Clarks Creek Watershed Fecal Coliform Bacteria Total Maximum Daily Load

Water Quality Improvement Report

May 2008

Publication No. 07-10-110

DEPARTMENT OF
ECOLOGY
State of Washington

Clarks Creek Watershed Fecal Coliform Bacteria, Total Maximum Daily Load

Water Quality Improvement Report

By
Charles P. Hoffman
Cindy James and
Greg Zentner

Water Quality Program
Washington State Department of Ecology
Olympia, Washington 98504-7775

May 2008

Waterbody No. WA-10-1025

Publication No. 07-10-110

Publication Information

This report is available on the Department of Ecology's website at
http://www.ecy.wa.gov/biblio/0710110.html

For more information contact:

Southwest Regional Office Water Quality Program
P.O. Box 47775
Olympia, WA 98504-7600

Phone: (360) 407-6270

Any use of product or firm names in this publication is for descriptive purposes only and does not imply endorsement by the author or the Department of Ecology.

If you need this publication in an alternate format, call (360) 407-6270. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.

Table of Contents

List of Figures and Tables

Page

Figures

Tables

Acknowledgment

In preparing this report, Ecology used the city of Puyallup's water quality data and their report, *Clarks Creek Watershed Pollution Reduction Project*, and Pierce County's report *Clear/Clarks Creek Basin Plan*. The Puyallup Tribe of Indians staff assisted the city in the data collection and is a member of the city's advisory committee. We thank all three entities and the advisory committee.

Executive Summary

The state of Washington's 2004 Water Quality Assessment Report (Assessment) identified Clarks Creek and Meeker Creek as listed for fecal coliform and pH under its Category 5 (polluted waters that require a water cleanup plan). The Assessment also identified Meeker Creek as a Category 2 (water of concern) for dissolved oxygen (DO) and temperature. Clarks Creek was listed in Category 2 (water of concern) for DO.

The federal Clean Water Act requires that states develop a total maximum daily load (TMDL, also called a water cleanup plan) for each of the water bodies on their 303(d) list. The 303(d) list is comprised of waters classified as Category 5 in the Assessment. The TMDL identifies pollution problems in the watershed and then specifies how much pollution needs to be reduced or eliminated to achieve clean water. Once the TMDL is completed, the Department of Ecology (Ecology) works with the local community to develop an overall approach to control the pollution, called the Implementation Strategy, and a monitoring plan to assess effectiveness of the water quality improvement activities. Together, the TMDL and the Implementation Strategy make up the Water Quality Improvement Report (WQIR).

Ecology is not required to do a TMDL for those waters in Category 2 – waters of concern. However, the recommendations in this WQIR should improve the Category 2 impairments.

In this WQIR, Ecology examines water quality in the Clarks Creek watershed in Pierce County and recommends reductions in fecal coliform levels. We also recommend restoration of riparian vegetation to lower temperatures and increase DO. Although not necessary to meet the DO or temperature standard, an increase in vegetation would benefit the aquatic/riparian ecosystem. Ecology does not recommend measures to address pH in Clarks Creek because this is a natural condition.

The study area for this TMDL consists of Clarks Creek, which lies within the Puget Sound uplands. Clarks Creek is located in the lower Puyallup River watershed in the southern part of the region. The Puyallup is the largest river in the South Puget Sound area, with a watershed of 970 square miles and an average flow of 3300 cubic feet per second (cfs). Clarks Creek has a watershed area of about 13 square miles and an average flow of roughly 60 cfs. Tributaries include Rody, Diru and Woodland Creeks, and Meeker Creek. Clarks Creek flows year-round with summer base flows of 30-40 cfs out of Maplewood Springs. Tributaries flow primarily in the wet season in response to rain.[1] This study area is in Water Resource Inventory Area (WRIA) 10.

Clarks Creek is a salmon-bearing stream supporting Chinook, coho, and chum salmon, and steelhead and cutthroat trout. Chinook salmon and steelhead using Clarks Creek are part of the *threatened* Puget Sound population designated by the National Marine Fisheries Service (NMFS) under the Endangered Species Act. Clarks Creek, from its mouth to Maplewood Springs, is part of the species' *critical habitat*. Coho in the region also receive attention under ESA. The Puget Sound/Georgia Basin coho population is a "species of concern."

[1] The groundwater discharge from Maplewood Springs does not occur in a discrete location; it occurs instead over a length of Clarks Creek in the vicinity of the state fish hatchery, upstream of sampling station CCURS-4.

Clarks Creek is an urban stream that provides recreation and aesthetic value to people who live in the watershed. Land uses in the watershed are increasing and vary from urban in the city of Puyallup to rural residential in the county. County planners estimate that population in the Clear and Clarks Creek basins will increase by 15 percent between 2000 and 2020, from 61,700 to 71,000. At full build-out, effective impervious area could increase from the current 25 percent of the basin to 35 percent.

In 2005, Ecology conducted a scoping process, involving local stakeholders, to prioritize 303(d)-listed waters in the South Puget Sound water resource inventory areas (WRIAs) 10, 11, and 12. South Prairie Creek and the Clarks Creek's watershed listings were the highest priorities identified among the local entities and Ecology.

In addition to fulfilling the requirements of the Clean Water Act, there were several opportunities to coordinate TMDL-related activities. The city of Puyallup obtained a Centennial Clean Water Fund grant to collect data in the Clarks Creek basin. This completed the first steps necessary to begin the TMDL process. This report will cover the "who" and the "what" of the cleanup actions needed to meet water quality standards. The next step will be the implementation plan. That report will contain the "how" and the "when."

The recommendations are as follows:

- The wasteload allocation for point sources to Clarks Creek or any of the tributaries, including future sources, is the water quality standards for fecal coliform bacteria.

- During the planning stages for this TMDL the stakeholders agreed to include a reserve of 13 percent for development. Pierce County, in the document titled *Clear/Clarks Creek Basin Plan* (2006), estimates that the population in the Clear and Clarks Creek watersheds will increase by 15 percent. (The Clear Creek watershed is adjacent to, and to the west of the Clarks Creek watershed.) The stakeholders chose 13 percent for the reserve because it is similar to the projected population increase.

- Ecology determined the load allocations (nonpoint in origin) for Clarks Creek and its tributaries by comparing current conditions to the water quality standard and then calculating the percent reduction needed to meet the standard. The more restrictive of the two parts of the water quality standards is used as the basis for the load allocation.

Action items identified were as follows:

- Riparian planting of Clarks Creek and Meeker Creek.
  Meeker Creek needs effective shade to improve temperature. Planting for shade is not a temperature recommendation for Clarks Creek, but there may be some benefit to aquatic habitat. The restoration of the riparian area of Clarks Creek would also benefit water quality.

- Septic system inspection and repair.
  The Tacoma Pierce County Health Department (TPCHD) will work to correct identified failing septic systems within the corridors of Clarks Creek and its tributaries.

- DeCoursey Pond.
  "No duck feeding" signs with educational information; removing the connection between the pond and Clarks Creek; and planting that will discourage waterfowl residence at the pond.

- Pet owner education.
  Implement a program to keep animal wastes from reaching the creek, for example, a city ordinance requiring pet owners to pick up pet waste and properly dispose it.

- Invasive plants.
  Remove invasive plants, particularly non-native blackberries, from the riparian corridor.

- Coordinated monitoring strategy.
  Summarize all monitoring being conducted in the basin to better understand water quality issues.

- Sediment reduction.
  Reduce sediment input to the system caused by stream incising. Remove sediment from ponds.

- Catch basin cleaning.
  Increase catch basin cleaning to twice per year.

- Best management practices for new development and re-development.
  Implement all necessary measures to control new sources of pollution from reaching Clarks Creek and its tributaries.

These recommendations are intended to be a framework of actions to improve water quality. During the development of the implementation plan, actual dates of implementation will be added along with any other suggestions made by the advisory committee.

What is a Total Maximum Daily Load (TMDL)?

Federal Clean Water Act requirements

The Clean Water Act established a process to identify and clean up polluted waters. Under the Clean Water Act, each state is required to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses for protection, such as cold water biota and drinking water supply, as well as criteria, usually numeric criteria, to achieve those uses.

Every two years, states are required to prepare a list of water bodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list. To develop the list, Ecology compiles its own water quality data along with data submitted by local state and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods, before those data are used to develop the 303(d) list. The 303(d) list is part of the larger Water Quality Assessment.

The Water Quality Assessment is a list that tells a more complete story about the condition of Washington's water. This list divides water bodies into one of five categories:

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

Category 2 – Waters of concern

Category 3 – Waters with no data available

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

- 4a. – Has a TMDL approved and it is being implemented
- 4b. – Has a pollution control program in place that should solve the problem
- 4c. – Impaired by a non-pollutant such as low water flow, dams, culverts

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

TMDL process overview

The Clean Water Act requires that a TMDL be developed for each of the water bodies on the 303(d) list. The TMDL identifies pollution problems in the watershed and then specifies how much pollution needs to be reduced or eliminated to meet clean water standards. After data collection and analysis, Ecology works with the local community to develop an overall approach to control the pollution, called the Improvement Report. Once the TMDL has been approved by U.S. Environmental Protection Agency (EPA), a *Water Quality Implementation Plan* must be developed within one year. This Plan identifies specific tasks, responsible parties and timelines for achieving clean water.

Elements required in a TMDL

The goal of a TMDL is to ensure that the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problems. The TMDL determines the amount of a given pollutant that can be discharged to the water body and still meet standards (the loading capacity) and allocates that load among the various sources.

If the pollutant comes from a discrete source (referred to as a point source) such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a wasteload allocation. If it comes from a set of diffuse sources (referred to as a nonpoint source) such as general urban, residential, or farm runoff, the cumulative share is called a load allocation.

The TMDL must also consider seasonal variations and include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A reserve capacity for future loads from growth pressures is sometimes included as well. The sum of the wasteload and load allocations, the margin of safety and any reserve capacity must be equal to or less than the loading capacity.

Identification of the contaminant loading capacity for a water body is an important step in developing a TMDL. EPA defines the loading capacity as "the greatest amount of loading that a water body can receive without violating water quality standards" (EPA, 2001). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with standards. The portion of the receiving water's loading capacity assigned to a particular source is a load or wasteload allocation. By definition, a TMDL is the sum of the allocations, which must not exceed the loading capacity.

A TMDL targets a level of pollutant loading by adding the pollutant sources, both point and nonpoint, and a margin of safety. A TMDL is typically expressed as:

TMDL = WLA + LA + Reserve + MOS

Where:

> WLA = Waste Load Allocation – the portion of the loading to the water body assigned to each existing and future <u>point</u> source (identifiable as a discharge from a pipe) of the pollutant
>
> LA = Load Allocation – the portion of the pollutant loading assigned to existing and future <u>nonpoint</u> sources of the pollutant
>
> Reserve – an allocation established for impairment caused by future development
>
> MOS = Margin of Safety – an accounting of the uncertainty of the pollutant load and the quality of the water body

What Part of the Process Are We In?

This report is intended to describe the general framework for improving water quality in the watershed. It describes the roles and authorities of organizations with jurisdiction, authority, or direct responsibility to improve water quality. It describes the programs or other means that will be used to address these water quality issues.

This Water Quality Improvement Report will be submitted to the U.S. Environmental Protection Agency (EPA) for review and approval. Interested and responsible parties will then work to develop a *Water Quality Implementation Plan*. That plan will describe and prioritize specific actions planned to improve water quality.

Why is Ecology Conducting a TMDL Study in this Watershed?

Overview

Ecology is conducting a TMDL study in this watershed because several datasets that show that Clarks Creek and Meeker Creek do not meet water quality standards. They are:

- City of Puyallup data, 2002-2003.
- Puyallup Tribe of Indians data, 1998-2001.
- Clarks Creek working group data 1996-1997.

Clarks Creek and Meeker Creek were identified as being impaired by fecal coliform on the 1996 303(d) list. On the 1998 303(d) list they were again listed for fecal coliform. Meeker Creek was also listed for pH, dissolved oxygen (DO), and temperature. In 2004, Ecology moved to a category system. The 2004 Water Quality Assessment Report identified Clarks Creek and Meeker Creek as listed for fecal coliform and pH under category 5 (polluted waters that require a TMDL). The 2004 Water Quality Assessment Report also identified Meeker Creek as a Category 2 (water of concern) for DO and temperature. Clarks Creek was listed as a Category 2 for DO.

The Clean Water Act requires that a TMDL be developed for all water bodies assessed as Category 5. Ecology is not required to do a TMDL for those waters assessed as Category 2. However, the recommendations in this report should improve the Category 2 impairments.

Pollutants addressed by this TMDL

This TMDL addresses fecal coliform bacteria. Impairments for pH were determined to be caused naturally and therefore no action items were recommended. Action items recommended for fecal coliform will also benefit impairments for temperature and DO.

Impaired beneficial uses and water bodies

The main beneficial uses to be protected by this TMDL are Recreation and Aquatic Habitat. The impairments listed on the 2004 WQ Assessment are summarized in Table 1. The tributaries that will be addressed in this report, but not on the assessment are also summarized in Table 2.

Table 1 - Impairments (Category 5) and Waters of Concern (Category 2) from the 2004 Water Quality Assessment

Category 5					
Water body	Parameter	Listing ID	Township	Range	Section
Clarks Creek	Fecal Coliform	7497	20N	04E	30
Clarks Creek	Fecal Coliform	7501	20N	04E	30
Meeker Creek	Fecal Coliform	7508	20N	04E	33
Clarks Creek	pH	7499	20N	04E	32
Meeker Creek	pH	7511	20N	04E	33
Category 2					
Meeker Creek	Dissolved Oxygen	7510	20N	04E	33
Meeker Creek	Temperature	7509	20N	04E	33
Clarks Creek	Dissolved Oxygen	35407	20N	04E	19
Meeker Creek	Fecal Coliform	7507	20N	04E	32

Table 2 – Clarks Creek Watershed Tributaries addressed in this report

Water body	Parameter	Township	Range	Section
Rody Creek	Fecal Coliform	20N	04E	30
Woodland Creek	Fecal Coliform	20N	04E	29
Diru Creek	Fecal Coliform	20N	04E	30

Why are we doing this TMDL now?

In 2005, Ecology conducted a scoping process, involving local stakeholders, to prioritize 303(d)-listed waters in the South Puget Sound water resource inventory areas (WRIAs) 10, 11, and 12. South Prairie Creek and the Clarks Creek's watershed listings were the highest priorities identified among the local entities and Ecology.

In addition to fulfilling the requirements of the Clean Water Act, there were several opportunities to coordinate water quality-related activities. The city of Puyallup obtained a Centennial Clean Water Fund grant, which they used to collect data in the Clarks Creek basin. The data were used to begin the TMDL process.

Water Quality Standards and Beneficial Uses

Table 3 - Washington State Water Quality Standard Changes

1997 Standards Classification	Water Quality Parameter	1997 Criteria[1]	2006 Use Revision	2006 Criteria[1]
Class AA	Temperature	16°C 1-Dmax[3]	Char Spawning/Rearing	12°C 7-DADMax[2, 4]
			Core Summer Salmonid Habitat	16°C 7-DADMax[2, 4]
	Diss. Oxygen	9.5 mg/l 1-DMin[5]	*Either of above*	9.5 mg/l 1-DMin[5]
	pH	6.5 to 8.5 units	*Either of above*	6.5 to 8.5 units
	Bacteria	50 cfu/100ml	*Either of above*	50 cfu/100ml
	Turbidity	5NTU and 10percent[6]	*Either of above*	5NTU and 10percent[6]
	TDG	110percent	*Either of above*	110percent
Class A	Temperature	18°C 1-Dmax[3]	Char Spawning/Rearing	12°C 7-DADMax[2, 4]
			Salmonid Spawning, Rearing, and Migration	17.5°C 7-DADMax[2, 4]
	Diss. Oxygen	8.0 mg/l 1-DMin[5]	Char Spawning/Rearing	9.5 mg/l 1-DMin[5]
			Salmonid Spawning, Rearing, and Migration	8.0 mg/l 1-DMin[5]
	pH	6.5 to 8.5 units	*Either of above*	6.5 to 8.5 units
	Bacteria	100 cfu/100ml	*Either of above*	100 cfu/100 ml
	Turbidity	5NTU and 10percent[6]	*Either of above*	5NTU and 10percent[6]
	TDG	110percent	*Either of above*	110percent
Class B	Temperature	21°C 1-Dmax[3]	"Salmonid Rearing & Migration Only"	17.5°C 7-DADMax[4]
	Diss. Oxygen	6.5 mg/l 1-DMin[5]		6.5 mg/l 1-DMin[5]
	pH	6.5 to 8.5 units		6.5 to 8.5 units
	Bacteria	200 cfu/100ml		200 cfu/100ml
	Turbidity	10NTU and 20percent[6]		10NTU and 20percent[6]
	TDG	110percent		110percent

1. Criteria have been established in the existing water quality standards for specific water bodies that differ from the general criteria shown in the above table. These special conditions can be found in WAC 173-201A-130 of the 1997 version, and WAC 173-201A-602 of the 2003 version of the standards.
2. The 2006 corrected water quality standards rule contains supplemental spawning and incubation temperature criteria (13°C for salmon and trout, and 9°C for native char) that are to be applied to specific portions of many of these waters.
3. 1-DMax means the highest annual daily maximum temperature occurring in the water body.
4. 7-DADMax means the highest annual running 7-day average of daily maximum temperatures.
5. 1-DMin means the lowest annual daily minimum oxygen concentration occurring in the water body.
6. Turbidity criteria are based on an allowable increase from background concentrations. The allowance changes from # NTU to a percent NTU as background increases above 50 NTU.

Bacteria

Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. In the state water quality standards, fecal coliform is used as an "indicator bacteria" for the state's freshwaters (e.g., lakes and streams). Fecal coliform in water "indicates" the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold blooded animals. The fecal coliform criteria are set at levels that have been shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

The “Primary Contact” use is intended for waters “where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and waterskiing.” More to the point, however, the use is to be applied to any waters where human exposure is likely to include eyes, ears, nose, and throat. Since children are the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection. To protect this use category: “Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when there are less than ten samples) obtained for calculating the geometric mean value exceeding 200/colonies mL” [WAC 173-201A-200(2)(b), 2003 edition].

Compliance is based on meeting both the geometric mean criterion and the number of samples limit. These two measures, used in combination, ensure that bacterial pollution in a water body will be maintained at levels that will not cause a greater risk to human health. While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both monthly (if there are 5 or more samples) and seasonal (summer versus winter) data sets.

The criteria for fecal coliform are based on allowing no more than the pre-determined risk of illness to humans that work or recreate in a water body. The criteria used in the state standards are designed to allow 7 or fewer illnesses out of every 1,000 people engaged in primary contact activities. Once the concentration of fecal coliform in the water reaches the numeric criterion, human activities that would increase the concentration above the criteria are not allowed. If the criterion is exceeded, the state requires that human activities be conducted in a manner that brings fecal coliform concentrations back into compliance with the standard.

If natural levels of fecal coliform (from wildlife) cause criteria to be exceeded then human sources cannot measurably increase bacterial pollution further. While the specific level of illness rates caused by animal versus human sources has not been quantitatively determined, warm-blooded animals (particularly those that are managed by humans and thus exposed to human-derived pathogens as well as those of animal origin) are a common source of serious waterborne illness for humans.

Dissolved oxygen

Aquatic organisms are very sensitive to reductions in the level of dissolved oxygen in the water. The health of fish and other aquatic species depends upon maintaining an adequate supply of oxygen dissolved in the water. Growth rates, swimming ability, susceptibility to disease, and response to other environmental stressors and pollutants are all affected by oxygen levels. The state’s criteria are designed to maintain conditions that support healthy populations of fish and other aquatic life, not direct mortality due to low dissolved oxygen.

Oxygen levels can fluctuate over the day and night in response to changes in climatic conditions as well as the respiratory demands of aquatic plants and algae. Since the health of aquatic species is tied predominantly to the pattern of daily minimum oxygen concentrations, the criteria are expressed as the lowest one-day minimum oxygen concentration that occurs in a water body.

In the state water quality standards, fresh water aquatic life use categories are described using key species (salmonid species or warm water species) and life-stage conditions (spawning or rearing). Minimum concentrations of dissolved oxygen are used as criteria to protect different categories of aquatic communities [WAC 173-201A-200; 2003 edition]. In this TMDL the following designated aquatic life use(s) and criteria is (are) to be protected:

> To protect the designated aquatic life use of "Core Summer Habitat" the lowest one-day minimum oxygen level must not fall below 9.5 mg/l more than once every ten years on average.

The above-described criteria are used to ensure that where a water body is naturally capable of providing full support for its designated aquatic life uses that condition will be maintained. However, the standards recognize that not all waters are naturally capable of staying above the fully protective dissolved oxygen criteria. When a water body is naturally lower in oxygen than the criteria, an additional allowance is provided for further depression of oxygen conditions due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.2 mg/l decrease below that naturally lower (inferior) oxygen condition.

While the numeric criteria generally apply throughout a water body they are not intended to apply to uncommon areas, such as shallow stagnant eddy pools, where natural features unrelated to human influences are the reason that the criteria are not met. For this reason, the standards instruct us to take measurements from well-mixed portions of rivers and streams. For similar reasons, samples should not be taken from unusually oxygen-rich areas. For example, in a slow moving stream, focusing sampling on a turbulent reach would provide data that is not representative to compare to the criteria.

Temperature

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

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

To protect the designated aquatic life uses of "Core Summer Salmonid Habitat", the highest 7-DADMax temperature must not exceed 16°C (60.8°F) more than once every ten years on average.

