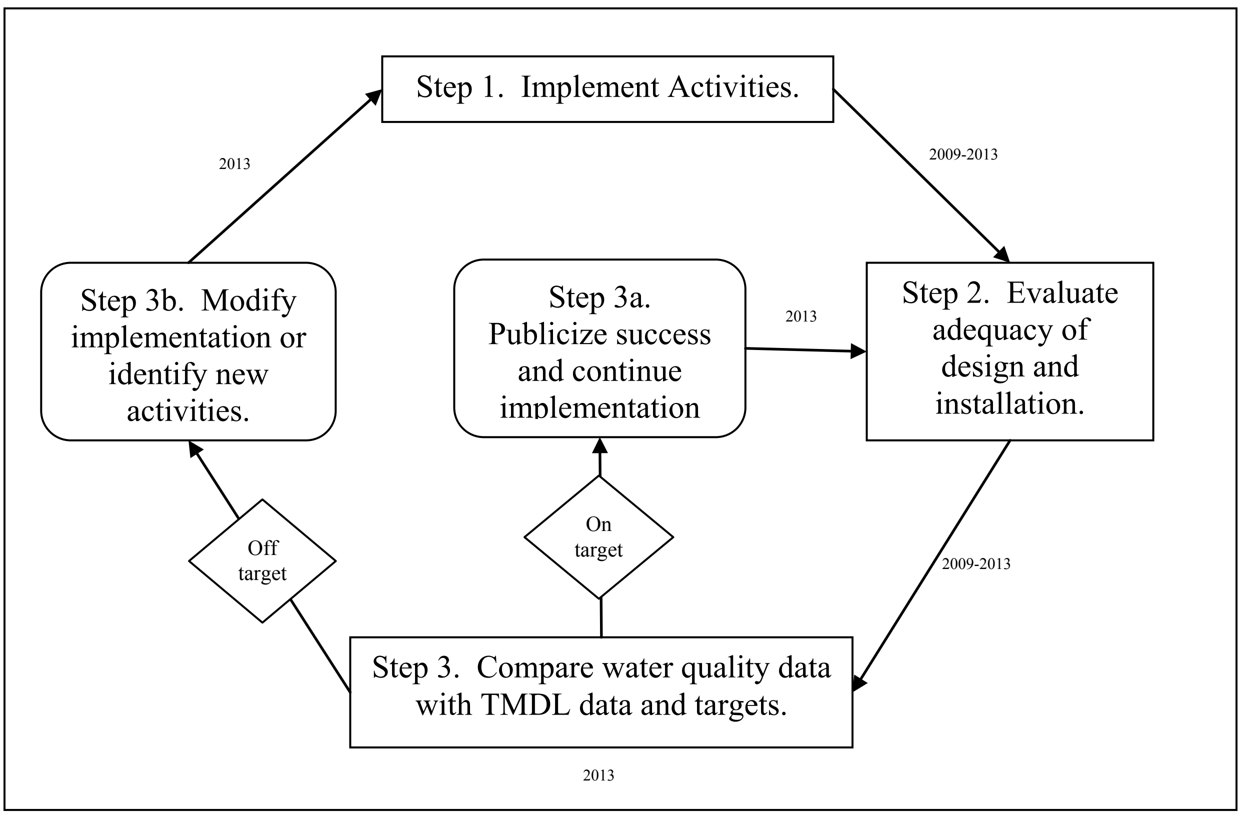

Figure 10. Feedback loop for determining the need for adaptive management.

Should water quality standards be achieved before the load allocations are achieved, then the TMDL will be considered to be satisfied.

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Funding Opportunities

A variety of potential funding sources exist for the water quality improvement projects in the Salmon Creek basin. There is also the potential for collaborating with other planning processes to maximize efficiency. Implementation activities are varied, and funding sources appropriate for some projects may not be suitable for others.

