WASHINGTON STATE
DEPARTMENT OF
E C O L O G Y

South Prairie Creek
Bacteria and Temperature
Total Maximum Daily Load
(Water Cleanup Plan)

Submittal Report

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(Water Cleanup Plan)

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Table of Contents

List of Figures

List of Tables

South Prairie Creek Bacteria and Temperature TMDL

Introduction

Section 303(d) of the federal Clean Water Act mandates that states establish Total Maximum Daily Loads (TMDLs) for surface waters that do not meet standards after application of technology-based pollution controls. The U.S. Environmental Protection Agency (EPA) has promulgated regulations (40 CFR 130) and developed guidance (EPA, 1991) for establishing TMDLs.

Under the Clean Water Act, each state develops standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses, such as cold water biota and drinking water supply, and criteria, usually numeric values, to achieve those uses. When a lake, river, or stream fails to meet water quality standards after application of required technology-based controls, the Clean Water Act requires the state to place the water body on a list of "impaired" water bodies, referred to as the 303(d) list after the Clean Water Act section number, and to prepare an analysis called a Total Maximum Daily Load.

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of both water quality problems and sources of the problems. The TMDL determines the loading capacity, which is the amount of a given pollutant that can be discharged to the water body and still meet standards, and the load and wasteload allocated among various sources. If the pollutant comes from a discrete source (referred to as a point source) such as a wastewater treatment plant discharge, that facility's share of the loading capacity is called a wasteload allocation. If it comes from a diffuse source (referred to as a nonpoint source) such as a residential development, that 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 regarding the causes of the water quality problem or a water body's loading capacity. The sum of the load and wasteload allocations and the margin of safety must be equal to or less than the loading capacity of the system.

Scope and Purpose of the South Prairie Creek TMDLs

This report presents TMDL analyses and recommendations for fecal coliform bacteria and temperature in South Prairie Creek and its tributaries. Figure 1 shows the study area. The 1996 and 1998 303(d) lists identify South Prairie Creek or its tributaries as impaired by fecal coliform bacteria, temperature, and copper. The fecal coliform bacteria listing was based on historical ambient monitoring conducted by Ecology. The original temperature listings on South Prairie Creek and its tributaries were based on data collected by the Muckleshoot Tribe. Subsequent monitoring by Ecology conducted under the present study indicates that much of the lower watershed exceeds the temperature standard. Finally, the copper listing for Wilkeson Creek, originally based on estimates rather than field data, was reevaluated in 2001. Golding and Johnson (2001) concluded that the creek remains in compliance with water quality standards during critical conditions and recommended that Wilkeson Creek no longer be listed for copper.
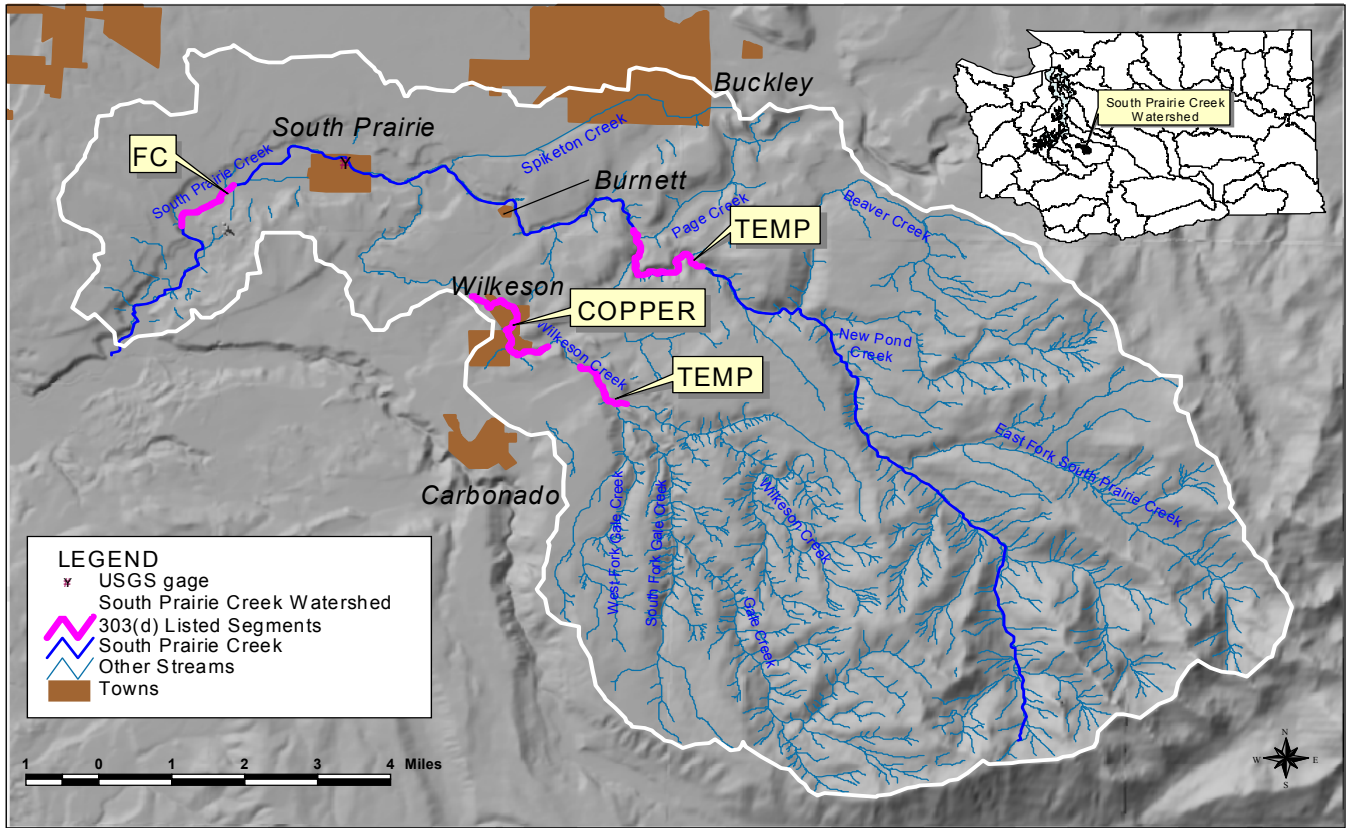
Figure 1. South Prairie Creek watershed with 303(d) listings.

Therefore, no copper TMDL was conducted. The fecal coliform bacteria and temperature analyses are presented in following sections of this report. Table 1 summarizes the water bodies addressed in this study.

Pollutants and Surrogate Measures

Fecal coliform bacteria are used by the state of Washington as indicators of pathogens associated with fecal contamination. Fecal pathogens are microorganisms capable of causing disease through ingestion or skin contact. Other indicators, such as *E. coli* and enterococci, have been evaluated as alternative or additional surrogates for pathogens under the triennial review of state water quality standards. However, at the time of publication, fecal coliform bacteria remain the designated indicator.

Table 1. Streams addressed in the fecal coliform bacteria and temperature TMDLs

Name	Parameter	Old ID	New ID	1996 303(d) list	1998 303(d) list	Impaired but not listed
South Prairie Creek	Fecal coliform bacteria	WA-10-1085	VC19MO	Yes	Yes	
Spiketon Creek	Fecal coliform bacteria	(none)	(none)	No	No	Yes
Wilkeson Creek	Fecal coliform bacteria	WA-10-1087	NX07HW	No	No	No
Unnamed Tributary	Fecal coliform bacteria	(none)	(none)	No	No	Yes
South Prairie Creek	Temperature	WA-10-1085	VC19MO	Yes*	Yes*	Yes*
Spiketon Creek	Temperature	(none)	(none)	No	No	Yes
Wilkeson/Gale Creeks	Temperature	WA-10-1087	NX07HW	Yes**	Yes**	Yes**

*South Prairie Creek was monitored by the Muckleshoot Tribe and subsequently placed on the 303(d) list in error by comparison with the Class AA water quality standards. South Prairie Creek is a Class A water body, and the historical monitoring data met the Class A water quality standards. However, monitoring conducted in 2000-2001 indicates that much of lower South Prairie Creek exceeds the Class A temperature standard; therefore, a TMDL was conducted.

**Wilkeson Creek, downstream of the confluence with Gale Creek, was monitored by the Muckleshoot Tribe and subsequently placed on the 303(d) list in error by comparison with the Class AA water quality standards. Wilkeson Creek is a Class A water body, and the historical monitoring data met the Class A water quality standards. Gale Creek, above the confluence with Wilkeson Creek, was also monitored by the Muckleshoot Tribe and was placed on the 303(d) list because it exceeded Class A water quality standards. Monitoring conducted in 2000-2001 indicates that the mouth of Wilkeson Creek exceeds Class A standards; therefore, a TMDL was conducted.

Temperature represents the equivalent of heat concentration within a water body. Thus, the present study evaluates and allocates the load of heat received by South Prairie Creek and its tributaries while comparing the resultant instream temperature to the water quality standards. Processes that affect water temperatures in the South Prairie Creek watershed include riparian vegetation disturbance that affects stream surface shading, reduced groundwater exchange that decreases heat exchange in the gravels, channel widening due to upstream sediment sources that increases the stream surface area exposed to solar radiation, reduced summer baseflows that reduce the volume of water available to absorb heat, and two point source discharges from wastewater treatment plants that introduce warm water. This study uses riparian shade as a surrogate measure of solar heat flux to water bodies. Effective shade is defined as the fraction of the potential solar shortwave radiation that is blocked by vegetation and topography before it reaches the stream surface; thus, effective shade includes interception of solar radiation by topographic features as well as vegetation.

South Prairie Creek Bacteria and Temperature TMDL

Background

Geographic Setting

The South Prairie Creek watershed (Figure 1) covers 90.7 mi^2 (235 km^2) and ranges in elevation from 5,933 ft (1800 m) at Pitcher Mountain to 285 ft (87 m) above mean sea level (Mastin, 1998), spanning the Puget Lowlands and Cascades eco-regions. The river flows 21.7 miles (34.8 km) from its headwaters within the Mt. Baker-Snoqualmie National Forest near the northwest corner of Mt. Rainier National Park to its confluence with the Carbon River, itself a tributary of the Puyallup River. The South Prairie Creek watershed includes three tributaries, of which Wilkeson Creek is the largest, with a watershed of 28 mi^2 (73 km^2). Spiketon Creek, also known as Spiketon Ditch, flows to South Prairie Creek upstream of the Wilkeson Creek confluence and has a watershed area of 3.2 mi^2 (8.2 km^2). A small unnamed ditch with a watershed of 0.7 mi^2 (1.8 km^2) originates in the town of South Prairie and discharges to South Prairie Creek downstream of the town; the ditch is part of Pierce County's stormwater infrastructure. The shape of the watershed is such that only very small tributaries other than these three enter the main stem of South Prairie Creek.

Basin Characteristics

Climate in the basin follows patterns typical of the Puget Lowlands and Cascades eco-regions, with wet, mild winters and dry, cool summers. Mean annual average precipitation in the watershed varies from 85 in/yr (2.2 m/yr) at the higher elevations to 38 in/yr (1.0 m/yr) at the mouth (DNR, 1995; Miller et al., 1973). Most of the average annual precipitation occurs between November and April. Winter precipitation falls as rain in the lowlands and a mix of rain and snow at higher elevations.

Streamflow also varies seasonally. Highest flows occur between November and February, while the lowest flows occur in August and September, based on the U.S. Geological Survey (USGS) stream gage located at the town of South Prairie (Figure 2). Average discharge for the water years[1] 1988 to 2001 is 223 cfs (6.31 m^3/s). Minimum 7-day average flows have ranged from 25 to 42 cfs (0.71 to 1.19 m^3/s).

The watershed is composed of well compacted glacial till and stratified drift deposits. The upper watershed is characterized by steeper gradients, but the local channel slope in the lowlands study area varies from 0.03 to 0.003. The Osceola mudflow spilled into the South Prairie Creek valley near the confluence of Spiketon Creek/Ditch. The low-permeability valley bottom includes the developed areas of South Prairie, Wilkeson, Buckley, and Burnett (USDA SCS, 1979).

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[1] Water year 2001 refers to the period October 1, 2000 through September 30, 2001.
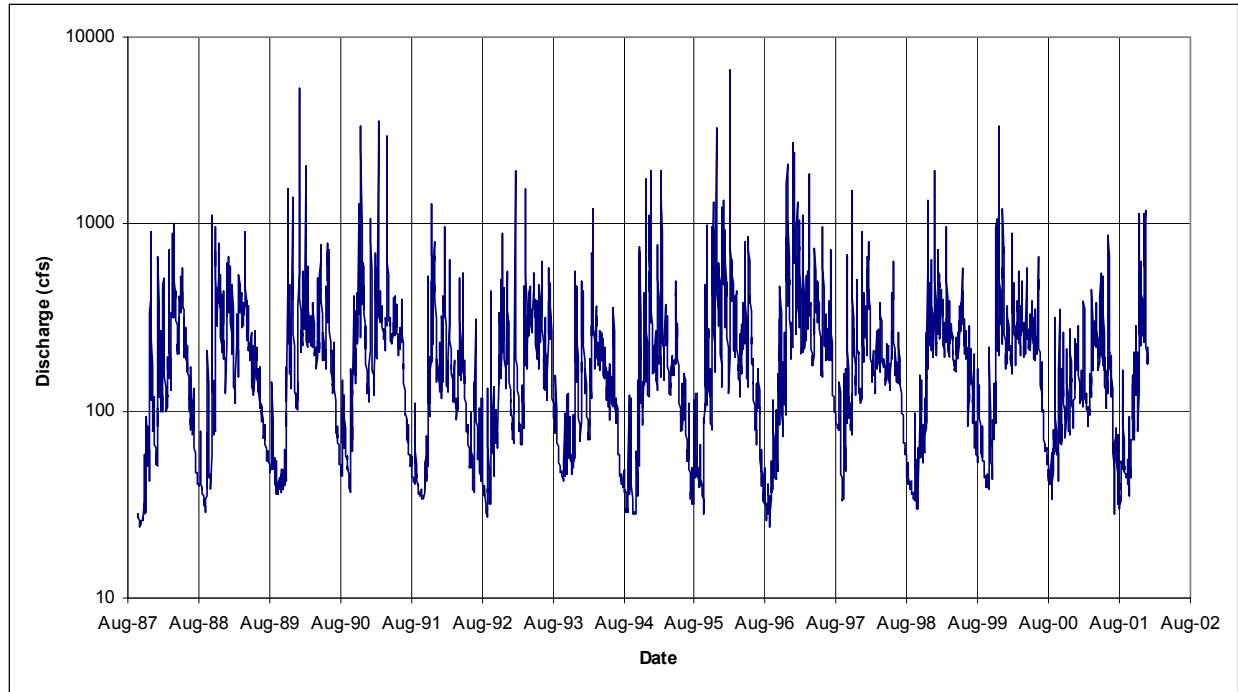
Figure 2. Historical discharge at USGS gage 12095000 on South Prairie Creek.

Current land use includes forestry operations in the higher elevations. The Mount Baker-Snoqualmie National Forest, administered by the White River Ranger District, includes 27 mi^2 (70 km^2; Mastin, 1998) of the headwaters of South Prairie Creek. The area is not included in the present modeling analysis, since no impairment has been identified. In addition, the U.S. Forest Service is required to develop forest plans under the National Forest Management Act. Private timber companies, including Plum Creek, own land within the South Prairie Creek watershed. The area falls under the jurisdiction of the Timber Fish and Wildlife (TFW) Agreement. The 1987 agreement and the subsequent Forests and Fish Report, presented to the Forest Practices Board of Washington of the Department of Natural Resources and the Governor's Salmon Recovery Office in 1999, establish the following goals: provide compliance with the Endangered Species Act for aquatic and riparian-dependent species on non-federal forest lands, restore and maintain riparian habitat to support a harvestable fish supply, meet the requirements of the Clean Water Act, and keep the timber industry economically viable.

Two dairy facilities located near the town of South Prairie are the only commercial agriculture operations in the watershed. However, small non-commercial farms occur throughout the lower watershed.

Residential land use includes both small urban centers and rural residential parcels. Wilkeson is the largest town in the watershed, with a population of 395, based on the 2000 census. Local springs provide drinking water. The town owns and operates a wastewater treatment plant that discharges to Wilkeson Creek. South Prairie is the next largest town with a population of 332, based the 2000 census. The town relies on local wells for drinking water and operates a wastewater treatment plant that discharges to South Prairie Creek. Burnett is the site of a large

on-site wastewater demonstration project that relies on various emerging technologies (Creveling, 2002). The project replaced direct wastewater discharges to the creek.

Buckley has a water right for 2 cfs (0.057 m³/s) and diverts a portion of upper South Prairie Creek for its water supply but did not gage the volume during the study period. The Department of Social and Health Services (DSHS) shares the diversion and has a water right for 3.5 cfs (0.10 m³/s) to serve the Rainier State School and Washington State University Dairy Forage Facility[2]. The combined diversion passes through a sand filter as part of Buckley's drinking water supply infrastructure. When the infiltration capacity of the filters is exceeded, the overflow is diverted to South Prairie Creek via Spiketon Creek/Ditch. However, the portion used by Buckley for drinking water is transferred out of the watershed, since Buckley discharges wastewater to the adjacent White River watershed.

Other scattered residential developments throughout the lower watershed rely on private wells and septic systems. One septic system serving a residential property near the South Prairie wastewater treatment plant failed during the February 28, 2001, Nisqually earthquake (Pieritz, 2002). The system has been repaired. The Tacoma/Pierce County Health Department has determined that soils in the area are unsuitable for septic systems.

Pollutant Sources

Two facilities have permits for domestic wastewater discharge, which contribute both fecal coliform bacteria and heat loads to the receiving waters. The Wilkeson wastewater treatment plant (NPDES permit number WA0023281) discharges to Wilkeson Creek about 4.2 mi. (6.7 km) upstream of the confluence with South Prairie Creek. The current permit limits do not include limits for discharge rate or temperature, although the facility reports both. Fecal coliform bacteria concentrations must not exceed 200/100 mL as the monthly geometric mean or 400/100 mL for a weekly geometric mean. The South Prairie wastewater treatment plant (NPDES permit number WA0040479) limits maximum daily inflow to the plant to 38,200 gpd (0.059 cfs or 0.0017 m³/s); the permit does not limit temperature, although the facility reports effluent temperature. Fecal coliform bacteria must meet a monthly geometric mean of 200/100 mL and weekly geometric mean limit of 400/100 ml.

Nonpoint sources of fecal coliform bacteria include septic systems, dairy operations, domestic animals, and wildlife. Loads are released directly to water bodies or indirectly through subsurface loads or surface loads. These sources were quantified geographically in the data collection program by isolating the various sources.

Nonpoint sources also influence stream temperature by decreasing effective shade, reducing surface water discharge, reducing groundwater exchange, or increasing stream surface area through channel widening. Local riparian vegetation removal reduces the amount of shortwave radiation absorbed by leaves in the canopy, which increases the incident shortwave radiation to the stream. These disturbances result in elevated temperatures that propagate downstream. As the amount of water in the stream decreases, the volume of water capable of absorbing the

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[2] The WSU facility ceased dairy operations as of July 2000 but continues farming operations.

heat decreases and temperature increases. Also, if the amount of groundwater discharging to surface water or the volume of mixed surface/groundwater that recirculates through the gravels decreases, surface water temperature increases. No evidence of channel widening was identified in the present study, and Mastin (1998) found no evidence of increased flood frequency or changes in channel geometry over the period 1965 to 1990. However, widening would result in higher stream surface area and more solar radiation absorbed in a given stream reach.

South Prairie Creek
Fecal Coliform Bacteria TMDL Section

Applicable Water Quality Criteria

The water quality standards, set forth in Chapter 173-201A of the Washington Administrative Code, include designated beneficial uses, classifications, numeric criteria, and narrative standards for surface waters of the state.

South Prairie Creek discharges to the Carbon River, which is a tributary to the Class A portion of the Puyallup River. Neither South Prairie Creek nor the Carbon River are classified separately from the Puyallup River in the water quality standards. Therefore, South Prairie Creek and its tributaries are classified as Class A from the confluence with the Carbon River upstream to the Mt. Baker-Snoqualmie National Forest boundary. All streams within the National Forest are classified as Class AA. The present study focuses on the Class A portions of the South Prairie Creek watershed.

Characteristic uses for Class A (excellent) water bodies include water supply (domestic, industrial, agricultural), stock watering, fish and shellfish (salmonid and other fish migration, rearing, spawning, harvesting), wildlife habitat, recreation (primary-contact recreation, sport fishing, boating, aesthetic enjoyment), and commerce and navigation. Numeric criteria for particular parameters are intended to protect designated uses.

For Class A freshwater bodies,

> *"...fecal coliform organism levels shall both not exceed a geometric mean value of 100 colonies/100 mL, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 mL."*
>
> [WAC 173-201A-030 (2)(c)(i)(A)]

Fecal coliform bacteria, while not disease-causing organisms, have been adopted as indicator organisms for other pathogens with a fecal pathway that could impact human health. During the technical studies for South Prairie Creek, the water quality standards were under review. Potential changes included use of *E. coli* or enterococci as indicators of fecal pathogenic organisms. Therefore, *E. coli* and enterococci were included in the monitoring program. However, at the time of publication, fecal coliform bacteria remain the indicator organism on which the present TMDL is based. Appendix A includes data for all three potential indicators should the indicator organism change in the future.

Water Quality and Resource Impairments

Data collected by Ecology under the ambient monitoring program at station 10F090 (3.8 miles, or 6.1 km from the mouth; station SPCB4 of present study) from October 1992 through September 1993 have a geometric mean concentration of 133/100 ml. Four of 12 samples (33%)

exceeded 200/100 ml. Therefore, South Prairie Creek did not meet either of the two parts of the fecal coliform bacteria standard. The impaired use is recreation (primary-contact recreation, sport fishing, boating, aesthetic enjoyment).

Additional sampling conducted as part of the present study shows that South Prairie Creek downstream of station 10F090, Spiketon Creek/Ditch, and the unnamed tributary/stormwater ditch near the town of South Prairie (stations T1 and T1ID) do not meet water quality standards. Figure 3 summarizes recent fecal coliform monitoring data. Table 2 describes monitoring locations.
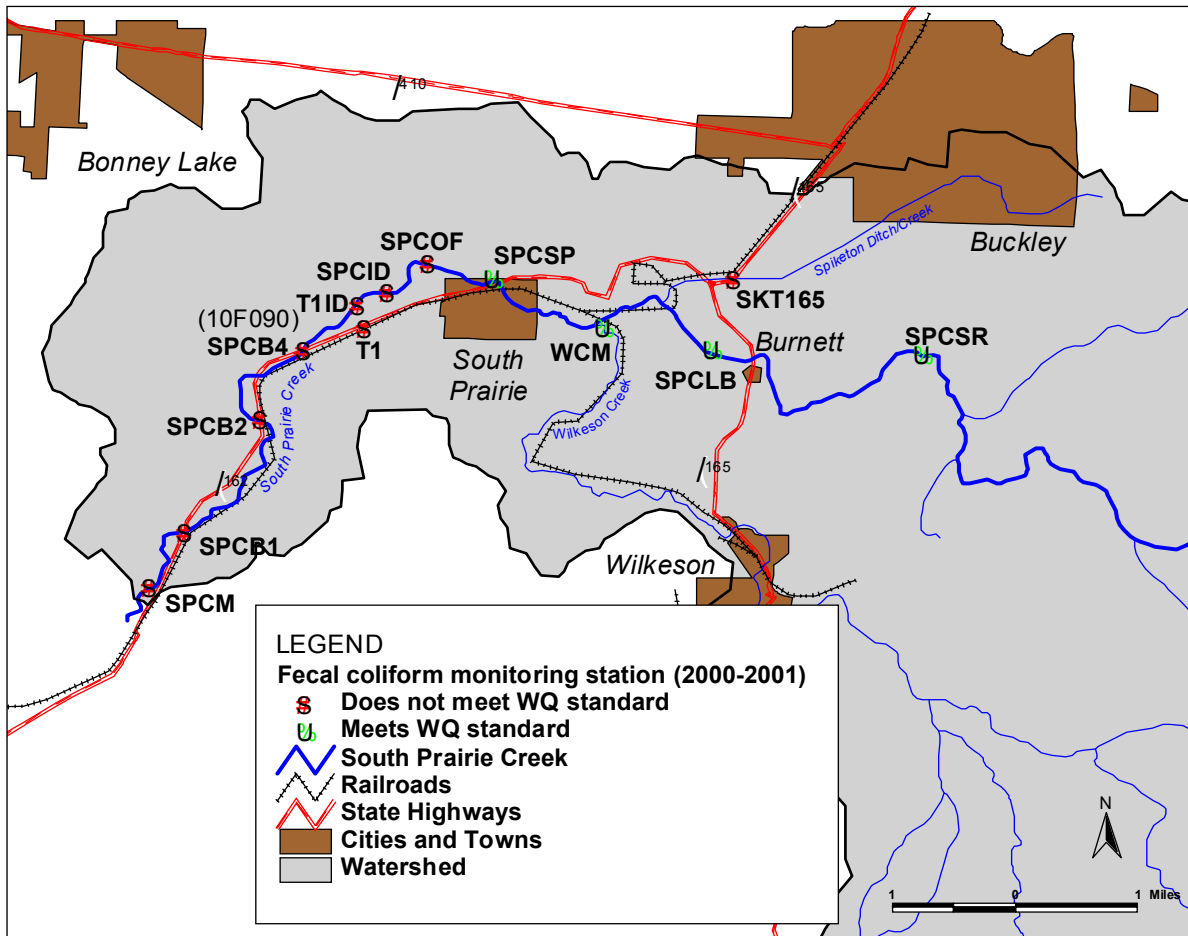
Figure 3. Stations not meeting the fecal coliform water quality standard, based on 2000-2001 monitoring data.

Table 2. Monitoring locations for the South Prairie Creek watershed bacteria study.

ID	Water Body	Description
SPCM	South Prairie Creek	At mouth, from South Prairie Creek Road
SPCB1	South Prairie Creek	At Route 162, first bridge north of Carbon River
SPCB2	South Prairie Creek	At Route 162, second bridge north of Carbon River
SPCB4	South Prairie Creek	At Route 162, fourth bridge north of Carbon River
SPCID	South Prairie Creek	At Inglin Dairy bridge
SPCOF	South Prairie Creek	At South Prairie wastewater treatment plant outfall; access from road by cabinet factory
SPCSP	South Prairie Creek	At South Prairie; access from fire station
SPCLB	South Prairie Creek	At Lower Burnett Road, downstream of Route 165 bridge
SPCSR	South Prairie Creek	At Spiketon Road, south of Buckley
T1	Unnamed tributary	At Route 162 culvert for ditch from South Prairie
T1ID	Unnamed tributary	At mouth of ditch from South Prairie; access from Inglin Dairy
WCM	Wilkeson Creek	At mouth; access from KC Crusaders Paintball
SKTM	Spiketon Creek/Ditch	At mouth; access from Lower Burnett Road

Seasonal Variation

Clean Water Act Section 303(d)(1)(C) requires that TMDLs "be established at a level necessary to implement the applicable water quality standards with seasonal variations…." The current regulation also states that determination of "TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters" [40 CFR 130.7(c)(1)]. Fecal coliform bacteria concentrations and loads show seasonal variations, particularly in the lower watershed. Higher fecal coliform loads tend to coincide with wet winter conditions (Figure 4); however, elevated concentrations occur throughout the year and at a range of discharges. There was no statistically significant difference in fecal coliform bacteria concentrations in dry and wet conditions[3] (P=0.646).

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[3] Dry is defined as <0.1 in of rain on the day of sampling or <0.2 in rain in the three days preceding. Wet conditions occur if at least 0.1 in fell on the day of sampling and at least 0.2 in fell in the previous days. Days where one condition is met but not the other were not included in the analysis.

The non-growing season (November through April) tends to coincide with wet-weather conditions in the Puget Lowlands. For South Prairie Creek main stem stations, concentrations are higher during the non-growing season than the growing season. At other stations, the growing season concentrations are greater than the non-growing season levels. Therefore, the load allocations include both growing season and non-growing season reductions.
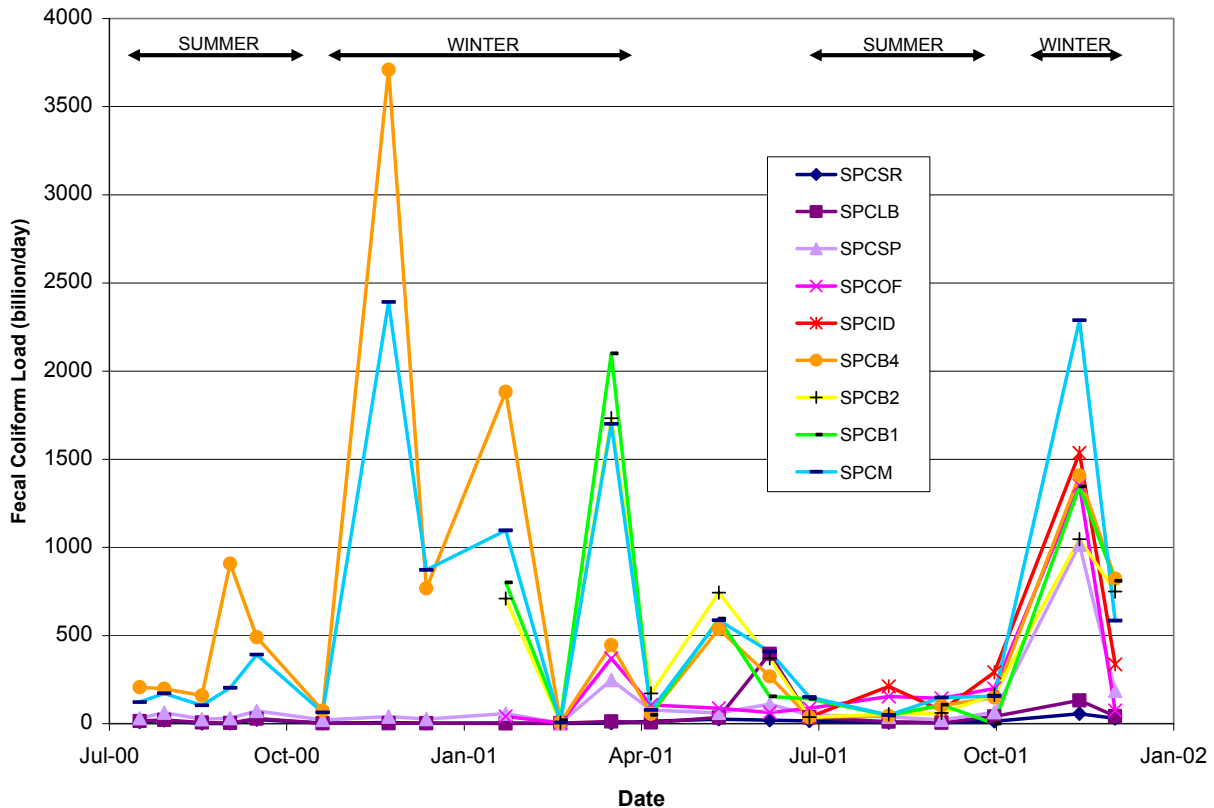
Figure 4. Time series of instantaneous fecal coliform loads at South Prairie Creek monitoring stations.

Technical Analyses

The technical analyses are based on historical and recent field and laboratory data collection, statistical analysis, and statistical modeling. The Quality Assurance Project Plans (Roberts, 2000 and 2001) describe the data collection program and methods.

Data Used in the Analysis

Water quality samples were collected and analyzed for fecal coliform twice monthly or monthly from July 2000 through December 2001. Nine monitoring stations were established over the 10.4-mi (16.8-km) study area to isolate potential sources. Instantaneous flows were measured at all accessible and appropriate stations using standard velocity-area methods (Ecology, 1993).

The USGS stream gage at the town of South Prairie provides a continuous flow record since October 1, 1987. Appendix A includes all monitoring data.

Data were compiled and analyzed using Microsoft Excel®. Instantaneous loads were calculated using instantaneous flow measurements where available. Where not available, flows were calculated using relationships with the USGS gage site or other instantaneous sites. Loads are analyzed as billion fecal coliform per day.

Critical Conditions

Elevated fecal coliform levels occur throughout the year and under different flow regimes. Critical conditions vary by station, as described above. Therefore, the TMDL analysis includes load reduction targets for both the growing season and the non-growing season.

Statistical Analysis

Sources of bacteria were identified and quantified by calculating the differential load entering a reach as the difference between the downstream and upstream loads using the pooled datasets. Both concentrations and loads were compared using one-tailed t-tests to identify whether loads at downstream stations were significantly greater than loads at the upstream station. Significant load increases (α=0.05) occurred between stations SPCSP and SPCB4, and between SPCSP and SPCOF (Figure 5). No significant load increases occurred downstream of SPCB4.
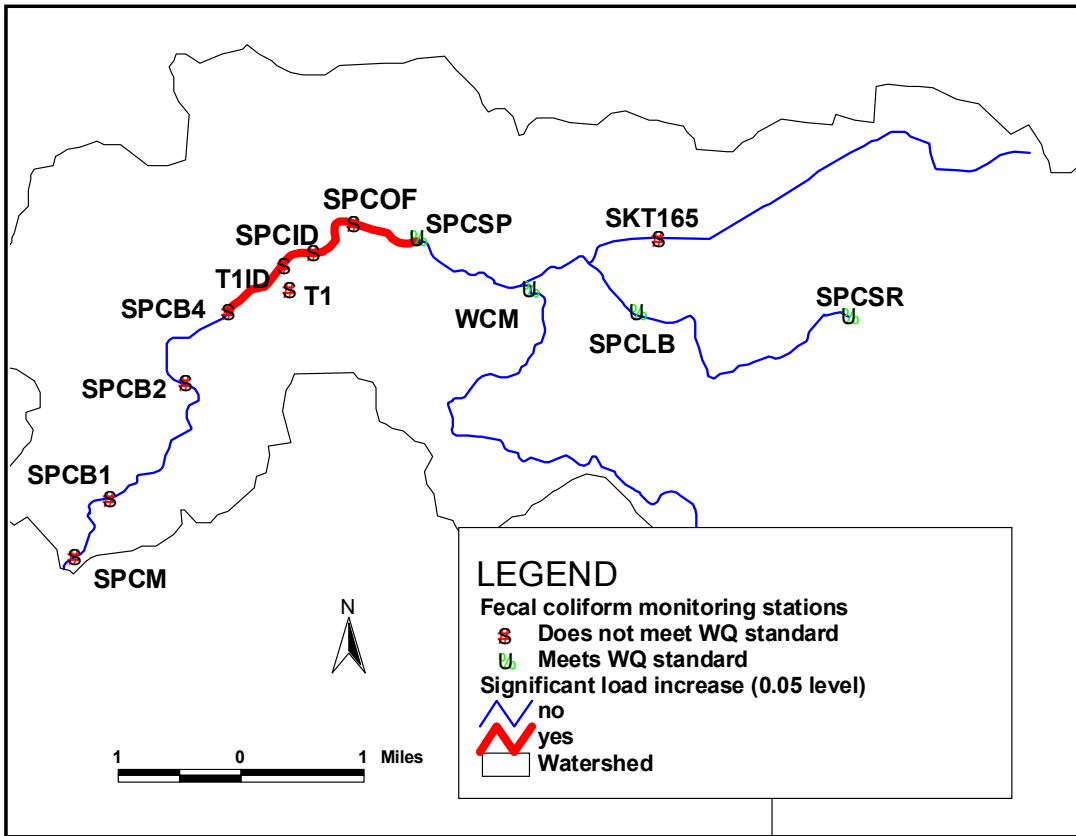
Figure 5. Significant increases in fecal coliform bacteria loads during 2000-2001 monitoring.