The criteria described above are used to ensure that full support for the water body's designated aquatic life uses will be maintained where the water body has that natural capability. However, the standards recognize that not all waters are naturally capable of staying below the fully protective temperature criteria. When a water body is naturally warmer than the above-described criteria, an additional allowance is provided for warming due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.3°C (0.54°F) increase above the naturally higher (but over criteria) temperature condition.

In addition to the maximum criteria noted above, compliance must also be assessed against criteria that limit the incremental amount of warming of otherwise cool waters due to human activities. When water is cooler than the criteria noted above, the allowable rate of warming up to, but not exceeding, the numeric criteria from human actions is restricted to:

A) Incremental temperature increases resulting from individual point source activities must not, at any time, exceed 28/T+7 as measured at the edge of a mixing zone boundary (where "T" represents the background temperature as measured at a point or points unaffected by the discharge), and

B) Incremental temperature increases resulting from the combined effect of all nonpoint source activities in the water body must not at any time exceed 2.8°C (5.04°F).

Special consideration is also required to protect spawning and incubation of salmonid species. Where Ecology determines that the temperature criteria established for a water body would likely not result in protective spawning and incubation temperatures, the following criteria apply:

A) Maximum 7-DADMax temperatures of 9°C (48.2°F) at the initiation of spawning and at fry emergence for char; and

B) Maximum 7-DADMax temperatures of 13°C (55.4°F) at the initiation of spawning for salmon and at fry emergence for salmon and trout.

In July 2003, Ecology made significant revisions to the state's surface water quality standards (Chapter 173-201A WAC). These changes included eliminating the classification system the state used for decades to designate uses for protection by water quality criteria (e.g., temperature, dissolved oxygen, turbidity, bacteria). Ecology also revised the numeric temperature criteria assigned to waters to protect specific types of aquatic life uses (e.g., native char, trout and salmon spawning and rearing, warm water fish habitat).

Ecology submitted the revised water quality standards regulation to the U.S. Environmental Protection Agency (EPA) for federal approval. EPA was not satisfied that Ecology's 2003 standards met the requirements of the federal Clean Water Act (CWA) and the federal Endangered Species Act (ESA). Their main concern was temperature criteria applied to waters that support endangered fish species (e.g. bull trout, salmon, and steelhead). As a consequence, EPA formally disapproved portions of the revised standards.

Ecology agreed to initiate state rule revision proceedings that considered making the changes EPA highlighted as necessary. The result of the corrective state rulemaking was that a number of streams and stream segments would receive more stringent temperature and dissolved oxygen criteria.

Find the revisions to the existing standards online at Ecology's water quality standards website http://www.ecy.wa.gov/programs/wq/swqs. Table 3 provides general structure for understanding the changes.

pH

The pH of natural waters is a measure of acid-base equilibrium of the various dissolved compounds, salts, and gases. pH is an important factor in the chemical and biological systems of natural waters. pH both directly and indirectly affects the ability of waters to have healthy populations of fish and other aquatic species. The degree of dissociation of weak acids or bases is affected by changes in pH. This effect is important because the toxicity of many compounds is affected by the degree of dissociation. While some compounds (e.g., cyanide) increase in toxicity at lower pH, others (e.g., ammonia) increase in toxicity at higher pH. While there is no definite pH range within which aquatic life is unharmed and outside of which it is damaged, there is a gradual deterioration as pH values are further removed from the normal range. However, at the extremes of pH lethal conditions can develop. For example, extremely low pH values (<5.0) may liberate sufficient carbon dioxide from bicarbonate in the water to be directly lethal to fish.

While the pH criteria in the state water quality standards are primarily established to protect aquatic life, they also serve to protect domestic water supply sources. Water supplies with either extreme pH or fluctuating pH (even within otherwise acceptable ranges) are more difficult and costly to manage as domestic water supplies. pH also directly affects the longevity of water collection and treatment systems. Low pH waters may cause metal pipes in the distribution system to release compounds that affect human health.

In the state's water quality standards, pH criteria are established to protect six different categories of aquatic communities [WAC 173-201A-200, 2003 edition].

To protect the designated aquatic life uses of "Char Spawning/Rearing, and "Core Summer Salmonid Habitat" pH must be kept within the range of 6.5 to 8.5, with a human-caused variation within the above range of less than 0.2 units.

Global Climate Change

Changes in climate are expected to affect both water quantity and quality in the Pacific Northwest (Casola et al., 2005). Summer streamflows depend on the snowpack stored during the wet season. Studies of the region's hydrology indicate a declining tendency in snow water storage coupled with earlier spring snowmelt and earlier peak spring streamflows (Hamlet et al., 2005). Factors affecting these changes include climate influences at both annual and decadal scales, and air temperature increases. Increases in air temperatures result in more precipitation falling as rain rather than snow and earlier melting of the winter snowpack.

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

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

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

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

Citations related to climate change

Casola, J.H., J.E. Kay, A.K. Snover, R.A. Norheim, L.C. Whitely Binder, and the Climate Impacts Group. Climate Impacts on Washington's Hydropower, Water Supply, Forests, Fish, and Agriculture. A report prepared for King County (Washington) by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle).

Hamlet A.F. and D.P. Lettenmaier, 1999. Effects of climate change on hydrology and water resources in the Columbia River Basin. Journal of the American Water Resources Association, 35(6):1597- 1623.

Hamlet, A.F., P.W. Mote, M. Clark, and D.P. Lettenmaier, 2005. Effects of temperature and precipitation variability on snowpack trends in the western U.S. Journal of Climate, 18 (21): 4545-4561.

Mote, P.W., E. Salathé, and C. Peacock, 2005. Scenarios of future climate for the Pacific Northwest, Climate Impacts Group, University of Washington, Seattle, WA. 13 pp.

Watershed Description

Clarks Creek watershed lies within the Puget Sound uplands, an extensive plateau of glacial deposits that border and underlie Puget Sound, extending south from British Columbia to the city of Olympia, and east and west to the foothills of the Olympic and Cascade mountain ranges. The region is dissected by a dozen major rivers and by numerous small creeks. Elevations range from sea level on Puget Sound to 400 feet on adjacent bluffs and 700-800 feet near the foothills.

Clarks Creek watershed is located in the lower Puyallup River watershed in the southern part of the region. The Puyallup is the largest river in the South Puget Sound area, with a watershed of 970 square miles and an average flow of 3300 cubic feet per second (cfs). Clarks Creek has a watershed area of about 13 square miles and an average flow of roughly 60 cfs. Tributaries include Rody, Diru, Woodland, and Meeker Creeks. Clarks Creek flows year-round out of Maplewood Springs with summer base flows of 30-40 cfs. Tributaries flow primarily in the wet season in response to rain.[2] This study area is in WRIA 10.

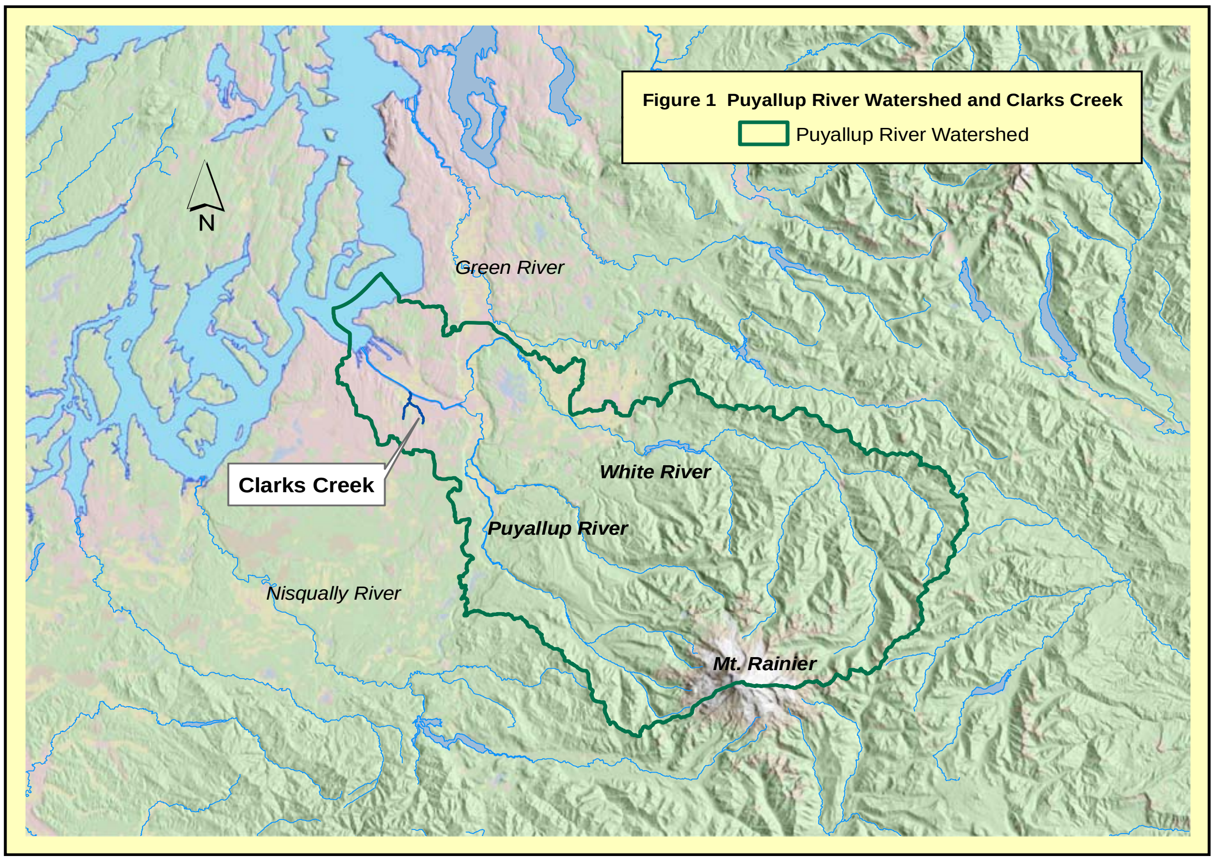

Figure 1 - Puyallup River Watershed

Chinook salmon and steelhead using Clarks Creek are part of the *threatened* Puget Sound population designated by the National Marine Fisheries Service (NMFS) under the Endangered Species Act. From its mouth to Maplewood Springs, Clarks Creek is part of the species' *critical habitat*. Coho in the region also receive attention under ESA regulations. The Puget

[2] The groundwater discharge from Maplewood Springs does not occur in a single location; it occurs instead over a length of Clarks Creek in the vicinity of the state fish hatchery, above sampling station CCURS-4.

Sound/Georgia Basin coho population is a "species of concern" and the status of steelhead is under review.

The upper, southern-most area of the watershed is a rolling terrain of low, north-trending ridges separated by swale- and wetland-dominated stream channels. North of this area, the watershed slopes down to the Puyallup River valley and streams have carved shallow ravines into hillsides. The lower, northern-most part of the watershed is flat, Puyallup River valley bottom. Soils in the watershed are dominated by the Kapowsin association. These soils formed in compacted glacial till that restricts infiltration, although they may include an overlay of well-drained outwash sands and gravel. In the upper and lower watershed, seasonal wetlands are common given the soils, stream gradients, and high or perched groundwater tables.

Land uses in the watershed are increasing and vary from urban in the city of Puyallup to rural residential in the county. County planners estimate that the population in the Clear and Clarks Creek basins will increase by 15 percent (from 61,700 to 71,000), and at buildout effective impervious area could increase by 40 percent (from 25 percent of the basin presently to 35 percent) by 2020.

Rainfall is typical of the Puget Sound region, averaging about 40 inches per year. Most rain falls between October and April. Air temperatures measured at Sea-Tac Airport range from an average daily low of 32°F (0°C) in January and February to an average daily high of 77°F (25°C) in July and August.

Water pollution in Clarks Creek appears to be caused by nonpoint sources attributed to land uses. This includes urban stormwater runoff, agricultural land runoff, and human-influenced wildlife populations such as water fowl and rats.

Brazilian elodea is an invasive aquatic weed, originating in South American that was propagated for use as an aquarium plant. Up until 1996 it was commonly sold in Washington pet stores and plant nurseries. Brazilian elodea appears annually in Clarks Creek. With enough sun and nutrients, this plant can grow up to 5 inches a day and grow to 25 feet long. Brazilian elodea grows well in Clarks Creek. As plant material dies off and settles to the bottom of the creek, its decomposition poses a problem by lowering dissolved oxygen, restricting stream flow, catching sediment, and destroying fish spawning beds.

Presently, the only portions free of elodea are the well-shaded areas at both ends of Clarks Creek. Each year, Pierce County Water Programs provides funding to the city of Puyallup to remove elodea. The cutting of this invasive weed is synchronized to precede the release of salmon from the nearby Puyallup Tribe's hatchery in June and the return of Chinook that spawn in September. It is only a temporary fix.

In areas where stream sediment has been removed no elodea is present, because its root system cannot get established. Therefore, removing sediment from the creek may decrease the occurrence of elodea.

Clarks Creek is a salmon-bearing stream supporting Chinook, coho, and chum salmon, steelhead, and cutthroat trout. Spawning occurs primarily above the confluence with Meeker Creek because of the predominance of sand substrate below the confluence. Rearing occurs throughout Clarks Creek and the lower reaches of its major tributaries.

Two fish hatcheries and a rearing pond discharge to Clarks Creek. The Washington State Department of Fisheries operates a hatchery at Maplewood Springs, and the Puyallup Tribe of Indians operates a hatchery on Diru Creek and a rearing pond that discharges to Clarks Creek. The state and the tribe are the only point-source dischargers to the creek; neither appears to cause a fecal coliform impairment.

The primary water pollution control issue at both facilities is organic fish waste, including uneaten food. Hatcheries typically have either a two-hour retention time in rearing ponds and allow solids to settle or operators pump bottom solids to a waste pond. In the former case, there is only a single, relatively large discharge from the rearing ponds. In the latter case, there is both a large rearing pond discharge and a very small waste pond flow.

The state hatchery operates under NPDES permit number WA0039748 and uses a waste pond to treat organic solids. The flow rate from the raceways ranges between 8-18 cfs but pollutant concentrations, as measured by total suspended solids, are negligible (Table 4). In contrast, the waste ponds have modest suspended solids concentration but negligible out flow. The combination results in a very small pollutant discharge from the waste ponds to Clarks Creek below Maplewood Springs.

Table 4 - Washington State Dept of Fish and Wildlife Puyallup Hatchery
Permit No. WA0039748 Discharge Data

	Flow (cfs)		**Total Suspended Solids (mg/L)**	
	Average	**Range**	**Average**	**Range**
Raceways	11	8 – 18	0.6	0 – 4
Waste Pond	0.005	0.001 – 0.009	15	1 – 140

The tribal hatchery is smaller than the state facility. The EPA (the permitting authority for tribal activities) has not required the Tribe to obtain a federal discharge permit. The tribal hatchery discharges to Diru Creek near Pioneer Way and the confluence with Clarks Creek. The satellite rearing pond discharges to Clarks Creek near 66th Avenue East.

Goals and Objectives

Project goals

The goal of the TMDL for Clarks Creek and its tributaries is to comply with the water quality standard for fecal coliform bacteria. The goal of the planning phase of the project is to develop a plan for meeting standards. Ecology's objectives are to:

1. Develop a water quality data set based upon a systematic sampling strategy.
2. Determine which parameters are exceeding standards, and which are not.
3. Determine the Total Maximum Daily Load.
4. Equitably distribute the TMDL.
5. Develop a TMDL report to document the study and guide future actions.

Ecology used the city of Puyallup's data for this study. The city's sampling program included:

- A review of existing water quality data and information.
- A field survey to identify monitoring locations (Figures 2 and 3).
- Twelve rounds of grab sampling in the mainstem for conventional parameters between September 2002 and October 2003, less frequently in tributaries.
- Continuous data logging over several week-long periods for DO, temperature and pH.
- Source sampling in city storm drains and pump stations.
- Flow and precipitation monitoring.
- Microbial source tracking.
- Data review for quality assurance and control.[3]

Table 5 - Sampling Stations

Table 5
Sampling Stations

Station	Location	Purpose
CCURS-1	Mouth of Clarks Creek	Watershed-wide water quality
CCURS-2	Below Pioneer Avenue	DeCoursey Park pond outlet / city stormdrains
CCURS-3	Above 7th Avenue	Upstream of major city sources
CCURS-4	Above Meeker Creek	Upstream of Meeker Creek and city sources
CCURS-5	Above WDFW Hatchery	County stormwater flows
MD-1	Mouth of Meeker Creek	Water quality of whole drainage
MD-2	Meeker Creek Upper Reach	Downstream of Western Washington Fairgrounds
RURS-1	Mouth of Rody Creek	Rody Creek, water quality of whole creek
DURS-2	Mouth of Diru Creek	Diru Creek, water quality of whole creek
WURS-1	Mouth of Woodland Creek	Woodland Creek, water quality of whole creek

[3] For more detailed information on sampling and quality assurance, see the *Clarks Creek Watershed Pollution Reduction Project Quality Assurance Project Plan (City of Puyallup, 2002).*

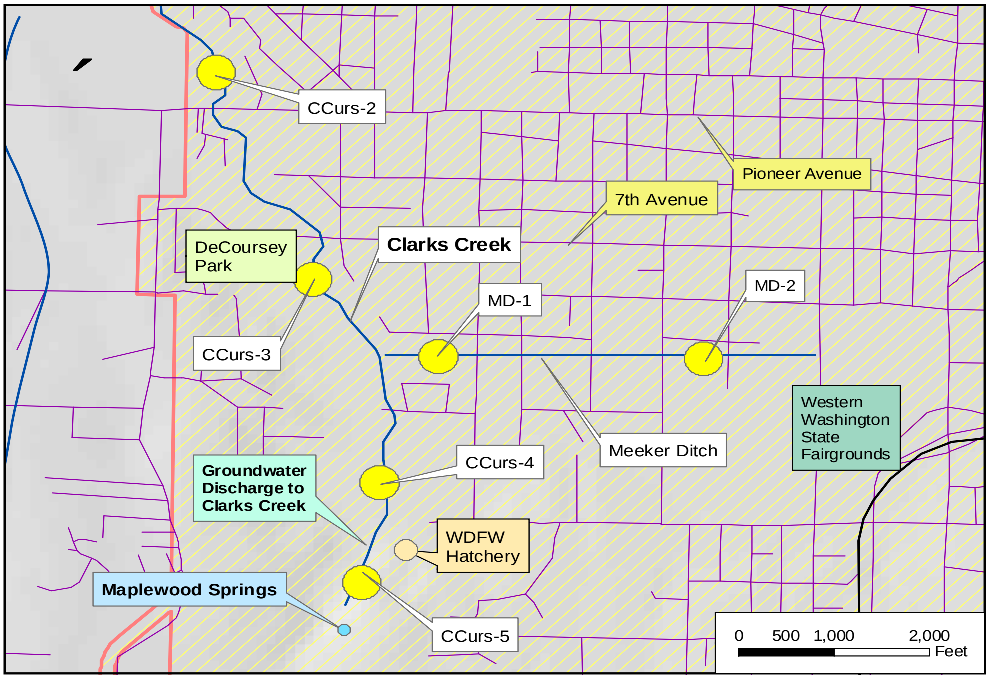

Figure 2 - Clarks Creek and Meeker Creek

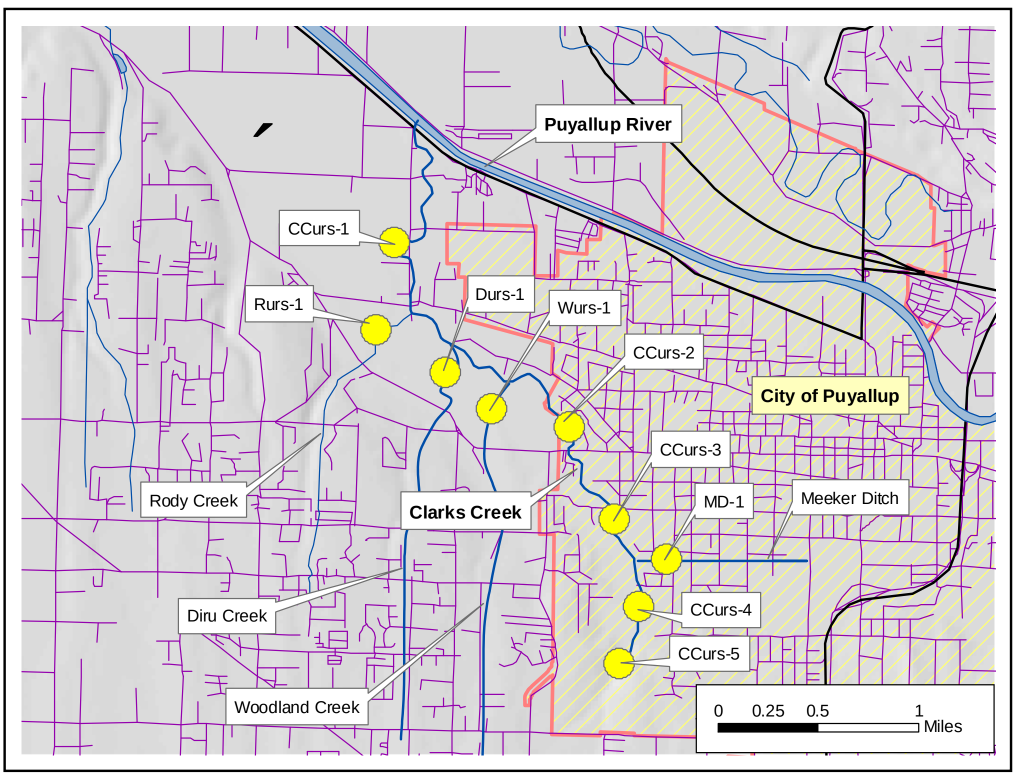

Figure 3 - Clarks Creek Sampling Stations

Results and Discussion

Precipitation and Creek Flows

Measurable precipitation fell prior to seven of the twelve sampling dates. On four of the dates, three-day antecedent precipitation was greater than half-inch, and on five sampling dates it was zero. The antecedent precipitation is the cumulative rainfall precipitation that falls prior to the sampling date. Antecedent precipitation can indicate if the soil conditions will allow infiltration of rainfall into the soil (dry condition) or if the rainfall would result in surface runoff (wet conditions).