Public sources of funding are administered by federal and state government programs. Private sources of funding normally come from private foundations. Foundations provide funding to nonprofit organizations with tax-exempt status. Forming partnerships with government agencies, nonprofit organizations, and private businesses can effectively maximize funding opportunities.

Potential funding sources include the following:

Centennial Clean Water Fund, Section 319 Nonpoint Source Fund, Washington State Water Pollution Control Revolving Loan Fund

The Centennial Clean Water Fund (CCWF), Section 319 Nonpoint Source Fund (Section 319) and the Washington State Water Pollution Control Revolving Loan Fund (SRF) are three funding sources managed by Ecology through one combined application program. Funds are available to public entities and some not-for-profit organizations (Section 319 only) as grants or low-interest loans. Grants require a 25-percent local match and they may be used for education/outreach, technical assistance, specific water quality projects, or as seed money to establish various kinds of water quality related programs or program components. Grants may not be used for capital improvements to private property without an easement being given; but riparian revegetation, riparian fencing, and alternative stock water projects are all eligible for funding consideration. Low-interest loans are available to public entities for all the above uses.

Coastal Zone Protection Fund

Since July 1998 Ecology has deposited funds from water quality penalties issued under the Water Pollution Control Act, Chapter 90.48 RCW into a sub-account of the Washington State Coastal Protection Fund (also referred to as Terry Husseman grants). A portion of this fund is made available to regional Ecology offices to support on-the-ground projects to perform environmental restoration and enhancement. Local governments, tribes, and state agencies must propose projects through Ecology staff. Stakeholders with projects that will reduce bacteria pollution are encouraged to contact their local TMDL Coordinator to determine if their project proposal is a good candidate for Coastal Zone Protection funding.

Columbia Land Trust

The mission of the Columbia Land Trust is to conserve the most important lands in the Columbia River region and then steward those lands forever. The trust has strategic organization plans and land conservation plans which identify signature landscapes and vital habitats to conserve. The trust acquires land or development rights (easements) on land through direct donations and by purchasing land outright. To date, the trust has conserved more than 9,800 acres of natural areas, farm and ranch lands, forests and critical habitat in Oregon and Washington.

Community Salmon Fund

In 2003, the National Fish and Wildlife Foundation (NFWF) and the Washington State Salmon Recovery Funding Board (SRFB) developed the SRFB Community Salmon Fund as a source of grants for on-the-ground restoration projects that engage private landowners and broaden local support for salmon recovery. Community Salmon Fund grant rounds are run in nine regional and sub-regional areas, with each area having its own Request for Proposals and unique timeline.

The overall goals of the Community Salmon Fund program are to: fund salmon habitat protection and restoration projects that have a substantial benefit to watershed health and are consistent with local salmon recovery strategies; engage landowners, business owners and community groups to carry out these projects and care for them in the long run; stimulate creativity and leadership among various constituencies to address conservation needs; and target constituencies that can be particularly helpful in salmon recovery, especially farmers, rural forest landowners, suburban homeowners, and the business community.

Conservation Reserve Enhancement Program

This federal program administered by NRCS provides incentives to restore and improve salmon and steelhead habitat on private land. This is a voluntary program to establish forested buffers along streams where streamside habitat is a significant limiting factor for salmonids. In addition to providing habitat, the buffers improve water quality and increase stream stability. Land enrolled in CREP is removed from production and grazing under 10-15 year contracts. In return, landowners receive annual rental, incentive, maintenance and cost share payments. The annual payments can equal twice the weighted average soil rental rate (incentive is 110 percent in areas designated by the Growth Management Act). The Clark CD administers this program in conjunction with the U.S. Department of Agriculture, Natural Resources Conservation Service.

Forestry Riparian Easement Program

This voluntary program, administered through the Washington State Department of Natural Resources, Small Forest Landowner Office, acknowledges the importance of small landowners and their contribution to protect wildlife habitat. The intent of the program is to help small forest landowners keep their land in forestry. The Forestry Riparian Easement Program partially compensates landowners for not cutting or removing qualifying timber under a 50-year easement. The landowner still owns property and retains full access, but has "leased" the trees and their associated riparian function to the state.

