WASHINGTON STATE DEPARTMENT OF ECOLOGY

Wilson Creek Sub-Basin Bacteria Total Maximum Daily Load (Water Cleanup Plan)

Submittal Report

June 2005
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Water Quality Program

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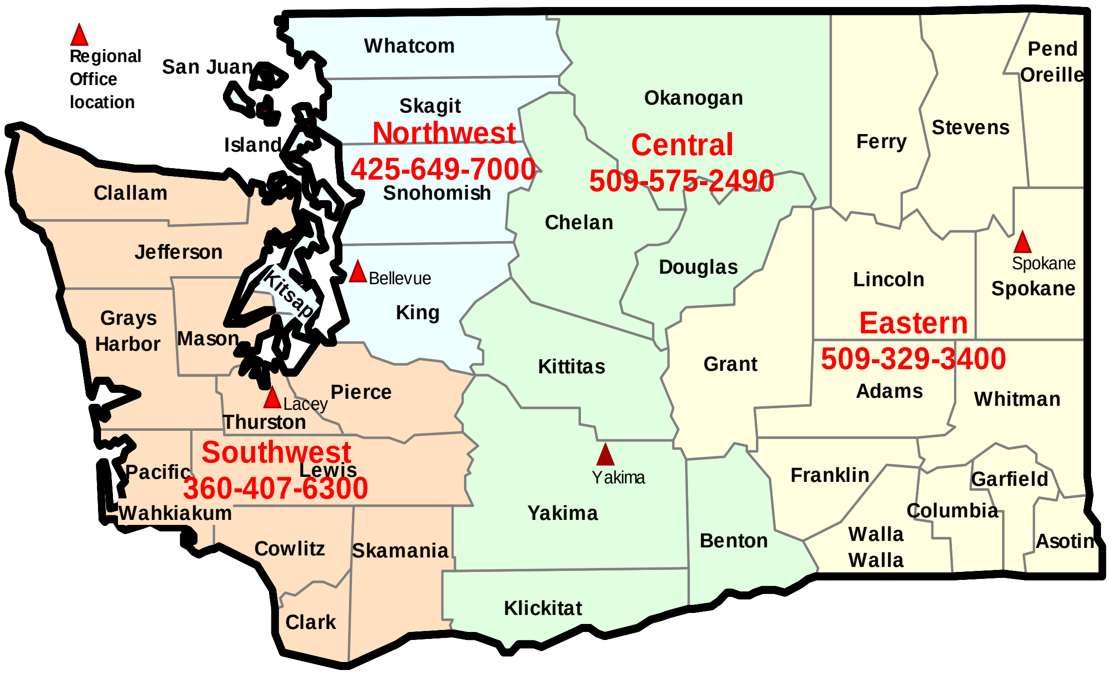

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Acknowledgments

- Many thanks to the members of the TMDL workgroup, for their technical support, wise suggestions, dedication to this project, and patience with our efforts.

- Many thanks to Department of Ecology staff who helped direct and support this project, including Tom Tebb, Jeff Lewis, Derek Sandison, and Ryan Anderson.

Executive Summary

Levels of bacteria in surface water in the Wilson Creek sub-basin have been evaluated by various governmental entities since the 1970s. Fecal coliform (FC) bacteria densities in the sub-basin have been determined to be highly variable. During the period April through October (the critical condition period[1]), the majority of the samples collected down-gradient of the Kittitas Reclamation District (KRD) irrigation canal contained FC densities in excess of the present Washington State (state) Class A water quality criteria. State FC water quality criteria for Class A water bodies are two-tiered: (1) a geometric mean of 100 cfu/100mL, and (2) not more than 10 percent of all samples obtained for calculating the geometric mean exceeding 200 cfu/100mL (90 percent value).

Five background sites were identified in the sub-basin, all located up-gradient of the KRD Canal, which typically were in compliance with the state's Class A water quality criteria for FC bacteria.

At sampling sites down-gradient of the KRD Canal, FC densities were typically not in compliance with the Class A water quality criteria for FC bacteria. These FC densities were also determined to be highly variable, but showed definite seasonality. The highest FC densities were found during the period of June to August (within the critical condition period). From March through June, FC densities and flows both had increasing trends, whereas beginning in July, flows decreased while FC densities continued their upward trend.

Primary sources of FC bacteria in the Wilson Creek sub-basin (listed in alphabetical order) include domestic pets, humans, livestock, and wildlife. The Kittitas County Conservation District recently completed an *Escherichia coli*[2] *(E. coli)* ribotyping study. The study determined that in the Wilson Creek sub-basin, bacterial isolates identified were attributable to the following animal host species (listed in alphabetical order): beaver/otter, birds, canine, cattle, deer, feline, horse, human, muskrat, opossum, porcupine, poultry, prairie dog, rabbit, raccoon, rodents, sheep, and shrew. About one-fifth of the bacterial isolates were unidentifiable. The results of such RNA analyses provide a reasonable qualitative (but not quantitative) indication of the predominant animal sources of FC bacteria within the sub-basin and show the complexity of the FC bacteria non-point sources.

Secondary sources potentially include bacterial re-growth and re-suspension from bottom sediments. Bacterial contributions from re-suspension are typically much greater than from re-growth, especially during high flows. However, as the source contributions of bacteria are reduced, re-suspension should eventually decline.

The two main transport mechanisms of FC bacteria in the Wilson Creek sub-basin are direct deposition and overland runoff. Overland runoff is the movement of water across the surface of the ground, and includes precipitation, snowmelt, and irrigation water. The second major transport mechanism is direct deposition of manure into the sub-basin's surface waters from

[1] See Appendix A for definition
[2] *Escherichia coli (E. coli)* is the most common type of fecal coliform bacteria.

wildlife and agricultural animals, as well as direct discharges from inadequate on-site septic systems and wastewater treatment facilities.

The ultimate goal of this total maximum daily load (TMDL) project is to comply with the state's current water quality standard: a geometric mean of 100 cfu/100mL and a 90% value of 200 cfu/100mL.

The wasteload allocation for the city of Kittitas wastewater treatment plant (POTW) will be (1) monthly average = 100 cfu/100mL; and (2) daily maximum = 200 cfu/100 mL. Ellensburg may be required to comply with the Phase II stormwater regulations; if so, the wasteload allocation for Ellensburg's storm water will be equal to Class A FC criteria (geometric mean of 100 cfu/100mL and a 90% value of 200 cfu/100mL). The wasteload allocation for the Concentrated Animal Feeding Operations (CAFOs)[3] in the watershed will be equal to zero because of the no-discharge requirement for all such facilities.

The Washington State Department of Ecology (Ecology) recognizes that there is a significant amount of FC bacteria contributed by wildlife to the water bodies throughout the sub-basin. Ecology also recognizes that nonpoint anthropogenic FC inputs may be significantly reduced (even if not 100 percent eradicated) through voluntary implementation of best management practices (BMPs). After initial development of the implementation plan, and as part of that plan, monitoring and adaptive management will be utilized to guide BMPs so that they are implemented in an efficient and effective manner.

Activities that will be undertaken to reduce anthropogenic bacterial inputs include improved irrigation management, improved pasture management, locating and fixing failing septic systems on waterfront property, fencing and other practices that reduce livestock contact with area water bodies, as well as public education regarding management of pet waste.

Groups responsible for implementing these actions include city, county and local governments, livestock managers, irrigators and waterfront property owners. Conservation agencies will provide technical and financial assistance, where possible.

In the future, microbial source tracking techniques are expected to develop to a point where they are more cost-effective and reliable, and their results are more widely accepted for quantitative purposes. As this happens, further source-tracking data will be collected, to promote more efficient voluntary implementation of BMPs.

As a result of this implementation, the community will attempt to reduce FC bacteria levels by up to 86 percent in the Wilson Creek sub-basin in order to meet TMDL targets in 2020.

[3] See Appendix A for definition.

Introduction

The Washington State Department of Ecology (Ecology) is establishing a total maximum daily load (TMDL) for the Wilson Creek sub-basin, which covers the pollution parameter of fecal coliform bacteria. This TMDL will address potential impairments of beneficial uses of Wilson Creek and its tributaries, some of which include water bodies listed in the 1998 Section 303(d) list of Washington State impaired surface waters.

Section 303(d) of the federal Clean Water Act mandates that the state of Washington (state) establish Total Maximum Daily Loads (TMDLs) for surface waters that do not meet standards after application of technology-based pollution controls[4]. The U.S. Environmental Protection Agency (EPA) has established regulations (40 CFR Part 130) and created guidance (EPA, 1991; EPA, 2001) for setting TMDLs. Ecology has also produced guidance for developing TMDLs (Butler, et al., 2002).

The Clean Water Act requires that states develop water quality standards to protect beneficial uses, such as swimming, fishing, and aquatic life habitat. Water quality standards consist of (1) beneficial uses designated to waters of the state, and (2) criteria to protect those uses. Criteria can be specific numeric limits set at a level to protect the use, or they can be narrative criteria designed more generally to protect uses. An example of a narrative criterion is the requirement that upstream actions must be conducted in a manner that meets downstream water body criteria. Narrative criteria typically require an analysis of the impacts to a use in order to develop controls or limits to meet it.

The goal of a TMDL is to ensure that the impaired water body will attain water quality standards within a reasonable period of time. A TMDL includes a written, quantitative assessment of the water quality problem and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant, called the **loading capacity**, which can be discharged to the water body and still meet water quality standards and, subsequently, allocates that load among the various sources. If the pollutant comes from a discrete source (referred to as a **point source**) such as an industrial facility's discharge pipe, that facility's share of the loading capacity is called a **wasteload allocation (WLA)**. If the pollution comes from a diffuse source (referred to as a **non-point source**), that share is called a **load allocation (LA)**.

The TMDL must also consider seasonal variations and include a **margin of safety (MOS)** that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. The sum of the individual allocations and the MOS must be equal to or less than the loading capacity.

A detailed implementation plan (DIP) must be developed within one year after TMDL approval by EPA, and will be based on the information presented in this document.

[4]*Technology-based pollution controls* are industry-specific *effluent* limitations applied to a *discharge* so that it will not cause a violation of *water quality standards* at low stream flows. Note that the alternative type of effluent limitation is the *water-quality based pollution controls*, which are based on the receiving water quality and are generally more stringent than the technology-based pollution controls.

Components of the TMDL

The five components of any TMDL as required by the Clean Water Act are defined as:

Loading Capacity: The maximum amount of the pollutant parameter loading that a receiving water can absorb without violating the respective state water quality standard.

Wasteload Allocation: That portion of a receiving waters' loading capacity that is allocated, or attributed, to existing and potential point sources of FC pollution. The only permitted point sources presently in the Wilson Creek sub-basin are the Kittitas municipal wastewater treatment plant, and a single active CAFO. The wasteload allocation for the city of Kittitas wastewater treatment plant (POTW) will be (1) monthly average = 100 cfu/100mL; and (2) daily maximum = 200 cfu/100 mL. Individual CAFO permits do not allow any wastewater discharge except as a result of a greater than 25-year, 24-hour storm event. Finally, the city of Ellensburg may be required to comply with the Phase II stormwater regulations; if so, the wasteload allocation for Ellensburg's storm water will equal the Class A FC criteria (geometric mean of 100 cfu/100mL and a 90% value of 200 cfu/100mL).

Load Allocation: That portion of a receiving waters' loading capacity that is attributed to existing and potential non-point sources of pollution, and to natural background sources.

Margin of Safety: The size of the margin of safety (MOS) is inversely proportional to the confidence in the data utilized in the calculations of load allocations. Two conservative assumptions were identified that provide an inherent MOS.

Seasonal Variation: Water quality data collected in the Wilson Creek sub-basin shows a significant pattern of seasonal variation. The greatest FC pollution was measured during the period from April through October; therefore, the critical condition period for the TMDL evaluation and compliance is considered to be April through October.

Background

The Wilson Creek sub-basin is located on the east side of the Cascade Mountain range within Kittitas County, near the geographic center of the state of Washington (state), and drains most of the area surrounding the city of Ellensburg. The climate of the sub-basin is considered semi-arid, with an average annual rainfall of 8.9 inches. The sub-basin covers approximately 244,500 acres (394 sq. miles) of land. Land uses in the basin vary from forestland, range, and intensively irrigated agriculture to urban and suburban areas. A network of supply canals, diversions, and irrigation return drains are concentrated in the Wilson Creek sub-basin. Water from the Yakima River and the streams flowing through the valley is directed through the sub-basin by a complicated network of irrigation canals. Figure 1 (provided by the KRD) gives an overview of the water bodies in the Wilson Creek sub-basin.

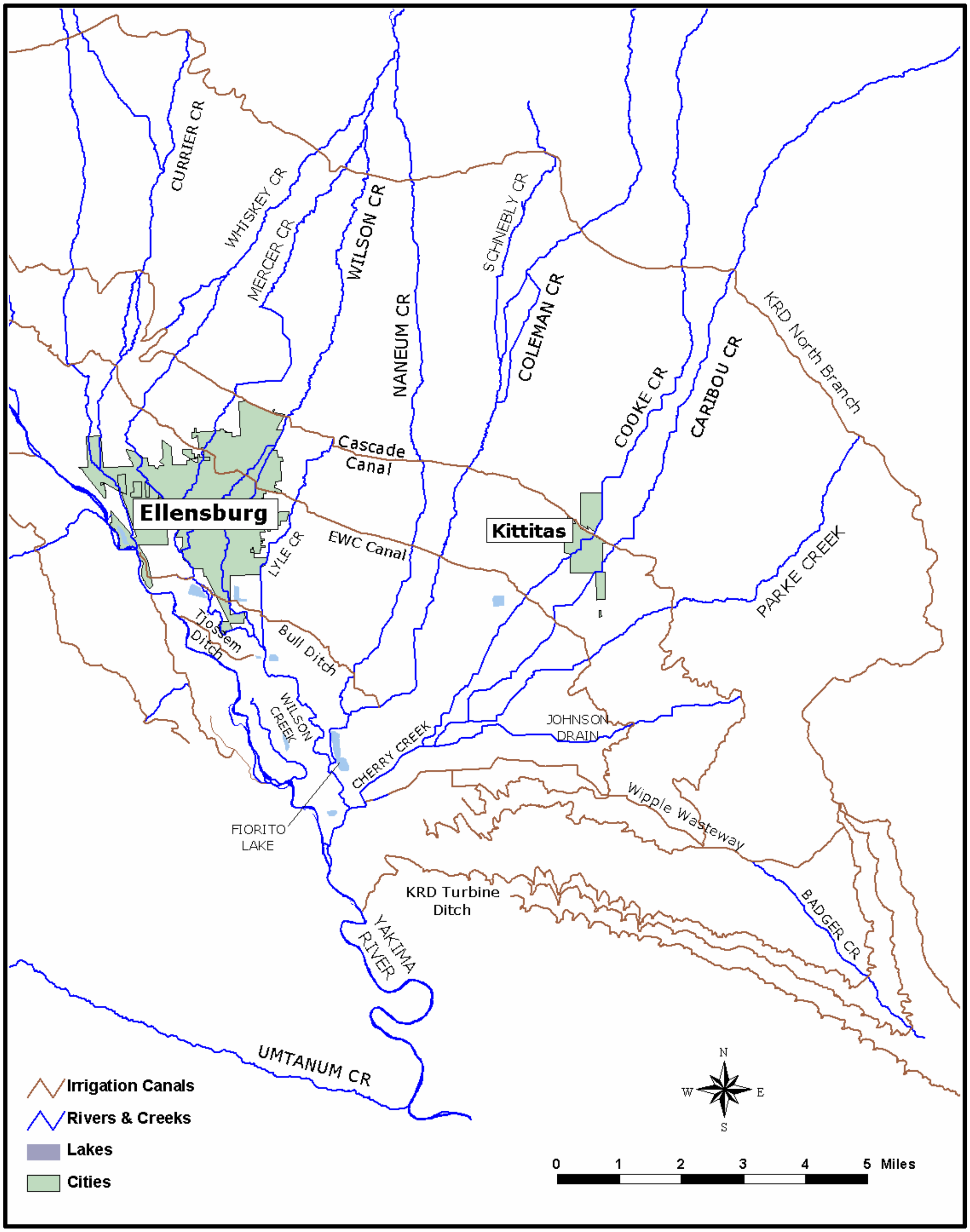

Figure 1: Water bodies (creeks, canals, and drains) in the Wilson Creek sub-basin.

The mainstem of Wilson Creek, the area's principal water body, discharges into the Yakima River and is composed primarily of irrigation return flow[5] during the irrigation season. The TMDL primary monitoring and assessment area consists of Wilson Creek and its tributaries. All of these surface waters are located within the Water Resource Inventory Area (WRIA) 39.

Within the Wilson Creek sub-basin, some creeks were placed on both the state 1996 and 1998 303(d) lists of impaired water bodies due to the water quality parameters exceeding the state Class A water quality standards. Two of the sub-basin creeks (Cooke Creek and Wilson Creek) were determined to have exceeded the state's Class A numeric two-tiered FC water quality criteria.

The listing of Cooke Creek and Wilson Creek as being *impaired* for FC bacteria indicates that such water bodies pose a potential health hazard to those persons having primary contact with them. Ecology must conduct a TMDL assessment for all impaired, 303(d)-listed water bodies. TMDLs are defined in 40 CFR Part 130 as the determination of maximum allowable individual point source wasteload allocations and non-point source load allocations. A previous TMDL for sediment, turbidity, and organochlorine pesticides[6] is already underway in the project area of the *Wilson Creek Sub-Basin Bacteria TMDL*.

In April 2004, the *Wilson Creek Sub-Basin Bacteria TMDL Technical Assessment* was completed by Ecology. This report found that:

1. Although the five upstream sites met state Class A water quality criteria for bacteria, most downstream sites did not meet these same criteria during the critical condition period (April – October).
2. The primary sources of FC bacteria in the Wilson Creek sub-basin are a composite of wildlife, agricultural animals, pets and humans. Potential secondary sources of FC bacteria in the Wilson Creek sub-basin are bacterial re-growth and re-suspension of streambed bacteria deposits.
3. The principal transport mechanisms of FC bacteria in the Wilson Creek sub-basin are direct deposition, as well as overland runoff caused by storm water (precipitation and snowmelt) and irrigation.
4. A bacterial source tracking study, performed by the KCCD, identified these primary sources of FC bacteria in the Wilson Creek sub-basin (listed alphabetically): domestic pets, humans, livestock, "unknown" and wildlife.

The purpose of the *Wilson Creek Sub-Basin Bacteria TMDL* project is to evaluate the effect of FC loads on water quality in the Wilson Creek sub-basin during the critical season (April through October), and to recommend best management practices (BMPs) for reducing FC bacteria in order to meet the water quality targets outlined in this TMDL. All agricultural BMPs should be approvable by the Natural Resources Conservation Service (NRCS), Kittitas County Conservation District (KCCD) and/or Washington State University (WSU) Extension Service. BMPs not related to agricultural applications should be approvable by Ecology.

[5] See Appendix A for definition
[6] The *Upper Yakima River Basin Suspended Sediment, Turbidity, and Organochlorine Pesticides TMDL*

The success of this TMDL is largely dependent on the willing cooperation of area stakeholders; in particular, livestock managers, irrigators, pet owners, waterfront landowners, and city and county governments. Therefore, it is critical that a firm bond of trust be established between these stakeholders and Ecology, with the understanding that stakeholders and Ecology will work toward sustainable[7] solutions and the voluntary implementation of appropriate BMPs, as all parties work together to meet the targets of this TMDL.

Applicable Water Quality Standards

Within the state, water quality standards are published pursuant to Chapter 90.48 of the Revised Code of Washington (RCW). Authority to adopt rules, regulations, and standards as necessary to protect the environment is vested with Ecology. Under the federal Clean Water Act, the EPA Regional Administrator must approve the water quality standards adopted by the state (Section 303(c) (3)). Through adoption of these water quality standards, the state has designated certain characteristic uses to be protected and the standards necessary to protect these uses [Chapter 173-201A of the Washington Administrative Code (WAC)]. These standards were last adopted in November 1997.

The key components of the state water quality standards are:

1. The designated uses assigned to water bodies (*e.g.*, fishing, swimming, boating, aquatic life and wildlife habitat, and water supply).
2. The numerical and narrative criteria set to protect those uses.
3. An overarching water quality antidegradation policy that provides added protection for water quality and designated uses.

All three of these components must be met in the water body and met by human activities that affect the quality of the water or its ability to support its designated uses.

The numerical water quality criteria are set at levels that fully protect designated uses. This ensures those uses will be fully protected when the water quality criteria are attained.

All of the surface waters within the area of study of the *Wilson Creek Sub-Basin Bacteria TMDL* are designated Class A water bodies. The characteristic beneficial uses and water quality standards for these classifications are listed in Table 1. State law does not establish a ranking or priority among the beneficial uses, but individual waters are expected to support all uses within the classification. This TMDL is designed to address impairments of characteristic (beneficial) uses in the watershed surface waters due to high levels of FC bacteria in the sub-basin.

[7] See Appendix A for definition

Table 1: Class A Water Quality Standards (freshwater) applicable to this TMDL

General:	Water of this class shall meet or exceed the requirements for all or substantially all uses.
Characteristic Uses:	Shall include, but not be limited to, the following: water supply (domestic, industrial, agricultural); stock watering; fish and shellfish: salmonid migration, rearing, spawning, and harvesting; other fish migration, rearing, spawning, and harvesting; crustaceans and other shellfish (crayfish) rearing, spawning, and harvesting; wildlife habitat; recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment); commerce and navigation.
Fecal Coliform:	Shall both not exceed a geometric mean value of 100 cfu/100mL and not have more than 10% of all samples obtained for calculating the geometric mean value exceeding 200 cfu/100mL.
Aesthetic Values:	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.

Water Quality and Resource Impairments

As a consequence of monitoring (Appendix) that indicated the state Class A FC water quality criteria had been exceeded, various surface waters within the Wilson Creek sub-basin were found to be impaired (see Table 2, below). Two of these water bodies (Cooke Creek and Wilson Creek) were previously included on both the state's 1996 and 1998 Section 303(d) lists.

Table 2: A summary of water bodies in the Wilson Creek sub-basin that exceed Class A water quality standards for fecal coliform bacteria.

Water body Name	Old ID#	New ID#	Town-ship	Rng.	Sec.	1996 303(d) List	1998 303(d) List	Unlisted Impaired*
Badger Creek		GI16HA	16N	20E	6			X
Bull Ditch			17N	19E	18			X
Caribou Creek		QB79IB	17N	19E	21			X
Caribou Creek		QB79IB	18N	20E	17			X
Cherry Creek	WA-39-1032	FT68CJ	17N	19E	29			X
CID Canal		GI16HA	17N	19E	35			X
CID Canal		GI16HA	17N	19E	33			X
Coleman Creek		QD56OA	18N	19E	14			X
Cooke Creek	WA-39-1034	SZ58XV	17N	19E	2			X
Cooke Creek**	WA-39-1034	SZ58XV	17N	19E	10		X	
Cooke Creek	WA-39-1034	SZ58XV	17N	19E	11	X	X	
Cooke Creek	WA-39-1034	SZ58XV	18N	20E	6			X
Cooke Creek	WA-39-1034	SZ58XV	18N	20E	18			X
EWC Canal		GZ06QM	17N	19E	6			X
EWC Canal		GZ06QM	18N	18E	26			X
Johnson Drain		NG76PO	17N	19E	22			X
KRD Canal		XD64YT	16N	19E	5			X
Mercer Creek		EY18WK	18N	19E	5			X
Naneum Creek	WA-39-1025	MA29CN	17N	19E	19			X
Parke Creek		NG76PO	17N	19E	22			X
Whiskey Creek		SO19BM	18N	19E	6			X
Wilson Creek	WA-39-1020	PY59BF	17N	18E	11			X
Wilson Creek***	WA-39-1020	PY59BF	17N	19E	30		X	
Wilson Creek	WA-39-1020	PY59BF	17N	19E	31	X		X
Wilson Creek	WA-39-1020	PY59BF	18N	19E	8			X
Wilson Creek	WA-39-1020	PY59BF	18N	19E	30		X	
Wipple Wasteway		GI16HA	17N	20E	31			X
Wipple Wasteway		GI16HA	17N	19E	26			X
Wipple Wasteway		GI16HA	17N	19E	28			X

* Impaired = does not meet state water quality standards.

** No additional data was collected at the site of the original listing (Sec. 10). Later FC data was collected just upstream and downstream from this location.

*** This site is Wilson Creek at Thrall Road, which was incorrectly identified on the 1996 and 1998 303(d) as being located at T17N R18E Sec. 25. Location information in the above table is correct.

The presence of FC bacteria in a water sample does not necessarily mean that pathogenic organisms are present, but it is an indicator. Excessive FC densities in a water body represent a statistically significant potential health risk for human beings due to pathogenic organisms, and could result in the loss of beneficial uses like swimming, fishing, boating, incidental contact, and water sports.

Beneficial uses of water bodies are required to be protected by both the federal Clean Water Act (CWA) and the state's own surface water quality standards. However, the local irrigation districts specifically prohibit most of the above-listed beneficial uses in their canals. Therefore, in a future formal process not related to this TMDL, certain local interests intend to initiate procedures to change current designated uses for some sub-basin water bodies.

Seasonal Variation

Water quality data collected in the Wilson Creek sub-basin, for this TMDL study and for other studies, shows a significant pattern of seasonal variation. The greatest FC pollution was measured during the period from April through October; therefore, the critical condition season for the *Wilson Creek Sub-Basin Bacteria TMDL* is considered to be April through October.

At sampling sites downgradient of the KRD Canal, the greatest FC densities were found during the period of June through August. From March through June, FC densities and flows both had increasing trends, whereas beginning in July, flows decreased while FC densities continued their upward trend to October.

TMDL Analysis

The majority of the following findings are associated with the recent (1999-2002) water quality monitoring data collected by the KCCD, KRD, and Ecology, as described in the *Wilson Creek Sub-Basin Total Maximum Daily Load Technical Assessment* (Appendix E).

Five sampling sites, all located upgradient of the KRD Canal, were identified as being representative of upstream conditions. The sites and their bacteria densities, are described in Table 3, below. It should be noted that these upstream sites are not pristine and include a limited amount of anthropogenic-related activities.

Table 3: Upstream sampling sites and respective bacteria densities.

Water body Name	Sampling Site Location	Sample Site Number	Geom. Mean During Critical Condition (cfu/100 mL)	90% Value During Critical Condition (cfu/100 mL)	Year of Data Collection / Sampler
Coleman Creek	Coleman Creek Rd.	CL-1	22	91	1999 / Ecology
Cooke Creek	Cooke Canyon Rd.	CK-1	90	300	1999 / Ecology
Naneum Creek	Naneum Rd.	NC-1	9	42	1999 / Ecology
Naneum Creek	Charlton/Farrell Rd.	NC-2	28	130	2000 & 2001 / KRD
Schnebly Creek	End of Fairview Rd.	SC-1	Not enough data to calculate.		1999 / Ecology

A sub-basin-wide statistical analysis of pooled monthly FC densities determined that June, July, and August had the largest FC densities, while March and November had the lowest FC densities. No samples were collected during January, February and December. The critical condition period (when FC densities exceeded the state's Class A FC water quality criteria) for the *Wilson Creek Sub-Basin Bacteria TMDL* was determined to be from April through October, which coincides with the onset and duration of warmer weather and the area's irrigation season.

A sub-basin-wide statistical analysis of pooled monthly water temperatures determined that July and August had the warmest water temperatures, while March and November had the coolest water temperatures. No samples were collected during January, February, and December. The distribution of monthly average water temperatures was very similar to the distribution of monthly geometric mean FC densities.

A sub-basin-wide statistical analysis of pooled monthly flow data determined that May and June had the largest flows, while November had the lowest flows. No samples were collected during January, February, and December. Flows in the Wilson Creek sub-basin show two distinct seasons: a large increasing trend during the March through June season, and a smaller more consistent July through October season that diminishes in November.

The diverted irrigation water entering the sub-basin via irrigation canals complies with the state Class A FC water quality criteria. However, all of the tail-end sections of those same irrigation canals have FC densities that are in excess of the same criteria. Therefore, the FC densities during the summer are concluded to have been produced within the sub-basin and not transported into the sub-basin along with the irrigation water supply.

In their recent *E. coli* ribotyping study conducted in the Wilson Creek sub-basin, the KCCD found that bacterial isolates identified were attributable to the following animal host species (listed in alphabetical order): beaver/otter, birds, canine, cattle, deer, feline, horse, human, muskrat, opossum, porcupine, poultry, prairie dog, rabbit, raccoon, rodents, sheep, and shrew. About one-fifth of the bacterial isolates were unidentifiable. This ribotyping study provides a reasonable qualitative (but not quantitative) indication of the predominant animal source species of *E. coli* bacteria within the sub-basin. Bacterial source tracking methods are still in the experimental stage and their results should be used with caution. However, this study helps illustrate the complexity of the FC bacteria non-point pollution problem. Moreover, the source information gathered from this study will help to determine the appropriate BMPs for implementation in order to reduce FC densities.

The principal transport mechanisms of FC bacteria within the Wilson Creek sub-basin are direct deposition by animals, as well as overland runoff.

Loading Capacity

Loading capacity is defined as the maximum amount of a pollutant that a water body can receive and still meet the state applicable surface water quality standards. The TMDL will not establish a specific loading capacity per se for each individual water body, but rather will achieve similar results by establishing a final TMDL target of reaching compliance with the state Class A FC water quality criteria.

Since the majority of the water bodies in the Wilson Creek sub-basin exceed the state Class A FC water quality criteria during the critical condition period, the final TMDL target will apply to all surface waters within the sub-basin. Specific sampling points of compliance are listed in Table 4; these 17 sampling points are intended to reflect the status of the water bodies currently listed as FC-impaired in Table 2.

This TMDL uses a different measure than *daily loads* to fulfill the requirements of Section 303(d). FC density will be used as allowed under EPA regulations [defined as *other appropriate measures* in 40 CFR §130.2(I)]. In such cases, a density measure is appropriate due to the consistent relationship between the FC water quality criteria and the receiving water quality for all receiving flow rates.

Load and Wasteload Allocations

As stated in the objectives for this TMDL, this assessment sets FC wasteload allocations for individual point sources and a single load allocation for all non-point sources located within the Wilson Creek sub-basin.

Wasteload Allocations

The Wilson Creek sub-basin contains one municipal point source: the city of Kittitas municipal wastewater treatment plant (NPDES permit = WA-002125-3). The sub-basin contains no known industrial/commercial point sources.

The city of Kittitas recently upgraded its municipal wastewater treatment plant, which included a conversion from chlorine to UV disinfection. Current FC limitations are: (1) monthly average = 100 cfu/100mL; and (2) weekly average = 200 cfu/100 mL. The city of Kittitas' current NPDES permit has an expiration date of September 30, 2006. All subsequent NPDES permits written for the city of Kittitas shall be required to contain bacterial effluent limits no less stringent than: (1) monthly geometric mean = 100 cfu/100mL; and (2) daily maximum of = 200 cfu/100 mL. Such limitations are more stringent than the facility's previous NPDES permits and will help to assure that the *Wilson Creek Sub-Basin Bacteria TMDL* will comply with state water quality standards.

The Wilson Creek sub-basin contains various animal source species of FC bacteria. CAFOs will be given an automatic wasteload allocation of zero because they are required to have no discharge of pollutants to the waters of the state, except under extreme circumstances. The only active CAFO in the sub-basin is Central Valley Holstein (WA-005229-9). It has been issued an NPDES permit that requires no discharge, unless caused by a storm event in excess of the area's 25-year, 24-hour precipitation amount.

Finally, the city of Ellensburg may be required to comply with the Phase II stormwater regulations. In this case, the wasteload allocation for Ellensburg's storm water shall be equal to Class A FC standards (geometric mean of 100 cfu/100mL and a 90% value of 200 cfu/100mL).

Load Allocations

A single load allocation has been determined for all non-point sources of FC pollution in the Wilson Creek sub-basin. The load allocation is compliance with the Class A FC water quality criteria of a geometric mean of 100 cfu/100mL and a 90% value of 200 cfu/100mL. The percent reductions in FC densities listed in Table 4 were determined through statistical analysis of the bacteria monitoring data, and subsequent comparison to both tiers of the state Class A FC water quality criteria. See Appendix D for more description of this method.

Table 4: Estimated reductions in FC densities necessary to meet Class A water quality standards.

Water body Name	Sampling Site Location	Geom. Mean During Critical Condition (cfu/100 mL)	90% Value During Critical Condition (cfu/100 mL)	Target Reduction Needed at Sampling Site (to Meet Class A FC Standards)
Badger Creek	above confluence with Wipple Wasteway	292	1,400	67.7%
Bull Ditch	at Tjossem Road	488	3,000	80.9%
Caribou Creek	at S. Ferguson Road	428	4,000	78.5%
CID Canal	at Thrall Road	570	2,300	83.3%
Cherry Creek	at Moe Road	402	1,200	75.9%
Coleman Creek	at Moe Road	378	1,400	74.8%
Cooke Creek	at #81 Road	492	5,900	81.4%
Cooke Creek	at S. Ferguson Road	300	1,140	68.2%
EWC Canal	at Thrall Road	499	3,000	81.3%
Johnson Drain	at S. Ferguson Road	616	1,800	84.3%
Mercer Creek	at KRD Canal	319	2,640	71.0%
Naneum Creek	at Fiorito Pond	265	620	62.8%
Parke Creek	at S. Ferguson Road	328	5,940	72.2%
Whiskey Creek	at KRD Canal	263	2,500	65.0%
Wilson Creek	at Sanders Road	552	1,000	81.7%
Wilson Creek	at Thrall Road	248	720	60.9%
Wipple Wasteway	at Moe Road	235	720	58.9%

Ecology recognizes that there is a significant amount of FC bacteria contributed by wildlife to the water bodies throughout the sub-basin. Ecology also recognizes that nonpoint anthropogenic FC inputs may be significantly reduced (even if not 100 percent eradicated) through voluntary implementation of best management practices (BMPs). After initial development of the implementation plan, and as part of that plan, monitoring and adaptive management will be utilized to guide BMPs so that they are implemented in an efficient and effective manner.

Compliance Targets and Schedule

First Interim Target: October 2010

During the critical condition period (April through October) of 2010, water samples collected at each of the sampling locations identified in Table 4 shall comply with the more stringent of either 1) a maximum geometric mean FC density of 500 cfu/100 ml and a maximum 90% value FC density of 1,500 cfu/100 ml or 2) existing conditions[8] as illustrated in Table 4.

Second Interim Target: October 2015

During the critical condition period (April through October) of 2015, water samples collected at each of the sampling locations identified in Table 4 shall comply with the more stringent of either 1) a maximum geometric mean FC density of 300 cfu/100 ml and a maximum 90% value FC density of 600 cfu/100 ml, or 2) existing conditions [9] as illustrated in Table 4.

Final Targets: October 2020

During the critical period (April through October) of 2020, water samples collected at each of the sampling locations identified in Table 4 shall comply with a maximum geometric mean FC density of 100 cfu/100 ml and a maximum 90% value FC density of 200 cfu/100 ml.

After all appropriate and practical BMPs have been implemented, then Ecology and the TMDL workgroup will re-evaluate jointly whether or not standards are being met. If water quality standards are not being met, then stakeholders can evaluate whether they have sufficient information and a basis for seeking to change the standards, or stakeholders (including Ecology) can re-evaluate the way existing standards (*e.g.*, natural conditions) apply to the watershed.[10]

In the future, microbial source tracking techniques are expected to develop to a point where they are more cost-effective and reliable, and their results are more widely accepted for quantitative purposes. As this happens, further source-tracking data will be collected to promote more efficient voluntary implementation of BMPs.

The success of this TMDL is primarily dependent on the willing cooperation of area stakeholders; in particular, livestock managers, irrigators, waterfront landowners, and city and county governments. Therefore, it is critical that a firm bond of trust be established between these stakeholders and Ecology, with the understanding that stakeholders and Ecology will work

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[8] Note that some sites currently have FC densities that are already lower than the interim targets, and Washington State's antidegradation provisions (WAC 173-201A-070) require that the water body will not degrade below existing conditions.

[9] Note that some sites currently have FC densities that are already lower than the interim targets, and Washington State's antidegradation provisions (WAC 173-201A-070) require that the water body will not degrade below existing conditions.

[10] EPA contributed the language for this paragraph.

toward sustainable[11] solutions and the voluntary implementation of appropriate BMPs, as all parties work together to meet the targets of this TMDL.

Margin of Safety

The margin of safety for this TMDL study is implicit through the use of conservative assumptions, summarized below.

The estimated targets do not account for any bacterial die-off in the water column or during travel from the source to the stream. As nearby sources are removed from the stream, bacterial travel time from the remaining sources to the stream would increase. Correspondingly, this would allow for greater exposure of the bacteria to environment conditions such as sedimentation, filtration, and predation, all of which would result in an increased potential for bacterial die-off.

Target reductions were based on seasonal evaluations where sufficient data were available. BMPs based on seasonal targets will substantially reduce the annual load at the various segments and tributaries.

[11] See Appendix A for definition

Summary Implementation Strategy

Introduction

Pursuant to the 1997 Memorandum of Agreement between Ecology and the EPA, a summary implementation strategy (SIS) is included in this submittal report for the *Wilson Creek Sub-Basin TMDL Evaluation*. This SIS explains how FC bacteria will be reduced within the Wilson Creek sub-basin in order to meet the targets for this TMDL. It is anticipated that voluntary implementation of the TMDL will return this water body to conditions that meet the targets and criteria noted above by October 2020. The SIS complies with the federal mandate of the Clean Water Act, state laws to control point and non-point source pollution, and the 1997 Memorandum of Agreement between EPA and Ecology.

A citizen's workgroup was formed in 2002 to guide development of the technical report and this implementation strategy. Groups represented in the TMDL workgroup include irrigated agriculture, ranchers, conservation districts and natural resource agencies, as well as numerous other interested parties or stakeholders, agencies, and organizations. The workgroup's continued active pursuit of the TMDL's goals will ultimately ensure the success of this TMDL.

The strategy to implement the TMDL is based upon the continuation of the many existing efforts (including BMPs) already underway throughout the watershed to reduce FC densities in project area waterways. The non-point sources (load allocations) will continue to be addressed by the use of BMPs. The principal focus of the TMDL will be to continue the voluntary implementation of seasonal and year-round BMPs to reduce the entry of anthropogenic FC bacteria into area water bodies. Additionally, continued monitoring of implementation activities and water quality is essential in assessing the progress of the TMDL.

A detailed implementation plan (DIP) will be prepared within a year following EPA approval of the TMDL submittal report. Continued workgroup support and additional public input will be sought to help prepare such plan. The DIP will identify specifically how, when, and where voluntary BMP activities will be implemented. A detailed monitoring plan will also be developed. Ecology and other entities will provide technical assistance and seek additional funding for these restoration activities and monitoring.