South Prairie Creek Bacteria and Temperature TMDL

Modeling Approach

The modeling approach uses the statistical rollback method to determine the load reduction necessary to achieve the fecal coliform water quality standard in South Prairie Creek, Spiketon Creek/Ditch, and the unnamed tributary at the town of South Prairie. The statistical rollback method (Ott, 1995) has been used by Ecology to determine the necessary reduction for both the geometric mean value (GMV) and 90th percentile bacteria concentration (Joy, 2000) to meet water quality standards. Compliance with the most restrictive of the dual fecal coliform criteria determines the bacteria reduction needed. Fecal coliform sample results for each site in this study were found to follow lognormal distributions, and the 90th percentile was calculated as the antilog of the mean of the log-transformed data plus 1.28 times the standard deviation of the log-transformed data.

The rollback method uses the statistical characteristics of a known data set to predict the statistical characteristics of a data set that would be collected after pollution controls have been implemented and maintained. In applying the rollback method, the target fecal coliform GMV and the target 90th percentile are set to the corresponding water quality standard. The reduction needed for each target value to be reached is determined. The rollback factor, $f_{rollback}$, is

$$f_{rollback} = \text{minimum } \{ (100/\text{sample GMV}), (200/\text{sample 90}^{th} \text{ percentile}) \}$$

The percent reduction ($f_{reduction}$) needed is

$$f_{reduction} = (1 - f_{rollback}) \text{ x } 100\%,$$

which is the percent reduction that allows both GMV and 90th percentile target values to be met. The result is a revised target value for both the GMV and the 90th percentile. In most cases, a reduction of the 90th percentile is needed and application of this reduction factor to the study GMV yields a target GMV that is usually less (i.e., more restrictive) than the water quality criterion. The 90th percentile is used as an equivalent expression to the "no more than 10%" criterion found in the second part of the water quality standards for fecal coliform bacteria. The reduction factors and description of sources are included under Load Allocations.

Loading Capacity

The loading capacity is the maximum load that can be assimilated by the receiving waters without violating water quality standards. Because fecal coliform has a two-part water quality standard for concentration, the load capacity also has two parts:

$$LC_{GMV} = Q \cdot 100/100 \text{ mL} \cdot f_{convert}$$
$$LC_{90\%ile} = Q \cdot 200/100 \text{ mL} \cdot f_{convert}$$

where LC is the load capacity in billion fecal coliform per day, Q is discharge in cfs, and $f_{convert}$ is 0.0245 to convert cfs $\cdot$ #/100 mL to billion fecal coliform per day. Load allocations are based on the reduction factors discussed above. Figure 6 compares current conditions with the loading capacity for geometric mean and 90th percentile fecal coliform bacteria concentrations. Loads must be reduced such that no bar extends above the water quality standards.
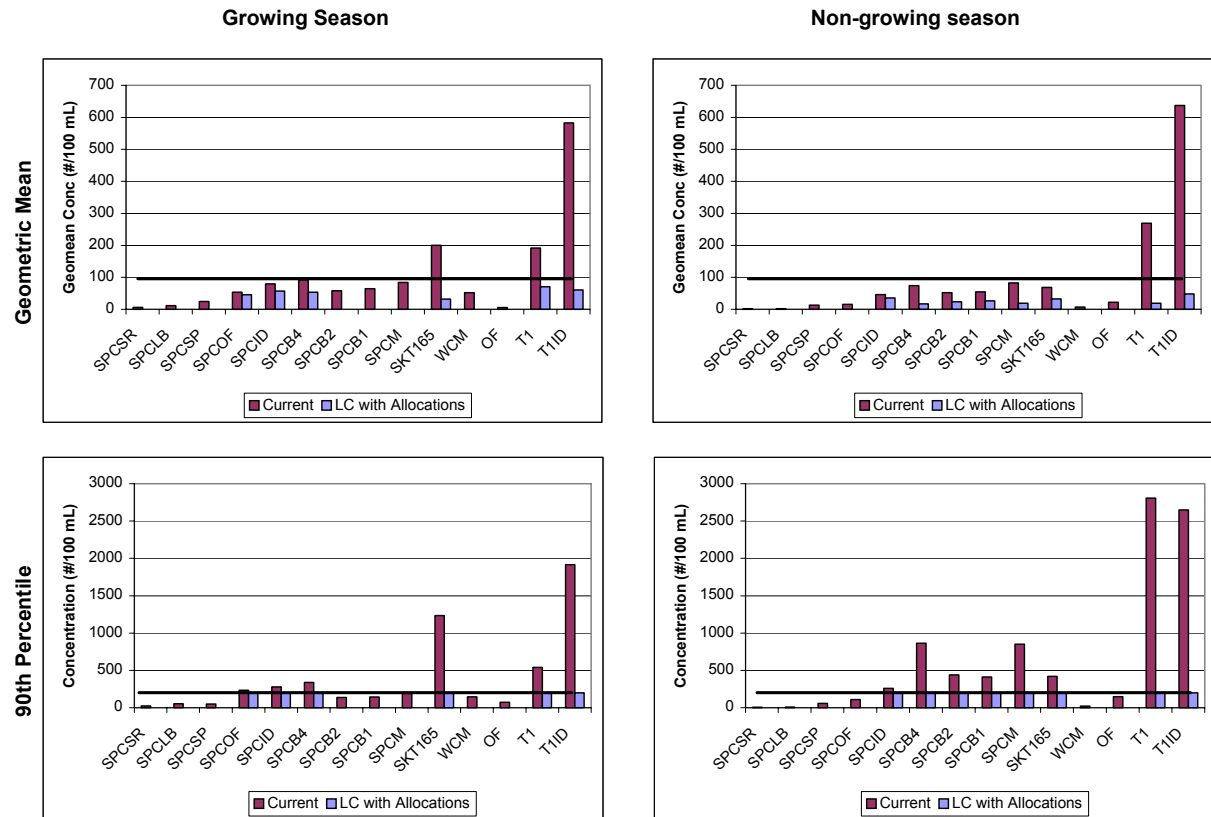
Figure 6. Fecal coliform bacteria loading capacity of South Prairie Creek represented as concentration. [source: new_fcb_rollback.xls/]

Load Allocations

Load allocations are set for South Prairie Creek downstream of the town of South Prairie (station SPCSP), Spiketon Creek/Ditch, and the unnamed tributary/stormwater ditch from the town of South Prairie using the rollback method to determine the reduction factors necessary to meet both parts of the water quality standard for fecal coliform. Reduction factors are calculated for two periods, the growing season (May through October) and the non-growing season (November through April), and load allocations are set for both. Only the recent monitoring data (July 2000 through December 2001) were used, since older historical data may not represent current conditions.

All load reduction factors are summarized in Table 3. Station reduction factors include all upstream reductions. The Spiketon Creek reduction factor includes the entire subwatershed. Wilkeson Creek meets the bacteria standard and does not require load allocations. The South Prairie wastewater treatment plant outfall also met the bacteria standard at the point of discharge.

Table 3. Load reduction factors summary by season.

Station	Growing Season	Non-growing Season
Main Stem of South Prairie Creek		
SPCSR	NA	NA
SPCLB	NA	NA
SPCSP	NA	NA
SPCOF	**14%**	NA
SPCID	**28%**	**23%**
SPCB4	**41%**	**77%**
SPCB2	NA	**54%**
SPCB1	NA	**52%**
SPCM	NA	**77%**
Tributaries to South Prairie Creek		
Spiketon Creek/Ditch (SKT165)	**84%**	**52%**
Wilkeson Creek (WCM)	NA	NA
SP WWTP outfall	NA	NA
Unnamed tributary at SR162 (T1)	**63%**	**93%**
Unnamed tributary at mouth (T1ID)	**90%**	**92%**

NA: not applicable; station meets water quality criterion

The unnamed tributary/stormwater ditch did not meet the water quality standard at either of two monitoring locations. Because the ditch is part of Pierce County's stormwater infrastructure, the reduction is included in the Wasteload Allocation section that follows, but is presented here for completeness. The reduction factor at the downstream station (T1ID at the mouth) is greater than the reduction factor for the upstream station (T1 at State Route 162). Thus, while loads must be reduced 63% in the growing season upstream of SR 162, additional load reductions are necessary between T1 and T1ID for a total of 90% reduction in bacteria levels for the entire tributary to meet water quality standards.

Table 4 presents the data on which the load reductions necessary during the growing season are based, while Table 5 presents the data for load reductions during the non-growing season. Several stations meet the water quality standards during the growing season but not during the non-growing season.

Table 4. Load reductions necessary to meet water quality standards during the growing season (May through October). Bold values exceed water quality standards.

Station	Number of Samples	Meets Std?	Geo-mean	90th %ile	$f_{rollback}$ for GMV (target to meet std)	$f_{rollback}$ for 90th %ile (target to meet std)	$f_{reduction}$ (reduction to meet std)	Target geo-mean	Target 90th %ile
Main Stem of South Prairie Creek									
SPCSR	12	YES	6	24	NA	NA	NA		
SPCLB	12	YES	12	54	NA	NA	NA		
SPCSP	12	YES	25	49	NA	NA	NA		
SPCOF	6	NO	54	**234**	NA	86%	**14%**	46	200
SPCID	4	NO	80	**280**	NA	72%	**28%**	57	200
SPCB4	12	NO	92	**340**	NA	59%	**41%**	54	200
SPCB2	6	YES	58	138	NA	NA	NA		
SPCB1	5	YES	64	142	NA	NA	NA		
SPCM	12	YES	84	192	NA	NA	NA		
Tributaries to South Prairie Creek									
SKT165	12	NO	**200**	**1234**	50%	16%	**84%**	32	200
WCM	12	YES	52	145	NA	NA	NA		
OF	6	YES	6	72	NA	NA	NA		
T1	6	NO	**192**	**542**	52%	37%	**63%**	71	200
T1ID	4	NO	**583**	**1916**	17%	10%	**90%**	61	200

NA: not applicable; station meets water quality criterion

From Table 3, loads entering South Prairie Creek between SPCSP and SPCB4 should be reduced by 41% in the growing season and 77% in the non-growing season. Slightly greater reduction is required during the non-growing season to meet water quality standards for that period because concentrations are greater. Potential sources include stormwater runoff from the town of South Prairie via the unnamed tributary (sampled at stations T1 and T1ID), the South Prairie wastewater treatment plant, failed septic systems, wildlife, or the dairy.

Table 5. Load reductions necessary to meet water quality standards during the non-growing season (November through April). Bold values exceed water quality standards.

Station	Number of Samples	Meets Std?	Geo-mean	90th %ile	$f_{rollback}$ for GMV (target to meet std)	$f_{rollback}$ for 90th %ile (target to meet std)	$f_{reduction}$ (reduction to meet std)	Target geo-mean	Target 90%ile
Main Stem of South Prairie Creek									
SPCSR	8	YES	2	7	NA	NA	NA		
SPCLB	8	YES	2	9	NA	NA	NA		
SPCSP	8	YES	13	58	NA	NA	NA		
SPCOF	6	YES	16	110	NA	NA	NA		
SPCID	2	NO	46	259	NA	77%	23%	36	200
SPCB4	8	NO	74	865	NA	23%	77%	17	200
SPCB2	6	NO	52	439	NA	46%	54%	24	200
SPCB1	6	NO	55	413	NA	48%	52%	27	200
SPCM	8	NO	83	851	NA	23%	77%	19	200
Tributaries to South Prairie Creek									
SKT165	8	NO	68	420	NA	48%	52%	33	200
WCM	8	YES	7	22	NA	NA	NA		
OF	5	YES	22	149	NA	NA	NA		
T1	6	NO	270	2809	37%	7%	93%	19	200
T1ID	2	NO	637	2649	16%	8%	92%	48	200

NA: not applicable; station meets water quality criterion

The unnamed tributary/stormwater ditch enters South Prairie Creek within this reach and requires significant load reductions to meet water quality standards before discharging to South Prairie Creek. Upstream of Route 162, as identified by station T1, the tributary fecal coliform loads should be reduced by 63% during the non-growing season and during high-flow conditions. The mouth of the tributary, identified as station T1ID, requires an overall reduction of 90%, which is required in both the growing and non-growing seasons and at both high- and low-flow conditions. Load reductions achieved upstream of Route 162 (station T1) will reduce loads at the mouth (station T1ID), but additional load reductions are necessary between Route 162 and the mouth of the tributary. Upstream of Route 162, land use is moderately dense residential development, with some commercial. Between Route 162 and the mouth, land use is agricultural with limited rural residential.

The unnamed tributary originates in the town of South Prairie and conveys groundwater and stormwater. The tributary had very high concentrations of fecal coliform bacteria during the 2001 monitoring program. Flow was not measured in the very small ditch. For a typical condition of a trapezoidal channel with 1:2 side slopes, bottom width of 3 ft, flow depth of 0.5 ft, channel slope of 0.005, and Manning's roughness of 0.35, Manning's equation estimates a flow of 0.3 cfs (0.008 m³/s):

$$Q = A * (1.49/n) * R^{2/3} S^{1/2},$$

where Q is discharge in cfs, A is cross-sectional area in ft², n is Manning's roughness, R is the hydraulic radius (equal to the cross-sectional area divided by the wetted perimeter), and S is

channel slope. Peak flows were estimated to be on the order of 1 cfs (0.03 m^3/s). The highest concentration was 2200/100 ml; with a flow of 1 cfs, the tributary may have contributed on the order of 50 billion fecal coliform/day, which could include failing septic system contributions. However, the average difference in loads between these upstream and downstream monitoring stations in South Prairie Creek was 300 billion fecal coliform per day; therefore, at most, T1 represents 17% of the incremental load to South Prairie Creek between SPCSP and SPCB4 and is not the only significant source.

Samples collected from the South Prairie wastewater treatment plant during the present study met the water quality standards with a geometric mean of 9/100 mL and a maximum of 80/100 mL (12 samples), without considering a mixing zone. The plant submits monthly reports of daily monitoring data. Table 6 presents low, medium, and high estimates of daily loads for each month of the monitoring program. The highest single-day load from the plant was 1.1 billion fecal coliform/day on September 19, 2000, a monitoring day along the creek. The instantaneous load upstream at SPCSP was 73 billion fecal coliform/day, while the load downstream at SPCB4 was 490 billion fecal coliform/day. The treatment plant contributed <0.5% of the differential load upstream of SPCB4 and is responsible for only a small portion of the increase.

Table 6. South Prairie wastewater treatment plant fecal coliform load estimates.

Month	Low [1] (10^9 fcb/day)	Medium [2] (10^9 fcb/day)	High [3] (10^9 fcb/day)
Jul-00	0.003	0.006	0.036
Aug-00	0.003	0.029	0.123
Sep-00	0.002	0.072	1.140
Oct-00	0.002	0.002	0.003
Nov-00	0.002	0.005	0.022
Dec-00	0.004	0.012	0.079
Jan-01	0.002	0.005	0.022
Feb-01	0.002	0.004	0.014
Mar-01	0.003	0.017	0.099
Apr-01	0.002	0.003	0.006
May-01	0.001	0.007	0.323
Jun-01	0.005	0.028	0.300
Jul-01	0.002	0.005	0.121
Aug-01	0.002	0.003	0.010
Sep-01	0.002	0.005	0.016
Oct-01	0.002	0.002	0.002
Nov-01	0.002	0.005	0.044
Dec-01	<0.001	<0.001	<0.001

1 Monthly average flow x min weekly fecal coliform concentration
2 Monthly average flow x geomean weekly fecal coliform concentration
3 Monthly average flow x max weekly fecal coliform concentration

With the exception of the failure during the Nisqually earthquake, no septic system failures have been located. However, the Tacoma/Pierce County Health District does not believe the soils in the South Prairie Creek valley are suitable for septic systems. At least ten homes in the area are served by septic systems. Assuming a per capita contribution of 2 billion fecal coliform/day (Metcalf and Eddy, 1991) and four people per household, failing septic systems could contribute 8 billion fecal coliform/day/system, or as much as 80 billion fecal coliform/day for ten homes. Thus, failing septic systems could contribute a significant portion of the load increase between SPCSP and SPCB4.

A synoptic survey, conducted in August 2001, found no other inflows with elevated fecal coliform concentrations. Several pipes and seeps were located between SPCSP and SPCB4 and sampled.

Wildlife contributions were not quantified explicitly in the study. However, using literature values for gull contributions of 0.1 billion fecal coliform/day (Gould and Fletcher, 1978; Nixon and Oviatt, 1973), 2,500 gulls would be necessary to contribute the differential fecal coliform load between SPCSP and SPCB4. There is no evidence that wildlife frequent this reach more than other reaches. Due to the level of development, wildlife are likely less prevalent between SPCSP and SPCB4.

Using literature values for cow contributions of 5.4 billion fecal coliform/day/cow (Metcalf and Eddy, 1991), waste from 46 cows would be sufficient to account for the differential load. While no direct discharges of waste from the dairy to South Prairie Creek were identified, field applications of manure were witnessed, and the dairy waste tank abuts South Prairie Creek. Both potential transport pathways could account for a significant proportion of the highly concentrated source entering South Prairie Creek between SPCSP and SPCB4. Either pathway could account for the intermittent nature of very high loads.

Load reductions achieved between SPCSP and SPCB4 will decrease the loads downstream of SPCB4. Travel time estimates were developed during low-flow conditions in 2001, which represent the slowest transport conditions over the year. Travel time from SPCSP to the mouth varies from 5 to 10 hours at a discharge of 40 cfs, and will be faster for higher flow rates. Therefore, there is little time for significant die-off to occur in this reach, meaning that upstream loads are not significantly attenuated. Unless the high bacteria loads masked low-level sources downstream of SPCB4, load reductions achieved between SPCSP and SPCB4 will cause downstream reaches to meet the water quality standards as well.

Wasteload Allocations

Wilkeson Creek met the fecal coliform bacteria water quality standard during the 2000-2001 monitoring period. Therefore, Wilkeson wastewater treatment plant (WA0023281) permit limits should remain at the current level of 200/100 mL for a monthly geometric mean and 400/100 mL for a weekly geometric mean, which are technology-based limits (Pieritz, personal communication, 2003). No further reduction in wasteload allocation is recommended, given that the plant contributes <1% of the load increase in the system, and the current permit limits represent the wasteload allocation for the Wilkeson wastewater treatment plant.

The South Prairie wastewater treatment plant (WA0040479) discharges to an impaired section of South Prairie Creek. Nonpoint sources contribute the vast majority of the bacteria load to South Prairie Creek. The point source contribution could increase the concentration at the edge of the mixing zone by 0 to 5 fecal coliform bacteria/100 mL, depending on the background contribution. Therefore, the permit limits should remain at 200/100 mL for a monthly geometric mean and 400/100 mL for a weekly geometric mean. If monitoring shows that the creek downstream of the treatment plant is still not meeting water quality standards by 2008, then the South Prairie wastewater treatment plant should receive water quality-based permit limits of 100/100 mL for a monthly geometric mean and 200/100 mL for a weekly geometric mean.

The TMDL submittal report to EPA, which will be based on the present technical report, must include reasonable assurance that implementation of nonpoint source management practices will occur and will reduce the bacteria load such that the creek meets the fecal coliform standard. Where reasonable assurance is not met, "the entire load reduction must be assigned to point sources," (EPA, 1991), meaning that point sources cannot discharge any bacteria load. This analysis recommends no additional reductions in the wasteload allocations through 2008, given that the South Prairie plant contributes <0.5% of the load increase between stations SPCSP and SPCB4.

As discussed under Load Allocations, the unnamed tributary sampled under the present study at State Route 162 (T1) and at the confluence with South Prairie Creek (T1ID) is part of Pierce County's stormwater conveyance system, covered under NPDES permit number WASM11002. Therefore, the reduction is considered a wasteload allocation. Bacteria levels must be reduced by 63% at State Route 162 and by 90% at the mouth. Details are presented under Load Allocations.

Summary of Load and Wasteload Allocations

Figure 7 compares the current conditions to the nonpoint source loading allocation and point source wasteload allocation for South Prairie Creek for the 90th percentile condition[4]. Current conditions exceed water quality standards, which is the loading capacity. The nonpoint load reductions discussed above will result in the load allocations shown. The point sources (shown multiplied by 10 or 100 to be visible in the figures) contribute small loads relative to the nonpoint sources, without considering die-off of the bacteria downstream of the discharge.

Margin of Safety

A margin of safety to account for scientific uncertainty must be considered in the TMDL in order for wasteload and load allocations to remain protective. The margin of safety for this TMDL is implicit; it is contained within conservative assumptions used to develop the TMDL. The rollback method assumes that the variance of the post-management data set will be equivalent to the variance of the pre-management data set. As pollution sources are managed, the frequency

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[4] Instream loads are based on average flows estimated for the growing and nongrowing seasons, while wastewater treatment plant wasteload allocations are based on peak monthly flows from the period of record of the DMRs.
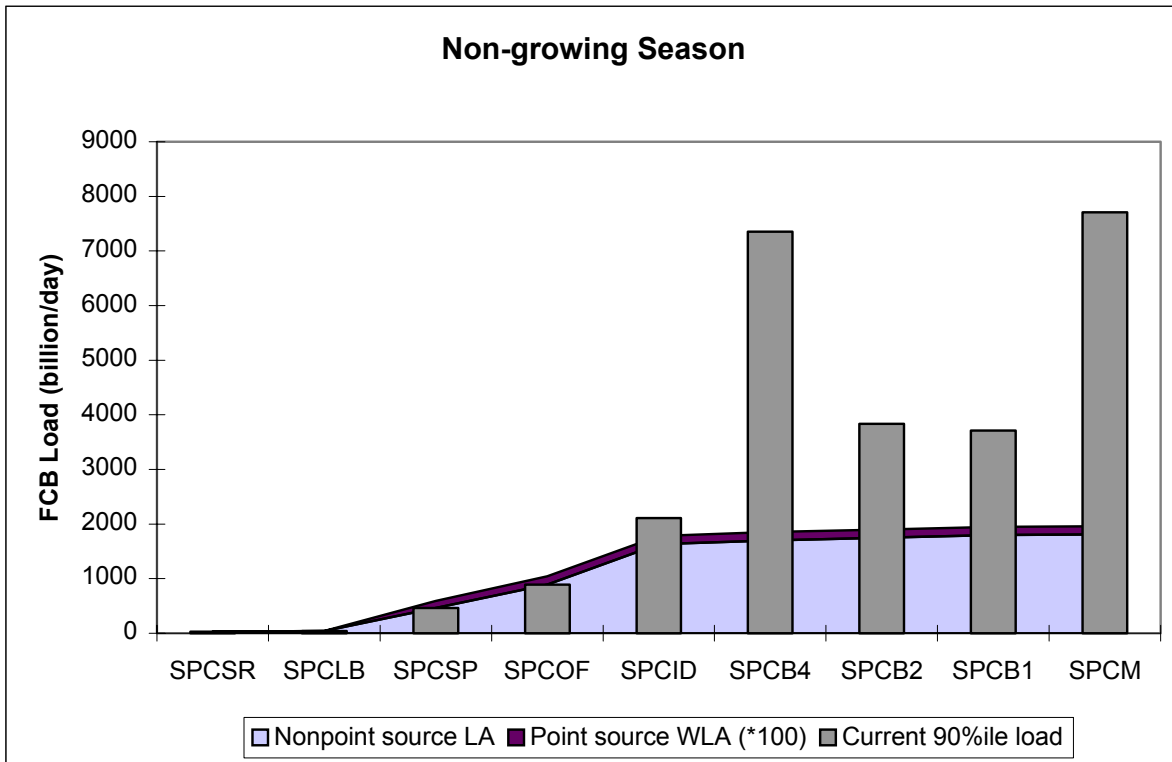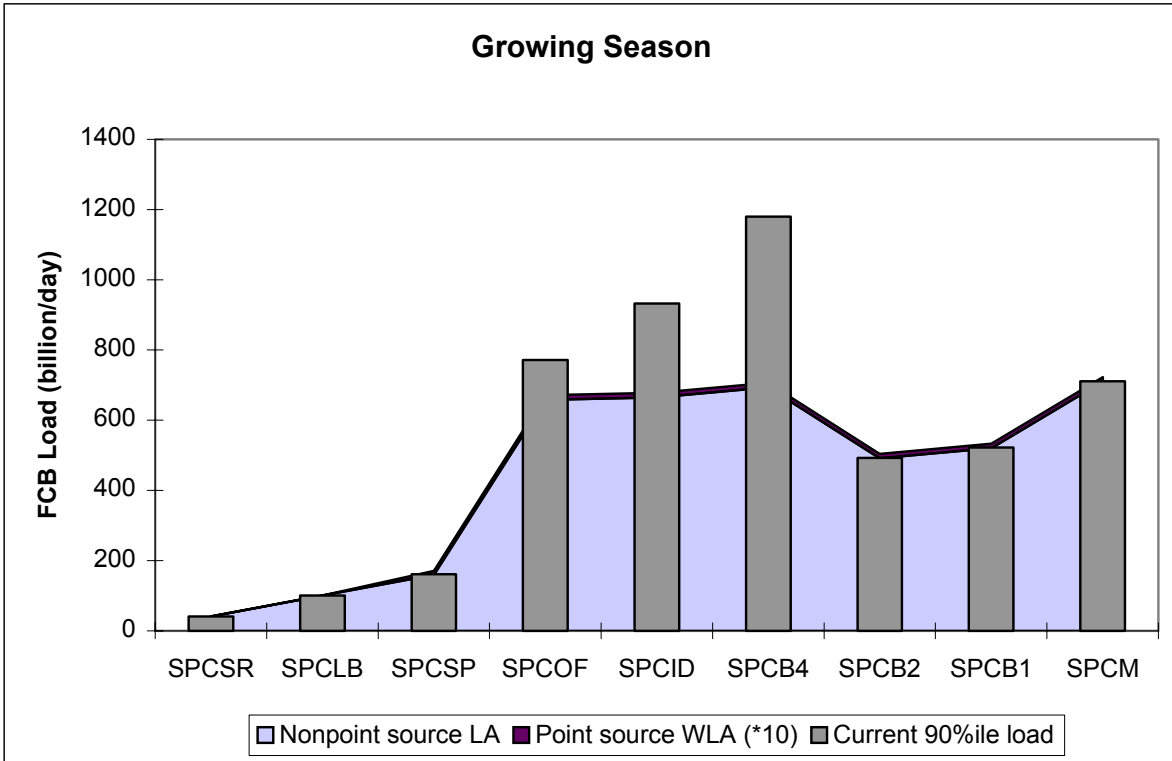
Figure 7. Current and allocated bacteria loads along South Prairie Creek. Point sources are multiplied by 10 and 100 to be visible in the charts.

of high fecal coliform values is likely to decrease, which should reduce the variance and 90th percentile of the post-management condition. Finally, differential reduction factors do not take into account bacterial decay.

Recommendations for Monitoring

To determine the success of fecal coliform control strategies, regular monitoring is recommended. Because stations SPCSP and upstream met the bacteria standards, SPCSP should be the upstream extent of regular monitoring. At a minimum, ten sites (SPCSP, SPCOF, SPCID, SPCB4, SPCB2, SPCB1, SPCM, SKTM, T1, and T1ID) should be monitored.

South Prairie Creek Temperature TMDL Section
Applicable Water Quality Criteria

The water quality standards, set forth in Chapter 173-201A of the Washington Administrative Code, include designated beneficial uses, classifications, numeric criteria, and narrative standards for surface waters of the state.

South Prairie Creek discharges to the Carbon River, which is a tributary to the Class A portion of the Puyallup River. Neither South Prairie Creek nor the Carbon River are classified separately from the Puyallup River in the water quality standards. Therefore, South Prairie Creek and its tributaries are classified as Class A to the Mt. Baker-Snoqualmie National Forest boundary. All streams within the National Forest are classified as Class AA. The present study focuses on the Class A portions of the South Prairie Creek watershed.

Characteristic uses for Class A (excellent) water bodies include water supply (domestic, industrial, agricultural), stock watering, fish and shellfish (salmonid and other fish migration, rearing, spawning, harvesting), wildlife habitat, recreation (primary-contact recreation, sport fishing, boating, aesthetic enjoyment), and commerce and navigation. Numeric criteria for particular parameters are intended to protect designated uses.

For Class A freshwater bodies,

> *"Temperature shall not exceed 18.0°C ... due to human activities. When natural conditions exceed 18.0°C ... no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C."*
>
> [WAC 173-201A-030 (2)(c)(iv)]

Surface water temperatures reflect the heat load to a given water body. Therefore, the South Prairie Creek watershed temperature TMDL is based on heat, considered a pollutant under Section 502(6) of the Clean Water Act. Heat loads are modeled as point sources from the wastewater treatment plants and tributaries, distributed sources from groundwater inflows, and incoming solar radiation to South Prairie Creek and its tributaries. Factors that affect solar radiation heat loads include topographic shade (from adjacent hillslopes), riparian shade (from vegetation), stream surface area and volume, and groundwater exchange.

Water Quality and Resource Impairments

Data collected by the Muckleshoot Indian Tribe in 1997 at a location upstream of SPCSR peaked at 16.5°C but did not exceed the Class A water quality standard of 18°C. The creek was placed on the 303(d) list in error, based on comparison with the Class AA standards. However, monitoring indicates that all of South Prairie Creek from the town of South Prairie downstream exceeds 18°C during the 2000-2001 study period. Figure 8 summarizes the 2001 (warmest) temperature monitoring data for South Prairie Creek. Table 7 describes the monitoring locations.
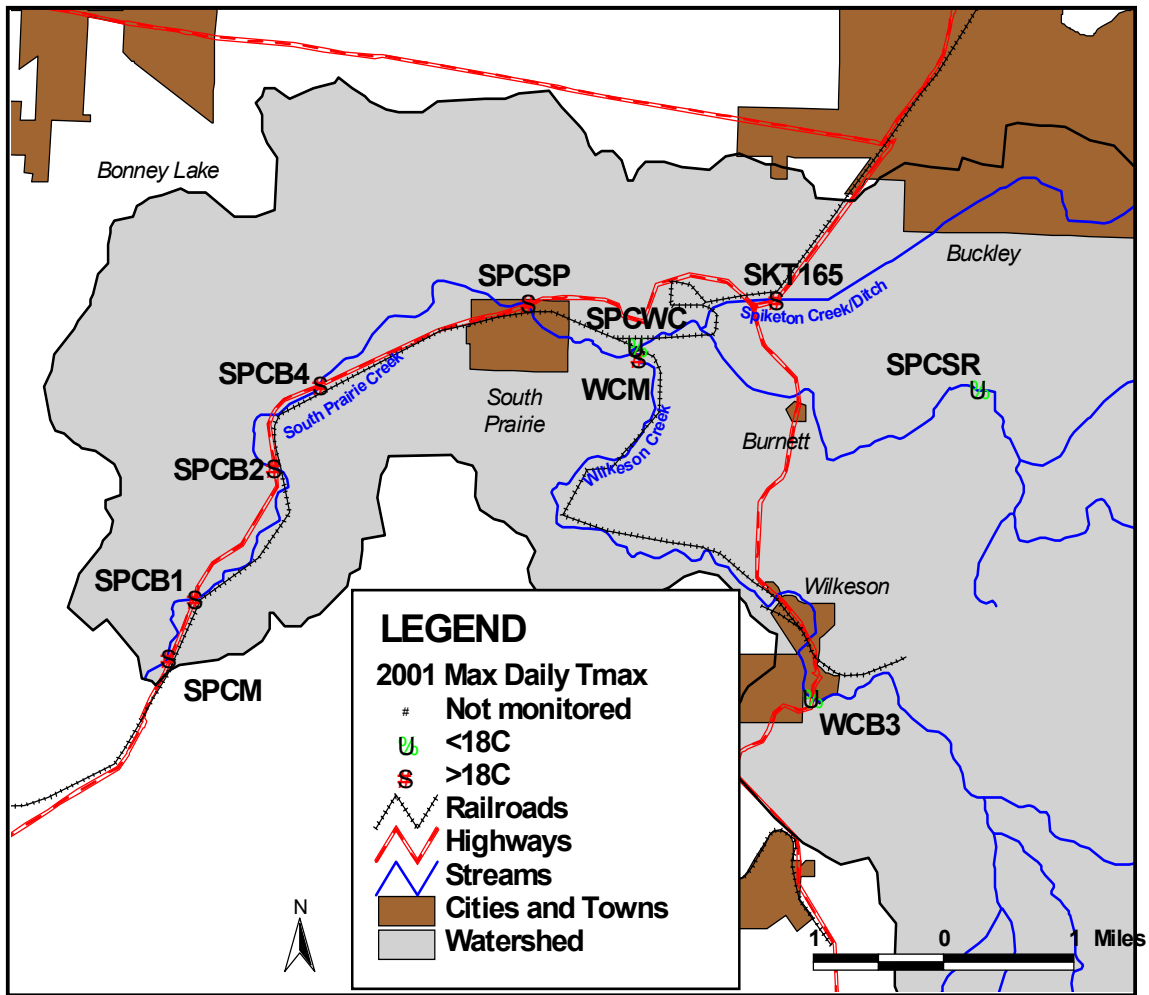
Figure 8. Summary of Ecology temperature monitoring results along South Prairie Creek, Wilkeson Creek, and Spiketon Creek/Ditch to 18°C temperature standard from 2001 monitoring.