Flows measured during sampling ranged from 32 cfs to 280 cfs in Clarks Creek (Figure 4).[4] In Meeker Creek, flow ranged from less than 2 cfs to 35 cfs during storms. Flows in other tributaries were in the 2-12 cfs range in the winter and less than 2 cfs in the summer. Average daily flow in Clarks Creek ranged from 30 to 140 cfs.

Much of the flow in Clarks Creek comes from groundwater discharge below the state fish hatchery, between stations CCURS-4 and CCURS-5 (Figures 4 and 5). During storms, flows from the sub-basin above station CCURS-2 ($CC\text{-}2_{sub}$) are also significant, arising out of storm drains on Seventh and Pioneer Avenues, and from the DeCoursey Park pond. Meeker Creek flow was substantial during some storms. Flows from other basins were variable but usually small.

We divided the data into wet (fall/winter) and dry (spring/summer) data sub-sets for analysis. Five of the six wet season sample dates had 24-hour precipitation that exceeded 0.1 inch, Ecology's previous threshold criteria for stormwater sampling. Five of the six dry season sample dates had no precipitation. We considered the September 2002 sample to be a dry season sample, and the September 2003 a wet season sample.

Two of the winter storms were not suitable to be included in the water quality analysis. We did not use the October 2003 storm in evaluating compliance or calculating load reductions because it was greater than Ecology's water quality design storm. (The October 20, 2003, rainfall is the wettest day on record at SeaTac Airport.) We did not use the September 2003 storm in calculating load reductions because of a possible error in flow measurement.

[4] Precipitation data is from McChord Air Force Base. A City of Puyallup gage registered more than 3 inches of rain during the October 2003 storm, when the City measured a peak flow of 280 cfs in Clarks Creek.

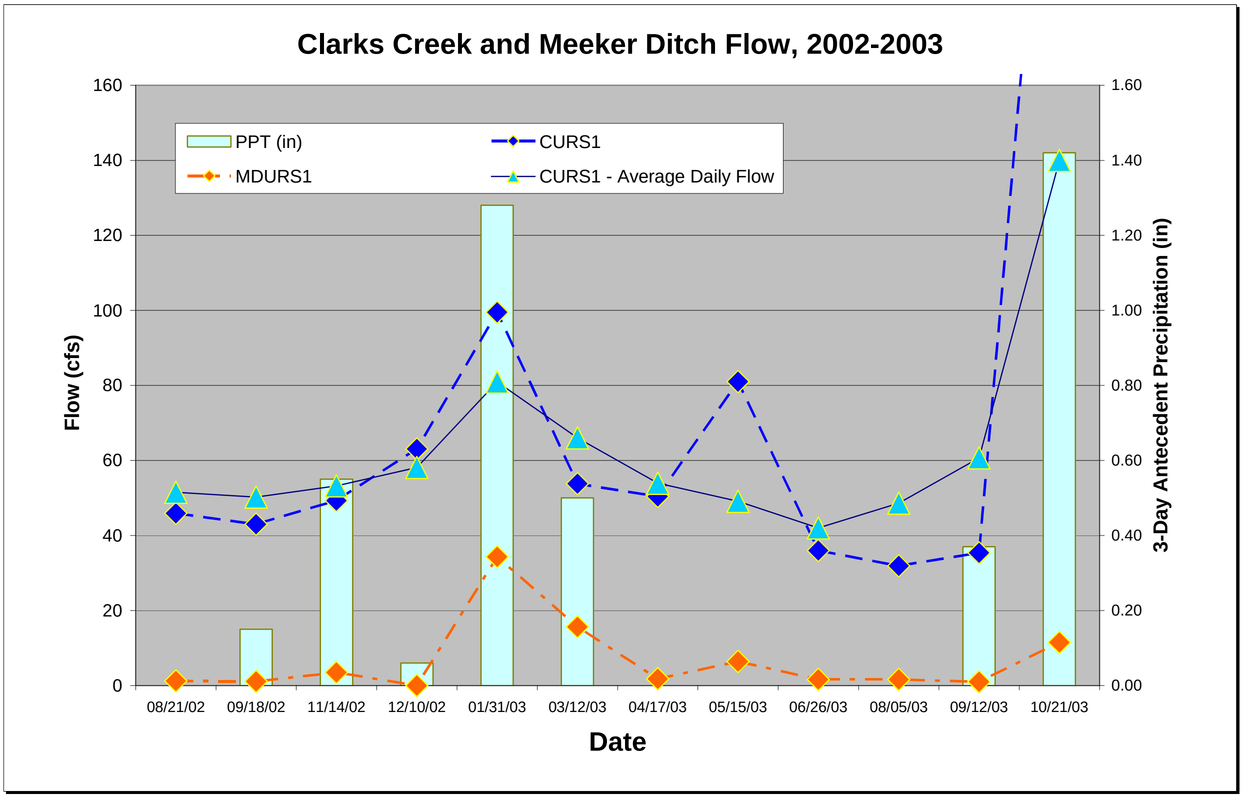

Figure 4 - Clarks Creek and Meeker Creek Flow

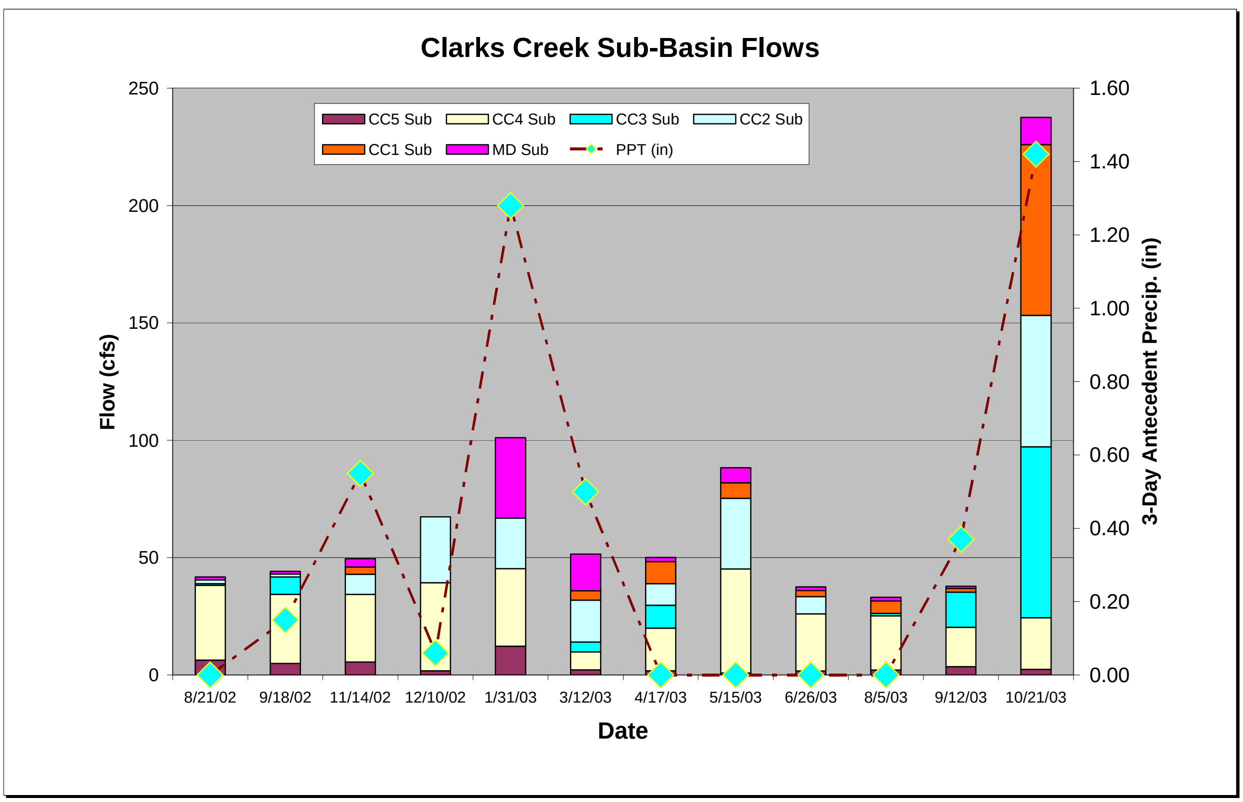

Figure 5 - Clarks Creek Flow Rates by Basin

Fecal Coliform

During the wet season, fecal coliform levels exceeded one or both numeric criteria at all stations except in Diru Creek and at Station CCURS-4 (Table 5, Appendix A). In the dry season, fecal coliform concentrations met standards at all stations except in Meeker Creek and Rody Creek. Fecal coliform levels in the lower portion of Clarks Creek were high compared to CCURS-4, and fecal coliform levels in Meeker Creek and Rody Creek were higher than levels in Clarks Creek (Figures 6 and 7 – note the difference in the fecal coliform concentration scale between the two graphs). There were insufficient data to evaluate compliance in Woodland Creek during the dry season.

Table 6 - Fecal Coliform Statistics

Table 6
Fecal Coliform Statistics

	Geometric Mean	90th Percentile (col/100 mL)	percent Samples (col/100 mL) > 200 col/100mL
Criteria	*100*		*1 of 10 (10 percent)*
Wet Season			
Clarks Creek 1-3[a]	202	700	8 of 15 (53 percent)
Clarks Creek-4	30	90	0 of 5
Clarks Creek-5	80	280	1 of 5 (20 percent)
Meeker Creek-1	620	1500	4 of 5 (80 percent)
Diru Creek	10	40	0 of 5
Rody Creek	560	2000	4 of 5 (80 percent)
Woodland Creek	160	420	1 of 5 (20 percent)
Dry Season			
Clarks Creek 1-3[b]	40	110	0 of 18
Clarks Creek-4	9	22	0 of 6
Clarks Creek-5	5	40	0 of 6
Meeker Creek-1	240	1000	5 of 6 (83 percent)
Diru Creek	20	50	0 of 6
Rody Creek	120	4300	3 of 6 (50 percent)
Woodland Creek	----	----	--------------

Notes
a. Pooled data from stations CURS-1, 2, and -3.

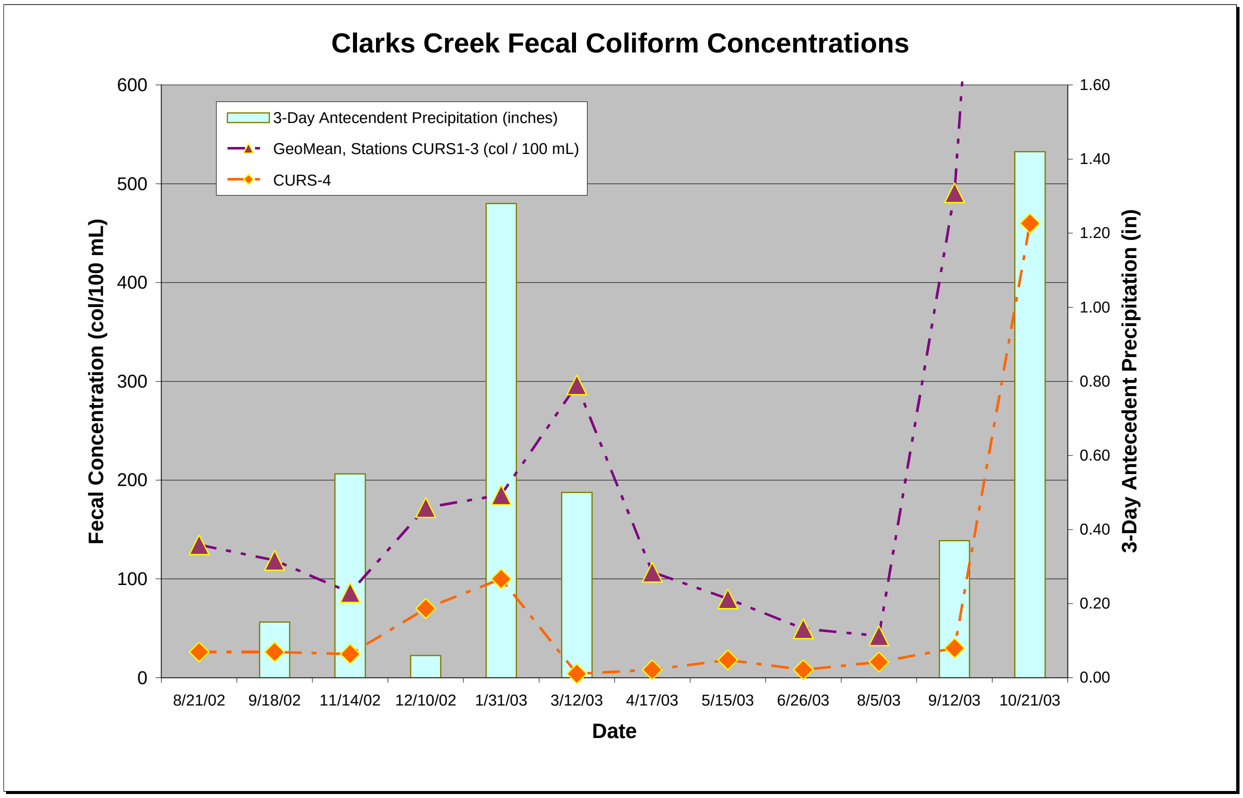

Figure 6 - Clarks Creek Fecal Coliform Concentrations

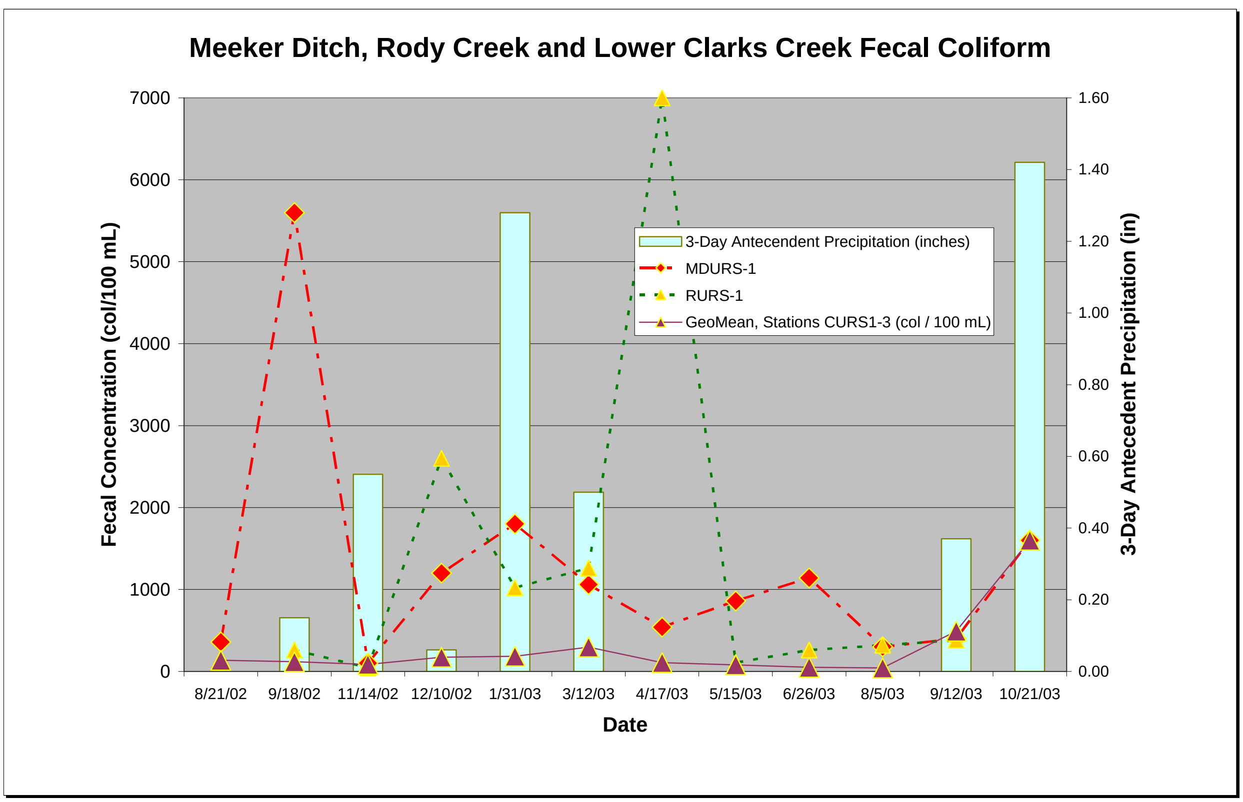

Figure 7 - Meeker Creek, Rody Creek and Lower Clarks Creek Fecal Coliform

During the sampling study, composite samples were analyzed to identify specific sources of fecal coliforms. The procedure, called microbial source tracking, and the results are discussed in detail in the report titled, *Clarks Creek*

Watershed Pollution Reduction Project (2005). The combined results from wet and dry seasons identified the sources of fecal coliform as bird/duck, rodent, dog, deer, and raccoon, human and unknown or miscellaneous.

Dissolved Oxygen, pH and Temperature

Sixty samples from Clarks Creek were tested for DO and pH. All but six of the samples complied with the DO standard. Two of those six samples were collected in September 2003. The other four samples were collected the day after the October 20, 2003, storm. The samples for Clarks Creek complied with the pH standard except for two stations sampled during the October storm event and one station sampled in August 2003. Both parameters appeared to be more variable in dry months, potentially due to aquatic plant influence on water chemistry.

DO and pH levels were generally within standards in Clarks Creek. Both parameters appeared to be more variable in dry months, potentially due to aquatic plant influences on water chemistry.

During the late fall and winter, DO in much of Clarks Creek was in the range of 9.5 to 10.5 mg/L, above the 9.5 mg/L criteria (Figure 8).[5] Beginning in late spring, DO levels began to diverge between stations, reaching a high of 12 mg/L in April and May in the most downstream stations and lows at these same stations in the range of 6-9 mg/L in late summer. For much of this time, background levels (as measured at CURS-4) were between 10 and 11 mg/L. Because temperatures are generally stable throughout the year, the increased variability in DO is probably a result of aquatic plant photosynthesis and respiration.[6]

Clarks Creek pH varies throughout the year. The pH is highest in the summer, gradually reduces to its lowest value in the winter and then rises in the spring until it again reaches it highest value during summer (Figure 9). In the wet season, pH is near 7. In the spring and summer, pH rises slightly, and the between-station variability increases as well. The data suggest that winter groundwater flow (CCURS-4) and winter stormwater flows are both near neutral. There is little change between CCURS-4 and stations downstream. Greater variability in pH in the summer probably reflects increased stream primary productivity and (perhaps) lower seasonal pH in groundwater.

DO and pH levels fell with the onset of the fall 2003 rainy season. The reason for the drop is not apparent. The data at station CURS-4 may suggest changes in groundwater quality.

DO and pH in Meeker Creek also follow seasonal trends. DO is lowest in the summer, probably reflecting high seasonal water temperatures. pH followed a seasonal pattern similar to Clarks Creek, indicating a vegetation influence.

Temperature in Clarks Creek ranged from 46ºF to 54ºF (8 -12ºC), below the criterion of 16ºC (Figure 9). Creek temperatures reflect groundwater temperatures. Adequate flow rate and the short length of stream prevent substantial heat gain. In contrast, Meeker Creek lacks substantial summer flow and shade, and temperatures rise in summer, at times above the criterion (Figure 10).

---

[5] In Figure 8, the large diamond is CCURS-4 and the moderately-sized circle is Meeker Ditch.
[6] The equilibrium dissolved oxygen concentration in freshwater at sea level is 11 mg/L at 11ºC and decreases by about 1 mg/L for every 3-4ºC change in temperature.

While Clarks Creek meets the temperature criterion, there are many places along the creek where native vegetation and shade are lacking. Healthy riparian areas are an important component of healthy stream ecosystems. Bank erosion from unprotected stream banks – where trees and other native vegetation have been removed - may be one source of the sand that limits spawning in Clarks Creek. And, the litter fall from riparian vegetation is one of the drivers of stream productivity. The lack of riparian buffers is probably limiting the quality of aquatic habitat in Clarks Creek.