Implementation Plan Development

Several key milestones in the evolution of the TMDL implementation plan are worth noting. Field studies were conducted by Ecology in 1999, with additional field studies also being completed by the KCCD and KCWP in 1999 through 2001. A preliminary technical analysis of Ecology's FC field data was completed in 2002. In late 2002, a technical advisory workgroup (TAW) formed to direct development of the TMDL. Numerous drafts of the technical report were presented to the workgroup for comment in 2003 and 2004, and the completed report became an appendix to this document (see Appendix E). The TAW assisted Ecology with development of a submittal document (this document) during additional meetings in 2004 and 2005. Ecology staff made additional presentations regarding this TMDL to interested groups. The public comment period for this TMDL was April 1 through May 10, 2005, and one public workshop was held during the public comment period. Newspaper display ads and media advisories were released to the press prior to the public comment period. Focus sheets explaining the TMDL were developed in March 2003 and revised in March 2005, and were distributed as appropriate from March 2003 through May 2005.

As noted previously, Ecology will facilitate development of a DIP, which will be completed within a year after EPA approval of the TMDL submittal. Many members of the TAW may choose to become members of the DIP workgroup. In addition, Ecology will seek to include other additional community members who will be actively involved in BMP implementation. As the DIP is developed, anticipated workgroup products may include commitments from stakeholders to pursue the TMDL targets, and each entity will be asked to commit to an implementation schedule, which will be appended to the DIP. Specific BMPs for each type of land use will be described in the DIP.

Additionally, the DIP workgroup will be asked to help develop a detailed monitoring plan. The plan will include monitoring to determine effectiveness of BMPs, more microbial source tracking (as methods are approved by Ecology) and assessment of success in meeting TMDL interim targets. FC levels will be monitored at compliance points. A more complete description of proposed monitoring activities appears later in this document.

Point sources (wasteload allocations) will not need to be addressed through modification of current National Pollutant Discharge Elimination System (NPDES) permits. When the next NPDES permit for the city of Kittitas POTW is issued, however, the FC effluent limitation will be lowered to be equivalent to the Class A FC criteria. If the city of Ellensburg is required to comply with the Phase II Stormwater regulations, their wasteload allocation will also be equivalent to the Class A FC criteria. The non-point sources (load allocations) will be addressed through the voluntary implementation of BMPs. Continued monitoring of implementation activities and water quality is essential in assessing the progress of the *Wilson Creek Sub-Basin Bacteria TMDL*.

Implementation Activities

FC bacteria targets (interim and final) are set by the TMDL for Wilson Creek and its tributaries. The principal focus of the TMDL will be to continue the voluntary implementation of BMPs to prevent the entry of FC bacteria into area water bodies.

Several major land use entities will continue to implement BMPs to reduce FC bacteria in the Wilson Creek sub-basin. These entities include state, county and municipal governments; homeowners with waterfront property; livestock managers; and irrigated agriculture.

In recent years, irrigators in the Wilson Creek sub-basin have implemented many sediment-reduction BMPs. Some sediment-reduction BMPs (such as applying polyacrylamide (PAM) during rill irrigation, or changing from rill to sprinkler irrigation) are also known to reduce levels of FC bacteria in other watersheds.

Livestock managers will continue to implement appropriate BMPs for grazing and pasture operations. These practices will help reduce livestock contact with water bodies, improve filtering and absorption capabilities of pastures, utilize prescribed and managed grazing practices, and improve control of irrigation water. The Washington State University (WSU)

Extension Service, Solar$, Natural Resources Conservation Service (NRCS) and KCCD will provide technical assistance to livestock managers to ensure correct implementation and application of these BMPs. The Washington State Department of Agriculture (WSDA) will offer technical assistance to livestock managers regarding AFOs and CAFOs.

Local agricultural advisory groups (KCCD, NRCS, Solar$, and others) will continue to offer technical assistance and secure funding to assist irrigators. Additionally, the Kittitas County Water Purveyors (KCWP) – a consortium of area irrigation districts, companies and creek water rights holders – will offer outreach to members to enable them to meet TMDL goals.

The Kittitas County Public Health Department will respond to reports of failed septic systems or illegal/direct discharges when a signed complaint is filed in writing in their office and will provide technical assistance to landowners as they correct these failing systems.

Kittitas County, the cities of Ellensburg and Kittitas, and Ecology will work together to develop public-education programs to help reduce pet waste deposited near water bodies. Additionally, following stormwater guidelines are expected to help reduce FC pollution.

Responsible Entities, Actions, and Timeline

The conservation agencies (the KCCD and NRCS) are the entities responsible for technical assistance and financial support (where possible) to promote voluntary implementation of agricultural BMPs throughout the watershed. The WSDA is also responsible for technical assistance regarding AFOs and CAFOs. Individual irrigators are responsible for the implementation of standard irrigation BMPs, where appropriate and practical. Ranchers and other livestock managers are responsible for implementing BMPs that prevent livestock-generated FC from entering area water bodies, where appropriate and practical. The KCWP is the entity currently (2004-07) conducting water quality monitoring on agricultural lands in Kittitas County per grant agreement – this may be modified in future years.

The Kittitas County Public Health Department will respond to reports of failed septic systems or illegal/direct discharges when a signed complaint is filed in writing in their office and will provide technical assistance to landowners as they correct these failing systems.

Individual waterfront homeowners are responsible for correcting problems that add FC to water bodies; these problems can include (1) septic systems that discharge into adjacent water bodies, (2) allowing frequent/continuous contact between livestock (*e.g.*, hobby farms) and water bodies, or (3) allowing pet waste to enter water bodies.

Ecology is the responsible entity for determining compliance with interim and final targets, and is the overall TMDL coordination entity.

Table 5, below, organizes the responsible entities, and general actions and timelines, for the implementation of the TMDL. The information listed in the table is part of the overall strategy and may change as personnel and monetary resources are better defined during the development of the DIP.

*Note: Please refer to the list of acronyms and abbreviations (**Appendix A**) for further assistance with **Table 5.***

Table 5: Organization of TMDL entities and their contributions

Entity	Responsibilities to be met	Year of TMDL															
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Technical Advisory Workgroup (TAW)	Identify future monitoring needs and funding sources, and develop strategy.	X															
Ecology	Distribute a brochure (in Spanish and English) regarding ways to reduce FC bacteria in area waterways	X	X														
Homeowners with waterfront property	Correct failing septic systems or reduce livestock contact with water bodies	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Irrigation Entities (Districts and Companies)	Where possible and appropriate, implement BMPs to prevent entry of FC into area waterways	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Irrigators	Where possible and appropriate, implement sediment BMPs; some sediment BMPs may also help reduce FC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KCCD, NRCS and Ecology	Continue to fund agricultural BMP implementation: controlling agricultural runoff, and reducing livestock contact with area water bodies	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KCCD, NRCS, WSU Extension, WSDA, Solar$	Extend outreach efforts and technical assistance to all agricultural producers (irrigators, livestock managers, others) in the watershed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
KCWP, KCCD	Continue to monitor water quality of the watershed's surface waters (as funding is available)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ranchers	Implement livestock management BMPs to reduce animal contact with water bodies, and reduce FC-laden runoff from pastures	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Entity	Responsibilities to be met	Year of TMDL															
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Kittitas County Public Health	Respond to reports of failed septic systems or illegal/direct discharges when a signed complaint is filed in writing in their office; provide technical assistance to landowners as they correct failing septic systems	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ecology, TAW	Complete the DIP		X														
TAW	Discuss results of new BMPs and determine appropriate locations for implementation.		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TAW	Review if interim target has been met, and if not, devise action plan.						X					X					
Ecology	Evaluate if the water quality samples at points of compliance (see Table 4) meet the interim and final targets						X					X					X
KCWP, KCCD	Determine if changes in monitoring sites, tests or frequency are needed.						X					X					X
Ecology, KCWP, KCCD	Determine if alternate outreach efforts are needed.						X					X					X
TAW	Review if final TMDL targets have been met, and if not, identify new timeline and BMPs needed.																X

Reasonable Assurance

Reasonable assurance is required only where point sources exceed the water quality standards, and therefore nonpoint sources must be consistently reduced in order to compensate for this exceedence. The Kittitas wastewater treatment plant is currently operating according to discharge limits that are similar to the Class A water quality standards. In September 30, 2006, this existing permit will expire and the new permit shall include compliance with the Class A standards. Therefore, reasonable assurance is not required.

Adaptive Management

Implementation of the *Wilson Creek Sub-Basin Bacteria TMDL* will be adaptively managed such that Wilson Creek and its tributaries will meet the TMDL targets by 2020. Adaptive management methods that may be used to implement this TMDL include (1) adjusting best management practices; (2) modifying stream sampling frequency and/or locations to further delineate fecal coliform sources; (3) conducting special inspections in identified source areas; (4) helping develop and fund water quality projects that address fecal coliform pollution; (5) local educational initiatives; (6) bacterial source tracking; and (7) other means of conforming management measures to current information on the impairment.

TMDL requirements are satisfied when adequate sampling is attained that shows that TMDL targets are being met after successful voluntary implementation of BMPs. Sampling is adequate when it represents all climatic, hydrologic, and land use characteristics. If water quality standards are met without attaining the load allocation reductions specified in Table 4, then the objectives of this TMDL are met and no further reductions are needed. If the load allocation reductions in Table 4 are met, but the water body still does not meet TMDL targets, then adaptive management methods listed above may be further employed to meet the objectives of this TMDL. Re-evaluation of the status of this TMDL will be conducted every five years.

TMDLs are living documents, which are intended to be (1) revisited periodically to evaluate whether the measures to implement the needed reductions are achieving targets, and (2) revised as conditions change and understanding of the problems in the watershed is broadened. Through implementation of the TMDL, we learn what it will take to achieve water quality standards. Ecology and EPA acknowledge that water quality standards are not perfect and can be changed – this is hard to do, but it can be done. The knowledge that water quality standards and TMDL targets can be changed (if supporting information to do so is established) can empower a community, allowing the stakeholders to move through the TMDL process and determine how much the pollution can be reduced. A TMDL should lead to voluntary implementation of measures to reduce nonpoint pollution where local stakeholders make efforts to comply with existing water quality standards. After all appropriate and practical BMPs have been implemented, then the TMDL workgroup and Ecology will re-evaluate jointly whether or not standards are being met. If water quality standards are not being met, then stakeholders can evaluate whether they have sufficient information and a basis for seeking to change the standards, or stakeholders (including Ecology) can re-evaluate the way existing standards (*e.g.* natural conditions) apply to the watershed.[12]

On-going ambient monitoring conducted by the KCWP and KCCD will assist in enabling the implementing jurisdictions to revise and shift implementation efforts as necessary in order to bring all tributaries back into compliance with TMDL targets. Ecology will continue to offer grant funding for developing and implementing monitoring programs through its annual water quality grants program.

Summary of Public Involvement

As noted previously, a citizens' workgroup was formed in 2002 to guide development of the technical report and implementation strategy. Entities represented in the TMDL workgroup include irrigated agriculture, ranchers, conservation districts and natural resource agencies, county and city governments, the Yakama Nation, and numerous other interested parties or stakeholders, agencies, and organizations. This workgroup met numerous times during the development of this TMDL.

In addition to the numerous meetings of the technical workgroup, Ecology staff presented information about this TMDL to several interested groups.

The public comment period occurred from April 1 through May 10, 2005; and one public workshop was held during this period. Newspaper display ads and an article in the local newspaper helped notify the public regarding the water cleanup plan and related comment period. An Ecology "Focus Sheet" summary of this TMDL was published in March 2003, handed out to numerous interested persons and distributed at several public meetings. In March 2005, the Focus Sheet was updated and again distributed to numerous interested parties. See Appendix B for an internet link to the focus sheet and descriptions of other public participation materials. Responses to public comments received during the public comment period can be found in Appendix C.

Monitoring Strategy

Ongoing monitoring of water quality trends and implementation activity will be performed, as this data is essential in order to:

1. Show where water quality is improving.
2. Help locate sources of pollution.
3. Help indicate effectiveness of cleanup activities.
4. Document achievement of compliance with TMDL targets.

The KCCD and KCWP monitoring and studies in the Wilson Creek/Cherry Creek sub-basin have been helpful for identifying water quality problem areas. These two groups should continue to work together and may want to become the core of a monitoring clearinghouse in the basin.

[12] EPA contributed language in this paragraph.

The following are monitoring needs identified during the course of the TMDL evaluation and recommended for inclusion into the final TMDL monitoring plan.

1. Monitoring to evaluate effectiveness of various BMPs with regards to reduction of FC bacteria in the Wilson Creek sub-basin.
2. Additional "travel sampling" (synoptic sampling) of FC bacteria.
3. Following acceptance (by both the technical advisory workgroup and Ecology) of approved microbial source tracking methods:
    - Further identification of sources of FC bacteria throughout the sub-basin.
    - Source identification at specific agricultural locations, including run-off water from pastures, fields growing row crops, hayfields, etc.

A comprehensive monitoring plan will be included in the *Detailed Implementation Plan (DIP)* for the *Wilson Creek Sub-Basin Bacteria TMDL*. The DIP will be developed by Ecology within one year of the approval date of this TMDL. Specific sampling locations and strategies for specific water bodies will be included in the DIP.

Potential Funding Sources

Potential funding sources available through Ecology's water quality grants program include the Centennial Clean Water Fund, Section 319 grants under the federal Clean Water Act, and the State Revolving Fund (SRF) grants.

The Natural Resources Conservation Service (NRCS) directs its Environmental Quality Incentives Program (EQIP). EQIP provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. This program is implemented through conservation plans that include structural, vegetative and land management practices, and includes nutrient management plans. Contracts are two to ten years long.

The KCCD provides cost-share programs to irrigators and ranchers, including riparian restoration, fencing, farm plans, and sprinkler conversion projects.

The KCWP also provides cost-share programs to irrigators, including fencing, riparian restoration, and installation of off-stream water devices.

Kittitas County, through the KCCD, provides cost-share money to supply polyacrylamide (PAM) to irrigators, which helps keep soil on-farm and has also been shown to reduce bacteria levels significantly in runoff water.

Because much of the upper Yakima River basin is considered critical, salmon habitat, state and federal salmon restoration efforts, and associated funding should support implementation under this TMDL.

The United States Bureau of Reclamation (USBR) also has been working with landowners in the upper Yakima Basin who are interested in selling conservation easements that could provide additional riparian protection. Funding is through the Yakima River Basin Water Enhancement Project (YRBWEP), Public Law 103-434.

References Cited

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US Environmental Protection Agency (EPA). 1991. *Guidance for water quality-based decisions: the TMDL process*. April 1991. EPA 444/4-91-001.

US Environmental Protection Agency (EPA). 1997. *Memorandum of agreement between the United States Environmental Protection Agency and the Washington State Department of Ecology regarding the implementation of Section 303(d) of the Federal Clean Water Act.*

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Appendix A:
Definitions, Abbreviations, and Acronyms

Table A-1: Definitions of frequently used terms

90% value	For the *Wilson Creek Sub-Basin Bacteria TMDL*, a 90% value is defined as that single data value which represents the beginning of the largest ten percent (10%) of data values after ranking all applicable data values, from highest to lowest. For example: if a data set contains 1 to 19 values, the 90% value shall be the largest value; if a data set contains 20 to 29 values, the 90% value shall be the second largest value; etc.
Anthropogenic	Human-caused, or of human origin.
Best Management Practices (BMPs)	Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources. For this TMDL, agricultural BMPs should be approvable by the Natural Resources Conservation Service (NRCS), Kittitas County Conservation District (KCCD) and/or Washington State University (WSU) Extension Service. BMPs not related to agricultural applications should be approvable by Ecology.
Animal Feeding Operation (AFO)	A lot or facility where animals have been, are, or will be stabled, or confined and fed or maintained for a total of 45 days or more in any 12-month period. Crops, vegetation forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility. It is not necessary that the same animals be fed or maintained on the lot for the entire 45-day period nor do the 45 days need to be consecutive. [CFR 122.23]
Concentrated Animal Feeding Operation (CAFO)	A large CAFO is defined as: an animal feeding operation, which meets one of the following: Has at least: (1) 700 mature dairy cows, whether milked or dry; (2) 1,000 veal calves; (3) 1,000 cattle other than mature dairy cows or veal calves (cattle includes but is not limited to heifers, steers, bulls and cow/calf pairs); (4) 2,500 swine each weighing 55 pounds or more; (4) 10,000 swine each weighing less than 55 pounds; (5) 500 horses; (6) 10,000 sheep or lambs; (7) 55,000 turkeys; (8) 30,000 laying hens or broilers, if the AFO uses a liquid manure handling system; (9) 125,000 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system; (10) 82,000 laying hens, if the AFO uses other than a liquid manure handling system; (11) 30,000 ducks, if the AFO uses other than a liquid manure handling system; or (12) 5,000 ducks, if the AFO uses a liquid manure handling system.
	A medium CAFO is defined as: an animal feeding operation, (1) having pollutants discharged into the waters of the United States either through a made-made ditch, flushing system, or other similar man-made device; or (2) having pollutants discharged directly into water of the United States that originate outside of and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation. Such AFO must also have: (1) 200 to 699 mature dairy cows, whether milked or dry; (2) 300 to 999 veal calves; (3) 300 to 999 cattle other than mature dairy cows or veal calves (cattle includes but is not limited to heifers, steers, bulls and cow/calf pairs); (4) 750 to 2,499 swine each weighing 55 pounds or more; (5) 3,000 to 9,999 swine each weighing less than 55 pounds; (6) 150 to 499 horses; (7) 3,000 to 9,999 sheep or lambs; (8) 16,500 to 54,999 turkeys; (9) 9,000 to 29,999 laying hens or broilers, if the AFO uses a liquid manure handling system; (10) 37,500 to 124,999 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system; (11) 25,000 to 81,999 laying hens, if the AFO uses other than a liquid manure handling system; (12) 10,000 to 29,999 ducks, if the AFO uses other than a liquid manure handling system; or (13) 1,500 to 4,999 ducks, if the AFO uses a liquid manure handling system.

	A designated CAFO is defined as: an animal feeding operation that is determined to be a significant contributor of pollutants to waters of the state and is found to have (1) pollutants discharged into the waters of the United States either through a made-made ditch, flushing system, or other similar man-made device; or (2) pollutants discharged directly into waters of the United States that originate outside of and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation. Such AFO must not be classifiable as either a large or a medium CAFO.
Critical Condition Period	That portion of the calendar year when the pollution parameter of interest demonstrates the greatest adverse impact on aquatic biota and existing or characteristic water uses.
Fecal Coliform (FC) Bacteria	Fecal coliform bacteria are bacteria present in the intestinal tracts and feces of warm-blooded animals. FC is used as an indicator organism for the possible presence of disease-carrying (pathogenic) organisms.
Hobby Farm	A facility that is operated on a part-time basis with off-farm income being the principal income for the owner/operator. Such facility typically has only a few animals and very little cropland, but may have several acres of pasture. Such facility can have any combination of various types of animals (e.g., horses, cattle, sheep, llamas, goats). Any facility operated commercially shall not be considered a hobby farm.
Irrigation Return Flow	That portion of the applied irrigation water that is not consumptively used by crops or irretrievably lost to evaporation, and which returns to a surface water or the groundwater.
Load Allocation	That portion of a receiving waters' loading capacity that is attributed either to one of its existing or potential non-point source of pollution or to natural background sources.
Loading Capacity	The maximum amount of the pollutant parameter loading that a receiving water can absorb without violating the respective state water quality standard.
Sustainable	Environmentally and economically sound, and socially acceptable
Wasteload Allocation	That portion of a receiving waters' loading capacity that is allocated, or attributed, to existing or potential point sources of pollution.

Table A-2: List of acronyms and abbreviations

303(d) list	Washington State's list of impaired water bodies (as required by Section 303(d) of the Clean Water Act)
AFO	animal feeding operation
BMPs	best management practices
CAFO	concentrated animal feeding operation
cfu	colony forming units
CI	Cascade Irrigation District
CWA	Clean Water Act
E. coli	*Escherichia coli*
Ecology	Washington Department of Ecology
EPA	United States Environmental Protection Agency
EWC	Ellensburg Water Company
FC	fecal coliform
KCCD	Kittitas County Conservation District
KCWP	Kittitas County Water Purveyors
KRD	Kittitas Reclamation District
LSD	least significant difference
mg/L	milligrams per liter
mL	milliliter(s)
MOS	margin of safety
N	number of samples
N/A	not applicable
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
RCW	Revised Code of Washington
RM	river mile
RNA	ribonucleic acid
state	Washington State
TMDL	total maximum daily load
USGS	United States Geological Survey
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
WSU	Washington State University

Appendix B:
Summary of Public Participation Materials

Appendix B

Summary of Public Participation Materials

1) Focus Sheet, subject: *Focus on Wilson Creek Sub-basin Bacteria TMDL*, Pub. No. 03-10-022, revised March 2005, 2 pages. Available online at http://www.ecy.wa.gov/biblio/0310022.html

2) Newspaper Article, subject: *Workshop looks at Wilson Creek bacteria problems*, Daily Record (Ellensburg, WA), April 16, 2005.

3) Display Advertisements (dated April 1, April 8 and April 21, 2005) and Affidavits of Publication, for public comment period and public workshop, Daily Record (Ellensburg, WA).

4) Mailing List for *Wilson Creek Sub-basin Bacteria TMDL*.

Item 1 available online (see above) or as hard-copy. Items 2-4 are hard-copy only, available on request from author.

Appendix C:
Summary of Responses to Public Comments

Appendix C

Summary of Responses to Public Comments

Ecology received written comments from these groups or individuals on the submittal document for the *Wilson Creek Sub-basin Bacteria TMDL*:

- Kittitas County Water Purveyors (KCWP)
- Kittitas Reclamation District (KRD)
- Kittitas County Conservation District (KCCD)
- Kittitas County Public Health Department (KCPHD)
- William Woods, Jr., Pat Jenkins and Vern Stokes
- Stuart McKenzie
- David M. Hall
- Anonymous email

Because many of the comment letters contained similar themes, the comments are arranged below by issues (rather than by individual letter). Comments are in bold/italic font, with Ecology's responses in plain font.

Comments and responses are grouped into six main categories:

1. Comments regarding beneficial uses and human health issues.
2. Comments regarding bacteria source tracking.
3. Comments regarding best management practices (BMPs).
4. Comments regarding TMDL targets.
5. Comments regarding anticipated success of this TMDL.
6. Other comments

Additionally, some public comment letters contained numerous specific valuable suggestions regarding word choice and correction of basic information. Many of these suggestions were accepted into the document, where possible, without discussion.

Ecology appreciates all comments submitted by the groups and individuals listed above, and thanks these parties for their interest in water quality. Copies of all comment letters are available on request from Ecology.

1. Comments regarding beneficial uses and human health issues.

   a. ***No health problems have been reported to the Kittitas County Health Department, nor did the Health Department participate in the process on a regular basis.***

   Representative of the Kittitas County Public Health Department (KCPHD) were not able to attend TMDL workgroup meetings on a regular basis, but this did not detract from their helpfulness to the TMDL as they provided significant information when contacted by Ecology. Additionally, cases of certain intestinal illnesses are regularly reported by local doctors to the Communicable Disease Nurse at the KCPHD. These cases of concern include several diseases (i.e. giardiasis, cryptosporidiosis) that can be contracted by ingesting water from local water bodies contaminated by fecal matter from warm-blooded animals.

   b. ***To receive community support for the TMDL and active voluntary BMP implementation, the following [is] necessary: ….. Show that the problem is causing impairment to some beneficial use.***

   The uses for which we are required to protect the water are typically illegal or non-existent (such as swimming). Where those uses could potentially exist in this sub-basin, no data has shown an exceedence over state standards.

   Data collected by the KRD, KCCD and Ecology show that elevated levels of FC bacteria are causing impairment to Class A characteristic beneficial uses. Two impaired beneficial uses are “primary contact recreation” (direct contact with water to the point of complete submergence, including swimming) and “secondary contact recreation” (e.g., wading). The high levels of FC bacteria currently render most sub-basin creeks and streams unsafe for swimming, because swimmers can contract any number of diseases related to immersion in or ingestion of water contaminated with feces from warm-blooded animals. Additionally, FC bacteria densities in many of the water bodies in the Wilson Creek sub-basin far exceed the levels that would protect even wading as a recreational use.

   Many of the creeks and streams in the Wilson Creek sub-basin often have relatively low flow levels – but these low flows don’t prevent some people (especially children) from immersing themselves in deeper sections of area water bodies. For example, this entry was found in Ellensburg’s *Daily Record* newspaper, in a July 2004 “Police Blotter” section: “Kittitas juveniles were damming up a creek behind a business to swim and it was causing flooding problems.”

   The commenter notes that swimming in irrigation canals is illegal. However, irrigation canals are classified as waters of the State and are therefore subject to compliance with all Class A surface water quality standards. Ecology understands that, in a future formal process not related to this TMDL, certain local interests intend to initiate procedures to change classification designations for some sub-basin water bodies (including canals).

   Two other beneficial uses that may be impaired by FC contamination of water bodies in the Wilson Creek sub-basin are agricultural water supply and stock watering. One irrigation district manager has reported that some buyers of farm produce are now requiring growers to supply water quality analyses (including FC bacteria densities) of irrigation water applied to certain crops. Additionally, recent studies indicate that livestock are healthier and have greater weight gains when drinking water that contains minimal bacteria densities. These topics were not discussed during earlier development of this TMDL, but can be explored further as the detailed implementation plan (DIP) for this TMDL is developed over the next year.

2. Comments regarding bacteria source tracking.

   a. ***There is no evidence that the bacteria levels are primarily the result of humans, either through faulty septic or land use practices. In fact, some evidence suggests the opposite.***

   Ecology agrees. The TMDL does not claim that human actions are the primary cause of the elevated FC bacteria levels throughout the Wilson Creek sub-basin. However, the TMDL does assert (and the workgroup has agreed) that human actions do contribute to these high bacteria levels.

   b. ***Identify the sources of the contamination within that area. Not just a laundry list, but how much of the bacteria within the water is human caused (septic, livestock, pets).***

   It is not surprising as detailed in the findings, the wide variety of sources of Fecal Coliform (utilized as an indicator organism) within the water bodies in the Wilson Creek Sub-basin. There has always been and will continue to be FC due to wildlife in one form or another that cannot be controlled by humans. In the executive summary, the listing in order of prevalence for FC was birds, cattle, rodents, canine, human, etc. with a wildlife caveat. However, in other areas of the document this information is listed alphabetically which can be misleading as to where intervention efforts should best be concentrated to make the greatest impact….Additionally, if DNA testing protocols that more effectively and specifically identify non-point human sources of fecal coliform and their location, we would be interested in working with you in the investigation of these sources.

   We are also concerned that the information available, if correct, does not provide enough identification of the potential source of the Fecal Coliform (FC) pollution for consideration of remedial Best Management Practices (BMP) to be undertaken. …In order to consider BMPs than might be undertaken to improve the conditions, we also feel that an appropriate source tracking test should be done on the new samples that could be taken this summer to confirm the sources of the FC readings among the alternatives of stock, wild game or other sources.

   This report is the result of a flawed process. We do not have a focused picture of the sources of bacteria….For the near future, we would recommend that Ecology assist us and the rest of the community in finding an accurate, reliable, and affordable method to track the sources of bacteria.

   The TMDL is not the result of a flawed process, but rather the result of new processes that are improving with time. Presently, scientific methods do not exist that would allow Ecology (or anyone else) to determine exactly the amount of FC pollution attributable to the various sources at different sites throughout the Wilson Creek sub-basin. Ecology hopes (as does the community) that scientific methods of microbial source tracking will be improved in the near future, in order to provide cost-effective quantitative analysis of FC bacteria in this sub-basin. However, we do have a list of the predominant sources, and technical assistance is available (see Summary Implementation Strategy) to recommend site-specific BMPs to reduce FC bacteria in most sub-basin waterways.

3. Comments regarding best management practices (BMPs).

   a. ***We have yet to be shown an instance where the suggested ag-related BMPs were effective in a landscape similar to our valley. Without assurance that implementing BMPs will reduce bacteria counts to the required levels, spending large sums of money on BMPs is outright unintelligent.***

      To receive community support for the TMDL and active voluntary BMP implementation, the following are necessary:

      i. ***…. Show that …. BMPs will restore [an impaired beneficial] use.***

      ii. ***Show that if an individual implements a BMP, it will have a positive effect on water quality. There should be an existing study that shows that the BMPs being suggested will have a positive impact on fecal coliform concentrations in an area with similar wildlife and irrigated ag influences.***

      iii. ***Show that an individual landowner or manager has a contribution, and its magnitude.***

      iv. ***[Show] that the beneficial use will be restored if everyone in the watershed does their part. There is concern that even if all bacteria from human caused sources are eliminated, standards will still not be met, and BMPs may increase wildlife contributions.***

   A comprehensive examination of specific BMPs applicable to FC bacteria reduction in the Wilson Creek sub-basin will occur during development of the detailed implementation plan (DIP) over the upcoming year. However, Ecology respectfully disagrees with the assertion that no instance of agriculture-related BMPs have been shown to be effective in a landscape similar to the Kittitas Valley.

   One example of ag-related BMPs effective for FC bacteria reduction in a landscape similar to the Kittitas Valley has been the *Granger Drain Fecal Coliform Bacteria TMDL*, which has been implementing BMPs during the past three years. That TMDL has shown a greater than 30% reduction in bacteria densities due largely to the reduction of overland runoff from croplands.

   Another example of a group of ag-related BMPs that will help reduce bacterial pollution in the Wilson Creek sub-basin concerns concentrated animal feeding operations (CAFOs). On several occasions the TMDL workgroup discussed identifying and modifying potential CAFOs as a basic step toward FC bacteria reduction, and listened to a presentation that included this information. Unimproved CAFOs have been clearly established as significant sources of FC bacteria, in all types of landscapes. Additionally, there are several sites in the Wilson Creek sub-basin that could run a risk of being designated as a CAFO. The Washington State University (WSU) Extension is currently leading a statewide effort to help producers determine if they could be designated a CAFO, and help these producers reduce their risks by providing information on where they can find technical and funding assistance. Simply identifying and modifying potential "designated" CAFOs in the sub-basin will likely take an important step toward reducing FC bacteria pollution.

Any BMP that reduces input of FC bacteria to area water bodies will help toward restoring a beneficial use. Several ag-related BMPs can help reduce bacteria contamination of water, under certain circumstances and if applied and managed properly. Effective BMPs tend to be site-specific and tailored to a particular situation and location. What may work well on one farm or ranch might not work at all on another. The resource agencies (KCCD, NRCS, and WSU Extension) are best suited to determine whether an individual landowner may be making a contribution to bacterial pollution, and which BMPs will work best in certain locations. Often significant changes can be made with (relatively) small sums of money, and frequently these funds can be grants or cost-share monies.

Finally, Ecology is aware that the possibility remains that full implementation of reasonable BMPs may not completely reduce FC bacteria to comply with state water quality standards. Two sections of this TMDL document address just such possibility: the "targets" section and the section on "adaptive management." The step-wise targets are designed to provide incremental goals for bacterial reduction. Adaptive management allows Ecology and the stakeholders to periodically re-evaluate the goals of the TMDL and adjust as necessary.

b. These [bacterial source tracking] tests would serve to indicate what efforts would be most appropriate.

[We do not have] sufficient evidence that the suggested practices will actually reduce the bacteria levels in our local waterways …Certainty about the sources of bacteria will lead to recommendations for the most appropriate management practices to reduce the bacteria levels in our waterways.

As noted earlier, scientific methods do not currently exist that would allow Ecology to determine exactly which sources are causing bacterial pollution (and at what relative rate) at various sites throughout the Wilson Creek sub-basin. Yes, this information would be very useful (and we hope that we can collect such data in the non-too-distant future, as microbial source tracking methods advance). However, in lieu of highly technical source tracking data, we must currently rely on the knowledge and experience of resource agencies and other technical experts, including the KCCD, NRCS, and WSU Extension, to help pinpoint obvious trouble spots, and suggest the most appropriate remedies.

c. [A portion of the draft report] reads "After all appropriate and practical BMPs have been implemented". Who decides what is included in "all, appropriate, and practical". It seems you are headed for problems with the use of these terms. However, I agree that you need some flexibility when defining and applying BMPs. I suggest deleting the word "all" and identifying an agency, like KCCD, to determine "appropriate and practical". Hope this helps.

This document includes the following sentencse to help alleviate questions regarding "approvable" BMPs: "All agricultural BMPs should be approvable by the Natural Resources Conservation Service (NRCS), Kittitas County Conservation District (KCCD) and/or

Washington State University (WSU) Extension Service. BMPs not related to agricultural applications should be approvable by Ecology."

4. Comments regarding TMDL targets.

   a. ***… the percentage of bacterial colony decrease required in some instances is statistically impossible. We've been told by Ecology that this is where adaptive management will play a role. It makes no sense to us to set statistically impossible goals just to change them later on.***

      We have little confidence that we can meet the stated goals for bacteria reduction given what we know (and don't know) at this point.

   Ecology is required by state and federal law to determine a total maximum daily load for impaired water bodies that will allow them to meet water quality standards. In the case of FC bacteria pollution throughout the Wilson Creek sub-basin, no quantifiable source tracking data is available (nor will it be in the near future due to the current lack of such microbial source tracking methods). Consequently, the ultimate goal of the *Wilson Creek Sub-basin Bacteria TMDL* is to meet state numeric criteria for FC bacteria. Over time, as this TMDL is reassessed and as more BMPs are implemented, the TMDL targets could possibly be modified (with sufficient supporting evidence and in accordance with state processes).

   One can look at the incremental steps in the TMDL targets as a goals set for many kinds of projects (fund-raising, weight loss, etc). Much of the time, when one sets out toward a goal, ultimate and complete achievement of the goal may not occur, but working toward that goal can greatly improve the problem at hand.

   b. ***I believe your compliance targets will prove to be unrealistic, especially the 200 cfu/100 ml. It is my guess that this standard will be met and exceeded in a rather random manner over the years. This is because most of the BMPs are most effective during non-storm events; with monitoring monthly or bimonthly during the critical period, it is likely you will have at least one storm-affected sampling which will exceed your standard. I suggest you start working now on a new statistics that could be used in this basin if what I suggest it true. One possibility may be to determine the origin or host of bacteria during storm events in the bacteria population, exempt the wildlife hosts and apply the standard to anthropogenic hosts, which your BMPs are aimed at controlling.***

   The commenter makes a good point – that primary FC bacteria sources during a storm event are likely different from primary sources during non-storm events; however, the assumption that most BMPs are most effective during non-storm events is not correct. It has been Ecology's experience that BMPs can be directed at either non-storm or storm events. The commenter's suggested method again requires quantifiable (and approvable) microbial source tracking methods that have not yet been developed. However, EPA requires that the TMDL process must continue whether or not the best technology is presently available. When appropriate microbial source tracking methodologies exist that will allow for generating quantitative data, this comment will be re-considered and incorporated into the TMDL, as funding allows.

5. Comments regarding anticipated success of this TMDL.

   a. ***Despite the efforts of the Technical Workgroup, Ecology, and EPA, the TMDL Submittal Report is still controversial and may not be well-met in our community …***

      …Of these requirements [to receive community support for the TMDL and active voluntary BMP implementation], only the first [(demonstrating that there is a water quality parameter that exceeds standards and isolate where the problem is occurring to a geographic region)] has been accomplished. Until the rest are done, there will not be many volunteers. [“The rest” includes showing that 1) BMPs will restore an impaired beneficial use, 2) if an individual implements a BMP, it will have a positive effect on water quality, 3) an individual landowner or manager has a contribution, and its magnitude, and 4) the beneficial use will be restored if everyone in the watershed does their part] Ecology may have accomplished what they are required to do for this part of the TMDL process, but landowners are not going to volunteer until they are shown to be causing a problem and that implementing BMPs will fix the problem.

      It will be difficult at best for us to sell this "Water Cleanup Plan" to the local landowners and citizens.

   Ecology believes that as some basic BMPs are implemented (e.g., encouraging control of pet waste, modifying potential CAFO situations, locating and renovating leaking streamside septic systems, etc.), FC bacteria levels will drop accordingly and that local enthusiasm for this project will improve. Additionally, more public education regarding the extent of FC pollution will help raise public awareness of the problem in the community. This increased public awareness will likely help motivate some citizens who do not perceive that a problem currently exists. Ecology suggests that every concerned landowner should review other bacterial TMDLs that have been completed in the State of Washington. The success of those TMDLs should help dispel many of the landowner’s concerns. BMPs are chosen based on the specific problems of the area and on their applicability as determined by the NCRS and local agencies.

6. Other comments.

   a. ***I wish to congratulate the authors on the near completion of this report; it is much improved since the first drafts.***

   Thank you.

   b. ***I could not replicate the target reduction numbers. I suggest you check these calculations and show how the calculations were made.***

   We have added an additional appendix (Appendix D) to explain the method for the target reductions.

c. ***Page 13, ph 2 and 3 and 4 – read "First Interim Target: October 2010 and 2015 and 2020." If you are going to monitor in 2010, 2015 and 2015 to determine if the interim targets are being met, I suggest you leave sufficient time to aggregate the data and calculate the results; this suggests to me that a date of March 2011, 2016 and 2021 might be more realistic.***

The date of the interim target is keyed to the last date of sample collection for that year's critical condition period. Data analysis will occur following data collection.

d. ***The City of Kittitas municipal sewer system is a point source that may be the largest contributing factor of the FC human indicator. The information provided indicates that that their current NPDES permit expires September 30, 2006 and that all subsequent NPDES permits shall be more stringent. "Such limitations are more stringent than the facility's previous NPDES permits and will help to assure that the Wilson Creek Sub-Basin Bacteria TMDL will comply with state water quality standards". This information contributes to our understanding that the Department of Ecology is aware that the current NPDES is not adequate and certainly contributes to degradation of water quality within the Wilson Creek Sub-Basin.***

The City of Kittitas's sewer treatment plant currently meets its current NPDES requirements for FC bacteria. This facility recently converted from chlorine disinfection to ultraviolet disinfection, and it now fully complies with its stringent FC effluent limitations. This facility now contributes its part to the reduction of FC pollution in the Wilson Creek sub-basin.

e. ***[The Kittitas County Public Health Department's] focus and authority as the local health jurisdiction is with FC originating from non-point human sources. As local Public Health is mandated through implementation of Chapter 246-272 WAC to ensure on-site sewage systems are installed according to the best available technology, we execute our authority to ensure that these systems do not contribute to degradation of groundwater. When a failing on-site sewage system is reported or discovered, we have in place a mechanism to confirm and correct the situation in a timely fashion.***

   It is stated in the draft document that "the Kittitas County Health Department will help to locate failing systems on waterfront properties" and that we are "the agency responsible for helping to locate" these. This wording will need to be modified for two reasons:

   i. ***Kittitas County Public Health simply does not have the human resources to devote to this task at this point in time.***

   ii. ***Without some evidence of a problem, we do not have the authority to enter onto private property and investigate such problems.***

   We would prefer to see some wording to the effect that "Kittitas County Public Health will respond to reports of failed septic systems or illegal/direct discharges when a signed complaint is filed in writing in our office." With a signed complaint, we can work with the county code enforcement officer, investigate these problems, and take corrective action when necessary ….