South Prairie Creek Bacteria and Temperature TMDL

Table 7. Monitoring locations for the South Prairie Creek watershed temperature study.

ID	Water Body	Description
SPCM	South Prairie Creek	At mouth, from South Prairie Creek Road
SPCB1	South Prairie Creek	At Route 162, first bridge north of Carbon River
SPCB2	South Prairie Creek	At Route 162, second bridge north of Carbon River
SPCB4	South Prairie Creek	At Route 162, fourth bridge north of Carbon River
SPCSP	South Prairie Creek	At South Prairie; access from fire station
SPCWC	South Prairie Creek	At Wilkeson Creek confluence near train trestle; access through KC Crusaders Paintball
SPCSR	South Prairie Creek	At Spiketon Road, south of Buckley
WCM	Wilkeson Creek	At mouth; access from KC Crusaders Paintball
WCB3	Wilkeson Creek	Upstream of town of Wilkeson, third bridge
SKT165	Spiketon Creek/Ditch	At Route 165 culvert

The Muckleshoot Indian Tribe also monitored two locations in the Wilkeson Creek watershed (including Gale Creek). The downstream location peaked at 17.1°C but did not exceed the Class A water quality standard of 18°C. The creek was placed on the 303(d) list in error, based on comparison with the Class AA standards. The upstream location peaked at 19.0°C and exceeded the Class A water quality standards. The upstream area is owned by Plum Creek Timber Company, Inc. and falls under the jurisdiction of the TFW Agreement. Monitoring conducted under the present study (Figure 10) indicates that while Wilkeson Creek met the 18°C standard at both locations in 2001, the station at the mouth (WCM) exceeded the standard in 2000.

Plum Creek recorded temperature continuously at numerous stations in the upper reaches of South Prairie Creek and Wilkeson/Gale Creek in 2000. As shown in Figure 9, although the four sites in upper South Prairie Creek met the 18°C standard, two sites on Gale Creek exceeded the standard. The area was not monitored by Ecology but is included in the narrative portion of the present TMDL; implementation is through the TFW Agreement.

In addition, Ecology monitored the temperature of Spiketon Creek/Ditch in 2000 and 2001. Results in Figure 8 indicate that Spiketon Creek/Ditch peaked at 19.7°C in 2001 and does not meet the 18°C Class A temperature standard.

Seasonal Variation

Clean Water Act Section 303(d)(1)(C) requires that TMDLs "be established at a level necessary to implement the applicable water quality standards with seasonal variations…." The current regulation also states that determination of "TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters" [40 CFR 130.7(c)(1)]. Finally, Section 303(d)(1)(D) suggests that the "total maximum daily thermal load required to assure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife … shall take into account the normal water temperatures, flow rates, seasonal variations, existing sources of heat input, and the dissipative capacity of the identified waters…."

Existing water temperature conditions in the South Prairie Creek watershed reflect seasonal variation. Cooler temperatures occur in the winter, while warmer temperatures are observed in the summer. Highest temperatures typically occur in July and August, which is the critical period for temperature TMDL development.

Technical Analyses

Technical analyses are based on recent field data collection and temperature modeling. The Quality Assurance Project Plans (Roberts, 2000 and 2001) describe the data collection program and methods.

Figure 9.

Plum Creek Timber Company temperature monitoring in the South Prairie Creek watershed (2000).

Stream temperatures recorded hourly from mid-July to mid-September, 2000

Map labels: East Fork South Prairie Creek · S. Prairie Creek · Wilkeson Creek · Gale Creek · W. F Gale Creek · S. F. Gale Creek · South Prairie Creek

T19N R06E · T19N R07E · T18N R06E

Site temperatures: 18°C · 17°C · 19°C · 16°C · 15°C · 16°C · 16°C · 20°C · 14°C · 15°C · 15°C · 13°C · 12°C

Provisional Data	Stream Temperature (C)				Estimated Canopy Closure (%)	Elevation (ft)	Minimum Canopy Target (for 16C)	Conforms to TFW Temperature Screen?
Site	Maximum Instantaneous	Maximum Daily Average	MWAT	MWMT				
Gale Creek 1	20	17	16	19	30	1440	60	yes
Gale Creek 2	19	17	16	18	75	1130	70	no *
S.F. Gale Creek	16	15	14	15	90	1450	60	yes
W.F. Gale Creek	16	15	14	15	90	1160	60	yes
Wilkeson Creek 1	16	15	14	15	60	1320	60	yes
Wilkeson Creek 2	15	14	13	14	80	1320	60	yes
Wilkeson Creek 3	17	16	15	16	75	1130	70	no *
Wilkeson Creek 4	18	16	15	17	55	810	70	yes
South Prairie Creek 1	12	12	11	12	90	1880	50	yes
South Prairie Creek 2	13	13	12	12	90	1880	50	yes
South Prairie Creek 3	15	13	13	14	55	1630	60	no **
E. F. South Prairie Cr.	14	12	11	13	55	1640	50	yes

* observed temperature higher than elevation/canopy combination would suggest
** observed temperature lower than elevation/canopy combination would suggest

AIR TEMPERATURE

	July	August
2000	17 F	17 F
Ten-Year Average (1990-1999) (mean +- 1 Std. Dev.)	17-19 F "normal"	17-19 F "normal"
Twenty-Year Average (1980-1999) (mean +- 1 Std. Dev.)	16-19 F "normal"	17-19 F "normal"

PRECIPITATION

	July	August
2000	0.8 in	0.7 in
Ten-Year Average (1990-1999) (mean +- 1 Std. Dev.)	0.6-2.5 in "normal"	0.7-2.3 in "normal"
Twenty-Year Average (1980-1999) (mean +- 1 Std. Dev.)	0.4-2.7 in "normal"	0.6-2.1 in "normal"

Source: NOAA climate data for Division 4, Washington

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PlumCreek
16 November 2000

Data Used in Analysis

Water Temperature, Air Temperature, and Relative Humidity

Water temperature, air temperature, and relative humidity were monitored continuously during the summer months in 2001, and partial records are available for 2000. Ten temperature monitoring stations were established over the 10.4-mi (16.8-km) study reaches. Appendix A includes the monitoring data. Data were compiled and analyzed using Microsoft Excel®.

Discharge Data, Hydraulic Geometry, and Channel Characteristics

Historical discharge data from the USGS station on South Prairie Creek at the town of South Prairie were used for statistical analyses. Only data from October 1, 1987 through December 31, 2001, were used in the present study, although the gage data include the period 1950 to 1979.

Ecology supplemented the continuous discharge records with instantaneous flows at eight locations between July 2000 and December 2001. Geometry and velocity data were used to generate relationships between discharge (Q) and channel width (w), average channel depth (d), and average velocity (u) using hydraulic geometry coefficients. Width, depth, and velocity can be related to discharge (Q) by power functions:

$$w = a \, Q^{\,b}$$
$$d = c \, Q^{\,f}$$
$$u = k \, Q^{\,m}$$

By continuity of mass,

$$Q = w \, d \, u = a \, Q^{\,b} * c \, Q^{\,f} * k \, Q^{\,m}$$

and

$$a * c * k = 1$$
$$b + f + m = 1$$

Coefficients were determined for individual stations by fitting power curves to data collected for instantaneous discharge measurements. The curves are used to estimate width and depth for flow regimes not specifically measured. Table 8 summarizes these equations. Relationships for a particular station were assumed to hold for reaches half the distance to the upstream station and half the distance to the downstream discharge station.

Additional channel characteristics were provided by habitat surveys, which were conducted in August 2001, at each temperature monitoring location. Ten cross sections were established, beginning at the monitoring station at 100-ft (33-m) intervals. At each cross section, the wetted width, bankfull width, width of near-stream disturbance zone, channel incision, and bankfull depth were recorded.

Table 8. Hydraulic geometry relationships for South Prairie Creek, Wilkeson Creek, and Spiketon Creek/Ditch (discharge, Q, in m³/s)

Station	Width (m)	Depth (m)	Velocity (m/s)
SPCLB	$W = 17.571\, Q^{0.0976}$	$D = 0.177\, Q^{0.3597}$	$U = 0.3215\, Q^{0.5427}$
SPCSP	$W = 15.316\, Q^{0.1101}$	$D = 0.3401\, Q^{0.2267}$	$U = 0.192\, Q^{0.6632}$
SPCB4	$W = 15.443\, Q^{0.1916}$	$D = 0.3101\, Q^{0.2509}$	$U = 0.2088\, Q^{0.5574}$
SPCB2	$W = 11.679\, Q^{0.4347}$	$D = 0.2474\, Q^{0.1989}$	$U = 0.346\, Q^{0.3664}$
SPCB1	$W = 15.96\, Q^{0.0152}$	$D = 0.3088\, Q^{0.376}$	$U = 0.2029\, Q^{0.6088}$
SPCM	$W = 18.903\, Q^{0.0798}$	$D = 0.2095\, Q^{0.4809}$	$U = 0.2525\, Q^{0.4393}$

Topographic Shade, Aspect, and Gradient

Shade angles from topographic features were calculated to the east, south, and west based on solar azimuth and a 10-m digital elevation model (DEM). The channel centerlines were used to estimate reach aspect. Channel gradient was averaged for each reach from electronic USGS quadrangle maps.

Riparian Vegetation and Effective Shade

Current vegetation characteristics, including height and density, are used to estimate effective shade from the riparian zone. No vegetation data layer was available for the watershed, however. Vegetation polygons were estimated from the most recent orthophotos[5] within 500 ft (150 m) of the centerline of South Prairie Creek, Wilkeson Creek, and Spiketon Creek/Ditch. Vegetation height, type, and canopy cover categories were assigned to each polygon, based on visual interpretation and field observations collected in the habitat surveys described above. Polygon attributes were verified or refined in the field using observations of vegetation type and a laser range finder for vegetation height at all accessible locations.

Habitat surveys also provided densiometer readings at ten cross sections upstream of each temperature monitoring location. Hemispherical photography was used to record canopy cover at monitoring stations. Photos were evaluated using HemiView Canopy Analysis Software version 2.1 (Delta-T Devices Ltd., 1999) based on the path of the sun for a date.

Critical Conditions

Seasonal estimates for stream flow, solar flux, and climatic variables are taken into account to develop critical conditions. During the July 2000 through December 2001 monitoring period, daily water temperature in South Prairie Creek peaked on August 1, 2000, and August 10, 2001,

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[5] South Prairie Creek riparian zone orthophotos were available from 7/20/98 for the upstream model boundary to SPCB2; for the mouth to SPCB2, 7/18/90 was the most recent imagery. For Wilkeson Creek, orthophotos were available from 7/20/98 for the 1.6 mi (2.6 km) upstream of the mouth; for the headwaters to 1.6 mi (2.6 km), data were available from 7/15/90. The 7/20/98 imagery covered nearly the entire Spiketon Creek/Ditch riparian zone, from the mouth to a point 4.9 mi (6.2 km) upstream.

with highest 7-day average of daily maximum temperatures occurring July 29 through August 4, 2000, and August 9 through August 15, 2001, for each summer. Thus, the critical period for temperature monitoring occurs in late July to early August, and the 7-day averages were used in the analysis.

Critical stream flows for the temperature TMDL were evaluated as the lowest 7-day average flows with a 2-year recurrence interval (7Q2) and 10-year recurrence interval (7Q10) for the months of July and August. The 7Q2 stream flow represents conditions that occur during a typical climatic year, and the 7Q10 stream flow represents a reasonable worst-case climatic year at the South Prairie USGS gage. WQHYDRO (Aroner, 1994) was used to calculate 7Q2 and 7Q10 using a variety of distributions, as shown in Table 9. Flows selected to represent the critical conditions are 40 cfs (1.1 cms) for 7Q2 and 28 cfs (0.79 cms) for 7Q10.

Table 9. Flow statistics for USGS gage (12095000) on South Prairie Creek.

Statistic	Distribution	Discharge	95% C.I.
7Q2	Distribution free	39 cfs 1.1 cms	
	Log Pearson III (no bias correction)	40 cfs 1.1 cms	33 to 49 cfs 0.92 to 1.4 cms
	Weibull	41 cfs 1.2 cms	30 to 52 cfs 0.84 to 1.5 cms
	Log-Normal (3 parameter)	39 cfs 1.1 cms	33 to 48 cfs 0.94 to 1.4 cms
7Q10	Distribution free	29 cfs 0.82 cms	
	Log Pearson III (no bias correction)	28 cfs 0.80 cms	20 to 35 cfs 0.57 to 0.98 cms
	Weibull	27 cfs 0.75 cms	18 to 35 cfs 0.50 to 1.0 cms
	Log-Normal (3 parameter)	29 cfs 0.81 cms	26 to 32 cfs 0.72 to 0.91 cms

Air temperature is available for the USGS meteorology station at South Prairie since 1999. Because the South Prairie air temperatures are highly correlated with the SeaTac Airport temperatures ($R^2 = 0.92$ for the 7-day average of daily maximum temperatures), the long-term SeaTac Airport record was used to develop statistics from the period 1948 to 2001. The annual maximum values of the 7-day running average of daily maximum temperatures were ranked. The median (50th percentile) was used for typical hydrologic conditions; while the daily maximum temperature exceeded 10% of the time (90th percentile) was used for extreme

hydrologic conditions. Table 10 summarizes the values from the SeaTac record and estimated for the South Prairie station.

Table 10. Air temperature statistics for South Prairie Creek.

	Typical Hydrologic Condition (exceeded 50% of time)		Extreme Hydrologic Condition (exceeded 10% of time)	
	(°C)	(°F)	(°C)	(°F)
SeaTac Airport (National Weather Service)	28.7	83.7	30.5	86.9
South Prairie Creek from regression with SeaTac record	28.6	83.5	30.4	86.7

Analytical Framework for Linking Shade and Instream Temperature

Riparian vegetation, stream morphology, hydrology, climate, and geographic location influence stream temperature. Stream temperature represents the concentration of heat. If heat loads gained by a stream reach exceed losses, the temperature increases. The change in heat is generally small compared with the heat entering from upstream. The heat budget expresses this in mathematical form:

$$J_{net} = J_{longwave} + J_{solar} + J_{convection} + J_{evaporation} + J_{bed} + J_{hyporheic} + J_{in} + J_{out}$$

where J represents the flux of each component, which can be positive or negative. Objects emit absorbed heat in the form of long-wave radiation ($J_{longwave}$). The atmosphere provides some long-wave radiation to water bodies, but more tends to be emitted by the water bodies, generally resulting in a net loss of heat. Solar, or short-wave radiation, (J_{solar}) tends to dominate the heat budget where effective shade is low. Solar radiation inputs peak at mid-day and do not occur at night. Heat can be transferred through convection ($J_{convection}$). If a stream is hotter than the air temperature above it, heat is transferred from the stream to the air, resulting in a decreased water temperature. Wind transfers that heat horizontally and dissipates air temperature gains next to the stream surface, which maintains the gradient of temperature that drives convection losses from the stream. If air temperature exceeds water temperature, heat is transferred into the stream. However, this term tends to be small relative to other heat fluxes. Evaporation ($J_{evaporation}$) results in a transfer of latent heat from the water body to the air (Dingman, 1994), although it is small relative to other terms in the heat budget equation. Finally, heat can be transferred to or from the bed through advective exchange of water containing heat ($J_{hyporheic}$) or by conduction (J_{bed}) with the sediments (Beschta et al., 1987). In addition, heat is advected in (J_{in}) and out (J_{out}) of a reach via surface water transport. Figure 10 provides an example of the heat flux components for a reach downstream of the town of South Prairie under 7Q10 hydrologic conditions.
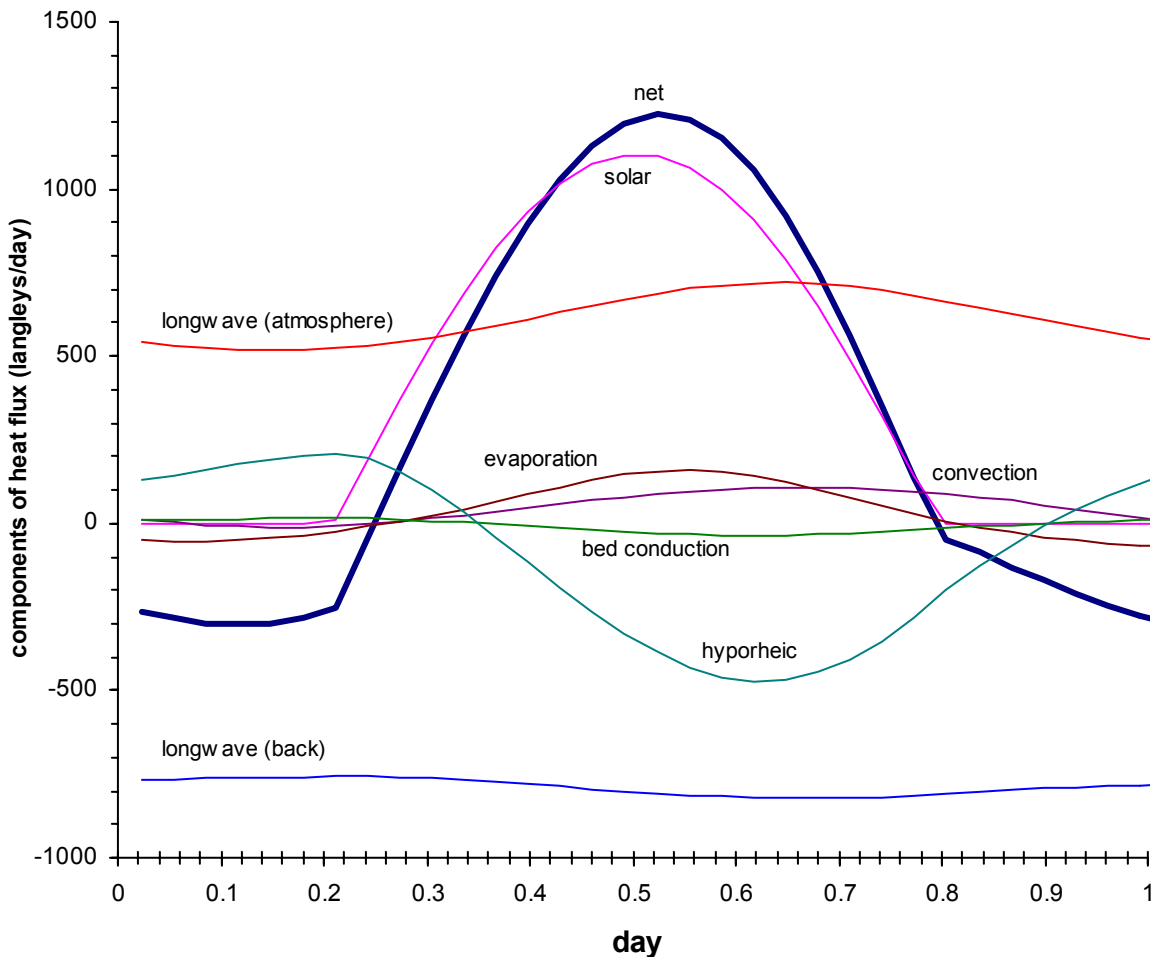
Figure 10. Heat flux components for South Prairie Creek downstream of South Prairie for 7Q10 conditions.

While climate and geographic location are outside of direct human control, riparian condition, channel morphology, and hydrology are affected by land use activities. Specifically, the elevated summer stream temperatures attributed to anthropogenic sources in the South Prairie Creek basin result from the following:

- Riparian vegetation disturbance reduces stream surface shading by decreasing riparian vegetation height, width, and density, thereby increasing the amount of solar radiation reaching the stream surface. Timber harvest, residential development, and agricultural activities decrease shade.

- Point source discharges from two wastewater treatment plants contribute heat loads to receiving water bodies.

- Channel widening (increased width to depth ratios) increases the stream surface area exposed to solar radiation.

South Prairie Creek Bacteria and Temperature TMDL

- Reduced summer base flows may result from instream withdrawals and hydraulically connected groundwater withdrawals or hydrologic effects of timber harvesting. Reducing the amount of water in a stream can increase stream temperature (Brown, 1972).

- Reduced surface water/groundwater interaction, also called hyporheic exchange flow, increases surface water temperatures by reducing heat loss to gravels and cool groundwater discharges. This can result from decreased channel complexity and/or clogging of the gravels by fine material.

The present study includes the effects of reduced shade, point source heat discharges, channel widening, typical and extreme baseflow conditions, and the effect of hyporheic exchange flow. The analysis includes flow as a fixed variable only, since flows do not fall under the jurisdiction of the TMDL program. However, any activities that increase water withdrawals or decrease groundwater discharge or hyporheic exchange flow will exacerbate the temperature exceedances on South Prairie Creek and its tributaries. Similarly, channel widening will increase the channel surface area exposed to solar radiation and increase the surface water temperature of South Prairie Creek and its tributaries.

Effective Shade Definition

Effective shade is defined as the fraction of the potential solar shortwave radiation that is blocked by vegetation and topography before it reaches the stream surface. Effective shade is a function of several landscape and stream geometric relationships. Some of the factors that influence effective shade include the following:

- latitude and longitude;
- time of year;
- stream aspect and width;
- vegetation buffer height, width, overhang, and canopy density;
- topographic shade angles.

In the Northern Hemisphere, the earth tilts on its axis toward the sun during the summer months allowing increased day length and higher solar altitude, both of which are functions of solar declination[6]. Geographic position (e.g., latitude and longitude) fixes the stream to a position on the globe, while aspect provides the stream orientation. Riparian vegetation height, width, and density describe the physical barriers between the stream and sun that can attenuate and scatter incoming solar radiation, which results in shade. The solar position has a vertical component (altitude) and a horizontal component (azimuth) that are both functions of time/date (solar declination) and the earth's rotation (hour angle). Relatively simple geometry describes the relationships using methods developed by the solar energy industry.

Percent effective shade is the most straightforward stream parameter to monitor and calculate, and it is easily translated into quantifiable water quality management and restoration objectives. Using solar tables or mathematical simulations, the potential daily solar load can be quantified.

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[6] measure of the earth's tilt toward the sun

The measured solar load at the stream surface can be measured with hemispherical photography or estimated using mathematical shade simulation computer programs.

Development of Effective Shade for South Prairie Creek and its Tributaries

The TTOOLS extension for ArcView, developed by Oregon Department of Environmental Quality (ODEQ, 2001) and modified by Ecology, samples and processes GIS data needed to calculate effective shade. First, South Prairie Creek and its tributaries were broken into 100-ft (30.5-m) segments. At the upstream end of each segment, TTOOLS develops the following attributes: stream aspect, elevation, gradient, topographic shade angle to the east, south, and west, channel width, distance from each channel bank to the edge of the nearstream disturbance zone (NSDZ), and the riparian vegetation code at varying distances from the edge of the NSDZ. The NSDZ is the active stream channel area without riparian vegetation, and includes features such as gravel bars.

Riparian vegetation is sampled at nine locations to either side of the channel (Figure 11). The sampling interval is every 15 ft (4.6 m) for a total of 135 ft (41 m) to each side of the NSDZ. Attributes for each riparian code include a unique combination of vegetation type, height, density and overhang. Overhang is generally assumed to be 10% of the vegetation height in the absence of other information. Table 11 lists the riparian vegetation codes used for the South Prairie Creek study. Appendix B presents an example of the vegetation datalayer developed for South Prairie Creek, with the current distribution of vegetation types within a 500-ft (150-m) buffer of the stream centerline.
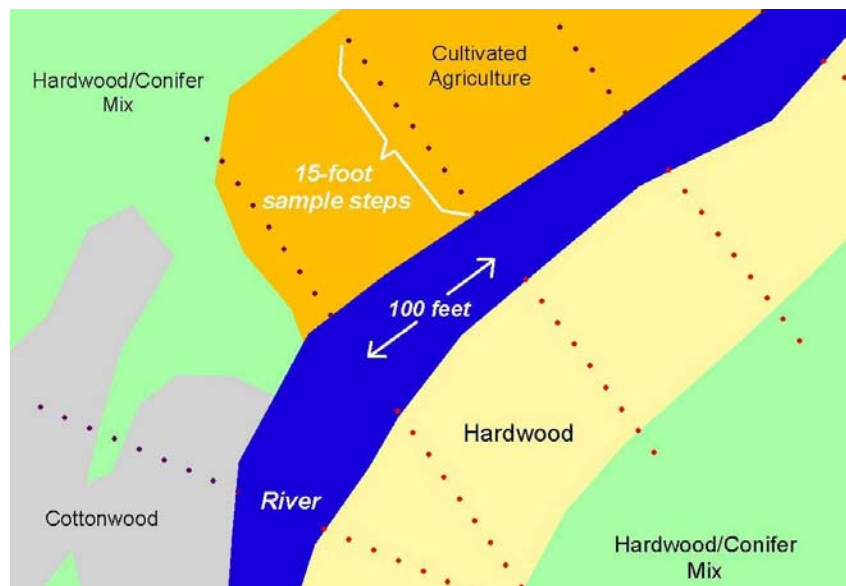
Figure 11. Riparian vegetation sampling example using TTOOLS (ODEQ, 2001).

Table 11. Riparian vegetation codes and characteristics used for South Prairie Creek.

78m Code	Description	Height (ft)	Height (m)	Density (%)	Overhang (ft)	Overhang (m)
302	Pasture, field, lawn	2	0.5	75%	0	0.0
400	Road, barren land	0	0.0	0%	0	0.0
500	Mixed forest	120	36.6	90%	8	2.4
502	Mixed forest	150	45.7	95%	15	4.6
550	Mixed forest	80	24.4	25%	8	2.4
551	Mixed forest	40	12.2	25%	4	1.2
600	Hardwood forest	90	27.4	90%	9	2.7
601	Hardwood forest	60	18.3	90%	4	1.2
700	Conifer forest	100	30.5	95%	10	3.1
800	Shrubs	15	4.6	75%	2	0.5
3011	Floodplain, river bottom	0	0.0	0%	0	0.0

The effective shade algorithm, modified from Boyd (1996) using the methods of Chen et al. (1998a and 1998b), uses the riparian vegetation codes in each zone, stream aspect, and topographic shade angles, together with a selected date and latitude/longitude to estimate effective shade for each of the 100-ft (30.5-m) segments. Results are averaged for ten segments to create shade characteristics for 1000-ft (305-m) reaches, which are used by the computer model QUAL2K, discussed below.

Figure 12 presents effective shade predicted along South Prairie Creek from SPCSR downstream to SPCM. Effective shade ranges from 45 to 70% due to a combination of vegetation removal, a wide NSDZ, and relatively little topographic shade from SPCSR to just upstream of SPCLB. South Prairie Creek flows through a narrow canyon with mature vegetation interrupted with some vegetation removal from SPCLB to just downstream of the Wilkeson Creek confluence (SPCWC). From the town of South Prairie downstream, residential and agricultural land use practices have removed or reduced riparian vegetation to a narrow buffer.

HemiView results and densiometer readings from August 2001, generally support the predicted trends in effective shade from Shadealator. The high HemiView shade calculated at SPCSP and SPCB1 are likely due to interference from bridge structures.
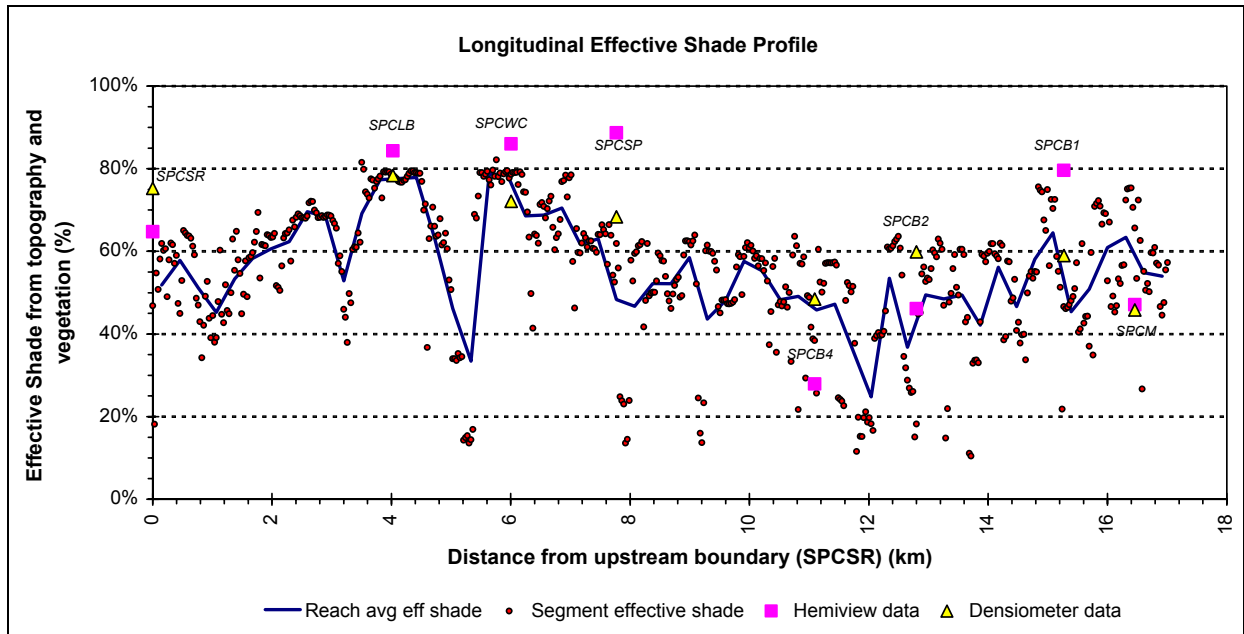
Figure 12. Longitudinal profile of effective shade for South Prairie Creek estimated using Shadealator.

Model Approach

QUAL2K Temperature Model Development

The QUAL2K model (Chapra, 2001) was used to calculate the components of the heat budget and to simulate water temperatures. QUAL2K, a Visual Basic application in a Microsoft Excel® environment, uses the kinetic formulations for the surface water heat budget described above and presented in Chapra (1997). In summary, QUAL2K is a steady-state, one-dimensional model that simulates diurnally varying water temperature using a finite-difference numerical method. Therefore, a single flow condition is selected to represent a given condition, such as a 7-day average flow. For temperature simulation, solar radiation, air temperature, relative humidity, headwater temperature, and point source/tributary water temperatures are specified as diurnally varying functions with a minimum and maximum value and time of the maximum value.

Heat flux components were calculated along the main stem of South Prairie Creek, with Wilkeson Creek, Spiketon Creek/Ditch, and the South Prairie wastewater treatment plant included as point sources. The model was calibrated using data collected during the hottest conditions of 2001 (August 9 through August 15) and verified with two different data sets: hottest water temperatures of 2000 (July 29 through August 4) and coolest steady-state maximum temperatures of 2001[7] (August 1 through August 7).

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[7] The coolest 7-day average of maximum daily temperatures occurred August 22-28, 2001. However, these temperatures occurred during a storm, and unsteady conditions cannot be modeled using QUAL2K. Therefore, the coolest peak temperatures during steady-state conditions were used for the second validation data set.

Table 12 summarizes model input data specified for any model run. Following are descriptions of how specific input parameters were developed:

- Differential flows along South Prairie Creek were calculated for calibration and validation runs using field measurements. Flows were estimated for ungaged locations using the ratio of watershed areas with a measured flow location. For 7Q2 and 7Q10 analyses, the distribution of flows throughout the watershed was based on regression equations between the USGS gage at South Prairie and instantaneous flow measurements recorded during the present study. Differential inflows are specified as total inflow rate over a specified distance.

- Headwater temperature boundary conditions were established using monitoring data for the calibration and validation data sets from station SPCSR.

- Reach hydraulic geometry coefficients were established for monitoring stations and were assumed to hold over half the distance to stations upstream and downstream. The hydraulic geometry used in calibration and validation runs was also used for 7Q2 and 7Q10 runs. Calibration flows (36 cfs or 1.0 cms at SPCSP) were close to 7Q2 conditions (40 cfs or 1.1 cms).

- Sediment thermal properties were based on literature values for wet sand with a porosity of 0.7.

- Hyporheic exchange flow was a calibration parameter held constant for the validation, 7Q2, and 7Q10 runs.

- Air temperatures for the calibration run were based on monitoring data. Minimum daily air temperatures increased slightly downstream from 10.9 to 11.9°C at the mouth with a peak of 12.3°C at SPCSP, but maximum daily air temperatures increased significantly from 23.9 to 29.0°C at the mouth with SPCB2 exhibiting a peak of 30.5°C. The variation is equivalent to a lapse rate of 50°C/km, which is far greater than that explained by the adiabatic lapse rate of 6.5°C/km under dry conditions. The distribution for the calibration period was used to relate temperature at each site to the SPCSP riparian air temperature measured in the 2001 data collection program. Station SPCSP is closest to the USGS meteorology gage. Tidbit data were correlated with the USGS meteorological station data ($R^2 = 0.92$) but were slightly cooler, likely due to the riparian microclimate. The 2000 validation period uses USGS meteorological station data to generate the SPCSP riparian temperatures and the longitudinal air temperature profile. The USGS meteorological data were related to the SeaTac Airport record. Thus, the longitudinal air temperature profiles were developed for 7Q2 and 7Q10 conditions based on the SeaTac air temperature data, corrected for South Prairie conditions.