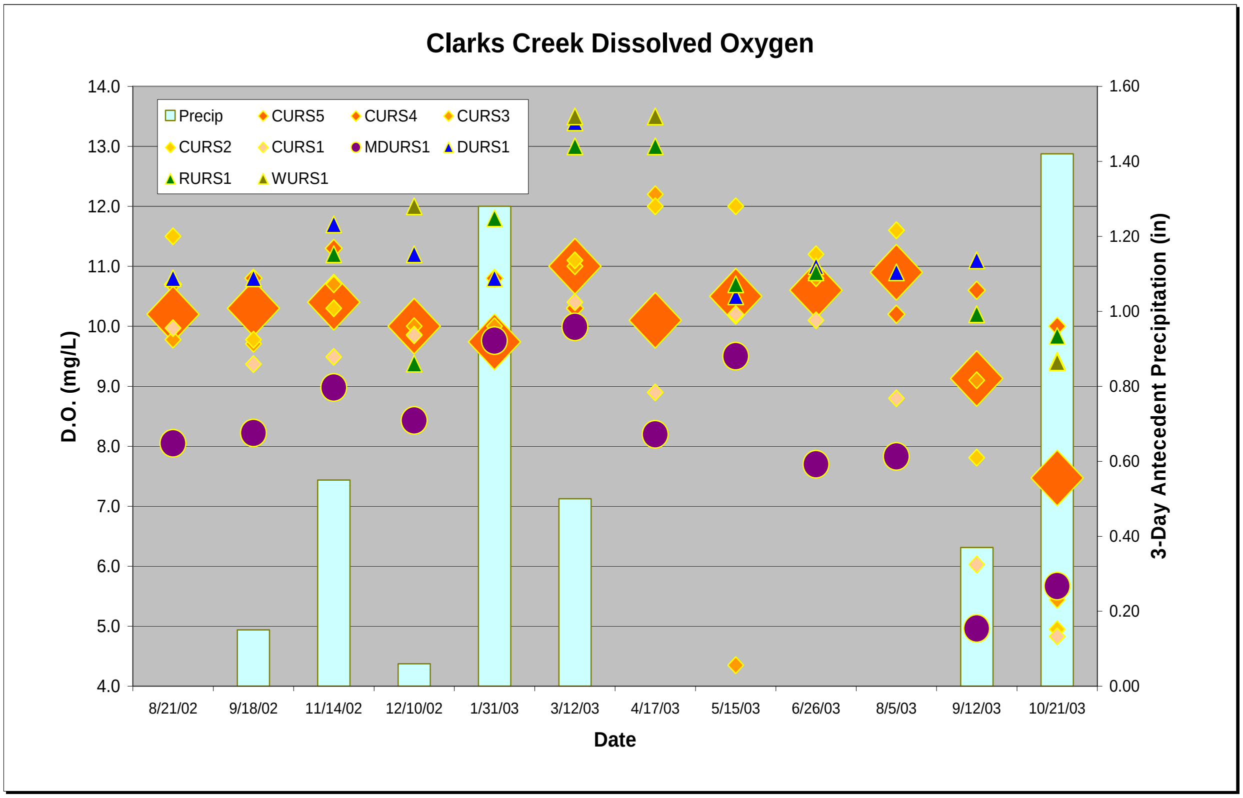

Figure 8 - Clarks Creek Dissolved Oxygen

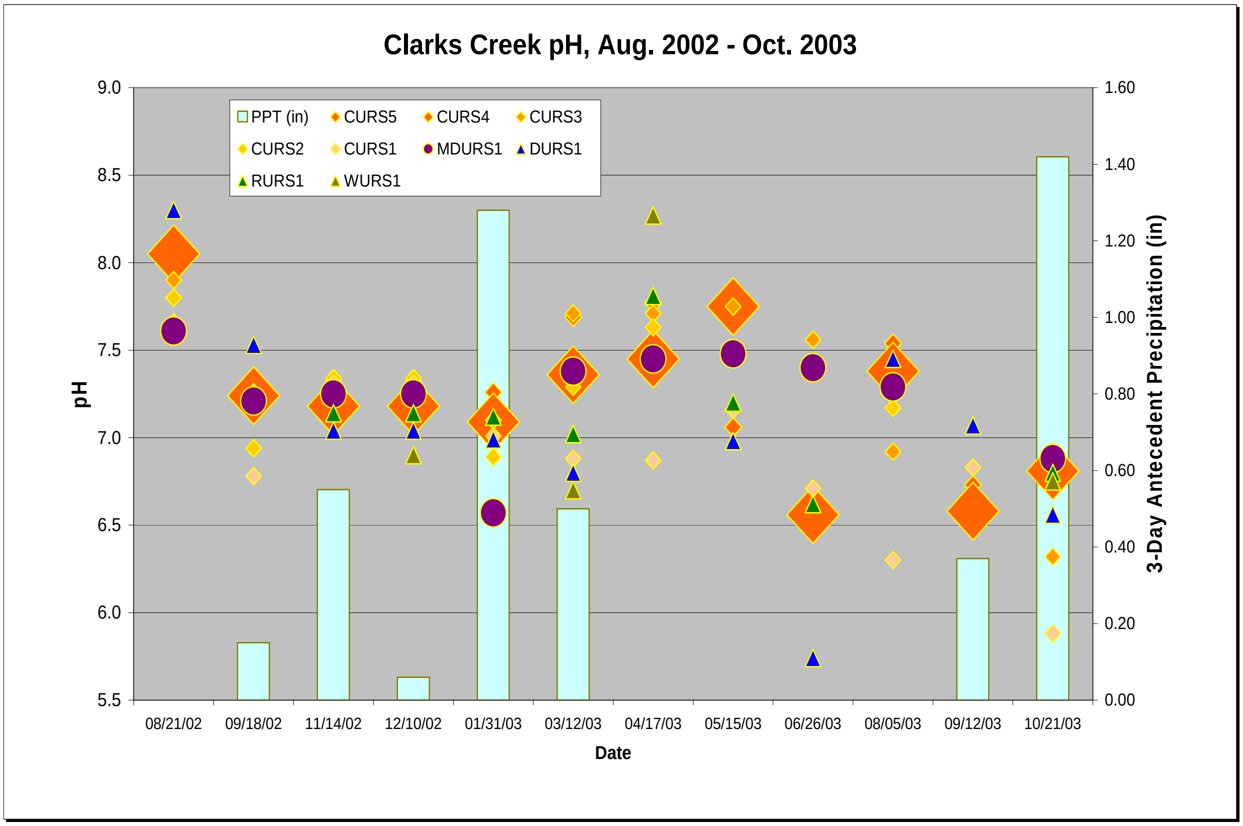

Figure 9 - Clarks Creek pH

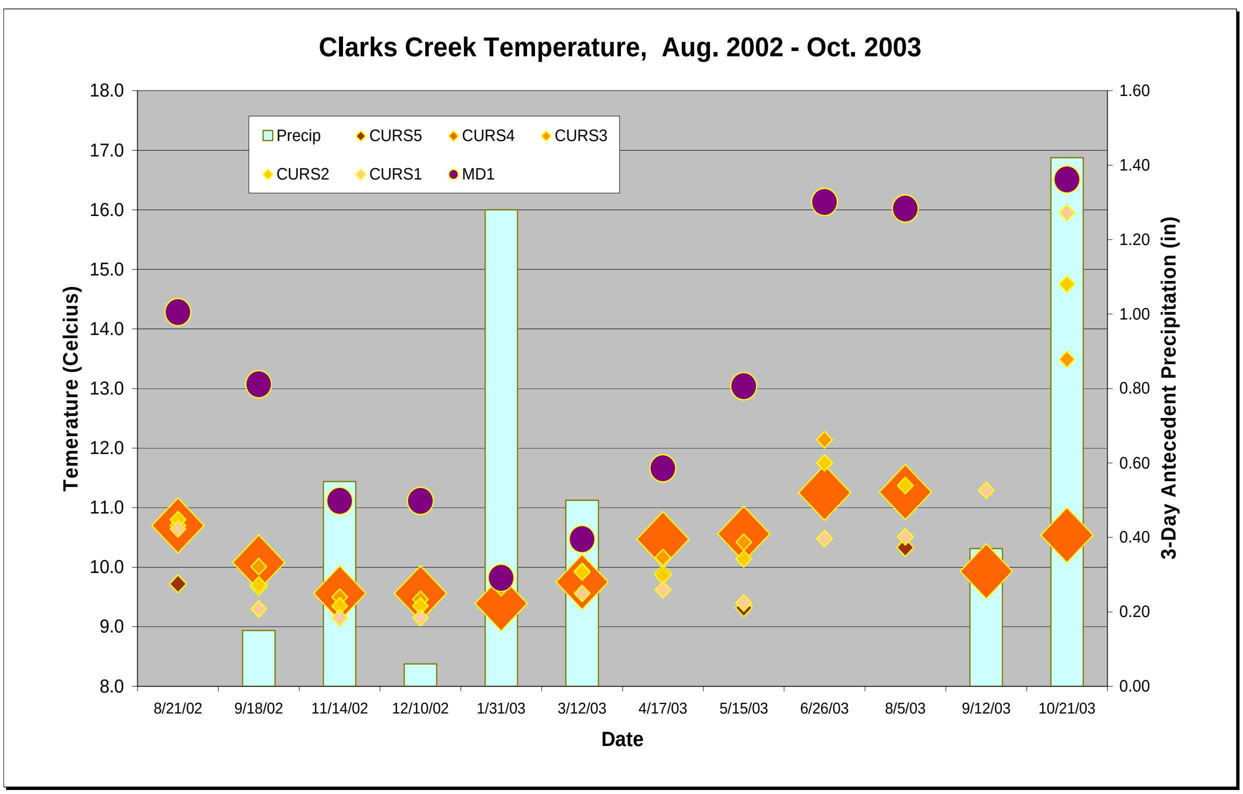

Figure 10 - Clarks Creek Temperature

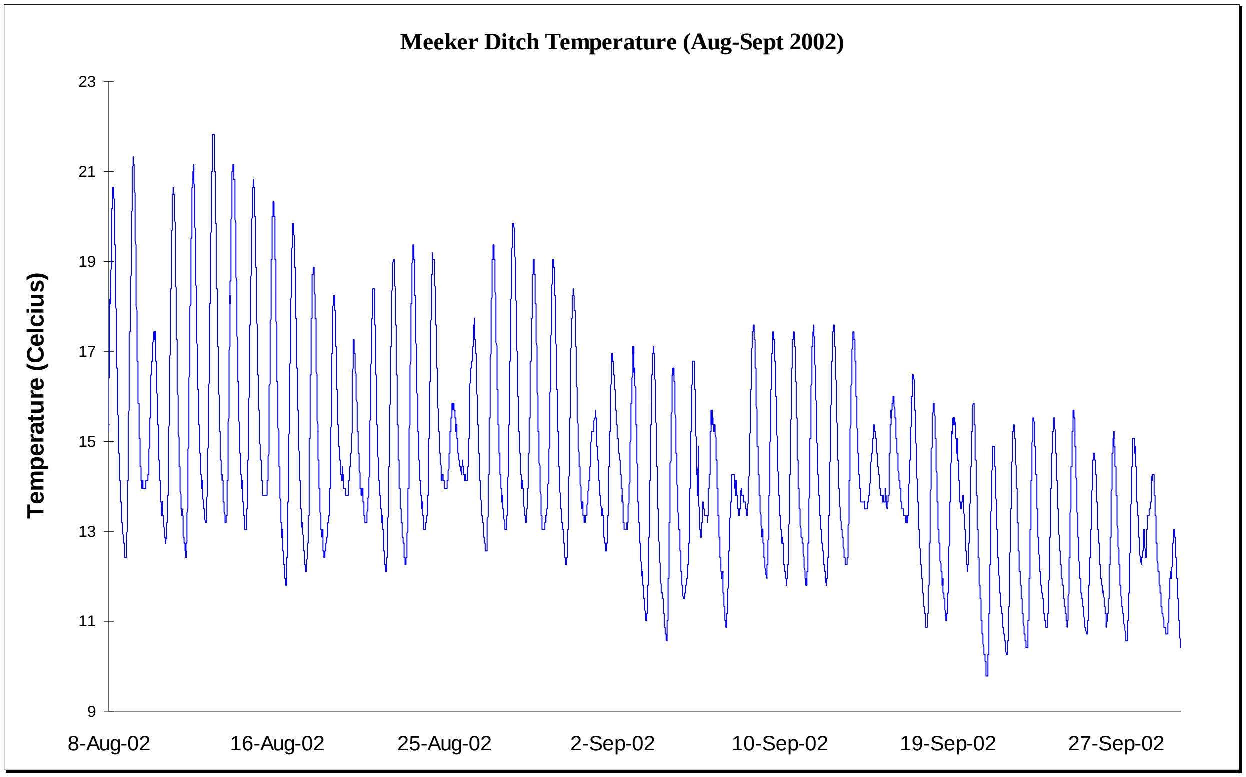

Figure 11 - Meeker Creek Temperature

Total Maximum Daily Load Analyses for Fecal Coliform Bacteria

Total Maximum Daily Load Overview

A total maximum daily load (TMDL) is a mathematical determination of amount of a pollutant loading that a water body can receive without violating the water quality standard for that specific pollutant. For most pollutants, TMDLs are expressed as mass loadings (e.g. pounds per day). TMDLs for bacteria, however, can be expressed as concentrations.

Wasteload Allocations

The wasteload allocation for point sources of fecal coliform bacteria to Clarks Creek or any of the tributaries, including future sources, is the water quality standard. The fecal coliform bacteria standard is concentration-based. If a point source complies with the fecal standard its addition to the water body will not increase the concentration of the combined streams.

Meeker Creek daylights at 5th Street SW on the west side of the fairgrounds. According to the draft report titled *Clarks Creek Watershed Pollution Reduction Project* (URS 2002), Meeker Creek receives stormwater runoff from approximately 1500 acres within the city of Puyallup. The URS report also states that Meeker Creek receives dry weather inflow from a collection system located near the southeast corner of the fairgrounds and another system that collects dry weather flow from a commercial area east and south of the fairgrounds. The report indicates the storm lines discharge to a vault located adjacent to 5th Street SW. However, the vault many have been covered or modified during a recent road construction project and may not be accessible for sampling from the individual lines.

The city of Puyallup also discharges stormwater to Clarks Creek at 7th Avenue SW, Pioneer Avenue SW, and at two locations downstream of Pioneer Avenue SW.

Federal regulations require TMDLs to assign a numeric wasteload allocation (WLA) to NPDES-regulated stormwater discharges (40 CFR§130.2(h)). Also, if data and information are not sufficient to assign each outfall a WLA, then the allocations from multiple point sources can be expressed as a single categorical WLA (40 CFR§130.2(i)). The WLA for the point source stormwater discharges is the water quality standard for fecal coliform bacteria:

> *Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies/100 mL. (WAC 173-201A-200(2)(b)*

The city's NPDES stormwater permit will include a WLA. However, the permit limits can be specified as best management practices (BMPs), and not as a numeric limit. The permit will specify BMPs and monitoring to determine if the load reductions are being achieved.

Load Allocations

In addition to the WLAs, Ecology determined the load allocations for Clarks Creek and its tributaries by comparing current conditions to the water quality standard and then calculating the percent reduction needed to meet the standard. The more restrictive of the two parts of the water quality standard is used as the basis for the load allocation.

Reserve

During the planning stages for this TMDL, the constituents agreed to include a reserve of 13 percent for future development in the watershed. Pierce County, in the document titled *Clear/Clarks Creek Basin Plan* (2006) estimates the population in the Clear and Clarks Creek watersheds will increase 15 percent from the year 2000 to 2020. (The Clear Creek watershed is adjacent to, and to the west of, the Clarks Creek watershed.) The constituents chose 13 percent for the reserve because it is similar to the projected population increase.

The reserve of 13 percent is included in the allocations and effectively increases the percent reduction of fecal coliform bacteria required by this TMDL. For example, instead of using a target fecal coliform load of 200 colony-forming units (cfu)/100 mL based on the water quality standard, the target is reduced by 13 percent or 26 cfu/100 ml, so the target load becomes 174 cfu/100 ml.

The reserve applies to each stream segment. However, because different entities (e.g. tribe, county, and city) have jurisdiction over the streams, those entities will have to agree on how to apply the reserve once the water quality standards are met during the adaptive management stage.

Margin of Safety

The margin of safety (MOS) in a TMDL can either be explicit or implicit. An explicit MOS is based on an actual value incorporated into the load allocations. For example, if the evaluations included a ten-percent MOS, then the target goal of 174 cfu/100 mL would have been reduced by 17 cfu/100 mL prior to determining the reductions required to meet the water quality standard. The result would have been an increase in the percent reductions required to meet the water quality standard.

An implicit MOS, applied in this TMDL, does not incorporate a separate value into the TMDL analyses. Instead, the MOS is incorporated implicitly into estimates of current pollutant loadings, the targeted water quality goal, and the load allocations. This is accomplished by making conservative assumptions throughout the TMDL development process. For example, the smaller the data set used for the rollback calculation, the more stringent the reduction necessary to meet the water quality standard. A smaller sample set has greater variability which makes the 90th percentile values higher.

In addition, the calculations for the target concentrations assume the fecal coliforms do not decay in the water. Typically, pathogen organisms (and the surrogate which we will actually measure) have limited capability to survive outside of the host and would decay over time. A rate of decay can be included in determining the wasteload allocation which would decrease the required percent reduction. By *not* incorporating a fecal decay rate in the calculation, greater protection of water quality is provided and adds to the assurance of the MOS.

Total Maximum Daily Load Development

With an implicit MOS and no WLA established, the TMDL for the Clarks Creek watershed will consist of a Load Allocation, when needed, for each creek and the reserve of 13 percent.

The state fecal coliform bacteria standard provides the basis for the Clarks Creek TMDL. The standard is expressed as the geometric mean concentration of fecal coliforms and a percentage of how many samples exceed a specific fecal coliform concentration. However, the quality of the data must be evaluated first, before wasteload allocations can be set. There are standard statistical procedures to determine data quality.

Analytical Process

Data collected from August 2002 to September 2003 were used to develop allowable loadings for fecal coliforms in Clarks Creek and its tributaries. Ecology typically applies the statistical rollback method (Ott, 1995) to estimate the reduction in fecal coliform loading necessary to meet both parts of the water quality standard: (1) geometric mean of the data not to exceed 100 colony forming units (cfu)/100 milliliters (mL) and, (2) not more than 10 percent of the samples used to calculate the geometric mean exceed 200 cfu/100 mL.

Fecal coliform concentrations measured over time at a station are assumed to follow a log-normal distribution. Log-normal distribution properties, therefore, are used to estimate the geometric mean and the 90th percentile bacteria concentrations. When the estimate values are greater than the standards, the target reductions are estimated by rolling back the estimated geometric mean or 90th percentile concentrations (whichever is more restrictive) to the respective water quality standard.

The process follows these steps:

1. The data are plotted on a log-scale against a linear cumulative probability function. A straight line signifies a log-normal distribution of the data.
2. The geometric mean of the data has a cumulative probability of 0.5. Alternately, the geometric mean can be estimated by the following equation:

   $$\text{geometric mean} = 10^{\mu_{\log}}$$

   where: $\mu_{\log}$ = mean of the log transformed data

3. The 90th percentile of the data has a cumulative probability of 0.9. This is equivalent to "not more than 10 percent samples exceeding. . . " criterion in the state's fecal coliform standard. Alternatively, the 90th percentile can also be estimated by the following statistical equation:

   $$\text{90th percentile} = 10^{(\mu_{log} + 1.28\sigma_{log})}$$

   where: σ_{log} = standard deviation of the log transformed data

4. The target percent reduction required is the greater result of the following two comparisons:

$$F_{\text{rollback 90th percentile}} = \left[\frac{\text{observed 90th percentile - 90th percentile criterion}}{\text{observed 90th percentile}}\right] \text{x } 100$$

   or:

$$F_{\text{rollback geometic mean}} = \left[\frac{\text{observed geometric mean - geometric mean criterion}}{\text{observed geometric mean}}\right] \text{x } 100$$

5. If the 90th percentile is more restrictive, then the goal is to meet the 90th percentile standard and no goal would be set for the geometric mean. Implementing the target reduction based on the 90th percentile value would also reduce the geometric mean. Conversely, if the geometric mean results in the more restrictive reduction, then the goal is to achieve compliance with the geometric mean standard with no goal for the 90th percentile concentration.

Clarks Creek Watershed Fecal Coliform Data Evaluations

Ecology has documented log-normal characteristics of fecal coliform data in several other water quality or TMDL studies. Figure 12 consists of a cumulative probability distribution of the Meeker Creek fecal coliform data that demonstrates the log-normal distribution. The Meeker Creek chart is used as an example. Plots of the data for Clarks Creek and its other tributaries have similar log-normal characteristics.