We appreciate your work on this TMDL and your patience with the process. Kittitas County Public Health supports the Department of Ecology in its efforts to clean-up the Wilson Creek Sub-basin and will do our part to help this happen. We encourage you to encourage your local participants to strengthen the reporting system around illegal/direct discharges and failed septic systems. In this way, we can be a more active participant in your efforts.

Ecology thanks Kittitas County Public Health for their willingness to help with implementation of this TMDL.

The State law cited above (Chapter 246-272 WAC) also requires that on-site septic systems (OSS) must not contaminate surface waters. Failing streamside septic systems can leach into area waterways, contaminating area creeks and streams with "inadequately treated effluent." Further, WAC 246-272-15501(2)(b)(ii) states that the local health department shall initiate periodic monitoring of each OSS no later than January 1, 2000, to assure that each OSS owner properly maintains and operates the OSS in accordance with this section and in accordance with other applicable operation and maintenance requirements.

The requested language has been changed in the report.

f. ***We ask that the Department of Ecology consider undertaking additional sampling in 2005 to verify both the level and sources of FC contamination at both the Whiskey Creek sampling station "WC-1" and the Mercer Creek sampling station "MC-1" before establishing the "Target Reductions" for these two water bodies in the "Compliance Targets and Schedule" for 2010, 2015 and 2020 referred to in Table 4 on page 12 and described in the text on page 13 of the draft report.***

Our concern over the accuracy of the "90% Values" is that they are atypically high relative to the rest of the samples taken during the 1999 sample period and do not reflect what we would anticipate from the stock management and transport sources in the area at the date of the samples. In the case of the Whiskey Creek (WC-1) samples shown on page C-13 of the draft report, the 7/28/99 FC reading of 2500 is 4.10 times the average of the 13 samples taken in 1999. Similarly, in the case of Mercer Creek (MC-1) shown on page C-9 of the draft report, the 6/28/99 FC reading of 2640 is 4.94 times the average of the average of the 12 samples taken in 1999.

The target reductions are simply an indication of how much FC bacteria should be reduced to meet state water quality standards for FC bacteria, based upon the data that Ecology presently has available. These target reductions are presented, in part, to give stakeholders a chance to prioritize which streams to look at first when designing implementation measures. Additional FC bacteria samples will be collected in 2010 (the year of the first interim target) to assess what progress has been made toward meeting targets. The first interim target is the same for all water bodies in the sub-basin.

g. ***Over the past month, I have talked with several agencies in Kittitas County, as well as the Dept of Ecology in Yakima, regarding what I see as a major polluting factor in Wilson Creek. I live south of Ellensburg, very near where Wilson Creek crosses Tjossem Road. For years, I have observed the residents of Mill Pond Mobile Home Park polluting Wilson Creek. On the east side of that park, Wilson Creek runs along***

the rear of the Park for approximately one quarter mile. On my daily walk north on Berry Road, I watch a never ending contamination of the creek. It would seem to me that the Park owner and on-site manager have a responsibility to insure that residents don't contaminate the creek ….

I've lived on Tjossem Road for 27 years. My children caught fish off the bridge over Wilson Creek, just down from our house. There used to be a steelhead run in that creek. Now, there are tires, Styrofoam, plastic bottles and bags, lawn debris, and anything else the residents of Mill Pond Manor want to get rid of!

It would seem to me that solutions for Wilson creek should address all landowners, not just the farmers and ranchers as the news article suggests.

Thank you for sharing your concerns about Wilson Creek. This water clean up plan is indeed intended to address all water bodies in the Wilson Creek sub-basin, and all landowners (and other users) who may impact these waters. Because you have observed several types of pollutants (in addition to possible FC bacteria contamination, the topic of this document), you are wise to talk with additional Ecology staff, and several other agencies, to help stop this pollution.

h. You might want to look at the amount of cows grazing the hillsides and creek bare in the crab creek drainage 6 miles west of Odessa. And the fact they stand and cr** in it all summer.

Thank you for the information; we have notified Ecology's Eastern Regional Office.

Appendix D:
Calculating Percent Reductions of Fecal Coliform Bacteria at Individual Sites

Appendix D

Calculating Percent Reductions of Fecal Coliform Bacteria at Individual Sites

As part of the *Wilson Creek Sub-basin Bacteria TMDL*, there is a requirement to list the percent reductions of fecal coliform bacteria at individual sites along the various water bodies located within the watershed. These values indicate the amount of reduction that should be achieved in order to comply with the State's two-tiered surface water quality fecal coliform criteria of: (1) a geometric mean of 100 cfu/100 mL, and (2) a 90% value of 200 cfu/100 mL. Previous bacteria TMDLs produced by Ecology have utilized one of two methods for calculating needed percent reductions: a least sophisticated method and a statistical rollback method. The *Wilson Creek Sub-basin Bacteria TMDL* has found that neither of these methods gives a true representation of the bacterial reduction needed in this sub-basin. The following paragraphs will give an overview of the theory and calculations utilized in determining the percent reductions according to an improved method that utilizes all of the bacteria sampling results and not just the geometric mean and 90% value.

Least Sophisticated Method. The least sophisticated method first calculates the percent difference between both tiers of the State's bacteria criteria and their corresponding actual values obtained from analysis of sampling data at a sampling site. The criterion having the greatest percent difference from its actual value is then selected as the overall needed bacterial percent reduction applicable to the specific site. However, this method makes no differentiation between sites with similar 90% values but substantially different geometric means (or vice-versa), since the needed percent difference is only based on one of the two criteria.

An example of such problem can be seen by a comparison of the bacterial densities sampled at "Caribou Creek at the KRD Canal" to those at "Johnson Drain at S. Ferguson Road" (see Table below). Even though both sites have the same 90% value (1,800 cfu/100 mL), their geometric means vary substantially at 154 and 616 cfu/100 mL, respectively. Using the least sophisticated method, however, both sites would need a bacterial reduction of 89% in order to comply with the TMDL. Considering both sites to need the same amount of bacterial reduction does not reflect the real world situation.

Table 6: Comparison of Bacterial Densities

Site	n	# samples exceeding the 90% criterion	Geometric Mean (cfu/100 mL)	% Reduction to reach criterion	90% Value (cfu/100 mL)	% Reduction to reach criterion
Caribou Creek	30	27	154	35	1,800	89
Johnson Drain	31	31	616	84	1,800	89

By comparing the whole data set for each water body, the difference in required reductions can be more readily assessed. Figure 1 (below) illustrates the differences by comparing the log of the bacterial densities at each site. The pink box represents 95% of a site's data, the red dot represents the median value, and the blue lines represent the range of data. The Caribou Creek site has significantly ($p = 3.86x10^{-7}$) less fecal coliform pollution than the Johnson Drain site (see figure below) at a 95% confidence level. The Caribou Creek site is located at a higher elevation in the watershed with few potential bacteria sources; while, the Johnson Drain site is located further down the watershed and receives drainage from various potential bacteria sources.

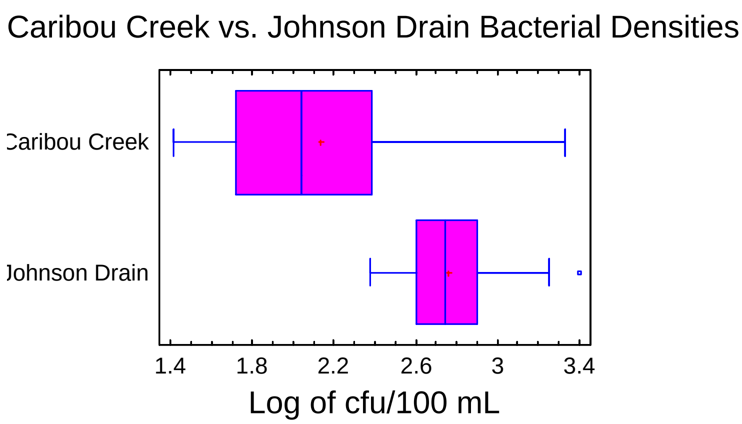

Figure 2: Comparison of bacterial densities in Caribou Creek and Johnson Drain

The best method utilized for calculating bacterial percent reductions should take into account all bacteria samples at a site and both tiers of the water quality criteria, rather than a single tier. Accordingly, the best method would calculate different bacterial percent reductions for the above two sites should expressly indicate that a lesser percent reduction would be appropriate for Caribou Creek.

Statistical Roll-back Method. The second method is based on a "statistical roll-back" (STR) method that was presented for the first time by Dr. Wayne R. Ott in his book: Environmental Statistics and Data Analysis (1995, CRC Press Inc.). The STR method is based on a prior Theory of Successive Random Dilutions (SRD) and on the assumption that the coefficient of variation for a pollutant parameter does not change even after dilution. Dr. Ott expressly stated that the SRD applies best to "physical or chemical substances that do not participate in biological processes or chemical reactions". It was specifically designed to be used with relatively inert substances initially released at very high concentrations, which then decrease due to increasing dilution downstream.

The application of STR to bacteria is also not always appropriate, as bacteria are not inert, and constantly undergo growth and death according to the varying availability of nutrients and predators in the medium. There is also the potential for having additional bacterial sources within a water body itself: resuspension and regrowth. In addition, the assumption of no change in the coefficient of variation as bacterial densities are sampled downstream is false. (Note: coefficient of variation = the ratio of the standard deviation to the mean). See Table 2 below, where Cooke Creek is used as an example (sites listed in order going downstream).

Table 7: Cooke Creek sites and related coefficients of variation (CV)

Site	CV
Cooke Creek at Cooke Canyon Road	27.5%
Cooke Creek at KRD Canal	33.3%
Cooke Creek at No. 81 Road	31.0%
Cooke Creek at Denmark Road	26.0%
Cooke Creek at South Ferguson Road	13.9%

It should be noted from the table that the Coefficient of Variation (CV) is not constant as one goes downstream, which discounts one of the principal assumptions of STR. This is the reason why STR is inappropriate in this situation.

Method used in the *Wilson Creek Sub-basin Bacteria TMDL*. The method determined by the *Wilson Creek Sub-basin Bacteria TMDL* to be most appropriate for calculating bacterial percent reductions is based on a statistically significant distribution of the individual sites and is calculated from both the geometric mean and 90% values of site-specific sampling. The final bacterial percent reduction is between the geometric mean and 90% value reductions, as calculated individually. (Note: An appropriate mathematical formula for calculating the final bacterial percent reductions would probably be different for each watershed being investigated, due to the variability of environmental conditions.) The basic hypothesis of this method is that the site-specific distribution of bacterial percent reductions should match the statistically significant distribution of bacterial densities determined by Multiple Range Tests. For example, those sites having the statistically greatest bacteria densities would consequently need the greatest percent reductions; and vice versa.

The final formula determined that 10% of the needed reduction for the 90% values plus 90% of the needed reduction for the geometric mean values produced a listing of final percent reductions that, when ranked in order of the greatest to the least, would achieve the most representative picture of bacterial reductions at each site. There is no set mathematical formula to determine the 10/90 split – rather, it is determined by an overlay. When all of the final percent reductions are calculated per site and then ranked from highest to lowest, an overlay of those sites is compared to the original distribution of sites that was made from statistical analysis of their actual bacterial densities, i.e. the 10/90 split is based on a best fit of the overlay.

All of the final bacterial percent reductions are greater than the respective geometric mean-only reduction, and less than the respective 90% value-only reduction. Table 3 (below) details the final bacterial percent reductions that are applicable to the sites selected for compliance with the *Wilson Creek Sub-basin Bacteria TMDL*.

Table 8: Final product for required percent reductions required (also Table 4 of main body of submittal document)

Water body Name	Sampling Site Location	Geom. Mean During Critical Condition (cfu/100 mL)	90% Value During Critical Condition (cfu/100 mL)	Target Reduction Needed at Sampling Site (to Meet Class A FC Standards)
Badger Creek	above confluence with Wipple Wasteway	292	1,400	66.0%
Bull Ditch	at Tjossem Road	488	3,000	79.6%
Caribou Creek	at S. Ferguson Road	428	4,000	76.8%
CID Canal	at Thrall Road	570	2,300	82.5%
Cherry Creek	at Moe Road	402	1,200	75.2%
Coleman Creek	at Moe Road	378	1,400	73.7%
Cooke Creek	at #81 Road	492	5,900	79.8%
Cooke Creek	at S. Ferguson Road	300	1,140	66.8%
EWC Canal	at Thrall Road	499	3,000	80.1%
Johnson Drain	at S. Ferguson Road	616	1,800	83.8%
Mercer Creek	at KRD Canal	319	2,640	68.9%
Naneum Creek	at Fiorito Pond	265	620	62.3%
Parke Creek	at S. Ferguson Road	328	5,940	69.8%
Whiskey Creek	at KRD Canal	263	2,500	62.3%
Wilson Creek	at Sanders Road	552	1,000	81.9%
Wilson Creek	at Thrall Road	248	720	59.8%
Wipple Wasteway	at Moe Road	235	720	57.6%

Appendix E:
Technical Assessment Report

Wilson Creek Sub-Basin Bacteria Total Daily Maximum Load: Technical Assessment

Gregory Bohn
April 2004

Washington State Department of Ecology
Water Quality Program

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Abstract

Section 303(d) of the federal Clean Water Act requires states to identify surface water bodies where technology-based point-source controls have been insufficient to meet applicable water quality standards or to support beneficial uses. Two of the water bodies (Wilson Creek and Cooke Creek) within the Wilson Creek sub-basin were included in the state of Washington's (state's) 1998 303(d) list due to exceedences of the state's two-tier Class A water quality standard for fecal coliform (FC) bacteria. The principal FC sources in the Wilson Creek sub-basin are the manure deposited by wildlife, agricultural animals and pets, as well as human fecal contamination via inadequate on-site septic systems as well as municipal wastewater treatment effluent.

The sub-basin contains five background sites, all of which are located upgradient of the Kittitas Reclamation District (KRD) irrigation canal. Although not pristine, the area upgradient of the KRD Canal has been historically determined to be the area of least human-related activity in the sub-basin as well as the lowest FC densities. The FC densities found at the background sites have generally complied with the state's Class A FC criteria.

The majority of the surface waters downgradient of the background sites were determined to be in excess of state's Class A FC water quality standard. When the data from all sampling sites was pooled, FC densities exhibited a distinct seasonality with a critical condition period that spans the months of April through October. Within the critical condition period, the highest FC densities were found during the months of June through August. The average monthly water temperatures follow a seasonal pattern similar to FC densities with the months of greatest water temperatures are July and August. An analysis of flows and FC densities showed a similar upward trend between monthly pooled geometric mean FC densities and geometric means for the months from March through June. However, beginning in July, flows throughout the Wilson Creek sub-basin decreased whereas FC densities continued to increase.

The Kittitas County Conservation District (KCCD) recently completed a project that analyzed the RNA of *E. coli* bacteria in order to determine the principal animal sources responsible for contributing FC bacteria. The three greatest numbers of bacterial isolates, in order, were identified as belonging to birds (21%), cattle (19%) and rodents (13%). Various other animal sources were identified. The analysis also contained a substantial unidentifiable component (21%). The data derived from the project suggests that the entire issue of identifying and controlling such sources is complex. Additional *E. coli* ribotyping should be considered for determining if any variation occurs in the sub-basin's principal bacterial sources throughout the entire year, as well as identifying the contribution by sources in order to monitor implementation actions.

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Executive Summary

Water quality in the Wilson Creek sub-basin has been sampled by various governmental entities since the 1930s, with levels of water-borne bacteria evaluated since the 1970s. Fecal coliform (FC) bacteria densities in the sub-basin have been determined to be highly variable, with the majority of the samples collected downgradient of the Kittitas Reclamation District (KRD) irrigation canal during the critical condition period[1] (April through October) containing FC densities in excess of the present Washington State (state) water quality standards. State FC water quality standards for Class A water bodies are two-tiered: (1) a geometric mean of 100 cfu/100mL, and (2) not more than 10% of all samples obtained for calculating the geometric mean exceeding 200 cfu/100mL.

Potential sources of the FC bacteria in any watershed include primary and secondary sources. Primary sources include wildlife, agricultural animals, pets, and humans. Secondary sources include bacterial re-growth and re-suspension. An *Escherichia coli (E. coli)* ribotyping study was recently completed by the Kittitas County Conservation District. The study determined that in the Wilson Creek sub-basin, the three greatest numbers of bacterial isolates identified were attributable to the following animal host species: birds, cattle and rodents (21%, 19% and 13%, respectively). Other identified isolates were identified, in order of appearance, as: canine, human, horse, raccoon, muskrat, rabbit, feline, deer, prairie dog, beaver/otter, opossum, porcupine, sheep, shrew, and poultry. 21% of the bacterial isolates were unidentifiable. The results of such RNA analyses provide a reasonable indication of the predominant animal sources of FC bacteria within the sub-basin and show the complexity of the FC bacteria non-point sources.

Five background sites were identified in the sub-basin, all located upgradient of the KRD Canal; these sites typically have FC densities in compliance with the state's Class A water quality standard. During 1999-2002, the geometric means varied from 6 to 81 cfu/100mL and the 90% values varied from 42 to 300 cfu/100mL. At the sampling sites downgradient of the KRD Canal, FC densities were determined to be highly variable but showed definite seasonality. FC densities were significantly largest during the critical condition period. The highest FC densities were found during the period of June to August, which coincides with the warmest months of the year. During the critical condition periods of 1999-2002, site-specific geometric mean FC densities varied from 21 to 1,400 cfu/100mL. Similarly, 90% value FC densities during the critical condition periods varied from 160 to 8,000 cfu/100mL. From March through June, FC densities and flows both had increasing trends, whereas beginning in July, flows decreased while FC densities continued their upward trend.

Based on the FC density data collected during 1999-2002 by various governmental entities, this technical assessment concludes that overland runoff associated with precipitation, snowmelt and irrigation is a substantial transport mechanism of FC pollution to the water bodies within the Wilson Creek sub-basin. Another transport mechanism is the direct deposition of manure into the sub-basin's surface waters from wildlife and agricultural animals, as well as direct discharges from inadequate on-site septic systems as well as a wastewater treatment facility.

[1] See Appendix A for definition of this term.

Even though the 1996 and 1998 Lists of Impaired water bodies in Washington State, (the 303(d) lists) identify only Cooke Creek and Wilson Creek as exceeding state Class A FC criteria, this technical assessment has determined that various other surface waters within the Wilson Creek sub-basin also exceed the same FC criteria. The Washington State Department of Ecology (Ecology) is therefore required to conduct a FC total maximum daily load (TMDL) assessment of the Wilson Creek sub-basin due to those exceedences that have occurred throughout the sub-basin.

The ultimate goal of this TMDL is to comply with the state's current water quality standards. In this case, FC densities shall meet the Class A fecal coliform (FC) water quality criteria, which is a geometric mean of 100cfu/100mL and a 90^{th} value of 200cfu/100mL.

Ecology recognizes that there is a significant amount of FC bacteria contributed by wildlife to the water bodies throughout the sub-basin. Ecology also recognizes that while anthropogenic FC inputs may be significantly reduced through TMDL implementation, it is unrealistic to expect that all such FC contributions will ever be completely eliminated from the Wilson Creek Sub-basin.

Introduction

Description of Area

The Wilson Creek sub-basin is located on the east side of the Cascade Mountain range within Kittitas County, near the geographic center of the state of Washington (state), and drains most of the area surrounding the city of Ellensburg. The sub-basin covers approximately 244,500 acres (382 sq. miles) of land and occupies latitudes ranging from 46° 50' N to 47° 20' N and longitudes ranging from 120° 15' W to 120° 35' W. The crest of the Wenatchee Mountains forms the northern boundary. The Yakima River generally forms the western boundary, Manastash Ridge the southern boundary, while the Colockum and Boylston Mountains and Naneum Ridge form the eastern boundary. Elevations range from 1,425 feet at Thrall (near confluence with Yakima River) to 6,359 feet at Lion Rock (near headwaters of Wilson Creek).

The climate of the sub-basin is considered semi-arid, with an average annual rainfall of 8.9 inches. 70 percent of the annual precipitation occurs during the months of October through March, 23 percent occurs during April through July, and 8 percent occurs during August and September. From mid-November through February, most of the precipitation falls as snow (average of 31.4 inches). Air temperature averages 27°F in winter and 69°F in summer.

Three major vegetation types have been identified in the sub-basin: agricultural, grassland, and coniferous forest zones. The agricultural zone is generally described as all the land area below the Kittitas Reclamation District (KRD) irrigation water supply canal, and is characterized by cultivated crops and irrigated pastures. Above the KRD Canal, but below the forested lands, the predominant vegetation is grassland shrub-steppe represented by sagebrush, grass, and other brush species. The grassland is used principally as rangeland, although irrigated pastures and cover crop production are present along the flatlands immediately upgradient of the canal. The highest elevation areas of the sub-basin occupy the southern slopes of the Wenatchee Mountains and are dominated by coniferous forest.

The majority of the soils in the Wilson Creek sub-basin are loams: cobbly loam in the north, to deep silt loams in the areas near Kittitas, to highly erodible clay loam on the hills south of Thrall Road. Agricultural fields along the Yakima River have slopes from 0.5 to 2 percent, while those in the Badger Pocket area (far southeastern portion of the sub-basin) are in the 5 to 18 percent range. The small particle sizes of the surface soil consequently are easily transported by water runoff, especially where there is a minimal vegetation cover present. To reduce sediment runoff in the upper Yakima River basin, a water cleanup plan for sediment and organochlorine pesticides[2] was completed in 2002.

[2] *Upper Yakima River Basin Suspended Sediment, Turbidity and Organochlorine Pesticide TMDL*.

Agriculture has been the mainstay of the Wilson Creek sub-basin since the middle 1800s. By 1902, the sub-basin was the most extensively irrigated area in the state during the agricultural growing season. Approximately 54,000 acres of the sub-basin are presently irrigated. The agricultural economy of the sub-basin is currently dominated by cover crop production (*e.g.*, timothy hay, alfalfa) that is typically rotated every five to six years with two years of other crops (*e.g.*, grains, corn, potatoes). The sub-basin also contains numerous rangelands, permanent irrigated pastures (that are not rotated or cropped), as well as some animal feeding operations[3] (AFOs) and hobby farms[4], with the principal agricultural animal species being beef cattle.

Hydrology

The Wilson Creek sub-basin has numerous tributaries that drain a watershed of approximately 394 square miles. All of the surface waters are located within the Water Resource Inventory Area (WRIA) 39. Wilson Creek discharges into the Yakima River (River Mile 147.0) and is composed primarily of irrigation return flow[5] during the irrigation season. According to state regulations (Chapter 173-201A WAC), Wilson Creek and all of its tributaries are classified as "Class A" water bodies. Ecology considers all irrigation water supply and drainage canals within the state to be *waters of the state* and as such they must also meet the state' water quality standards. Table 1 lists the state Class A water quality standards.

The current hydrologic characteristics of the Wilson Creek sub-basin natural surface waters are typical of streams east of the Cascade Range, in that most of their naturally-occurring flow results principally from melting of the upgradient snowpack, which accumulated during the previous winter as well as spring precipitation events (typically during the months of March through June). To supply the water necessary for the sub-basin's annual agricultural growing season (April 15 through October 15), a substantial amount of supplemental water is diverted from the Yakima River and delivered to the sub-basin via man-made irrigation canals. According to the Kittitas Reclamation District (KRD), portions of many, if not all, streams in the Wilson Creek sub-basin dry up every year when no irrigation water supplements the natural flow.

The amount of supplemental water is approximately 4.5 times the amount of naturally supplied water via local surface waters (Ecology, 2002). During the sub-basin's agricultural irrigation season, irrigation water applied to crops is either utilized through evapotranspiration or returns back into the overall hydrology of the sub-basin via overland runoff (tailwater) or percolation. Lael (2000) stated that percolation losses are usually the largest part (64%) of the sub-basin irrigation water budget. According to the data presented, out of an average of 11.5 acre-feet typically applied to rill-irrigated Timothy hay, there were: 1.1 acre-feet of tailwater, 3.0 acre-feet of consumptive use by crops and 7.4 acre-feet of percolation below the root zone.

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3 See Appendix A for definition.
4 See Appendix A for definition.
5 See Appendix A for definition.

Table 1: Class A Water Quality Standards (freshwater)

General:	Water of this class shall meet or exceed the requirements for all or substantially all uses.
Characteristic Uses:	Shall include, but not be limited to, the following: water supply (domestic, industrial, agricultural); stock watering; fish and shellfish: salmonid migration, rearing, spawning, and harvesting; other fish migration, rearing, spawning, and harvesting; crustaceans and other shellfish (crayfish) rearing, spawning, and harvesting; wildlife habitat; recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment); commerce and navigation.
Fecal Coliform:	Shall both not exceed a geometric mean value of 100 cfu/100mL and not have more than 10% of all samples obtained for calculating the geometric mean value exceeding 200 cfu/100mL.
Dissolved Oxygen:	Shall exceed 8.0 mg/L.
Total Dissolved Gas:	Shall not exceed 110% of saturation at any point of sample collection
Temperature:	Shall not exceed 18ºC due to human activities. When natural conditions exceed 18ºC, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3ºC. Incremental temperature increases resulting from non-point activities shall not exceed 2.8ºC. Incremental increases from point source activities shall not, at any time, exceed t=28/(T+7). ("T" represents the background temperature increase as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge. "t" represents the maximum permissible temperature increase measured at a mixing zone boundary.)
pH:	Shall be within the range of 6.5 to 8.5 with a human–caused variation within the above range of less than 0.5 units.
Turbidity:	Shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10% increase in turbidity when the background turbidity is more then 50 NTU.
Toxic, radioactive, or deleterious material:	Shall be below those which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon the those waters, or adversely affect public health, as determined by Ecology.
Aesthetic Values:	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.

The uppermost layer of ground water in the Wilson Creek sub-basin is located within an unconsolidated alluvial mixture of silt, sand, and gravel. The layer is typically less than 100 feet deep and overlies a clay hardpan stratum. The clay hardpan layer keeps the upper ground water in direct continuity with local surface waters as it prevents further percolation and recharge of the lower aquifers (Ecology, 1985; Golder Associates, 2002).

The unconfined alluvial water table is subject to seasonal variations in water level caused by droughts, precipitation, leakage from adjacent streams and canals, as well as irrigation return flow (Bain, 1999; Owens, 1995; Ecology, 1985). Man-made subsurface drainage is widespread throughout the Wilson Creek sub-basin in order to drain high water tables for agricultural activities (Owens, 1995). Lael (2000) reported that there are numerous subsurface field drains in the Cherry Creek drainage area and that shallow irrigation-induced ground waters seep into waterways. All of the groundwater layers gently slope down from the northern and eastern areas toward the center (lowest) portion of the sub-basin, southwest of Kittitas and north of the Badger Pocket area. Both the surface and shallow ground waters in the Wilson Creek/Cherry Creek area then flow westward toward and ultimately discharge into the Yakima River.

The majority of the Wilson Creek sub-basin's major surface waters (Caribou Creek, Coleman Creek, Cooke Creek, Naneum Creek, and Wilson Creek) originate to the north of Ellensburg in the south side foothills of the Wenatchee Mountains, and flow generally southwesterly. Parke Creek, Wipple Wasteway and Badger Creek flow respectively out of the eastern and south-eastern portions of the sub-basin. Table 2 lists all of the tributaries to the sub-basin's major surface waters.

Table 2: Tributaries to the Major Water Bodies in the Wilson Creek Sub-Basin

Surface Water	Tributaries
Caribou Creek	Little Caribou Creek, Parke Creek
Cherry Creek	Caribou Creek, Cooke Creek, Johnson Drain, Wipple Wasteway
Coleman Creek	Schnebly Creek, Bull Ditch
Cooke Creek	Sheep Creek, Trail Creek
Mercer Creek	Whiskey Creek
Naneum Creek	Boulder Creek, Coleman Creek, Dot Creek, Drop Creek, High Creek, Howard Creek, Little Naneum Creek, Nealy Creek, Owl Creek, Pearson Creek, Swift Creek
Parke Creek	Whiskey Jim Creek
Whiskey Creek	N/A
Wilson Creek	Bear Creek, Cherry Creek, Lyle Creek, Mercer Creek, Naneum Creek
Wipple Wasteway	Badger Creek, CID Canal, EWC Canal

Supplementing the above water bodies, the Wilson Creek sub-basin contains three principal man-made irrigation water supply canals (Table 3) that transect the sub-basin from the northwest to the southeast. These canals divert irrigation water from the Yakima River at various upstream locations.

Table 3: Principal Irrigation Canals in the Wilson Creek Sub-Basin

Canal Name	Description	Completed
Kittitas Reclamation District (KRD) Canal	Most upgradient canal. Supplies irrigation water for approximately 59,000 acres. Diversion located at river mile (RM) 202.5 on Yakima River at Lake Easton (reservoir).	1933
Cascade Irrigation District (CID) Canal	Middle gradient canal. Supplies irrigation water for approximately 12,500 acres. Diversion originally located at RM 168.9 on Yakima River. Flume was demolished in a landslide, so a new diversion was built at RM 160.4.	1904
Ellensburg Water Company (EWC) Canal	Lower gradient canal. Supplies irrigation water to approximately 10,150 acres. Diversion located at RM 161.3 on Yakima River.	1892

The sub-basin also includes a few smaller irrigation canals:

1. Bull Ditch conveys water from the Yakima River at RM 153.7 and feeds approximately 1,300 acres in an easterly direction along I-90 ultimately commingling with Wilson Creek and Naneum Creek and finally proceeding to Coleman Creek where it terminates, southeast of the city of Ellensburg;
2. Johnson Drain conveys water from the CID and EWC Canals in a westerly direction toward its confluence with Cherry Creek; and
3. Tjossem Ditch, a relatively short (5.2 miles) irrigation canal, which diverts Yakima River water at RM 152.2 and ultimately discharges back into Wilson Creek, just upstream of its confluence with the Yakima River.

The flow pattern of the sub-basin's natural streams is complicated by a network of irrigation canals and drains. Figure 1 (provided by the KRD) should be used as a guide to understanding flows. Table 4, which follows Figure 1, details the actual sampling sites associated with the irrigation canals.

Wilson Creek begins at Table Mountain due north of Ellensburg. It flows southeasterly until it combines with Naneum Creek approximately 13 miles north-east of Ellensburg and about 4 miles above the KRD Canal. The Wilson/Naneum Creek segment continues southward for another 1.5 miles where it then separates, from west to east, into: Whiskey Creek, Mercer Creek, Wilson Creek and Naneum Creek. All of those creeks continue to flow in a southwesterly direction, with: (1) Whiskey Creek flowing around the west side of the Ellensburg airport; (2) Mercer Creek flowing around the east side of the Ellensburg airport; (3) Wilson Creek flowing directly through the city of Ellensburg; and (4) Naneum Creek flowing directly southward on the east side of city of Ellensburg.

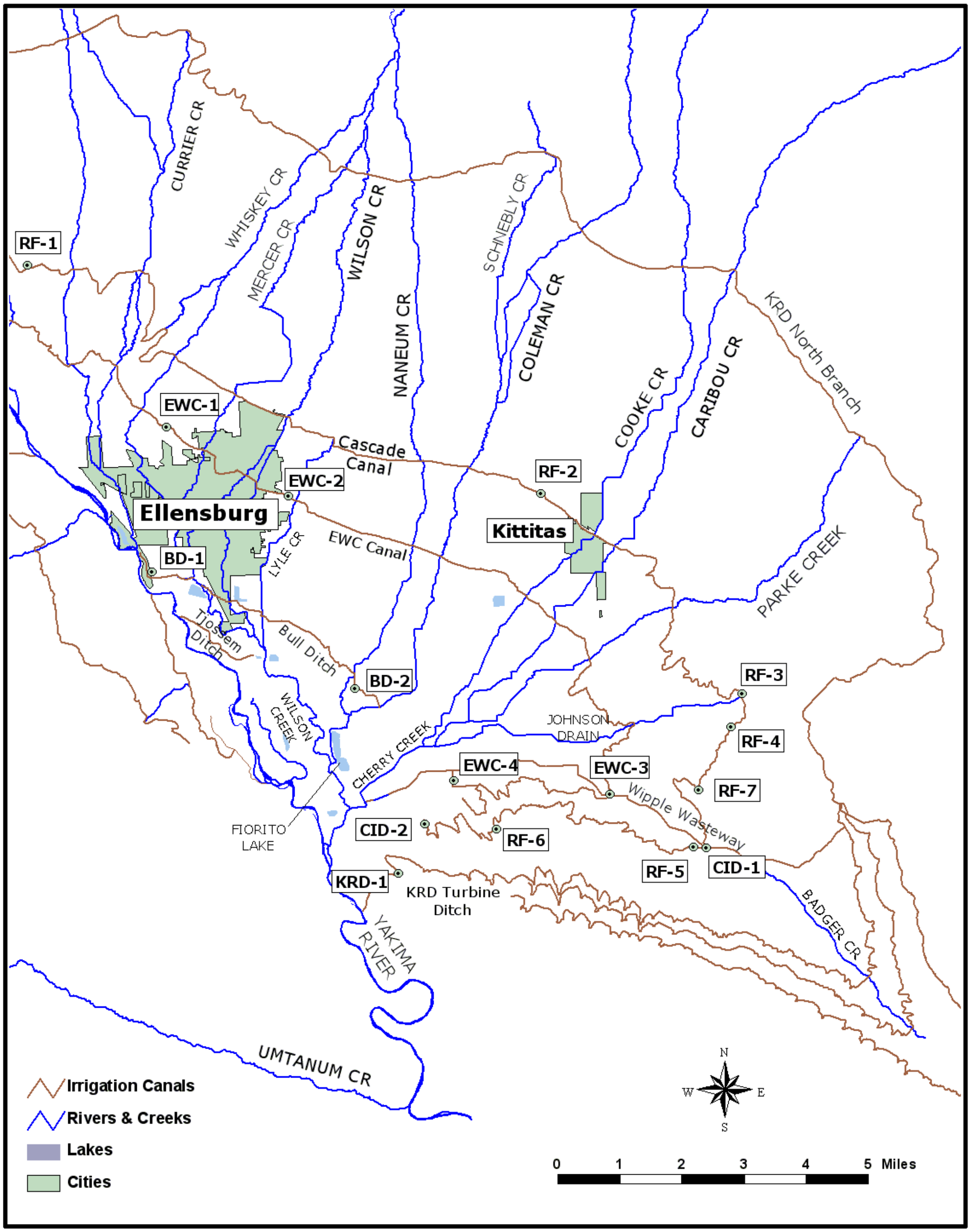

Figure 1: Irrigation Water Sampling Sites in the Wilson Creek Sub-Basin

Table 4: Sampling Site Locations for Figure 1

Canal Name	Site #	Site Location
Kittitas Reclamation District Canal	KRD-1	at Turbine Ditch Spillway
Cascade Irrigation District Canal	CID-1	at Thrall Road into Wipple Wasteway
"	CID-2	at Tailend Spillway
Ellensburg Water Company Canal	EWC-1	at Hannah Road
"	EWC-2	at East 3rd Avenue
"	EWC-3	at Thrall Road
"	EWC-4	at Tailend Spillway into Wipple
Bull Ditch	BD-1	at Diversion
"	BD-2	at Tjossem Road

After flowing under the CID and EWC Canals, Whiskey Creek turns southward and then passes through the western part of the city of Ellensburg and ultimately joins Mercer Creek. Whereas Mercer Creek enters the city on its north edge, combines with Whiskey Creek within the city, and continues flowing south until it rejoins Wilson Creek on the city's southwest edge. Wilson Creek, after passing under the CID Canal, splits into two branches (described as stormwater canals with numerous sharp turns, and alternately buried and exposed sections) with each one flowing through the city of Ellensburg. The two branches (west and east) rejoin approximately three miles downstream of the city on its far south side.

Lyle Creek is located approximately two miles to the east of the east branch of Wilson Creek. Lyle Creek begins just north of the Cascade Canal and drains an area along the far eastern edge of the city of Ellensburg. The creek flows southerly and ultimately discharges into Wilson Creek just after the merging of the latter two branches, to the south of the city.

After passing underneath the CID Canal, Naneum Creek flows directly southward on the far east side of the city to just north-east of Fiorito Pond. There it combines with Coleman Creek (flowing parallel along its east side) and Little Naneum Creek (flowing parallel along its west side). Once combined, Naneum Creek then flows along the west edge of the pond until it ultimately discharges into Wilson Creek, just north of the Cherry Creek confluence.

Moving eastward, the next major natural surface water, Coleman Creek, begins in the foothills to the far northeast of the city of Ellensburg as actually two creeks above the KRD Canal: Schnebly Creek and Coleman Creek. It discharges into Naneum Creek just north-east of Fiorito Pond.

Next is Cooke Creek, which flows south out of the Colockum Pass area. After passing under the KRD Canal, the creek travels approximately six miles until it passes beneath the CID Canal. The creek then flows through the city of Kittitas, including an underground portion, and then turns southwest where it intersects with the EWC Canal. From there it continues southwest, and flows under I-90 until it ultimately discharges into Cherry Creek.

Adjacent to Cooke Creek is Caribou Creek, which runs parallel throughout its entire length. Caribou Creek flows south out of the Colockum Pass area and passes under the KRD Canal immediately north of the intersection of Erickson and N. Caribou Roads. After flowing downstream in a southwesterly direction for approximately six more miles, the stream crosses the CID Canal and then passes by the south-east corner of the city of Kittitas. The stream intersects with the EWC Canal 1.6 miles downstream from the city. After continuing downstream for another 2.5 miles, Caribou Creek joins with Parke Creek to form Cherry Creek.

Further eastward, Parke Creek flows southwest and parallel to I-90, westward toward Ellensburg, and crosses all three of the irrigation canals. Parke Creek merges with Caribou Creek to form Cherry Creek approximately ½ mile east of the confluence with Johnson Drain. Johnson Drain lies directly south of Parke Creek and begins at the Cascade Canal and flows westward until it ultimately merges with Cherry Creek. Cherry Creek is short (1.4 miles) and continues southwest, receiving discharges from Cooke Creek and the Wipple Wasteway, and ultimately discharges into Wilson Creek.

Wipple Wasteway begins as a discharge from the up-gradient KRD turbine canal spillway. Approximately 1.5 miles prior to flowing under the CID Canal, Badger Creek enters the Wasteway from the southeast portion of the Wilson Creek sub-basin. Along its path, Wipple Wasteway receives water from the CID and EWC Canals. The Wasteway flows northwesterly until it discharges into Cherry Creek, just prior to its confluence with Wilson Creek.