- Relative humidity values for the calibration and validation runs were based on 2001 data for the mouth of Wilkeson Creek (WCM) to characterize reaches from the upstream boundary (SPCSR) to the town of South Prairie (SPCSP) and 2001 data from the mouth of South Prairie Creek (SPCM) for the remainder of the study area. Minimum relative humidity occurs in late afternoon, while nearly 100% relative humidity occurs just before sunrise, even in summer conditions. The 2000 validation, 7Q2, and 7Q10 runs use 2001 monitoring results of approximately 60% minimum relative humidity and 100% maximum relative humidity.

- Wind speed was recorded near the South Prairie wastewater treatment plant in summer 2001, and data from the calibration and validation time periods were used. The 2000 validation uses the SeaTac data. The calibration values were used for 7Q2 and 7Q10 runs. Pollution index was set to 2 (clear) for all runs.

- Tributary point source inputs were developed from monitoring data at the mouth of Wilkeson Creek (WCM) and the mouth of Spiketon Creek/Ditch (SKT165/SKTM) for the 2001 calibration and validation and 2000 validation runs. For 7Q2 and 7Q10 conditions, maximum temperatures were assumed to be 18°C, with minimum temperatures set to the calibration run values.

- The South Prairie wastewater treatment plant point source inputs were developed from monitoring data reported in the Daily Monitoring Reports submitted to Ecology by the plant operator. Only one daily temperature is reported; 7-day average values of this temperature were used for both the maximum and minimum effluent temperature, essentially holding the temperature constant throughout the day.

- Diffuse source temperatures were assigned the average annual temperature (10.9°C), based on SeaTac mean daily air temperatures for the period October 1999 through September 2001[8]. The shape of the watershed is such that only very small surface tributaries other than Wilkeson Creek, Spiketon Creek/Ditch, and the unnamed tributary from the town of South Prairie enter the main stem of South Prairie Creek. Therefore, differential flows are assumed to be dominated by groundwater, and groundwater temperatures are often similar to the mean annual air temperature (Theurer et al., 1984).

Table 12. QUAL2K model input data summary

Category	Model Input Data
Run Information	Date, sunrise
Headwater	Latitude, longitude, elevation, discharge, discharge coefficients of upstream reach, minimum temperature, maximum temperature, time of maximum temperature
Reach	Reach labels, length, latitude, longitude, hydraulic geometry coefficients, effective shade, sediment thermal properties, hyporheic exchange flow
Meteorology	Minimum air temperature, maximum air temperature, time of maximum air temperature, minimum relative humidity, maximum relative humidity, time of maximum relative humidity, wind speed, cloud cover, pollution index (all specified by reach)
Point Sources	Name, location of inflow point, discharge, maximum temperature, minimum temperature, time of maximum temperature
Diffuse Sources	Upstream extent of source, downstream extent of source, discharge, temperature

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[8] The long-term (1948 to 2001) mean daily air temperature is similar at 10.7°C.

Model Calibration

Figure 13 presents the calibration run for South Prairie Creek for the 7-day average conditions for the period August 9 through August 15, 2001. The model appropriately represents the maximum temperature profile for the calibration conditions. The uncertainty of the temperatures predicted by the QUAL2K model can be assessed using the root mean square error[9] (RMSE) of the predicted versus observed maximum and minimum temperatures. For the calibration period, the RMSE is 0.54°C.
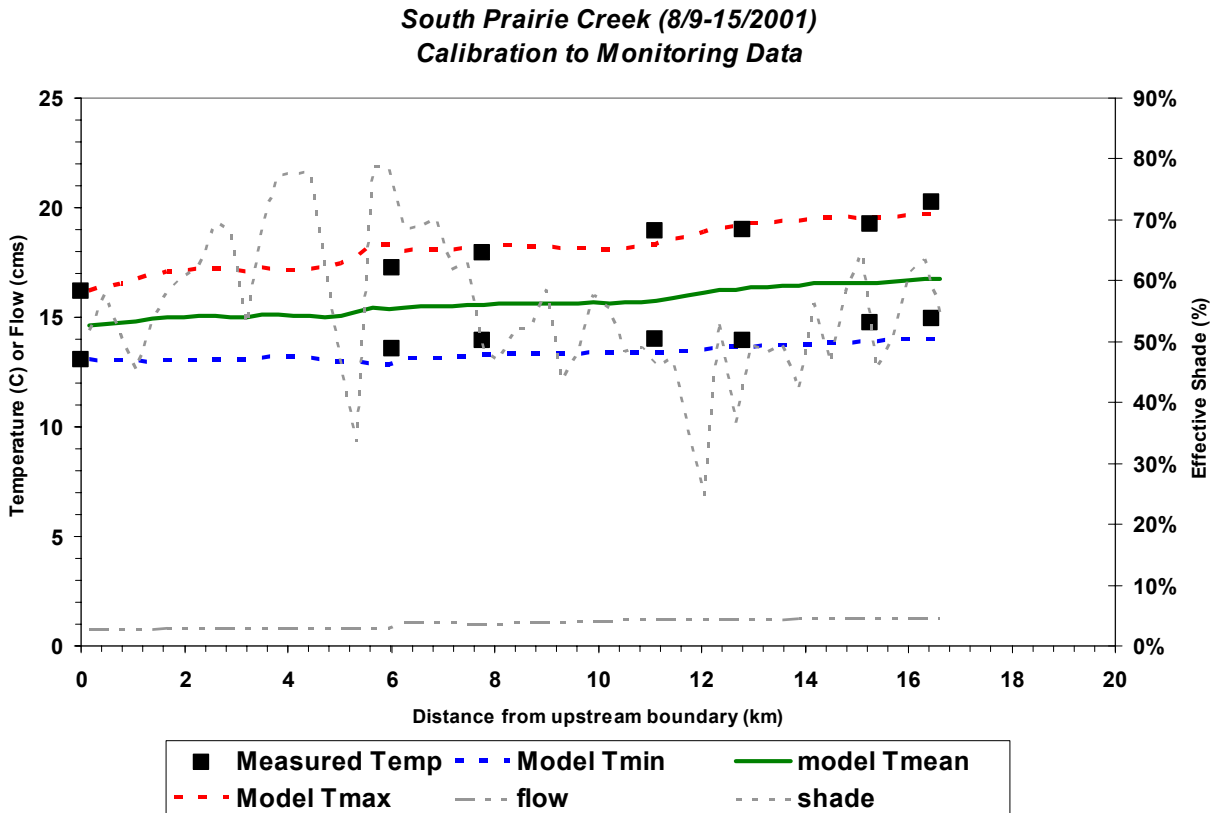
Figure 13. Comparison of predicted and observed minimum and maximum temperatures for South Prairie Creek for the calibration period August 9 through 15, 2001 (RMSE = 0.54°C)

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[9] RMSE is the square root of the sum of the squared differences between observed and predicted values.

Model Validation

Two additional data sets were evaluated to verify that the model appropriately represents the temperature processes important to South Prairie Creek. Figure 14 compares the temperatures predicted by the QUAL2K model with measured data for the warm validation period, July 29 through August 4, 2000, using the effective shade and hyporheic exchange flows calibrated for the 2001 calibration period. Model uncertainty is relatively low, with a RMSE of 0.64°C. Similarly, Figure 15 compares predicted temperatures with measured data for the cool validation period, August 1 through August 7, 2001, using the calibration values for effective shade and hyporheic exchange flows. The RMSE is slightly higher at 0.91°C, but the model still appropriately represents cool peak temperature conditions.
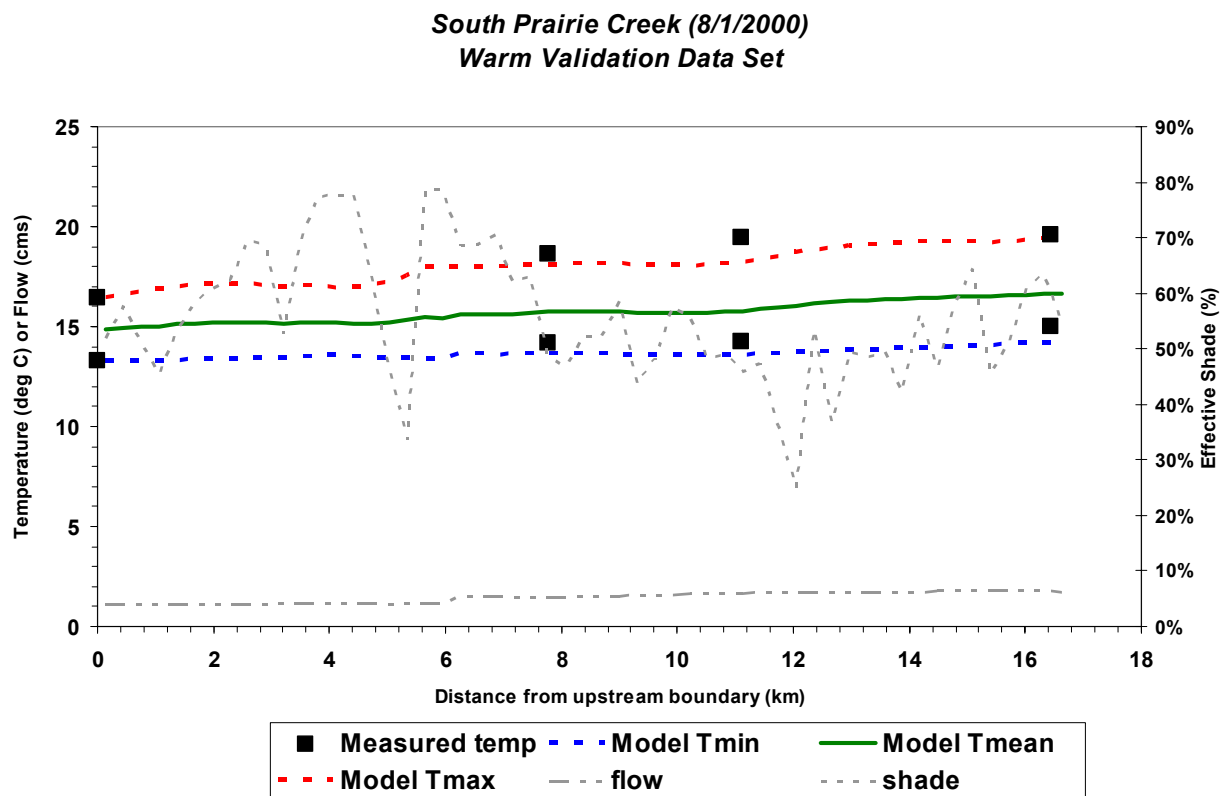
Figure 14. Comparison of predicted and observed minimum and maximum temperatures for South Prairie Creek for the warm validation period of July 29 through August 4, 2000 (RMSE = 0.64°C).

South Prairie Creek Bacteria and Temperature TMDL

South Prairie Creek (8/1-7/2001)
Cool Validation Data Set
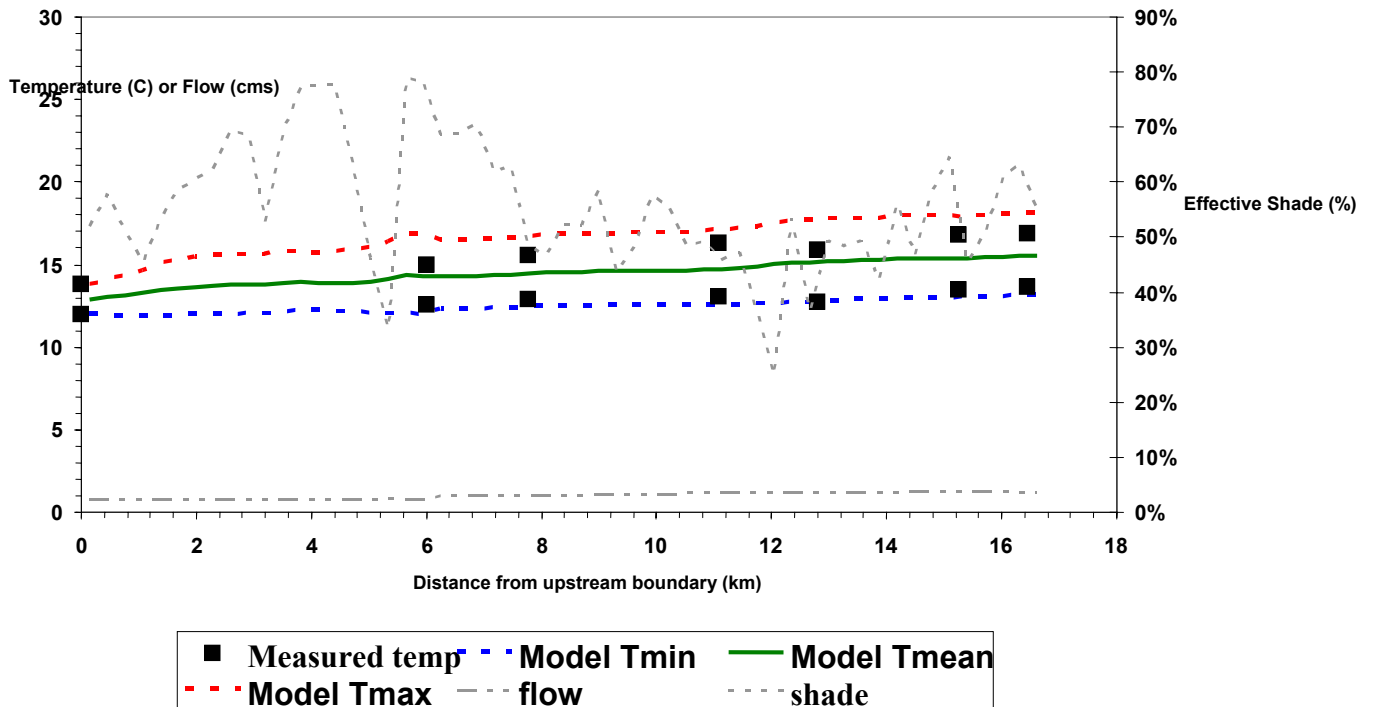
Figure 15. Comparison of predicted and observed minimum and maximum temperatures for South Prairie Creek for the cool validation period of August 1 through 7, 2001 (RMSE = 0.91°C).

7Q2 and 7Q10 Conditions

Predicted daily maximum temperatures for typical and extreme hydrologic conditions are presented in Figure 16 with the calibration results. Because calibration air temperature and flow conditions were close to 7Q2 conditions, the predicted temperatures are similar. However, the higher air temperatures and lower flow conditions expected under 7Q10 conditions result in significantly increased water temperatures along the entire length of South Prairie Creek. Lengths of stream exceeding the 18°C standard are 6.9 and 9.2 mi (11.1 and 14.8 km) for typical and extreme hydrologic conditions, respectively.
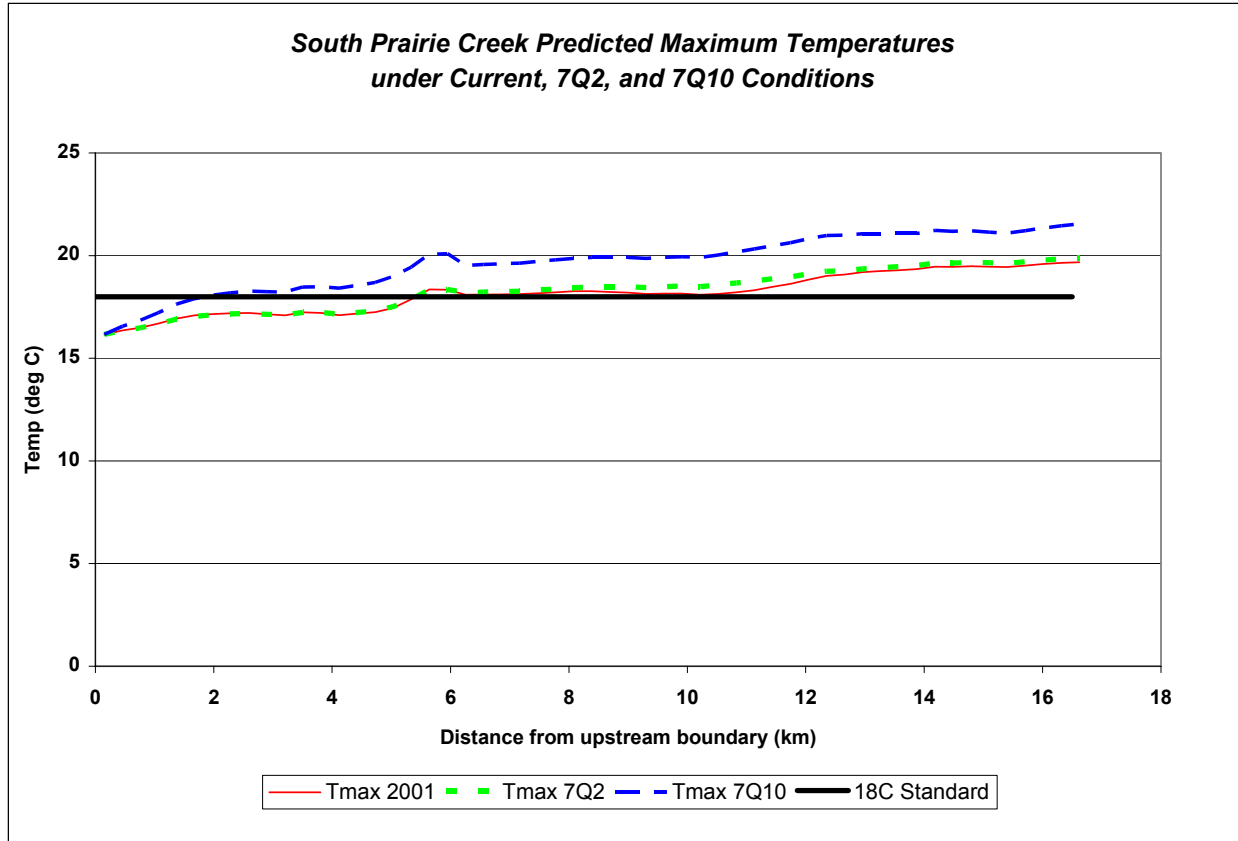
Figure 16. Predicted temperatures in South Prairie Creek under current, typical (7Q2), and extreme (7Q10) hydrologic conditions.

Loading Capacity

The calibrated QUAL2K model was used to determine the loading capacity for effective shade for South Prairie Creek from the upstream boundary at Spiketon Road (SPCSR) to the mouth. Loading capacity was determined based on prediction of water temperatures under typical and extreme flow and climate conditions combined with a range of effective shade conditions. The 7Q2 low flow was selected to represent a typical climatic year, and the 7Q10 low flow was selected to represent a reasonable worst-case condition for the July-August summer period.

The site potential vegetation is a cedar/hemlock/Douglas fir forest. A tree height of 55 m (180 ft) and canopy density of 90%, based on the current vegetation found along South Prairie Creek at the Wilkeson Creek confluence (SPCWC) and at the Lower Burnett Road crossing (SPCLB) (see Figure 12), was used to define maximum potential effective shade from mature riparian vegetation. The DNR soils datalayer indicates the area has a site index of 129, which represents the height in feet of the dominant or co-dominant vegetation at a stand age of 50 years for forests west of the Cascades. This is close to the highest site index value for all of WRIA 10 (132 ft, or 40 m). Much of the South Prairie Creek riparian area had been modified prior to the 1936 vegetation survey (USFS, 1996), which indicates older trees near the confluence with Wilkeson Creek (Figure 17). Thus, the current vegetation does not represent undisturbed conditions. The parameters representing mature riparian conditions exceed the height expected within 50 years, based on the site index from soil surveys, and are within the values for mature western Washington forests documented in Beschta et al. (1987).
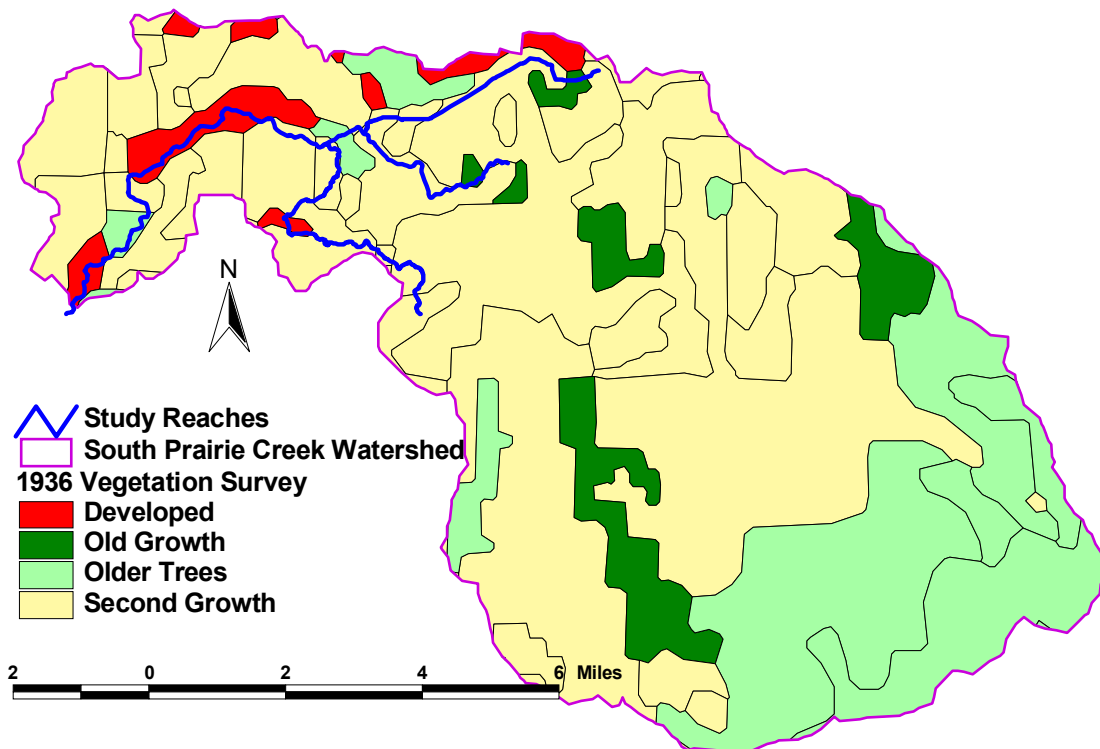
Figure 17. Vegetation present during 1936 vegetation survey.

Figure 18 presents the predicted water temperature in South Prairie Creek for the lowest 7-day average discharge during July and August with a two-year recurrence interval (7Q2) and a ten-year recurrence interval (7Q10). The increase in effective shade from mature riparian vegetation has the potential to significantly decrease water temperature under both typical and extreme hydrologic conditions.

Effect of Maximum Vegetation at 7Q2 Conditions

Legend: Tmax 7Q2 with current veg — Tmax 7Q2 with max veg — 18C

Effect of Maximum Vegetation and All Management Options at 7Q10 Conditions

Legend: Tmax 7Q10 with current veg — Tmax 7Q10 with max veg — Tmax 7Q10 with all mgmt options — 18C
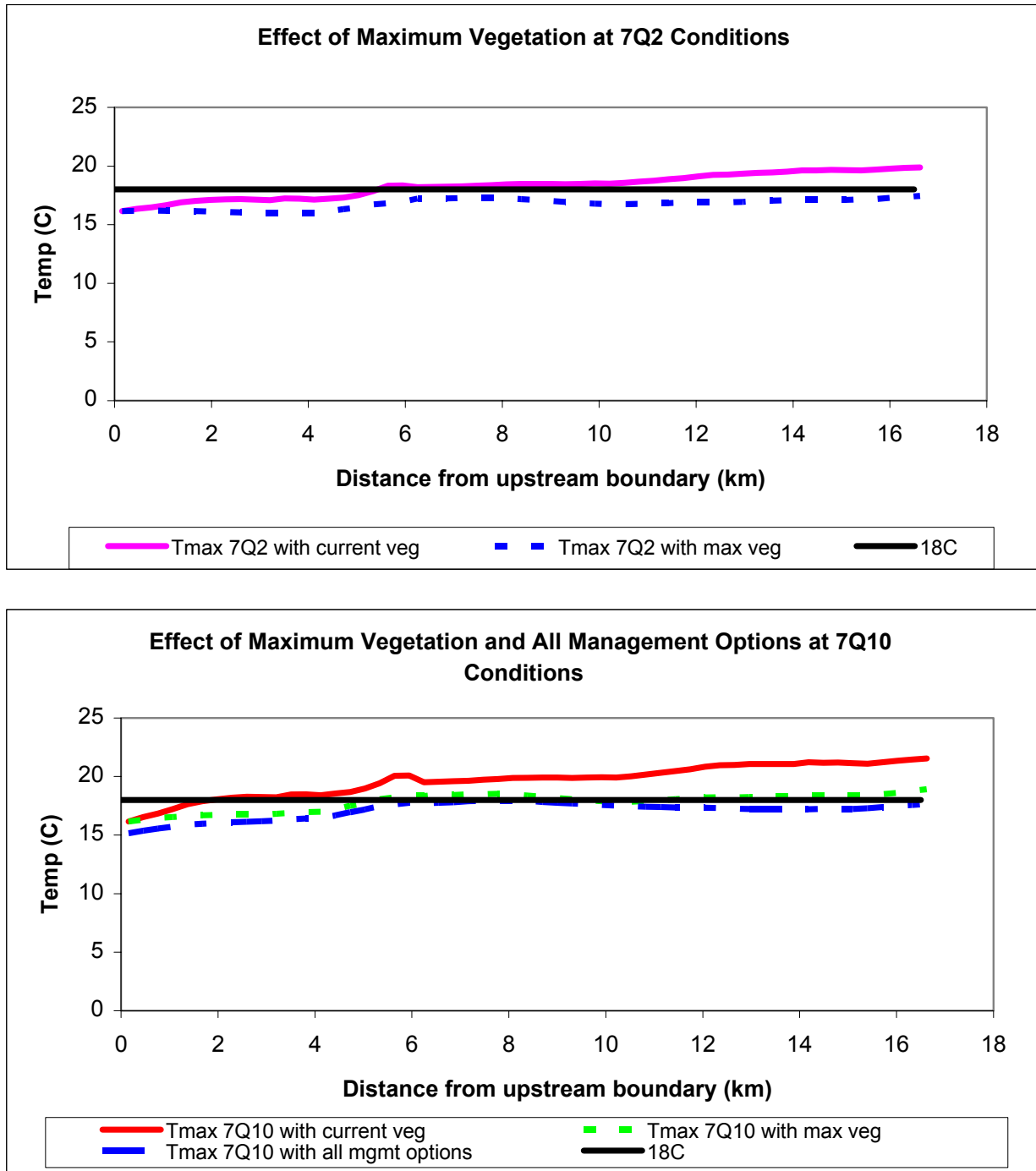
Figure 18. Predicted daily maximum temperature in South Prairie Creek under critical conditions for the TMDL.

With current vegetation, South Prairie Creek exceeds the numeric standard in the lower 11.1 km during 7Q2 conditions. Under mature vegetation conditions within the modeled area, South Prairie Creek should meet numeric standards along the entire length. Under 7Q10 conditions, current vegetation produces water temperatures that exceed 18°C for the lower 14.8 km of the creek with a peak temperature of 21.5°C. For the same flow conditions with mature vegetation within the model area, solar radiation is significantly attenuated such that an additional 7.8 km meets the 18°C criterion and temperatures peak at 18.9°C.

The background temperature expected within the study area was determined using the upstream boundary condition measured in 2001. The area was simulated with no upstream water withdrawals, mature riparian vegetation throughout the model area, and an intact riparian microclimate that reduces air temperatures. Temperature peaks at 18.2°C, as shown in Figure 18. Therefore, 18.2°C represents the background temperature against which anthropogenic impacts and management strategies are compared. Human activities cannot increase the temperature by >0.3°C above this, or 18.5°C.

Maximum vegetation alone will significantly decrease daily maximum temperatures, but South Prairie Creek may exceed 18°C under extreme hydrologic events, represented by 7Q10 conditions. Several additional ongoing and potential management strategies were simulated as a series of scenarios: increased baseflow, decreased upstream boundary condition temperatures, decreased channel widths, and decreased air temperatures. Table 13 summarizes the results.

Table 13. Management scenarios and decreases in peak temperatures in South Prairie Creek for extreme hydrologic conditions (7Q10). [±0.6 to 0.9 °C for model uncertainty]

Scenario	T_{max} (°C)	T_{max}*	Length <18°C	
Current vegetation**	21.5	(2.6)	2.0 km	12%
Mature riparian vegetation	18.9	0.0	7.0 km	42%
No DSHS withdrawal (increase headwater discharge by 3.5 cfs = 0.10 m³/s)	18.8	0.1	8.2 km	49%
No DSHS withdrawal and augment flows another 6.5 cfs	18.5	0.4	13.1 km	78%
No DSHS withdrawal and cool headwater boundary condition T_{max} by 1°C to 15.16°C	18.7	0.2	10.7 km	64%
No DSHS withdrawal and cool headwater boundary condition T_{max} by 2°C to 14.16°C	18.5	0.4	14.0 km	84%
No DSHS withdrawal and cool Wilkeson Creek T_{max} to 17°C	18.7	0.2	9.8 km	58%
No DSHS withdrawal and decrease channel width near mouth by 15% from 19m to 16m	18.6	0.3	8.2 km	49%
No DSHS withdrawal and keep SPCSP T_{air} constant downstream to mimic riparian microclimate	18.3	0.6	12.5 km	75%
No DSHS withdrawal, T_{air} constant from SPCSP downstream, decrease width, decrease SPC upstream boundary by 1°C, decrease Wilkeson Creek by 1°C	18.0	0.9	16.6	100%

* compared with maximum potential vegetation
** current vegetation produces peak temperatures 2.6°C greater than mature riparian vegetation

First, the streamflow at the upstream model boundary was increased under 7Q10 conditions to simulate a retired water right or other flow augmentation. DSHS may no longer exercise its water right of 3.5 cfs (0.10 cms). Adding the equivalent volume to the headwater boundary condition reduces the peak temperature to 18.8°C compared with 18.9°C for maximum potential vegetation; 8.2 km or 49% of the model study area would have surface water temperatures less than 18°C. If the upstream boundary discharge increased by another 6.5 cfs, or a total of 10 cfs including the DSHS water right, peak temperatures would decrease further to 18.5°C, and 78% of the study area would not exceed 18°C.

Second, to simulate the results of the TFW Agreement, the daily maximum temperature at the upstream boundary in South Prairie Creek was decreased by 1°C and 2°C to 15.16°C and 14.16°C, respectively. Peak temperatures would decrease from 18.9 in South Prairie Creek to 18.7 in South Prairie Creek and the length of stream not exceeding 18 in South Prairie Creek would increase from 8.2 to 10.7 km. A 2°C increase would result in a decrease in peak temperature from 18.9°C to 18.5°C, and 14.0 km (84%) of the study area would not exceed 18°C. Similarly, the Wilkeson Creek discharge was reduced to 17°C. This results in a similar decrease in peak temperature from 18.9°C to 18.7°C and increase in length of stream not exceeding 18°C from 8.2 to 9.8 km.

Third, by decreasing the channel width near the mouth by 15% from 62 ft to 53 ft (19 m to 16 m), peak temperatures decrease from 18.9°C to 18.6°C; the length of stream not exceeding 18°C would not change.

Finally, the model was used to simulate the effects of potential air temperature decreases due to a riparian microclimate that could result from continuous mature riparian vegetation. As described under Model Approach, longitudinal air temperatures varied from a maximum of 23.9°C during 2001 at the upstream boundary (SPCSR) to 29.0°C at the mouth (SPCM). This increase is far greater than can be explained by the dry adiabatic lapse rate to account for changes of elevation. The 2001 distribution of peak temperatures was used to relate air temperatures at the USGS meteorology station to riparian air temperatures upstream and downstream. The lack of continuous, mature riparian vegetation downstream of the town of South Prairie likely contributed to the 6.1°C increase in air temperatures as compared with the upstream area, where topography and vegetation likely create cool riparian microclimates. If the air temperature at the town of South Prairie is held constant downstream, temperature peaks at 18.3°C compared with 18.8°C, and 75% of the model area does not exceed 18°C.

In summary, increased shade from mature riparian vegetation significantly reduces peak water temperatures and increases the length of stream not exceeding 18°C. The secondary beneficial impacts of the riparian microclimate to air temperatures further reduces peak temperatures and increases the length of stream not exceeding 18°C. Increasing baseflow, decreasing upstream boundary temperatures, and decreasing stream width near the mouth also decrease peak temperatures. If all activities coincide, the model predicts that no part of South Prairie Creek will exceed 18°C. However, common practice (Pelletier, 2002; Brock and Stohr, 2002) in temperature TMDLs is to use model uncertainty (RMSE of 0.64°C and 0.91°C, from validation

runs) as part of the margin of safety. While peak temperatures will exceed 18°C minus the uncertainty, or 17.1°C to 17.4°C, for all ongoing and potential management strategies, these practices significantly decrease daily maximum temperatures during critical conditions and increase the length of stream not exceeding 18°C. This attenuation of the diurnal thermal range is beneficial to salmonids and other aquatic species using the creeks for refugia.

Load Allocations

The Load Allocations for effective shade in the South Prairie Creek watershed are as follows:

- For all perennial streams in the South Prairie Creek watershed, the load allocation for effective shade is the maximum potential effective shade that would occur from mature riparian vegetation.

Load Allocations for effective shade are quantified for the modeled reaches of South Prairie Creek in Table 14 as an example. For all other perennial streams in the watershed, the Load Allocation for effective shade is the maximum potential effective shade that would occur from mature riparian vegetation.

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

- For U.S. Forest Service land, the riparian reserves in the Northwest Forest Plan are recommended for establishment of mature riparian vegetation.

- For privately owned forest land, the riparian vegetation prescriptions in the Forests and Fish Report are recommended for all perennial streams. Load allocations are included in this TMDL for forest lands in the South Prairie Creek watershed in accordance with the section of Forests and Fish entitled "TMDLs produced prior to 2009 in mixed use watersheds," using the shade curve methodology developed in the Upper White River Watershed Temperature TMDL (Ketcheson et al., 2003). Figure 19 presents the effective shade provided to streams of different NSDZ widths, varying stream aspects, and varying tree heights to represent an aging riparian forest. For example, for an east-west stream segment (aspect 90°) with a width of 66 ft (20 m) effective shade can be expected to increase from 18% to 35% to 62% to 80% as riparian tree height increases from 30 ft (9 m) to 60 ft (18 m) to 120 ft (37 m) to 180 ft (55 m).