Rivers and Habitat Open Space Program

This voluntary program, formerly known as Riparian Open Space, is administered by the Washington State Department of Natural Resources (DNR), Small Forest Landowner Office, to acquire (through purchase or donation) an interest in lands within unconfined channel migration zones and habitat of threatened and endangered species as designated by the Forest Practices Board. The DNR may acquire permanent conservation easement over such lands.

Salmon Recovery Funding Board Program

In 1999, the Washington State Legislature created the Salmon Recovery Funding Board, located in the Washington State Office of Interagency Committee. The board provides grants to protect or restore salmon habitat and assist related activities. Composed of five citizens appointed by the Governor, and five state agency directors, the board brings together the experiences and viewpoints of citizens and the major state natural resource agencies. The board funds projects that protect existing, high quality habitats for salmon and that restore degraded habitat to increase overall habitat health and biological productivity. The board also awards grants for feasibility assessments to determine future projects and for other salmon related activities.

Projects may include the actual habitat used by salmon and the land and water that support ecosystem functions and processes important to salmon. Applicants must submit their proposals to their local lead entity rather than directly to the Salmon Recovery Funding Board. The lead entity is responsible for assembling a ranked list of projects from its area and submitting them to the Salmon Recovery Funding Board for consideration.

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Summary of Public Involvement Methods

Ecology developed a web site for the *Salmon Creek Temperature TMDL* and used the web site as the primary means of distributing information to the public. Ecology also maintained an email distribution list of individuals and organizations with a particular interest in the watershed and sent the group information about clean-up activities, when appropriate.

Individual discussions and meetings were held with the key cleanup partners and entities responsible for implementation to develop the language and targets in this implementation plan.

Ecology held a public meeting on June 15, 2011 utilizing the Washington State Department of Fish and Wildlife Meeting Room, in Vancouver, WA, to introduce the study and process for developing this TMDL.

A 30-day public comment period for the draft version of this report was held from June 6, 2011 to July 5, 2011 and a copy of the draft report for public review was placed in the Three Creeks Community Library in Vancouver, WA. Display ads were also placed in the Columbian and Battleground Reporter newspapers. Notification of the meeting and public comment period was also shown on Ecology's Internet Public Involvement Calendar.

Responding to a comment received from the U.S. EPA during the 30-day public review and comment period, Ecology added WSDOT to the categorical stormwater WLA in this TMDL. Because WSDOT was not originally included as a TMDL stakeholder and was not following the development of this TMDL, they were given a special opportunity between August 24, 2011 and September 15, 2011 to review the draft TMDL and comment. Responses to comments received from the US. EPA and WSDOT are in Appendix B.

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Appendices

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Appendix A. Glossary, acronyms, and abbreviations

Glossary

Bankfull stage: Formally defined as the stream level that "corresponds to the discharge at which channel maintenance is most effective. That is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels" (Dunne and Leopold, 1978). The bankfull channel is filled by moderate sized flood events that typically occur every one and a half years.

Bankfull width: The width of the bankfull channel. Numerous guidance documents give good instructions on bankfull width measurement techniques. Some of these are *Applied River Morphology* (Rosgen, 1996), *Stream Inventory Handbook; Level I and II* (USFS, 2001), and *TFW Monitoring Program Method Manual for the Stream Temperature Survey* (Rashin et al., 1999).

Best management practices (BMPs): Physical, structural, or operational practices that, when used singularly or in combination, prevent or reduce pollutant discharges.

Char: Char (genus *Salvelinus*) are distinguished from trout and salmon by the absence of teeth in the roof of the mouth, presence of light colored spots on a dark background, absence of spots on the dorsal fin, small scales, and differences in the structure of their skeleton. (Trout and salmon have dark spots on a lighter background.)