Problem Statement

Within the Wilson Creek sub-basin, some creeks were placed on both the state 1996 and 1998 303(d) lists of impaired water bodies due to the water quality parameters exceeding the state Class A water quality standards. Two of sub-basin's creeks (Cooke Creek and Wilson Creek) were determined to have exceeded the state Class A numeric two-tiered fecal coliform (FC) water quality standard without consideration of the sub-basin's natural conditions. Table 5 details all of the sub-basin 1996 and 1998 303(d) listings.

Table 5: 1996 and 1998 303(d) Listings in the Wilson Creek Sub-basin

Year	Water body Name	WRIA	Water Body Old #	Water Body New #	Township/ Range/ Section	Parameter
1996	Cooke Creek	39	WA-39-1034	N/A	N/A	Dissolved Oxygen
”	” ”	”	”	N/A	N/A	**Fecal Coliform**
”	” ”	”	”	N/A	N/A	Temperature
”	Wilson Creek	”	WA-39-1020	N/A	N/A	**Fecal Coliform**
”	” ”	”	”	N/A	N/A	Temperature
1998	Cherry Creek	39	WA-39-1032	FT68CT	17N/19E/29	4,4'-DDE
”	” ”	”	”	”	”	DDT
”	” ”	”	”	”	”	Dieldrin
”	” ”	”	”	”	17N/19E/31	Temperature
”	Cooke Creek	”	WA-39-1034	SZ58XV	17N/19E/10	Dissolved Oxygen
”	” ”	”	”	”	”	**Fecal Coliform**
”	” ”	”	”	”	17N/19E/11	Dissolved Oxygen
”	” ”	”	”	”	”	**Fecal Coliform**
”	” ”	”	”	”	19N/20E/19	Temperature
”	Naneum Creek	”	WA-39-1025	MA29CN	19N/19E/03	Temperature
”	Wilson Creek	”	WA-39-1020	EB21AR	17N/18E/25	**Fecal Coliform**
”	” ”	”	”	PY59BF	17N/19E/30	Temperature
”	” ”	”	”	”	17N/19E/31	Temperature
”	” ”	”	”	”	18N/19E/30	**Fecal Coliform**

The listing of Cooke Creek and Wilson Creek as being *impaired* for FC bacteria indicates that such water bodies pose a potential health hazard to those persons having primary contact with them. Ecology must conduct a TMDL assessment for all impaired, 303(d)-listed water bodies. TMDLs are defined in 40 CFR Part 130 as the determination of maximum allowable individual point source wasteload allocations and non-point source load allocations. As noted previously, a TMDL for sediment, turbidity and organochlorine pesticides that includes the project area of the *Wilson Creek Sub-basin Bacteria TMDL* is currently in place.

Objectives

The main objectives of this technical assessment are:

1. Review historical data to:

   A. Establish the difference between the current FC densities in the surface waters of the Wilson Creek sub-basin and the state two-tiered FC water quality standard; and

   B. Relate the FC water quality densities to past and present land use activities;

2. Determine, to the extent possible, the sources and transport mechanisms of FC pollution throughout the Wilson Creek sub-basin; and

3. Set FC wasteload allocations for individual point sources and a single load allocation for all combined non-point sources located within the Wilson Creek sub-basin.

Background

What are Fecal Coliform Bacteria?

FC bacteria are a subset of total coliform bacteria. Total coliform bacteria are aerobic or facultatively anaerobic, gram-negative, non-sporeforming, rod-shaped bacteria that ferment lactose with gas production in 24 to 48 hours. FC bacteria are more thermo-tolerant than the other types of total coliform bacteria, so they are specifically identified after having been incubated in the laboratory at 44.5˚C. *Escherichia coli* (*E. coli*) are the predominant subset species of the FC group of bacteria, typically representing 90-99% of that group.

What are the Sources of Fecal Coliform Bacteria?

FC bacteria are bacteria that originate from the intestinal tracts of homothermic (warm-blooded) animals and have an excellent positive correlation with fecal contamination of water from war-blooded animals (Greenberg et al., 1992). The scientific literature indicates that there are numerous point and non-point sources of FC bacteria including, but not limited to, primary sources such as wildlife, agricultural animals, pets, humans, and naturally occurring bacteria. Potential secondary sources include bacterial re-growth and re-suspension. All of these sources are present in the Wilson Creek sub-basin; however, the extent of each source's importance needs to be determined. A short description of each source type follows:

1. **Primary Sources**: The primary sources of FC bacteria in the Wilson Creek sub-basin are: wildlife, agricultural animals, pets, humans, and naturally-occurring bacteria.

   Agricultural Animals: In the Wilson Creek sub-basin, agricultural animals include commercial livestock (beef cattle) as well as those species typically found on non-commercial hobby farms (horses, cattle, sheep, and poultry).

   Wildlife: Types of wildlife determined to contribute FC bacteria to local water bodies within the sub-basin include birds, rodents, deer, skunks, opossums, raccoons, muskrats, rabbits, prairie dogs, beaver, otters, porcupines, and shrews.

Pets: Domestic dogs and cats are the primary pet contributors of FC in the Wilson Creek sub-basin.

Humans: Humans generally deposit waste into either individual on-site septic systems (OSS) or larger municipal collection and treatment systems.

Naturally occurring bacteria: It is also important to note that not all FC are attributable to warm-blooded animals. There are some bacteria (Klebsiella, Enterobacter and Serratia), which contain specific species that naturally occur as free-living bacteria on plants and soils. These bacteria may produce false positives during FC testing; however, they can be isolated during analysis by using as the bacterial growth medium “m FC broth”, which includes bile salts and pH indicating dye. These bacteria are inhibited by the bile salts while the pH indicator dye will cause any remaining non-fecal bacteria colonies to appear a different color.

2. **Secondary Sources**: Potential secondary sources of FC bacteria in the Wilson Creek sub-basin are bacterial re-growth and re-suspension.

Bacterial re-growth: FC bacterial densities undergo population increases (after growth) in deposited manure in two stages: an initial re-growth during the first three to six after deposition, and a slower “delayed re-growth” period following ten days after deposition (Crane, 1988; Wang and Mankin, 2001). Significant FC re-growth in surface waters occurs during the summer months, even with increased die-off rates (Edmond, R.L., (1976; Doran and Linn, 1979; and Howell et al., 1996).

Re-suspension: FC densities in surface waters can also occur due to increases in flow or other sediment disturbances, which causes the re-suspension of bacteria-rich stream bottom sediments (Sherer et al, 1992).

It is possible to estimate the FC loading from each animal species in a watershed by multiplying the average number of animals of a species by the average daily output of FC bacteria corresponding to that individual species by using Table 6. Although this method gives an estimate of the potential bacterial contributions of the various animal sources within a watershed, it provides a poor estimate of the actual bacterial loadings from all of the various primary sources to the local water bodies. This is because some animal species can spend more or less time near surface waters than others, and that different land areas have varying surface runoff rates.

Table 6: Average Output of FC Bacteria

Animal Type	(x 10^9 cfu/day/individual)
beef cow[1.,3] (confined)	105.0
beef cow[2] (grazing)	38.4
goose[4,7,8]	24.0
sheep[1,3,5]	14.1
hog[1,3,4,5]	10.2
duck[1,3,4,5]	6.71
dog[7]	4.09
elk	2.06
deer[3]	0.500
horse[1,3]	0.419
chicken[1,3,4,5]	0.188
human[6] (failing septic tank)	0.175
raccoon[1]	0.113
turkey[1,3,5]	0.104
beaver[7]	0.093
cat[7]	0.005

1 From ASEA D384.1 DEC99: Manure Production and Characteristics.
2 From University of California Cooperative Extension, 2002.
3 From North Carolina Cooperative Extension Service, 1994.
4 From LIRPB, 1978.
5 From Metcalf and Eddy, 1991.
6 From Horsley and Witten, 1996
7 From Virginia Department of Environmental Quality, 1999.
8 From Alderisio and DeLuca, 1999.

For example, many animals are not located adjacent to surface waters and buffer areas of various sizes exist. The loading estimations obtained would be far from representative of actual conditions. In addition, such method does not account for the secondary sources of FC bacterial such as re-growth and re-suspension of bacteria-rich stream bottom sediments resulting from high flows and physical disturbance of the surface waters. Therefore, this technical assessment prefers to utilize *E. coli* ribotyping data, such as that conducted recently by the KCCD and which estimated the actual predominant sources of FC bacteria within the Wilson Creek sub-basin. Such information will help in determining the appropriate best management practices (BMPs) for implementation in order to reduce FC densities.

Fecal Coliform Bacteria Transport Mechanisms

The principal transport mechanisms of FC bacteria are direct deposition by wildlife, agricultural animals, pets and human sources, as well as overland runoff caused by storm water (precipitation and snowmelt) and irrigation.

Overland runoff and direct deposition are the principal transport mechanisms of FC from wildlife and agricultural animals. FC bacteria from pet (dogs and cats) waste typically enter local surface waters through urban runoff, direct deposition, and overland runoff. Urban runoff is water washed into local water bodies due to storm water and irrigation runoff from yards and impervious constructions such as driveways, sidewalks, and streets.

Human FC bacteria typically enter surface waters through wastewater treatment effluent, inadequate OSS, and urban runoff. The only wastewater treatment facility discharging FC directly into the sub-basin is the city of Kittitas, which discharges into Cooke Creek. Rural homes that are located adjacent to area waterways (especially older homes) may have OSS that are inadequately functioning. Septic drainfields can develop *channels* in soils toward downgradient streams and ditches, so that inadequately treated sewage enters those waterways. Additionally, pipes may be discharging inadequately treated sewage directly into area waterways.

The major transport mechanisms of fecal bacteria after manure application to soils include leaching and surface runoff (Reddy et al., 1981). Overland runoff from heavy rainfall was found to produce substantial microbial loading to downstream surface waters (Kistemann et al., 2002) FC bacteria can be strongly hydrophobic and adsorb onto sediment particles (attached-phase bacteria), especially fine-grained clay (Baudart et al., 2000). However, they can also selectively detach from sediment and become free-living (aqueous-phase) bacteria, especially in response to changes in nutrient availability, growth stages, and/or even as a survival mechanism (Bolster et al., 2000; Ginn et al., 2002). Attached-phase bacteria can be filtered as they move through soil, whereas aqueous-phase bacteria are unimpeded.

FC transport through soils depends on several factors such as: (1) filtration rates, (2) soil capacity to retain bacteria or virus, (3) soil water content, (4) soil water flux, (5) soil type, and (6) soil particle size. The capacity of a soil to filter-out FC bacteria decreases with an increase in soil-water content. Therefore, saturated lands and shallow ground waters are highly vulnerable to bacterial contamination. In non-saturated soils, Rahe et al. (1978) indicated that: "…[aqueous-phase bacteria] were transported through [soil] macropores relatively unaffected by the medium through which they were being moved." Hagedorn et al. (1978) found *E. coli* populations in shallow ground water to be largest after a rise in the water table following major rainfall events.

The scientific literature also indicates that FC densities in surface water runoff are in direct relation to bacterial counts in soil (VanDonsel et al., 1967); while, FC densities in soil depends upon animal density and duration of grazing (Edwards et al., 2000). Vegetation filter strips impede surface runoff flow and cause particulates with attached bacteria to settle out, with removal efficiencies increasing with greater length of filter. Settling ponds and the use of polyacrylamide (Entry et al., 2003) also reduce FC densities, similar to the reductions of suspended sediments. Direct deposition of manure by animals into surface waters can occur when they enter such waters to drink. Sheffield and Mostaghimi (1996) found that when provided with an off-stream water trough, each cow spent an average of 51 percent less time in the local stream, which produced a corresponding 51 percent reduction in FC densities in the local surface waters.

Fecal Coliform Bacteria Survival Factors

FC survival is affected by various factors. FC densities in manure deposits usually decline as exposure times for desiccation and to ultraviolet light increase (Elliot and Ellis, 1977). However, moist conditions and crusting of manure deposits tend to increase bacterial densities and lengthen survival times (Crane et al., 1980). FC bacteria usually decline below detectable levels within sixty days of disperse manure deposition, but can survive over one year in manure deposits of both domestic and wild herbivores (Clemm, 1977; Kudva et al, 1998; Marsh and Campling, 1970). *Escherichia coli (E. coli),* the predominant subset of FC bacteria, were never recovered from the dry top layer of manure piles but were numerous inside the moist piles.

Interestingly, Kudva et al. (1998) determined that *E. coli 0157:H7* survive longer in manure in the environment than in the gastrointestinal tract of animals.

FC bacteria survive for long periods in environmental samples at cooler temperatures. In fact, *E. coli O157:H7* (a verotoxin-producing strain) bacteria have been found to survive at least 100 days in bovine manure frozen at -20˚C (Kudva et al., 1998). Wang et al. (1996) determined that *E. coli O157:H7* in bovine manure can survive for up to nine weeks in the field, while still retaining its ability to produce verotoxins. For ovine (sheep) manure, Kudva et al. (1998) determnined that *E. coli O157:H7* survived for more than one year under natural environmental conditions. Wang and Doyle (1998) determined that fecal bacteria survival in water was greatest at 8°C (91 days) and least at 25°C (49 to 84 days). However, when kept dry, Wang and Mankin (2001) determined that the greatest growth of FC bacteria occurred at 27°C, where bacterial densities increased by 3.5 log units after 42 days.

In general, zoonotic pathogens (those transferable from animals to humans) appear to survive longer in water, followed by soil and manure (Guan and Holley, 2003). In stream bottoms, FC bacteria can survive and reproduce for months (Howell et al., 1996). Entry et al. (2000) correlated the increased survival of FC bacteria in soils to increased soil moisture content. In cold (4 -6°C) soil, most pathogens can survive for at least 30 days. If soil pores do not become clogged, *E. coli 0157:H7* can travel below the top layers of soil for more than 2 months after initial application to the land surface (Gagliardi and Karns, 2000).

Significance of Fecal Coliform Bacteria Pollution

There are more than 100 different waterborne enteric pathogens known to be related to the feces of warm-blooded animals, including man. Many diseases/pathogens can be transmitted to humans from animal manure, including cryptosporidiosis, giardiasis, salmonellosis, shigellosis, toxoplasmosis, *Ascaris suum*, *Campylobacter jujuni*, *Escherichia coli* (*E. coli*) O157:H7 and *Yersinia enterocolitica*. Due to the diversity and unpredictability of individual pathogens, water quality testing for each individual pathogen would be very time-consuming, technically intensive, and prohibitively costly. Fortunately, testing for an indicator organism is much easier and has been utilized during the past 100 years. FC is currently the standard for determining microbial water quality in the state, although a change to *E. coli* (approximately 97 percent of FC bacteria) has been discussed.

The presence of FC indicator organisms in a water sample does not necessarily mean that pathogenic organisms are present. However, excessive FC densities in a water body represents a statistically significant potential health risk for human beings, and could result in the loss of beneficial uses like swimming, fishing, boating, incidental contact, and water sports. Beneficial uses of water bodies are required to be protected by both the federal Clean Water Act (CWA) and the state's own surface water quality standards. However, the majority of the beneficial uses listed above infrequently exist in the sub-basin's surface waters and many are specifically prohibited by the local irrigation districts. In the near future, local interests intend to petition to change current designated uses for many sub-basin water bodies.

Background Fecal Coliform Bacteria Pollution

Based on historical information, background FC sampling sites for the *Wilson Creek Sub-basin Bacteria TMDL* were selected as all of the sampling sites located upgradient of the KRD Canal, on the edge of upland forests and intensive agriculture. The specific background water quality sampling sites utilized for this technical assessment include the same four background sites that were established by the *Upper Yakima River Basin Suspended Sediment and Organochlorine Pesticide Total Maximum Daily Load Evaluation*, with addition of a second site on Naneum Creek at Charlton/Farrell Road. The geometric mean and 90% value FC densities for those sites were 18 and 91 cfu/100mL (CL-1); 81 and 300 cfu/100mL (CK-1); 6 and 42 cfu/100mL (NC-1); 24 and 280 cfu/100mL (NC-2 during 2000); and, 32 and 130 cfu/100mL (NC-2 during 2001). The combined (N=46) background geometric mean and 90% value FC densities were 24 and 130 cfu/100mL, respectively. Table 7 contains a description of the five background sampling sites utilized for this technical assessment and are identified in both Figures 2 and 3.

Table 7: Background Sampling Sites for the Wilson Creek Sub-basin Bacteria TMDL

Site Locations	Site #
Coleman Creek: at first bridge on Coleman Creek Road	CL-1
Cooke Creek: at Cooke Canyon Road	CK-1
Naneum Creek: at first bridge on Naneum Road	NC-1
Naneum Creek: at Charlton/Farrell Road	NC-2
Schnebly Creek: at the end of Fairview Road	SC-1

Land-use Inventory

Land-use distribution in the Wilson Creek sub-basin was estimated from 1992 Landsat imagery presented in Figure 2. Figure 3 details the distribution of various agricultural crop types throughout the Wilson Creek sub-basin during 1999 and 2000. In addition to the crop types, there are located various hobby farms and AFOs throughout the sub-basin. Figures 2 and 3 were provided to Ecology by the Kittitas County Conservation District (KCCD). Table 8 details the sampling site locations associated with Figures 2 and 3.

[6] See Appendix A for definition.

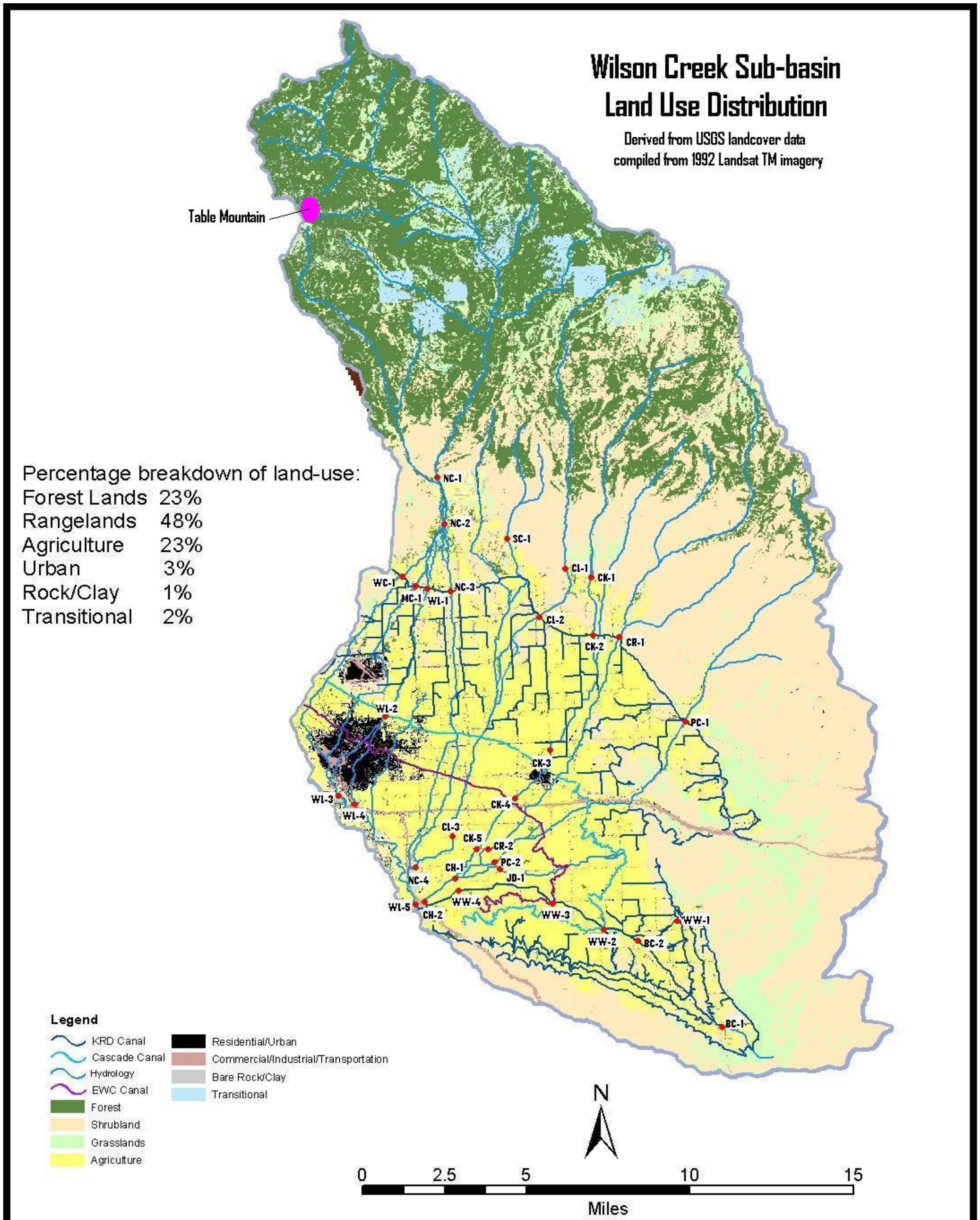

Figure 2: Wilson Creek Sub-basin Land Use Distribution

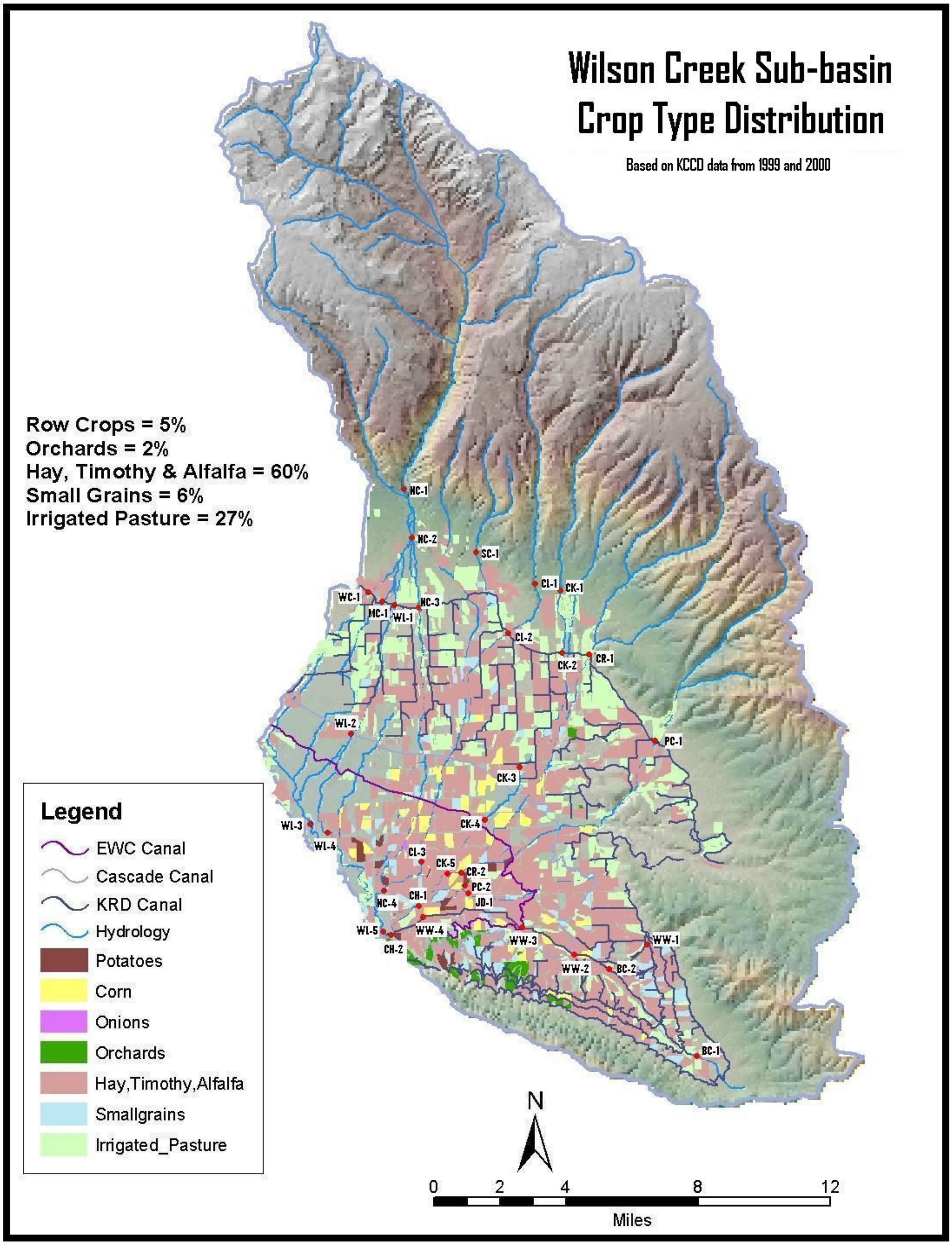

Figure 3: Wilson Creek Sub-basin Crop Type Distribution

Table 8: Sampling Site Locations for Figures 2 and 3

Surface Water	Site #	Site Location
Badger Creek	BC-1	at Silica Road
"	BC-2	at Double K Ranch
Caribou Creek	CR-1	at the KRD Canal
"	CR-2	at South Ferguson Road
Cherry Creek	CH-1	at Moe Road
"	CH-2	at Thrall Road
Coleman Creek	CL-1	at Coleman Creek Road
"	CL-2	at the KRD Canal
"	CL-3	at Moe Road
Cooke Creek	CK-1	at Cooke Canyon Road
"	CK-2	at the KRD Canal
"	CK-3	at No. 81 Road
"	CK-4	at Fairview Road
"	CK-5	at South Ferguson Road
Johnson Drain	JD-1	at South Ferguson Road
Mercer Creek	MC-1	at the KRD Canal
Naneum Creek	NC-1	at Naneum Road
"	NC-2	at Charlton Road
"	NC-3	at the KRD Canal
"	NC-4	at Fiorito Pond
Parke Creek	PC-1	at the KRD Canal
"	PC-2	at South Ferguson Road
Schnebly Creek	SC-1	at end of Fairview Road
Whiskey Creek	WC-1	at the KRD Canal
Wilson Creek	WL-1	at the KRD Canal
"	WL-2	at Sanders Road
"	WL-3	at Umtanum Road
"	WL-4	behind Comfort Inn
"	WL-5	at Thrall Road
Wipple Wasteway	WW-1	at Headworks
"	WW-2	at CID Spillway
"	WW-3	at EWC Spillway
"	WW-4	at Moe Road

Point sources of FC bacteria are limited to concentrated animal feeding operations[7] (CAFOs) and municipal wastewater treatment facility effluent. Presently, there are two active CAFO permits in the sub-basin: Central Valley Holstein (WA-005229-9) and Beef Northwest Feeders, LLC. (WA-005222-1). However, only the first facility is still in operation (located on Old Vantage Highway near KRD Canal). The only municipal wastewater treatment facility that discharges effluent into the Wilson Creek watershed is the city of Kittitas.

[7] See Appendix A for definition.

Historical Information

The surface waters located within the Wilson Creek sub-basin have historically exceeded the state Class A FC water quality standard. The following chronological information will demonstrate the historical problem of FC contamination within the Wilson Creek sub-basin:

1. A CH_2M Hill (1973) report detailed the results of August 29-30, 1973 water quality monitoring that included the mouth of Wilson Creek on the Yakima River. The FC densities at that site varied from 160 to 560 cfu/100mL. All but one of the five samples exceeded the state Class A FC 90% value standard of 200 cfu/100mL.
2. A report compiled by JARA Consulting (1975) gave the results of bacterial water quality sampling data collected by the Kittitas County Conservation District (KCCD) in 1974, which indicated that FC pollution typically does not exceed the state's Class A FC water quality standards at the higher locations upgradient of KRD Canal of the sub-basin. As the waterways flow downgradient through the sub-basin, the FC densities increased to a maximum of 5,300 cfu/100mL (Wilson Creek at Sanders Road). All of the lower locations (downgradient of the KRD Canal) exceed the state Class A FC water quality standards.
3. Ecology (1976) water quality sampling of Wilson Creek in 1975 indicated twenty-four FC densities ranging from 0 to 11,000 cfu/100mL with a mean of 970 cfu/100mL (arithmetric mean, not geometric mean).
4. The U.S. Army Corps of Engineers (1978) published a report containing FC sampling conducted by the U.S. Bureau of Reclamation during May and October 1974 throughout the Yakima River Basin. The report contained eight FC densities ranging from 130 cfu/100mL to 7,000 cfu/100mL that were collected throughout the length of Wilson Creek.
5. A 1980 Ecology report discussed the results of bacterial water quality samples collected during the periods of July-October of 1978 and May-July of 1979. The report determined that FC densities: (1) within the KRD Canal and its up-gradient water bodies were predominantly in compliance with the Class A FC water quality standard; (2) increased successively when progressing downgradient through the sub-basin; and (3) were largest in the area located between the KRD and EWC Canals, and had a median density of 4,000 cfu/100mL.
6. The USGS (1987) background sites in forested areas contained the lowest concentrations of turbidity, bacteria, nutrients and major ions. The greatest concentrations were found in agricultural return drains. The report indicated that this is because hydrophobic contaminants, such as attached-phase FC, will be transported via suspended sediment during the irrigation season, during major storm events, or when Chinook (warm) winds melt the snow and cause increased overland runoff and high flows in the return drains.
7. The USGS (1992) indicated that the only sites, in the northern Yakima River Basin, not in compliance with EPA limits for bacteria in recreational waters were the water bodies near the town of Ellensburg. Seventeen FC samples were taken from Wilson Creek during the irrigation season throughout the years of 1972-1985, which indicated a maximum of 11,000 cfu/100mL and a median of 500 cfu/100mL. In addition, on 7/26/88, two irrigation water supply canals passing near Ellensburg contained high concentrations of *E. coli*: CID Canal = 1,200 cfu/100mL; and EWC Canal = 730 cfu/100mL.

Various scientific literature indicates that FC bacteria in manure deposited on land can be transported to local surface waters via overland and subsurface runoff caused by stormwater events, snowmelt and irrigation return flow (Drapcho and Hubbs, 2002; Gburek, 2000; Fischer and Endale, 1999; Lim et al., 1998; Edwards et al., 1997; Sinton et al., 1997; USGS, 1992; Maret et al., 1991; Buckhouse and Bohn, 1983; and Doran and Lin, 1979). Manure can also be deposited directly into surface waters when animals have direct access to such waters (Bagshaw, 2002). Other sources of FC bacteria within the Wilson Creek sub-basin include inadequate OSS; urban runoff; natural re-growth of bacterial populations; and re-suspension of bacteria-rich stream bottom sediments. In the Wilson Creek sub-basin, analysis of several subsurface drains has shown little, if any, FC pollution.

Water Quality Technical Assessment

2001 Kittitas County Microbial Source Tracking Project

The majority of the information concerning this section was made via personal communication with Anna Lael of the Kittitas County Conservation District (KCCD). In an effort to determine the animal species that are sources of the FC pollution within the Wilson Creek sub-basin, the KCCD collected water quality samples at six sites from April to November of 2001. The sites were: CID Headworks (outside of sub-basin), CID Canal at Thrall Road (CID-1 in Fig. 1), Cooke Creek at No. 81 Road (CK-3 in Fig. 2 & 3), Cooke Creek at Fairview Road (CK-4 in Fig. 2 & 3), Cherry Creek at Moe Road (CH-1 in Fig. 2 & 3), and Wipple Wasteway at Moe Road (WW-4 in Fig. 2 & 3).

At each site, for each sample date, five water samples were collected two minutes apart. Water samples were shipped to the Bureau of Reclamation laboratory in Boise, Idaho for *E. coli* analysis. *E. coli* growth plates were sent to Dr. Samadpour at the University of Washington for RNA analysis and comparison to an extensive library of previously collected data. A total of 1,060 *E. coli* isolates were compared to the source library using only two isolates per plate. This method uses two restriction enzymes, EcoRI and PvuII, in order to increase the probability of correctly identifying the host of each *E. coli* isolate.

The ribotyping data determined that the three greatest number of isolates, in order, were identified as avian (21.3%), bovine (19.3%), and rodents (12.8%). Other identified species were: canine (7.1%), human (5.7%), horse (3.2%), raccoon (2.4%), muskrat (2.0%), rabbit (1.7%), feline (1.7%), deer (0.6%), prairie dog (0.4%), beaver/otter (0.3%), opossum (0.2%), porcupine (0.2%), sheep (0.2%), shrew (0.1%), and poultry (0.1%). The report also indicated a high proportion (20.8%) of *E. coli* isolates that were not identified as to their respective animal sources. Even with this large amount of unidentifiable isolates, the ribotyping data represents the best available science to-date for identification of the animal sources of *E. coli* pollution within the Wilson Creek sub-basin. The KCCD study did not include any control samples of manure taken from animal species within the test area, and relied only on the pre-existent library of *E. coli* isolates collected by Dr. Samadpour from various areas of the nation.

However, there are some concerns with ribotyping *E. coli* bacteria. Jenkins et al. (2003) indicated that the temporal change and diversity of *E. coli* within individual host animals, as well as within each host species, is so great that in order to allow any appropriate conclusions a large number (>900) of isolates would need to be collected from each host species. In addition, Hartel et al. (2002) determined that there is substantial geographic variability in *E. coli* bacteria that suggests that ribotyping has good promise to discriminate among host animal species at one location, but not when different locations exceed a 175-km radius. Later research by Hartel et al. (2003) indicated that differences in diet also affect the ribotype diversity of *E. coli* in deer. Fogarty et al. (2003) determined that genomic characteristics of *E. coli* in seagulls differ *within faecal samples, between faecal samples collected on the same date and between samples collected on different dates.*

1999-2002 Wilson Creek Sub-basin Bacterial Sampling

The KCCD, KRD and Ecology monitored water quality throughout the Wilson Creek sub-basin during 1999. In order to prevent duplication of sampling efforts, the Kittitas County Water Purveyors (KCWP) began coordinating sub-basin sampling efforts beginning in the year 2000. The KCWP is composed of representatives from various water companies, districts, creek diverters and area users. Appendix C of this report contains all of the water quality data collected during 1999 through 2002 by the KRD, KWCP and KCCD and submitted to Ecology, as well as data collected by Ecology in 1999. All statistical analyses presented in this section compare the $\log_{10}$ transformations of actual bacterial densities, which provide normally distributed data for proper statistical analyses. All of the presented calculated geometric means and 90 % values are rounded to two significant figures.

1. Monthly Variation in FC Densities

Utilizing the 1999–2002 data, a statistical analysis was made of 1,042 FC densities collected from throughout the Wilson Creek sub-basin. Water samples collected at diversion points along the Yakima River (114 samples) were not included because they were collected from outside the sub-basin. The densities were sorted by the calendar month in which they were collected, with statistical analysis then performed on the pooled monthly data. No samples were collected during the months of January, February, and December. Table 9 details the statistics of the pooled monthly data. Figure 4 illustrates the distribution of the pooled monthly data.

Table 9: Wilson Creek Sub-basin-wide FC Statistics (cfu/100mL) Categorized by Month: 1999-2002

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
N	39	88	168	187	146	142	132	77	63
Geom. Mean	22	96	190	285	349	285	220	119	30
90% Value	300	800	1,100	1,600	2,900	1,000	900	900	140

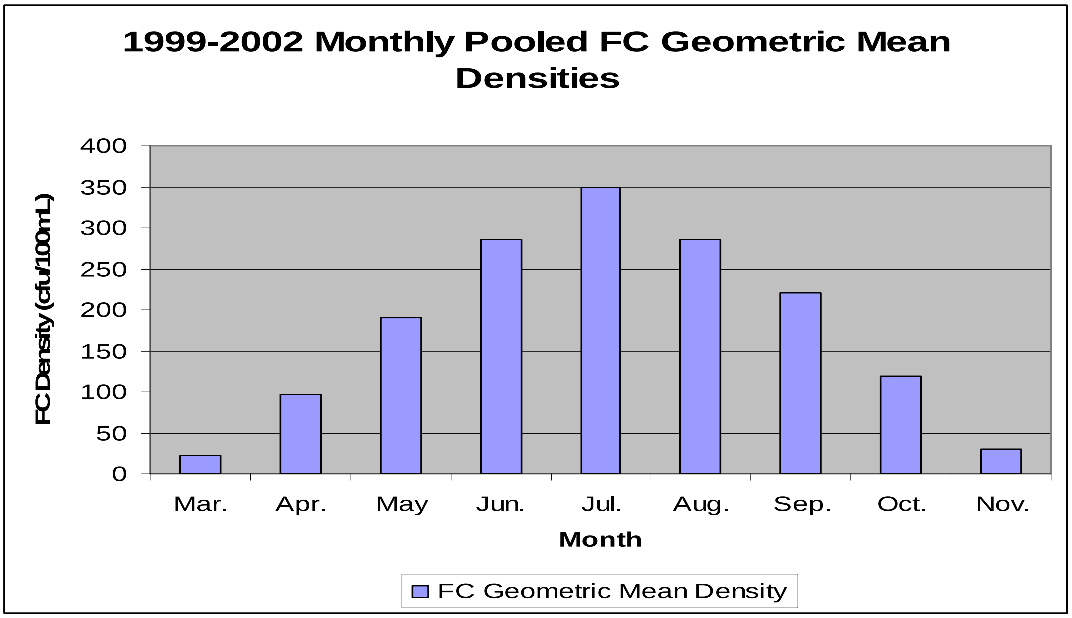

Figure 4: 1999-2002 Monthly Pooled FC Geometric Mean Densities

A least significant differences (LSD) test statistical analysis of the 1999–2002 pooled data found a highly significant[8] difference between the monthly FC geometric mean densities. March and November had the lowest FC densities, while the months of June, July and August had the largest FC densities. April and October had statistically equivalent FC densities that were significantly[9] larger than March and November, but less than the FC densities of May and September. Overall, the state Class A FC geometric mean criterion was exceeded during all of the months from April through October. Other studies such as Hunter et al. (1999) have found similar seasonal variations, although they were conducted in England.

[8] ANOVA, F-test, $p = 2.85 \times 10^{-49}$
[9] $p < 0.05$

The monthly variation in FC densities suggests that specific environmental occurrences beginning in April and terminating in October are directly related to the variation of FC densities in the surface waters of the sub-basin. The most notable environmental occurrence that coincides with this monthly distribution of FC densities is the onset and duration of warmer weather throughout the sub-basin. The scientific literature indicates that FC densities increase in conjunction with increasing temperatures (Baudisova, 1997; Edwards et al., 1997; Thurston et al., 2001; USGS, 2002). Figure 5 shows the 1999-2002 monthly average water temperatures.