- Instream flows and water withdrawals are managed through regulatory avenues separate from TMDLs. However, stream temperature is directly related to the amount of instream flow, and reductions in flow result in increases in temperatures. Given the temperature exceedance in South Prairie Creek and the inability to meet the temperature standard under full mature riparian vegetation, no further water withdrawals should be permitted. Voluntary retirement of existing water rights should be encouraged.

- While this study did not find evidence of channel widening in the South Prairie Creek watershed and a previous study found no evidence of changes in channel geometry

(Mastin, 1998), future development and management activities should control potential channel widening processes.

Table 14. Effective shade, solar flux, and load allocations for South Prairie Creek.

Station	Reach	Distance from upstream boundary to middle of stream reach (km)	Distance from mouth to middle of stream reach (km)	Reach-average effective shade for current conditions (%)	Reach-average solar radiation received at the water surface on August 1 with current vegetation (langley/day)	Reach-average effective shade with mature riparian vegetation (%)	Reach-average solar radiation received at the water surface on August 1 with mature riparian vegetation (langley/day)	Load allocation for effective shade assuming mature riparian vegetation (180 ft and 90% canopy density)
SPCSR	1	0.15	16.6	52%	316	71%	193	71%
	2	0.46	16.3	58%	279	72%	191	72%
	3	0.76	16.0	51%	318	74%	186	74%
	4	1.07	15.7	45%	353	72%	167	72%
	5	1.37	15.4	53%	304	77%	185	77%
	6	1.68	15.1	58%	274	76%	153	76%
	7	1.98	14.8	61%	260	77%	156	77%
	8	2.29	14.5	62%	248	78%	152	78%
	9	2.59	14.2	70%	202	78%	146	78%
	10	2.90	13.9	68%	211	73%	149	73%
	11	3.20	13.6	53%	310	75%	177	75%
	12	3.51	13.3	69%	203	77%	165	77%
SPCLB	13	3.81	13.0	77%	147	78%	147	78%
	14	4.12	12.7	78%	148	78%	148	78%
	15	4.42	12.4	78%	148	71%	148	78%
	16	4.73	12.0	63%	242	74%	193	74%
SKTM	17	5.03	11.7	46%	346	66%	167	66%
	18	5.34	11.4	33%	433	79%	223	79%
	19	5.64	11.1	79%	139	79%	139	79%
SPCWC	20	5.95	10.8	79%	141	69%	141	79%
	21	6.25	10.5	69%	206	76%	220	76%
	22	6.56	10.2	69%	202	75%	156	75%
	23	6.86	9.9	70%	187	74%	161	74%
	24	7.17	9.6	62%	252	77%	174	77%
SPCSP	25	7.47	9.3	63%	244	78%	150	78%
	26	7.78	9.0	48%	336	76%	145	76%
	27	8.08	8.7	47%	349	78%	160	78%
	28	8.39	8.4	52%	313	78%	146	78%
SPCOF	29	8.69	8.1	52%	312	76%	147	76%
	30	9.00	7.8	58%	274	78%	155	78%
	31	9.30	7.5	44%	369	76%	149	76%
	32	9.61	7.2	48%	336	77%	154	77%
	33	9.91	6.9	58%	279	75%	154	75%
	34	10.22	6.6	55%	293	76%	162	76%
	35	10.52	6.3	48%	335	75%	158	75%
SPCB4	36	10.83	5.9	49%	334	71%	167	71%
	37	11.13	5.6	46%	354	76%	190	76%
	38	11.44	5.3	47%	345	72%	160	72%
	39	11.74	5.0	36%	413	72%	183	72%
	40	12.05	4.7	25%	485	72%	180	72%
	41	12.35	4.4	53%	307	75%	184	75%
SPCB2	42	12.66	4.1	37%	414	71%	162	71%
	43	12.96	3.8	49%	331	64%	189	64%
	44	13.27	3.5	48%	338	70%	237	70%
	45	13.57	3.2	49%	332	73%	196	73%
	46	13.88	2.9	42%	374	72%	178	72%
	47	14.18	2.6	56%	290	74%	184	74%
	48	14.49	2.3	47%	348	74%	170	74%
	49	14.79	2.0	58%	276	73%	169	73%
SPCB1	50	15.10	1.7	64%	232	70%	179	70%
	51	15.40	1.4	45%	355	64%	193	64%
	52	15.71	1.1	51%	324	67%	235	67%
	53	16.01	0.8	61%	256	72%	218	72%
SPCM	54	16.32	0.5	63%	239	73%	184	73%
	55	16.62	0.2	55%	293	73%	178	73%

Hyporheic exchange flows and groundwater discharges are important to maintain the current temperature regime and reduce maximum daily instream temperatures. Factors that influence hyporheic exchange flow include the vertical hydraulic gradient between surface and subsurface waters as well as the conductivity of the bed sediments. Therefore, activities that reduce groundwater elevations could hamper the exchange of water through the hyporheic zone, which would result in raised stream temperatures. Similarly, activities that reduce the conductivity of bed sediments could increase stream temperatures. Therefore, future development and management activities should reduce upland and channel erosion and avoid sedimentation of fine materials in the stream substrate.
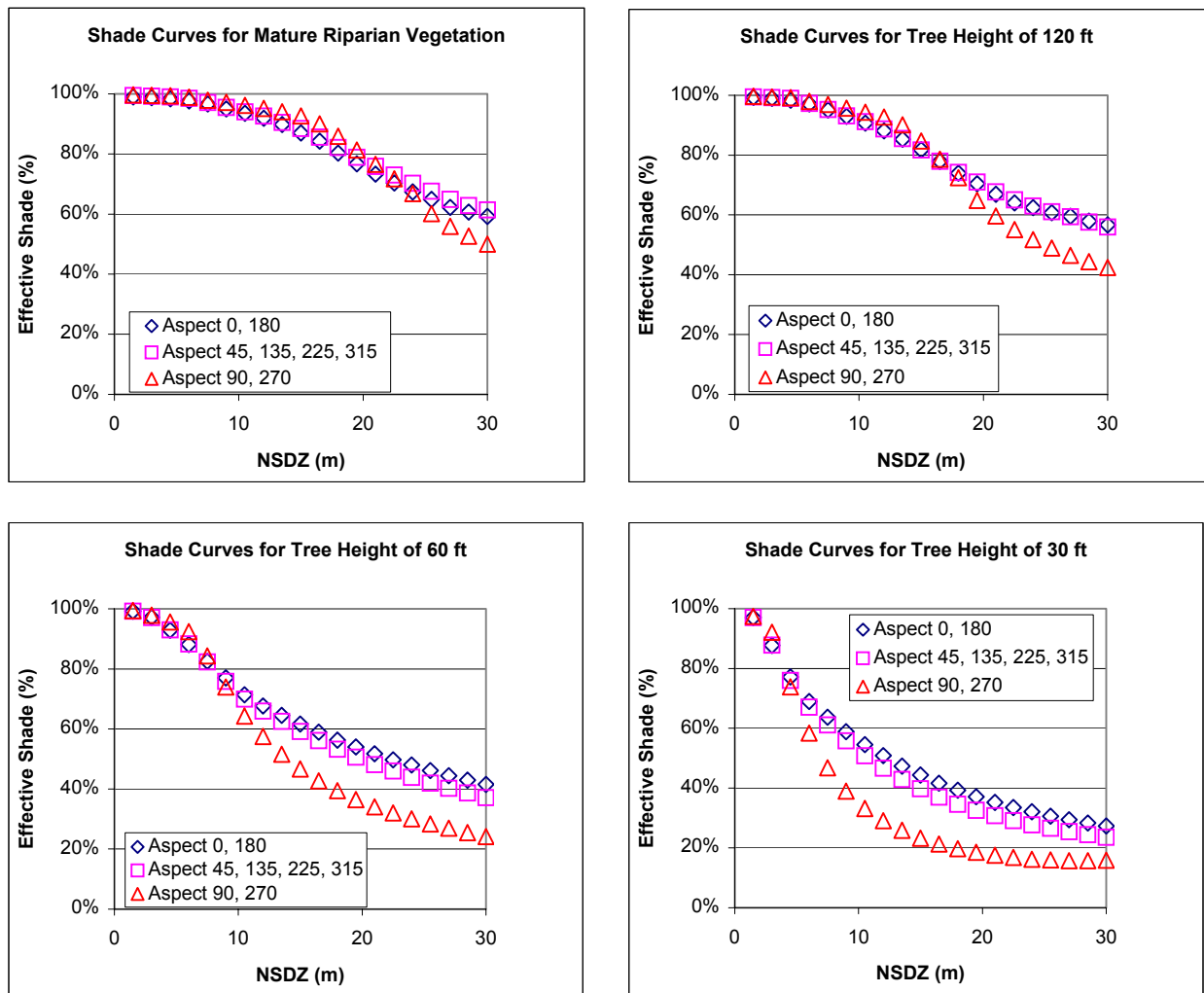
Figure 19. Effective shade provided by riparian vegetation of varying heights, stream aspect, and NSDZ width.

Wasteload Allocations

South Prairie Wastewater Treatment Plant

The South Prairie wastewater treatment plant discharges to South Prairie Creek under NPDES permit number WA0040479. The permit does not have an effluent limit for temperature. Because South Prairie Creek currently exceeds the 18°C standard near the discharge, based on the monitored conditions of 2000 and 2001 and predicted 7Q2 and 7Q10 conditions, the water quality standards stipulate that "…no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C," which includes point source and nonpoint source contributions.

No mixing zone analysis was conducted for the South Prairie wastewater treatment plant. In the absence of a previously defined mixing zone, the effluent can mix with one-quarter of the stream discharge at the point of comparison with the water quality standards (Bailey, 2002).

Table 15 summarizes the information for the South Prairie wastewater treatment plant. When the plant discharges at the maximum summer flow reported in DMRs during the period January 1995 through December 2001, the resultant temperature increase in South Prairie Creek is 0.03°C, less than the 0.3°C maximum increase in the water quality standards. Even if the South Prairie WWTP discharged at the maximum daily rate reported in the DMRs[10] at the maximum temperature, the resultant temperature increase is 0.07°C, still less than the incremental increase allowed in the water quality standards. Therefore, the load allocation is set as a function of flow rate. Effluent temperature cannot exceed

$$T_{wwtp} \, (°C) < [\, 0.452 \, / \, Q_{wwtp} \, (mgd) \,] + 18.1$$

where Q_{wwtp} is the effluent flow rate in mgd and T_{wwtp} is the effluent temperature in °C. Figure 20 illustrates the effect. The wasteload allocation does not permit the facility to exceed an effluent temperature of 33°C at any time.

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[10] Flows exceeded the permit limit of 0.0382 mgd (0.59 cfs or 0.0017 cms) in the DMRs. This analysis is presented for information purposes only and does not constitute an increase in the permit limit for flow.

Table 15. South Prairie wastewater treatment plant and receiving water characteristics.

Item	mgd	cfs	cms	°C
South Prairie Creek critical conditions at WWTP discharge				
7Q10 discharge	18.10	28.0	0.79	
Allowable mixing volume				
25% 7Q10 discharge	4.52	7.00	0.198	
Theoretical temperature increase (maximum summer discharge and maximum summer temperature)				
Summer peak effluent discharge	0.0354	0.055	0.0016	
Summer peak effluent temperature				21.8
Temperature at edge of mixing zone				18.03
Theoretical temperature increase (permit limit and maximum summer temperature)				
Permit limit for discharge	0.0382	0.059	0.0017	
Summer peak effluent temperature				21.8
Temperature at edge of mixing zone				18.03
Theoretical temperature increase (maximum annual discharge and maximum summer temperature)				
Peak discharge in DMRs	0.083	0.13	0.0036	
Summer peak effluent temperature				21.8
Temperature at edge of mixing zone				18.07
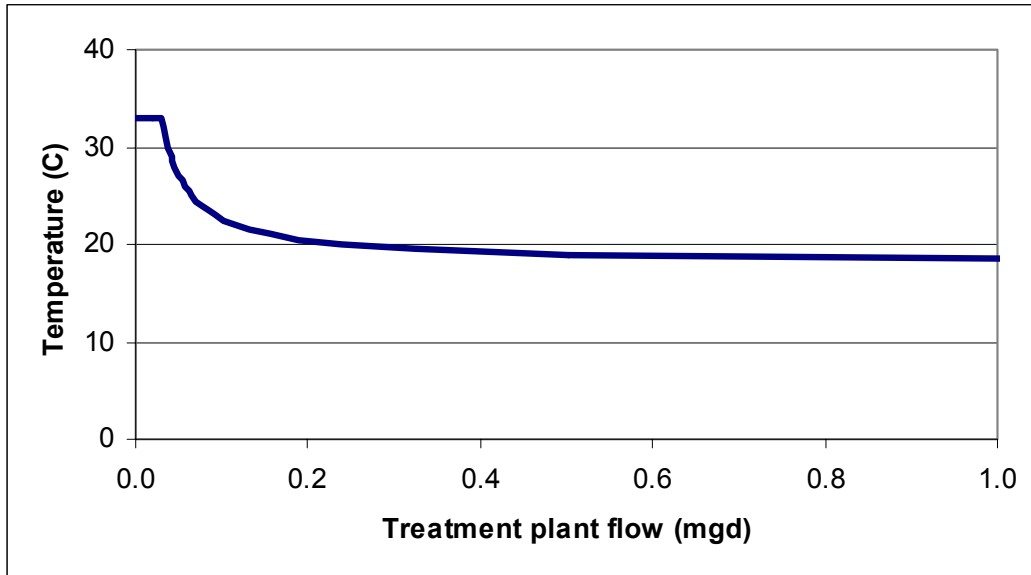
Figure 20. South Prairie wastewater treatment plant wasteload allocation.

Wilkeson Wastewater Treatment Plant

The Wilkeson wastewater treatment plant discharges to Wilkeson Creek under NPDES permit number WA0023281. The permit does not have an effluent limit for temperature. Wilkeson Creek currently meets the 18°C standard near the discharge, based on the monitored conditions of 2000 and 2001, but exceeds the standard at the mouth. The water quality standards stipulate that "…no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C," which includes point source and nonpoint source contributions.

No mixing zone analysis was conducted for the Wilkeson wastewater treatment plant. In the absence of a previously defined mixing zone, the effluent can mix with one-quarter of the stream discharge at the point of comparison with the water quality standards (Bailey, 2002). No 7Q10 has been developed for Wilkeson Creek at the wastewater treatment plant. However, using the 2000 and 2001 flow monitoring data together with the long-term discharge record on South Prairie Creek, 7Q10 flow conditions are estimated to be 6.4 cfs (0.18 cms) based on the relationship between flows at the mouth of Wilkeson Creek to those recorded at the South Prairie USGS gage, then scaled to the tributary area upstream of the discharge point.

Table 16 summarizes the information for the Wilkeson wastewater treatment plant. When the plant discharges at the maximum summer flow reported in DMRs during the period February 1991 through December 2001, the resultant temperature increase in Wilkeson Creek is 0.05°C, less than the 0.3°C maximum increase in the water quality standards. Even if the plant discharged at the maximum daily rate reported in the DMRs at the maximum temperature, the

resultant temperature increase is <0.3°C. Therefore, the load allocation is set as a function of flow rate. Effluent temperature cannot exceed

$$T_{wwtp} \, (°C) < [\; 0.104 \, / \, Q_{wwtp} \, (mgd) \;] + 18.1$$

where Q_{wwtp} is the effluent flow rate in mgd and T_{wwtp} is the effluent temperature in °C. Figure 21 illustrates the effect. The wasteload allocation does not permit the facility to exceed an effluent temperature of 33°C at any time.

Table 16. Wilkeson wastewater treatment plant and receiving water characteristics.

Item	mgd	cfs	cms	°C
Wilkeson Creek critical conditions at WWTP discharge				
7Q10 discharge	4.2	6.4	0.18	
Allowable mixing volume				
25% 7Q10 discharge	1.04	1.61	0.046	
Theoretical temperature increase (maximum summer discharge and maximum summer temperature)				
Summer peak effluent discharge	0.028	0.043	0.0012	
Summer peak effluent temperature				20
Temperature at edge of mixing zone				18.05
Theoretical temperature increase (maximum annual discharge and maximum summer temperature)				
Peak discharge in DMRs	0.118	0.18	0.0052	
Summer peak effluent temperature				20
Temperature at edge of mixing zone				18.21
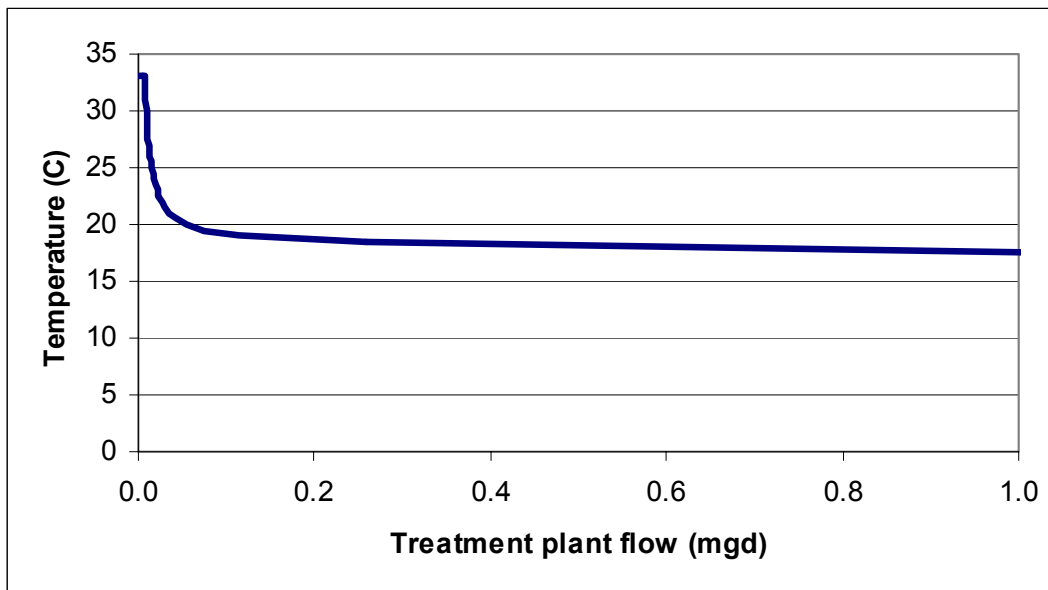
Figure 21. Wilkeson wastewater treatment plant wasteload allocation.

Summary of Load and Wasteload Allocations

Figure 22 compares current water temperature with the nonpoint source wasteload allocations and the point source load allocations for South Prairie Creek under 7Q10 conditions. Current conditions exceed water quality standards, which is the loading capacity. The effective shade allocations will decrease stream heating. The point sources contribute small thermal loads relative to the nonpoint influences on stream heating.
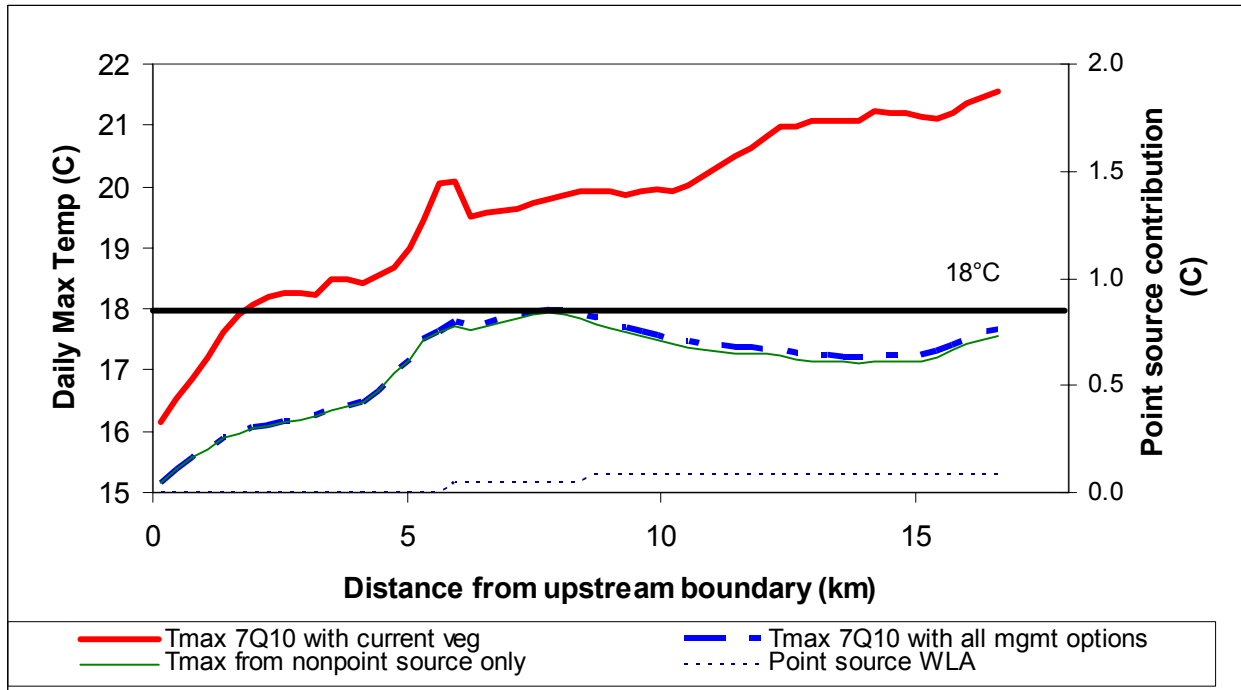
Figure 22. Current and allocated temperature along South Prairie Creek, distinguishing nonpoint source (thin green solid line) and point source (thin blue dashed line on secondary axis) contributions.

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 addressed by using critical climatic conditions in the modeling analysis. Conservative assumptions for critical conditions include the following:

- The 90th percentile of air temperatures recorded at SeaTac Airport were used to develop reasonable worst case conditions air temperatures at South Prairie Creek.

- 7Q10 low-flow conditions were used to evaluate reasonable worst-case conditions. Typical conditions were evaluated using 7Q2 low flow conditions.

Model uncertainty was assessed by estimating the root-mean-square error (RMSE) of model predictions compared with observed temperatures during model validation. The warm validation data set resulted in a RMSE of 0.64°C, while the cool validation data set resulted in a RMSE of 0.91°C.

The load allocations are set to the effective shade provided by full mature riparian shade, which are the maximum values achievable in the South Prairie Creek system.

Recommendations for Monitoring

To determine the effects of management strategies within the model area and upstream in both South Prairie Creek and Wilkeson Creek, regular monitoring is recommended. The model predicts local temperature maxima at two locations: the mouth of South Prairie Creek and at the confluence with Wilkeson Creek (Figure 16). At a minimum, continuous temperature monitors should be installed at the following sites: SPCSR, SPCWC, SPCSP, SPCB2, SPCM, WCM, and SKT165. Probes should be deployed from June through September to capture the critical conditions. Shade management practices involve the development of mature riparian vegetation, which requires more than five years to become established. Interim monitoring is recommended, however, perhaps at five-year intervals.

South Prairie Creek Bacteria and Temperature Total Maximum Daily Load Summary Implementation Strategy

Introduction

The purpose of this Summary Implementation Strategy (SIS) is to describe how the waters addressed by the South Prairie Creek Bacteria and Temperature Total Maximum Daily Load (TMDL) can achieve water quality standards. This SIS meets the requirements of a TMDL submittal for approval as outlined in the 1997 Memorandum of Agreement between the U.S. Environmental Protection Agency and the Washington State Department of Ecology.

Overview

Implementers will use existing regulations and programs to reduce high bacteria and temperatures in the South Prairie Creek watershed. After EPA approves this TMDL, interested parties will help develop a Detailed Implementation Plan. That plan will recommend specific actions to take so that the creek and its tributaries can meet water quality standards in the future.

A recent document that provides recommendations for reducing pollution in this area is the Upper Puyallup Watershed Characterization and Action Plan (Upper Puyallup Watershed Committee, published by Pierce County Water Programs Division, April 2002). The Upper Puyallup Watershed Action Plan was developed by a committee which included citizen, municipal, county, state, and industry group representatives, with input from federal agency representatives. The plan includes action items to help solve water quality problems associated with agriculture, forestry, on-site sewage, and stormwater and erosion non-point pollution sources.

Examples of actions which might help South Prairie Creek achieve water quality standards for bacteria and temperature are tabulated in Appendix C. Note that these actions are only recommendations, and that Ecology will not compel Pierce County or other entities to implement the Upper Puyallup Watershed Characterization and Action Plan. The full plan is available on line at http://www.co.pierce.wa.us/pc/services/home/environ/planning/waplan.htm.

Existing regulations such as those implementing the Dairy Nutrient Management Act (Ch. 90.64 RCW), the Water Pollution Control Act (Ch. 90.48 RCW), the Forest Practices Act (Ch. 76.09 RCW), the Growth Management Act (Ch. 36.70A RCW), the Water Resources Act of 1971 (Ch. 90.54 RCW) and Minimum Water Flows and Levels (Ch. 90.22 RCW) will help protect and facilitate improvements in water quality.

All locations monitored in the TMDL study are expected to meet water quality standards for bacteria by June 30, 2008. Water quality standards for temperature may not be met until 2089.

Implementation Plan Development

The following key agencies and other groups have influence, regulatory authority, information, resources or other involvement that will be coordinated to implement the TMDL. Ecology and the Water Resources Committee of the Puyallup River Watershed Council will coordinate development and implementation of the Detailed Implementation Plan in 2004.

Involved Parties and Regulatory Authorities

Cascade Land Conservancy

The Cascade Land Conservancy is a non-profit organization that preserves natural and open lands in urban and rural communities. Because South Prairie Creek is the sub-basin ranked highest for salmon habitat protection in Pierce County, the land conservancy developed the "South Prairie Creek Action Plan: Salmon Habitat Protection" (Cascade Land Conservancy, December 2002). The action plan identifies high priority parcels to target for habitat protection. Cascade Land Conservancy and other entities may be able to use salmon-related funding to obtain easements and protect riparian land here. Riparian buffers would help limit fecal coliform inputs to the creeks. Since the buffers would likely be enhanced with trees, they will provide additional shading and help lower temperatures in the creeks.

Ecology

Washington State Department of Ecology has been delegated authority under the federal Clean Water Act by the U.S. Environmental Protection Agency to establish water quality standards and enforce water quality regulations under the Water Pollution Control Act, Chapter 90.48 RCW. In addition to this regulatory role, Ecology can provide financial assistance to local governments, tribes, and conservation districts for water quality projects. Projects that implement Water Cleanup Plans are a high priority for funding.

Ecology enforces the Dairy Nutrient Management Act (Ch. 90.64 RCW). The Act requires dairy farmers to have approved dairy waste management plans by July 1, 2002, and to implement the plans by December, 2003. Currently, all farms are inspected at least annually. If a dairy has a documented discharge to a waterbody, and the state has issued a National Pollutant Discharge Elimination System (NPDES) permit, the owner will need to implement an approved dairy plan in accordance with the dates in the permit. Farmers are referred to Conservation Districts who write the plans.

For non-dairy agricultural problems, if Ecology confirms that poor farm management practices are likely to be polluting surface waters, farmers are typically referred to Pierce Conservation District for technical assistance. If necessary, Ecology can require specific actions under Ch. 90.48 RCW, such as implementation of an approved farm plan, to correct the problem.

South Prairie Creek and all its tributaries are closed to further consumptive water rights (Ch. 173-510 WAC). Ecology requires metering for certain existing withdrawals, including those for the City of Buckley (2 cfs) and Washington State Department of Social and Health Services (Rainier School)/Washington State University (3.5 cfs).

Pierce Conservation District

Pierce Conservation District, under the authority of Ch. 89.08 RCW, Conservation Districts, develops conservation plans for farms, and provides education and technical assistance to residents. Farmers receiving a Notice of Correction from Ecology will normally be referred to Pierce Conservation District for assistance. When developing conservation plans, the district uses guidance and specifications from the U.S. Natural Resource Conservation Service.

Pierce Conservation District currently has funding from a variety of local governments, the Department of Ecology, the Washington Conservation Commission, the Washington State Salmon Recovery Funding Board, and others. In addition to conservation planning and education, the district also helps with riparian fencing and re-vegetation projects. It also has funds for in-stream projects such as culvert replacements and stream restoration to benefit salmon.

Pierce Conservation District works with dairy farmers to develop and implement dairy nutrient management plans under the Dairy Nutrient Management Act. The Conservation District and dairy farmers will certify that Dairy Nutrient Management Plans are implemented. Implementation of the plans should significantly lower fecal coliform loads to South Prairie Creek.

Pierce Conservation District's Stream Team provides education to the public through workshops, tours, and displays at special events. Stream Team volunteers improve water quality through a variety of activities from water quality monitoring to planting native vegetation along streams. At the most upstream station in the TMDL study (South Prairie Creek at Spiketon Road), volunteers monitor macroinvertebrates annually. Near the "South Prairie Creek at South Prairie" station, volunteer's measure or sample stream flow, dissolved oxygen, temperature, pH, nitrates and turbidity two to four times a year, and assess the riparian area annually. A tributary to Wilkeson Creek is also monitored.

Pierce County

Pierce County led the effort to develop the Upper Puyallup Watershed Characterization and Action Plan, with financial assistance from an Ecology grant and county stormwater fees. The Water Programs Division coordinates implementation of these watershed action plans, which are prepared in accordance with Washington Administrative Code Chapter 400-12, Local Planning and Management of Nonpoint Source Pollution, for the purposes of addressing nonpoint sources of water pollution.

The county regulates land use in unincorporated areas of the South Prairie Creek Basin. The County has a Critical Areas Ordinance (Ch. 18E.60.050) in accordance with Washington State's Growth Management Act, Ch. 36.70A. For new developments, the ordinance requires a 150 foot buffer of undisturbed natural vegetation along South Prairie Creek, which will help protect stream temperatures. The ordinance is undergoing revision but will be at least as protective as it is now.

The Water Programs Division is responsible for compliance with the stormwater quality management requirements of the Clean Water Act. It has a stormwater conveyance system in

this watershed and has mapped 24 pipes discharging into South Prairie Creek. The county has a NPDES Phase 1 Stormwater Permit under CFR Title 40 122.26. Property owners are charged a fee for surface water management services. The county has a stormwater manual and a best management practices manual.

Chapter 11.05 of the Pierce County Code, Illicit Stormwater Discharges (Ordinance No. 96-47), makes it unlawful for any person to discharge any pollutants into Municipal Drainage Facilities. The county normally addresses nonpoint source pollution entering drainage ditches through education and technical assistance, but can require immediate cessation of discharges and implementation of best management practices.

The Water Programs Division will be developing a Comprehensive Basin Plan for South Prairie Creek in the next few years. The basin plan will address existing and expected future flooding and environmental problems in unincorporated areas of the county and will contain recommended management strategies to correct or reduce the problems. There may be limited monitoring to fill in data gaps for bacteria, pH, temperature, biochemical oxygen demand, dissolved oxygen, and nutrients.

Other Water Programs Division responsibilities include stream gauging and water quality monitoring, gathering of rainfall data, emergency response during floods, and public education regarding stormwater quality and quantity.

Pierce County can acquire riparian lands, especially for flood management, salmon habitat, and county parks. The county has been acquiring land associated with an abandoned railroad bed for the Foothills Trail. When completed, the Foothills Trail will extend 26 miles from McMillin through Orting and South Prairie to Buckley. It will also branch from Cascade Junction to Wilkeson and Carbonado. The Water Programs Division of Pierce County is currently developing a management program for land it owns.

South Prairie Creek is a high priority area for salmon habitat protection and restoration. Pierce County has been using Ecosystem, Diagnosis and Treatment methodology, a habitat-based procedure for relating environmental conditions to the performance of salmon populations. The county has developed a prioritized list of stream reaches and is working on a prioritized list of actions and a Habitat Restoration Plan. The products will be valuable aids to the many entities and agencies working within the watersheds to develop and coordinate action plans.

Pierce County's Housing Programs can facilitate loan acquisition for certain low-income residents, to repair on-site septic systems. HOME Rehabilitation/Utility Loans are funded by the U.S. Dept. of Housing and Urban Development through the Community Development Corporation.

Puyallup River Watershed Council

The Puyallup River Watershed Council is an organization of local, state, tribal, and federal governments, as well as educators, citizens, businesses, and environmental groups in the Puyallup River Basin. Its goal is to assist citizens in restoring, maintaining, and enhancing the

environmental, economic, and cultural health of the watershed. A non-profit (501C3) organization with an elected board also provides support to the Council.

The Council has Executive, Water Resources, Historical and Cultural, Fish and Wildlife, and Education committees. It oversees implementation of the Upper Puyallup Watershed Characterization and Action Plan addressing nonpoint pollution sources. The council will help coordinate development and implementation of the Detailed Implementation Plan for this TMDL.

Puyallup Tribe of Indians

The Puyallup Tribe has been collecting bacteria data in the South Prairie Creek watershed since 1998. The Tribe is interested in conducting periodic follow-up monitoring, especially for temperature.

South Prairie

The Town of South Prairie, with a population of fewer than 500 people, owns and maintains a wastewater treatment plant in accordance with its National Discharge Elimination System Discharge (NPDES) permit. Because the treatment plant is already at capacity, there is a moratorium on new hookups to it. If the town makes improvements to the plant, it may be able to allow additional hookups within five years.

The town has swale-type ditches which drain runoff from urban streets to ditches and eventually to South Prairie Creek. There are no stormwater ponds.

South Prairie has a critical areas ordinance, adopted in 1992 under the Growth Management Act (Ch. 36.70A RCW). The ordinance requires a 150 foot riparian buffer of natural vegetation for new development along South Prairie Creek, with smaller buffers for tributaries.

Tacoma Pierce County Health Department

TPCHD regulates on-site sewage systems in accordance with Ch. 246-272 WAC, and has an on-site operations and maintenance program. It also requires that pumpers and installers be certified by the county. The operations and maintenance program applies to new or newly acquired septic systems in the county.