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Critical condition: When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses. For steady-state discharges to riverine systems, the critical condition may be assumed to be equal to the 7Q10 (see definition) flow event unless determined otherwise by the department.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Dilution factor: The relative proportion of effluent to stream (receiving water) flows occurring at the edge of a mixing zone during critical discharge conditions as authorized in accordance with the state's mixing zone regulations at WAC 173-201A-100. http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-020.

Diurnal: Of, or pertaining to, a day or each day; daily. (1) Occurring during the daytime only, as different from nocturnal or crepuscular, or (2) Daily; related to actions which are completed in the course of a calendar day, and which typically recur every calendar day. (For example, diurnal temperature rises during the day and falls during the night.)

Effective shade: The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of a stream or other defined area.

Exceeded criteria: Did not meet criteria.

Fecal coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Hyporheic: The area beneath and adjacent to a stream where surface water and groundwater intermix.

Load allocation: The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

Municipal separate storm sewer systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (1) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, stormwater, or other wastes and (2) designed or used for collecting or conveying stormwater; (3) which is not a combined sewer; and (4) which is not part of a Publicly Owned Treatment Works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

National Pollutant Discharge Elimination System (NPDES): National program for issuing and revising permits, as well as imposing and enforcing pretreatment requirements, under the Clean Water Act. The NPDES permit program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Near-stream disturbance zone (NSDZ): The active channel area without riparian vegetation that includes features such as gravel bars.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to, atmospheric deposition; surface water runoff from agricultural lands; urban areas; or forest lands; subsurface or underground sources; or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System Program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Phase I stormwater permit: The first phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to medium and large municipal separate storm sewer systems (MS4s) and construction sites of five or more acres.

Phase II stormwater permit: The second phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to smaller municipal separate storm sewer systems (MS4s) and construction sites over one acre.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than five acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Primary contact recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Reach: A specific portion or segment of a stream.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Any fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

Surrogate measures: To provide more meaningful and measurable pollutant loading targets, EPA regulations [40 CFR 130.2(i)] allow other appropriate measures, or surrogate measures in a TMDL. The Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program (EPA, 1998) includes the following guidance on the use of surrogate measures for TMDL development:

When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional "pollutant," the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not.

System-potential channel morphology: The more stable configuration that would occur with less human disturbance.

System-potential mature riparian vegetation: Vegetation that can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes.

System-potential riparian microclimate: The best estimate of air temperature reductions that are expected under mature riparian vegetation. System-potential riparian microclimate can also include expected changes to wind speed and relative humidity.

System-potential temperature: An approximation of the temperatures that would occur under natural conditions. System potential is our best understanding of natural conditions that can be supported by available analytical methods. The simulation of the system-potential condition uses best estimates of *mature riparian vegetation, system potential channel morphology, and system-potential riparian microclimate* that would occur absent any human alteration.

System potential: The design condition used for TMDL analysis.

Total maximum daily load (TMDL): A distribution of a substance in a water body designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Turbidity: A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

Wasteload allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

1-DMax or 1-day maximum temperature: The highest water temperature reached on any given day. This measure can be obtained using calibrated maximum and minimum thermometers or continuous monitoring probes having sampling intervals of 30 minutes or less.

7-DADMax or 7-day average of the daily maximum temperatures: The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days prior and the three days after that date.

7Q10 flow: A critical low-flow condition. The 7Q10 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every 10 years on average. The 7Q10 flow is commonly used to represent the critical flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q10 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

303(d) List: Section 303(d) of the federal Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited water bodies (ocean waters, estuaries, lakes, and streams) that fall short of state surface water quality standards, and are not expected to improve within the next two years.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10 percent of the data exists and below which 90 percent of the data exists.

Acronyms and abbreviations

Following are acronyms and abbreviations used frequently in this report.