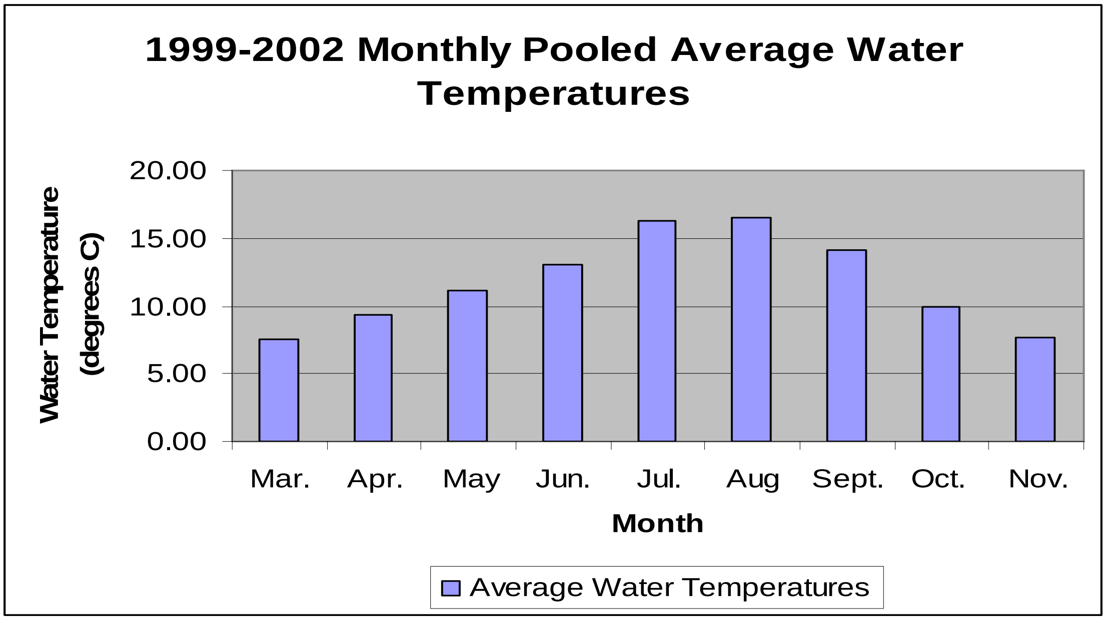

Figure 5: 1999-2002 Monthly Pooled Average Water Temperatures

From Figure 5, it is evident that water temperatures throughout the Wilson Creek sub-basin are coolest in the winter and hottest in the summer. A comparison of Figures 4 and 5 show a commonality in that both FC densities and water temperatures are greatest during the summer months. Warmer weather generally results in various occurrences that have the potential to increase FC densities:

A. Although bacterial die-off rates are higher in warmer temperatures (Reddy et al., 1981), the rates of bacterial re-growth in warmer temperatures exceed the die-off rates. This population dynamics differential has accounted for an overall increase in resident FC densities within surface waters (Doran and Lin, 1979; Stephenson and Street, 1978). LeJeune et al. (2001) even found warmer weather bacterial increases in cattle water troughs.

B. When animal activity and numbers increase during warmer weather, such changes will also cause an overall increase in manure deposition (Thurston et al., 2001; Bagshaw, 2002), which probably includes direct deposition into surface waters.

   Hunter et al. (1999) found that lambing and stocking densities during the summer months were higher than during the winter months.

C. The onset of warmer weather coincides with the sub-basin's annual agricultural growing season. The agricultural growing season requires the application of irrigation water, which results in higher water tables and provides downstream surface water flows. Various authors have determined that overland runoff transports FC off original deposition sites and into local streams and ditches. The USGS hypothesized that this transport mechanism for FC bacteria exists throughout the Yakima River Basin (2002).

Figure 6 shows the 1999-2002 monthly geometric mean stream flows. (Geometric mean stream flows were utilized rather than average stream flows in order to compensate for the natural lognormal distribution of such flows.)

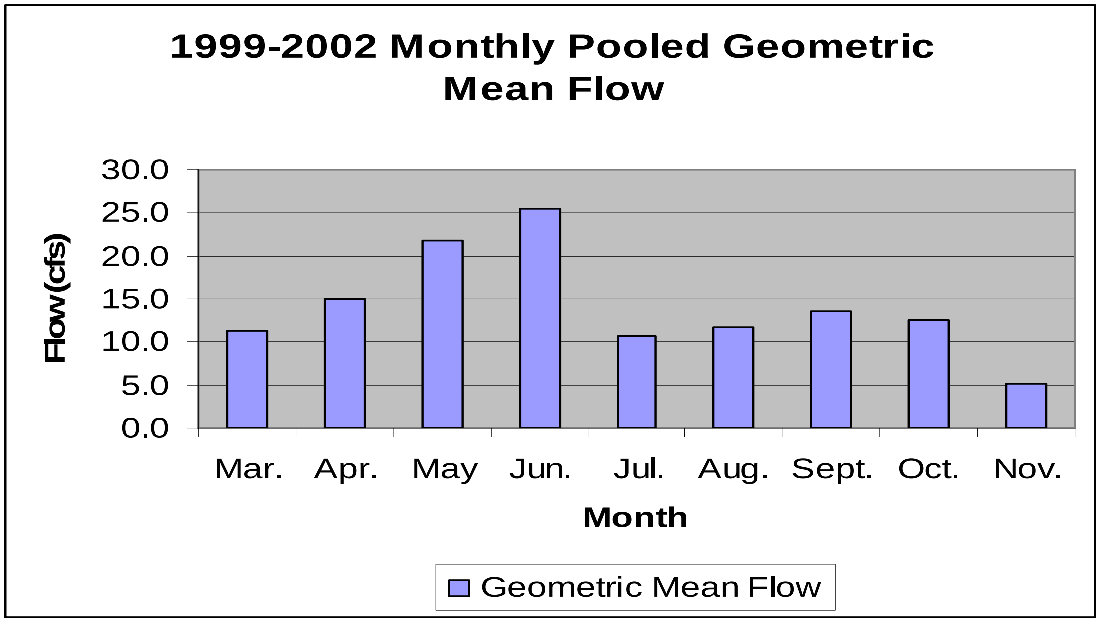

Figure 6: 1999-2002 Monthly Pooled Geometric Mean Flow

The natural stream flows throughout the Wilson Creek sub-basin show two distinct seasons: a large increasing trend during the March through June season (storm water, snowmelt and the start-up of irrigation season), and a smaller consistent July through October season that ends abruptly in November (irrigation water only). Two possible explanations by which excessive FC densities might be found in overland runoff are: (1) the bacteria are brought into the sub-basin along with the supplied storm water and/or irrigation water, or (2) the bacteria are produced within the sub-basin. The next sections of this technical assessment will try to determine which of these two explanations best explains the excessive FC densities found in overland runoff during the summer when minor storm water exists.

2. FC Densities in Irrigation Canals

An assessment of the irrigation water being diverted from the Yakima River (includes Lake Easton) and supplied to Wilson Creek sub-basin is important for determining if that water is the source of the excessive FC densities. Table 10 presents the general statistics of FC pollution at the diversion point of the sub-basin's four major irrigation canals.

Table 10: C Statistics at Irrigation Canal Diversion Sites: 1999-2001

Canal Name	River Mile	N	Geom. Mean (cfu/100/mL)	90% Value (cfu/100mL)
KRD Canal	Lake Easton (Yakima RM 202.5)	33	3	10
EWC Canal	Yakima RM 161.3	35	8	26
CID Canal	Yakima RM 160.4	23	10	30
Bull Ditch	Yakima RM 153.7	23	28	68

The data presented in Table 10 indicates that all of the sampled irrigation water diverted to the Wilson Creek sub-basin from Lake Easton and the Yakima River complies with the state's Class A FC water quality criteria. Since the irrigation water diverted from the Yakima River does not contain excessive FC densities, the excessive FC densities are concluded to have been produced within the Wilson Creek sub-basin. To verify this, the downstream sections of the same irrigation water supply canals should also contain greater FC densities since they receive direct discharges of manure from wildlife, agricultural animals and pets, as well as overland flow from irrigation activities.

Table 11 presents the general statistics of the FC densities at the downstream sites along each of the sub-basin's principal irrigation canals.

Table 11: FC Statistics at Irrigation Canal Downstream Sites: 1999-2002

Canal Name	Site #	N	Geom. Mean (cfu/100/mL)	90% Value (cfu/100mL)
KRD Canal	KRD-1	29	160	3,700
CID Canal	CID-2	35	290	1,100
EWC Canal	EWC-4	35	270	900
Bull Ditch	BD-2	12	490	3,000

Shaded cells indicate FC densities in excess of Class A water quality criteria.

A statistical analysis of the data used in preparing Table 11 determined that highly significant[10] larger FC densities were present at each individual canal's downstream sampling site than at its respective upstream diversion site (Table 10). Ecology concludes that the excessive FC densities are produced within the Wilson Creek sub-basin, and do not enter the sub-basin via the diverted Yakima River irrigation water. (Note: Bain (1999) suggested that run-off from cattle pastures and barnyards as well as septic tank discharges are suspected as causes of high FC densities in the CID Canal.)

3. FC Densities in Streams

In order to determine the extent of excessive FC densities in the Wilson Creek sub-basin, various statistical analyses were conducted on data sampled from seven of the sub-basin's longest streams during the critical condition period (April through October) of 1999-2002. The data at each site were pooled from all years and the geometric mean and 90 percent values calculated. The results are presented in Table 12 and indicate that, during the critical condition period, all of the downstream sampling sites had highly significantly larger FC densities than their respective upstream sites. The widespread increase in FC densities throughout the sub-basin's downstream surface waters further supports Ecology's conclusion that excessive FC densities are produced within the Wilson Creek sub-basin. Lael (2000) found similar FC geometric means (306 to 509 cfu/100mL) during the irrigation season.

Table 12: FC Statistics at Upstream and Downstream Stream Sites: 1999-2002

Surface Water Name	Location	Site #	N	Geom. Mean (cfu/100/mL)	90% Value (cfu/100mL)
Caribou Creek	Upstream	CR-1	33	160	1,800
"	Downstream	CR-2	38	430	4,000
Coleman Creek	Upstream	CL-1	6	13	91
"	Downstream	CL-3	13	380	1,400
Cooke Creek	Upstream	CK-1	8	70	300
"	Downstream	CK-5	40	300	1,100
Naneum Creek	Upstream	NC-1 & NC-2	38	17	120
"	Downstream	NC-4	39	190	520
Wilson Creek	Upstream	WL-1	11	100	500
"	Downstream	WL-5	33	230	720
Wipple Wasteway	Upstream	WW-1	28	32	148
"	Downstream	WW-4	52	221	720

Shaded cells indicate FC densities in excess of Class A water quality criteria.

[10] t-test, $p < 0.01$

Figure 7 details the most recent critical condition period geometric mean and 90 percent value FC densities of the principal tributaries that enter the mainstem Wilson Creek. This method of presentation is made in an effort to help the reader understand the extent of FC pollution throughout the Wilson Creek sub-basin, although Ecology acknowledges that the actual hydrologic connections are more complex than the figure indicates.

It is important to note that the sub-basin's only active CAFO is located immediately downstream of sampling site PC-1. There are no known discharges from the facility; however, there exists a potential for FC to enter Parke Creek between PC-1 and PC-2. In addition, the only municipal wastewater treatment facility discharging into the sub-basin is located at the city of Kittitas, between sampling sites CK-3 and CK-4. However, the facility has undergone many recent process control and collection system improvements and is not presently contributing substantial FC to Cooke Creek. In fact, statistical analyses have shown that the upstream and downstream FC densities during 1999 and 2001 were not significantly different (paired t-tests, $p = 0.3089$ and 0.4570, respectively).

Figure 8 details the latest critical condition period average FC loadings calculated as: *FC geometric mean density (cfu/100mL) x flow (cfs) x 283.2 (100mL/cf)* and given in units of cfu/sec. Such instream loadings are included into this technical assessment only for illustration purposes as FC densities are too variable to be conducive to mass balance analyses (Ecology, 2002). From the information presented in Figure 8, the approximate critical condition period percent FC loadings that enter the Yakima River through the Wilson Creek outfall are distributed as follows: (1) 52% percent via Cherry Creek, and (2) 48 percent via Wilson Creek. This indicates that FC pollution throughout the Wilson

Creek sub-basin is widespread and distributed relatively equally. Ecology acknowledges that the actual hydrologic connections are more complex than the figure indicates.

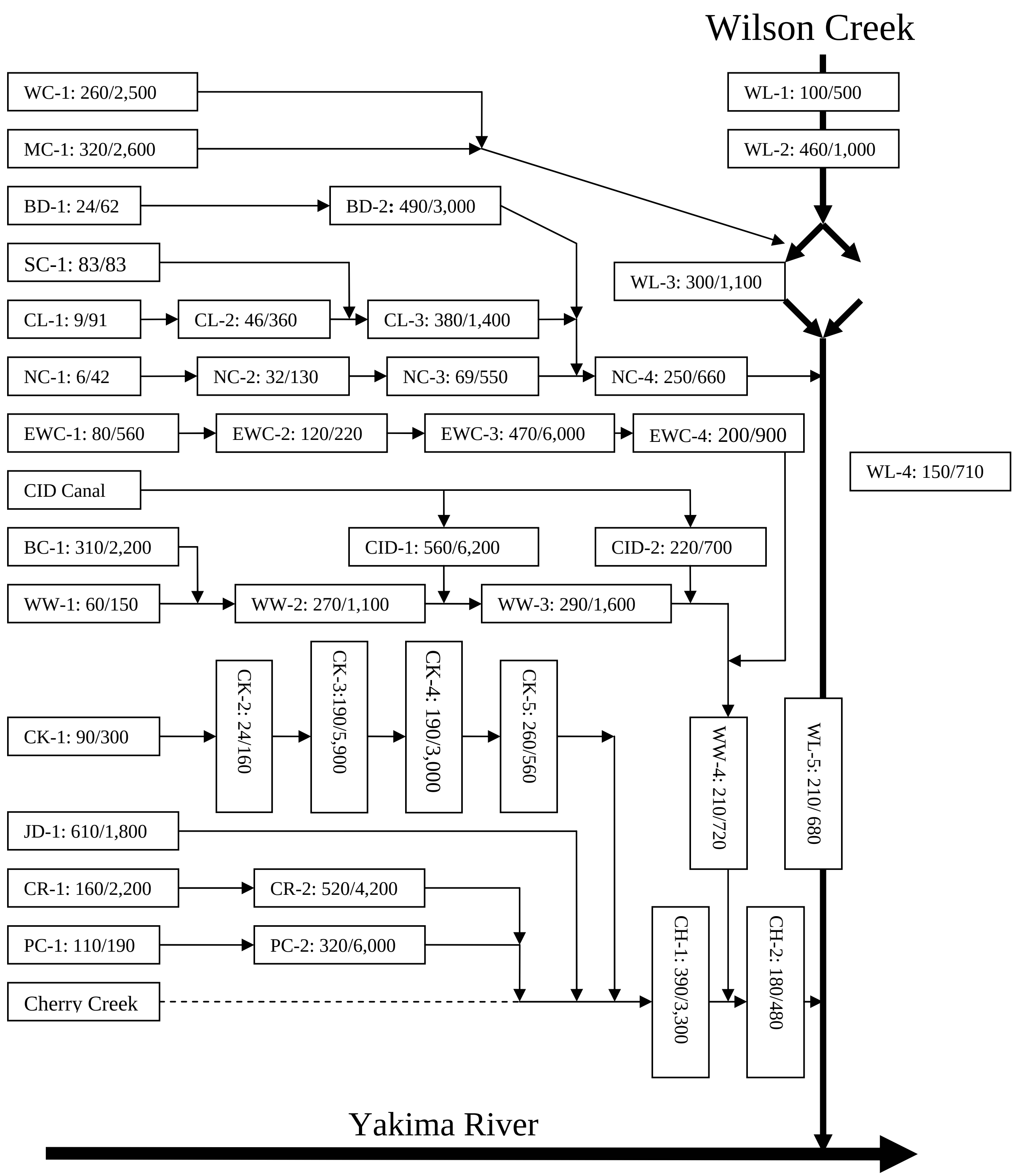

Figure 7: Latest Critical Condition Period Mainstem Wilson Creek and Tributary Geometric Mean/90% Value FC Densities (cfu/100mL)

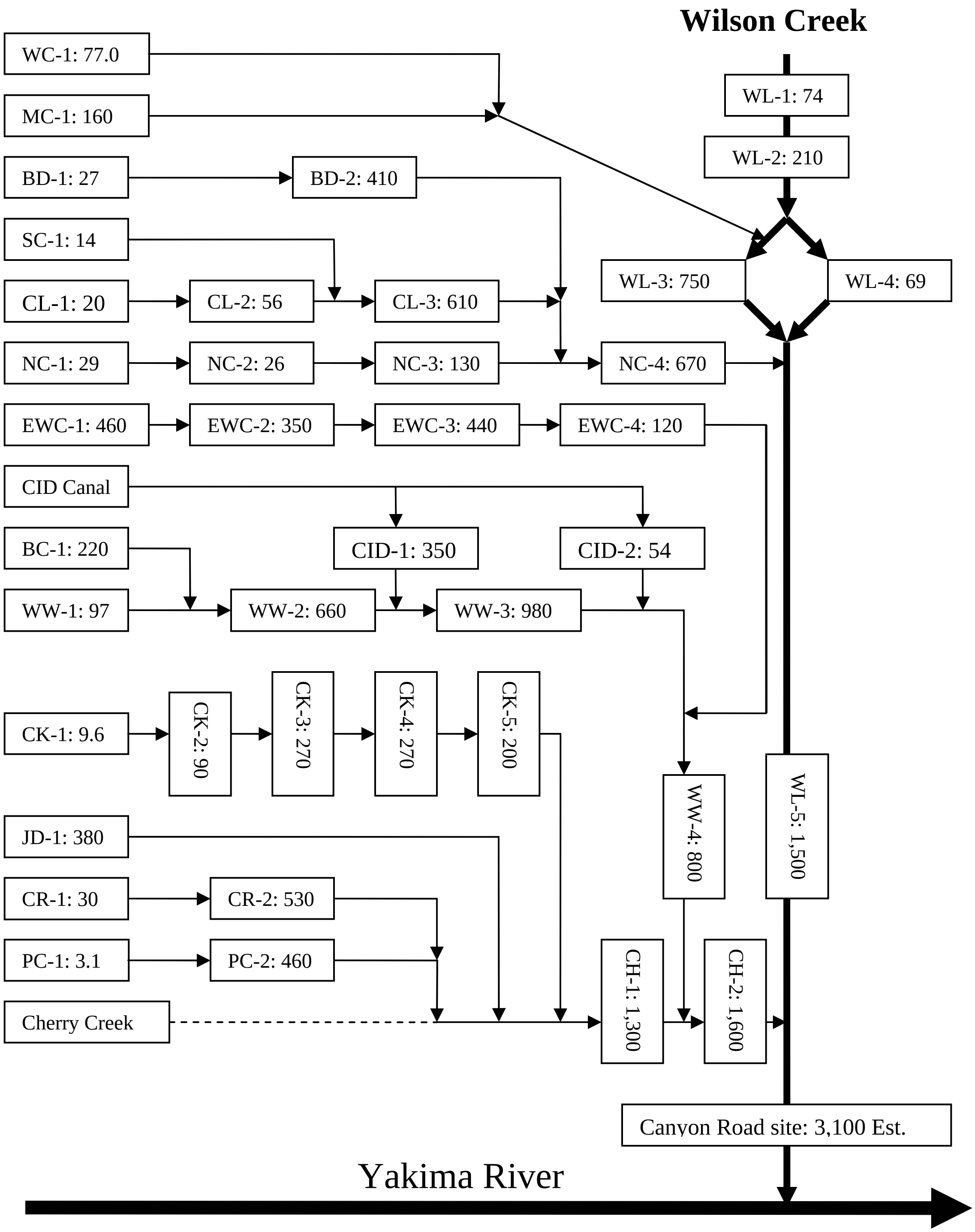

Figure 8: Latest Critical Condition Period Mainstem Wilson Creek and Tributary Average FC Loadings (x10^4 cfu/sec)

Conclusions

The majority of the following conclusions are associated with the recent (1999-2002) water quality monitoring data collected by the KCCD, KRD and Ecology, and which is presented in Appendix C of this technical assessment.

1. Five sampling sites, all located upgradient of the KRD Canal, were identified as being representative of background conditions. The sites are Coleman Creek at Coleman Creek Road (site CL-1), Cooke Creek at Cooke Canyon Road (CK-1), Naneum Creek at Naneum Road (site NC-1), Naneum Creek at Charlton/Farrell Road (NC-2), and Schnebly Creek at the end of Fairview Road (SC-1). The geometric mean and 90 percent value FC densities for those sites were 18 and 91 cfu/100mL (CL-1); 81 and 300 cfu/100mL (CK-1); 6 and 42 cfu/100mL (NC-1); 24 and 280 cfu/100mL (NC-2 during 2000); and, 32 and 130 cfu/100mL (NC-2 during 2001). The Schnebly Creek site (SC-1) did not have enough data to allow calculation of either a geometric mean or 90% value. It should be noted that these background sites are not pristine and include limited amounts of anthropogenic-related activities.

2. A sub-basin-wide statistical analysis of pooled monthly FC densities determined that June, July, and August had the largest FC densities, while March and November had the lowest FC densities. No samples were collected during January, February, and December. The critical condition period (when FC densities exceeded the state numeric Class A FC water quality criteria) for the *Wilson Creek Sub-Basin Bacteria TMDL* was determined to be from April through October, which coincides with the onset and duration of warmer weather and the irrigation season.

3. A sub-basin-wide statistical analysis of pooled monthly water temperatures determined that July and August had the warmest water temperatures, while March and November had the coolest water temperatures. No samples were collected during January, February, and December. The distribution of monthly average water temperatures was very similar to the distribution of monthly geometric mean FC densities.

4. A sub-basin-wide statistical analysis of pooled monthly flow data determined that May and June had the largest flows, while November had the lowest flows. No samples were collected during January, February, and December. Flows in the Wilson Creek sub-basin flows show two distinct seasons: a large increasing trend during March through June season, and a smaller more consistent July through October season that ends abruptly in November.

5. The diverted irrigation water entering the sub-basin via the irrigation canals complies with the state Class A FC water quality criteria. However, all of the tailend sections of those same irrigation canals have FC densities that are in excess of that same criteria. Therefore, the FC densities during the summer are concluded to have been produced within the sub-basin and not transported into the sub-basin along with the irrigation water supply.

6. The KCCD determined that the three most significant animal groups identified as *E. coli* contributors were, in order, birds, cattle and rodents. Other identified animal source species were canine, human, horse, raccoon, muskrat, rabbit, feline, deer, prairie dog, beaver/otter, opossum, porcupine, sheep, shrew, and poultry. This provides a reasonable indication of the predominant animal source species of FC bacteria within the sub-basin and shows the complexity of the FC bacteria nonpoint sources.

7. The principal transport mechanisms of FC bacteria are direct deposition by animals, as well as overland runoff.

TMDL Analysis

Critical Condition Discussion

After analysis of the 1999-2002 water quality sampling data, the critical conditions for FC pollution throughout the Wilson Creek sub-basin are as follows:

- The critical condition period for FC bacteria was determined to be from April through October. During this period, the majority of the FC densities in portions of the seventeen major surface waters located downstream of the KRD Canal were determined to exceed the state's numeric Class A FC water quality criteria. Such surface waters are Badger Creek, Bull Ditch, Caribou Creek, Cherry Creek, CID Canal, Coleman Creek, Cooke Creek, EWC Canal, Johnson Drain, KRD Canal, Mercer Creek, Naneum Creek, Parke Creek, Whiskey Creek, Wilson Creek, and Wipple Wasteway.
- The TMDL FC density analyses are based on data from only the critical condition period (April 15[t] through October 15[h]). Depending on the specific BMP, some BMPs can be applied seasonally while others will need to be applied year-round, as appropriate for each individual BMP.

Loading Capacity

Loading capacity is defined as the maximum amount of a pollutant that a water body can receive and still meet the state applicable surface water quality standards. The TMDL will not establish a specific loading capacity per se for each individual water body, but will rather achieve similar results by establishing a final TMDL target of reaching compliance the state Class A FC water quality criteria.

Since the majority of the water bodies in the Wilson Creek sub-basin exceed the state' numeric Class A FC water quality criteria during the critical condition period, the final TMDL target will apply to all surface waters within the sub-basin. Specific sampling points of compliance will be indicated in the final TMDL Submittal Report and shall be located throughout all the sub-basin's surface waters and incorporate, at a minimum, monitoring at all of their downstream ends. The exact monitoring sites and schedule will be determined in cooperation with the local entities that will be cooperating with Ecology to implement the *Wilson Creek Sub-Basin Bacteria TMDL*.

The TMDL will use a different measure than *daily load* to fulfill the requirements of Section 303(d). FC density will be used as allowed under EPA regulations [defined as *other appropriate measures* in 40 CFR §130.2(I)]. In such cases, a density measure is appropriate due to the consistent relationship between the FC water quality criteria and the receiving water quality for all receiving flow rates.

Load and Wasteload Allocations

As stated in the objectives for this TMDL, this assessment sets FC wasteload allocations for individual point sources and a single load allocation for all combined non-point sources located within the Wilson Creek sub-basin.

1. **Wasteload Allocations**

   The Wilson Creek sub-basin contains one municipal point source: the city of Kittitas municipal wastewater treatment plant (NPDES permit = WA-002125-3). The sub-basin contains no known industrial/commercial point sources. Due to past treatment problems, the city of Kittitas is currently upgrading its municipal wastewater treatment plant, which includes a change from chlorine to UV disinfection. Correspondingly, the facility is required to comply with interim FC bacteria effluent limitations of (1) monthly average = 200 cfu/100mL; and (2) weekly average = 400 cfu/100mL. These interim limitations will be valid only until November 30, 2004, after which the facility upgrades should be completed. Final FC limitations will be: (1) monthly average = 100 cfu/100mL; and (2) weekly average = 200 cfu/100 mL.

   The city of Kittitas' current NPDES permit has an expiration date of September 30, 2006. All subsequent NPDES permits written for the city of Kittitas shall be required to contain bacterial effluent limits no less stringent than: (1) monthly geometric mean = 100 cfu/100mL; and (2) daily maximum of = 200 cfu/100 mL.

   The Wilson Creek sub-basin contains various animal source species of FC bacteria. CAFOs will be given an automatic wasteload allocation of zero because they are required to have no discharge of pollutants at any time to the waters of the state. The only active CAFO in the sub-basin is Central Valley Holstein (WA-005229-9). It has been issued an NPDES permit that requires no discharge, unless caused by a storm event in excess of the area's 25-year, 24-hour precipitation amount.

2. **Load Allocations**

   A single load allocation has been determined for all nonpoint sources of FC pollution in the Wilson Creek sub-basin. The present load allocation is compliance with the Class A fecal coliform (FC) water quality criteria of a geometric mean of 100cfu/100mL and a 90th value of 200cfu/100mL. Ecology may also develop use-based standards in the future, in which case the above load allocation will correspondingly change.

   Ecology recognizes that there is a significant amount of FC bacteria contributed by wildlife to the water bodies throughout the sub-basin. Ecology also recognizes that while anthropogenic FC inputs may be significantly reduced through TMDL implementation, it is unrealistic to expect that all such FC contributions will ever be completely eliminated from the Wilson Creek Sub-basin.

Margin of Safety

The following is a discussion of the margin of safety (MOS) to account for uncertainty in the recommendations. Because all point sources associated with this TMDL are already in compliance, a MOS is not strictly required for completion of this technical assessment. However, certain elements of this study offer extra assurance that the calculations accurately assess the nature of the pollution problem, and are noted in this section.

The MOS can be placed either implicitly in the assumptions, or explicitly as a separate load allocation or target component. The *Wilson Creek Sub-basin Bacteria TMDL* contains the following implicit MOS factors:

- The 1999-2002 sampling data utilized for comparison to the state's Class A FC water quality criteria were taken only from the critical condition period and are, therefore, not skewed by the addition of significantly lower FC densities typically found outside the critical condition period. This represents a slight amount of MOS.

[11] See Appendix A for definition.

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APPENDIX A
(to Technical Assessment)

APPENDIX A

Definitions of Selected Terms

90% value:

For the *Wilson Creek Sub-basin Bacteria TMDL*, a 90$^{t\%}$ value is defined as that single data value which represents the beginning of the largest ten percent (10%) of data values after ranking all applicable data values, from highest to lowest. For example: if a data set contains 1 to 19 values, the 90% value shall be the largest value; if a data set contains 20 to 29 values, the 90% value shall be the second largest value; etc.

Animal Feeding Operation (AFO):

A lot or facility where animals have been, are, or will be stabled, or confined and fed or maintained for a total of 45 days or more in any 12-month period. Crops, vegetation forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility. It is not necessary that the same animals be fed or maintained on the lot for the entire 45-day period nor do the 45 days need to be consecutive. [CFR 122.23]

Concentrated Animal Feeding Operation (CAFO):

A large CAFO is defined as: an animal feeding operation, which meets one of the following: (1) Has at least: 700 mature dairy cows, whether milked or dry; 1,000 veal calves; 1,000 cattle other than mature dairy cows or veal calves (cattle includes but is not limited to heifers, steers, bulls and cow/calf pairs); 2,500 swine each weighing 55 pounds or more; 10,000 swine each weighing less than 55 pounds; 500 horses; 10,000 sheep or lambs; 55,000 turkeys; 30,000 laying hens or broilers, if the AFO uses a liquid manure handling system; 125,000 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system; 82,000 laying hens; if the AFO uses other than a liquid manure handling system; 30,000 ducks (if the AFO uses other than a liquid manure handling system); or 5,000 ducks (if the AFO uses a liquid manure handling system).

A medium CAFO is defined as: an animal feeding operation, having pollutants discharged into the waters of the United States either through a made-made ditch, flushing system, or other similar man-made device; or having pollutants discharged directly into water of the United States that originate outside of and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation. Such AFO must also have: 200 to 699 mature dairy cows, whether milked or dry; 300 to 999 veal calves; 300 to 999 cattle other than mature dairy cows or veal calves (cattle includes but is not limited to heifers, steers, bulls and cow/calf pairs); 750 to 2,499 swine each weighing 55 pounds or more; 3,000 to 9,999 swine each weighing less than 55 pounds; 150 to 499 horses; 3,000 to 9,999 sheep or lambs; 16,500 to 54,999 turkeys; 9,000 to 29,999 laying hens or broilers, if the AFO uses a liquid manure handling system; 37,500 to 124,999 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system; 25,000 to 81,999 laying hens, if the AFO uses other than a liquid manure handling system; 10,000 to 29,999 ducks (if the AFO uses other than a liquid manure handling system); or 1,500 to 4,999 ducks (if the AFO uses a liquid manure handling system).

A small CAFO is defined as: an animal feeding operation, having pollutants discharged into the waters of the United States either through a made-made ditch, flushing system, or other similar man-made device; or having pollutants discharged directly into water of the United States that originate outside of and pass over, across, or through the facility or otherwise come into direct contact with the animals confined in the operation. Such AFO must not be either a large or medium CAFO. [Federal Register, Vol. 68, No. 29, Wednesday, February 12, 2003, pages 7265-7266]

Critical Condition Period:

That portion of the calendar year when the pollution parameter of interest demonstrates the greatest adverse impact on aquatic biota and existing or characteristic water uses.

Hobby Farm:

A facility that is operated on a part-time basis with off-farm income being the principal income for the owner/operator. Such facility typically has only a few animals and very little cropland, but may have several acres of pasture. Such facility can have any combination of various types of animals (e.g., horses, cattle, sheep, llamas, goats). Any facility operated commercially shall not be considered a hobby farm.

Irrigation Return Flow:

That portion of the applied irrigation water that is not consumptively used by crops or irretrievably lost to evaporation, and which returns to a surface water or the groundwater.

Load Allocation:

That portion of a receiving water loading capacity that is attributed either to one of its existing or potential non-point source of pollution or to natural background sources.

Loading Capacity:

The maximum amount of the pollutant parameter loading that a receiving water can absorb without violating the respective state water quality standard.

Natural Conditions:

The surface water quality that was present before any human-caused pollution.

Wasteload Allocation:

That portion of a receiving waters loading capacity that is allocated, or attributed, to existing or potential point sources of pollution.

APPENDIX B
(to Technical Assessment)

APPENDIX B

Acronyms and Abbreviations

°C –	degrees Centigrade
303(d) list –	Washington State's list of impaired water bodies (as required by Section 303(d) of the Clean Water Act)
AFO –	animal feeding operation
BMPs –	best management practices
CAFO –	concentrated animal feeding operation
cfu –	colony-forming units
CID –	Cascade Irrigation District
CWA –	Clean Water Act
E. coli –	*Escherichia coli*
Ecology –	Washington Department of Ecology
EWC –	Ellensburg Water Company
FC –	fecal coliform
KCCD –	Kittitas County Conservation District
KCWP –	Kittitas County Water Purveyors
KRD –	Kittitas Reclamation District
LSD –	least significant difference
mg/L –	milligrams per liter
mL –	milliliter(s)
MOS –	margin of safety
N –	number of samples
N/A –	not applicable
NPDES –	National Pollutant Discharge Elimination System
RCW –	Revised Code of Washington
RM –	river mile
RNA –	ribonucleic acid
state –	Washington State
TMDL –	total maximum daily load
USEPA –	United States Environmental Protection Agency
USGS –	United States Geological Survey
WAC –	Washington Administrative Code
WRIA –	Water Resource Inventory Area

APPENDIX C
(to Technical Assessment)

APPENDIX C

1999-2002 WILSON CREEK SUB-BASIN SAMPLING DATA

Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	BC-2	3/24/99	100	8.03	227410	2.0000	458.0	2.31	0.149	4	2	11.0	approx. 0.5 mile upstream from its discharge into the
KRD	BC-2	4/19/99	600	19.87	3376310	2.7782	245.0	1.01	0.118	19	9	9.5	
KRD	BC-2	5/19/99	200	23.00	1302720	2.3010	250.0	1.31	0.210	22	7	12.3	
KRD	BC-2	6/2/99	130	26.40	971942	2.1139	267.0	1.42	0.190	16	6	12.0	
KRD	BC-2	6/14/99	1400	20.00	7929600	3.1461	313.0	1.47	0.260	50	16	18.0	
KRD	BC-2	6/28/99	500	26.00	3681600	2.6990	259.0	1.04	0.153	16	5	12.0	
KRD	BC-2	7/14/99	770	18.70	4077797	2.8865	326.0	1.83	0.160	4	3	14.5	
KRD	BC-2	7/28/99	440	30.40	3788083	2.6435	290.0	1.35	0.210	22	6	15.0	
KRD	BC-2	8/9/99	140	23.20	919834	2.1461	318.0	1.24	0.113	10	3	17.5	
KRD	BC-2	8/24/99	260	24.30	1789258	2.4150	311.0	1.16	0.207	10	4	15.0	
KRD	BC-2	9/8/99	200	29.40	1665216	2.3010	229.0	1.08	0.130	13	4	11.5	
KRD	BC-2	9/22/99	600	24.90	4231008	2.7782	305.0	1.32	0.220	20	3	14.5	
KRD	BC-2	10/4/99	140	24.60	975341	2.1461	301.0	1.17	0.168	10	3	10.8	
KRD	BC-2	11/3/99	34	16.70	160801	1.5315	443.0	2.17	0.182	5	2	9.5	
KRD	BC-2	3/22/00	2	11.42	6470	0.3010	486.0	2.52	0.148	3	1	9.4	ducks in water upon arrival; DO calibration check
KRD	BC-2	4/18/00	82	14.53	337436	1.9138	295.0	0.01	0.099	7	4	12.2	sunny
KRD	BC-2	5/2/00	134	25.41	964111	2.1271	243.0	1.03	0.185	11	6	11.6	
KRD	BC-2	5/16/00	420	23.08	2744659	2.6232	306.0	0.90	0.210	8	7	13.7	
KRD	BC-2	5/31/00	780	32.40	7156275	2.8921	259.0	0.91	0.220	17	8	12.1	
KRD	BC-2	6/13/00	110	40.16	1251201	2.0414	257.0	0.74	0.180	12	6	11.9	waterfowl & horses have access to creek
KRD	BC-2	6/27/00	220	16.86	1050506	2.3424	307.0	1.20	0.190	10	5	16.4	horses in creek
KRD	BC-2	7/11/00	200	31.62	1790945	2.3010	317.0	1.68	0.250	44	10	14.9	horses near/in water
KRD	BC-2	7/24/00	500	37.83	5357300	2.6990	281.0	1.29	0.240	26	9	14.7	barometer: 30.12; calm, sunny & clear
KRD	BC-2	8/8/00	110	31.62	985020	2.0414	321.0	1.36	0.210	21	7	15.0	
KRD	BC-2	8/22/00	320	44.05	3991831	2.5051	281.0	0.82	0.170	27	8	16.4	
KRD	BC-2	9/19/00	400	31.62	3581891	2.6021	289.0	0.96	0.228	26	5	15.9	
KRD	BC-2	10/3/00	280	24.63	1952964	2.4472	353.0	1.56	0.230	16	5	12.0	
KRD	BC-2	11/7/00	48	12.20	165846	1.6812	439.0	2.08	0.260	4	2	10.7	overcast, cold & calm
KRD	BC-2	3/27/01	94	7.61	202584	1.9731	455.0	2.52	0.169	6	2	8.7	cattle in & near creek; ducks present
KRD	BC-2	4/18/01	62	8.03	140952	1.7924	485.0	2.34	0.151	4	1	10.2	cattle have access
KRD	BC-2	5/1/01	1480	16.53	6928150	3.1703	337.0	1.98	0.180	42	11	9.5	cattle, birds; dog in & near creek; sunny, light breeze &
KRD	BC-2	5/15/01	220	12.93	805591	2.3424	380.0	2.47	0.230	7	4	12.8	
KRD	BC-2	5/30/01	2220	16.28	10235301	3.3464	369.0	1.69	0.220	14	6	12.4	
KRD	BC-2	6/12/01	480	20.53	2790766	2.6812		1.43	0.200	10	4	10.8	cold, raining, & calm
KRD	BC-2	6/26/01	220	21.30	1327075	2.3424	345.0	1.60	0.180	12	5	12.4	overcast, cool & calm
KRD	BC-2	7/10/01	412	11.75	1370971	2.6149	435.0	2.31	0.182	5	2	15.7	lots of algae on creek bottom; sunny, clear, light wind &
KRD	BC-2	7/24/01	140	9.28	367933	2.1461	464.0	1.90	0.184	3	2	16.0	NaCl emptied out of pH probe; sunny, hot & windy
KRD	BC-2	8/7/01	180	8.43	429830	2.2553	425.0	1.97	0.182	6	3	16.1	no pH sample; sunny, hot & windy
KRD	BC-2	8/21/01	252	5.53	394656	2.4014		3.79	0.178	0.5	2	15.0	no pH sample & no sc sample; cloudy, warm & calm
KRD	BC-2	9/5/01	136	7.27	280006	2.1335	474.0	2.16	0.179	10	2	13.0	cool & windy
KRD	BC-2	9/18/01	580	5.25	862344	2.7634	478.0	2.07	0.179	6	1	15.7	sunny, mild, slight breeze
KRD	BC-2	10/3/01	210	6.22	369916	2.3222	452.0	2.30	0.191	8	3	10.7	
KRD	BC-2	11/7/01	72	7.98	162715	1.8573	444.0	4.41	0.200	37	8	11.0	horses in/near creek; subsurface field drain enters

Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	Bull Ditch	5/15/00	12	26.00	88358	1.0792	102.7	0.06	0.021	6	2	12.8	
KRD	Bull Ditch	5/30/00	34	29.90	287901	1.5315	70.0	0.06	0.019	8	3	10.8	
KRD	Bull Ditch	6/12/00	30	26.00	220896	1.4771	75.4	0.07	0.010	6	4	11.8	
KRD	Bull Ditch	6/26/00	62	25.20	442472	1.7924	85.8	0.07	0.052	2	3	13.5	
KRD	Bull Ditch	7/10/00	18	28.30	144262	1.2553	60.2	0.05	0.026	3	2	11.6	
KRD	Bull Ditch	7/26/00	22	29.90	186289	1.3424	52.7	0.05	0.018	5	3	11.9	warm, calm, & sunny
KRD	Bull Ditch	8/7/00	68	34.00	654758	1.8325	56.1	0.04	0.020	5	2	15.3	barometer 29.83, 21.5 C, 49% humidity
KRD	Bull Ditch	8/21/00	98	30.70	852036	1.9912	65.3	0.02	0.016	4	3	17.2	
KRD	Bull Ditch	9/5/00	60	23.70	402710	1.7782	78.9	0.07	0.024	2	2	14.1	
KRD	Bull Ditch	9/18/00	32	19.40	175811	1.5051	84.3	0.05	0.040	2	2	16.1	
KRD	Bull Ditch	10/2/00	22	19.40	120870	1.3424	82.2	0.05	0.028	3	2	12.5	
KRD	Bull Ditch	4/16/01	2	21.48	12168	0.3010	95.2	0.04	0.015	3	1	9.8	
KRD	Bull Ditch	4/30/01	52	25.34	373110	1.7160	92.9	0.11	0.030	7	3	7.4	cool, raining, & calm
KRD	Bull Ditch	5/14/01	54	30.65	468770	1.7324	96.9	0.12	0.036	6	3	10.7	
KRD	Bull Ditch	5/29/01	62	22.24	390429	1.7924	100.3	0.14	0.026	7	3	10.3	
KRD	Bull Ditch	6/11/01	10	24.94	70634	1.0000	78.1	0.06	0.023	7	3	12.5	cool, raining, & windy
KRD	Bull Ditch	6/25/01	32	27.34	247776	1.5051	73.4	0.05	0.021	8	3	11.4	sunny, warm & calm
KRD	Bull Ditch	7/9/01	20	28.16	159482	1.3010	59.5	0.07	0.020	10	2	17.6	
KRD	Bull Ditch	7/23/01	28	29.40	233100	1.4472	69.3	0.06	0.018	5	2	16.8	sunny, hot & calm
KRD	Bull Ditch	8/6/01	24			1.3802	60.4	0.06	0.015	6	2	17.6	no pH sample; sunny, hot & calm
KRD	Bull Ditch	8/20/01	24	19.27	131000	1.3802	63.4	0.02	0.014	6	2	18.4	sunny, warm & light wind
KRD	Bull Ditch	9/4/01	46	18.91	246391	1.6628	69.7	0.01	0.010	3	2	16.3	overcast, calm & cool
KRD	BD-2	4/30/02	260	24.17	1779685	2.4150		0.19	0.084	35	9	15.1	
KRD	BD-2	5/13/02	1340	18.72	7104015	3.1271		0.17	0.141	32	10	12.3	

KRD	BD-2	5/28/02	340	15.72	1513647	2.5315		0.13	0.162	22	8	14.5	
KRD	BD-2	6/11/02	2540	18.82	13537753	3.4048		0.15	0.142	27	11	15.0	
KRD	BD-2	6/24/02	160	46.18	2092508	2.2041		0.47	0.149	33	7	13.9	
KRD	BD-2	7/8/02	300	20.55	1745928	2.4771		0.29	0.200	23	6	18.4	
KRD	BD-2	7/23/02	3000	9.79	8317584	3.4771		0.42	0.220	9	3	17.6	
KRD	BD-2	8/5/02	300	13.24	1124870	2.4771		0.26	0.083	15	7	14.2	
KRD	BD-2	8/19/02	1500	15.00	6372000	3.1761		0.24	0.056	18	4	18.0	
KRD	BD-2	9/3/02	100	23.73	672034	2.0000		0.10	0.089	14	4	15.0	
KRD	BD-2	9/17/02	100	8.24	233357	2.0000		0.16	0.098	8	4	14.5	
KRD	BD-2	10/2/02	940	16.18	4307245	2.9731		0.20	0.089	9	5	11.8	
Ecology	CR-1	4/13/99	490	24.40	3385939	2.6902	105.0			32	15	3.5	immediately south of KRD Canal. NE of Ellensburg.
Ecology	CR-1	5/4/99	120	23.90	812218	2.0792	110.0			18	6.8	5.1	
Ecology	CR-1	6/2/99	190	1.30	69950	2.2788	205.0			7	4.5	8.8	
Ecology	CR-1	6/28/99	46	14.10	183684	1.6628	91.0			6	3.2	11.4	
Ecology	CR-1	7/28/99	84	1.30	30925	1.9243	135.0			3	2.2	14.3	
Ecology	CR-1	8/24/99	280	1.30	103085	2.4472	141.0			3	1.3	15.5	
Ecology	CR-1	9/22/99	1800	0.40	203904	3.2553	150.0			16	5.1	13.9	
Ecology	CR-1	10/19/99	54	0.80	12234	1.7324	270.0			1	0.6	7.8	
Ecology	CR-1	11/17/99	48	1.60	21750	1.6812	288.0			40	3.4	8.3	
KRD	CR-1	3/22/00	4	5.48	6208	0.6021	210.0	0.50	0.064	4	2	7.5	
KRD	CR-1	4/18/00	190	7.00	376656	2.2788	139.3	0.14	0.082	15	6	12.8	sunny
KRD	CR-1	5/2/00	26	4.16	30601	1.4150	257.0	0.51	0.076	2	2	10.8	fecal sheen, water fowl, fresh horsh tracks
KRD	CR-1	5/16/00	40	1.80	20390	1.6021	273.0	0.49	0.142	2	2	14.9	fecal orange goop
KRD	CR-1	5/31/00	200	1.48	83827	2.3010	295.0	0.63	0.131	2	2	10.7	overcast, cool & light precipitation
KRD	CR-1	6/13/00	30	1.76	14953	1.4771	272.0	0.58	0.120	3	3	14.3	
KRD	CR-1	6/27/00	198	0.75	42111	2.2967	314.0	0.76	0.106	2	2	14.8	
KRD	CR-1	7/11/00	8000	1.69	3833395	3.9031	305.0	0.66	0.141	8	3	12.9	
KRD	CR-1	7/24/00	600	1.45	246384	2.7782	289.0	0.68	0.135	3	2	13.5	
KRD	CR-1	8/7/00	172	1.43	69656	2.2355	276.0	0.70	0.115	2	2	16.1	
KRD	CR-1	8/22/00	88	1.40	34890	1.9445	296.0	0.70	0.092	3	2	14.5	
KRD	CR-1	9/19/00	52	1.12	16547	1.7160	277.0	0.80	0.130	2	2	14.4	
KRD	CR-1	10/3/00	56	1.19	18849	1.7482	286.0	0.81	0.143	3	2	12.0	
KRD	CR-1	11/7/00	2	0.91	515	0.3010	264.0	0.80	0.184	0.5	1	10.8	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	CR-1	3/27/01	2	1.51	855	0.3010	272.0	0.67	0.074	2	2	9.6	
KRD	CR-1	4/18/01	82	1.26	29193	1.9138	273.0	0.65	0.070	3	1	11.3	
KRD	CR-1	5/1/01	42	5.85	69582	1.6232	175.5	0.30	0.088	5	4	7.4	deer tracks on bank
KRD	CR-1	5/15/01	600	1.70	288864	2.7782	303.0	0.66	0.122	6	2	11.3	
KRD	CR-1	5/30/01	244	1.28	88449	2.3874	292.0	0.75	0.116	6	2	12.8	grazing apparent
KRD	CR-1	6/12/01	300	1.67	141883	2.4771	199.9	0.57	0.132	5	2	11.2	
KRD	CR-1	6/26/01	48	1.44	19575	1.6812	296.0	0.82	0.090	4	2	12.1	rodent in & near structure
KRD	CR-1	7/10/01	34	1.39	13384	1.5315	291.0	0.72	0.076	4	2	15.2	
KRD	CR-1	7/24/01	2160	1.17	715703	3.3345	289.0	0.72	0.105	4	2	14.7	fecal sheen
KRD	CR-1	8/7/01	100	1.05	29594	2.0000	284.0	0.81	0.084	6	2	13.4	
KRD	CR-1	8/21/01	80	0.85	19258	1.9031	292.0	0.76	0.084	2	2	12.6	cloudy, warm & calm
KRD	CR-1	9/5/01	58	0.92	15112	1.7634	290.0	0.88	0.066	4	1	11.6	cool & windy
KRD	CR-1	9/18/01	980	1.24	344145	2.9912	284.0	0.84	0.084	4	0.5	12.4	sunny, mild & slight breeze
KRD	CR-1	10/2/01	130	1.22	44916	2.1139	264.0	0.80	0.094	2	1	13.1	
KRD	CR-1	11/7/01	8	0.85	1926	0.9031	283.0	0.85	0.092	2	1	10.8	
KCCD	CR-2	3/24/99	23			1.3617		0.40	0.220	90	31	9.5	downstream end of Caribou Creek, prior to Cooke
KCCD	CR-2	4/19/99	1700			3.2304		0.70	0.410	144	53	6.9	
KCCD	CR-2	5/4/99	130			2.1139		1.10	0.200	50	14	7.6	
KCCD	CR-2	5/19/99	500			2.6990		0.80	0.250	61	14	12.0	
KCCD	CR-2	6/3/99	800			2.9031		0.70	0.240	43	30	11.9	
KCCD	CR-2	6/14/99	1100			3.0414		0.70	0.190	42	10	15.6	
KCCD	CR-2	6/28/99	300			2.4771		0.60	0.230	40	12	15.2	
KCCD	CR-2	7/14/99	170			2.2304		5.40	0.250	7	5.4	17.2	
KCCD	CR-2	7/29/99	230			2.3617		2.50	0.360	25	6.05	15.7	
KCCD	CR-2	8/9/99	500			2.6990		3.10	0.380	23	8.83	19.1	
KCCD	CR-2	8/24/99	500			2.6990		0.90	0.210	33	8.83	19.6	
KCCD	CR-2	9/8/99	300			2.4771		0.60	0.130	17	2.82	11.4	
KCCD	CR-2	9/23/99	2400			3.3802		1.00	0.220	16	6.19	13.1	
KCCD	CR-2	10/4/99	230			2.3617		0.80	0.150	23	7.87	10.7	
KCCD	CR-2	11/3/99	50			1.6990		1.10	0.150	12	3.9	8.7	
KCCD	CR-2	3/20/00	2	18.95	10733	0.3010		0.66	0.068	14	4		
KCCD	CR-2	4/18/00	64	24.30	440433	1.8062		0.50	0.140	48	13	11.7	
KCCD	CR-2	5/2/00	90	30.19	769483	1.9542		1.24	0.230	50	20	12.7	
KCCD	CR-2	5/16/00	240	9.74	662008	2.3802		2.45	0.250	46	9	13.1	
KCCD	CR-2	6/13/00	700	37.14	7362634	2.8451		0.38	0.240	8	7	12.3	
KCCD	CR-2	6/27/00	540	30.54	4670421	2.7324		0.84	0.210	29	8	16.8	
KCCD	CR-2	7/12/00	8000	3.79	8586624	3.9031		4.15	0.360	22	8	17.1	
KCCD	CR-2	7/24/00	700	11.15	2210376	2.8451		2.43	0.300	35	11	14.1	
KCCD	CR-2	8/8/00	146	7.07	292325	2.1644		1.65	0.200	21	9	15.3	
KCCD	CR-2	8/21/00	320	33.60	3044966	2.5051		1.20	0.250	45	12	14.1	
KCCD	CR-2	9/6/00	196	71.92	3992078	2.2923		0.29	0.140	31	8	14.6	
KCCD	CR-2	9/19/00	190	30.41	1636301	2.2788		1.60	0.240	36	10	15.1	
KCCD	CR-2	10/3/00	184	22.55	1175053	2.2648		1.10	0.190	12	5	11.0	
KCCD	CR-2	11/7/00	20	15.06	85300	1.3010		1.02	0.142	13	3	8.0	
KCCD	CR-2	3/20/02	44	15.39	191772	1.6435		0.55	0.073	18	4	5.5	
KCCD	CR-2	4/15/02	228	67.83	4379756	2.3579		0.45	0.270	160	33	6.2	
KCCD	CR-2	4/30/02	30	15.70	133387	1.4771		1.19	0.200	23	9	13.9	
KCCD	CR-2	5/13/02	80	25.91	587017	1.9031		1.63	0.540	42	10	13.9	

KCCD	CR-2	5/28/02	1240	32.53	11423495	3.0934		0.75	0.267	63	13	14.6	
KCCD	CR-2	6/11/02	4000	41.95	47520960	3.6021		0.72	0.220	45	12	13.9	
KCCD	CR-2	6/24/02	1200	58.34	19826266	3.0792		0.44	0.240	98	14	16.4	
KCCD	CR-2	7/8/02	4200	4.05	4817232	3.6232		2.63	0.310	34	11	17.2	
KCCD	CR-2	7/23/02	4000	14.70	16652160	3.6021		2.20	0.330	114	36	17.7	
KCCD	CR-2	8/5/02	700	12.60	2497824	2.8451		1.65	0.210	44	9	15.8	
KCCD	CR-2	8/19/02	200	21.39	1211530	2.3010		1.14	0.180	42	11	15.2	
KCCD	CR-2	9/3/02	300	38.83	3298997	2.4771		0.47	0.165	53	11	14.4	
KCCD	CR-2	9/17/02	300	22.66	1925194	2.4771		1.50	0.164	16	5	15.1	
KCCD	CR-2	10/2/02	320	23.65	2143258	2.5051		1.16	0.200	46	12	11.3	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KCCD	CR-2	11/12/02	135	21.79	833075	2.1303		0.74	0.108	17	3	10.6	
KRD	CID	5/1/00	6	72.01		0.7782	93.5	0.01	0.012	2	1	8.3	diversion point of canal on Yakima River. 21 miles
KRD	CID	5/15/00	16	97.73		1.2041	81.5	0.01	0.011	2	1	10.3	
KRD	CID	5/30/00	6	80.70		0.7782	65.4	0.02	0.017	7	2	10.2	water fowl, muskrat(?) den upstream (~40 ft) of
KRD	CID	6/12/00	16	59.98		1.2041	65.8	0.02	0.005	6	2	11.4	
KRD	CID	6/26/00	2	68.51		0.3010	60.1	0.02	0.018	3	2	14.4	
KRD	CID	7/10/00	16	113.21		1.2041	60.6	0.02	0.019	6	2	9.5	clear, light breeze & mild temp
KRD	CID	7/24/00	4	131.78		0.6021	52.4	0.01	0.014	3	3	12.7	
KRD	CID	8/7/00	8	115.95		0.9031	52.5	0.01	0.018	3	2	15.8	
KRD	CID	8/21/00	2	99.22		0.3010	59.2	0.01	0.011	4	2	15.3	
KRD	CID	9/5/00	80	78.54		1.9031	64.4	0.02	0.018	2	2	16.0	
KRD	CID	9/18/00	24	77.51		1.3802	65.3	0.02	0.029	2	1	15.9	
KRD	CID	10/2/00	16	60.63		1.2041	66.1	0.01	0.016	2	2	13.3	
KRD	CID	4/16/01	12	41.90		1.0792	94.2	0.02	0.028	3	2	7.5	
KRD	CID	4/30/01	14	113.10		1.1461		0.02	0.012	3	2	6.5	
KRD	CID	5/14/01	20	117.50		1.3010	77.3	0.02	0.037	14	3	9.9	
KRD	CID	5/29/01	6	99.00		0.7782	80.7	0.01	0.010	3	2	11.7	
KRD	CID	6/11/01	8	113.40		0.9031	69.1	0.01	0.010	5	2	11.3	
KRD	CID	6/25/01	20	99.00		1.3010	61.4	0.01	0.012	5	3		
KRD	CID	7/9/01	30	115.40		1.4771	61.9	0.01	0.013	6	3	14.7	sunny, clear, light breeze & hot
KRD	CID	7/23/01	14	117.60		1.1461	59.5	0.01	0.011	4	2	18.9	
KRD	CID	8/6/01	6	119.30		0.7782	55.3	0.02	0.005	7	2	20.0	
KRD	CID	8/20/01	8	119.80		0.9031	55.1	0.01	0.012	7	2	16.5	sunny, warm & light wind
KRD	CID	9/4/01	1	99.80		0.0000	60.1	0.01	0.005	4	1	17.3	overcast, calm & cool
KCCD	CID-1	4/19/99	1400			3.1461		0.10	0.320	117	43	8.5	approx. 15 miles down from Kittitas. SE of Ellensburg.
KCCD	CID-1	5/4/99	1100			3.0414		1.10	0.470	28	16	9.0	
KCCD	CID-1	5/19/99	800			2.9031		0.80	0.270	41	27	16.0	
KCCD	CID-1	6/3/99	1700			3.2304		0.90	0.330	47	18	11.2	
KCCD	CID-1	6/14/99	2300			3.3617		0.50	0.280	29	16	17.0	
KCCD	CID-1	6/28/99	5000			3.6990		0.60	0.280	2	7.6	17.8	
KCCD	CID-1	7/14/99	500			2.6990		1.00	0.270	21	11	18.2	
KCCD	CID-1	7/29/99	2300			3.3617		1.20	0.270	9	6.6	17.5	
KCCD	CID-1	8/9/99	900			2.9542		0.50	0.320	33	8.5	21.1	
KCCD	CID-1	8/24/99	2300			3.3617		0.80	0.380	10	6.8	21.9	
KCCD	CID-1	9/8/99	1700			3.2304		0.70	0.240	27	5.6	12.2	
KCCD	CID-1	9/23/99	800			2.9031		0.80	0.200	27	4.6	15.0	
KCCD	CID-1	10/4/99	900			2.9542		0.80	0.170	19	13.5	10.1	
KCCD	CID-1	4/18/00	400			2.6021		0.13	0.230	77	25	9.4	
KCCD	CID-1	5/2/00	100			2.0000		0.97	0.560	38	12	15.1	
KCCD	CID-1	5/16/00	560	13.92	2207601	2.7482		0.37	0.390	26	14	13.5	
KCCD	CID-1	6/13/00	1300	20.23	7447877	3.1139		0.68	0.300	59	15	14.4	
KCCD	CID-1	6/27/00	234	11.19	741548	2.3692		0.54	0.087	5	4	17.9	
KCCD	CID-1	7/12/00	860	3.18	774495	2.9345		0.93	0.230	7	5	21.4	
KCCD	CID-1	7/24/00	860	22.26	5421468	2.9345		1.99	0.270	20	8	16.4	
KCCD	CID-1	8/6/00	370	8.06	844559	2.5682		0.49	0.150	8	6	15.5	
KCCD	CID-1	9/6/00	164	2.22	103107	2.2148		0.63	0.098	4	4	14.0	
KCCD	CID-1	9/19/00	172	8.80	428652	2.2355		1.08	0.125	1	4	18.6	
KCCD	CID-1	10/3/00	172	19.44	946930	2.2355		0.68	0.220	10	6	9.5	
KCCD	CID-1	4/18/01	98	19.26	534534	1.9912	119.0	0.37	0.120	110	24	10.4	
KCCD	CID-1	5/2/01	42	2.81	33423	1.6232	106.0	0.29	0.104	8	8	8.5	
KCCD	CID-1	5/16/01	560	8.71	1381336	2.7482	148.0	0.31	0.260	20	8	12.0	
KCCD	CID-1	5/30/01	1200	19.28	6552115	3.0792	167.0	0.34	0.260	43	15	14.0	
KCCD	CID-1	6/13/01	360	17.10	1743379	2.5563	157.0	0.29	0.170	29	13	12.9	turbid
KCCD	CID-1	6/27/01	1480	16.62	6966040	3.1703	193.0	0.51	0.220	19	6	15.3	
KCCD	CID-1	7/11/01	1690	1.28	612618	3.2279	190.0	0.42	0.300	6	5	23.0	very low flow & clear water
KCCD	CID-1	7/25/01	560			2.7482	169.0	0.37	0.192	6	8	22.4	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KCCD	CID-1	8/8/01	110	7.06	219933	2.0414	118.0	0.03	0.059	10	3	21.0	
KCCD	CID-1	9/5/01	62	10.77	189104	1.7924	101.0	0.05	0.045	12	4	16.0	
KCCD	CID-1	4/15/02	112	22.32	707955	2.0492		0.36	0.280	127	36	9.1	
KCCD	CID-1	4/30/02	90	15.34	390986	1.9542		0.67	0.310	42	13	13.5	
KCCD	CID-1	5/13/02	308	14.50	1264771	2.4886		0.79	0.440	20	7	14.0	
KCCD	CID-1	5/28/02	1200	22.37	7602221	3.0792		0.38	0.329	30	12	14.4	
KCCD	CID-1	6/11/02	260	24.70	1818710	2.4150		0.60	0.230	17	10	13.9	
KCCD	CID-1	6/24/02	1660	6.83	3210865	3.2201		0.32	0.200	8	6	17.0	
KCCD	CID-1	7/8/02	6200	13.87	24353501	3.7924		1.03	0.250	140	28	17.3	
KCCD	CID-1	7/23/02	2640	15.33	11461444	3.4216		2.08	0.280	64	13	19.0	
KCCD	CID-1	8/5/02	900	21.37	5446786	2.9542		1.60	0.300	26	7	14.3	

KCCD	CID-1	8/19/02	1200	24.66	8380454	3.0792		0.66	0.220	46	13	17.8	
KCCD	CID-1	9/3/02	500	32.37	4583592	2.6990		0.50	0.210	24	10	16.5	
KCCD	CID-1	9/17/02	220	16.03	998733	2.3424		0.39	0.168	8	4	15.9	
KCCD	CID-1	10/2/02	180	13.45	685627	2.2553		1.07	0.190	4	4	9.5	
Ecology	CID-2	4/13/99	1100	0.55	171336	3.0414	495.0			858	410	7.8	downstream end of canal. 0.5 mile north of I-82.
KRD	CID-2	4/19/99	400	2.34	265075	2.6021	280.0	1.02	0.240	186	33	9.8	
Ecology	CID-2	5/4/99	210			2.3222	200.0			242	85	9.2	
KRD	CID-2	5/19/99	300	1.80	152928	2.4771	183.0	0.88	0.220	39	26	11.5	
KRD	CID-2	6/2/99	300	2.60	220896	2.4771	164.0	0.69	0.260	92	40	13.0	
KRD	CID-2	6/14/99	340	2.69	259015	2.5315	151.0	0.47	0.210	61	25	23.5	
KRD	CID-2	6/28/99	340	4.68	450628	2.5315	183.0	0.28	0.178	35	19	15.0	
Ecology	CID-2	6/28/99	500	5.74	812784	2.6990	220.0			100	8.4	17.3	
KRD	CID-2	7/14/99	3900	5.80	6405984	3.5911	147.0	0.85	0.680	222	52	15.0	
KRD	CID-2	7/28/99	3000	3.10	2633760	3.4771	182.0	1.01	0.200	26	14	17.0	
KRD	CID-2	8/9/99	700	5.60	1110144	2.8451	189.0	0.68	0.230	35	17	18.7	
KRD	CID-2	8/24/99	600	1.90	322848	2.7782	166.0	0.49	0.250	57	55	18.5	
KRD	CID-2	9/8/99	130	1.70	62587	2.1139	189.0	0.44	0.120	13	9	10.5	
KRD	CID-2	9/22/99	40	1.44	16312	1.6021	218.0	0.71	0.134	14	3	18.6	
KRD	CID-2	10/4/99	80	5.23	118491	1.9031	189.0	0.71	0.176	30	12	10.8	
KRD	CID-2	4/18/00	276	7.33	572968	2.4409	213.0	0.02	0.220	156	46	10.2	foamy goop on trash rack, picture taken; sunny
KRD	CID-2	5/2/00	120	2.08	70853	2.0792	179.9	0.51	0.310	65	40	14.5	
KRD	CID-2	5/31/00	580	3.13	514791	2.7634	179.7	0.56	0.230	66	28	10.4	trash rack goop
KRD	CID-2	6/13/00	220	4.75	295764	2.3424	159.0	0.39	0.170	43	26	14.2	warm
KRD	CID-2	6/27/00	82	2.38	55170	1.9138	180.1	0.23	0.097	6	12	20.3	
KRD	CID-2	7/24/00	500	4.64	656656	2.6990	216.0	0.91	0.260	28	14	16.8	
KRD	CID-2	8/8/00	960	1.96	534228	2.9823	204.0	0.59	0.190	20	14	18.2	
KRD	CID-2	8/22/00	260	2.11	155004	2.4150	213.0	0.60	0.168	22	13	18.1	may have been treated recently for moss
KRD	CID-2	9/19/00	170	2.63	126404	2.2304	239.0	0.68	0.400	288	60	16.6	dog in canal above sampling point
KRD	CID-2	10/3/00	56	1.92	30481	1.7482	20.4	0.73	0.180	16	9	8.3	
KRD	CID-2	4/18/01	108	3.17	96803	2.0334	469.0	2.20	0.186	53	17	10.0	
KRD	CID-2	5/1/01	360	4.02	409847	2.5563	179.9	0.70	0.153	97	31	8.3	
KRD	CID-2	5/15/01	280	3.71	294188	2.4472	158.2	0.65	0.260	60	22	13.9	
KRD	CID-2	5/30/01	320	4.02	364308	2.5051	159.6	0.51	0.230	75	25	12.5	moss in sample bottle
KRD	CID-2	6/12/01	700	3.53	699787	2.8451		0.38	0.170	37	18	11.0	
KRD	CID-2	6/26/01	280	3.29	260884	2.4472	154.8	0.30	0.088	10	7	13.9	
KRD	CID-2	7/24/01	240	0.74	50296	2.3802	156.7	0.27	0.103	7	8	19.3	
KRD	CID-2	8/21/01	96	3.50	95155	1.9823		0.20	0.052	19	7	18.0	cloudy, warm & calm
KRD	CID-2	9/5/01	78	2.53	55887	1.8921	138.7	0.32	0.052	22	6	14.5	cool & windy
KRD	CID-2	9/18/01	206	1.01	58923	2.3139	154.9	0.34	0.070	12	4	18.0	sunny, mild & slight breeze
KCCD	CH-1	3/24/99	170			2.2304		0.70	0.560	103	38	9.5	immediately downstream of discharge of Parke Creek.
Ecology	CH-1	4/13/99	22	87.00	542045	1.3424	230.0			26	13	7.8	
KCCD	CH-1	4/19/99	1300			3.1139		0.90	0.460	179	53	7.9	
Ecology	CH-1	5/4/99	680	244.00	46988544	2.8325	235.0			146	45	9.0	
KCCD	CH-1	5/4/99	500			2.6990		1.40	0.340	123	30	9.4	
KCCD	CH-1	5/19/99	230			2.3617		1.40	0.340	78	17	14.0	

Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
Ecology	CH-1	6/2/99	229	260.00	16861728	2.3598				113	36	10.0	
KCCD	CH-1	6/3/99	500			2.6990		1.30	0.290	69	20	12.3	
KCCD	CH-1	6/14/99	300			2.4771		1.30	0.260	49	9	16.4	
Ecology	CH-1	6/28/99	630	151.00	26940816	2.7993	255.0			36	120	12.0	
KCCD	CH-1	6/28/99	700			2.8451		1.00	0.210	32	13	15.9	
KCCD	CH-1	7/14/99	220			2.3424		3.30	0.400	61	23	16.4	
Ecology	CH-1	7/28/99	350	114.00	11299680	2.5441	373.0			46	23	15.8	
KCCD	CH-1	7/29/99	300			2.4771		2.30	0.310	31	6.3	15.1	
KCCD	CH-1	8/9/99	1100			3.0414		1.50	0.360	47	9.4	18.6	
Ecology	CH-1	8/24/99	400	90.00	10195200	2.6021	325.0			33	12	19.2	
KCCD	CH-1	8/24/99	800			2.9031		1.30	0.230	37	9.6	19.4	
KCCD	CH-1	9/8/99	300			2.4771		1.40	0.090	45	6.5	12.1	
Ecology	CH-1	9/22/99	1100	104.00	32398080	3.0414	335.0			26	13	13.7	
KCCD	CH-1	9/23/99	500			2.6990		1.30	0.230	27	5.2	14.5	
KCCD	CH-1	10/4/99	350			2.5441		1.40	0.190	23	8.8	11.3	
Ecology	CH-1	10/19/99	310	81.00	7111152	2.4914	365.0			34	12	8.7	
KCCD	CH-1	11/3/99	90			1.9542		1.90	0.240	29	10	8.9	
Ecology	CH-1	11/17/99	69			1.8388	420.0			28	9.1	9.3	
KRD	CH-1	3/22/00	28	62.00	491635	1.4472	381.0	1.37	0.102	15	4	7.5	
KRD	CH-1	4/18/00	170	97.00	4669968	2.2304	221.0	0.50	0.240	61	16	8.5	sunny
KRD	CH-1	5/2/00	900	123.00	31350240	2.9542	334.0	1.46	0.380	88	22	12.3	
KRD	CH-1	5/16/00	260	120.00	8835840	2.4150	326.0	1.41	0.240	49	15	12.8	
KRD	CH-1	5/31/00	440	131.00	16323648	2.6435	311.0	1.44	0.260	49	11	9.9	rodent droppings upstream of sampling point
KRD	CH-1	6/13/00	500	125.00	17700000	2.6990	267.0	0.78	0.240	52	12	12.6	dead baby duck in water & rodent feces present nearby
KRD	CH-1	6/27/00	560	85.00	13480320	2.7482	258.0	1.07	0.240	43	10	14.2	
KRD	CH-1	7/11/00	280	47.65	3778454	2.4472	426.0	1.52	0.290	22	12	16.3	
KRD	CH-1	7/24/00	300	83.60	7102656	2.4771	387.0	2.32	0.320	29	10	13.3	
KRD	CH-1	8/8/00	120	61.62	2094094	2.0792	397.0	1.56	0.250	22	8	15.5	
KRD	CH-1	8/22/00	260	137.17	10100101	2.4150	339.0	1.22	0.240	79	18	13.9	
KRD	CH-1	9/6/00	296	162.21	13597610	2.4713	265.0	0.60	0.220	90	20	14.2	
KRD	CH-1	9/19/00	330	94.52	8833461	2.5185	329.0	1.26	0.270	36	10	15.4	
KRD	CH-1	10/3/00	220	102.19	6366846	2.3424	350.0	1.35	0.610	377	60	10.3	
KRD	CH-1	11/7/00	52	47.00	692141	1.7160	414.0	1.73	0.210	12	4	8.4	
KRD	CH-1	3/28/01	46	49.39	643413	1.6628	417.0	1.40	0.169	20	6	7.6	
KRD	CH-1	4/18/01	96	30.18	820428	1.9823	394.0	1.71	0.180	13	4	8.8	birds present upon arrival

Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	CH-1	5/2/01	204	51.05	2949301	2.3096	340.0	1.81	0.500	56	17	7.8	
KRD	CH-1	5/16/01	340	95.09	9156026	2.5315	327.0	1.71	0.340	68	13	9.9	
KRD	CH-1	5/30/01	400	96.95	10982496	2.6021	350.0	1.44	0.290	40	12	10.5	
KRD	CH-1	6/13/01	240	167.05	11354054	2.3802	308.0	0.93	0.220	52	11	11.4	
KRD	CH-1	6/27/01	1200	180.72	61415885	3.0792	380.0	1.51	0.370	159	30	14.5	turbidity at Moe 61.7; light, moderate rain in AM
KRD	CH-1	7/11/01	80	42.48	962427	1.9031	404.0	1.98	0.260	11	5	14.7	
KRD	CH-1	7/25/01	192	65.24	3547386	2.2833	405.0	2.80	0.260	42	15	14.3	
KRD	CH-1	8/8/01	380	59.39	6391314	2.5798	433.0	2.16	0.290	20	8	15.6	sunny, hot & calm
KRD	CH-1	8/22/01	1500	64.94	27586512	3.1761	415.0	1.84	0.250	13	5	15.8	overcast & light rain
KRD	CH-1	9/5/01	720	76.54	15606812	2.8573	345.0	1.14	0.210	19	7	14.1	cool & windy
KRD	CH-1	9/19/01	290	36.60	3005885	2.4624	400.0	1.60	0.200	10	6	13.0	sunny, warm & breezy
KRD	CH-1	10/3/01	3280	37.00	34369152	3.5159	450.0	2.09	0.200	10	4	11.9	
KRD	CH-1	11/7/01	50	29.40	416304	1.6990	440.0	2.01	0.193	29	3	6.3	leaves in stream
KCCD	CH-2	3/24/99	170			2.2304		0.90	0.200	93	36	11.3	
KCCD	CH-2	4/19/99	800			2.9031		1.00	0.440	134	45	9.5	
KCCD	CH-2	5/4/99	1100			3.0414		1.40	0.340	93	21	10.3	
KCCD	CH-2	5/19/99	400			2.6021		1.20	0.270	87	21	12.0	
KCCD	CH-2	6/3/99	500			2.6990		1.30	0.290	62	22	12.0	
KCCD	CH-2	6/14/99	1100			3.0414		1.30	0.260	47	9.3	18.0	
KCCD	CH-2	6/28/99	300			2.4771		0.80	0.200	52	16	14.5	
KCCD	CH-2	7/14/99	230			2.3617		2.00	0.230	33	8.1	16.4	
KCCD	CH-2	7/29/99	230			2.3617		1.90	0.310	32	6.1	16.2	
KCCD	CH-2	8/9/99	1300			3.1139		1.20	0.380	47	6.6	18.1	
KCCD	CH-2	8/24/99	500			2.6990		1.20	0.800	32	4.8	18.3	
KCCD	CH-2	9/8/99	140			2.1461		1.00	0.150	33	4.1	13.8	
KCCD	CH-2	9/23/99	500			2.6990		1.40	0.190	23	4.7	14.6	
KCCD	CH-2	10/4/99	1100			3.0414		1.20	0.150	29	11	10.8	
KCCD	CH-2	11/3/99	80			1.9031		2.10	0.210	0.5	6.1	8.8	
KCCD	CH-2	3/20/00	40	8.64	97874	1.6021		1.66	0.134	14	5		
KCCD	CH-2	4/18/00	244	536.00	37038029	2.3874		0.61	0.360	214	48	8.7	
KCCD	CH-2	5/2/00	80	422.50	9572160	1.9031		1.24	0.300	50	14	13.3	
KRD	CH-2	5/2/00	124			2.0934	294.0	1.22	0.220	51	14	13.9	
KCCD	CH-2	5/16/00	220			2.3424		1.11	0.290	37	11	12.8	
KCCD	CH-2	6/13/00	120			2.0792		0.67	0.190	68	13	13.8	
KCCD	CH-2	6/27/00	240			2.3802		0.82	0.180	36	8	14.8	
KRD	CH-2	7/11/00	160			2.2041	341.0	1.86	0.230	39	11	16.7	
KCCD	CH-2	7/11/00	160			2.2041		1.85	0.250	38	10	16.4	
KCCD	CH-2	7/24/00	300			2.4771		1.92	0.330	54	12	14.0	
KCCD	CH-2	8/8/00	172			2.2355		1.48	0.250	25	8	17.8	
KCCD	CH-2	8/22/00	480			2.6812		1.19	0.220	54	13	13.5	
KCCD	CH-2	9/6/00	160			2.2041		0.53	0.140	54	12	14.4	
KCCD	CH-2	9/19/00	172			2.2355		0.84	0.200	31	8	15.9	
KRD	CH-2	10/3/00	180			2.2553	287.0	0.99	0.310	178	32	10.1	
KCCD	CH-2	10/3/00	180			2.2553		1.01	0.320	201	36	9.8	
KRD	CH-2	11/7/00	70			1.8451	445.0	1.82	0.200	10	4	8.7	
KCCD	CH-2	11/7/00	48			1.6812	445.0	1.82	0.200	12	3	8.5	
Ecology	CL-1	4/13/99	1	34.00	9629	0.0000	86.0			9	5.9	2.6	approx. 3 miles above of KRD Canal. NE of
Ecology	CL-1	5/4/99	11	54.90	171024	1.0414	75.0			10	5.9	3.5	
Ecology	CL-1	6/2/99	91	56.10	1445764	1.9590	62.0			12	6.3	4.7	
Ecology	CL-1	6/28/99	8	22.80	51656	0.9031	57.0			4	1.9	17.7	
Ecology	CL-1	7/28/99	18	9.90	50466	1.2553	83.0			4	2	12.8	
Ecology	CL-1	8/24/99	14	3.50	13877	1.1461	101.0			3	1.3	14.0	
Ecology	CL-1	9/22/99	51	2.40	34664	1.7076	107.0			3	2	9.9	
Ecology	CL-1	10/19/99	6	2.40	4078	0.7782	100.0			1	1	4.0	
Ecology	CL-1	11/17/99	1	3.50	991	0.0000	105.0			1	0.9	5.4	
KRD	CL-2	5/19/99	90	30.00	764640	1.9542	76.0	0.04	0.052	12	4	8.7	approx. 7.5 miles above CID Canal. NE of Ellensburg.
KRD	CL-2	6/2/99	40	40.00	453120	1.6021	64.0	0.05	0.045	10	4	5.5	
KRD	CL-2	6/14/99	68	10.00	192576	1.8325	73.0	0.02	0.066	10	3	12.0	
KRD	CL-2	6/28/99	400	20.00	2265600	2.6021	79.0	0.02	0.048	4	2	9.5	
KRD	CL-2	7/14/99	90	0.50	12744	1.9542	106.0	0.15	0.040	2	2	9.0	
KRD	CL-2	7/28/99	500	1.10	155760	2.6990	113.0	0.17	0.072	2	1	14.0	
KRD	CL-2	8/9/99	50	0.80	11328	1.6990	50.0	0.07	0.080	2	1	14.0	
KRD	CL-2	8/24/99	300	2.00	169920	2.4771	111.0	0.07	0.121	2	1	17.0	
KRD	CL-2	9/8/99	130	0.90	33134	2.1139	111.0	0.12	0.055	1	1	10.5	
KRD	CL-2	9/22/99	830	0.04	9402	2.9191	113.0	0.17	0.037	1	2	12.0	
KRD	CL-2	11/3/99	14	1.00	3965	1.1461	115.0	0.01	0.144	1	2	3.0	
KRD	CL-2	3/21/00	2	3.67	2079	0.3010	104.5	0.05	0.039	4	2	9.3	2 ducks at sampling point on arrival; windy
KRD	CL-2	4/18/00	320	31.82	2883237	2.5051	78.4	0.02	0.042	22	7	9.2	sunny
KRD	CL-2	5/2/00	1000	29.03	8220930	3.0000	85.6	0.13	0.057	30	9	7.4	
KRD	CL-2	5/16/00	50	4.43	62776	1.6990	96.4	0.70	0.120	29	12	13.2	windy
KRD	CL-2	5/31/00	96	4.04	109884	1.9823	51.7	0.43	0.098	16	6	7.6	
KRD	CL-2	6/13/00	20	2.47	13967	1.3010	101.4	0.39	0.067	4	3	12.5	
KRD	CL-2	6/27/00	12	0.30	1020	1.0792	162.2	0.56	0.070	3	2	14.7	
KRD	CL-2	11/7/00	66	0.51	9439	1.8195	113.1	0.04	0.110	2	2	6.4	
KRD	CL-2	3/27/01	4	2.82	3194	0.6021	116.8	0.04	0.036	5	3	3.5	
KRD	CL-2	4/18/01	2	2.96	1677	0.3010	99.3	0.02	0.041	4	3	8.2	
KRD	CL-2	5/1/01	6	1.29	2192	0.7782	116.9	0.50	0.066	2	3	6.1	
KRD	CL-2	5/15/01	114	3.83	123651	2.0569	117.4	0.26	0.109	11	6	9.0	
KRD	CL-2	5/30/01	120	1.27	43160	2.0792	141.3	0.05	0.080	8	4	12.3	

Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	CL-2	6/12/01	12	0.56	1903	1.0792	199.9	0.04	0.042	5	2	8.2	
KRD	CL-2	7/24/01	208	0.64	37700	2.3181	127.4	0.02	0.057	8	5	16.5	<0.5 cfs at Schnebly Road
KRD	CL-2	8/7/01	132	0.18	6617	2.1206	132.8	0.02	0.055	6	4	14.6	
KRD	CL-2	8/21/01	360	0.16	16312	2.5563	124.6	0.25	0.073	3	9	13.3	cloudy, warm & calm
KCCD	CL-3	3/20/02	86	11.20	272778	1.9345		0.12	0.068	12	5	2.0	
KCCD	CL-3	4/15/02	680	51.93	10000472	2.8325		2.14	0.400	125	26	11.4	
KCCD	CL-3	4/30/02	20	12.16	68874	1.3010		1.61	0.210	19	8	14.8	
KCCD	CL-3	5/13/02	210	29.46	1752045	2.3222		1.16	0.280	32	9	11.7	
KCCD	CL-3	5/28/02	1400	81.47	32301226	3.1461		0.44	0.244	69	15	14.0	
KCCD	CL-3	6/11/02	820	73.77	17131164	2.9138		0.45	0.180	39	10	13.0	
KCCD	CL-3	6/24/02	500	46.18	6539088	2.6990		0.47	0.149	34	8	13.9	
KCCD	CL-3	7/8/02	480	11.68	1587732	2.6812		1.15	0.290	10	4	19.6	
KCCD	CL-3	7/23/02	540	10.98	1679149	2.7324		1.21	0.210	12	4	18.9	
KCCD	CL-3	8/5/02	300	3.13	265925	2.4771		0.81	0.092	5	3	14.4	
KCCD	CL-3	8/19/02	700	7.61	1508606	2.8451		0.48	0.080	14	5	16.3	
KCCD	CL-3	9/3/02	400	36.88	4177766	2.6021		0.24	0.117	24	7	13.5	
KCCD	CL-3	9/17/02	110	34.14	1063529	2.0414		0.33	0.122	16	5	13.5	
KCCD	CL-3	10/2/02	820	53.03	12314839	2.9138		0.38	0.143	28	9	10.6	
KCCD	CL-3	11/12/02	30	13.95	118519	1.4771		0.24	0.073	4	2	8.9	
Ecology	CK-1	4/13/99	24	25.00	169920	1.3802	89.0			9	5.6	2.3	approx. 3.5 miles above KRD Canal. NE of
Ecology	CK-1	5/4/99	11	54.70	170401	1.0414	60.0			11	5.7	3.3	
Ecology	CK-1	6/2/99	73	21.00	434146	1.8633	70.0			9	4.3	5.4	
Ecology	CK-1	6/28/99	230	0.80	52109	2.3617	102.0			2	1.6	8.8	
Ecology	CK-1	7/28/99	190	0.10	5381	2.2788	114.0			2	1.2	15.1	
Ecology	CK-1	8/24/99	51	0.10	1444	1.7076	119.0			1	1	15.8	
Ecology	CK-1	9/22/99	300	0.10	8496	2.4771	118.0			1	4.3	12.2	
Ecology	CK-1	10/19/99	43	1.70	20702	1.6335	100.0			6	1.3	4.5	
Ecology	CK-1	11/17/99	9	2.00	5098	0.9542	119.0			1	1	5.4	
KRD	CK-2	5/19/99	240	40.00	2718720	2.3802	74.0	0.03	0.051	15	4	9.0	approx. 0.5 mile above KRD Canal. NE of Ellensburg.
KRD	CK-2	6/2/99	60	20.00	339840	1.7782	98.0	0.05	0.048	13	3	8.0	
KRD	CK-2	6/14/99	1400	10.00	3964800	3.1461	108.0	0.01	0.077	7	4	16.0	
KRD	CK-2	6/28/99	420	3.00	356832	2.6232	151.0	0.01	0.066	4	2	10.0	
KRD	CK-2	7/14/99	80	0.50	11328	1.9031	142.0	0.01	0.060	1	1	9.5	
KRD	CK-2	7/28/99	26	0.25	1841	1.4150	252.0	0.11	0.064	2	1	14.0	
KRD	CK-2	11/3/99	86	0.45	10960	1.9345	121.0	0.01	0.053	2	2	1.5	
KRD	CK-2	3/22/00	1260	4.71	1679723	3.1004	123.3	0.01	0.041	10	5	4.5	
KRD	CK-2	4/18/00	480	37.63	5115816	2.6812	79.9	0.13	0.042	18	6	10.1	ducks in water upon arrival; sunny
KRD	CK-2	5/2/00	360	23.53	2398644	2.5563	82.4	0.06	0.035	11	4	7.9	
KRD	CK-2	5/16/00	60	3.62	61515	1.7782	118.3	0.01	0.070	6	4	15.7	small fecal sheen
KRD	CK-2	5/31/00	160	2.28	103437	2.2041	201.0	0.04	0.112	4	3	8.3	
KRD	CK-2	6/13/00	60	2.16	36753	1.7782	182.6	0.03	0.094	2	2	15.0	
KRD	CK-2	6/27/00	120	0.44	14958	2.0792	241.0	0.02	0.070	0.5	2	17.4	
KRD	CK-2	3/27/01	2	0.93	527	0.3010	136.2	0.12	0.036	1	2	5.3	
KRD	CK-2	4/18/01	2	0.57	321	0.3010	131.9	0.07	0.050	2	2	9.4	
KRD	CK-2	5/1/01	32	4.30	38968	1.5051	142.5	0.27	0.055	1	3	7.1	
KRD	CK-2	5/15/01	156	5.10	225314	2.1931	159.0	0.04	0.071	2	2	10.4	
KRD	CK-2	5/30/01	32	0.18	1631	1.5051	195.9	0.05	0.053	2	1		
Ecology	CK-3	4/13/99	850	16.40	3947808	2.9294	110.0			20	12	5.5	approx. 0.5 mile above Cascade Canal. Prior to City
Ecology	CK-3	5/4/99	77	59.50	1297481	1.8865	98.0			31	12	5.8	
Ecology	CK-3	6/2/99	850	58.30	14033976	2.9294	142.0			19	7.7	8.3	
Ecology	CK-3	6/28/99	1600	24.90	11282688	3.2041	136.0			19	7.7	11.5	
Ecology	CK-3	7/28/99	2900	8.60	7063008	3.4624	182.0			18	13	15.6	
Ecology	CK-3	8/24/99	2500	6.70	4743600	3.3979	198.0			18	6.9	16.4	
Ecology	CK-3	9/22/99	900	3.50	892080	2.9542	212.0			5	3.1	12.3	
Ecology	CK-3	10/19/99	85	3.30	79438	1.9294	251.0			1	1.4	5.0	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
Ecology	CK-3	11/17/99	23	1.00	6514	1.3617	244.0			2	1.3	6.3	
KCCD	CK-3	4/9/01	2	0.73	413	0.3010		0.04	0.042	4	3	6.5	
KCCD	CK-3	4/18/01	10	1.05	2974	1.0000	233.0	0.19	0.050	7	3	12.5	
KCCD	CK-3	5/2/01	18	0.33	1682	1.2553	233.0	0.30	0.155	9	4	13.5	
KCCD	CK-3	5/16/01	92	1.09	28399	1.9638	201.0	0.04	0.135	6	2	10.5	
KCCD	CK-3	5/30/01	5900	1.59	2656699	3.7709	150.0	0.11	0.310	8	5	18.0	
KCCD	CK-3	6/13/01	300	3.34	283766	2.4771	248.0	0.28	0.091	12	6	11.8	
KCCD	CK-3	6/27/01	3700	4.44	4652410	3.5682	162.0	0.18	0.350	38	7	15.0	
KCCD	CK-3	7/11/01	680	0.28	53921	2.8325	319.0	0.08	0.112	8	4	20.2	
KCCD	CK-3	7/25/01	380	0.50	53808	2.5798	264.0	0.07	0.112	6	8	15.7	
KCCD	CK-3	8/8/01	1260	0.19	67798	3.1004	288.0	0.04	0.115	4	4	15.6	cows in creek just upstream of sampling site
Ecology	CK-4	4/13/99	100	21.20	600384	2.0000	125.0			18	11	5.8	
Ecology	CK-4	5/4/99	96	60.10	1633951	1.9823	115.0			43	18	6.0	
Ecology	CK-4	6/2/99	1700	33.00	15887520	3.2304	169.0			22	9.8	8.5	
Ecology	CK-4	6/28/99	2100	17.70	10526544	3.3222	168.0			16	8	11.4	
Ecology	CK-4	7/28/99	830	13.60	3196762	2.9191	222.0			17	8.6	15.9	
Ecology	CK-4	8/24/99	1800	15.90	8105184	3.2553	221.0			58	22	17.0	
Ecology	CK-4	9/22/99	730	9.60	1984666	2.8633	268.0			12	7	13.3	
Ecology	CK-4	10/19/99	46	6.60	85980	1.6628	300.0			3	1.8	5.9	
Ecology	CK-4	11/17/99	35	4.70	46586	1.5441	326.0			2	2	7.2	

KCCD	CK-4	4/9/01	2	1.35	765	0.3010		0.93	0.460	16	5	8.6	
KCCD	CK-4	4/18/01	28	2.20	17445	1.4472	359.0	0.90	0.520	66	32	12.0	
KCCD	CK-4	5/2/01	18	1.63	8309	1.2553	353.0	2.44	0.860	8	4	14.5	
KCCD	CK-4	5/16/01	2000	2.95	1670880	3.3010	286.0	2.03	0.660	18	6	13.0	water coming from west ditch
KCCD	CK-4	5/30/01	2700	0.49	374674	3.4314	364.0	8.06	1.300	9	6	19.4	flow is up
KCCD	CK-4	6/13/01	300	7.18	610013	2.4771	250.0	0.42	0.138	42	11	12.5	
KCCD	CK-4	6/27/01	3000	18.85	16014960	3.4771	180.0	0.57	0.280	34	7	15.0	cattle in & around stream (downstream of sampling site)
KCCD	CK-4	7/11/01	500	1.83	259128	2.6990	375.0	2.45	0.590	4	4	19.4	
KCCD	CK-4	7/25/01	160	1.27	57546	2.2041	332.0	1.62	0.450	6	4	17.4	
KCCD	CK-4	8/801	570	1.07	172724	2.7559	360.0	1.71	0.380	4	2	18.7	
KCCD	CK-4	9/5/01	112	0.50	15859	2.0492	148.0	0.36	0.142	12	7	17.1	
KCCD	CK-4	9/19/01	144	0.50	20390	2.1584	389.0	1.74	0.470	4	2	10.8	
KCCD	CK-4	10/3/01	156	0.50	22090	2.1931	461.0	2.09	0.280	2	2	11.3	
KCCD	CK-4	11/7/01	28	0.50	3965	1.4472		1.69	0.240	4	4	10.6	
KCCD	CK-5	3/24/99	300			2.4771		0.40	0.260	127	50	8.9	south of I-90 just upstream of the confluence of Caribou
KCCD	CK-5	4/19/99	1300			3.1139		0.30	0.380	133	41	8.1	
KCCD	CK-5	5/4/99	170			2.2304		0.80	0.170	41	10	9.3	
KCCD	CK-5	5/19/99	500			2.6990		0.60	0.210	79	25	14.0	
KCCD	CK-5	6/3/99	300			2.4771		0.70	0.180	97	28	12.4	
KCCD	CK-5	6/14/99	800			2.9031		0.90	0.170	55	17	16.4	
KCCD	CK-5	6/28/99	90			1.9542		0.90	0.270	121	38	18.8	
KCCD	CK-5	7/14/99	800			2.9031		1.50	0.250	71	19	18.7	
KCCD	CK-5	7/29/99	230			2.3617		1.20	0.200	29	5.6	17.1	
KCCD	CK-5	8/9/99	500			2.6990		1.90	0.190	68	12	19.9	
KCCD	CK-5	8/24/99	140			2.1461		0.80	0.160	15	3.8	19.9	
KCCD	CK-5	9/8/99	110			2.0414		0.40	0.090	29	8.7	11.2	
KCCD	CK-5	9/23/99	800			2.9031		1.20	0.170	15	4	14.4	
KCCD	CK-5	10/4/99	1300			3.1139		1.20	0.310	142	57	11.1	
KCCD	CK-5	11/3/99	50			1.6990		1.50	0.210	4	2.9	6.5	
KCCD	CK-5	3/20/00	34	12.62	121515	1.5315		0.89	0.109	17	7		
KCCD	CK-5	4/18/00	160	29.97	1358001	2.2041		0.52	0.330	252	58	12.6	
KCCD	CK-5	5/2/00	210	40.66	2418132	2.3222		0.89	0.320	104	28	13.8	
KCCD	CK-5	5/16/00	500	17.06	2415696	2.6990		0.52	0.300	34	10	13.0	
KRD	CK-5	5/16/00	130			2.1139	190.6	0.53	0.144	39	10	16.0	
KCCD	CK-5	6/13/00	220	31.92	1988744	2.3424		0.53	0.120	33	10	15.5	
KCCD	CK-5	6/27/00	1300	17.08	6288173	3.1139		1.25	0.180	12	5	19.3	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KCCD	CK-5	7/12/00	220	9.69	603726	2.3424		2.32	0.290	26	10	19.1	
KCCD	CK-5	7/24/00	170	13.84	666313	2.2304		1.16	0.250	43	10	14.3	
KCCD	CK-5	8/8/00	156	16.51	729399	2.1931		0.62	0.190	24	8	15.9	
KCCD	CK-5	8/21/00	276	16.91	1321740	2.4409		0.29	0.200	148	28	14.2	
KRD	CK-5	8/22/00	248			2.3945	245.0	0.30	0.210	112	28	14.4	
KCCD	CK-5	9/6/00	220	24.96	1555108	2.3424		0.42	0.160	29	10	15.1	
KCCD	CK-5	9/19/00	232	21.20	1392891	2.3655		0.36	0.171	34	9	17.4	
KCCD	CK-5	10/3/00	1140	16.26	5249508	3.0569		0.59	0.184	80	15	10.9	
KCCD	CK-5	11/7/00	172	5.98	291288	2.2355		1.30	0.175	7	3	6.2	
KCCD	CK-5	3/20/02	36	1.25	12744	1.5563		0.97	0.320	7	3	3.2	
KCCD	CK-5	4/15/02	400	46.06	5217677	2.6021		0.55	0.330	136	49	6.3	
KCCD	CK-5	4/30/02	160	28.49	1290939	2.2041		0.82	0.420	74	18	15.5	
KCCD	CK-5	5/13/02	124	25.51	895830	2.0934		0.54	0.350	125	26	14.3	
KCCD	CK-5	5/28/02	192	28.70	1560545	2.2833		0.23	0.109	29	8	14.4	
KCCD	CK-5	6/11/02	320	30.60	2773094	2.5051		0.56	0.190	30	12	14.5	
KCCD	CK-5	6/24/02	340	29.40	2830867	2.5315		0.54	0.126	26	8	18.4	
KCCD	CK-5	7/8/02	74	16.61	348092	1.8692		1.98	0.160	12	4	18.6	
KCCD	CK-5	7/23/02	560	24.51	3887090	2.7482		1.47	0.210	32	6	19.4	
KCCD	CK-5	8/5/02	70	20.43	405004	1.8451		0.73	0.110	15	4	16.9	
KCCD	CK-5	8/19/02	340	21.12	2033603	2.5315		0.45	0.128	26	6	15.8	
KCCD	CK-5	9/3/02	560	27.02	4285156	2.7482		0.32	0.101	12	5	15.2	
KCCD	CK-5	9/17/02	500	23.03	3261048	2.6990		0.45	0.193	23	7	15.8	
KCCD	CK-5	10/2/02	500	16.88	2390208	2.6990		0.44	0.112	12	5	11.5	
KCCD	CK-5	11/12/02	95	2.39	64301	1.9777		1.23	0.124	3	2	8.8	
Ecology	JD-1	4/13/99	15	2.00	8496	1.1761	650.0			8	3.2	7.6	immediately upstream of its discharge into Parke Creek.
Ecology	JD-1	5/4/99	420	22.00	2616768	2.6232	330.0			106	28	8.6	
Ecology	JD-1	6/2/99	710	27.30	5489266	2.8513	305.0			107	26	10.1	
Ecology	JD-1	6/28/99	2500	19.80	14018400	3.3979	470.0			54	120	11.8	
Ecology	JD-1	7/28/99	830	23.20	5453299	2.9191	380.0			35	15	16.5	
Ecology	JD-1	8/24/99	600	23.20	3942144	2.7782	400.0			18	6.1	16.8	
Ecology	JD-1	9/22/99	550	28.50	4439160	2.7404	350.0			35	11	13.5	
Ecology	JD-1	10/19/99	15	10.40	44179	1.1761	390.0			4	1.7	8.4	
Ecology	JD-1	11/17/99	92	7.90	205830	1.9638	635.0			17	5.9	9.1	
KCCD	JD-1	3/20/00	2	7.15	4050	0.3010		2.91	0.151	20	4		
KCCD	JD-1	4/18/00	460	9.36	1219346	2.6628		1.22	0.780	136	33	10.8	
KCCD	JD-1	5/2/00	360	21.50	2191968	2.5563		1.28	0.480	57	22	14.2	
KRD	JD-1	5/16/00	640			2.8062	384.0	1.11	0.480	42	12	13.6	
KCCD	JD-1	5/16/00	560	7.15	1133933	2.7482		1.12	0.490	53	13	13.9	
KCCD	JD-1	6/13/00	270	21.07	1611096	2.4314		0.75	0.140	23	8	13.5	
KCCD	JD-1	6/27/00	290	12.25	1006068	2.4624		1.61	0.340	38	9	17.1	
KCCD	JD-1	7/12/00	800	12.28	2782157	2.9031		2.56	0.460	20	5	17.3	
KCCD	JD-1	7/24/00	1400	29.23	11589110	3.1461		1.10	0.470	41	8	14.8	
KCCD	JD-1	8/8/00	440	17.28	2153226	2.6435		1.25	0.330	34	10	15.6	
KCCD	JD-1	8/21/00	236	17.37	1160927	2.3729		1.18	0.240	24	8	14.0	

KCCD	JD-1	9/6/00	580	11.15	1831454	2.7634		1.08	0.240	24	7	13.4	
KCCD	JD-1	9/19/00	4140	22.96	26919406	3.6170		1.16	0.350	48	11	16.5	
KCCD	JD-1	10/3/00	460	10.70	1393910	2.6628		1.27	0.250	51	12	10.5	
KCCD	JD-1	11/7/00	460	7.24	943169	2.6628		2.42	0.230	18	5	8.4	
KCCD	JD-1	3/20/02	192	3.08	167473	2.2833		2.43	0.157	10	2	3.5	
KCCD	JD-1	4/15/02	320	7.77	704148	2.5051		2.14	0.400	125	26	11.4	
KCCD	JD-1	4/30/02	560	26.06	4132908	2.7482		1.59	0.800	259	28	13.2	
KCCD	JD-1	5/13/02	660	27.54	5147556	2.8195		0.97	0.440	137	23	13.7	
KCCD	JD-1	5/28/02	840	30.03	7143777	2.9243		0.96	0.435	88	20	14.5	
KCCD	JD-1	6/11/02	300	30.20	2565792	2.4771		0.88	0.327	158	20	13.1	
KCCD	JD-1	6/24/02	760	13.29	2860433	2.8808		1.50	0.360	37	10	14.8	
KCCD	JD-1	7/8/02	380	20.54	2210433	2.5798		2.41	0.420	38	7	16.0	
KCCD	JD-1	7/23/02	960	19.40	5274317	2.9823		2.11	0.450	35	6	18.2	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KCCD	JD-1	8/5/02	600	21.25	3610800	2.7782		1.34	0.380	34	7	14.9	
KCCD	JD-1	8/19/02	1800	22.67	11556259	3.2553		0.99	0.280	53	10	15.4	
KCCD	JD-1	9/3/02	460	18.91	2463444	2.6628		0.66	0.210	24	6	15.1	
KCCD	JD-1	9/17/02	900	11.29	2877595	2.9542		1.01	0.280	36	7	13.9	
KCCD	JD-1	10/2/02	400	24.72	2800282	2.6021		0.93	0.220	17	6	9.6	
KCCD	JD-1	11/12/02	10	4.28	12121	1.0000		2.50	0.180	25	4	10.0	
KRD	MC-1	5/19/99	180	18.00	917568	2.2553	74.0	0.01	0.051	6	3	8.8	approx. 1 mile due east of Whiskey Creek and running
KRD	MC-1	6/2/99	120	50.00	1699200	2.0792	57.0	0.02	0.046	10	4	6.0	
KRD	MC-1	6/14/99	90	35.00	892080	1.9542	57.0	0.01	0.060	14	4	9.5	
KRD	MC-1	6/28/99	2640	18.00	13457664	3.4216	65.0	0.01	0.057	4	2	9.0	
KRD	MC-1	7/14/99	400	5.60	634368	2.6021	90.0	0.01	0.062	4	2	10.5	
KRD	MC-1	7/28/99	600	1.30	220896	2.7782	134.0	0.01	0.100	3	2	18.0	
KRD	MC-1	8/9/99	280			2.4472	138.0	0.01	0.116	2	2	15.8	
KRD	MC-1	8/24/99	1100	0.50	155760	3.0414	166.0	0.01	0.155	3	2	18.5	
KRD	MC-1	9/8/99	122	1.30	44916	2.0864	156.0	0.02	0.095	2	2	13.2	
KRD	MC-1	9/22/99	500	0.34	48144	2.6990	167.0	0.03	0.060	1	2	12.5	
KRD	MC-1	10/4/99	150	0.30	12744	2.1761	161.0	0.03	0.061	1	2	8.5	
KRD	MC-1	11/3/99	220	2.00	124608	2.3424	108.0	0.01	0.048	1	2	1.5	
Ecology	NC-1	4/13/99	3	297.10	252416	0.4771	100.00			4	4.7	2.1	immediately upstream of where Wilson and Naneum
Ecology	NC-1	5/4/99	5	210.50	298068	0.6990	79.00			4	3.6	3.4	
Ecology	NC-1	6/2/99	3	419.20	356152	0.4771	55.0			11	6	4.2	
Ecology	NC-1	6/28/99	25	152.20	1077576	1.3979	51.00			4	2.5	16.6	
Ecology	NC-1	7/28/99	42	30.70	365158	1.6232	80.00			2	1.7	11.3	
Ecology	NC-1	8/24/99	3	24.60	20900	0.4771	87.00			3	1.5	12.5	
Ecology	NC-1	9/22/99	8	20.10	45539	0.9031	90.00			3	1.5	9.4	
Ecology	NC-1	10/19/99	1	19.70	5579	0.0000	88.00			1	0.8	2.8	
Ecology	NC-1	11/17/99	15	34.00	144432	1.1761	92.0			1	1.5	5.5	
KRD	NC-2	3/21/00	26	31.11	229082	1.4150	107.0	0.01	0.042	2	4	7.2	upstream of where Mercer, Wilson and Naneum Creeks
KRD	NC-2	4/18/00	2	178.22	100942	0.3010	82.1	0.02	0.031	7	5	8.9	sunny
KRD	NC-2	5/2/00	4	174.71	197911	0.6021	65.6	0.01	0.032	3	4	5.7	overcast, some sun & breezy
KRD	NC-2	5/16/00	14	167.80	665305	1.1461	68.4	0.01	0.045	6	4	9.0	
KRD	NC-2	5/31/00	36	154.42	1574333	1.5563	61.0	0.01	0.061	5	3	5.9	
KRD	NC-2	6/13/00	10	107.96	305748	1.0000	61.6	0.01	0.057	4	3	10.4	
KRD	NC-2	6/27/00	18	53.92	274855	1.2553	76.6	0.01	0.095	2	2	14.4	
KRD	NC-2	7/11/00	26	31.11	229082	1.4150	83.4	0.01	0.065	3	2	10.8	calm, clear & light breeze
KRD	NC-2	7/24/00	120	15.32	520499	2.0792	83.8	0.02	0.072	2	2	13.1	
KRD	NC-2	8/7/00	280	6.93	549209	2.4472	87.9	0.13	0.072	4	2	18.1	
KRD	NC-2	8/22/00	84	19.63	466942	1.9243	84.4	0.01	0.056	4	2	14.2	
KRD	NC-2	9/19/00	52	11.73	172707	1.7160	87.6	0.01	0.083	4	2	15.0	
KRD	NC-2	10/3/00	12	15.32	52050	1.0792	91.5	0.01	0.084	2	2	7.7	
KRD	NC-2	11/7/00	2	16.21	9182	0.3010	94.7	0.01	0.099	2	2	3.9	
KRD	NC-2	3/27/01	6	23.08	39218	0.7782	104.5	0.02	0.042	4	5	2.1	overcast, calm & cold
KRD	NC-2	4/18/01	22	17.13	106702	1.3424	104.3	0.01	0.042	5	3	7.6	
KRD	NC-2	5/1/01	1	32.09	9088	0.0000	76.6	0.01	0.043	3	4	3.7	cold & windy
KRD	NC-2	5/15/01	4	78.25	88642	0.6021	56.0	0.01	0.045	6	3	6.4	
KRD	NC-2	5/30/01	20	42.21	239077	1.3010	64.8	0.01	0.045	4	3	9.4	
KRD	NC-2	6/12/01	72	21.00	428198	1.8573	71.4	0.01	0.032	3	2	6.7	
KRD	NC-2	6/26/01	42	9.47	112640	1.6232	81.5	0.02	0.038	3	1	10.5	
KRD	NC-2	7/10/01	122	8.37	289187	2.0864	84.8	0.01	0.052	5	2	15.6	
KRD	NC-2	7/24/01	72	7.50	152928	1.8573	87.6	0.01	0.060	4	2	17.5	
KRD	NC-2	8/7/01	80	4.50	101839	1.9031	89.6	0.01	0.052	6	3	14.4	
KRD	NC-2	8/21/01	54	6.69	102309	1.7324	90.8	0.01	0.051	5	2	12.2	cloudy, warm & calm
KRD	NC-2	9/5/01	130	6.12	225314	2.1139	93.9	0.01	0.047	4	2	11.1	cool & windy
KRD	NC-2	9/18/01	68	4.92	94747	1.8325	93.1	0.01	0.051	5	1	11.0	sunny, mild & slight breeze
KRD	NC-2	10/2/01	20	4.88	27640	1.3010	93.1	0.01	0.052	2	1	10.6	
KRD	NC-2	11/7/01	8	7.13	16154	0.9031	99.9	0.01	0.052	0.5	2	3.7	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	NC-3	5/19/99	40	85.00	962880	1.6021	70.0	0.01	0.047	6	3	8.5	approx. 3 miles down from diverg. of Mercer, Wilson &
KRD	NC-3	6/2/99	4	130.00	147264	0.6021	51.0	0.03	0.038	13	5	5.0	
KRD	NC-3	6/14/99	66	110.00	2056032	1.8195	54.0	0.01	0.060	8	3	9.5	
KRD	NC-3	6/28/99	550	68.00	10591680	2.7404	57.0	0.01	0.040	4	2	9.0	
KRD	NC-3	7/14/99	100	31.30	886416	2.0000	68.0	0.01	0.036	3	2	9.5	
KRD	NC-3	7/28/99	100	12.50	354000	2.0000	76.0	0.01	0.060	2	1	14.0	
KRD	NC-3	8/9/99	130	7.20	265075	2.1139	88.0	0.01	0.078	1	1	13.7	
KRD	NC-3	8/24/99	160	4.00	181248	2.2041	94.0	0.01	0.092	1	1	17.4	

KRD	NC-3	9/8/99	80	3.80	86093	1.9031	101.0	0.01	0.044	1	1	10.7	
KRD	NC-3	9/22/99	90	2.77	70602	1.9542	97.0	0.01	0.043	6	1	11.5	
KRD	NC-3	10/4/99	20	2.88	16312	1.3010	101.0	0.02	0.055	8	1	7.5	
KRD	NC-3	11/3/99	16	8.80	39875	1.2041	91.0	0.01	0.040	1	1	2.0	
Ecology	NC-4	4/13/99	53	58.00	870557	1.7243	150.0			25	15	8.0	downstream end of creek, prior to Fiorito Pond.
Ecology	NC-4	5/4/99	220	211.00	13146144	2.3424	160.0			52	20	7.1	
Ecology	NC-4	6/2/99	340	327.00	31486176	2.5315	142.0			39	16	9.9	
Ecology	NC-4	6/28/99	420	195.00	23194080	2.6232	143.0			35	140	12.8	
Ecology	NC-4	7/28/99	490	78.00	10823904	2.6902	203.0			29	14	18.7	
Ecology	NC-4	8/24/99	400	92.00	10421760	2.6021	203.0			25	9.2	16.7	
Ecology	NC-4	9/22/99	240	83.00	5641344	2.3802	202.0			13	10	14.5	
Ecology	NC-4	10/19/99	88	74.00	1844198	1.9445	202.0			6	4	7.4	
Ecology	NC-4	11/17/99	14	43.00	170486	1.1461	227.0			4	3.5	8.3	
KRD	NC-4	3/22/00	24	44.46	302159	1.3802	203.0	0.32	0.036	9	4	6.7	small amounts of foam in water
KRD	NC-4	4/18/00	126	154.75	5522118	2.1004	133.8	0.32	0.173	52	14	7.4	deep water; sunny
KRD	NC-4	5/2/00	110	109.69	3416938	2.0414	203.0	0.62	0.230	40	12	12.6	
KRD	NC-4	5/16/00	120	134.59	4573975	2.0792	191.7	0.33	0.150	40	12	11.7	birds
KRD	NC-4	5/31/00	680	151.20	29116721	2.8325	194.0	0.39	0.162	31	8	10.7	
KRD	NC-4	6/13/00	320	165.07	14958851	2.5051	173.4	0.29	0.144	34	10	13.7	
KRD	NC-4	6/27/00	520	50.00	7363200	2.7160	229.0	0.98	0.163	14	7	14.3	
KRD	NC-4	7/11/00	94	60.00	1597248	1.9731	253.0	1.37	0.165	4	4	18.1	
KRD	NC-4	7/24/00	280	50.00	3964800	2.4472	260.0	0.90	0.154	6	4	14.0	
KRD	NC-4	8/8/00	270	47.50	3631887	2.4314	225.0	0.94	0.133	6	4	16.9	seaweed & muskrat
KRD	NC-4	8/22/00	500	95.05	13459753	2.6990	221.0	0.46	0.134	26	10	14.2	
KRD	NC-4	9/6/00	220	98.43	6132583	2.3424	203.0	0.26	0.118	16	10	14.5	
KRD	NC-4	9/19/00	272	72.69	5599340	2.4346	201.0	0.36	0.154	16	8	15.9	
KRD	NC-4	10/3/00	320	96.43	8738718	2.5051	202.0	0.46	0.150	12	5	9.5	sunny, clear, cold, frost on ground & no wind
KRD	NC-4	11/7/00	144	21.02	857172	2.1584	271.0	0.51	0.144	2	3	7.4	
KRD	NC-4	3/27/01	100	30.45	862344	2.0000	214.0	0.32	0.072	9	5	5.8	geese
KRD	NC-4	4/18/01	62	31.25	548682	1.7924	194.0	0.30	0.109	12	6	9.3	
KRD	NC-4	5/2/01	150	45.94	1951531	2.1761	236.0	0.91	0.160	17	8	7.1	
KRD	NC-4	5/16/01	620	63.34	11121491	2.7924	183.3	0.54	0.220	34	11	10.9	
KRD	NC-4	5/30/01	360	59.56	6072261	2.5563	231.0	0.48	0.170	14	7	11.2	birds
KRD	NC-4	6/12/01	240	80.09	5443557	2.3802		0.35	0.118	29	10	10.9	
KRD	NC-4	6/27/01	660	57.91	10824074	2.8195	216.0	0.77	0.200	32	10	14.5	
KRD	NC-4	7/11/01	260	32.01	2356960	2.4150	269.0	1.66	0.150	5	4	16.0	lots of seaweed
KRD	NC-4	7/25/01	400	32.73	3707654	2.6021	266.0	1.11	0.177	6	5	14.9	
KRD	NC-4	8/8/01	310	37.99	3335218	2.4914	266.0	1.32	0.149	4	4	16.0	
KRD	NC-4	8/22/01	460	45.84	5971668	2.6628	267.0	0.76	0.183	9	4	16.5	overcast & light rain
KRD	NC-4	9/5/01	190	33.43	1798801	2.2788	190.6	0.30	0.071	7	3	15.1	cool & windy
KRD	NC-4	9/19/01	120	23.55	800323	2.0792	260.0	0.52	0.153	2	3	13.3	sunny, warm & breezy
KRD	NC-4	10/3/01	164	24.90	1156476	2.2148	270.0	0.80	0.089	2	2	12.2	
KRD	NC-4	11/7/01	4	7.02	7952	0.6021	306.0	0.98	0.103	0.5	1	6.0	
KRD	KRD	5/19/99	10	760.00		1.0000	42.0	0.03	0.011	2	1	6.8	diversion point on Yakima River. Approx. 25 miles NE
KRD	KRD	6/2/99	2	690.00		0.3010	39.0	0.04	0.020	6	7	8.0	
KRD	KRD	6/14/99	4	860.00		0.6021	37.0	0.01	0.014	2	2	10.0	
KRD	KRD	6/28/99	8	810.00		0.9031	37.0	0.01	0.010	1	1	10.0	
KRD	KRD	7/14/99	6	1020.00		0.7782	35.0	0.01	0.010	1	1	13.0	
KRD	KRD	7/28/99	2	1090.00		0.3010	29.0	0.03	0.010	1	1	12.5	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	KRD	8/9/99	8	1090.00		0.9031	29.0	0.02	0.010	1	1	13.0	
KRD	KRD	8/24/99	10	1050.00		1.0000	30.0	0.01	0.012	1	1	16.0	
KRD	KRD	9/8/99	2	1095.00		0.3010	40.0	0.01	0.010	1	1	13.8	
KRD	KRD	9/22/99	20	1105.00		1.3010	39.0	0.11	0.010	1	1	16.0	
KRD	KRD	10/4/99	10	1105.00		1.0000	40.0	0.02	0.010	1	2	12.5	
KRD	KRD	5/1/00	2	706.90		0.3010	45.5	0.03	0.005	1	1	7.8	
KRD	KRD	5/15/00	2	875.20		0.3010	46.7	0.03	0.024	8	2	8.4	
KRD	KRD	5/30/00	2	898.00		0.3010	46.4	0.03	0.012	5	3	8.9	overcast & light precipitation
KRD	KRD	6/12/00	2	823.00		0.3010	51.3	0.02	0.005	4	2	9.7	
KRD	KRD	6/26/00	2	914.00		0.3010	43.6	0.03	0.015	3	2	11.4	
KRD	KRD	7/10/00	2	1094.50		0.3010	39.2	0.03	0.014	2	2	12.3	
KRD	KRD	7/24/00	2	1126.70		0.3010	35.3	0.02	0.011	1	2	13.3	
KRD	KRD	8/7/00	4	1135.90		0.6021	38.9	0.01	0.015	0.5	2	16.3	
KRD	KRD	8/21/00	2	1092.20		0.3010	41.4	0.01	0.005	1	2	15.9	
KRD	KRD	9/5/00	2	1092.20		0.3010	51.0	0.01	0.005	1	1	15.9	
KRD	KRD	9/18/00	2	1096.37		0.3010	44.0	0.01	0.015	2	2	16.3	
KRD	KRD	10/2/00	6	1094.59		0.7782	46.2	0.01	0.010	2	2	13.3	
KRD	KRD	4/30/01	2	453.71		0.3010	42.1	0.01	0.013	4	4	5.6	Cabin Creek 3.50 NTU
KRD	KRD	5/14/01	2	762.71		0.3010	48.7	0.01	0.013	4	2	9.0	
KRD	KRD	5/29/01	1	812.54		0.0000	45.8	0.01	0.015	2	1	10.7	
KRD	KRD	6/11/01	1	819.25		0.0000	45.0	0.01	0.005	1	1	8.2	
KRD	KRD	6/25/01	2	762.71		0.3010	45.5	0.01	0.005	0.5	2	12.8	
KRD	KRD	7/9/01	2	712.87		0.3010	23.0	0.01	0.005	2	1	16.1	
KRD	KRD	7/23/01	2	809.31		0.3010	48.7	0.01	0.005	0.5	2	18.3	
KRD	KRD	8/6/01	5	606.77		0.6990	46.8	0.02	0.017	2	3	19.6	
KRD	KRD	8/20/01	10	563.36		1.0000	45.4	0.01	0.005	6	2	17.6	sunny, warm & light wind
KRD	KRD	9/4/01	4	447.47		0.6021	46.1	0.01	0.005	2	2	17.1	overcast, calm & cool
KCCD	KRD-1	5/4/99	800			2.9031		0.15	0.190	69	29.8	9.2	downstream end of ditch, approx. 3 miles prior to
KCCD	KRD-1	5/19/99	700			2.8451		0.50	0.150	8	7.6	15.0	
KCCD	KRD-1	6/14/99	1700			3.2304		0.05	0.090	4	7.2	24.2	