Tacoma-Pierce County Board of Health Resolution No. 2002-3411 requires evaluations of on-site septic systems when properties are sold. If a system is suspected of failing, the Health Department uses dye-testing for confirmation. If future fecal coliform monitoring raises concerns about particular septic systems near surface water, those systems would be a high priority for dye-testing.

Washington State Department of Natural Resources

DNR has primary administrative and enforcement responsibilities for the Forest Practices Act (Ch. 76.09 RCW), which includes implementation of the 1999 "Forests and Fish Report." The Forests and Fish Report (ESHB 2091) was adopted by the state legislature to protect salmon listed under the federal Endangered Species Act and other fish. The resulting rules address forest

roads, unstable slopes, riparian shading, and effectiveness monitoring. Implementation of these rules in the upper watershed should help the lower watershed meet water quality standards for temperature in the future.

Washington State Department of Transportation

WSDOT manages stormwater from highways under the NPDES program. State Route 162 runs along Lower South Prairie Creek, crossing it multiple times. Implementation of DOT's 1997 Stormwater Management Plan, 2002 Maintenance Manual, 2002 Instruction Letter 4020.02 (Endangered Species Act-related stormwater guidance) and, if new or re-development occurs, the most current Highway Runoff Manual and WSDOT's erosion control program will help minimize the impact of highway stormwater runoff on South Prairie Creek water quality.

Wilkeson

The Town of Wilkeson owns and maintains a wastewater treatment plant in accordance with its NPDES permit. It also has stormwater which drains to Wilkeson Creek.

Wilkeson has a critical areas ordinance, adopted in 1992 under the Growth Management Act (Ch. 36.70A RCW). The ordinance requires a 35 foot riparian buffer of natural vegetation for new development along streams.

Implementation Activities

The Puyallup River Watershed Council will oversee implementation of the Upper Puyallup Watershed Characterization and Action Plan, and help coordinate implementation of the Detailed Implementation Plan for this TMDL. Both of these plans will help South Prairie Creek achieve water quality standards. The Detailed Implementation Plan should include information and education campaigns for both the general public and public officials. Future work related to salmon habitat enhancement and stormwater management will also likely help protect and restore water quality in South Prairie Creek.

Fecal Coliform Bacteria
Dairies in the watershed need to implement best management practices in 2003 in accordance with the Dairy Nutrient Management Act. There should be no discharge of fecal coliform bacteria from either of the two dairies after June 2003.

The Towns of South Prairie and Wilkeson will continue operating their wastewater treatment plants in compliance with their wastewater discharge permits. Pierce County will continue implementing its stormwater program in compliance with its stormwater permit, and will prepare a basin plan for this watershed in the next few years. The Detailed Implementation Plan for this TMDL may include actions that will be required in a future municipal stormwater permit.

Temperature
Riparian areas in the upper watershed will continue to mature, and remain protected through the Forest Practices Act. Riparian areas in developing areas will be protected through Critical Areas Ordinances under the Growth Management Act. The Detailed Implementation Plan will include ways to encourage replanting of trees, especially along the south and west sides of South Prairie

and Wilkeson Creeks. Special attention should be given to replacing the noxious weed, Japanese knotweed also known as Mexican Bamboo, with trees in riparian areas.

Milestones for Meeting Water Quality Standards

For fecal coliform bacteria, significant improvements are expected by December 31, 2004, in South Prairie Creek at and downstream of the fourth bridge north of the Carbon River, as well as in Spiketon Creek and unnamed tributaries monitored during the TMDL study.

All locations monitored in the TMDL study are expected to meet water quality standards for bacteria by June 30, 2008.

For temperature, measurable improvements are expected after trees planted in riparian areas which currently have less than 60% effective shade, reach maturity. Native trees will be mature in 50 years, with an estimated height of 129 feet. Certain non-native species such as hybrid poplars will reach that height within 30 years.

Growth parameters are difficult to estimate, given that most research has focused on upland and not riparian areas. Figure A summarizes the effective shade in South Prairie Creek as a function of minimum tree height to illustrate the expected changes over time. Relatively little increase in effective shade is expected until tree height reaches 120 ft.

Figure A. South Prairie Creek

Effective shade within study area as a function of minimum tree height (proxy for age)
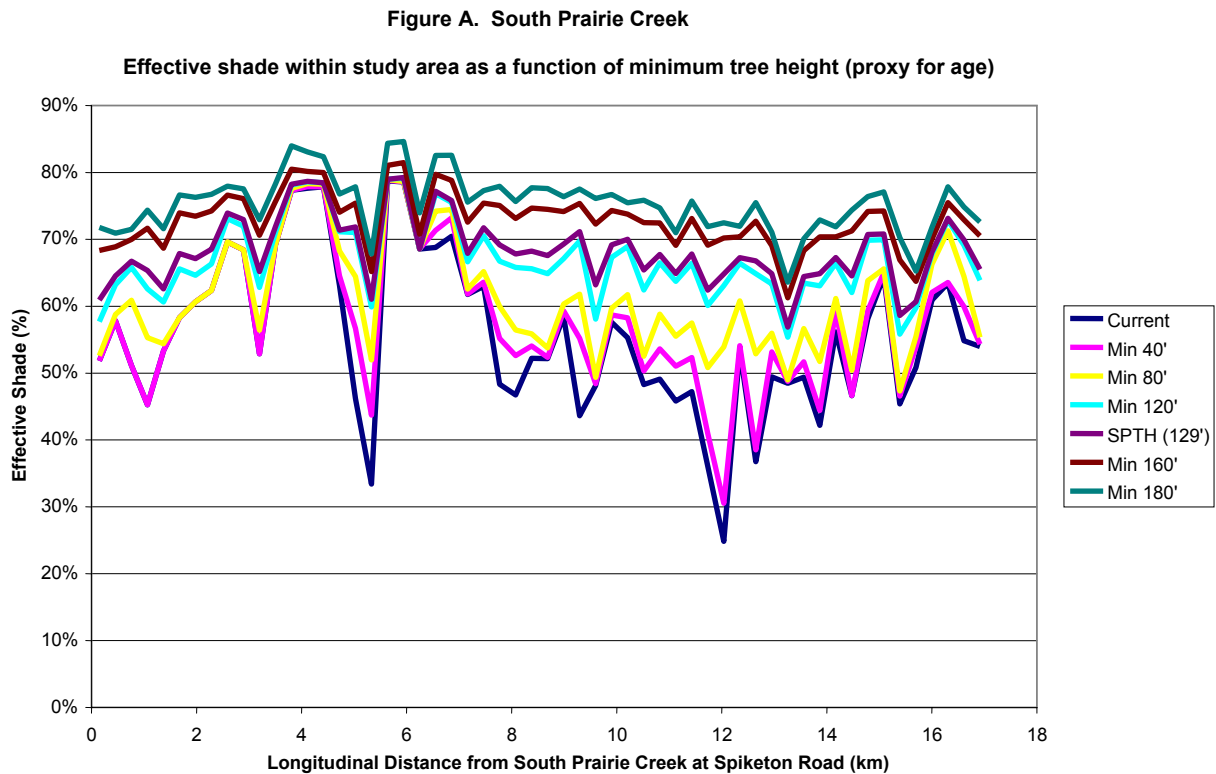
Water quality standards for temperature will be met when newly planted vegetation reaches its maximum height (180 feet, at approximately 80 years old) and canopy density is 90%. So, if riparian areas are re-planted by 2009, water quality will meet standards in 2089.

Summary of Public Involvement Methods

Ecology began distributing information about the Total Maximum Daily Load study to interested parties in the summer of 2000, and held a TMDL kickoff meeting for the public on November 16, 2000. The draft Quality Assurance Project Plan for the study was posted on the internet and sent to interested parties for comment. The Tacoma News Tribune published a story on the study on December 26, 2000. Ecology sent quarterly updates to a distribution list as the study progressed, and presented annual updates to the Puyallup River Watershed Council (PRWC).

The draft technical report and information about the public comment period and public meeting were posted on the internet in March 2003. Links to this information were sent to a distribution list of interested parties. The agency worked with the PRWC Water Committee on the draft Summary Implementation Strategy, which was posted on the internet April 3, 2003. At the same time, information about the study, the implementation plan, the public comment period, and the public meeting was mailed to basin residents. The documents were made available on-line, at the South Prairie Creek Town Hall, at the public meeting, and by mail if requested. There was an article in the Tacoma News Tribune on April 8, 2003, announcing the public meeting, comment period and where to find copies of the documents.

After the public comment period, the Water Cleanup Plan (this TMDL Submittal Document) was revised (see Appendix D for the Response to Public Comments). The document will be submitted to the U.S. Environmental Protection Agency in June 2003 for approval. After the Water Cleanup Plan is approved, the public will be invited to participate in the development of the Detailed Implementation Plan for this TMDL.

Reasonable Assurances

While this TMDL was being developed, Ecology initiated enforcement actions for known sources of fecal coliform contamination on South Prairie Creek and Spiketon Creek. Under Chapter 90.48 RCW and other existing regulations, the state will ensure that known unpermitted fecal coliform discharges will be corrected.

South Prairie Creek and Spiketon Creek will be monitored after best management practices are implemented for known bacteria sources. If fecal coliform concentrations are still too high, Ecology, Pierce County, and the Tacoma Pierce County Health Department will take additional actions under existing regulations and programs to identify and correct bacteria problems.

Regulatory authorities for these and other involved parties are listed in the previous discussion of "Involved Parties and Regulatory Authorities" under "Implementation Plan Development."

Protection and enhancement of South Prairie Creek and Wilkeson Creek will rank high for funding from the Salmon Recovery Funding Board and other sources because they have the best

remaining salmon habitat in Pierce County. The Cascade Land Conservancy, Pierce Conservation District, the Puyallup Tribe, and other cooperators are actively seeking funding to help protect riparian areas for these creeks. Enhancement activities will include re-vegetating riparian areas when needed. Regulatory authorities for protecting existing riparian vegetation and stream flows are listed in the previous section.

Adaptive Management Approach

Dairy Nutrient Management Plans have been developed for both dairies in the South Prairie Creek watershed. One of the dairies has implemented its plan; the other dairy must implement its plan before July 2003. A farm where cows have access to Spiketon Creek has been ordered to implement a farm plan by May 2003. If, in 2004, monitoring shows that bacteria concentrations in South Prairie Creek and Spiketon Creek are still too high, additional sources will be identified.

If stormwater is a likely source, Pierce County, Ecology, or the towns of South Prairie or Wilkeson will work to correct the problem. If septic systems are a suspected source, the Tacoma Pierce County Health Department will confirm whether one or more systems are leaking and if necessary, work with residents to correct the problem. If farm animals adjacent to streams are a likely source, Ecology will make sure that landowners seek assistance from Pierce Conservation District and prevent manure from getting into surface waters.

Correcting temperature problems will take more time. At five year intervals, Ecology will evaluate whether riparian vegetation will be sufficient to prevent temperature from exceeding standards when the vegetation reaches maturity. Ecology will work with other interested parties to encourage more tree planting, if necessary.

Monitoring Strategy

Measuring Implementation Activities

Ecology will follow up on current and future enforcement actions to ensure that best management practices are implemented. Pierce Conservation District and dairy farmers will certify that Dairy Nutrient Management Plans are implemented. The Washington State Department of Natural Resources will ensure that the Forest Practices Act is implemented. Pierce County enforces natural vegetation buffer requirements for the county's critical areas ordinance. The towns of South Prairie and Wilkeson are responsible for enforcing critical areas ordinances within their jurisdictions. For re-vegetation projects, the implementing entity will be responsible for tracking what is planted and plant survival rates.

Measuring Achievement of Interim Targets and Water Quality Standards

The Puyallup River Watershed Council with assistance from Pierce Conservation District's Stream Team, is applying for funding to monitor fecal coliform bacteria in 2004 and 2005. The Puyallup Tribe is interested in monitoring temperature in this watershed. Pierce County may do monitoring to fill in data gaps as part of the stormwater basin planning effort for South Prairie Creek in approximately 2005.

Ecology is required under Section 303(d) of the federal Clean Water Act to periodically prepare a statewide list of impaired surface waters. Ecology will use the most current data available to determine if South Prairie Creek and its tributaries meet standards. Every five years, as part of its Watershed Approach to Water Quality Management, Ecology will determine whether the quality of waters covered by this TMDL have improved, whether the agency needs to conduct effectiveness monitoring, or whether additional actions need to take place.

Potential Funding Sources

In addition to normal funding sources for existing programs, various assistance programs could help with implementation and monitoring costs. These include:

- Centennial Clean Water Fund, Washington State Water Pollution Control Revolving Fund (SRF) and Federal Clean Water Act Section 319 Funds, administered by Ecology

- Environmental Quality Incentives Program, Conservation Reserve Enhancement Program, and Wildlife Habitat Incentives Program cost-share money from the U.S. Dept. of Agriculture's Natural Resources Conservation Service

- Flood Control Assistance Account Program grants from Ecology and Hazard Mitigation grants from the Washington State Military Dept. Emergency Management Division

- Public Involvement and Education funding from the Puget Sound Action Team

- Salmon Recovery Funding Board grants and Washington Wildlife and Recreation Program grants from the Washington Interagency Committee for Outdoor Recreation

- HOME Rehabilitation/Utility Loans to lower income households, funded by the U.S. Dept. of Housing and Urban Development (contact Pierce County Housing Programs).

- U.S. Dept. of Agriculture Rural Development, Home Repair Loan and Grant Programs (as authorized by Section 504 of the Housing Act of 1949, 7 CFR Part 3550; contact U.S.D.A. Service Center of Puyallup, Washington, (253) 845-0553).

Additional sources of funding are listed in "Phase 4 Watershed Plan Committee Implementation Report to the Legislature" (2002, Ecology Publication 02-06-023).

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South Prairie Creek Bacteria and Temperature TMDL

Appendix A

Water Quality Data for
South Prairie Creek and Tributaries

South Prairie Creek Bacteria and Temperature TMDL

Table A1. Phase I Assessment Water Quality Data (Ecology)

	Date	Station	Flow (cfs)	Fecal Coliform (#/100 ml)	*E. coli* (#/100 ml)	Entero-cocci (#/100 ml)	TPN (mg/L)	Ammonia (mg/L)	Nitrite/ Nitrate (mg/L)	Nitrite (mg/L)	Total Phosphorus (mg/L)	Ortho-phosphate (mg/L)	TSS (mg/L)	pH	Temp (C)	DO (mg/L)
Main Stem Stations	7/19/2000	SPCSR		8											13.65	
	8/1/2000	SPCSR		20	20	4	0.255	0.010 U	0.201	0.010 U	0.015	0.005 U	1 U	7.6	14.6	9.9
	8/21/2000	SPCSR		1										7.9	10.95	
	9/5/2000	SPCSR		2	2	44	0.208	0.010 U	0.179	0.010 U	0.017	0.005 U	2	8.3	9.9	10.8
	9/19/2000	SPCSR		22										8.1	12.4	
	10/24/2000	SPCSR		1	1		0.288	0.010 U	0.277	0.010 UJ	0.012	0.005 U	1 U		6.2	11.7
	12/18/2000	SPCSR													2.9	
	7/5/2000	SPCLB	90.9													
	7/19/2000	SPCLB	54.8	11											14.65	
	8/1/2000	SPCLB	40.6	21	20	10	0.273	0.010 U	0.207	0.010 U	0.013	0.005 U		7.8	15.35	10
	8/21/2000	SPCLB	39.1	6										7.7	12.4	
	9/5/2000	SPCLB	37.2	4	4	32	0.225	0.010 U	0.190	0.010 U	0.018	0.005		7.5	11	10.8
	9/19/2000	SPCLB	45.8	26										7.6	12.85	
	10/24/2000	SPCLB	81.4	1	1		0.271	0.010 U	0.281	0.010 UJ	0.013	0.005 U			6.4	11.65
	11/28/2000	SPCLB	126.0													
	12/18/2000	SPCLB	103.9												3.1	
	7/12/2000	SPCSP													13.85	
	7/19/2000	SPCSP		20											14.55	
	8/1/2000	SPCSP	51.6	49	45	24	0.305	0.010 U	0.239	0.010 U	0.020	0.006		8.1	16.85	10.25
	8/21/2000	SPCSP	47.1	22										7.7	13.75	
	9/5/2000	SPCSP	44.6	29	23	89	0.248	0.010 U	0.204	0.010 U	0.020	0.007		8.0	12.4	10.9
	9/19/2000	SPCSP	59.4	50										7.6	14.05	
	10/24/2000	SPCSP	110.6	8	8		0.336	0.010 U	0.357	0.010 UJ	0.015	0.006			7.4	11.5
	11/28/2000	SPCSP	201.8													
	12/18/2000	SPCSP													3.4	
	7/12/2000	SPCB4													13	
	7/19/2000	SPCB4		120											13.85	
	8/1/2000	SPCB4		140	130	19	0.523	0.013	0.426	0.010 U	0.028	0.012		8.3	19	9.4
	8/21/2000	SPCB4	54.5	120										7.9	15.8	

Continued

Table A1. Phase I Assessment Water Quality Data (Ecology)

	Date	Station	Flow (cfs)	Fecal Coliform (#/100 ml)	E. coli (#/100 ml)	Entero-cocci (#/100 ml)	TPN (mg/L)	Ammonia (mg/L)	Nitrite/ Nitrate (mg/L)	Nitrite (mg/L)	Total Phosphorus (mg/L)	Ortho-phosphate (mg/L)	TSS (mg/L)	pH	Temp (C)	DO (mg/L)
	9/5/2000	SPCB4	48.8	760 J	740	73	0.504	0.010 U	0.461	0.010 U	0.029	0.013		7.8	12.7	10.7
	9/19/2000	SPCB4	66.8	300										7.6	14.7	
	10/24/2000	SPCB4	103.3	29	17		0.468	0.010 U	0.440	0.010 UJ	0.018	0.008			8.1	11.45
	12/18/2000	SPCB4													3.95	
	7/5/2000	SPCM	165.8													
	7/12/2000	SPCM													12.8	
	7/19/2000	SPCM	77.0	65											13.6	
	8/1/2000	SPCM	63.9	110	92	20	0.493	0.010 U	0.398	0.010 U	0.026	0.009	2	7.9	19.3	9.7
	8/21/2000	SPCM	54.7	77										7.6	16.05	
	9/5/2000	SPCM	52.0	160 J	140	86	0.498	0.010 U	0.432	0.010 U	0.028	0.010	2	7.7	13	10.5
	9/19/2000	SPCM	66.7	240										7.4	15.2	
	10/24/2000	SPCM	112.7	23	14		0.412	0.010 U	0.441	0.010 UJ	0.018	0.007	1 U		8.4	11.15
	11/28/2000	SPCM	207.9													
	12/18/2000	SPCM	169.6													
Tributary Stations	7/5/2000	SD165	1.8													
	7/12/2000	SD165													14.8	
	7/19/2000	SD165	1.2	800											15.05	
	8/1/2000	SD165	1.2	760	760	130	0.287	0.010	0.143	0.010 U	0.029	0.010		7.3	16.1	9.3
	8/21/2000	SD165	1.4	670										7.4	11.6	
	9/5/2000	SD165	1.3	240	210	260	0.153	0.010 U	0.089	0.010 U	0.022	0.007		7.9	10.1	10.7
	9/19/2000	SD165	1.4	880										7.4	13.55	
	10/24/2000	SD165	1.5	40	37		0.222	0.010 U	0.156	0.010 UJ	0.021	0.007			6.4	11.05
	11/28/2000	SD165	2.4													
	12/18/2000	SD165	2.8												2.8	
	7/12/2000	WCM													15.75	
	7/19/2000	WCM	14.6	29											16.45	
	8/1/2000	WCM	11.7	41	39	37	0.441	0.011	0.356	0.010 U	0.029	0.011	1	8.0	17.8	9.5
	8/21/2000	WCM	10.3	37										8.0	13.75	
	9/5/2000	WCM	10.4	76	73	88	0.391	0.010 U	0.328	0.010 U	0.028	0.011	1	7.8	11.9	10.85

South Prairie Creek Bacteria and Temperature TMDL

Continued

Table A1. Phase I Assessment Water Quality Data (Ecology)

	Date	Station	Flow (cfs)	Fecal Coliform (#/100 ml)	E. coli (#/100 ml)	Entero-cocci (#/100 ml)	TPN (mg/L)	Ammonia (mg/L)	Nitrite/Nitrate (mg/L)	Nitrite (mg/L)	Total Phosphorus (mg/L)	Ortho-phosphate (mg/L)	TSS (mg/L)	pH	Temp (C)	DO (mg/L)
	9/19/2000	WCM	14.9	170										7.6	13.9	
	10/24/2000	WCM	31.4	29	26		0.616	0.010 U	0.572	0.010 UJ	0.019	0.008	1		6.6	11.4
	11/28/2000	WCM	76.3													
	12/18/2000	WCM	66.3												3.4	
Miscellaneous Locations	8/21/2000	SD1		39												
	8/21/2000	SD2		680 J												
	9/5/2000	SDSR		59												
	9/19/2000	SPC246		57												
	11/1/2000	SPCUS		7												
	9/19/2000	14309		1400												
	10/24/2000	EMERY1		8												

Sampling stations are identified in Figures 3 and 8.

U Not detected at or above the reported detection limit.

J Estimated values; very high density of organisms on plate, and actual concentration may be greater than or equal to reported results.

Table A2. Phase II Assessment Water Quality Data (Ecology)

	Date	Station	Measured Streamflows (cfs)	Fecal Coliform (#/100 ml)	FC Qualifier	Entero-cocci (#/100 ml)	EC Qualifier	Temperature (ºC)
	1/29/2001	SPCSR		2	J	1	UJ	3.6
	2/27/2001	SPCSR		1	UJ	1	UJ	2.2
	3/26/2001	SPCSR		1	UJ	1	J	5.4
	4/16/2001	SPCSR		5	J	1	UJ	6.2
	5/22/2001	SPCSR		7	J	1	J	8.6
	6/18/2001	SPCSR		6	J	1	UJ	8.6
	7/9/2001	SPCSR		12	J	2	J	12
	8/20/2001	SPCSR		9	J	5	J	11.8
	9/17/2001	SPCSR		13	J	45	J	11.6
	10/15/2001	SPCSR		7	J	41	J	7.4
	11/29/2001	SPCSR		10	J	2	J	5.7
	12/18/2001	SPCSR		3	J	4	J	4.3
	1/29/2001	SPCLB	68	1	UJ	2	J	3.6
	2/27/2001	SPCLB	50	2	J	3	J	2.3
	3/26/2001	SPCLB	163	3		1		6.2
	4/16/2001	SPCLB	125	2	J	1	UJ	6.8
Main Stem Stations	5/22/2001	SPCLB	153	9	J	5	J	9.1
	6/18/2001	SPCLB	158	110		100		9.4
	7/9/2001	SPCLB	53	28	J	6	J	12.6
	8/20/2001	SPCLB	30	16	J	4	J	12.2
	9/17/2001	SPCLB	22	8	J	150	J	12.1
	10/15/2001	SPCLB	89	19	J	35	J	7.8
	11/29/2001	SPCLB	245	22		19		5.8
	12/18/2001	SPCLB	430	4	J	3	J	4.5
	1/29/2001	SPCWC						3.9
	2/27/2001	SPCWC						3
	3/26/2001	SPCWC						6.8
	4/16/2001	SPCWC						7.3
	5/22/2001	SPCWC						10.2
	6/18/2001	SPCWC	149					
	7/9/2001	SPCWC						13.5
	8/20/2001	SPCWC						12.7
	9/17/2001	SPCWC						12.5
	10/15/2001	SPCWC	80					
	11/29/2001	SPCWC						5.8
	12/18/2001	SPCWC						4.5
	1/29/2001	SPCSP	111	21		10		4.1
	2/27/2001	SPCSP	79	2		6		3.9
	3/26/2001	SPCSP		39		60		7.3

Continued

Table A2. Phase II Assessment Water Quality Data (Ecology)

Date	Station	Measured Streamflows (cfs)	Fecal Coliform (#/100 ml)	FC Qualifier	Entero-cocci (#/100 ml)	EC Qualifier	Temperature (ºC)
4/16/2001	SPCSP	227	14		5		7.9
5/22/2001	SPCSP	209	12		8		11.2
6/18/2001	SPCSP	215	21		11		12.1
7/9/2001	SPCSP	70	28		16		14.5
8/20/2001	SPCSP	39	41		16		14.4
9/17/2001	SPCSP	29	29		41		12.8
10/15/2001	SPCSP	111	24		60		8.6
11/29/2001	SPCSP	597	83		270		5.8
12/18/2001	SPCSP	759	10		11		4.8
1/29/2001	SPCOF		15		80		4.2
2/27/2001	SPCOF		2	J	80	J	3.4
3/26/2001	SPCOF		58		89		7.7
4/16/2001	SPCOF		19		14		7.9
5/22/2001	SPCOF		17		19		11.2
6/18/2001	SPCOF		12		17		12.2
7/9/2001	SPCOF		50		43		14.3
8/20/2001	SPCOF		160		39		13
9/17/2001	SPCOF		200		150		12.8
10/15/2001	SPCOF		74		81		8.6
11/29/2001	SPCOF		110		380		5.8
12/18/2001	SPCOF		4		3		4.8
7/9/2001	SPCID		18		25		16.4
8/20/2001	SPCID		200	J	61		13
9/17/2001	SPCID		92		170		12.8
10/15/2001	SPCID		110		270		9.1
11/29/2001	SPCID		120		440		
12/18/2001	SPCID		18		20		5
1/29/2001	SPCB4		690	J	970		4.3
2/27/2001	SPCB4	82	3	U	40		5
3/26/2001	SPCB4		68		70		7.8
4/16/2001	SPCB4		10		27		8.9
5/22/2001	SPCB4	185	120	J	230		13.2
6/18/2001	SPCB4		51		11		13.1
7/9/2001	SPCB4		19		21		16.2
8/20/2001	SPCB4	50	37		51		15.1
9/17/2001	SPCB4	38	110		100		12.8
10/15/2001	SPCB4	110	55		150		9.6
11/29/2001	SPCB4		110		850	J	
12/18/2001	SPCB4		44		110		5
1/29/2001	SPCB2		260	J	930	J	4.4

Main Stem Stations (left-margin label spanning SPCID through SPCB2 rows)

Continued

Table A2. Phase II Assessment Water Quality Data (Ecology)

	Date	Station	Measured Streamflows (cfs)	Fecal Coliform (#/100 ml)	FC Qualifier	Entero-cocci (#/100 ml)	EC Qualifier	Temperature (ºC)
	2/27/2001	SPCB2		3		23		5.2
	3/26/2001	SPCB2		260	J	220	J	7.8
	4/16/2001	SPCB2		31		34		9.1
	5/22/2001	SPCB2		150	J	200		14.1
	6/18/2001	SPCB2	215	71		29		13.3
	7/9/2001	SPCB2		19		21		16.6
	8/20/2001	SPCB2	44	48		110		15.7
	9/17/2001	SPCB2	40	71		120		13.1
	10/15/2001	SPCB2	118	57		140		9.8
	11/29/2001	SPCB2		80		890	J	
	12/18/2001	SPCB2		40		88		5.1
	1/29/2001	SPCB1	126	260	J	770	J	4.4
	2/27/2001	SPCB1		9		14		5.4
	3/26/2001	SPCB1		310		300		7.9
	4/16/2001	SPCB1	225	9		26		9.2
	5/22/2001	SPCB1	202	120		52		14.6
	6/18/2001	SPCB1	220	29		37		13.6
	7/9/2001	SPCB1	81	71		21		17.5
	8/20/2001	SPCB1	46	41		35		15.6
	9/17/2001	SPCB1	40	110		180	J	13
	10/15/2001	SPCB1	118					9.8
	11/29/2001	SPCB1	550	100		900	J	
	12/18/2001	SPCB1	700	43		71		5.1
	1/29/2001	SPCM	112	400	J	770		4.6
	2/27/2001	SPCM	83	3		6		5.3
	3/26/2001	SPCM	278	250	J	160		8.3
	4/16/2001	SPCM		14		23		9.3
	5/22/2001	SPCM	200	120		81		15
	6/18/2001	SPCM	209	80		25		13.6
	7/9/2001	SPCM	86	72		11		17.9
	8/20/2001	SPCM	48	41		75		15.7
	9/17/2001	SPCM	38	160	J	390		13.1
	10/15/2001	SPCM	106	60		120		10.2
	11/29/2001	SPCM		170		1000	J	
	12/18/2001	SPCM		31		80		5.1
Tributary Stations	1/29/2001	SKT165	2.1					
	2/27/2001	SKT165	1.8					
	3/26/2001	SKT165	13	680		280		7
	4/16/2001	SKT165						
	5/22/2001	SKT165	1.7					10.9

Continued

Table A2. Phase II Assessment Water Quality Data (Ecology)

Date	Station	Measured Streamflows (cfs)	Fecal Coliform (#/100 ml)	FC Qualifier	Entero-cocci (#/100 ml)	EC Qualifier	Temperature (ºC)
6/18/2001	SKT165	3.7					10.3
7/9/2001	SKT165	0.9					13.5
8/20/2001	SKT165	0.8					11.6
9/17/2001	SKT165	1.0					11.9
10/15/2001	SKT165	3.2					8
11/29/2001	SKT165	21					
12/18/2001	SKT165	14					4
1/29/2001	SKTM		28	J	63	J	3.9
2/27/2001	SKTM		48	J	36	J	2.5
3/26/2001	SKTM						
4/16/2001	SKTM		92	J	49	J	8.3
5/22/2001	SKTM		320		13		11
6/18/2001	SKTM		7		6		10.3
7/9/2001	SKTM		180	J	140	J	12.7
8/20/2001	SKTM		230	J	300	J	11.7
9/17/2001	SKTM		94		330		11.9
10/15/2001	SKTM		140		130		8.4
11/29/2001	SKTM		500		1900	J	5.8
12/18/2001	SKTM		26	J	54	J	4.3
1/29/2001	WCM	36	11	J	5	J	3.9
2/27/2001	WCM	25	3	J	8	J	2.75
3/26/2001	WCM	79	5		29		7.1
4/16/2001	WCM		8		15		7.6
5/22/2001	WCM	47	19		11		11.4
6/18/2001	WCM	56	19		23		11.8
7/9/2001	WCM	20	53	J	32	J	14.2
8/20/2001	WCM	12	130	J	57	J	12.4
9/17/2001	WCM	8.6	46		140		12.6
10/15/2001	WCM	27	200		140		8.9
11/29/2001	WCM	168	34		74		5.9
12/18/2001	WCM	247	8		7		4.9
1/29/2001	T1		15		8	U	
2/27/2001	T1		68		650	J	
3/26/2001	T1		950	J	840		
4/16/2001	T1		1100		210		
5/22/2001	T1		540		210		
6/18/2001	T1		210		69		15.3
7/9/2001	T1		83		130		13.5
8/20/2001	T1		84		84		12.2
9/17/2001	T1		450		240		11.7

Continued

Table A2. Phase II Assessment Water Quality Data (Ecology)

	Date	Station	Measured Streamflows (cfs)	Fecal Coliform (#/100 ml)	FC Qualifier	Entero-cocci (#/100 ml)	EC Qualifier	Temperature (ºC)
	10/15/2001	T1		140		140		10.4
	11/29/2001	T1		1500		13000	J	
	12/18/2001	T1		240		220		6.1
	7/9/2001	T1ID		340		200		15.9
	8/20/2001	T1ID		2200	J	2100	J	13
	9/17/2001	T1ID		280		230		12.2
	10/15/2001	T1ID		550		230		11.4
	11/29/2001	T1ID		1400		14000	J	
	12/18/2001	T1ID		290		380		6.2
Point Source	1/29/2001	OF		37		8		
	2/27/2001	OF		7		3		
	3/26/2001	OF		80		57		
	4/16/2001	OF		1		4		
	5/22/2001	OF		25		7		
	6/18/2001	OF		76		22		
	7/9/2001	OF		19		10		
	8/20/2001	OF		1		1	U	
	9/17/2001	OF		1	U	2		
	10/15/2001	OF		3		1		
	11/29/2001	OF		82		39		
	12/18/2001	OF		1	U	2		

Sampling stations are identified in Figures 3 and 8.
U Not detected at or above the reported detection limit.
J Estimated values; very high density of organisms on plate, and actual concentration may be greater than or equal to reported results.