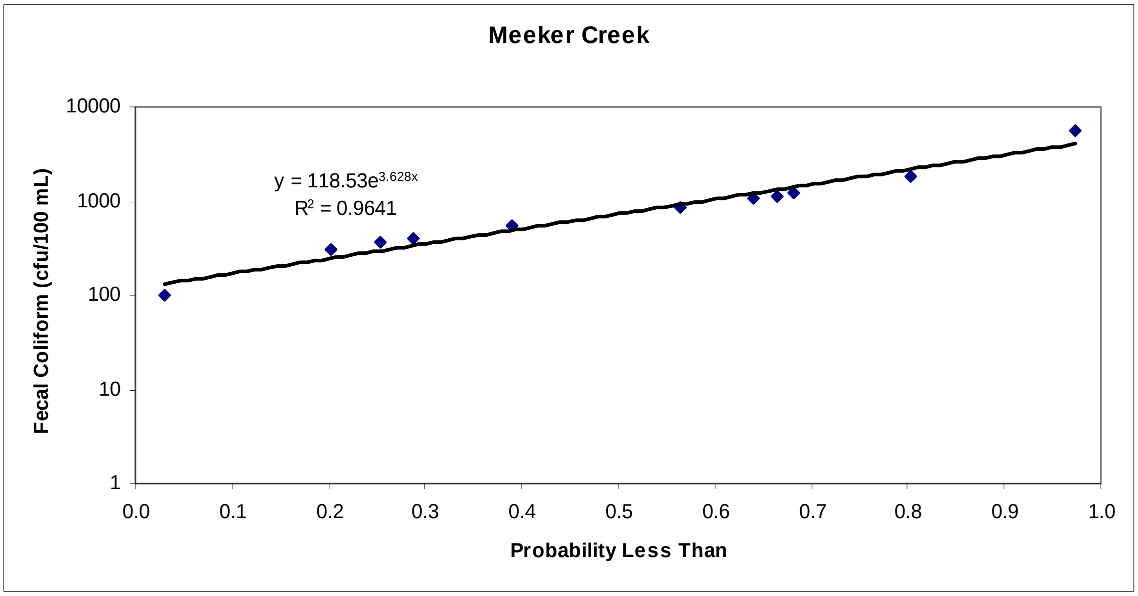

Figure 12 - Meeker Creek cumulative probability distribution for fecal coliforms

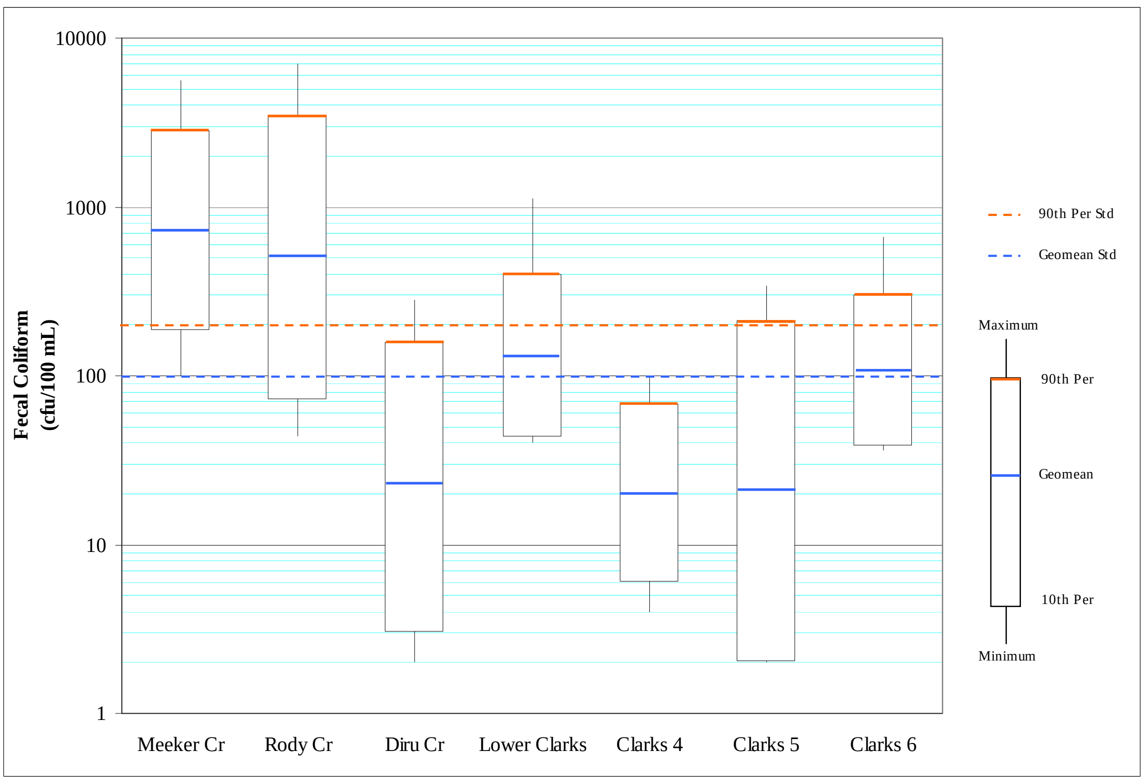

Figure 13 - Fecal coliform distribution for Clarks Creek Watershed

Figure 13 shows the geometric mean and 90th percentile values of the data for each sampling station. This figure also illustrates that the data for Diru Creek, and Clarks Creek at station 4 are in compliance with the water quality standards. (The 90th percentile value for Clarks Creek 5 is slightly greater than the standard.) The data for

Clarks Creek 6 has both the geometric mean and the 90th percentile greater than the water quality. One data point in the set of 12 values caused the geometric mean and the 90th percentile value to be greater than the corresponding standards.

However, analysis of the data for **Meeker Creek**, **Rody Creek**, and **lower Clarks Creek** (Clarks Creek stations 1-3) show the geometric mean and the 90th percentile values of the respective data sets exceed the water quality standard.

Fecal Coliform Total Maximum Daily Loads for Clarks Creek Watershed

Concentration-based Evaluation

Ecology evaluated data collected from August 2002 to September 2003 as combined data sets because not enough data points are available to evaluate separate wet and dry seasons. A valid statistical analysis of fecal coliform data requires a minimum of 10 data points. In addition, the samples that exceeded the water quality standards occurred throughout the year. The results do not indicate a "critical condition" attributed to rainfall or a particular season.

Table 7 presents the results of the analysis described in the section titled "Analytical Process." The table identifies the percent reductions needed (reserve included) for each creek to achieve compliance with the water quality standard.

Table 7 - Percent Reduction to Meet Fecal Coliform Water Quality Standard

Stream	N	Geometric Mean (cfu/100 mL)	90th Percentile (cfu/100 mL)	Percent Reduction to Meet Geometric Mean	Percent Reduction to Meet 90th Percentile	Target Capacity Geometric Mean (cfu/100 mL)*
Clarks Creek 1-3	32	132	402	34	57	57
Clarks Creek 4	11	20	68	none	none	20
Clarks Creek 5	11	21	211	none	18	17
Clarks Creek 6	10	107	301	18	42	62
Meeker Creek	11	725	2823	88	94	44
Rody Creek	10	496	3420	82	95	25
Diru Creek	10	23	158	none	none	23
*target capacity includes 13 percent reduction						

The target reductions necessary to comply with the water quality standard are calculated using both the geometric mean (100 cfu/100 mL) and the 90th percentile value (200 cfu/100 mL). These reductions are presented, respectively in the Table 7 columns with the headings "Percent Reduction to Meet Geometric Mean" and "Percent Reduction to Meet 90th Percentile". The most restrictive reduction becomes the target reduction.

For the creeks in the TMDL that were not in compliance with the water quality standard, compliance with the 90th percentile value (compared to the geometric mean) requires the greater reduction in fecal coliform bacteria. The last column in Table 7, "Target Capacity Geometric Mean" presents the reductions, all based on compliance with the 90th percentile value, in the context of the geometric mean. If the fecal coliform bacteria concentrations meet the respective target geometric mean then the water will be in compliance with both parts of the water quality standard.

Four samples were collected for Woodland Creek, but the number of samples was too low to allow valid statistical analysis. Clarks Creek 5 and Clarks Creek 6 each had a single sample in each data set that caused the data set to exceed the water quality standard. More data should be collected from these sampling locations to determine if additional effort is necessary.

The analyses indicate two streams and a segment, Meeker Creek, Rody Creek, and lower Clarks Creek (which is partly influenced by Meeker Creek and Rody Creek) have the most serious fecal coliform bacteria challenges. For these evaluations, the percent reductions needed to meet the 90th percentile value are the more conservative values and are used to establish the load allocations.

The percent reductions calculated in these evaluations are goals. The final standard for achieving the TMDL is to comply with the water quality standard in Clarks Creek and its tributaries. This TMDL will be achieved when water quality standard is met throughout the Clarks Creek watershed.

Mass-based Evaluation

Statistical evaluation of fecal coliform concentration (number of cfu/100 mL) data is required to evaluate compliance with the water quality standard. Fecal coliform mass loadings (i.e. no. of organisms/day), although not applicable to evaluate compliance with the standard, can provide additional information to evaluate sources, dispersion, and transport mechanisms.

Ecology calculated the mass loadings of fecal coliforms in Meeker Creek, Rody Creek, and lower Clarks Creek using the stream flows measured during the sampling events and the respective fecal coliform concentrations according to the following mathematical expression:

> Mass Loading = stream flow (cubic feet per second (cfs)) · number cfu/100 mL · conversion factor (0.0245)
>
> The conversion factor of 0.0245 converts flow (cfs), multiplied by the number of organisms per 100 mL, to billion (10^9) fecal coliforms per day.

A waterbody's hypothetical load capacity for that same day is calculated in a similar manner using the flow data and the water quality standard for the 90th percentile value of 200 cfu/100 mL (the value equivalent to "not more than 10 percent of the samples").

Table 8 presents the calculated mass loadings of fecal coliforms and the corresponding loading capacity for that particular measured stream flow for Meeker Creek, Rody Creek, and the lower Clarks Creek. The measurements for both fecal coliforms and stream flow are instantaneous values. These values would vary throughout the 24-hour period. However, due to sampling and testing constraints, Ecology used the collected data to project a daily loading for the three streams and compare those loadings to the corresponding load capacity based on 200 cfu/100 mL.

The mass loading evaluations do not provide additional information regarding compliance with the water quality standard. If the sample exceeds 200 cfu/100 mL, then the mass loading will exceed the mass-based load capacity of the stream.

Table 8 - Fecal Coliform Mass Loadings for Meeker Creek, Rody Creek, and lower Clarks Creek

	Meeker Creek					Rody Creek					Lower Clarks Creek				
Sampling Date	Fecal Count (cfu/100 mL)	Flow (cfs)	Fecal Loading (10^9/day)	Fecal Load Capacity (10^9/day)[7]	Exceed Load Capacity?	Fecal Count (cfu/100 mL)	Flow (cfs)	Fecal Loading (10^9/day)	Fecal Load Capacity (10^9/day)	Exceed Load Capacity?	Fecal Count (cfu/100 mL)	Flow (cfs)	Fecal Loading (10^9/day)	Fecal Load Capacity (10^9/day)	Exceed Load Capacity?
8/20/2002	360	1.2	10.6	5.87	yes						180	45.9	202	225	no
9/18/2002	5600	1.1	151	5.38	yes	260	0.7	4.45	3.43	yes	152	43.0	160	210	no
11/14/2002	100	3.5	8.56	17.1	no	44	0.7	0.7	3.43	no	80	49.3	96.5	241	no
12/10/2002	1200					2600	1.3				106	63.1	164	309	no
1/31/2002	1800	34.3	1510	168	yes	1020	9.9	247	48.4	yes	220	99.5	536	487	yes
3/12/2002	1060	15.6	405	76.3	yes	1260	1.7	52.4	8.32	yes	440	53.8	579	263	yes
4/17/2003	540	1.8	23.8	8.81	yes	7000					108	50.4	133	247	no
5/15/2003	860	6.4	135	31.3	yes	106	1.5	3.89	7.34	no	106	81.0	210	396	no
6/26/2003	1140	1.6	44.6	7.83	yes	260	0.7	4.45	3.43	yes	84	36.0	74.0	176	no
8/5/2003	300	1.6	11.7	7.83	yes	320	0.8	6.26	3.91	yes	40	31.9	31.2	156	no
9/12/2003	400	1.0	9.79	4.89	yes	380	0.7	6.51	3.43	yes	280	35.4	243	173	yes

Blank spaces indicate data not available

[7] Fecal Load capacity is the maximum mass fecal coliform loading in the stream that would not exceed the water quality standard

Figure 14 shows the averages of the mass-based loadings of the data in Table 8 compared to the average load capacity based on the 90th percentile water quality standard and stream flows. While not applicable for evaluating compliance with the water quality standard, the mass-based evaluations provide another indication of the streams that could benefit from a TMDL and corrective action.

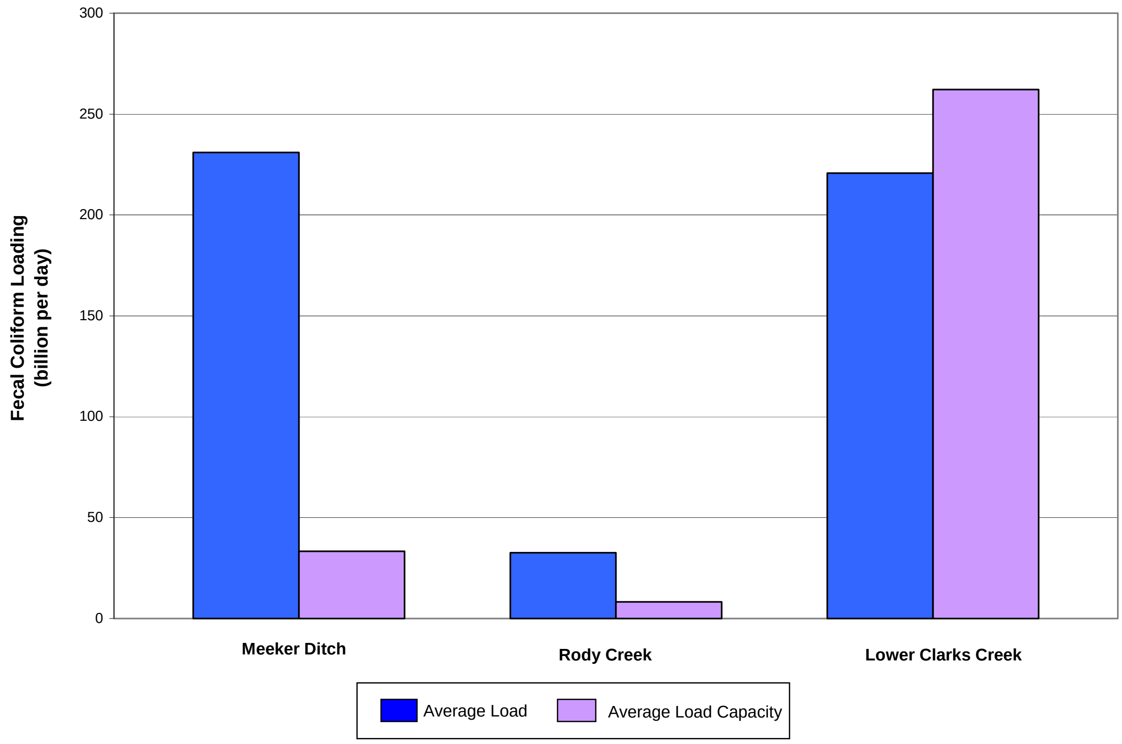

Figure 14 - Average fecal coliform mass loadings and corresponding average load capacities

Temperature, Dissolved Oxygen and pH

Temperature improvements can occur with effective shade that would result from a buffer of mature vegetation native to the lowland Puget Sound area. We base the temperature improvement recommendations on Ecology's Lower Skagit River Tributaries TMDL, where Ecology used a detailed engineering analysis to predict changes in water temperature due to riparian vegetation in small streams. Ecology's analysis predicted that vegetation would, in most cases, reduce temperatures to below the criterion.

Ecology's analysis on the Skagit River may paint an optimistic picture of what can be achieved on Meeker Creek. On the Skagit tributaries, Ecology assumed that tree heights in the buffer would be 120-170 feet, and that buffers would be 90-130 feet wide, with effective shade of 70 to 90 percent. In urban areas, land ownership and the built environment may preclude buffer widths such as these. Still, a buffer of native trees and shrubs of even a modest width and height would be an improvement over the existing condition. A final determination on buffer width will be made during implementation where issues such as property ownership can be explored.

Dissolved oxygen was also looked at in this TMDL effort. Recommendations in this report will help lower temperature. This will likely result in higher DO levels, but because DO is identified as a Category 2 pollutant, allocations are not needed at this time.

The 2002 – 2003 data sets for pH consists of 97 data points obtained at 10 monitoring stations. Of the 97 data points, five are outside the water quality criterion of 6.5 to 8.5 standard units (SU). Four measurements are lower than the water quality criterion of 6.5 SU and one measurement is greater than the water quality standard upper range of 8.5 SU. Two of the pH excursions were measured at Station CCURS-1 (located near the mouth of Clarks Creek) and one excursion each at Stations CCURS-3, DURS-1, and RURS-1. Diru and Rody Creeks, Stations DURS-1 and RURS-1 respectively, are intermittent streams.

Two excursions occurred on October 21, 2003, the day of the 5-inch storm event (Sea-Tac Airport measurement). The data obtained during the storm event "may be atypical because it occurred during a large, relatively rare storm event" (Brown and Caldwell, 2005).

Rainfall typically has a pH ranging from 5.6 to 5.8 SU due to the formation of carbonic acid (H_2CO_3) when rain reacts with carbon dioxide in the air. The acid is often neutralized as rainfall infiltrates into the soil. However, in an intense rainfall event the precipitation exceeds the infiltration rate of the soil and the runoff reflects the rainwater pH value. While two of the stations, CCURS-1 and CCURS-3, had pH measurements lower than the criterion, the data collected during this storm at the other stations all had lower pH values than the other measurements in the respective data sets of the stations. This indicates two of the 5 pH excursions in the data set were caused by a natural, although rare, event.

The other excursion at Station CCURS-1 and the excursion at RURS-1 occurred on August 5, 2003. The Brown and Caldwell report states, "the apparent exceedence at Rody Creek may be attributable to equipment malfunction, as field meter problems were observed at a number of stations during that round."

The remaining pH violation occurred at Station DURS-1 on May 15, 2003. Diru Creek is one of the three intermittent streams that flow into Clarks Creek. The data set for Diru Creek consists of ten measurements with only the one value lower than the pH standard. The antecedent three-day precipitation was zero at the time of sampling and the sub-basin flow evaluation indicates the three intermittent streams probably had low flow rates. The low pH value could have been caused by a longer residence time allowing the water to react with material in the creek bed that would lower the pH, adsorption of carbon dioxide from the atmosphere, or, because the value is not consistent with the other values in the data set, the reading could have been due to instrument error. The available information does not allow for a conclusive explanation for the measurement.

In conclusion, four of the five pH violations are probably not due to conditions that would cause consistent pH problems in Clarks Creek. The remaining pH excursion in one of the intermittent streams can not be explained with the available information, but it also does not seem to be a consistent problem.

Figure 15 - Meeker Creek, August 2005

Conclusions

The study conducted by the city of Puyallup found that fecal coliform concentrations in Clarks Creek and its tributaries often exceeded the state standards. Monitoring also suggested that pH is not a significant water quality problem in Clarks Creek or its tributaries.

The study conducted by the city in 2002-2003 showed that:

- Fecal coliform bacteria exceeded numeric criteria in much of the watershed in the winter. Meeker Creek and Rody Creek exceeded the criteria in the summer.

- High levels of bacteria are not a natural condition but instead appear to be traceable to rodents, waterfowl, and pet feces in stormwater, and other sources including human sources.

- Dissolved oxygen and pH appear to meet criteria in Clarks Creek and its tributaries.

- Clarks Creek meets the state's criteria for temperature throughout the year. Temperatures do not exceed 16°C and are infrequently above 15°C. The temperature of the water emerging from Maplewood Springs (9-10°C) and the short travel time between the Springs and the mouth of the creek combined to keep temperature within standards.

After analysis of the data, Ecology has concluded:

- Enforceable numeric allocations for fecal coliform bacteria in Clarks Creek and its tributaries will be incorporated to meet state water quality standards.

- Temperatures meet water quality standards in Clarks Creek but not Meeker Creek, so actions are listed for Meeker Creek but not Clarks Creek.

- Violations in pH are probably not due to conditions that would cause consistent pH problems in Clarks Creek. The remaining pH excursion in one of the intermittent streams can not be explained with the available information, but it also does not seem to be a consistent problem.

Recommendations

Ecology conducted an analysis of the data listed in the Clarks Creek Watershed Pollution Reduction Project prepared for the city of Puyallup by URS Group Inc, and Brown and Caldwell. Ecology's analysis of the data in the project report supports the following findings:

Best Management Practices for New Development and Re-development

Implement all necessary measures to control new sources of pollution from reaching Clarks Creek or its tributaries. Any new discharges of stormwater must implement current city standards and best management practices for water quantity and control treatment. New projects within the Clarks Creek basin must show that there will be no net increase in pollution reaching Clarks Creek or its tributaries from the impacts of stormwater discharges from the project activities. Any new discharges must meet Washington State water quality standards for fecal coliform.

Septic System Inspection and Repair

Septic systems located near the surface within the corporate boundary of the city of Puyallup, in Puyallup's Urban Growth Area, and in Pierce County have been identified as potential sources of fecal coliform bacteria. The Tacoma Pierce County Board of Health Department (TPCHD) regulates septic systems within Pierce County, and when a system is found to be failing, it has the authority to require connection to the public sewer. Where applicable, the city of Puyallup will cooperate with TPCHD to facilitate and coordinate the connection of failing septic systems to the city sanitary sewer system. It is recommended that the TPCHD increase the effort to inspect those septic systems found within the Clark Creek and Meeker Creek tributary corridors (within 200 feet).

Sanitary and Storm Sewer Inspection and Repair

Expand and refocus sanitary and storm system inspection in order to reduce the potential of creek contamination. Ruptures, leaks or overflows from the sanitary sewer system in the vicinity of surface water bodies can have a direct impact on concentrations of fecal coliform and potentially harmful bacteria in those water bodies. Standing water and accumulated sediments in stormwater catch basins and manholes can be a potential significant source of fecal coliform. The city currently inspects and cleans stormwater catch basins and manholes every fifteen months on a revolving city-wide basis. It is recommended that the catch basins in the Clarks Creek basin be cleaned out at least twice a year.

The city has currently contracted to evaluate and update the city's comprehensive plan for sewers. The plan is anticipated to be completed in mid-2008.

Riparian Planting of Clarks Creek and Meeker Creek

Develop a detailed planting plan for the riparian zone of Clarks Creek and Meeker Creek. Improvement in Clarks Creek and Meeker Creek water quality can be achieved by reducing waterfowl use and rodent habitat. Native trees and shrubs should be selected for planting. Preferred species would be smaller hydrophytic trees and shrubs. Red alders interspersed with willows (Sitka, Pacific, and Scoulers) will grow quickly under existing conditions.

DeCoursey Pond

The connection between DeCoursey Pond and Clarks Creek should be removed and/or modified to prevent pond waste from entering the creek. It must be noted that DeCoursey Pond is an important feature to numerous citizens, and destruction of the pond would be met with public resistance. The city must balance the continued existence of DeCoursey Pond with any proposed pond modifications to disconnect the pond from the creek. Post "No Feeding" signs and regulate feeding of waterfowl. There is a need to progressively step up enforcement from education to issuance of fines or other disincentives. The city must develop a detailed planting plan for the riparian zone of the ponds to discourage waterfowl residence at the pond.