BMPs	(See Glossary above)
DNR	Washington State Department of Natural Resources
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
NPDES	(See Glossary above)
TMDL	(See Glossary above)
WRIA	Water Resources Inventory Area

Units of Measurement

°C	degrees centigrade
deg	degree
°F	degrees Fahrenheit
ft	feet
m	meter

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Appendix B. Response to public comments

Ecology received two sets of comments to the *Salmon Creek Temperature Total Maximum Daily Load Water Quality Improvement Report and Implementation Plan*, May 2011 Draft, Publication No. 11-10-044. The comments received and responses are as follows:

Comments from Dave Ragsdale, U.S. Environmental Protection Agency, June 10, 2011 email response to Kim McKee

Comment 1:

Clarification was requested to why wasteload allocations were not being proposed for the MS4s and WSDOT?

Response:

A wasteload allocation is now proposed for the municipal stormwater general permit holders and WSDOT to be consistent with other recently published TMDLs. Although we do not expect stormwater to cause greater than a 0.3° C increase in Salmon Creek and violate temperature criteria, without a specified WLA, the default allocation would be zero. Zero heat discharge is impossible in this situation and since all water carries some amount of heat. Adhering to less than a 0.3^{o}C increase allows for the discharge to occur and water quality standards to be met.

Comment 2:

The report references future temperature monitoring is recommended. What would trigger this further study?

Response:

If stormwater were being discharged to Salmon Creek and its tributaries in larger quantities than current amounts during the critical summer season, this would trigger further study. Clark County will be developing a monitoring strategy as part of its municipal stormwater permit requirements and will identify a strategy for stormwater outfalls as part of their water quality monitoring quality assurance project plan.

Comment 3:

Since no wasteload allocations are proposed, the TMDL should at a minimum specify the monitoring needed for temp and flow by the dischargers under the general permit.

Response:

Same as Ecology response to Comment 1.

Comment 4:

Is there any progress to report on implementation of the 2001 TMDL?

Response:

This reference is to a fecal coliform bacteria and turbidity TMDL previously completed in January 2001. Implementation actions have been pursued as recommended in a Detailed Implementation Plan (DIP) completed in March 2005. Four agencies identified in the DIP have worked diligently to clean up Salmon Creek. They are Clark County, Clark County Public Health, Clark Public Utilities, and Clark Conservation District. Specific results from these efforts are described in Ecology Publication No. 09-10-087, available on the Internet.

Comment 5:

The commenter recommends including a table in the discussion to identify water segments that are impaired but not listed on the current 303(d) list.

Response:

A new table has been added to the report to identify those water segments. This information is now shown as Table 2.

Comment 6:

What is the width of the riparian area and the density of trees needed to meet the shade target?

Response:

Additional text has been provided. As shown in Figure 8, a density of 85% is needed to meet the shade target. A large riparian area was used to generate the shade target numbers to ensure that those targets are equivalent to the natural condition. In this case a width of 150 feet was used. However, for narrower streams, a narrower buffer of trees may be able to meet the shade target. Whether a shade target has been met can be verified by monitoring. A similar TMDL, developed by Ecology during 2011 for the Snoqualmie River, showed that a 79 foot buffer would result in a density of 81%.

The technical analysis performed under this TMDL did not recommend buffer widths associated with the load allocations. Buffer widths are an important consideration of any temperature improvement effort. In the absence of specific recommendations, they should be based upon existing regulatory requirements. For Salmon Creek and its tributaries, these include: Clark County's Critical Areas Ordinance and Shoreline Master Program requirements; Washington State Forest Practices Act rules and the Forest Practice Board Manual (applies to private and state-owned timberlands); city of Battleground ordinances codified in Title 18 Environmental Protection requirements (applicable for portions of Mill and Woodin Creeks); and if federal, state, or private funding is involved, specific requirements associated with these respective programs.

Comment 7:

Why isn't there a wasteload allocation proposed for the Washington State Department of Transportation?