Table A3. Puyallup Tribe Water Quality Data

Parameter	Site	2/9/2001	3/12/2001	3/26/2001	5/2/2001	5/22/2001	6/18/2001	7/25/2001	8/21/2001	9/26/2001
FIELD DATA										
D.O. (mg/L)	SPC-1	13.27	12.87	12.70	13.90	11.90	11.52	9.66	11.06	10.16
D.O. (mg/L)	SPC-2	13.70	13.60	12.71	14.04	12.78	11.27	9.46	10.79	10.29
D.O. (mg/L)	SPC-3	13.14	14.04	11.74	14.17	11.14	10.70	10.84	12.22	9.59
D.O.%	SPC-1	99.7	106.5	103.2	105.8	105.6		95.1	103.7	94.3
D.O.%	SPC-2	103.9	112.7	103.7	113.8	114.2		93.6	102.3	95.9
D.O.%	SPC-3	99.5	14.0	97.9	116.0	100.3		107.7	117.1	89.8
Temp. (C)	SPC-1	3.39	7.82	6.54	6.94	10.19	10.04	14.69	13.17	12.05
Temp. (C)	SPC-2	3.58	7.39	6.89	7.18	10.54	10.95	15.16	13.15	12.16
Temp. (C)	SPC-3	3.71	7.36	7.66	7.44	11.01	11.36	15.15	13.47	12.38
Cond. (µs/cm)	SPC-1	62.6	94.5	66.9	55.9	64.8	64.6	111.1	127.6	122.9
Cond. (µs/cm)	SPC-2	75.2	103.8	76.3	61.5	71.4	72.4	125.2	143.0	135.7
Cond. (µs/cm)	SPC-3	75.5	104.7	87.6	62.6	77.4	73.8	123.8	139.1	133.7
pH	SPC-1	7.19	7.28	7.04	7.13	7.36	6.97	7.63	7.03	7.73
pH	SPC-2	7.04	7.28	6.84	7.08	7.34	6.89	7.87	7.17	7.65
pH	SPC-3	7.12	7.43	6.94	7.13	7.29	6.96	7.75	7.31	7.62
TDS (mg/L)	SPC-1	0.0401	0.0606	0.0428	0.0358	0.0415		0.7120	0.0815	0.0787
TDS (mg/L)	SPC-2	0.0481	0.0664	0.0488	0.0394	0.0458		0.0803	0.0913	0.0869
TDS (mg/L)	SPC-3	0.0483	0.0670	0.0523	0.0401	0.0497		0.0792	0.0890	0.0856

Continued

Table A3. Puyallup Tribe Water Quality Data

Parameter	Site	2/9/2001	3/12/2001	3/26/2001	5/2/2001	5/22/2001	6/18/2001	7/25/2001	8/21/2001	9/26/2001
Salinity (ppt)	SPC-1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salinity (ppt)	SPC-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Salinity (ppt)	SPC-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LABORATORY DATA										
Ortho (mg/L)	SPC-1									
Ortho (mg/L)	SPC-2									
Ortho (mg/L)	SPC-3									
Total Phos. (mg/L)	SPC-1			0.04			0.06			
Total Phos. (mg/L)	SPC-2									
Total Phos. (mg/L)	SPC-3			0.09			0.07			
Nitrate + Nitrite (mg/L)	SPC-1						0.24			
Nitrate + Nitrite (mg/L)	SPC-2									
Nitrate + Nitrite (mg/L)	SPC-3						0.35			
TSS (mg/L)	SPC-1			3			ND			
TSS (mg/L)	SPC-2									
TSS (mg/L)	SPC-3			4			10			
Fecal Coliform (col/100mL)	SPC-1			70			31			
Fecal Coliform (col/100mL)	SPC-2									
Fecal Coliform (col/100mL)	SPC-3			800			80			

Continued

Table A3. Puyallup Tribe Water Quality Data

Parameter	Site	2/9/2001	3/12/2001	3/26/2001	5/2/2001	5/22/2001	6/18/2001	7/25/2001	8/21/2001	9/26/2001
Ammonia (mg/L)	SPC-1			ND			ND			
Ammonia (mg/L)	SPC-2									
Ammonia (mg/L)	SPC-3			0.1			ND			

ND = Not Detected

Station Descriptions
SPC-1 (Puyallup Tribe)   SPCSP (Ecology/TMDL)
SPC-2 (Puyallup Tribe)   SPCB4 (Ecology/TMDL)
SPC-3 (Puyallup Tribe)   SPCM (Ecology/TMDL)

Table A4. Daily Minimum and Maximum Temperature Monitoring Data (2000)

Date	SPCSR		SPCSP		SPCB4		SPCM		WCM		SKT165	
	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax
7/12/00	12.31	14.01	13.66	15.86	13.09	16.71	12.92	17.16	14.11	15.85	14.11	15.21
7/13/00	11.07	12.93	11.79	14.91	12.01	15.76	12.61	16.21	12.09	14.89	12.09	14.73
7/14/00	11.38	12.78	12.41	14.43	12.63	14.97	13.23	15.57	13.03	14.58	12.71	14.42
7/15/00	9.98	14.01	10.7	15.86	10.92	16.87	11.52	17.16	11.01	15.85	10.69	14.89
7/16/00	10.92	14.95	11.63	16.82	11.85	17.83	12.45	18.12	11.94	16.8	11.62	16.01
7/17/00	11.84	15.11	12.57	16.97	12.78	17.99	13.38	18.12	13.03	17.12	12.87	16.64
7/18/00	12.47	13.39	13.34	14.91	13.56	15.6	14.15	16.37	13.65	15.37	13.64	15.21
7/19/00	12	15.27	13.03	17.13	13.09	18.15	13.53	18.44	13.34	16.96	13.33	16.32
7/20/00	12.31	15.59	13.19	17.61	13.41	18.63	13.99	18.77	13.49	17.43	13.49	16.96
7/21/00	12.62	16.38	13.5	18.26	13.72	19.29	14.31	19.43	13.96	18.08	13.79	17.92
7/22/00	12.93	14.48	13.97	16.02	14.18	16.56	14.62	17.8	14.11	16.48	14.26	16.64
7/23/00	12.62	14.48	13.34	16.34	13.56	17.19	13.99	16.84	13.49	15.85	13.64	16.17
7/24/00	11.53	15.43	12.41	17.29	12.47	18.15	13.07	18.44	12.56	16.96	12.24	16.32
7/25/00	12.47	13.71	13.34	15.54	13.41	16.08	14.15	16.84	13.65	15.53	13.64	15.69
7/26/00	12.47	14.17	13.5	15.86	13.56	17.03	14.15	17.8	13.8	15.69	13.64	16.01
7/27/00	12.31	15.27	13.34	17.46	13.41	17.83	14.15	18.12	13.65	17.12	13.49	17.12
7/28/00	13.24	14.32	14.59	15.86	14.66	16.56	15.42	17.16	15.06	16.01	15.21	16.48
7/29/00	12.93	16.22	13.97	18.42	14.03	19.45	14.62	19.43	14.27	18.24	14.42	17.92
7/30/00	13.39	16.86	14.28	19.07	14.49	20.11	15.26	20.23	14.74	18.73	14.58	18.56
7/31/00	13.86	17.17	14.75	19.39	14.81	20.27	15.57	20.39	15.06	19.05	15.05	18.73
8/1/00	14.48	16.86	15.7	18.74	15.76	19.45	16.52	19.59	15.69	18.4	15.53	18.08
8/2/00	12.78	16.22	13.5	18.26	13.56	18.96	14.31	19.1	13.49	17.59	13.02	16.8
8/3/00	12.78	15.59	13.5	17.77	13.56	18.63	14.31	18.77	13.49	17.12	13.18	17.12
8/4/00	12.78	16.38	13.66	18.58	13.56	19.45	14.46	19.43	13.65	18.08	13.49	17.59
8/5/00	13.39	16.54	14.28	18.42	14.49	19.12	15.26	19.1	14.42	17.76	14.26	17.43
8/6/00	13.39	16.07	14.28	17.93	14.34	18.63	15.09	18.61	14.27	17.28	14.26	17.12
8/7/00	13.71	15.43	14.43	16.97	14.49	17.51	15.26	17.32	14.42	16.17	14.58	16.64
8/8/00	12.93	16.22	13.66	18.09	13.72	18.8	14.62	18.77	13.49	17.43	13.33	16.96
8/9/00	13.24	15.91	13.97	17.29	14.03	17.99	14.93	17.8	13.96	16.64	13.95	16.8
8/10/00	13.24	14.48	14.12	15.86	14.18	16.08	14.93	16.68	13.8	15.21	14.11	15.85
8/11/00	12.16	14.17	13.03	15.7	13.09	15.92	13.84	16.05	12.87	15.06	12.87	15.21
8/12/00	11.23	14.48	11.79	16.34	11.69	17.19	12.45	17	11.63	15.69	10.85	14.89
8/13/00	11.23	14.01	11.79	15.7	11.85	16.56	12.76	16.68	11.63	15.06	11.01	14.89
8/14/00	11.69	13.55	12.26	15.22	12.16	15.92	12.92	15.89	12.09	14.58	11.62	14.11
8/15/00	10.92	13.71	11.48	15.86	11.38	16.56	12.14	16.52	11.17	15.06	10.54	13.79
8/16/00	10.92	14.17	11.32	15.86	11.38	16.71	12.14	16.68	11.17	15.37	10.38	14.26
8/17/00	11.07	14.32	11.63	16.02	11.69	17.03	12.45	16.84	11.47	15.37	10.69	14.58
8/18/00	11.84	12.78	12.57	14.28	12.94	14.81	13.53	15.42	12.41	13.8	12.24	13.79
8/19/00	11.69	13.24	12.41	14.43	12.63	14.97	13.23	15.42	12.41	14.27	12.24	13.79
8/20/00	11.53	13.86	12.26	15.38	12.32	16.24	12.92	16.21	12.25	15.06	11.93	14.58
8/21/00	11.07	14.01	11.63	15.7	11.69	16.71	12.61	16.68	11.47	15.37	11.16	14.73
8/22/00	11.38	14.48	11.94	16.34	12.01	17.51	12.92	17.32	11.94	15.85	11.47	15.37
8/23/00	11.84	14.95	12.57	16.66	12.78	17.83	13.53	17.64	12.72	16.17	12.56	16.17
8/24/00	12.47	15.27	13.19	16.82	13.41	17.83	14.15	17.64	13.34	16.48	13.18	16.17
8/25/00	13.39	14.48	14.28	16.49	14.49	17.19	15.26	17.48	14.27	16.01	14.58	16.17
8/26/00	13.09	14.17	13.97	15.38	14.03	15.76	14.78	16.21	13.96	15.06	13.64	14.89
8/27/00	12.16	13.55	12.88	15.07	12.78	15.28	13.53	15.89	12.72	14.42	12.4	14.11
8/28/00	10.76	13.71	11.01	15.22	11.08	16.08	11.83	15.89	10.86	14.58	10.23	13.95

Continued

Table A4. Daily Minimum and Maximum Temperature Monitoring Data (2000)

Date	SPCSR Tmin	SPCSR Tmax	SPCSP Tmin	SPCSP Tmax	SPCB4 Tmin	SPCB4 Tmax	SPCM Tmin	SPCM Tmax	WCM Tmin	WCM Tmax	SKT165 Tmin	SKT165 Tmax
8/29/00	10.92	12.78	11.48	14.12	11.54	14.18	12.29	14.46	11.32	13.8	11.01	13.49
8/30/00	12.16	12.78	13.03	14.12	13.25	14.49	13.69	14.93	13.03	13.8	12.87	13.79
8/31/00	11.84	13.09	12.72	14.28	12.78	14.49	13.38	14.93	12.56	14.11	12.24	13.79
9/1/00	10.61	12.78	11.01	13.81	11.08	14.66	11.83	14.62	10.86	13.49	10.38	12.71
9/2/00	10.76	12	11.48	13.19	11.54	13.72	12.14	14.31	11.32	12.87	10.69	12.24
9/3/00	10.14	11.69	10.7	12.88	10.77	13.41	11.52	13.84	10.54	12.72	9.91	12.09
9/4/00	10.14	12.31	10.7	13.81	10.77	14.66	11.36	14.78	10.7	13.65	10.07	12.71
9/5/00	9.98	11.69	10.39	12.72	10.46	13.09	11.21	13.38	10.39	12.56	9.6	11.93
9/6/00	11.07	12	11.94	13.19	12.16	13.56	12.61	13.99	11.94	12.87	11.47	13.02
9/7/00	9.98	11.84	10.39	13.03	10.46	13.56	11.21	13.84	10.39	13.03	9.76	12.4
9/8/00	10.14	11.23	11.01	12.72	11.23	13.41	11.67	13.84	11.63	12.87	11.47	12.4
9/9/00	9.98	10.92	10.54	11.63	10.77	12.01	11.06	12.29	11.17	12.09	10.69	11.78
9/10/00	10.14	10.61	10.86	11.32	10.92	11.69	11.21	12.14	11.47	11.94	11.16	12.09
9/11/00	9.98	11.38	10.7	12.57	10.77	12.94	10.9	13.38	11.17	13.03	11.01	13.02
9/12/00	9.83	11.84	10.39	13.03	10.46	13.41	10.74	13.99	10.86	13.34	10.38	13.18
9/13/00	10.14	12.16	10.7	13.34	10.77	13.87	10.9	14.31	11.17	13.65	10.69	13.49
9/14/00	11.07	13.09	11.63	14.43	11.69	15.13	12.14	15.57	12.09	14.74	11.93	14.42
9/15/00	12.16	13.24	12.88	14.75	12.94	15.6	13.23	15.57	13.34	15.06	13.33	15.05
9/16/00	12.16	13.09	12.88	14.43	13.09	14.81	13.53	15.09	13.49	14.58	13.33	14.73
9/17/00	11.84	13.39	12.72	14.75	12.94	15.6	13.23	15.89	13.18	15.06	13.02	14.89
9/18/00	12.16	12.78	13.03	14.28	13.25	14.66	13.69	15.09	13.49	14.58	13.49	14.58
9/19/00	12.31	13.71	13.34	14.91	13.56	15.92	13.99	15.89	13.65	15.37	13.49	15.53
9/20/00	11.38	12.31	11.94	13.19	11.85	13.56	12.45	14.15	12.09	13.65	11.78	13.33
9/21/00	11.07	12.47	11.94	13.5	12.16	14.34	12.76	14.46	12.09	13.65	11.62	13.18
9/22/00	9.52	11.38	10.23	12.1	10.3	12.94	10.74	13.07	10.23	12.25	9.76	11.47
9/23/00	8.13	10.29	8.21	11.17	8.28	12.01	8.72	11.98	8.06	11.17	7.58	10.54
9/24/00	8.13	10.29	8.37	11.48	8.28	12.32	8.87	12.14	8.37	11.47	7.58	10.54
9/25/00	8.43	10.61	8.83	11.63	8.74	12.47	9.18	12.45	8.99	11.78	8.36	10.85
9/26/00	8.59	10.76	8.99	11.79	8.9	12.78	9.34	12.61	9.14	12.09	8.52	11.01
9/27/00	9.05	11.07	9.46	12.1	9.37	12.94	9.81	12.92	9.77	12.41	9.29	11.62
9/28/00	9.36	10.76	9.92	11.79	9.99	12.01	10.59	12.29	10.23	11.78	9.44	11.62
9/29/00	10.29	11.38	11.01	12.41	11.08	12.94	11.52	13.07	11.17	12.56	11.16	13.33
9/30/00	11.07	11.69	11.79	12.57	12.01	12.94	12.14	13.23	12.25	13.03	12.56	13.49
10/1/00	10.14	11.23	10.7	11.79	10.77	12.01	11.06	12.14	11.17	12.56	11.01	12.56
10/2/00	9.05	10.14	9.61	11.01	9.83	11.23	10.28	11.52	9.77	11.17	9.13	11.01
10/3/00	7.97	9.21	8.21	10.08	8.28	10.46	8.57	10.74	8.37	10.08	7.27	10.38
10/4/00	7.19	8.59	7.43	9.46	7.5	9.99	7.64	10.28	7.44	9.46	5.87	9.29
10/5/00	7.04	8.59	7.12	9.46	7.19	9.99	7.48	10.28	7.13	9.61	5.72	9.44
10/6/00	7.19	8.89	7.28	9.77	7.19	10.46	7.48	10.59	7.44	10.08	6.81	10.69
10/7/00	7.51	9.21	7.9	10.08	7.81	10.92	7.95	11.06	7.91	10.39	8.52	12.09
10/8/00	7.97	9.67	8.21	10.54	8.28	10.77	8.57	10.9	8.37	10.54	8.67	11.01
10/9/00	9.21	9.67	9.77	10.39	9.83	10.61	10.28	10.74	9.92	10.54	10.23	10.69
10/10/00	9.36	9.52	9.92	10.23	10.14	10.3	10.43	10.59	10.23	10.39	10.23	10.38

Table A5. Daily Minimum and Maximum Temperature Monitoring Data (2001)

Date	SPCSR Tmin	SPCSR Tmax	SPCWC Tmin	SPCWC Tmax	SPCSP Tmin	SPCSP Tmax	SPCB4 Tmin	SPCB4 Tmax	SPCB2 Tmin	SPCB2 Tmax	SPCB1 Tmin	SPCB1 Tmax	SPCM Tmin	SPCM Tmax	WCB3 Tmin	WCB3 Tmax	WCM Tmin	WCM Tmax	SKT165 Tmin	SKT165 Tmax
6/8/01			10.74	12.91	11.49	13.67	11.73	14.37	11.68	14.61	11.82	14.93	11.86	14.97	11.16	12.87	12.21	14.22	12.73	14.43
6/9/01			9.65	11.19	10.26	11.81	10.48	12.19	10.75	12.45	11.04	12.75	11.08	12.79	10.38	12.09	11.27	12.83	11.49	13.04
6/10/01			8.87	10.27	9.32	10.72	9.55	11.11	9.66	11.37	9.79	11.51	9.84	11.55	9.13	10.54	10.03	11.27	9.94	11.8
6/11/01			8.1	9.49	8.39	9.94	8.62	10.17	8.74	10.28	8.86	10.58	8.92	10.62	7.89	9.91	8.78	10.65	9.78	11.95
6/12/01			7.48	7.95	7.62	8.39	7.84	8.62	7.81	8.74	7.94	8.86	7.84	8.76	7.58	8.21	7.86	8.63	9.17	10.41
6/13/01			7.64	9.65	7.93	10.1	8.16	10.33	8.12	10.44	8.25	10.58	8.14	10.62	8.05	9.91	8.32	10.34	9.63	13.19
6/14/01			8.1	9.65	8.39	9.94	8.62	10.33	8.58	10.44	8.71	10.58	8.76	10.47	8.21	10.07	8.78	10.49	10.26	12.11
6/15/01			8.57	10.12	8.86	10.41	9.08	10.64	9.04	10.91	9.17	11.2	9.23	11.24	8.67	10.23	9.25	10.65	10.26	12.26
6/16/01			8.1	10.27	8.39	10.57	8.62	11.11	8.74	11.21	8.86	11.35	8.76	11.24	8.21	10.23	8.94	10.96	9.63	11.8
6/17/01			8.57	11.35	9.01	11.65	9.24	11.88	9.36	12.14	9.48	12.28	9.38	12.48	8.82	10.85	9.56	11.74	10.1	12.11
6/18/01			8.87	16.83	9.32	15.07	9.55	15.79	9.66	14.61	9.79	16.2	9.84	16.07	8.98	11.93	9.87	13.14	9.78	14.43
6/19/01			9.03	13.37	9.32	13.67	9.55	14.37	9.66	14.61	9.95	14.77	9.84	14.81	8.98	17.12	10.03	15.96	9.63	13.81
6/20/01			10.12	14.3	10.57	14.76	10.79	15.48	10.91	15.72	11.04	15.88	10.93	15.92	10.38	13.95	11.27	15.17	10.88	15.22
6/21/01			10.74	14.93	11.34	15.54	11.42	16.12	11.52	16.36	11.82	16.52	11.86	16.55	11.16	14.58	12.05	15.96	12.11	15.69
6/22/01			11.35	12.76	11.81	13.36	12.19	13.59	12.29	13.84	12.44	14.3	12.48	15.44	11.62	13.49	12.36	14.85	12.42	14.27
6/23/01			10.43	12.91	10.72	13.51	10.95	14.06	10.91	14.3	11.2	14.46	11.08	14.49	10.69	12.56	11.12	13.61	11.49	13.96
6/24/01			10.27	11.35	10.72	11.81	10.95	12.04	11.06	12.14	11.35	12.59	11.39	13.41	10.38	11.78	10.96	12.83	11.18	12.57
6/25/01			9.65	12.91	9.94	13.51	10.17	14.21	10.28	14.46	10.42	14.62	10.47	14.49	9.6	12.24	10.34	13.61	10.26	13.04
6/26/01			10.27	13.07	10.72	13.51	10.79	14.06	10.91	14.3	11.2	14.62	11.24	14.65	10.54	12.71	11.12	13.91	11.49	13.5
6/27/01			11.19	11.97	11.65	12.58	11.88	13.13	11.99	13.38	12.13	13.53	12.17	13.57	11.62	12.4	12.36	13.14	12.26	13.04
6/28/01			10.89	11.82	11.19	12.27	11.42	12.66	11.52	12.92	11.82	13.37	11.71	13.41	11.01	11.62	11.74	12.67	12.26	13.04
6/29/01			9.65	12.44	9.94	12.89	10.17	13.74	10.28	13.99	10.58	14.14	10.47	14.18	9.76	11.78	10.34	13.29	10.41	13.66
6/30/01			9.81	13.22	10.26	13.51	10.48	14.06	10.59	14.46	10.73	14.62	10.78	14.81	10.07	12.56	10.65	13.91	10.88	13.5
7/1/01			10.89	14.46	11.34	14.92	11.57	15.79	11.68	16.04	11.97	16.2	11.86	16.07	11.16	13.79	11.89	15.01	11.64	14.43
7/2/01			10.43	14.93	10.72	15.54	10.95	16.27	11.06	16.67	11.35	16.68	11.39	16.71	10.54	14.11	11.27	15.64	10.88	15.06
7/3/01			10.89	15.41	11.34	16.02	11.57	16.75	11.68	16.99	11.97	17.31	12.02	17.18	11.16	14.58	11.89	16.12	11.8	15.85

South Prairie Creek Bacteria and Temperature TMDL

Continued

Table A5. Daily Minimum and Maximum Temperature Monitoring Data (2001)

Date	SPCSR Tmin	SPCSR Tmax	SPCWC Tmin	SPCWC Tmax	SPCSP Tmin	SPCSP Tmax	SPCB4 Tmin	SPCB4 Tmax	SPCB2 Tmin	SPCB2 Tmax	SPCB1 Tmin	SPCB1 Tmax	SPCM Tmin	SPCM Tmax	WCB3 Tmin	WCB3 Tmax	WCM Tmin	WCM Tmax	SKT165 Tmin	SKT165 Tmax
7/4/01			11.97	16.19	12.42	16.66	12.66	17.39	12.76	17.78	13.06	18.12	12.95	17.99	12.4	15.53	12.83	16.76	13.04	16.96
7/5/01			12.28	15.09	12.58	15.54	12.82	16.27	12.92	16.51	13.37	16.52	13.41	16.87	12.4	14.42	12.98	15.96	13.04	15.22
7/6/01			10.89	14.93	11.19	15.39	11.42	16.12	11.52	16.51	11.82	16.52	11.86	16.39	10.85	13.95	11.27	15.17	11.03	15.37
7/7/01			11.04	15.56	11.34	16.02	11.57	16.91	11.68	17.31	11.97	17.31	12.02	17.18	11.01	14.42	11.43	15.96	11.34	15.22
7/8/01			11.51	16.19	11.81	16.82	12.04	17.55	12.14	18.11	12.44	18.12	12.48	17.83	11.47	15.05	11.89	16.59	11.8	15.85
7/9/01	13.24	15.75	12.13	16.99	12.58	17.61	12.82	18.36	12.76	18.92	13.22	18.93	13.26	18.63	12.24	15.85	12.83	17.39	12.88	17.27
7/10/01	12.31	16.07	12.76	16.99	13.2	17.61	13.28	18.36	13.38	18.59	13.83	18.76	13.87	18.63	12.87	16.17	13.45	17.56	13.66	17.75
7/11/01	12.62	16.07	13.07	17.31	13.51	17.93	13.74	18.68	13.68	19.24	14.14	19.25	14.18	18.96	13.18	16.32	13.61	17.56	13.81	17.27
7/12/01	12.62	15.12	13.07	16.19	13.51	16.66	13.59	17.39	13.68	17.94	14.14	17.79	14.18	17.99	13.02	15.53	13.61	16.44	13.66	16.48
7/13/01	12.31	14.64	12.76	15.88	13.04	16.34	13.28	17.07	13.22	17.78	13.68	17.47	13.72	17.51	12.56	15.05	13.14	15.96	13.04	15.85
7/14/01	12.16	13.24	12.6	13.83	12.89	14.29	12.97	14.53	12.92	14.77	13.22	15.25	13.26	16.39	12.4	13.33	12.98	14.85	13.04	14.27
7/15/01	11.69	12.31	12.13	13.07	12.42	13.36	12.51	13.44	12.61	13.53	12.91	13.99	12.95	14.34	11.93	12.56	12.36	13.45	12.42	13.66
7/16/01	11.22	12.62	11.66	13.22	11.81	13.51	12.04	13.9	11.99	13.99	12.28	14.14	12.33	14.18	11.47	12.56	11.89	13.45	11.64	13.19
7/17/01	11.07	12.31	11.66	13.22	11.96	13.67	12.04	14.06	12.14	13.99	12.44	14.3	12.48	14.18	11.47	12.56	12.05	13.61	11.8	13.34
7/18/01	11.07	13.24	11.66	13.99	11.96	14.29	12.19	14.84	12.29	15.25	12.44	15.57	12.48	15.28	11.62	13.33	12.21	14.22	11.95	14.27
7/19/01	10.91	13.55	11.51	15.09	11.81	15.54	11.88	15.96	11.99	16.51	12.28	16.52	12.33	16.39	11.62	13.49	12.05	15.17	11.8	15.06
7/20/01	11.22	12.47	11.51	13.68	11.96	14.29	12.19	15	12.45	15.72	12.75	15.41	12.79	15.6	11.78	12.71	12.36	14.53	11.8	13.96
7/21/01	11.38	12.16	11.97	12.91	12.42	13.36	12.66	13.74	12.76	13.99	13.06	14.3	13.11	14.81	12.09	12.56	12.67	13.61	12.42	13.34
7/22/01	11.38	12.93	11.97	14.14	12.27	14.6	12.51	15.16	12.61	15.57	12.91	15.57	12.95	15.44	12.09	13.49	12.67	14.38	12.42	14.43
7/23/01	11.38	15.12	11.66	16.36	12.12	16.82	12.35	17.71	12.45	18.27	12.75	18.12	12.79	17.99	11.93	15.37	12.52	16.44	12.26	16.16
7/24/01	12.62	14.02	13.22	15.09	13.67	15.39	13.74	16.12	14.14	16.36	14.3	16.36	14.34	17.02	13.18	14.58	13.91	15.64	14.12	16.16
7/25/01	12.31	15.59	12.91	16.99	13.36	17.61	13.44	18.52	13.68	18.75	13.83	19.09	13.87	18.96	12.71	15.85	13.61	17.07	13.66	16.79
7/26/01	12.16	14.8	12.6	15.88	12.89	16.49	13.13	17.23	13.84	17.46	13.68	17.63	13.41	17.83	12.4	15.05	13.14	15.96	13.04	15.85
7/27/01	12.16	14.02	12.44	14.93	12.73	15.54	12.97	15.96	13.53	16.51	13.37	16.52	13.11	16.71	12.24	14.42	12.83	15.17	12.57	15.06
7/28/01	12.31	13.55	12.91	14.3	13.36	14.92	13.59	15.79	13.68	16.04	13.99	16.36	14.03	16.39	12.87	14.26	13.61	15.17	13.34	15.06
7/29/01	11.53	12.93	12.13	13.99	12.42	14.44	12.66	15	12.76	15.25	12.91	15.57	12.95	15.6	12.09	13.33	12.67	14.53	12.42	14.27

Continued

Table A5. Daily Minimum and Maximum Temperature Monitoring Data (2001)

	SPCSR		SPCWC		SPCSP		SPCB4		SPCB2		SPCB1		SPCM		WCB3		WCM		SKT165	
Date	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax
7/30/01	11.07	12.62	11.35	13.68	11.65	14.6	11.88	16.12	11.83	16.04	12.28	17.47	12.33	16.07	11.47	13.18	11.89	15.96	11.49	16.63
7/31/01	11.53	12.62	12.13	13.68	12.42	14.13	12.51	14.68	12.76	15.09	12.91	15.57	12.95	15.44	12.09	12.87	12.67	14.07	12.26	13.81
8/1/01	10.61	12.93	11.04	13.83	11.34	14.29	11.42	15	11.52	15.41	11.82	15.41	12.02	15.28	11.01	13.02	11.43	14.38	10.88	13.96
8/2/01	11.69	13.71	12.44	15.41	12.73	16.02	12.97	17.07	13.22	17.62	13.37	18.12	13.57	17.99	12.4	14.73	13.14	15.96	13.04	15.69
8/3/01	12.16	13.4	12.76	14.61	13.2	15.07	13.28	15.64	13.53	15.88	13.83	15.88	14.03	15.92	13.02	14.26	13.76	14.85	13.66	15.53
8/4/01	12.31	13.55	12.91	14.14	13.2	14.76	13.28	15.48	13.38	15.88	13.68	16.04	13.72	16.39	12.87	13.64	13.61	14.69	13.66	14.58
8/5/01	11.69	14.17	12.13	15.24	12.42	15.71	12.66	16.27	12.76	16.51	13.06	16.68	13.26	16.55	12.24	14.58	12.67	15.49	12.42	15.37
8/6/01	12.62	13.86	13.37	14.77	13.67	15.54	13.9	16.43	14.14	16.67	14.46	16.83	14.65	16.87	13.33	14.42	14.22	15.33	14.12	15.69
8/7/01	12.62	15.12	13.22	16.52	13.51	17.29	13.74	18.36	13.99	18.59	14.14	18.76	14.34	18.96	13.33	15.69	13.91	16.91	14.12	16.96
8/8/01	11.69	15.12	12.13	16.52	12.42	17.13	12.66	18.36	12.92	18.75	13.22	18.6	13.41	18.96	12.09	15.69	12.83	16.59	12.11	16.96
8/9/01	12.31	15.91	12.91	17.31	13.2	18.09	13.59	19.17	13.84	19.56	14.14	19.58	14.34	20.41	12.87	16.48	13.61	17.56	13.34	18.72
8/10/01	12.78	16.38	13.37	17.63	13.82	18.41	14.06	19.5	14.3	19.88	14.62	19.74	14.81	20.73	13.33	16.96	14.22	18.04	13.96	19.68
8/11/01	12.78	16.07	13.22	17.47	13.67	18.09	13.9	19.17	14.14	19.56	14.62	19.41	14.81	20.73	13.02	16.48	14.07	17.56	13.66	18.56
8/12/01	12.93	16.38	13.37	17.63	13.82	18.41	13.9	19.5	14.14	19.88	14.62	19.74	14.81	20.73	13.18	16.8	14.07	17.88	13.81	19.04
8/13/01	13.71	16.54	14.3	17.63	14.6	18.25	13.74	19.17	14.3	19.56	15.41	19.41	15.6	20.41	13.95	16.8	14.85	17.72	15.06	18.88
8/14/01	13.55	16.07	13.99	16.67	14.44	17.45	14.68	18.36	14.77	18.75	15.09	18.6	15.44	19.6	13.64	16.17	14.53	16.91	14.58	17.91
8/15/01	13.24	15.75	13.68	16.52	13.98	16.97	14.21	17.71	14.46	18.11	14.77	18.12	14.97	19.12	13.33	15.85	14.07	16.44	13.96	17.11
8/16/01	13.55	14.33	13.83	15.41	14.13	15.71	14.21	16.27	14.46	16.51	14.77	16.68	14.97	17.02	13.33	14.26	14.07	15.33	14.12	15.69
8/17/01	12.93	14.17	13.37	15.09	13.51	15.54	13.59	15.79	13.68	16.04	13.99	16.52	14.03	16.87	12.71	14.11	13.29	14.69	13.5	15.53
8/18/01	12.78	14.02	13.22	14.93	13.51	15.39	13.44	15.64	13.68	15.88	13.99	16.04	14.03	16.39	12.71	13.79	13.45	14.85	13.66	15.06
8/19/01	11.84	14.17	12.13	15.41	12.27	15.71	12.35	16.43	12.61	16.67	12.91	16.68	12.95	17.83	11.78	14.11	12.21	15.17	11.95	14.9
8/20/01	11.38	14.48	11.66	15.24	11.81	15.71	11.73	16.43	11.83	16.67	12.28	16.52	12.33	17.34	11.32	14.26	11.74	15.17	11.18	14.9
8/21/01	11.69	12.93	12.13	13.68	12.27	13.98	12.35	13.9	12.45	14.3	12.75	14.93	12.95	14.97	11.62	12.71	12.21	13.61	11.8	13.5
8/22/01	12.31	12.78	12.91	13.37	13.04	13.67	13.13	13.9	13.38	13.99	13.53	14.14	13.57	14.18	12.4	13.18	12.98	13.61	12.42	13.5
8/23/01	12.16	12.93	12.44	13.53	12.58	13.67	12.82	13.9	12.92	14.14	13.06	14.46	12.95	14.34	12.24	13.02	12.83	13.45	12.57	13.81
8/24/01	11.69	13.86	11.97	14.61	12.12	14.92	12.35	15.79	12.45	15.88	12.59	16.04	12.64	16.07	11.78	13.49	12.21	14.53	12.11	14.27

Continued

Table A5. Daily Minimum and Maximum Temperature Monitoring Data (2001)