Pet Owner Education

Include pet waste management in the Phase II stormwater program. Include pet waste stations at Meeker Creek with waste pickup and collection stations. Develop a pet waste ordinance.

Implementation Strategy

Introduction

This Implementation Strategy is intended to describe the framework for improving water quality. It explains the roles and authorities of cleanup partners (i.e., those organizations with jurisdiction, authority, or direct responsibility for cleanup) and the programs or other means through which they will address these water quality issues.

Following EPA approval of this TMDL, interested and responsible parties will work together to develop a *Water Quality Implementation Plan*. That plan will describe and prioritize specific actions planned to improve water quality and achieve water quality standards.

What Needs to be Done?

Many items need to be implemented to achieve the needed reductions. The following list of items was developed by the Advisory Group. There may be more items added as we continue to adaptively manage this watershed.

- The focus of the implementation is on Rody Creek, since it is not too heavily populated. Pierce County has already identified the area from Pioneer Avenue to Clark Creek as a project location.
- The TPCHD will focus on failing septic systems in the Clarks Creek Watershed. Where specific problems are suspected, TPCHD staff will utilize one or more of the following tools to gauge if a dye test is needed: perform water quality sampling for fecal coliform or E. coli bacteria enumeration; visually inspect the drain field area for pooled water, discoloration and scum formation, or other visual indication of a failing septic system; and/or check for sewage odors. If deemed necessary, a dye test will be conducted to confirm that the septic system is failing. If the septic system is confirmed to be failing, the TPCHD will require that the system be repaired or replaced if it cannot be repaired. If a sanitary sewer system is in close proximity and if capacity is available, the property will be required to connect to this system. All contacts with the property owner are voluntary unless there is sufficient probable cause of a failing septic system.
- The city recently constructed the Silver Creek wetland adjacent to Meeker Creek in an effort to improve water quality and provide off-channel sedimentation basins. The city must continue to explore opportunities to purchase available properties adjacent to Meeker Creek and Clarks Creek.
- Source identification monitoring is needed for Meeker Creek to further pinpoint bacterial loadings. One solution is detention on the south side of 15th Street, west of SR 512.
- Remove non-native blackberries and plant native vegetation along Meeker Creek to address rodent habitat and improve temperatures.
- Stream incising is occurring in the upper watershed. This is a likely source of sediment to the system. This action should be addressed through the Pierce County Basin Plan.

- Continuing TPCHD compliance work is needed at Majestic Manor Mobile Home Park. Majestic Manor completed septic system repair work and corrected some of the problems, but additional work remains to be accomplished. TPCHD continues to work with a number of other agencies to address issues at Majestic Manor.
- Increase the catch basin cleaning program to twice a year within the Clarks Creek basin.
- Update the sewer comprehensive plan with emphasis on reduction of sewage contamination/connections to the Clarks Creek system.
- Provide for stream bank restoration through the development process.
- Look for opportunities to purchase strategic shoreline properties where habitat enhancement projects could be located.
- Implement stream bank planting projects initiated on city-owned shoreline properties.
- Reduce water fowl impacts to Clarks Creek with an initial focus on DeCoursey Pond. Initial actions include: "No duck feeding" signs with education information, removing the connection between the pond and Clarks Creek, and plantings that will discourage water fowl residence at the pond.
- Implement a Pet Owner Education program.
- Continue the weekly street sweeping program.
- Inspect storm ponds within the Clarks Creek basin for water fowl presence and take measures to reduce water fowl, rodent and pet impacts to the storm ponds.
- Continue development of a potential plan between Pierce County and the Washington State Department of Fish and Wildlife (WDFW) to work on removal of sediment from the pond where sediment is an issue.
- Develop a coordinated strategy to capture all monitoring activities in the basin. Future compliance monitoring, when water quality standards are believed to be achieved, would be a valuable asset to implementation.
- Coordinate with all stakeholders to work on habitat restoration near the fish hatchery.
- Coordinate efforts to remove sediment from the ponds located near the fish hatchery.
- Work on channel morphology where land ownership allows.

Who Needs to Participate?

City of Puyallup

The city of Puyallup is a partner in the development of this Water Quality Improvement Report. The Engineering and Collection Division of the city's Development Services Department is responsible for stormwater infrastructure, drainage and flood protection, improving surface water quality, incorporating current development standards, and stormwater management. The city recently received coverage under the Phase II NPDES Municipal Stormwater Permit and is currently in the process of assessing and enhancing the city's stormwater program.

The city's current stormwater program is governed by the requirements of Chapter 21.10 of the Puyallup Municipal Code (PMC). New development within city jurisdiction must meet criteria in the specified King County Manual and current city Standards. PMC Chapter 21.10 also states that it is unlawful to discharge pollutants into the public storm drainage system directly or indirectly, and prohibits any cross-connection between the storm drainage system and any sanitary sewer system.

The city of Puyallup Planning Division is responsible for decision making regarding land use actions within the city. This is accomplished through evaluating land use proposals for compliance with existing city regulations and through compliance with the Critical Areas Ordinance contained in Chapter 21.06 of the Puyallup Municipal Code and developed in accordance with the state of Washington's Growth Management Act. The Planning Division has enforcement authority for improper land use actions. Planning decisions will have a large impact upon future loadings.

Friends of Clarks Creek

Friends of Clarks Creek are an informal, but important group of citizens who live on or nearby Clarks Creek. They have been very effective in persuading local landowners to plant native riparian vegetation. They also organize creek cleanups. They are the driving force between local governments and the citizens of this watershed.

Pierce County Public Works and Utilities, Water Programs Division

In addition to other responsibilities, the Water Programs Division of Pierce County's Public Works and Utilities Department is responsible for managing water quality and flooding through basin-specific planning efforts, ensuring compliance with the stormwater quality management requirements of the Clean Water Act. It is also responsible for gathering existing water quality data; performing physical surveys; water quality monitoring; and coordinating public input for initiative of the Water Programs Division.

Under federal regulation CFR Title 40 122.26, Pierce County manages a stormwater system. The unincorporated areas of the county are covered under a Phase I municipal stormwater National Pollutant Discharge Elimination System (NPDES) permit. The county has oversight of the permit requirements and developed both a stormwater manual and a best management practices manual for potential dischargers to this system.

Chapter 11.05 of the Pierce County Code, Illicit Stormwater Discharges (Ordinance Number 96-47), makes it unlawful for any person to discharge any pollutants into municipal drainage facilities. The county usually uses education and technical assistance to address nonpoint source pollution entering drainage ditches, but can require immediate cessation of discharges and implementation of best management practices.

Puyallup Tribe of Indians

The Puyallup Tribe is collecting bacteria data in Clarks Creek watershed. The tribe continues to perform water quality monitoring in the watershed.

The Puyallup Land Claims Settlement Agreement states that the Tribe and EPA have exclusive jurisdiction for administration and implementation of environmental laws on trust lands within the 1873 Survey Area of the Puyallup Reservation. EPA granted the tribe treatment as a state, under Section 518(e) of the Clean Water Act, to carry out the water quality standards program under Section 303 of the Clean Water Act on trust lands within the Reservation, including the Puyallup River. In October 1994 EPA approved the tribe's water quality standards, which apply to the Puyallup River within Reservation boundaries.

Pierce Stream Team

Pierce County Water Programs and the cities of Tacoma, Bonney Lake, Fife, and Sumner, as well as monies collected from the Conservation Assessment Fee (from unincorporated Pierce County and the cities of Tacoma, Lakewood, Puyallup, Sumner, University Place, Fircrest, Steilacoom, and Milton) support the Pierce Stream Team. The Stream Team is a coalition of volunteers whose goal is to improve the quality of streams in Pierce County for the benefit of fish, wildlife, and people through public education and action projects. Stream Team offers opportunities for volunteers to participate in water quality monitoring, streamside revegetation with native plants, storm drain stenciling, and stream clean-up projects. Stream Team members educate the public through participation in educational displays about streams and related issues at a variety of events, including the Puyallup Fair. In addition, the Stream Team program offers workshops and tours dealing with stream improvement and habitat enhancement for salmon and other wildlife living in and along streams.

Pierce Conservation District

Pierce Conservation District, under authority of Ch. 89.08 RCW, Conservation Districts, provides education and technical assistance to residents, develops conservation plans for farms, and assists with design and installation of best management practices. When developing conservation plans, the district uses guidance and specifications from the U.S. Natural Resources Conservation Service. Farmers who receive a Notice of Correction from Ecology are normally referred to Pierce Conservation District for assistance.

In 2002, the district requested, and was granted, fee funding from the Pierce County Council, in accordance with Chapter 89.08.400 RCW. This provided a stable source of funding and allowed an increase in services.

Tacoma Pierce County Health Department

TPCHD regulates on-site septic systems in Pierce County in accordance with Ch. 246-272 WAC, and Tacoma Pierce County Board of Health Resolution 2001-3411 has an on-site operations and maintenance program. High-volume business systems and complex systems, both business and residential, are required to perform yearly inspections. Moderate volume business systems and systems using enhanced treatment technology are required to perform inspections every three years. Other residential systems must be inspected at time of sale. Sanitary surveys or other investigative work are usually complaint or problem-driven and usually must be grant funded. Education and outreach is accomplished through a variety of tasks, including: providing educational DVDs, presentations, and “as-built” information to property owners; giving presentations to community groups and organizations; and mailings of educational materials to targeted audiences.

Washington State Department of Ecology

Washington State Department of Ecology is responsible, under the federal Clean Water Act, for establishing water quality standards, coordinating water cleanup projects (TMDLs), and enforcing water quality regulations under the Water Pollution Control Act (Chapter 90.48 RCW). In addition to this regulatory role, Ecology gives grants and loans to local governments, tribes, conservation districts, and citizen groups for water quality projects. Projects that carry out water cleanup plans for TMDLs are given a high priority for funding.

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

Washington State Department of Fish and Wildlife

The mission of the Washington State Department of Fish and Wildlife (WDFW) is to provide sound stewardship of fish and wildlife. The health and well-being of fish and wildlife is important, not only to the species themselves but to humans as well. Often, when fish and wildlife populations are threatened, their decline can predict environmental hazards or patterns that also may have a negative impact on people.

The WDFW is an important partner in managing the Clarks Creek Watershed. The agency provides technical assistance about the design of restoration projects, reviews hydraulic permit approvals (HPAs), and participates in the Clarks Creek Technical Advisory Committee activities to help create and implement sound watershed management policies. The WDFW Puyallup Hatchery operates under a NPDES hatchery permit issued by Ecology. Their discharges to Clarks Creek are regulated by the permit. The WDFW is working to remove sediment from the intake pond that contributes to the sediments reaching Clarks Creek.

Western Washington Fair Association

The Western Washington Fair Association has the authority to plant riparian vegetation along streams located on their property. They are required by the state Water Pollution Control Act (Chapter 90.48 RCW) to ensure that no pollution from their site reaches waters of the state.

What is the Schedule for Achieving Water Quality Standards?

The goal is to meet water quality standards for bacteria by the end of 2015. To reach the bacteria standards, many implementation actions are planned.

Reasonable Assurances

When establishing a TMDL, reductions of a particular pollutant are allocated among the pollutant sources (both point and nonpoint sources); the Clarks Creek Watershed Fecal Coliform TMDL only has nonpoint sources. TMDLs (and related Action Plans) must show “reasonable assurance” that these sources will be reduced to their allocated amount. Education, outreach, technical and financial assistance, permit administration, and enforcement will all be used to ensure that the goals of this water clean up plan are met.

The goal of the plan for fecal coliform is to meet the state’s water quality standards in the waters in the basin. There is considerable interest and local involvement in resolving the water quality problems in Clarks Creek/Meeker Creek. Numerous organizations and agencies are already engaged in stream restoration and source correction actions that will help resolve the fecal coliform problem. The following rationale helps provide reasonable assurance that the Clarks Creek Watershed nonpoint source TMDL goals for fecal coliform contributions will be met by 2015.

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

The EPA requires some assurances that TMDL implementation measures will actually occur. Responsible parties, regulatory authorities, detailed implementation measures and schedules, and funding mechanisms must be identified. The following actions are currently underway or planned and should help to reduce the contribution of nonpoint pollutants:

- In the fall of 2006, TPCHD developed a pre-activity survey for residents in the Clarks Creek Watershed to determine their level of knowledge and interest regarding septic systems. TPCHD conducted water quality sampling and sanitary survey work on the Rody Creek portion of the watershed in the winter and spring of 2007 because this area was targeted in the TMDL for a tremendous reduction in fecal coliform concentrations. The sanitary survey found one failing septic system. This property is in the process of connecting to a sanitary sewer system. The water quality sampling generally found much lower fecal coliform counts than the earlier sampling by the city of Puyallup. It is not known why bacterial water quality in Rody Creek appears to have improved, but it may be due in part to fewer livestock having direct access to the Creek. During the sanitary survey a number of residents remarked that at least two properties had cows or horses with direct access to the creek up until one or two years ago.

- In the fall of 2007, the Western Washington Fairgrounds put many practices in place that prevent fecal coliform from reaching stormwater drains onsite. They are working with the Pierce County Stream Team to replant the property owned by the fairgrounds along Meeker Creek.

- In the fall of 2006, the city of Puyallup, assisted by Pierce County Water Programs, planted portions of Clarks Creek Park, adjacent to Clarks Creek, with native trees and shrubs. The city will encourage the private property owner(s) to plant the Meeker Creek riparian corridor of their property with native vegetation.

- Pierce County finalized the basin plan for Clarks/Clear Creek. Many of the action items will improve water quality and are funded through the County's stormwater utility.

- The Pierce County Stream Team is very active in the watershed. They completed five planting events on Clarks Creek, and at least two more are planned. The Stream Team is very helpful in determining native species that will thrive in the basin conditions. They can help with plant replacement after invasive plant removal.

- WDFW hired a construction crew to open up the drainage ditch from the hatchery. They removed about ten cubic yards of material from the intake pond that is currently contributing sediments downstream.

- The Puyallup Tribe conducts a monthly ambient water quality monitoring program on surface waters within the exterior boundaries of the 1873 Survey Area of the Puyallup Reservation, including Clarks Creek. Three stations are monitored on Clarks Creek: 1) above the state hatchery; 2) 12th Street bridge; and 3) 66th Street and Stewart. They collect water samples monthly and analyze them for fecal coliform, *E. coli*, total suspended solids, ammonia, orthophosphate, total phosphorus, and nitrate+nitrite. Instantaneous measurements, using a calibrated water quality meter, are taken for dissolved oxygen, temperature, pH, specific conductivity, turbidity, and salinity.

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

Ecology will consider and issue notices of noncompliance in accordance with the Regulatory Reform Act in situations where the cause or contribution of cause of noncompliance with load allocations can be established.

Adaptive Management

TMDL reductions for fecal coliform should be achieved by 2015. The *Water Quality Implementation Plan* will identify interim targets. These targets will be described in terms of concentrations and/or loads, as well as in terms of implemented cleanup actions. Partners will work together to monitor progress towards these goals, evaluate successes, obstacles, and changing needs, and make adjustments to the cleanup strategy as needed. This adaptive management process will help to adjust implementation efforts in order to make them the most effective. More details on how this will be accomplished will be listed in the Water Quality Implementation Plan.

It is ultimately Ecology's responsibility to assure that cleanup is being actively pursued and water standards are achieved.

Monitoring Progress

Conclusions, recommendations, and action items currently presented in this Water Quality Improvement Report may be revised based on new data as it becomes available. It is also expected that any new data gathered from further studies will be incorporated into the Water Quality Implementation Plan. It will describe the coordinated monitoring strategy. This may refine actions that have already been identified.

Entities with enforcement authority will be responsible for following up on any enforcement actions. Stormwater permit holders will be responsible for meeting the requirements of their permits. Those conducting restoration projects or installing BMPs will be responsible for monitoring plant survival rates and maintenance of improvements, structures and fencing. Compliance monitoring will be needed when water quality standards are believed to be achieved.

Potential Funding Sources

Sponsoring Entity	Funding Source	Uses to be Made of Funds
Department of Ecology, WQP	Centennial Clean Water Fund, Section 319, and State Revolving Fund http://www.ecy.wa.gov/programs/wq/funding/	Facilities and water pollution control-related activities; implementation, design, acquisition, construction, and improvement of water pollution control. Priorities include: implementing water cleanup plans; keeping pollution out of streams and aquifers; modernizing aging wastewater treatment facilities; reclaiming and reusing waste water.
Pierce County Conservation District	Federal Conservation Reserve Enhancement Program http://www.piercecountycd.org/home.html	Conservation easements; cost-share for implementing agricultural/riparian best management practices (BMPs).
Natural Resources Conservation Service	Environmental Quality Incentive Program http://www.nrcs.usda.gov/programs/eqip/	Voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals; includes cost-share funds for farm BMPs.

Sponsoring Entity	Funding Source	Uses to be Made of Funds
Department of Ecology, SEA	Coastal Zone Protection Fund	Projects must be for environmental restoration and enhancement projects intended to restore or enhance environmental, recreational, archaeological, or aesthetic resources for the benefit of Washington's citizens; or the development and implementation of an aquatic land geographic information system.
Office of Interagency Committee, Salmon Recovery Board	Salmon Recovery Funding Board http://www.iac.wa.gov/srfb/grants.asp	Provides grants for habitat restoration, land acquisition and habitat assessment.
Natural Resources Conservation Service	Emergency Watershed Protection http://www.nrcs.usda.gov/programs/ewp/index.html	NRCS purchases land vulnerable to flooding to ease flooding impacts.
Natural Resources Conservation Service	Wetland Reserve Program http://www.wa.nrcs.usda.gov/programs/wrp/wrp.html	Landowners may receive incentives to enhance wetlands in exchange for retiring marginal agricultural land.

Ecology will work with stakeholders to identify funding sources and prepare appropriate scopes of work that will help implement this TMDL.

Summary of Public Involvement Methods

The Clarks Creek/Meeker Creek TMDL was presented to the Puyallup River Watershed Council on October 25, 2006. This was an overview of the technical findings. The presentation was recorded by the local television station for playback on the community broadcast channel.

A presentation was made to the Friends of Clarks Creek at a Saturday neighborhood meeting on May 19, 2007. The meeting was held at the Washington On-Site Sewage Association Training Center at the WSU-Puyallup Campus, 7612 Pioneer Way East, Puyallup, WA.

A display ad was placed in the Puyallup Herald on January 17, 2008.

Next Steps

Once EPA approves the TMDL a *Water Quality Implementation Plan* must be developed within one year. Ecology works with local stakeholders to create the plan, choosing the combination of possible solutions they think will be most effective in their watershed. Elements of this plan include: who will commit to do what, how will we figure out whether it worked, what will be done if the implementation plan doesn’t work, and potential funding sources.

References

Casola, J.H., J.E. Kay, A.K. Snover, R.A. Norheim, L.C. Whitely Binder, and the Climate Impacts Group. Climate Impacts on Washington's Hydropower, Water Supply, Forests, Fish, and Agriculture. A report prepared for King County (Washington) by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle).

Ebert, J.C. *Water Quality in the lower Puyallup River Valley and Adjacent Uplands, Pierce County, Washington*. U.S. Geological Survey Water Resources Investigations Report 86-4154

EPA, 2001. Overview of Current Total Maximum Daily Load - TMDL - Program and Regulations. U.S. Environmental Protection Agency. www.epa.gov/owow/tmdl/overviewfs.html

Hamlet A.F. and D.P. Lettenmaier, 1999. Effects of climate change on hydrology and water resources in the Columbia River Basin. Journal of the American Water Resources Association, 35(6):1597- 1623.

Hamlet, A.F., P.W. Mote, M. Clark, and D.P. Lettenmaier, 2005. Effects of temperature and precipitation variability on snowpack trends in the western U.S. Journal of Climate, 18 (21): 4545-4561.

Lombard, S. and C. Kirchmer, 2004. Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies. Washington State Department of Ecology, Olympia, WA. Publication No. 04-03-030. www.ecy.wa.gov/biblio/0403030.html.

Mote, P.W., E. Salathé, and C. Peacock, 2005. Scenarios of future climate for the Pacific Northwest, Climate Impacts Group, University of Washington, Seattle, WA. 13 pp.

Pierce County. 2005. *Clear / Clarks Creek Basin Plan*. Prepared by the Pierce County Department of Public Works and Utilities, Water Programs Division.

City of Puyallup. 2002. *Clarks Creek Watershed Pollution Reduction Project Quality Assurance Project Plan*. Prepared by URS and Brown and Caldwell.

City of Puyallup. 2005. *Clarks Creek Watershed Pollution Reduction Project Submittal Report*. Prepared by URS and Brown and Caldwell.

Washington State Department of Ecology. 2003. *Focus Sheet: Riparian Areas*. Publication Number 00-10-23.

Washington State Department of Ecology. 2004. *Lower Skagit River Tributaries Temperature Total Maximum Daily Load Study*. Publication Number 04-03-01.

Washington State Department of Ecology. 2000. *Nooksack River Watershed Bacteria Total Maximum Daily Load.* Publication number 00-10-36. www.ecy.wa.gov/pubs/0010036.pdf

Appendices

Appendix A. Glossary and Acronyms

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

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

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

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

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

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

Enterococci: A subgroup of the fecal streptococci that includes S. *faecalis, S. faecium* , *S. gallinarum* and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5percent sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C.

Existing Uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Extraordinary primary contact: Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

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

Geometric Mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from ten to 10,000 fold over a given period. The calculation is performed by either: 1) taking the nth root of a product of n factors, or 2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

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

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

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

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

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

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

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

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

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

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

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental, or injurious to the public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish, or other aquatic life.