Response:

Same as Ecology response to Comment 1.

Comments from Ken Stone, Washington State Department of Transportation, September 12, 2011 letter to Kim McKee

Overall Comment:

We question why stormwater point sources are required to receive wasteload allocations or even be a part of this TMDL implementation plan, given various statements in the report related to stormwater not being considered a significant source that impacts temperature. Based on these statements by Ecology and no site-specific quantifiable data to the contrary, we request that WSDOT be removed from this TMDL.

Response:

The U.S. Environmental Protection Agency provided guidance to TMDL development entities in 2002, which deals with the establishment of wasteload allocations (WLAs) and load allocations (LAs) for stormwater. This directive, known as the "Wayland memo" states "EPA expects TMDL authorities to make separate allocations to NPDES-regulated storm water discharges (in the form of WLAs) and unregulated storm water (in the form of LAs). EPA recognizes that these allocations might be fairly rudimentary because of data limitations and variability in the system."

While stormwater is not considered a significant contributing factor to thermal loading during the summer critical period, there may be summer storms, which do cause stormwater thermal wasteloads to Salmon Creek. Accordingly, WSDOT is given a WLA for their stormwater discharge in this TMDL.

Comment 1:

Text reference, page 25, second paragraph, first sentence: "Ecology does not consider stormwater discharges as significant direct sources of thermal pollution during the summer critical period."

In light of this statement, we question why stormwater point sources are required to receive wasteload allocations or even be a part of this TMDL implementation plan. Please refer to comment #2 below for additional information.

Response:

Same as Ecology response to Overall Comment above.

Comment 2:

Text reference page 25, second paragraph, last sentence: "Although thermal loadings from permitted stormwater are of minimal size, all NPDES-permitted discharges must be provided wasteload allocations."

To be consistent with the regulations and guidelines used to establish TMDLs, site specific data or information is needed that indicates WSDOT facilities are a significant source or contributor of the pollutant of concern. We feel it is Ecology's responsibility to characterize the sources of pollution and assign numeric WLAs on when there is credible information to support it. In the absence of site specific stormwater outfall data, a numeric WLA assigned to WSDOT is presumptuous and without just cause.

However, in the event new data or other actionable information should later reveal that WSDOT is a significant temperature source or contributor under certain conditions, it would be appropriate to assign WSDOT actions, or a numeric WLA if supported by site-specific, scientifically credible data, under the TMDL via the adaptive management process.

Response

Federal regulations state that it is reasonable to express allocations for NPDES-regulated stormwater discharges from multiple point sources as a single categorical wasteload allocation when data and information are insufficient to assign each source or outfall individual WLAs. Please refer to 40 C.F.R. § 130.2(i). Discharges from WSDOT facilities are included in the categorical WLA for permitted stormwater because although rare, summer stormwater discharges can and do occur.

Comment 3:

Text reference page 25, third paragraph, first bullet: "Cumulative stormwater discharges from all permitted sources may not cause the 7DADMax receiving water temperature to increase more than 0.3 degrees during the June – September critical period."

Considering that page 25, second paragraph, first sentence of the implementation plan states: "Ecology does not consider stormwater discharges as significant direct sources of thermal pollution during the summer critical period," we feel a numeric WLA for stormwater dischargers is not warranted based on comments #1 and 2. WSDOT further suggests that if Ecology determines WLA are warranted, they be assigned in the form of actions since site-specific data are not available to assign numeric WLAs.

If a numeric WLA will remain for WSDOT, suggest adding the following sentence to this TMDL implementation plan: "Compliance with assigned action items constitutes compliance with assigned WLAs."

Response

The numeric WLA will remain in this TMDL. However as you have suggested, text has been added on page 49 to acknowledge that compliance for municipal stormwater permittees, like WSDOT, is linked to completion of the action items identified in Table 5.