	SPCSR		SPCWC		SPCSP		SPCB4		SPCB2		SPCB1		SPCM		WCB3		WCM		SKT165	
Date	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax	Tmin	Tmax
8/25/01	11.22	14.02	11.51	15.09	11.65	15.39	11.73	16.43	11.83	16.67	12.13	16.83	12.17	16.55	11.32	13.79	11.74	15.01	11.49	14.9
8/26/01	11.69	14.64	11.97	15.72	12.27	16.02	12.35	17.07	12.61	17.46	12.91	17.47	12.95	17.18	11.93	14.58	12.36	15.64	12.26	15.53
8/27/01	12	14.64	12.28	15.56	12.73	16.02	12.82	16.91	13.07	17.14	13.37	17.31	13.41	17.67	12.24	14.58	12.83	15.33	12.42	15.22
8/28/01	12.78	15.12	13.53	16.19	13.82	16.66	14.06	17.71	14.3	18.11	14.62	17.96	14.65	18.79	13.18	15.21	14.07	16.28	13.96	16.48
8/29/01	12.47	14.96	12.91	15.88	13.2	16.34	13.44	17.07	13.68	17.62	14.14	17.63	14.18	18.79	12.87	15.05	13.29	15.81	13.19	16.16
8/30/01	12.62	15.43	13.07	16.19	13.36	16.82	13.59	17.71	13.68	18.11	14.14	17.96	14.34	18.79	12.87	15.37	13.61	16.28	13.34	16.32
8/31/01	13.24	15.27	13.99	15.88	14.29	16.66	14.37	17.07	14.61	17.46	14.77	17.47	14.97	18.31	13.49	14.89	14.38	16.12	14.43	16.01
9/1/01	12.62	13.86	13.22	14.61	13.51	14.92	13.74	15.16	13.99	15.57	14.46	15.88	14.49	16.07	12.71	13.79	13.45	14.85	13.19	14.58
9/2/01	11.53	14.02	11.82	14.93	12.12	15.23	12.04	15.96	12.29	16.36	12.59	16.52	12.64	17.02	11.62	13.95	11.89	14.85	11.49	14.43
9/3/01	12.31	13.4	12.76	14.61	13.04	14.92	13.13	15	13.38	15.25	13.53	15.41	13.72	15.44	12.24	13.33	12.98	14.38	12.73	14.12
9/4/01	12.31	14.02	12.91	14.77	13.04	15.23	13.13	15.79	13.38	16.04	13.53	16.04	13.57	16.87	12.56	13.79	13.14	14.85	12.88	14.58
9/5/01	11.53	12.78	11.97	13.53	12.12	13.82	12.19	13.9	12.45	14.14	12.75	14.62	12.79	14.97	11.47	12.87	12.05	13.61	11.49	13.19
9/6/01	10.91	12.62	11.35	13.53	11.34	13.98	11.42	14.21	11.37	14.61	11.51	14.77	11.55	15.13	10.85	12.71	11.27	13.45	10.88	12.88
9/7/01	11.38	13.24	11.97	14.3	12.27	14.6	12.35	15.79	12.61	16.04	12.91	16.04	12.79	17.18	11.62	13.33	12.21	14.22	11.64	13.81
9/8/01	10.45	13.09	10.74	13.99	10.88	14.44	10.95	15.48	11.06	15.88	11.51	15.73	11.55	16.55	10.54	13.18	10.96	13.91	10.26	13.34
9/9/01	10.45	13.09	10.74	13.83	11.03	14.29	10.95	15.48	11.21	15.72	11.51	15.57	11.55	16.55	10.54	13.18	10.96	13.91	10.26	13.5
9/10/01	10.29	12.93	10.58	13.68	10.72	14.29	10.79	15.16	10.91	15.57	11.35	15.41	11.39	16.39	10.38	13.02	10.81	13.76	10.1	13.34
9/11/01	10.61	13.24	10.89	13.99	11.19	14.44	11.11	15.48	11.37	15.88	11.66	15.73	11.55	16.71	10.69	13.33	11.12	14.07	10.57	13.66
9/12/01	10.91	13.55	11.19	14.3	11.34	14.76	11.42	15.79	11.52	16.2	11.97	16.04	11.86	16.87	11.01	13.64	11.58	14.38	10.88	14.27
9/13/01	11.07	13.71	11.35	14.3	11.65	14.92	11.73	16.12	11.83	16.36	12.13	16.2	12.17	17.02	11.32	13.79	11.74	14.53	11.34	14.43
9/14/01	11.38	13.86	11.82	14.61	11.96	15.23	12.04	16.27	12.14	16.67	12.44	16.36	12.48	17.51	11.62	13.95	12.21	14.85	11.8	14.9
9/15/01	11.69	14.02	12.13	14.77	12.27	15.39	12.35	16.27	12.61	16.67	12.91	16.36	12.95	17.51	11.93	14.11	12.52	15.01	12.11	15.06
9/16/01	11.53	12.93	11.97	13.68	12.27	13.98	12.51	14.37	12.61	14.61	12.91	14.93	12.95	15.44	11.62	12.87	12.36	13.91	11.8	13.66
9/17/01	11.69	16.54	12.13	12.6	12.27	12.89	12.35	12.82	12.45	13.07	12.75	13.53	12.79	13.72	11.62	11.93	12.21	12.52	11.95	12.42
9/18/01	10.61	11.84	11.04	12.6	11.34	12.89	11.42	13.13	11.68	13.38	11.97	13.37	12.02	13.72	10.69	11.78	11.12	12.52	10.41	12.11
9/19/01	11.07	12.62	11.51	13.22	11.65	13.51	11.73	14.37	11.83	14.46	12.13	14.93	12.02	15.76	11.01	12.56	11.58	13.14	11.03	12.73

Table A5. Daily Minimum and Maximum Temperature Monitoring Data (2001)

Date	SPCSR Tmin	SPCSR Tmax	SPCWC Tmin	SPCWC Tmax	SPCSP Tmin	SPCSP Tmax	SPCB4 Tmin	SPCB4 Tmax	SPCB2 Tmin	SPCB2 Tmax	SPCB1 Tmin	SPCB1 Tmax	SPCM Tmin	SPCM Tmax	WCB3 Tmin	WCB3 Tmax	WCM Tmin	WCM Tmax	SKT165 Tmin	SKT165 Tmax
9/20/01	9.67	12	9.81	12.6	9.94	12.89	10.02	13.74	10.13	13.99	10.42	13.83	10.47	14.65	9.6	12.09	9.87	12.36	9.01	11.95
9/21/01	10.45	12	10.89	12.76	11.03	13.2	11.11	13.59	11.21	13.84	11.51	13.83	11.55	14.34	10.38	12.09	10.96	12.98	10.57	12.42
9/22/01	10.45	12.78	10.74	13.37	11.03	13.82	10.95	15	11.21	15.41	11.51	15.09	11.55	15.92	10.69	13.02	10.96	13.61	10.41	13.34
9/23/01	10.76	13.09	11.19	13.68	11.34	14.13	11.42	15.32	11.68	15.57	11.97	15.25	12.02	16.23	11.16	13.33	11.58	14.07	11.03	13.81
9/24/01	11.22	12.93	11.66	13.53	11.81	13.82	11.88	14.21	12.14	14.3	12.28	14.3	12.48	14.97	11.47	13.02	12.05	13.76	11.64	13.81
9/25/01	11.38	12.16	11.97	12.91	12.27	13.2	12.35	13.28	12.61	13.38	12.91	13.53	12.95	14.03	11.47	12.24	12.21	13.14	12.11	12.88
9/26/01	10.45	11.69	10.89	12.44	11.19	12.58	11.42	12.66	11.52	12.92	11.66	13.06	11.71	13.26	10.69	11.93	11.27	12.52	10.88	12.26
9/27/01	9.06	10.61	9.34	11.19	9.48	11.34	9.39	11.57	9.51	11.83	9.79	11.97	9.69	11.86	8.98	10.54	9.41	11.12	8.71	10.88
9/28/01	9.06	10.91	9.18	11.35	9.32	11.65	9.39	12.66	9.51	12.92	9.64	12.75	9.69	12.64	8.98	11.01	9.25	11.58	8.55	11.18
9/29/01	8.9	11.07	9.18	11.66	9.32	11.96	9.24	12.82	9.36	12.92	9.79	12.59	9.69	13.26	8.98	11.32	9.41	11.89	8.86	11.8
9/30/01	9.21	10.76	9.49	11.35	9.63	11.49	9.71	12.04	9.82	12.14	10.27	12.13	10.16	12.79	9.29	11.01	9.72	11.43	8.86	10.88
10/1/01	9.21	11.22	9.34	11.51	9.48	11.96	9.86	12.82	10.13	12.92	10.42	12.75	10.31	14.03	9.29	11.32	9.56	11.89	8.71	11.49
10/2/01	8.74	10.76	8.87	11.04	9.01	11.49	9.08	12.35	9.2	12.61	9.64	12.44	9.69	13.57	8.82	10.85	9.09	11.27	8.24	10.72
10/3/01	8.44	10.14	8.57	10.43	8.7	10.72	8.77	11.11	8.89	11.21	9.17	11.2	9.07	12.17	8.52	10.23	8.78	10.65	7.78	9.94
10/4/01	8.13	10.14	8.1	10.43	8.24	10.72	8.46	11.73	8.58	11.99	9.02	11.82	8.76	12.79	8.21	10.38	8.17	10.65	7.01	9.94
10/5/01	7.82	9.98	7.95	10.43	7.93	10.72	7.84	11.57	7.97	11.83	8.25	11.51	8.14	12.17	7.89	10.23	8.01	10.65	8.4	11.34
10/6/01	8.44	10.29	8.87	10.58	8.86	10.88	8.93	11.57	9.04	11.83	9.17	11.82	9.23	12.17	8.52	10.38	8.94	10.81	9.01	10.72
10/7/01	8.74	9.83	8.87	10.27	9.01	10.41	9.08	10.64	9.2	10.75	9.48	10.73	9.38	10.78	8.82	9.76	9.09	10.34	8.55	9.78
10/8/01	9.21	10.29	9.81	10.89	9.94	11.19	10.02	11.73	10.13	11.99	10.27	11.97	10.16	12.64	9.44	10.38	9.87	10.96	9.32	10.26
10/9/01	8.59	9.67	9.03	10.27	9.32	10.57	9.39	11.11	9.51	11.21	9.79	11.2	9.69	11.08	8.82	10.07	9.25	10.49	8.4	9.94
10/10/01	7.82	8.59	7.95	9.03	7.93	9.17	8	9.39	7.97	9.51	8.25	9.79	8.3	9.84	7.89	8.67	7.86	9.09	7.17	8.71
10/11/01	8.13	8.9	8.57	9.49	8.54	9.79	8.62	10.17	8.74	10.28	8.86	10.58	8.92	10.47	8.36	9.13	8.78	9.87	8.4	9.78
10/12/01	7.98	9.21	8.1	9.65	8.24	9.79	8.46	10.02	8.43	10.13	8.56	10.11	8.61	10	8.05	9.29	8.48	9.87	8.4	9.63
10/13/01	8.59	9.36	8.87	9.96	9.01	10.1	9.24	10.48	9.36	10.59	9.48	10.73	9.53	10.78	8.82	9.76	9.41	10.49	9.01	10.1
10/14/01	8.9	9.52	9.18	9.96	9.48	10.1	9.71	10.64	9.82	10.75	9.79	10.89	9.84	10.93	9.44	10.23	10.03	11.12	9.63	10.88
10/15/01	7.51	8.74	7.95	10.12	8.39	9.48	8.77	9.86	8.89	10.13	9.02	10.42	9.07	10.31	7.89	9.76	8.78	10.18	8.09	9.63

South Prairie Creek Bacteria and Temperature TMDL

Appendix B
Example Vegetation GIS Data Layer

South Prairie Creek Bacteria and Temperature TMDL

Example of Vegetation GIS Data Layer
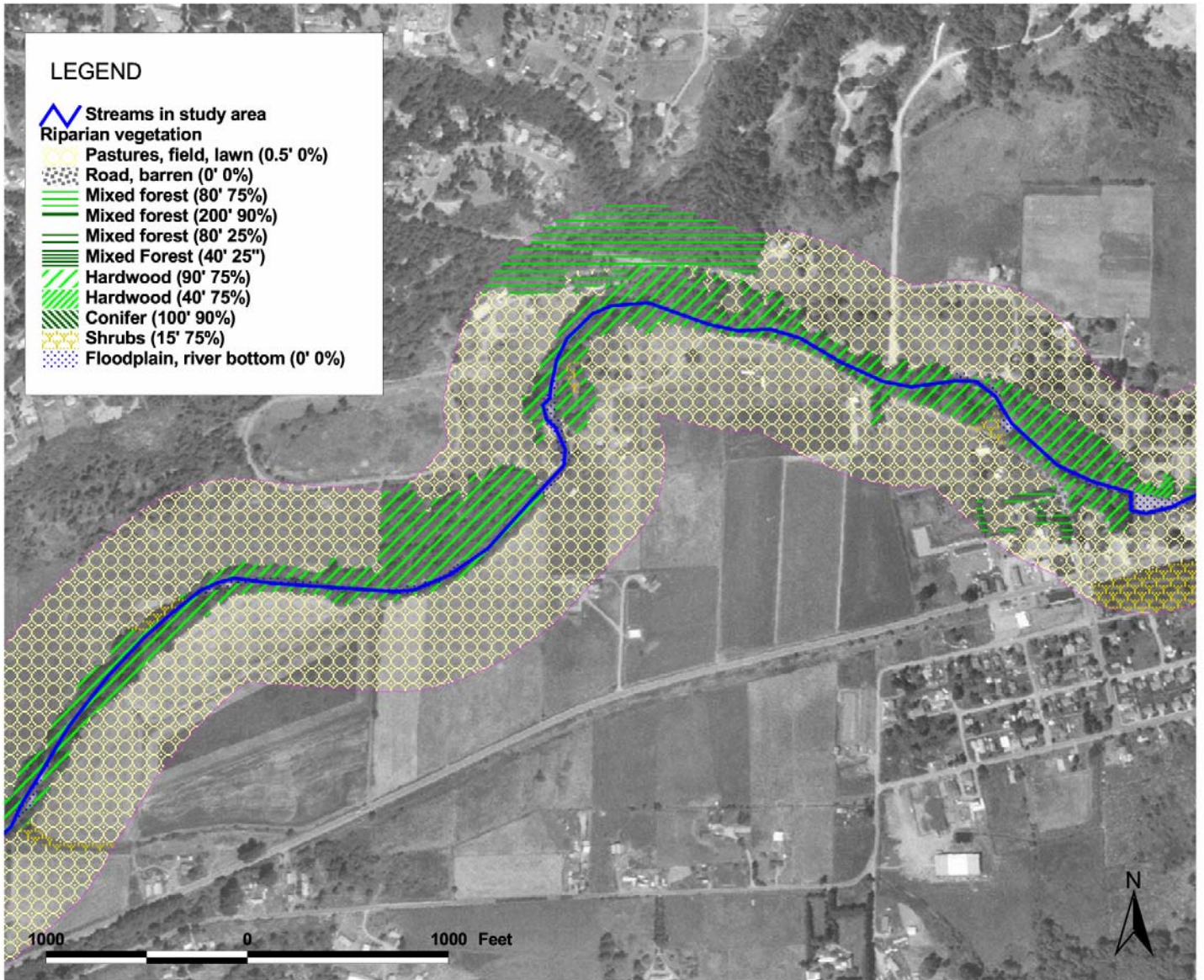# Developed for South Prairie Creek

Figure B-1. Digital orthophoto, with overlay of vegetation polygons derived from orthophotos and habitat surveys.

Appendix C
Example Action Items from the
Upper Puyallup Watershed Characterization and Action Plan
(Upper Puyallup Watershed Committee, 2002)

AG 03   **INCREASE DEVELOPMENT AND IMPLEMENTATION OF "BEST MANAGEMENT PRACTICES" (BMP'S) AND FARM PLANS** $150,000.00

Lead Implementers	Time Frame: Ongoing	Priority Item

● Pierce Conservation District

AG 04   **ESTABLISH THE PIERCE CONSERVATION DISTRICT AS A "SPECIAL ASSESSMENT DISTRICT"** $10,000.00

Lead Implementers	Time Frame: One-Time	Priority Item

● Pierce County Council

AG 05   **MAINTAIN KING COUNTY LIVESTOCK ORDINANCE AND INSTITUTE A LIVESTOCK MANAGEMENT ORDINANCE FOR PIERCE COUNTY** $10,000.00

Lead Implementers	Time Frame: Ongoing	Priority Item

● Pierce County Council

AG 06   **CREATE AN INTERDISCIPLINARY TEAM TO HELP LANDOWNERS RE-ESTABLISH RIPARIAN ZONES** $15,000.00

Lead Implementers	Time Frame: Ongoing	Priority Item

● Puyallup River Watershed Council

AG 07   **FACILITATE RIPARIAN RESTORATION BY USING VOLUNTEERS** $50,000.00

Lead Implementers	Time Frame: Ongoing	Priority Item

● Puyallup River Watershed Council
● Stream Team
● Pierce Conservation District

AG 11   **IMPROVE AND COORDINATE ENFORCEMENT OF AGRICULTURAL REGULATIONS** $80,000.00

Lead Implementers	Time Frame: Ongoing	Priority Item

● Washington State Department of Ecology

AG 15   **ENHANCE WATER QUALITY MONITORING IN AGRICULTURAL AREAS** $300,000.00

Lead Implementers	Time Frame: Ongoing	Priority Item

● Pierce Conservation District
● Puyallup River Watershed Council
● Pierce County Water Programs

AG 16   **MAINTAIN AND SUPPORT WORKSHOPS AND EDUCATION SEMINARS ABOUT HOBBY FARM MANAGEMENT** $5,000.00

Lead Implementers	Time Frame: Ongoing	Priority Item

● Pierce Conservation District

AG 18   **DEVELOP A PROGRAM TO SUPPORT THE PURCHASE OF DEVELOPMENT RIGHTS** $100,000.00

Lead Implementers	Time Frame: Ongoing	Priority Item

● Pierce County

AG 19   SUPPORT AND EXPAND THE CONSERVATION RESERVE
ENHANCEMENT PROGRAM $5,000.00

Lead Implementers   Time Frame: Ongoing   Priority Item
● Pierce Conservation District
● Puyallup River Watershed Council

FOR 01   SUPPORT THE "FOREST AND FISH" RULES FOR FOREST ROAD
POLICIES AND REGULATIONS

Lead Implementers   Time Frame: Ongoing   Priority Item
● Forest Practice Board
● Washington State Department of Natural Resources

FOR 02   ENCOURAGE ROAD ABANDONMENT IN ROAD MAINTENANCE PLANS

Lead Implementers   Time Frame: Ongoing   Priority Item
● Washington State Department of Natural Resources
● US Forest Service

FOR 03   EXPLORE AND IMPLEMENT FINANCIAL INCENTIVES TO
DECOMMISSION HIGH RISK, UNUSED ROADS $25,000.00

Lead Implementers   Time Frame: Ongoing   Priority Item
● Pierce County Assessor/Treasurer
● Washington State Department of Revenue

FOR 07   DEVELOP INCENTIVES FOR LANDOWNERS WHO EMPLOY
SUSTAINABLE FOREST MANAGEMENT AND HABITAT
ENHANCEMENT STRATEGIES $50,000.00

Lead Implementers   Time Frame: One-Time   Priority Item
● Washington Forest Protection Association
● Washington Farm-Forestry Association

FOR 18   CREATE A FOREST ADVISORY COMMISION FOR THE PUYALLUP
WATERSHED WHICH ENCOURAGES FOREST PRESERVATION AND
STEWARDSHIP $15,000.00

Lead Implementers   Time Frame: Ongoing   Priority Item
● Pierce County

FOR 19   CONTINUE AND EXPAND FOREST STEWARDSHIP PROGRAMS $160,000.00

Lead Implementers   Time Frame: Ongoing   Priority Item
● Pierce County
● Washington State Department of Natural Resources

HB 02   CONTINUE TO IDENTIFY POTENTIAL SALMON HABITAT $80,000.00
PRESERVATION AND RESTORATION PROJECT SITES AND PURSUE
FUNDING

Lead Implementers   Time Frame: One-Time   Priority Item
● Puyallup River Watershed Council

HB 04   PURCHASE CONSERVATION EASEMENTS OR DEVELOPMENT $200,000.00
RIGHTS ON WETLANDS, SALMON HABITAT, AND OTHER
SENSITIVE AREAS AND THEIR BUFFERS

Lead Implementers   Time Frame: Ongoing   Priority Item
● Pierce County

● Cascade Land Conservancy

HB 05   **EXPAND STREAM TEAM PROGRAMS RELATED TO RESTORING** $50,000.00
            STREAMS AND RIPARIAN CORRIDORS

    Lead Implementers   Time Frame: Ongoing   Priority Item
    ● Pierce Conservation District

MO 01   **DEVELOP AND COORDINATE A COMPREHENSIVE LONG-TERM** $300,000.00
            WATERSHED HEALTH MONITORING AND EVALUATION PROGRAM

    Lead Implementers   Time Frame: Ongoing   Priority Item
    ● Puyallup River Watershed Council
    ● Pierce County Water Programs

MO 02   **EXPAND STREAM TEAM, LAND/WATER STEWARDSHIP PROGRAMS** $50,000.00
            AND OTHER VOLUNTEER MONITORING OPPORTUNITIES

    Lead Implementers   Time Frame: Ongoing   Priority Item
    ● Pierce County

OS 01   **CONTINUE TO PROVIDE "ON-SITE SEWAGE SYSTEM"** $5,000.00
            EDUCATIONAL MATERIALS TO HOMEBUYERS

    Lead Implementers   Time Frame: Ongoing   Priority Item
    ● Pierce County Board of Realtors

OS 02   **ON-SITE MAINTENANCE MEDIA COMPAIGN** $50,000.00

    Lead Implementers   Time Frame: One-Time   Priority Item
    ● Seattle-King County Health Department
    ● Tacoma-Pierce County Health Department

OS 03   **MAIL MAINTENANCE REMINDER NOTICES TO ON-SITE OWNERS** $5,000.00

    Lead Implementers   Time Frame: Ongoing   Priority Item
    ● On-site System Pumpers

OS 04   **HOMES WILL BE ENROLLED IN THE "OPERATION & MAINTENANCE**
            PROGRAM" AT TIME OF SALE

    Lead Implementers   Time Frame: Ongoing   Priority Item
    ● Tacoma-Pierce County Health Department

OS 14   **OFFER FINANCIAL ASSISTANCE AND INCENTIVES TO REPAIR** $150,000.00
            FAILING SEPTIC SYSTEMS OR ALLOW CONNECTION TO SEWERS

    Lead Implementers   Time Frame: Ongoing   Priority Item
    ● Tacoma-Pierce County Health Department

OS 15   **SURVEY AREAS POTENTIALLY IMPACTED BY FAILING ON-SITE** $200,000.00
            SEWAGE SYSTEMS

    Lead Implementers   Time Frame: Ongoing   Priority Item
    ● Tacoma-Pierce County Health Department

OS 21   **EXPLORE INCENTIVES FOR PEOPLE WHO HAVE THEIR SYSTEMS** $10,000.00
            SERVICED REGULARLY

    Lead Implementers   Time Frame: Ongoing   Priority Item
    ● Tacoma-Pierce County Health Department

OT 15 **HOST NATIVE PLANT LANDSCAPING SEMINARS** $20,000.00

 <u>**Lead Implementers**</u>   Time Frame: Ongoing   Priority Item
 ● Washington State University Cooperative Extension

SW 02 **CREATE AND IMPLEMENT A COORDINATED AND COMPREHENSIVE** $500,000.00
            FLOODPLAIN ACQUISTION AND MANAGEMENT PROGRAM

 <u>**Lead Implementers**</u>   Time Frame: Ongoing   Priority Item
 ● Pierce County

SW 04 **SUPPORT PUBLIC POLICY THAT RESTRICTS OR PROHIBITS** $100,000.00
            BUILDING AND/OR REDEVELOPMENT IN FLOODPLAINS

 <u>**Lead Implementers**</u>   Time Frame: One-Time   Priority Item
 ● Pierce County Planning & Land Services
 ● Cities & Towns Planning Departments

SW 08 **PRESERVE VEGETATION ON STEEP SLOPES AND BUFFER AREAS** $100,000.00

 <u>**Lead Implementers**</u>   Time Frame: Ongoing   Priority Item
 ● Pierce County
 ● Cities & Towns

SW 09 **SUPPORT LAND/WATER STEWARDSHIP PROGRAMS AND "ADOPT-** $100,000.00
            A-STREAM" PROGRAMS

 <u>**Lead Implementers**</u>   Time Frame: Ongoing   Priority Item
 ● Washington State University Cooperative Extension
 ● Pierce Conservation District

SW 10 **PROMOTE NATIVE PLANT LANDSCAPING PROGRAMS** $100,000.00

 <u>**Lead Implementers**</u>   Time Frame: Ongoing   Priority Item
 ● Master Gardeners
 ● Pierce County
 ● Washington Native Plant Society
 ● Washington State University Cooperative Extension

SW 11 **MODIFY LANDSCAPING ORDINANCES TO ENCOURAGE NATIVE** $50,000.00
            PLANTS

 <u>**Lead Implementers**</u>   Time Frame: One-Time   Priority Item
 ● Pierce County
 ● Cities & Towns

For complete descriptions of action items, see
http://www.co.pierce.wa.us/pc/services/home/environ/planning/waplan.htm.

Appendix D
Response to Public Comments

South Prairie Creek Bacteria and Temperature TMDL

Response to Public Comments

The Washington Department of Ecology held a public comment period on the Draft Water Cleanup Plan for fecal coliform bacteria and temperature in South Prairie Creek from April 7 through May 7, 2003. Notification of the public comment period was directly mailed to 5,714 addresses in the basin, e-mailed to 69 external addresses, announced in articles in the April 8, 2003 Tacoma News Tribune, the April 8, 2003, Business Examiner Daily and the April 25, 2003, Capital Press, as well as being posted on Ecology's internet site. A public meeting was hosted by the Puyallup River Watershed Council on April 23, 2003. Not counting Ecology staff, 35 people signed in at the meeting.

The following people submitted written comments related to the Water Cleanup Plan:

- Conor Barclay
- Mardel Chowen, Friends of the Carbon Canyon
- Tim Ramsaur, Manager, Pierce County Water Programs
- Layne Ross, Mayor, Town of South Prairie
- Dave Schmidt, Administrator, City of Buckley
- Marvin Sundstrom

On the basis of comments received, Ecology made several changes to the Water Cleanup Plan. Those changes are noted in the responses that follow.

Town of South Prairie Wastewater Treatment Plant

Layne Ross said that South Prairie is concerned that decreasing the permit limits to 200 weekly mean and 100 monthly mean (per 100 mL) from the current limits of 400/200 would result in permit limit violations, since the current system was designed to achieve 400/200.

Ecology agrees that South Prairie's wastewater treatment plant contributes very little bacteria to the creek. Ecology will modify the wasteload allocation for the Town of South Prairie to maintain the current permit limits until at least 2008. If monitoring shows that the creek downstream of the treatment plant is still not meeting water quality standards for bacteria by then, South Prairie's wastewater treatment plant will receive water-quality-based permit limits of 200 weekly mean and 100 monthly mean fecal coliform bacteria per 100/mL.

Layne Ross suggested rewording the last sentence of the last paragraph on page 18 to describe the treatment plant contribution as less than 0.5% of the differential fecal coliform load, rather than the current wording of less than 1%.

Ecology will change <1% to <0.5% in the final report.

Pollution sources

Conor Barclay emphasized the importance of protecting salmon and steelhead productivity in South Prairie Creek. He commented that the stream has dairy cows on it and is not shaded in many areas, and advocated planting trees.

Ecology appreciates the comments and hopes that Conor and others will help Ecology develop a Detailed Implementation Plan for South Prairie Creek in the coming year.

Mardel Chowen said that septic systems, particularly those in and near Wilkeson, are contributing fecal coliform to the system. The Wilkeson wastewater treatment plant is also a concern.

As the water cleanup plan states, septic systems in and near the Town of South Prairie could be contributing high bacteria levels in that area. One system in particular failed following the Nisqually earthquake, resulting in high bacteria levels in the drainage from that site. Septic system failures are a public health risk and suspected failures should be reported to the Tacoma Pierce County Health Department. However, the mouth of Wilkeson Creek met the fecal coliform standard during 2000-2001 monitoring. If future monitoring indicates that bacteria are a problem in the Wilkeson Creek system, Ecology may recommend additional controls specifically for that area.

The Wilkeson wastewater treatment plant discharges did not exceed permit limits for fecal coliform bacteria during the study period (July 2000 through December 2001). Historically, the plant experienced 14 violations of the monthly limit and 30 violations of the weekly limit from August 1990 through June 2000. Plant operations appear to have improved significantly. Because the creek met water quality standards for bacteria, no change to the permit limits are recommended in the present study.

Mardel Chowen commented that intense clear-cutting and small buffers of deciduous vegetation provide little shade to the streams and none in winter and spring.

The upstream boundaries for Ecology's temperature study were South Prairie Creek at Spiketon Road and Wilkeson Creek at the bridge upstream of the Town of Wilkeson. Neither of those stations exceeded the water quality standards for temperature during the monitoring period. Plum Creek Timber Company has documented some streams that exceed the temperature standards upstream of the areas Ecology monitored. As discussed in the draft report on pages 25 and 48, privately owned timberlands fall under the jurisdiction of the Washington Forest Practices rules, which now include more stringent requirements for leaving streamside vegetation.

Mardel Chowen commented that the creek floods frequently and silt has increased. Formerly deep pools have disappeared in the summer. The flooding, especially following the 1996 event, may have raised the river bed level.

The U.S. Geological Survey completed a study of the flood potential of South Prairie Creek in 1998 (Mastin, 1998). The mean of the number of peak flows greater than 1,400 cfs was higher from 1988 to1996 than from 1950 to 1971, but the difference is not statistically significant. However, damaging floods were recorded in 1990 and 1996.

Excess sedimentation can lead to wider, shallower streams that heat up faster. Therefore, any activities that increase sedimentation could lead to higher temperatures. Page 48 of the draft report describes some of these processes. Sediment controls are included as narrative discussions rather than quantified as load allocations in the Water Cleanup Plan. Ecology will reference the 1998 USGS study in the final document.

Mardel Chowen, as well as others expressed concern that a gravel pit being planned above Wilkeson will add silt to the creek.

Any activities that increase sedimentation could exacerbate the temperature exceedances in South Prairie Creek. However, the Sunset Lake Quarry must comply with Pierce County requirements and a state wastewater discharge permit from the Department of Ecology. While activities associated with gravel mining are unlikely to impact Wilkeson Creek directly, best management practices are required by the discharge permit to promote on-site stormwater infiltration and adequate buffer protection to nearby wetlands.

Mardel Chowen asked if bamboo, which has spread rapidly from Wilkeson downstream, could contribute to the warming of the streams. It has wiped out most of the native brush on her tributary (Gale/Wilkeson Creek). Many creek drainages are affected by dirt bike paths and garbage dumping.

Monitoring teams noted large stands of Japanese knotweed, also known as Mexican bamboo, along stream margins in the South Prairie Creek watershed. The plant is on Washington's list of noxious weeds because it colonizes riparian areas and crowds out all other vegetation. Since Japanese knotweed does not provide tall effective shade for streams, its presence will reduce the ability of riparian areas to provide effective shade. Ecology will add a sentence to the Implementation Activities section of the Water Cleanup Plan, recommending that the Detailed Implementation Plan include a strategy for managing Japanese knotweed.

Ecology will also add a sentence in the Implementation Activities section recommending that the Detailed Implementation Strategy include education and awareness campaigns for the general public and public officials. These could reduce unintentional impacts on South Prairie Creek and its tributaries. Any activities that lead to channel widening, such as heavily used fords, should be controlled. Page 48 of the draft report states that "… management activities should control potential channel widening processes."

Mardel Chowen commented that Ecology should evaluate chemicals used on timberlands. While DNR issues permits, the cumulative effect is not considered. She expressed concern that drinking water may be affected.

Drinking water quality and toxic chemicals were not evaluated under this study. Implementation of the Safe Drinking Water Act falls under the jurisdiction of the Department of Health. Under Washington Forest Practices rules (WAC 222), no spraying may take place within 50 ft of a water body, and it is illegal to spray a flowing or standing water body. Enforcement of the rules falls under the jurisdiction of the Department of Natural Resources.

Upper Puyallup Watershed Action Plan and Puyallup River Watershed Council

Tim Ramsaur expressed concern that Ecology would compel Pierce County to implement the Upper Puyallup Watershed Action Plan (citation). Although acknowledging that Pierce County Water Programs was a partner in development of the Upper Puyallup plan, he listed four reasons why it should not be included in the TMDL implementation plan.

In response to Pierce County's concerns, Ecology modified the Overview section of the Summary Implementation Strategy to further clarify that Ecology will not compel Pierce County or other entities to implement the Upper Puyallup Watershed Characterization and Action Plan.

The TMDL itself creates no legal or financial obligation on implementers. However, Ecology will add the following sentence for clarity in the Implementation Activities section of the Summary Implementation Strategy:

The Detailed Implementation Plan for this TMDL may include actions that will be required in a future municipal stormwater permit.

Tim Ramsaur requested that Ecology clarify that only Ecology can monitor compliance with the Water Cleanup Plan, not the Puyallup River Watershed Council.

Ecology will modify the second paragraph under "Puyallup River Watershed Council" in the Involved Parties and Regulatory Authorities section of the Summary Implementation Strategy. Rather than stating that the council will "help oversee implementation of this TMDL," it will state that the council will "help coordinate implementation of this TMDL."

Water Diversion

Dave Schmidt described the water infrastructure for the City of Buckley and stated that if the water diverted from upper South Prairie Creek exceeds the infiltration capacity of Buckley's sand filter system, the overflow is diverted to Spiketon Creek/Ditch. Therefore, not all of the diversion represents an out-of-basin transfer.

The final report will state that the portion of the diversion that exceeds the infiltration capacity is returned to South Prairie Creek via an overflow to Spiketon Creek/Ditch, but that the overflow volume is ungaged. The water that is returned has been accounted for in the analyses and modeling by measuring flows in Spiketon Creek/Ditch near the mouth. The remaining water leaves the South Prairie Creek watershed.

Dave Schmidt asked if the Department of Social and Health Services (Rainier School) diversion flow has been measured to confirm whether the full 3.5 cfs water right is being withdrawn. If not, what affect on temperature would there be if the model used a reduced instream flow based upon actual diversion versus an assumed quantity?

The South Prairie Creek temperature model is calibrated to reflect actual conditions in the stream, which accounts for the actual diversion from all water rights. However, these water withdrawals are not measured, either at the point of diversion or within the system. The model estimates the relative temperature benefit provided by adding more water upstream. One scenario uses the entire DSHS water right (3.5 cfs), while another accounts for an addition of 10 cfs. If DSHS actually used less than its full water right during the critical time period, then the benefit to temperature of returning those flows would be less than 0.1°C. The report does not set allocations for flows under the TMDL process.

Mr. Sundstrom provided additional information about water rights for Buckley, DSHS (Rainier School) and Washington State University.

Ecology appreciates receiving the information and will be in contact with Mr. Sundstrom concerning these diversions and planned metering.

South Prairie Creek Bacteria and Temperature TMDL

Appendix E
South Prairie Creek Total Maximum Daily Load Phase II Evaluation

South Prairie Creek Total Maximum Daily Load Phase II Evaluation:
Quality Assurance Project Plan

By

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January 2001
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This document may be viewed at the following site:
http://www.ecy.wa.gov/biblio/030302.html

South Prairie Creek Bacteria and Temperature TMDL

Appendix F
Technical Report

**South Prairie Creek
Bacteria and Temperature
Total Maximum Daily Load Study**

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**This document may be viewed at
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