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

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

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

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

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

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

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

Appendix B. Record of Public Participation

Introduction

A presentation of the technical findings was given on October 25, 2006, to the Puyallup River Watershed Council. Another presentation was given to streamside neighbors after the report was developed. Input was requested from those who live along the creek for action items to reduced fecal coliform bacteria.

A display ad was placed in the Puyallup Herald on January 17, 2008. It announced the public comment period January 15 to February 22, 2008. Example below:

Display ad place in the Puyallup Herald

There are too many fecal coliform bacteria in the Clarks Creek watershed. In 2002, the City of Puyallup collected water quality data in response to impairment listings on the 303(d) list. The results showed that waters in the Clarks Creek watershed were unhealthy. The Department of Ecology (Ecology) analyzed the City's data and made recommendations to reduce fecal coliform pollution in Clarks Creek and several of its tributaries.

For the past year Ecology, the City of Puyallup, Pierce County, Tacoma Pierce County Health Department and other partners have been working on a water quality improvement report to clean up unhealthy waters in the Clarks Creek watershed. The report identifies some potential sources of pollution including on-site septic systems, livestock, pet waste, stormwater runoff, and DeCoursey Pond.

Your comments are encouraged during the public comment period through February 22, 2008.

Following EPA approval, Ecology will work with residents, local jurisdictions, and other interested parties, using information from the water quality improvement report to develop a detailed implementation plan. That plan will guide subsequent cleanup activities.

For more information, please call Cindy James at 360-407-6556, or e-mail cjam461@ecy.wa.gov.

Public comment period
January 15–February 22, 2008

The Plan is available for review online:

http://www.ecy.wa.gov/biblio/0710110.html

In person:

Puyallup Library
324 S Meridian
Puyallup, WA 98371

Puyallup City Hall
330 Third Street S.W.
Puyallup, WA 98371

Please send comments by February 22, 2008 to Cindy James, Department of Ecology, PO Box 47775, Olympia WA 98504-7775, or email at cjam461@ecy.wa.gov

Summary of comments and responses

Ecology received comments from both the EPA and the Puyallup Tribe of Indians. Below are the comments and responses to them:

Comments received from the Puyallup Tribe of Indians

Comment:

Legends on many of the figures in the report, particularly Figures 8, 9, and 10 are too small to discern.

Response:

Comment noted, we were unable to reformat the figures in the report

Comment:

Data is insufficient to support the conclusion that low dissolved oxygen in Clark's Creek is due to natural conditions. Historically, we have observed low dissolved oxygen levels in the creek in the summer and spring. To our knowledge, a sediment oxygen demand analysis and intensive sampling has never been done to evaluate oxygen demands in the creek.

The technical analysis that was used to develop the improvement report determined that there is low dissolved oxygen in Clarks Creek. The synoptic sampling data collected from August 2002 to October 2003 at the 5 Clarks Creek locations had dissolved oxygen (DO) concentrations that exceeded the water quality standard (values greater than 8.0 mg/L) with two exceptions. For the September 12, 2003, sampling event, the two most downstream stations (CURS2 and CURS1) had DO concentrations of 7.8 and 6.0 mg/L, respectively. The results of the October 21, 2003, sampling event had 4 of the 5 stations lower than the DO standard, with the lowest measurement at 4.8 mg/L.

Without additional information the September results could be due to higher water temperatures that affect DO saturation. However, the October sampling event, which had the lowest DO results, occurred a day after a significant rainfall event of 5 inches (recorded at SeaTac airport). The test results had descending DO concentrations from the upstream to downstream sampling locations. The report titled, "Clarks Creek Watershed Pollution Reduction Project, Draft Report", dated June 2005, by URS, Inc. and Brown and Caldwell, stated that the October 21, 2003, sampling event was conducted during a large intense storm event and may not represent typical conditions. That is an understatement because the October 20, 2003, is the highest rainfall event on record.

On the day of the sampling the flow in Clarks Creek was approximately 140 cubic feet per second (cfs). A typical Clarks Creek flow is about 50 cfs. The low DO results could have been caused by reactions of inorganic iron and sulfide that can cause rapid DO depletion during stormwater runoff events. The iron and sulfide, if the cause of the DO depletion, could have been from land surfaces carried by the runoff to the creek and/or from creek bottom sediment that was scoured and suspended in the water column due to the high flow. Aquatic sediments *can have considerable inorganic oxygen demand which can significantly deplete DO when the bedded sediment becomes suspended in the water column.*

During the synoptic sampling, tests were conducted for 5-day biochemical oxygen demand (BOD5) for the first 5 sampling events. Of the 25 samples tested, 12 samples had results below the reporting limit of 1 mg/L, 10 had results between 1 and 2 mg/L, the other 3 samples were between 2 and 2.8 mg/L. Due to the short time it takes the creek to flow from the upper sources to the mouth, between 5 to 7 hours, the low oxygen demand measured as BOD5 may not significantly affect DO.

Additional sampling would be helpful as part of the implementation plan. A sediment oxygen demand analysis would also help answer the natural condition issue. Action items listed in the improvement report will also help increase dissolved oxygen in the creek, and will be discussed with more detail during the implementation phase.

Comment:

Ecology's Draft 2008 Water Quality Assessment lists Clark's Creek as Category 5 water for dissolved oxygen, which requires a TMDL. The TMDL report states Clark's Creek is a Category 2 water for dissolved oxygen.

Response:

Ecology used the Clarks Creek August 2002 to October 2003 sampling data for the Draft 2008 Water Quality Assessment. We recently reviewed the data and determined that unqualified dissolved oxygen data were included in the assessment. These data were obtained with a meter on the same day as the samples were collected for testing with the Winkler method. The meter test results were substantially different from the results using the Winkler method. The meter test results, which should not have been included, will not be included in the assessment data. The Winkler data indicates Clarks Creek should be classified as Category 2. The Final 2008 Water Quality Assessment will include the correction. Further implementation actions focused on fecal coliform will also help improve dissolved oxygen in the creek.

Comment:

Clark's Creek is an important spawning and rearing tributary on the Puyallup Reservation for Chinook, coho and chum salmon, and steelhead and cutthroat trout. Spawning is significantly limited in the lower reaches of the creek due to the absence of suitable spawning gravel. The creek bed is dominated by fine sand and silt in the lower portions of the creek. Evaluations to address channel instability and sediment inputs in the creek should be initiated to address these concerns. Addressing the causes of sediment loads into the creek will also likely slow the rate of elodea growth in Clark's Creek.

Response:

One of the major implementation challenges will be to brainstorm ideas on how to deal with sediment issues in Clarks Creek. Please bring these ideas forward so we can capture them during the detailed implementation phase.

Comment:

With projected increases in population and impervious area (potentially from 25% to 35%) in the basin, it will be increasingly difficult to meet water quality standards and protect beneficial uses. It isn't clear how the recommended actions will result in sufficient reductions in fecal coliform loading to meet water quality standards.

Response:

After we receive approval of the Water Quality Improvement report, we will begin working with stakeholders to develop the Water Quality Implementation Plan. One of the required actions will be to conduct annual adaptive management meetings. The purpose of those meetings will be to adapt the recommended actions until water quality standards are met.

Comments received from the Environmental Protection Agency (EPA)

Comment:

Page 39, Wasteload allocations, 2nd paragraph. Who manages the vault that discharges stormwater to Meeker Creek? If this vault is managed by a municipality covered by the MS4 stormwater permit, this may be a point source that would need a WLA in the TMDL.

Response:

Meeker Creek daylights on the west side of 5th Street SW and flows in a man made channel due west to its confluence with Clarks Creek. We're trying to get additional information from the city but the vault may not be accessible due to road construction.

A WLA can be assigned to the point source stormwater discharges as the water quality standard.

Comment:

Tribal fish hatchery, page 27.   Please remove the statement that "EPA does not require the Tribe to obtain a federal discharge permit for the hatchery." EPA does not currently have production information for the two Tribal hatcheries that discharge within the area covered by this TMDL, and has not determined whether or not these facilities will be regulated by an NPDES permit. I recommend you say that "The Tribal hatcheries are smaller than the state facility and are not currently covered under a NPDES discharge permits." The Puyallup Tribe has a second hatchery that discharges to Clarks Creek, which you may want to mention in the TMDL.

Response:

We will replace the sentence you quote in the comment with following based on your explanation:

> *EPA has jurisdiction for permitting the tribe's hatchery that discharges to Diru Creek but presently does not have production information for the hatchery or for the tribe's rearing pond that discharges to Clarks Creek. EPA has not yet determined whether these facilities will be regulated by NPDES permits.*

We would rather not include the statement in quotes that states the tribal hatcheries are smaller than the state facility because Ecology, like EPA, does not have production information from the tribe. Also, we understand that the "second hatchery" is actually a rearing pond.

Comment:

Concentration Based Evaluation (page 44 and Table 7). Text on page 44 explains that compliance with 90th percentile requires a greater reduction than meeting the geometric mean standard - - implying that the load allocations / target reductions will be based on the 90th percentile reductions. In Table 7, however, the target capacity (far right column) appears to be based on the geometric mean, rather than the 90th percentile.

Response:

The target reductions necessary to comply with the water quality standard are calculated using the geometric mean and the 90th percentile value. The more restrictive reduction becomes the basis for the target reduction. For the creeks in this TMDL that were not in compliance with the water quality standard, compliance with the 90th percentile value requires a greater reduction in fecal coliform bacteria than compliance with the geometric mean. The last column of Table 7 presents the required reductions (all based on the 90th percentile values) in the context of the geometric mean. We will add additional explanation in the two paragraphs that follow Table 7.

Comments:

Additionally, the first paragraph on page 44 states that "the load allocations are the percent reductions needed for each creek to achieve compliance with the water quality standards." Load allocations, however, must be expressed in a numeric form (rather than a percent reduction). Please include a loading capacity in Table 7 that will achieve the water quality standards (e.g. is based on the 90th percentile reductions) and that is expressed in concentration units
(rather than percent reduction).

Response:

The target reductions are based on compliance with the fecal coliform bacteria standard. We will change the quoted sentence to:

> *The table presents the percent reduction needed (reserve included) for each creek to achieve compliance with the water quality standard.*

The load allocation, like the WLA for the end-of-pipe municipal stormwater discharges, is the water quality standard (WAC 173-201A-200(2)(b):

> *Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 colonies/100 mL.*

We will quote the water quality standard as the load allocation.

List of public meetings

Clarks Creek Technical Presentation
Puyallup River Watershed Council
Sumner City Hall
October 25, 2006

Streamside Neighborhood Meeting
Friends of Clarks Creek
Washington On-Site Sewage Association Training Center
WSU-Puyallup Campus, 7612 Pioneer Way East
Puyallup, WA
May 19, 2007

Appendix C   Synoptic Survey Data

Station	Date	Sampling Round	TSS (mg/L)	TP (mg/L)	SRP (mg/L)	NO (mg/L)	NH3 (mg/L)	FC #/100 mL	e.coli	DO (mg/L)	BOD (mg/L)
CCURS-1	8/20/2002	R1	16	0.142	0.032	1.79	0.035	180	NA	9.97	1.82
CCURS-1	9/18/2002	R2	13	0.133	0.045	1.93	0.102	152	<300	9.37	2.78
CCURS-1	11/14/2002	R3	7	0.096	0.042	1.91	0.037	80	NA	9.49	<1
CCURS-1	12/10/2002	R4	12	0.155	0.043	2	0.089	106	NA	9.85	<1
CCURS-1	1/31/2003	R5	20	0.193	0.065	1.65	0.111	220	NA	9.86	1.72
CCURS-1	3/12/2003	R6	13	0.141	0.052	1.95	0.149	440	NA	10.4	NA
CCURS-1	4/17/2003	R7	2.9	0.075	0.032	1.78	0.038	108	NA	8.9	NA
CCURS-1	5/15/2003	R8	2.2	0.052	0.018	1.97	0.031	106	NA	10.2	NA
CCURS-1	6/26/2003	R9	0.5	0.047	0.030	2.35	0.024	84	NA	10.1	NA
CCURS-1	8/5/2003	R10	0.75	0.054	0.03	2.02	0.018	40	NA	8.8	NA
CCURS-1	9/12/2003	R11	1.1	0.062	0.04	1.95	0.03	280.0	540.0	6.0	NA
CCURS-1	10/21/2003	R12	20	0.257	0.141	1.54	0.085	>1600	NA	4.83	NA
CCURS-2	8/20/2002	R1	10	0.097	0.039	1.89	0.025	94	NA	11.5	1.88
CCURS-2	9/18/2002	R2	5.8	0.085	0.052	1.97	0.1 104	NA	9.78	<1	
CCURS-2	11/14/2002	R3	1.8	0.065	0.047	2.24	0.039	80	NA	10.3	1.06
CCURS-2	12/10/2002	R4	8.2	0.135	0.041	1.89	0.083	280	NA	9.86	1.3
CCURS-2	1/31/2003	R5	29	0.179	0.050	1.31	0.093	180	NA	9.78	1.64
CCURS-2	3/12/2003	R6	7.2	0.102	0.053	1.92	0.149	740	NA	11.1	NA
CCURS-2	4/17/2003	R7	1.8	0.064	0.037	1.93	0.024	88	NA	12.0	NA
CCURS-2	5/15/2003	R8	5.9	0.079	0.029	2.22	0.027	60	NA	12.0	NA
CCURS-2	6/26/2003	R9	1.3	0.055	0.042	2.49	0.020	40	NA	11.2	NA
CCURS-2	8/5/2003	R10	<0.5	0.056	0.04	2.16	0.038	48	NA	11.6	NA
CCURS-2	9/12/2003	R11	<.5	0.06	0.047	2.18	0.06	640.0	NA	7.8	NA
CCURS-2	10/21/2003	R12	26	0.249	0.134	1.49	0.105	>1600	NA	4.95	N

Station	Date	Sampling Round	TSS (mg/L)	TP (mg/L)	SRP (mg/L)	NO (mg/L)	NH3 (mg/L)	FC #/100 mL	e.coli	DO (mg/L)	BOD (mg/L)
CCURS-3	8/20/2002	R1	9	0.084	0.039	1.98	0.016	84	NA	9.78	< 1
CCURS-3	9/18/2002	R2	4.6	0.07	0.053	2.14	0.091	98	NA	9.71	1.94
CCURS-3	11/14/2002	R3	2	0.064	0.046	2.17	0.032	58	NA	10.7	<1
CCURS-3	12/10/2002	R4	13	0.168	0.05	2.02	0.058	240	NA	10	1.3
CCURS-3	1/31/2003	R5	55	0.246	0.052	1.40	0.077	1120	NA	10.00	2.6
CCURS-3	3/12/2003	R6	16	0.087	0.052	2.10	0.117	52	NA	11.0	NA
CCURS-3	4/17/2003	R7	1	0.057	0.040	2.05	0.020	66	NA	12.2	NA
CCURS-3	5/15/2003	R8	6.8	0.080	0.031	2.35	0.018	84	NA	11.7	NA
CCURS-3	6/26/2003	R9	1.8	0.050	0.042	2.60	0.026	46	NA	10.8	NA
CCURS-3	8/5/2003	R10	0.75	0.064	0.048	2.19	0.054	82	NA	11.6	NA
CCURS-3	9/12/2003	R11	<.5	0.06	0.051	2.31	0.067	106.0	NA	9.1	NA
CCURS-3	10/21/2003	R12	11	0.204	0.126	1.93	0.103	>1600	NA	5.44	NA
CCURS-4	8/20/2002	R1	<0.5	0.046	0.039	2.05	<0.01	26	NA	10.2	< 1
CCURS-4	9/18/2002	R2	0.75	0.05	0.051	2.15	0.06	26	NA	10.3	1.06
CCURS-4	11/14/2002	R3	0.8	0.056	0.045	2.25	0.014	24	NA	10.4	<1
CCURS-4	12/10/2002	R4	1.6	0.103	0.094	2.26	0.116	70	NA	10	<1
CCURS-4	1/31/2003	R5	5	0.080	0.050	2.23	0.079	100	NA	9.74	<1
CCURS-4	3/12/2003	R6	1.5	0.058	0.051	2.43	0.075	4	NA	11.0	NA
CCURS-4	4/17/2003	R7	<0.5	0.046	0.039	2.26	0.018	est 8	NA	10.1	NA
CCURS-4	5/15/2003	R8	1.1	0.042	0.037	2.50	0.006	est 18	NA	10.5	NA
CCURS-4	6/26/2003	R9	1.1	0.046	0.042	2.70	0.016	est 8	NA	10.6	NA
CCURS-4	8/5/2003	R10	1	0.063	0.048	2.33	0.069	16	NA	10.9	NA
CCURS-4	9/12/2003	R11	<.5	0.055	0.05	2.39	0.063	30.0	NA	9.1	NA
CCURS-4	10/21/2003	R12	<0.50	0.247	0.056	2.51	0.037	460	NA	7.47	NA

Station	Date	Sampling Round	TSS (mg/L)	TP (mg/L)	SRP (mg/L)	NO (mg/L)	NH3 (mg/L)	FC #/100 mL	e.coli	DO (mg/L)	BOD (mg/L)
CCURS-5	8/20/2002	R1	0.67	0.043	0.037	1.99	<0.01	12	NA	10.7	< 1
CCURS-5	9/18/2002	R2	0.86	0.042	0.046	2.2	0.018	<2	NA	10.8	1.6
CCURS-5	11/14/2002	R3	4.7	0.051	0.042	2.34	0.011	180	NA	11.3	<1
CCURS-5	12/10/2002	R4	4.6	0.071	0.044	2.3	0.021	104	NA	10.3	<1
CCURS-5	1/31/2003	R5	33	0.138	0.046	2.28	0.090	340	NA	10.80	2.08
CCURS-5	3/12/2003	R6	2.4	0.048	0.041	2.32	0.016	22	NA	10.3	NA
CCURS-5	4/17/2003	R7	0.5	0.050	0.042	2.35	0.014	<2	NA	10.1	NA
CCURS-5	5/15/2003	R8	1.3	0.046	0.042	2.55	0.012	64	NA	10.5	NA
CCURS-5	6/26/2003	R9	<0.5	0.036	0.036	3.01	0.057	<2	NA	10.3	NA
CCURS-5	8/5/2003	R10	5.2	0.052	0.043	2.21	0.009	16	NA	10.2	NA
CCURS-5	9/12/2003	R11	2.8	0.044	0.041	2.46	0.011	20	NA	10.6	NA
CCURS-5	10/21/2003	R12	12	0.061	0.047	2.51	0.012	840	NA	10.00	NA
CCURS-6	8/20/2002	R1	19	0.162	0.033	1.85	0.026	144	NA	10.2	1.2
CCURS-6	9/18/2002	R2	13.8	0.125	0.046	1.98	0.103	106	NA	9.36	2.1
CCURS-6	11/14/2002	R3	6.7	0.097	0.047	1.93	0.032	100	NA	9.95	<1
CCURS-6	12/10/2002	R4	NS	NS	NS	NS	NS NS	NS	NS	NS	
CCURS-6	1/31/2003	R5	18	0.192	0.062	1.62	0.107	160	NA	9.35	<1
CCURS-6	3/12/2003	R6	12	0.148	0.052	1.97	0.160	80	NA	11.6	NA
CCURS-6	4/17/2003	R7	2.9	0.093	0.036	1.97	0.034	128	NA	8.7	NA
CCURS-6	5/15/2003	R8	2.6	0.054	0.020	1.97	0.032	80	NA	10.0	NA
CCURS-6	6/26/2003	R9	1.8	0.052	0.043	2.58	0.008	est 36	NA	10.7	NA
CCURS-6	8/5/2003	R10	0.75	0.06	0.042	2.12	0.037	40	NA	11.4	NA
CCURS-6	9/12/2003	R11	0.63	0.061	0.046	2.19	0.061	660	NA	7.91	NA
CCURS-6	10/21/2003	R12	10	0.201	0.126	2.02	0.105	>1600	NA	5.48	NA

Station	Date	Sampling Round	TSS (mg/L)	TP (mg/L)	SRP (mg/L)	NO (mg/L)	NH3 (mg/L)	FC #/100 mL	e.coli	DO (mg/L)	BOD (mg/L)
DURS-1	8/20/2002	R1	0.75	0.048	0.042	2.41	<0.01	58	NA	10.8	< 1
DURS-1	9/18/2002	R2	0.25	0.05	0.053	2.27	0.017	280	NA	10.8	1.86
DURS-1	11/14/2002	R3	1.7	0.055	0.041	2.13	<0.01	2	NA	11.7	1.36
DURS-1	12/10/2002	R4	1.3	0.088	0.053	2.08	0.022	34	NA	11.2	1.02
DURS-1	1/31/2003	R5	84	0.451	0.026	1.46	0.018	20	NA	10.80	2.84
DURS-1	3/12/2003	R6	0.87	0.035	0.029	1.77	0.015	2	NA	13.4	NA
DURS-1	4/17/2003	R7	NS	NS	NS	NS	NS NS	NS	NS	NS	
DURS-1	5/15/2003	R8	14	0.185	0.043	2.44	0.010	est 16	NA	10.500	NA
DURS-1	6/26/2003	R9	1.5	0.048	0.042	2.90	0.064	48	NA	11.0	NA
DURS-1	8/5/2003	R10	2	0.058	0.048	2.4	0.009	34	NA	10.9	NA
DURS-1	9/12/2003	R11	0.87	0.057	0.049	2.31	<0.01	38	NA	11.1	NA
DURS-1	10/21/2003	R12	47	0.140	0.046	2.01	0.024	1660	NA	9.43	NA
MDURS-1	8/20/2002	R1	3.5	0.196	0.065	0.519	0.644	360	NA	8.05	1.8
MDURS-1	9/18/2002	R2	4.5	0.22	0.083	0.456	0.792	5600	<300	8.22	3
MDURS-1	11/14/2002	R3	3.3	0.197	0.091	0.481	0.353	100	NA	8.98	<1
MDURS-1	12/10/2002	R4	59	1.1	0.092	0.488	0.523	1200	NA	8.43	4.18
MDURS-1	1/31/2003	R5	186	0.391	0.063	0.76	0.061	1800	NA	9.76	2.38
MDURS-1	3/12/2003	R6	13	0.138	0.057	0.71	0.198	1060	NA	10.0	NA
MDURS-1	4/17/2003	R7	3.7	0.214	0.106	0.72	0.620	540	NA	8.2	NA
MDURS-1	5/15/2003	R8	31	0.779	0.024	0.71	0.695	860	NA	9.5	NA
MDURS-1	6/26/2003	R9	5.8	0.200	0.101	0.77	0.717	1140	NA	7.7	NA
MDURS-1	8/5/2003	R10	3	0.566	0.054	0.616	0.473	300	NA	7.83	NA
MDURS-1	9/12/2003	R11	6.5	2.12	0.112	0.827	0.449	400	>1600	4.96	NA
MDURS-1	10/21/2003	R12	24	0.326	0.069	1.34	0.138	>1600	NA	5.67	NA