Comment 4:

Text reference page 25, third paragraph, second bullet: "All appropriate best management practices required in the stormwater permit for controlling thermal loadings to surface water are applied to the discharge to protect designated aquatic life uses."

Suggest replacing this action item with the following: "Compliance with the permit constitutes compliance with the goals of this TMDL." The action as previously stated is vague and this revision would provide clarity and consistency with the last sentence of the first paragraph under Current Stormwater Program and Monitoring on page 26 which states, "…it is expected that implementation of the NPDES permit-mandated stormwater control program will achieve compliance with targets for temperature," and the action item assigned to WSDOT in Table 5 on page 47.

Response

With the clarification provided to address Comment 4, this bullet is no longer necessary and has been eliminated.

Comment 5:

Text reference page 43, fourth paragraph: "The Washington State Department of Transportation (WSDOT) water quality program provides guidance and technical support to road planning, design, construction, and maintenance of state transportation projects. To achieve compliance with the federal Clean Water Act and state water quality laws, WSDOT prepares stormwater pollution prevention plans for major road projects, prepares annual NPDES compliance reports and plans, conducts mitigation stream restoration projects, and monitoring water quality."

Suggest the following replacement: "The Washington State Department of Transportation (SWDOT) implements their NPDES Municipal Stormwater Permit and Stormwater Management Program Plan (SWMPP) in all applicable Phase I and II coverage areas, and implements the Highway Runoff Manual statewide. Implementation of the permit includes, but is not limited to, the following:

- *discharge inventory and mapping,*
- *Illicit Discharge Detection and Elimination (IDDE),*

- *stormwater design per the WSDOT Highway Runoff Manual (stormwater BMP design manual equivalent to Ecology's Stormwater Management Manuals),*
- *water quality monitoring (at selected sites statewide per the Permit requirements),*
- *stormwater BMP retrofit program, and*
- *highway maintenance program."*

Response

The referenced text on page 43 has been revised to reflect this comment.

Comment 6:

Text reference page 43, fifth paragraph: "Since 1995, WSDOT has been regulated under Ecology's Phase I Municipal Stormwater General permit. In compliance with permit requirements, in 1997 WSDOT submitted a stormwater management plan (SWMP) to Ecology which identified six elements as having the highest priority: (1) construction of structural stormwater BMP facilities; (2) monitoring and research related to stormwater BMPs; (3) erosion and sediment control programs; (4) attaining full funding for operations and maintenance programs; (5) watershed-based mitigation strategies; and (6) water quality-related training. These elements continue to be high priorities for WSDOT to achieve."

Suggest the following revision as the current information is out-dated: "Between 1995 and 2009, WSDOT was regulated under Ecology's Phase 1 Municipal Stormwater permits. WSDOT's current permit was issued in February 2009 and modified in May 2010. WSDOT's Stormwater Management Program Plan (SWMMP) was updated in 2009."

Response

The referenced text on page 44 has been revised to reflect this comment.

Comment 7:

Text reference page 87, the section on Measuring Progress toward Goals.

Suggest revising this section to clarify who will be responsible for performing monitoring to assess progress toward meeting TMDL implementation plan goals. We believe Ecology should be named the responsible party for compliance monitoring.

Response

Ecology will inventory implementation projects and exercise its water quality regulatory authority where needed. Ecology may also conduct effectiveness monitoring after riparian plantings have naturalized. In addition, Ecology intends to conduct compliance monitoring in the future or might rely on existing data if it is available to assess compliance with the temperature TMDL. Ecology's ability to bear the full burden for monitoring is subject to budgetary limitations, similar to those facing other cleanup partners. Joint efforts to address monitoring needs are needed to reduce the financial impact on any one cleanup partner. Ecology welcomes monitoring participation by all stakeholder partners, including WSDOT.

Other Comments:

WSDOT has not performed a QA/QC check on the water quality or flow data presented in this report, nor have we re-computed the math behind derived values, and reserve the right to make corrections if errors are found at a later date.

Response

Comment noted.