Station	Date	Sampling Round	TSS (mg/L)	TP (mg/L)	SRP (mg/L)	NO (mg/L)	NH3 (mg/L)	FC #/100 mL	e.coli	DO (mg/L)	BOD (mg/L)
MDURS-2	8/20/2002	R1	0.83	0.109	0.084	0.707	<0.01	260	NA	8.78	< 1
MDURS-2	9/18/2002	R2	0.87	0.132	0.095	0.77	0.088	1800	NA	7.04	2.16
MDURS-2	11/14/2002	R3	2	0.134	0.087	0.392	0.134	320	NA	9.66	<1
MDURS-2	12/10/2002	R4	125	0.455	0.027	0.356	0.182	1600	NA	10.7	5.98
MDURS-2	1/31/2003	R5	274	0.871	0.044	1.00	0.061	1320	NA	9.94	2.08
MDURS-2	3/12/2003	R6	8.5	0.089	0.038	0.84	0.102	740	NA	10.0	NA
MDURS-2	4/17/2003	R7	5.7	0.122	0.051	0.92	0.131	est 180	NA	7.9	NA
MDURS-2	5/15/2003	R8	2.3	0.111	0.047	1.02	0.089	94	NA	8.6	NA
MDURS-2	6/26/2003	R9	2	0.118	0.079	1.08	0.057	56	NA	8.9	NA
MDURS-2	8/5/2003	R10	44	0.131	0.08	0.904	0.047	600	NA	9.35	NA
MDURS-2	9/12/2003	R11	2.5	0.132	0.085	0.995	0.067	2180	NA	6	NA
MDURS-2	10/21/2003	R12	60	0.258	0.168	1.87	0.154	1340	NA	7.71	NA
RURS-1	9/18/2002	R2	2.38	0.048	0.04	2.55	0.021	260	NA	10.3	<1
RURS-1	11/14/2002	R3	0.67	0.041	0.027	2.56	0.011	44	NA	11.2	<1
RURS-1	12/10/2002	R4	204	0.625	0.027	1.71	0.13	2600	NA	9.38	8.38
RURS-1	1/31/2003	R5	96	0.221	0.026	1.55	0.031	1020	NA	11.80	1.96
RURS-1	3/12/2003	R6	4.4	0.046	0.025	2.41	0.027	1260	NA	13.0	NA
RURS-1	4/17/2003	R7	4.4	0.046	0.025	2.41	0.027	7000	NA	13.0	NA
RURS-1	5/15/2003	R8	2.4	0.038	0.030	2.54	0.014	106	NA	10.7	NA
RURS-1	6/26/2003	R9	3.9	0.042	0.031	3.08	0.043	est 260	NA	10.9	NA
RURS-1	8/5/2003	R10	3.3	0.047	0.031	2.76	0.009	320	NA	11.1	NA
RURS-1	9/12/2003	R11	1.9	0.047	0.035	2.73	<0.01	380	NA	10.2	NA
RURS-1	10/21/2003	R12	14	0.088	0.040	2.62	0.030	1000	NA	9.84	NA

Station	Date	Sampling Round	TSS (mg/L)	TP (mg/L)	SRP (mg/L)	NO (mg/L)	NH3 (mg/L)	FC #/100 mL	e.coli	DO (mg/L)	BOD (mg/L)
WURS-1	12/10/2002	R4	36	0.204	0.041	0.612	0.095	200	NA	12	2.36
WURS-1	1/31/2003	R5	326	0.531	0.031	1.86	0.037	480	NA	*	2.7
WURS-1	3/12/2003	R6	1.9	0.029	0.015	0.96	0.015	6	NA	13.5	NA
WURS-1	4/17/2003	R7	1.9	0.029	0.015	0.96	0.015	2	NA	13.5	NA
WURS-1	5/15/2003	R8	NS	NS	NS	NS	NS NS	NS	NS	NS	
WURS-1	6/26/2003	R9	NS	NS	NS	NS	NS NS	NS	NS	NS	
WURS-1	8/5/2003	R10	NS	NS	NS	NS	NS NS	NS	NS	NS	
WURS-1	9/12/2003	R11	NS	NS	NS	NS	NS NS	NS	NS	NS	
WURS-1	10/21/2003	R12	7.8	0.127	0.073	3.46	0.030	1700	NA	9.40	NA
DPURS-1	9/12/2003	R11	0.87	0.068	0.045	2.2	0.064	1240	NA	7.23	NS
DPURS-1	10/21/2003	R12	21	0.253	0.130	1.63	0.128	>1600	NA	5.25	NA
SCURS-1	9/12/2003	R11	5.2	0.091	0.041	1.15	0.023	540	NA	7.49	NS
SCURS-1	10/21/2003	R12	58	0.243	0.086	1.42	0.078	1840	NA	6.69	NA
PSURS-1	9/12/2003	R11	9.5	0.84	0.204	0.067	3.56	28	NA	6.04	NS
SAVE-1	10/21/2003	R12	6.5	0.205	0.077	1.30	0.663	780	NA	3.57	NA
PAVE-1	10/21/2003	R12	17	0.145	0.066	0.765	0.121	>1600	NA	7.73	NA

SCURS-1: Silver Creek, tributary to Meeker Creek
PSURS-1: Pump Station, tributary to Meeker Creek
SAVE-1: Seventh Avenue Storm Drain, tributary to Clarks Creek
PAVE-1: Pioneer Avenue Pump Station, tributary to Clarks Creek
DPIRS-1: DeCoursey Park Duck Pond, tributary to Clarks Creek

Fecal Coliform Data
(col / 100 mL)

Wet Season

	Jan 14 2002	Dec 10 2002	Jan 31 2003	Mar 12 2003	Sep 122003	Oct 21 2003
Precip (in)	0.55	0.06	1.28	0.50	0.37	1.42
CCURS-5	180	104	340	22	20	840
CCURS-4	24	70	100	4	30	460
CCURS-3	58	240	1120	52	106	1600
CURS-2	80	280	180	740	640	1600
CURS-1	80	106	220	440	280	1600
MDURS-2	320	1600	1320	740	2180	1340
MDURS-1	100	1200	1800	1060	400	1600
DURS-1	2	34	20	2	38	1660
RURS-1	44	2600	1020	1260	380	1000
WURS-1		200	480	6	NS	1700
DPURS-1					1240	1600
SCURS-1					540	1840
SAVE-1					28	780
PAVE-1						1600

Dry Season

	Aug 21 2002	Sep 18 2002	Apr 17 2003	May 15 2003	Jun 26 2003	Aug 5 2003
Precip (in)	0.00	0.15	0.00	0.00	0.00	0.00
CCURS-5	12	2	1	64	1	16
CCURS-4	26	1	8	18	8	16
CCURS-3	84	2	66	84	46	82
CURS-2	94	1	88	60	40	48
CURS-1	180	3	108	106	84	40
CCURS-6	144	2	128	80	36	40
MDURS-2	260	2	180	94	56	600
MDURS-1	360	3	540	860	1140	300
DURS-1	58	2	NS	16	48	34
RURS-1		1	7000	106	260	320
WURS-1			2	NS	NS	NS

Dissolved Oxygen Data

(col / 100 mL)

Clarks Creek *Upstream Stations >>>>>>>>>>>>>>>>>> Downstream Stations*

Date	Prec. (in)	CURS5	CURS4	CURS3	CURS2	CURS1
8/21/2002	0.00	10.7	10.2	9.8	11.5	10.0
9/18/2002	0.15	10.8	10.3	9.7	9.8	9.4
11/14/2002	0.55	11.3	10.4	10.7	10.3	9.5
12/10/2002	0.06	10.3	10.0	10.0	9.9	9.9
1/31/2003	1.28	10.8	9.7	10.0	9.8	9.9
3/12/2003	0.50	10.3	11.0	11.0	11.1	10.4
4/17/2003	0.00	10.1	10.1	12.2	12.0	8.9
5/15/2003	0.00	10.5	10.5	4.4	12.0	10.2
6/26/2003	0.00	10.3	10.6	10.8	11.2	10.1
8/5/2003	0.00	10.2	10.9	11.6	11.6	8.8
9/12/2003	0.37	10.6	9.1	9.1	7.8	6.0
10/21/2003	1.42	10.0	7.5	5.4	5.0	4.8

Tribuatries

Date	Prec (in)	MDURS1	MDURS2	DURS1	RURS1	WURS1
8/21/2002	0.00	8.1	8.8	10.8		
9/18/2002	0.15	8.2	7.0	10.8		
11/14/2002	0.55	9.0	9.7	11.7	11.2	
12/10/2002	0.06	8.4	10.7	11.2	9.4	12.0
1/31/2003	1.28	9.8	9.9	10.8	11.8	
3/12/2003	0.50	10.0	10.0	13.4	13.0	13.5
4/17/2003	0.00	8.2	7.9	NS	13.0	13.5
5/15/2003	0.00	9.5	8.6	10.5	10.7	NS
6/26/2003	0.00	7.7	8.9	11.0	10.9	NS
8/5/2003	0.00	7.8	9.4	10.9		
9/12/2003	0.37	5.0	6.0	11.1	10.2	NS
10/21/2003	1.42	5.7	7.7	9.4	9.8	9.4

			DP	SC	PAVE	SAVE
9/12/2003	0.37	7.23	7.49			
10/21/2003	1.42	1.94	2.11	2.39	1.92	

pH Data
(standard units)

Clarks Creek *Upstream Stations >>>>>>>>>>>>>>>>>>> Downstream Stations*

Date	Prec. (in)	CURS5	CURS4	CURS3	CURS2	CURS1
8/21/2002	0.00	8.1	8.1	7.9	7.8	7.7
9/18/2002	0.15	7.4	7.2	7.3	6.9	6.8
11/14/2002	0.55		7.2	7.3	7.3	7.3
12/10/2002	0.06		7.2	7.3	7.3	7.3
1/31/2003	1.28	7.3	7.1	7.1	6.9	7.0
3/12/2003	0.50	7.7	7.4	7.7	7.3	6.9
4/17/2003	0.00	7.8	7.5	7.7	7.6	6.9
5/15/2003	0.00	7.1	7.8	7.8	7.5	7.2
6/26/2003	0.00		6.6	7.6	7.4	6.7
8/5/2003	0.00	7.5	7.4	6.9	7.2	6.3
9/12/2003	0.37	6.7	6.6			6.8
10/21/2003	1.42		6.8	6.3	6.9	5.9

Tributaries

Date	Prec (in)	MDURS1	MDURS2	DURS1	RURS1	WURS1
8/21/2002	0.00	7.21	7.27	7.53		
9/18/2002	0.15	7.25	7.29	7.04	7.14	
11/14/2002	0.55	7.25	7.29	7.04	7.14	6.9
12/10/2002	0.06	6.57	6.79	6.99	7.12	
1/31/2003	1.28	7.38	7.17	6.8	7.02	6.7
3/12/2003	0.50	7.45	7.27		7.81	8.27
4/17/2003	0.00	7.48	7.48	6.98	7.2	
5/15/2003	0.00	7.4	7.26	5.74	6.62	
6/26/2003	0.00	7.29	7.27	7.45		
8/5/2003	0.00			7.07	9.49	
9/12/2003	0.37	6.88	6.94	6.56	6.8	6.75
10/21/2003	1.42					

		Prec. (in.)	DP	SC	PAVE	SAVE
10/21/2003	1.42	6.7	6.8	6.09	6.16	

Appendix D. Statistical Theory of Rollback

The statistical rollback method describes a way to use a numeric distribution of a water quality parameter to estimate the distribution after abatement processes are applied to sources. The method relies on basic dispersion and dilution assumptions and their effect on the distribution of a chemical or a bacterial population at a monitoring site downstream from a source. It then provides a statistical estimate of the new population after a chosen reduction factor is applied to the existing pollutant source. In the case of the TMDL, compliance with the most restrictive of the dual fecal coliform criteria will determine the reduction factor needed.

As with many water quality parameters, fecal coliform (FC) counts collected over time at an individual site usually follows a lognormal distribution. That is, over the course of a year's sampling period, most of the counts are low, but a few are much higher. When monthly FC data are plotted on a logarithmic-probability graph (the open diamonds in Figure B-1), they appear to form nearly a straight line.

The 50^{th} percentile, an estimate of the geometric mean, and the 90^{th} -percentile, a representation of the level over which ten percent of the samples lie, can be located along a line plotted from an equation estimating the original monthly FC data distribution. In the graphical example, these numbers are 75 cfu/100 mL and 383 cfu/100 mL, respectively. Using the statistical rollback method, the 90^{th} -percentile value is then reduced to 200 cfu/100 mL (Class A 90^{th} -percentile criterion), since 75 cfu/100 mL meets the Class A geometric mean criterion. The new distribution is plotted parallel to the original. The estimate of the geometric mean for this new distribution, located at the 50^{th} percentile, is 39 cfu/100 mL. The result is a geometric mean target of a sample distribution that would likely have less than 10 percent of its samples over 200 cfu/100 mL. A 48percent FC reduction is required from combined sources to meet this target distribution from the simple calculation: (383 - 200) / 383 = 0.477 * 100 = 48percent.

The following is a brief summary of the major theorems and corollaries for the Statistical Theory of Rollback (STR) from *Environmental Statistics and Data Analysis* by Ott (1995).

1. If Q = the concentration of a contaminant at a source, and D = the dilution-diffusion factor, and X = the concentration of the contaminant at the monitoring site, then X = Q*D.
2. Successive random dilution and diffusion of a contaminant Q in the environment often result in a lognormal distribution of the contaminant X at a distant monitoring site.
3. The coefficient of variation (CV) of Q is the same before and after applying a "rollback", i.e., the CV in the post-control state will be the same as the CV in the pre-control state. The rollback factor = r, a reduction factor expressed as a decimal (a 70percent reduction would be a rollback factor of 0.3). The random variable Q represents a pre-control source output state and rQ represents the post-control state.
4. If D remains consistent in the pre-control and post-control states (long-term hydrological and climatic conditions remain unchanged), then CV(Q)*CV(D)=CV(X), and CV(X) will be the same before and after the rollback is applied.

5. If X is multiplied by the rollback factor r, then the variance in the post-control state will be multiplied by r^2, and the post-control standard deviation will be multiplied by r.
6. If X is multiplied by the rollback factor r the quantiles of the concentration distribution will be scaled geometrically.
7. If any random variable is multiplied by a factor r, then its expected value and standard deviation also will be multiplied by r, and its CV will be unchanged. (Ott uses “expected value” for the mean.)

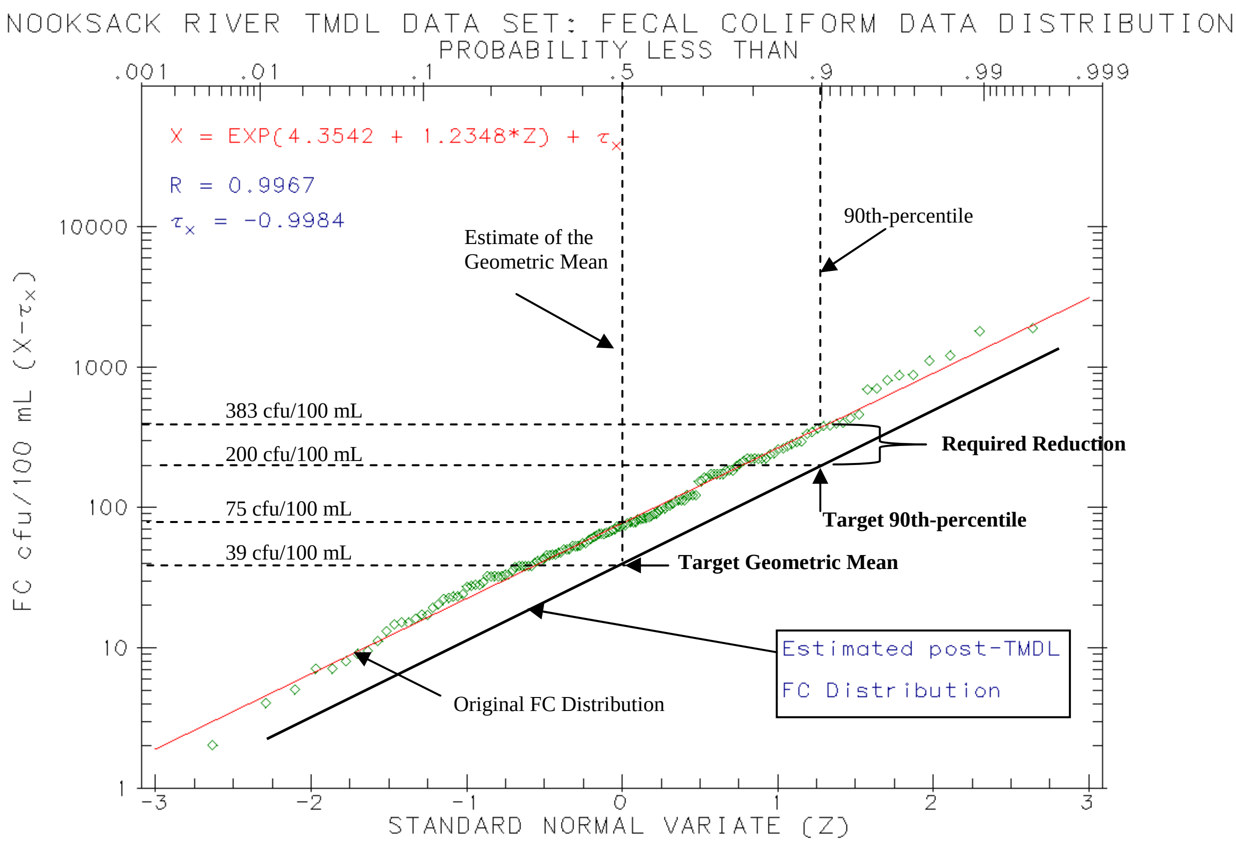

Figure B-1. Graphical demonstration of the statistical rollback method (Ott, 1995) used to calculate the fecal coliform TMDL target on the lower Nooksack River.

Statistical Formulae for Deriving Percentile Values

The 90th-percentile value for a population can be derived in a couple of ways. The set of fecal coliform counts collected at a site were subjected to a statistically-based formula used by the Federal Food and Drug Administration to evaluate growing areas for shellfish sanitation. The National Shellfish Sanitation Program Model Ordinance (USFDA, 2000) states:

The estimated 90th percentile shall be calculated by:

(a) Calculating the arithmetic mean and standard deviation of the sample result logarithms (base 10);

(b) Multiplying the standard deviation in (a) by 1.28;

(c) Adding the product from (b) to the arithmetic mean;

(d) Taking the antilog (base 10) of the results in (c) to get the estimated 90th percentile; and

(e) The MPN values that signify the upper or lower range of sensitivity of the MPN tests in the 90th percentile calculation shall be increased or decreased by one significant number.

The 90^{th}-percentile derived using this formula assumes a log-normal distribution of the fecal coliform data. The variability in the data is expressed by the standard deviation, and with some datasets it is possible to calculate a 90^{th}-percentile greater than any of the measured data.

The 10^{th} and 90^{th}-percentile values for pH and dissolved oxygen were calculated using the EXCEL® spreadsheet based on the rank order of the dataset. The 10^{th}-percentile of a dataset containing n data is estimated as at the k^{th} ordered datum:

$$k = ((n - 1)*0.1) + 1$$

Likewise, the 90^{th}-percentile is calculated:

$$k = ((n - 1)*0.9) + 1$$

For example, given a simple dataset of 10 datum in the following rank order:

6.94, 7.05, 7.07, 7.09, 7.3, 7.32, 7.42, 7.45, 7.52, 7.63

the 10^{th}-percentile is located at ((10 – 1)*0.1) + 1 = 1.9. Between rank 1 (6.94) and rank 2 (7.05), the 10^{th}-percentile is estimated as 7.04. The 90^{th} percentile is located at ((10 – 1)*0.9) + 1 = 9.1. Between rank 9 (7.52) and rank 10 (7.63), the 90^{th}-percentile is estimated as 7.53.

The Simple Method to Calculate Urban Stormwater Loads

I. Annual Load in Pounds (L_P)

$$L_P = 0.226 * R * C * A$$

II. Annual Load in Billions of Colonies (L_C)

$$L_C = 0.001 * R * C * A$$

R = Annual runoff in inches
C = Pollutant concentration in (I): mg/L; or (II) # / 100 mL.
A = Area in acres
0.226 and 0.001 = unit conversion factors
R = P * Pj * Rv
P = Annual rainfall in inches
Pj = Fraction of annual rainfall events that produce runoff
Rv = Runoff coefficient
Rv = 0.05 + 0.9Ia
Ia = Percent impervious cover