KCCD	KRD-1	6/28/99	800			2.9031		0.05	0.120	6	6.7	18.1	
KCCD	KRD-1	7/14/99	17			1.2304		0.30	0.130	14	11.1	19.3	
KCCD	KRD-1	7/29/99	230			2.3617		0.05	0.120	8	7.6	19.3	
KCCD	KRD-1	8/9/99	220			2.3424		0.05	0.180	7	6.4	21.1	
KCCD	KRD-1	8/24/99	230			2.3617		0.05	0.080	6	5.6	21.6	
KCCD	KRD-1	9/8/99	50			1.6990		0.20	0.030	5	3.1	15.0	
KCCD	KRD-1	9/23/99	30			1.4771		0.20	0.030	6	4.4	16.3	
KCCD	KRD-1	10/4/99	23			1.3617		0.05	0.030	10	13.4	11.2	
KRD	KRD-1	4/18/00	12	3.31	11237	1.0792	117.6	0.79	0.052	10	7	12.4	sunny
KRD	KRD-1	5/16/00	10000	6.19	17530080	4.0000	63.6	0.01	0.209	79	32	13.8	cattle in & around ditch, turbid, visible particles; sunny,
KRD	KRD-1	5/31/00	3740	8.58	9087661	3.5729	55.9	0.01	0.088	36	15	10.7	cattle in & around ditch (direct feces contribution)
KRD	KRD-1	6/13/00	280	6.65	527318	2.4472	56.6	0.01	0.040	8	6	14.3	
KRD	KRD-1	6/27/00	54	1.80	27527	1.7324	82.9	0.01	0.053	2	5	21.0	
KRD	KRD-1	7/11/00	28	0.75	5947	1.4472	66.7	0.01	0.043	5	6	20.4	large mass of aquatic plants in ditch
KRD	KRD-1	7/24/00	60	5.52	93813	1.7782	46.7	0.02	0.046	5	6	17.9	
KRD	KRD-1	8/8/00	28	1.37	10857	1.4472	46.8	0.01	0.022	2	4	19.6	seaweed
KRD	KRD-1	8/22/00	34	5.74	55273	1.5315	49.5	0.02	0.043	5	4	17.9	waterfowl present
KRD	KRD-1	9/19/00	34	3.49	33624	1.5315	54.3	0.01	0.033	6	5	17.0	
KRD	KRD-1	10/3/00	126	3.68	131341	2.1004	56.2	0.02	0.056	8	6	10.4	
KRD	KRD-1	5/1/01	32	7.11	64477	1.5051	65.5	0.20	0.081	13	9	8.7	waterfowl
KRD	KRD-1	5/15/01	134	6.19	234809	2.1271	52.1	0.01	0.073	15	9	12.3	
KRD	KRD-1	5/30/01	212	4.67	280379	2.3263	56.4	0.01	0.061	19	11	13.9	many cattle along and in tailend; pictures taken
KRD	KRD-1	6/12/01	1600	2.95	1334948	3.2041		0.01	0.033	9	6	11.4	
KRD	KRD-1	6/26/01	620	8.08	1419450	2.7924	53.4	0.02	0.038	9	6	15.2	
KRD	KRD-1	7/10/01	390	1.95	215590	2.5911	57.1	0.01	0.032	6	4	23.6	
KRD	KRD-1	7/24/01	100	1.80	50973	2.0000	51.9	0.01	0.013	4	4	20.7	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
Ecology	PC-1	4/13/99	110	2.50	77880	2.0414	123.0			9	9	4.7	approx. 3 miles down from Whiskey Jim Creek
Ecology	PC-1	5/4/99	190	0.80	43046	2.2788	245.0			3	1.6	7.3	
Ecology	PC-1	6/2/99	66	0.10	1869	1.8195	222.0			3	0.7	9.5	
KRD	PC-1	4/18/00	2	0.55	312	0.3010	188.3	0.10	0.067	2	3	17.0	sunny
KCCD	PC-2	3/24/99	300			2.4771		0.60	0.150	34	14	10.4	downstream end of creek, immediately prior to where
KCCD	PC-2	4/19/99	500			2.6990		1.10	0.480	136	55	8.0	
KCCD	PC-2	5/4/99	7000			3.8451		1.30	0.260	76	11	8.7	
KCCD	PC-2	5/19/99	130			2.1139		1.30	0.270	84	22	12.0	
KCCD	PC-2	6/3/99	1300			3.1139		1.20	0.290	50	17	11.8	
KCCD	PC-2	6/14/99	170			2.2304		0.90	0.230	67	14	14.7	
KCCD	PC-2	6/28/99	350			2.5441		0.80	0.230	35	6.6	15.1	
KCCD	PC-2	7/14/99	500			2.6990		2.00	0.440	167	76	15.7	
KCCD	PC-2	7/29/99	230			2.3617		2.00	0.340	62	8.2	14.5	
KCCD	PC-2	8/9/99	500			2.6990		1.00	0.400	82	11	17.1	
KCCD	PC-2	8/24/99	1700			3.2304		1.10	0.280	48	15	17.9	
KCCD	PC-2	9/8/99	50			1.6990		0.50	0.160	38	5.9	12.3	
KCCD	PC-2	9/23/99	800			2.9031		1.30	0.240	41	12	13.8	
KCCD	PC-2	10/4/99	800			2.9031		1.10	0.220	28	11	11.4	
KCCD	PC-2	11/3/99	140			2.1461		1.40	0.210	0.5	1.9	9.2	
KCCD	PC-2	3/20/00	2	13.75	7788	0.3010		1.23	0.126	5	2		
KCCD	PC-2	4/18/00	96	17.09	464629	1.9823		1.00	0.160	45	12	10.9	
KCCD	PC-2	5/2/00	70	35.48	703356	1.8451		1.67	0.280	42	10	12.4	
KCCD	PC-2	5/16/00	360	44.91	4578664	2.5563		1.15	0.300	95	14	11.9	
KCCD	PC-2	6/13/00	560	88.46	14029048	2.7482		0.66	0.180	61	11	12.1	
KCCD	PC-2	6/27/00	440	69.44	8652780	2.6435		0.65	0.201	60	13	13.9	
KCCD	PC-2	7/12/00	1600	19.22	8708966	3.2041		1.71	0.300	22	8	13.9	
KCCD	PC-2	7/24/00	120	33.04	1122831	2.0792		2.01	0.290	27	7	14.1	
KCCD	PC-2	8/8/00	96	18.16	493720	1.9823		1.89	0.240	23	8	13.5	
KCCD	PC-2	8/21/00	420	57.94	6891615	2.6232		1.14	0.220	61	11	14.2	
KCCD	PC-2	9/6/00	144	55.47	2262111	2.1584		0.74	0.260	204	24	14.6	
KCCD	PC-2	9/19/00	176	26.65	1328321	2.2455		1.30	0.230	14	4	15.5	
KCCD	PC-2	10/3/00	100	47.41	1342651	2.0000		1.17	0.200	16	4	11.5	
KCCD	PC-2	11/7/00	22	13.61	84796	1.3424		1.52	0.200	8	2	10.1	
KCCD	PC-2	3/20/02	32	3.45	31265	1.5051		1.01	0.137	5	2	5.4	
KCCD	PC-2	4/15/02	280	16.89	1339309	2.4472		1.05	0.370	224	45	8.9	
KCCD	PC-2	4/30/02	80	20.03	453800	1.9031		3.21	0.420	64	16	13.2	
KCCD	PC-2	5/13/02	380	37.50	4035600	2.5798		1.63	0.540	42	10	12.4	
KCCD	PC-2	5/28/02	270	92.57	7078272	2.4314		0.86	0.389	281	38	12.9	
KCCD	PC-2	6/11/02	420	53.18	6325442	2.6232		1.42	0.220	69	13	22.7	
KCCD	PC-2	6/24/02	130	43.84	1614013	2.1139		1.03	0.200	48	8	14.9	
KCCD	PC-2	7/8/02	5940	16.04	26982616	3.7738		2.18	0.240	51	8	14.4	
KCCD	PC-2	7/23/02	6000	13.33	22650336	3.7782		2.58	0.260	44	10	15.2	
KCCD	PC-2	8/5/02	700	16.59	3288802	2.8451		2.25	0.220	26	7	14.8	
KCCD	PC-2	8/19/02	10	21.80	61738	1.0000		1.96	0.210	24	6	14.6	
KCCD	PC-2	9/3/02	200	58.57	3317405	2.3010		0.47	0.165	53	11	15.2	
KCCD	PC-2	9/17/02	480	34.33	4666683	2.6812		1.39	0.220	73	11	14.8	
KCCD	PC-2	10/2/02	100	29.07	823262	2.0000		1.66	0.200	30	6	12.6	
KCCD	PC-2	11/12/02	65	8.13	149657	1.8129		1.83	0.166	7	2	12.0	
Ecology	SC-1	5/4/99	83	0.60	14103	1.9191	100.0			2	2	3.9	approx. 4 miles north of KRD Canal.
KRD	EWC	4/19/99	2	91.00		0.3010	84.0	0.03	0.047	55	19	7.0	diversion point on Yakima River. Approx. 12 miles
KRD	EWC	5/19/99	10	108.00		1.0000	78.0	0.01	0.026	7	2	9.0	
KRD	EWC	6/2/99	18	97.00		1.2553	68.0	0.04	0.017	12	6	9.0	

KRD	EWC	6/14/99	26	102.00		1.4150	62.0	0.01	0.023	18	6	10.5	
KRD	EWC	6/28/99	10	105.00		1.0000	52.0	0.01	0.015	16	5	12.0	
KRD	EWC	7/14/99	20	126.00		1.3010	51.0	0.01	0.017	4	2	14.5	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	EWC	7/28/99	2			0.3010	53.0	0.02	0.011	2	1	17.5	
KRD	EWC	8/9/99	10			1.0000	48.0	0.03	0.010	1	1	10.0	
KRD	EWC	8/24/99	2			0.3010	44.0	0.01	0.029	1	1	11.5	
KRD	EWC	9/8/99	2			0.3010	58.0	0.02	0.011	1	1	12.5	
KRD	EWC	9/22/99	14			1.1461	59.0	0.02	0.010	2	1	12.5	
KRD	EWC	10/4/99	10			1.0000	57.0	0.02	0.011	1	1	8.5	
KRD	EWC	5/1/00	10	145.80		1.0000	45.5	0.01	0.005	3	2	8.0	
KRD	EWC	5/15/00	14	128.20		1.1461	84.7	0.01	0.015	2	1	9.8	
KRD	EWC	5/30/00	18	130.40		1.2553	60.7	0.02	0.013	6	3	10.1	
KRD	EWC	6/12/00	12	104.00		1.0792	65.3	0.01	0.005	4	3	11.6	
KRD	EWC	6/26/00	6	142.50		0.7782	63.4	0.02	0.017	2	2	14.0	
KRD	EWC	7/10/00	12	138.10		1.0792	53.3	0.01	0.026	2	2	9.5	
KRD	EWC	7/24/00	2	130.40		0.3010	49.9	0.01	0.014	2	3	12.6	
KRD	EWC	8/7/00	2	117.20		0.3010	52.3	0.01	0.015	3	2	15.6	
KRD	EWC	8/21/00	6	109.50		0.7782	52.8	0.01	0.011	4	2	15.2	
KRD	EWC	9/5/00	6	80.00		0.7782	57.2	0.01	0.005	1	2	15.9	
KRD	EWC	9/18/00	14	70.00		1.1461	61.9	0.02	0.043	3	2	16.0	
KRD	EWC	10/2/00	4	40.00		0.6021	65.5	0.01	0.014	2	2	13.2	
KRD	EWC	4/30/01	16	100.70		1.2041		0.02	0.011	4	2	6.4	
KRD	EWC	5/14/01	38	144.70		1.5798	75.4	0.01	0.018	7	3	9.7	
KRD	EWC	5/29/01	10	124.90		1.0000	82.6	0.01	0.005	3	2	11.1	
KRD	EWC	6/11/01	28	129.30		1.4472	64.2	0.01	0.011	4	2	11.3	
KRD	EWC	6/25/01	12	124.90		1.0792	55.6	0.01	0.016	4	3		
KRD	EWC	7/9/01	22	128.20		1.3424	57.1	0.01	0.012	6	2	14.6	
KRD	EWC	7/23/01	10	129.30		1.0000	58.8	0.01	0.005	4	2	18.5	
KRD	EWC	8/6/01	2	135.90		0.3010	55.1	0.02	0.005	5	2	19.7	
KRD	EWC	8/20/01	10	132.60		1.0000	55.7	0.01	0.011	6	1	16.7	sunny, warm & light wind
KRD	EWC	9/4/01	1	112.80		0.0000	61.7	0.01	0.005	3	1	16.1	overcast, calm & cool
KRD	EWC	10/2/01	8	55.00		0.9031	80.1	0.01	0.014	0.5	1	12.1	
Ecology	EWC-1	4/13/99	260	90.00	6626880	2.4150	105.0			39	16	7.6	approx. 0.75 mile up from (NE) of Ellensburg.
Ecology	EWC-1	5/4/99	66	105.00	1962576	1.8195	110.0			8	5.6	8.6	
Ecology	EWC-1	6/2/99	560	95.00	15066240	2.7482	104.0			11	9.3	8.8	
Ecology	EWC-1	6/28/99	280	97.00	7691712	2.4472	79.0			10	8	12.2	
Ecology	EWC-1	7/28/99	140	120.00	4757760	2.1461	90.0			5	3.4	18.7	
Ecology	EWC-1	8/24/99	96	129.00	3507149	1.9823	80.0			3	1.8	13.8	
Ecology	EWC-1	9/22/99	65	85.00	1564680	1.8129	98.0			3	3.5	15.0	
Ecology	EWC-1	10/19/99	1	59.00	16709	0.0000	89.0			3	1.6	8.4	
Ecology	EWC-1	11/17/99	3	0.10	85	0.4771	350.0			4	5.8	8.9	
Ecology	EWC-2	4/13/99	370	80.00	8382720	2.5682	108.0			223	70	8.2	approx. 0.75 mile down from Ellensburg. In
Ecology	EWC-2	5/4/99	60	95.00	1614240	1.7782	115.0			11	6.7	9.0	
Ecology	EWC-2	6/2/99	220	85.00	5295840	2.3424	112.0			17	9.6	9.2	
Ecology	EWC-2	6/28/99	220	87.00	5420448	2.3424	83.0			10	7	12.4	
Ecology	EWC-2	7/28/99	160	110.00	4984320	2.2041	92.0			8	5.1	18.8	
Ecology	EWC-2	8/24/99	100	119.00	3370080	2.0000	85.0			8	2.8	14.6	
Ecology	EWC-2	9/22/99	100	75.00	2124000	2.0000	100.0			3	2.9	15.5	
Ecology	EWC-2	10/19/99	28	49.00	388550	1.4472	95.0			3	1.8	8.5	
Ecology	EWC-2	11/17/99	110	0.10	3115	2.0414	310.0			7	4.3	9.3	
KCCD	EWC-3	4/19/99	700			2.8451		0.80	0.460	22	13	8.2	approx. 8 miles upstream of end of canal. SE of
KCCD	EWC-3	5/4/99	80			1.9031		1.40	0.520	22	11	8.8	
KCCD	EWC-3	5/19/99	300			2.4771		1.00	0.320	8	7.7	13.0	
KCCD	EWC-3	6/3/99	3000			3.4771		1.00	0.370	11	12	11.3	
KCCD	EWC-3	6/14/99	1300			3.1139		0.80	0.280	7	6.1	16.2	
KCCD	EWC-3	6/28/99	500			2.6990		1.70	0.370	9	9.7	18.8	
KCCD	EWC-3	7/14/99	500			2.6990		1.60	0.380	5	4.6	17.3	
KCCD	EWC-3	7/29/99	5000			3.6990		1.30	0.320	12	4.6	16.5	
KCCD	EWC-3	8/9/99	800			2.9031		0.70	0.380	17	6.6	19.3	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KCCD	EWC-3	8/24/99	300			2.4771		1.10	0.220	5	3.3	19.3	
KCCD	EWC-3	9/8/99	800			2.9031		0.60	0.150	6	2.7	12.5	
KCCD	EWC-3	9/23/99	700			2.8451		0.70	0.270	13	2.1	13.9	
KCCD	EWC-3	10/4/99	220			2.3424		1.30	0.170	7	2.9	10.5	
KCCD	EWC-3	4/18/00	218			2.3385		0.65	0.350	28	14	8.8	
KCCD	EWC-3	5/2/00	110			2.0414		1.06	0.230	12	9	13.4	
KCCD	EWC-3	5/16/00	1120	14.52	4605512	3.0492		0.61	0.350	25	14	15.2	
KCCD	EWC-3	6/13/00	600			2.7782		0.16	0.160	8	9	12.5	
KCCD	EWC-3	6/27/00	180			2.2553		0.64	0.420	7	4	16.6	
KCCD	EWC-3	7/12/00	220	20.12	1253556	2.3424		1.46	0.310	7	4	18.6	
KCCD	EWC-3	7/24/00	1280	33.84	12266865	3.1072		0.91	0.300	7	4	15.7	
KCCD	EWC-3	8/8/00	970	13.81	3793662	2.9868		0.88	0.280	6	6	15.8	
KCCD	EWC-3	8/21/00	600	35.88	6096730	2.7782		0.71	0.230	18	6	15.6	
KCCD	EWC-3	9/6/00	470	17.22	2292051	2.6721		0.51	0.170	4	4	13.4	
KCCD	EWC-3	9/16/00	330	11.84	1106519	2.5185		0.60	0.180	7	5	17.0	
KCCD	EWC-3	10/3/00	320	12.32	1116488	2.5051		1.18	0.165	4	4	9.9	
KCCD	EWC-3	4/15/02	316	21.87	1957173	2.4997		0.63	0.250	53	32	6.6	

KCCD	EWC-3	4/30/02	100	23.62	668918	2.0000		0.86	0.410	64	14	12.2	
KCCD	EWC-3	5/13/02	236	27.98	1870049	2.3729		0.74	0.410	18	10	12.8	
KCCD	EWC-3	5/28/02	380	23.05	2480549	2.5798		0.60	0.293	32	14	14.0	
KCCD	EWC-3	6/11/02	260	16.81	1237754	2.4150		0.65	0.240	16	10	13.3	
KCCD	EWC-3	7/8/02	2780	10.57	8321719	3.4440		2.45	0.330	8	4	16.3	
KCCD	EWC-3	7/23/02	6000	15.49	26320608	3.7782		1.44	0.440	7	3	18.4	
KCCD	EWC-3	8/5/02	900	17.62	4490986	2.9542		1.60	0.300	5	3	13.8	
KCCD	EWC-3	8/19/02	800	11.74	2659814	2.9031		4.01	0.220	8	4	16.9	
KCCD	EWC-3	9/3/02	100	36.64	1037645	2.0000		0.82	0.200	9	6	15.5	
KCCD	EWC-3	9/17/02	680	18.73	3606948	2.8325		1.14	0.220	8	4	15.4	
KCCD	EWC-3	10/2/02	200	13.45	761808	2.3010		1.07	0.190	4	4	9.5	
KRD	EWC-4	4/19/99	310	6.35	557479	2.4914	244.0	1.05	0.260	17	11	9.5	downstream end of canal. SE of Ellensburg.
KRD	EWC-4	5/19/99	200	13.00	736320	2.3010	273.0	0.76	0.250	16	8	11.0	
KRD	EWC-4	6/2/99	2000	8.20	4644480	3.3010	310.0	0.70	0.290	20	10	12.0	
KRD	EWC-4	6/14/99	300	22.00	1869120	2.4771	263.0	0.55	0.220	8	7	20.0	
KRD	EWC-4	6/28/99	190	1.90	102235	2.2788	333.0	0.57	0.150	4	6	14.0	
KRD	EWC-4	7/14/99	500	13.90	1968240	2.6990	293.0	1.00	0.178	12	4	14.0	
KRD	EWC-4	7/28/99	230	11.40	742550	2.3617	314.0	1.10	0.260	24	7	16.0	
KRD	EWC-4	8/9/99	580	13.90	2283158	2.7634	295.0	0.75	0.280	22	10	18.8	
KRD	EWC-4	8/24/99	170	9.10	438110	2.2304	366.0	0.94	0.240	10	5	17.0	
KRD	EWC-4	9/8/99	90	9.10	231941	1.9542	296.0	0.53	0.150	5	4	11.9	
KRD	EWC-4	9/22/99	120	12.70	431597	2.0792	314.0	0.58	0.184	9	8	15.0	
KRD	EWC-4	10/4/99	230	5.55	361505	2.3617	300.0	0.86	0.157	9	5	10.5	
KRD	EWC-4	4/18/00	174	12.68	624906	2.2405	251.0	1.10	0.300	48	17	10.0	sunny
KRD	EWC-4	5/2/00	78	7.05	155812	1.8921	278.0	0.84	0.300	24	16	13.2	mostly sunny
KRD	EWC-4	5/16/00	680	8.05	1550417	2.8325	291.0	0.56	0.300	18	15	13.4	
KRD	EWC-4	5/31/00	2500	22.38	15845040	3.3979	287.0	0.62	0.260	32	12	10.2	windy
KRD	EWC-4	6/13/00	150	7.05	299639	2.1761	273.0	0.37	0.200	14	12	13.2	
KRD	EWC-4	6/27/00	294	9.67	804894	2.4683	287.0	0.57	0.190	5	4	18.8	
KRD	EWC-4	7/11/00	200	1.06	60247	2.3010	367.0	1.20	0.250	4	5	17.3	water caramel colored – picture taken
KRD	EWC-4	7/24/00	600	17.10	2905632	2.7782	382.0	1.07	0.310	20	8	15.8	
KRD	EWC-4	8/8/00	880	4.84	1206475	2.9445	363.0	1.02	0.250	16	8	16.4	
KRD	EWC-4	8/22/00	860	3.19	777553	2.9345	343.0	0.74	0.200	20	10	16.4	
KRD	EWC-4	10/3/00	118	12.68	423787	2.0719	360.0	1.00	0.185	6	4	10.0	
KRD	EWC-4	11/7/00	30	7.05	59928	1.4771	457.0	1.98	0.139	6	3	7.4	
KRD	EWC-4	4/18/01	70	0.70	13962	1.8451	460.0	1.90	0.159	16	8	10.0	
KRD	EWC-4	5/1/01	50	4.93	69809	1.6990	225.0	0.77	0.240	12	7	8.2	
KRD	EWC-4	5/16/01	140	5.27	208945	2.1461	292.0	0.88	0.280	11	6	9.9	
KRD	EWC-4	5/30/01	480	0.27	36703	2.6812	326.0	0.74	0.260	10	8	12.4	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	EWC-4	6/12/01	900	0.46	117245	2.9542		0.86	0.240	17	8	10.8	
KRD	EWC-4	6/26/01	160	3.03	137295	2.2041	304.0	0.75	0.170	10	6	14.1	
KRD	EWC-4	7/10/01	476	1.32	177940	2.6776	266.0	0.62	0.128	6	4	20.0	
KRD	EWC-4	7/24/01	410	5.36	622360	2.6128	311.0	0.91	0.185	10	7	18.4	
KRD	EWC-4	8/21/01	204	0.69	39863	2.3096		0.70	0.190	10	5	16.0	cloudy, warm & calm
KRD	EWC-4	9/5/01	300	18.42	1564963	2.4771	246.0	0.47	0.145	31	10	13.8	cool & windy
KRD	EWC-4	10/3/01	60	6.58	111807	1.7782	502.0	1.96	0.182	12	5	11.5	
KRD	WC-1	4/19/99	4	23.00	26054	0.6021	91.0	0.12	0.112	50	11	6.0	approx. 2.5 miles down from convergence of Wilson &
KRD	WC-1	5/19/99	210	16.00	951552	2.3222	78.0	0.01	0.056	9	4	9.5	
KRD	WC-1	6/2/99	500	12.00	1699200	2.6990	69.0	0.02	0.056	9	4	7.0	
KRD	WC-1	6/14/99	180	12.00	611712	2.2553	65.0	0.01	0.058	8	3	10.0	
KRD	WC-1	6/28/99	120	8.40	285466	2.0792	74.0	0.01	0.050	5	2	9.5	
KRD	WC-1	7/14/99	230		0	2.3617	87.0	0.01	0.050	4	2	10.0	
KRD	WC-1	7/28/99	2500		0	3.3979	124.0	0.03	0.149	3	2	16.0	
KRD	WC-1	8/9/99	300		0	2.4771	123.0	0.02	0.116	3	3	14.0	
KRD	WC-1	8/24/99	40	2.00	22656	1.6021	160.0	0.02	0.220	2	2	18.5	
KRD	WC-1	9/8/99	820	2.00	464448	2.9138	191.0	0.01	0.085	1	2	12.2	
KRD	WC-1	9/22/99	1100	1.55	482856	3.0414	205.0	0.02	0.079	3	5	11.2	
KRD	WC-1	10/4/99	1900	2.09	1124587	3.2788	187.0	0.03	0.087	1	3	8.0	
KRD	WC-1	11/3/99	20	2.60	14726	1.3010	119.0	0.01	0.056	1	2	2.5	
KRD	WL-1	5/19/99	10	51.60	146131	1.0000	72.0	0.01	0.049	7	3	8.5	
KRD	WL-1	6/2/99	20	80.00	453120	1.3010	54.0	0.02	0.047	10	4	5.5	
KRD	WL-1	6/14/99	280	66.00	5233536	2.4472	55.0	0.01	0.058	13	4	10.0	
KRD	WL-1	6/28/99	120	36.00	1223424	2.0792	61.0	0.01	0.051	8	3	9.0	
KRD	WL-1	7/14/99	60	16.00	271872	1.7782	74.0	0.01	0.045	6	2	10.0	
KRD	WL-1	7/28/99	500	5.30	750480	2.6990	103.0	0.01	0.130	5	3	16.5	
KRD	WL-1	8/9/99	370	5.30	555355	2.5682	119.0	0.02	0.154	3	2	16.0	
KRD	WL-1	8/24/99	160	2.10	95155	2.2041	141.0	0.02	0.173	2	1	19.5	
KRD	WL-1	9/8/99	78	2.00	44179	1.8921	124.0	0.01	0.068	2	1	11.9	
KRD	WL-1	9/22/99	330	0.59	55139	2.5185	146.0	0.02	0.066	2	2	12.6	
KRD	WL-1	10/4/99	40	0.59	6684	1.6021	133.0	0.02	0.063	1	2	8.0	
KRD	WL-1	11/3/99	10	1.60	4531	1.0000	107.0	0.01	0.059	1	2	2.0	
Ecology	WL-2	4/13/99	360	8.50	866592	2.5563	118.0			7	5.8	8.0	at same site where Cascade Ditch crosses Wilson
Ecology	WL-2	5/4/99	550	48.90	7616664	2.7404	102.0			10	6.1	9.1	
Ecology	WL-2	6/2/99	230	110.80	7217069	2.3617	77.0			10	7.1	7.7	
Ecology	WL-2	6/28/99	300	21.20	1801152	2.4771	111.0			9	5.3	11.3	
Ecology	WL-2	7/28/99	860	3.10	755011	2.9345	145.0			5	5.5	19.3	
Ecology	WL-2	8/24/99	1000	0.10	28320	3.0000	135.0			5	3.4	17.9	
Ecology	WL-2	9/22/99	870	2.00	492768	2.9395	121.0			4	3	16.6	
Ecology	WL-2	10/19/99	190	0.60	32285	2.2788	185.0			1	1.1	7.8	
Ecology	WL-2	11/17/99	85	0.10	2407	1.9294	197.0			1	1	7.8	

Ecology	WL-3	4/13/99	140	24.30	963446	2.1461	180.0			8	6	8.9	west split of Wilson Creek. Approx. 1 mile down from
Ecology	WL-3	5/4/99	170	70.50	3394152	2.2304	160.0			12	8	9.6	
Ecology	WL-3	6/2/99	290	107.20	8804122	2.4624	142.0			11	8.1	9.8	
Ecology	WL-3	6/28/99	910	62.50	16107000	2.9590	159.0			12	7.1	12.5	
Ecology	WL-3	7/28/99	1000	24.40	6910080	3.0000	220.0			8	4.6	18.2	
Ecology	WL-3	8/24/99	2000	34.50	19540800	3.3010	220.0			8	4.9	16.9	
Ecology	WL-3	9/22/99	1100	30.90	9625968	3.0414	215.0			6	4.4	15.2	
Ecology	WL-3	10/19/99	510	12.90	1863173	2.7076	250.0			1	1.4	9.6	
Ecology	WL-3	11/17/99	130	11.20	412339	2.1139	256.0			1	1.4	9.0	
Ecology	WL-4	4/13/99	16	4.20	19031	1.2041	150.0			24	23	9.5	east split of Wilson Creek. Approx. 1.5 miles down
Ecology	WL-4	5/4/99	340	25.00	2407200	2.5315	115.0			16	10	8.4	
Ecology	WL-4	6/2/99	170	45.90	2209810	2.2304	90.0			13	8.9	8.4	
Ecology	WL-4	6/28/99	190	11.60	624173	2.2788	134.0			16	8.5	12.4	
Ecology	WL-4	7/28/99	320	2.80	253747	2.5051	229.0			9	5	20.0	
Ecology	WL-4	8/24/99	380	2.04	219537	2.5798	198.0			7	5	19.0	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
Ecology	WL-4	9/22/99	710	2.50	502680	2.8513	185.0			11	6.3	16.3	
Ecology	WL-4	10/19/99	15	0.80	3398	1.1761	275.0			2	2	8.7	
Ecology	WL-4	11/17/99	13	0.80	2945	1.1139	280.0			1	0.8	9.0	
Ecology	WL-5	4/13/99	46	103.00	1341802	1.6628	155.0			23	13	10.1	approx. 1 mile up from discharge into the Yakima River.
Ecology	WL-5	5/4/99	170	471.50	22699896	2.2304	152.0			43	20	10.0	
Ecology	WL-5	6/2/99	290	588.40	48324115	2.4624	150.0			27	14	10.5	
Ecology	WL-5	6/28/99	290	427.40	35101507	2.4624	153.0			28	9.8	13.8	
Ecology	WL-5	7/28/99	320	147.50	13367040	2.5051	212.0			17	9.7	21.3	
Ecology	WL-5	8/24/99	1000	177.00	50126400	3.0000	202.0			13	6	20.0	
Ecology	WL-5	9/22/99	290	112.70	9255826	2.4624	215.0			9	6.3	17.3	
Ecology	WL-5	10/19/99	150	89.00	3780720	2.1761	205.0			6	3.6	10.1	
Ecology	WL-5	11/17/99	26	59.60	438847	1.4150	253.0			6	3.5	9.5	
KRD	WL-5	3/22/00	54	66.90	1023088	1.7324	232.0	0.33	0.043	8	4	7.6	there may be too much sediment in the sample
KRD	WL-5	4/18/00	164	218.80	10162122	2.2148	154.2	0.37	0.198	40	12	7.9	sunny
KRD	WL-5	5/2/00	150	172.50	7327800	2.1761	211.0	0.50	0.181	27	9	13.5	
KRD	WL-5	5/16/00	176	289.70	14439575	2.2455	200.0	0.29	0.160	28	10	12.9	birds (100+ swallows) flying around
KRD	WL-5	5/31/00	720	290.10	59152550	2.8573	203.0	0.34	0.151	25	8	10.7	scores of birds(swallows), nests under bridge
KRD	WL-5	6/13/00	240	348.60	23693645	2.3802	183.4	0.23	0.132	25	8	13.3	hundreds of birds (swallows) nesting on bridge
KRD	WL-5	6/27/00	340	177.64	17104600	2.5315	206.0	0.59	0.123	12	5	15.8	
KRD	WL-5	7/11/00	100	136.35	3861432	2.0000	223.0	0.98	0.122	6	5	17.4	very few birds (<10) nests empty
KRD	WL-5	7/24/00	2360	113.03	75543827	3.3729	226.0	0.59	0.141	10	4	14.7	ducks upstream
KRD	WL-5	8/8/00	300	116.53	9900771	2.4771	207.0	0.51	0.102	8	4	18.4	seaweed
KRD	WL-5	8/22/00	400	158.90	18000192	2.6021	216.0	0.37	0.108	20	6	14.6	
KRD	WL-5	9/6/00	112	352.80	11190252	2.0492	194.0	0.23	0.100	10	5	14.7	
KRD	WL-5	9/19/00	144	154.78	6312052	2.1584	192.5	0.27	0.131	11	6	16.6	
KRD	WL-5	10/3/00	208	164.70	9701752	2.3181	207.0	0.46	0.130	8	4	10.2	
KRD	WL-5	11/7/00	68	49.36	950555	1.8325	275.0	0.53	0.153	7	3	8.0	
KRD	WL-5	3/28/01	380	56.81	6113665	2.5798	248.0	0.47	0.096	10	7	6.2	
KRD	WL-5	4/18/01	52	50.29	740591	1.7160	203.0	0.32	0.089	11	5	9.6	decaying bird nests in/near water
KRD	WL-5	5/2/01	140	67.80	2688134	2.1461	233.0	0.96	0.210	13	7	7.5	
KRD	WL-5	5/16/01	460	124.07	16162847	2.6628	213.0	0.52	0.160	24	8	12.4	
KRD	WL-5	5/30/01	340	102.64	9883000	2.5315	242.0	0.60	0.142	9	5	11.4	many birds under bridge (>50)
KRD	WL-5	6/13/01	310	170.15	14937809	2.4914	209.0	0.29	0.097	18	7	11.5	integrated grab sample; sunny, warm & calm
KRD	WL-5	6/27/01	420	150.50	17901072	2.6232	221.0	0.62	0.154	14	6	14.7	
KRD	WL-5	7/11/01	90	71.24	1815765	1.9542	249.0	1.23	0.109	4	3	18.6	lots of seaweed
KRD	WL-5	7/25/01	220	89.91	5601753	2.3424	247.0	0.81	0.126	8	6	17.4	
KRD	WL-5	8/8/01	680	87.36	16823439	2.8325	253.0	0.69	0.119	5	4	16.1	
KRD	WL-5	8/22/01	520	100.09	14739654	2.7160	257.0	0.49	0.126	9	4	16.8	overcast & light rain
KRD	WL-5	9/5/01	106	125.60	3770412	2.0253	200.0	0.26	0.069	8	3	15.3	cool & windy
KRD	WL-5	9/19/01	164	55.38	2572113	2.2148	272.0	0.46	0.116	4	4	13.5	sunny, warm & breezy
KRD	WL-5	10/3/01	72	46.69	952028	1.8573	291.0	0.66	0.081	4	2	13.7	
KRD	WL-5	11/7/01	12	21.78	74017	1.0792	316.0	0.68	0.086	4	3	6.7	
KRD	WW-1	6/14/99	14	29.00	114979	1.1461	42.0	0.01	0.016	7	3	15.5	approx. 0.5 mile down from Wipple Creek.
KRD	WW-1	7/14/99	34	61.00	587357	1.5315	36.0	0.01	0.010	8	3	13.5	
KRD	WW-1	8/9/99	28	38.90	308461	1.4472	31.0	0.02	0.010	4	1	11.4	
KRD	WW-1	9/8/99	40	139.00	1574592	1.6021	41.0	0.02	0.010	3	1	14.0	
KRD	WW-1	10/4/99	10	99.00	280368	1.0000	41.0	0.03	0.010	2	1	11.1	
KRD	WW-1	4/18/00	240	109.20	7422106	2.3802	57.6	0.01	0.071	63	13	9.8	sunny
KRD	WW-1	5/2/00	6	29.00	49277	0.7782	49.9	0.03	0.005	7	3	9.8	
KRD	WW-1	5/16/00	46	21.00	273571	1.6628	48.7	0.01	0.005	5	3	12.4	
KRD	WW-1	5/31/00	44	17.30	215572	1.6435	50.8	0.01	0.017	4	3	10.3	
KRD	WW-1	6/13/00	62	88.60	1555674	1.7924	50.4	0.01	0.005	5	3	11.4	sunny, cool & slight breeze
KRD	WW-1	6/27/00	14	100.40	398066	1.1461	46.0	0.01	0.024	3	2	16.2	resident ducks & pollen on water
KRD	WW-1	7/11/00	20	23.90	135370	1.3010	39.1	0.02	0.015	2	3	14.5	
KRD	WW-1	7/24/00	12	2.00	6797	1.0792	39.2	0.01	0.020	4	4	15.7	
KRD	WW-1	8/8/00	4	2.00	2266	0.6021	36.4	0.01	0.011	3	3	17.5	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
KRD	WW-1	8/22/00	12	22.20	75444	1.0792	41.9	0.01	0.010	3	2	18.1	
KRD	WW-1	9/19/00	18	68.60	349695	1.2553	46.7	0.01	0.030	3	2	17.1	
KRD	WW-1	10/3/00	14	66.80	264849	1.1461	48.3	0.01	0.031	2	2	12.2	
KRD	WW-1	5/1/01	112	58.90	1868214	2.0492	54.1	0.01	0.069	8	5	7.1	

KRD	WW-1	5/15/01	28	88.00	697805	1.4472	49.4	0.01	0.024	13	3	10.8	
KRD	WW-1	5/30/01	20	69.70	394781	1.3010	53.5	0.01	0.012	6	3	11.7	calibration check
KRD	WW-1	6/12/01	56	64.10	1016575	1.7482		0.01	0.005	4	2	7.1	
KRD	WW-1	6/26/01	30	198.80	1689005	1.4771	44.2	0.01	0.005	5	2	13.7	
KRD	WW-1	7/10/01	78	57.20	1263525	1.8921	42.8	0.01	0.005	5	2	19.1	algae floating in water, photo taken
KRD	WW-1	7/24/01	52	61.00	898310	1.7160	46.3	0.01	0.005	6	3	19.0	
KRD	WW-1	8/7/01	148	61.80	2590260	2.1703	51.5	0.01	0.012	6	3	19.9	
KRD	WW-1	8/21/01	92	65.17	1697965	1.9638		0.01	0.011	2	3	16.8	overcast & light rain
KRD	WW-1	9/5/01	112	38.84	1231943	2.0492	52.7	0.01	0.005	14	2	14.3	lots of floating algae; cool & windy
KRD	WW-1	9/18/01	56	4.15	65816	1.7482	54.3	0.01	0.014	10	2	16.5	sunny, mild & slight breeze
KRD	WW-2	3/24/99	2	8.78	4973	0.3010	360.0	1.04	0.085	12	5	12.0	approx. 1.5 miles down from wasteway headworks.
KRD	WW-2	4/19/99	450	32.70	4167288	2.6532	216.0	0.78	0.115	36	9	9.5	
KRD	WW-2	5/19/99	160	106.00	4803072	2.2041	134.0	0.52	0.100	20	5	11.0	
KRD	WW-2	6/2/99	200	73.00	4134720	2.3010	156.0	0.64	0.105	15	7	12.0	
KRD	WW-2	6/14/99	660	50.00	9345600	2.8195	188.0	0.68	0.138	24	8	18.0	
KRD	WW-2	6/28/99	180	129.00	6575904	2.2553	114.0	0.31	0.060	20	5	12.0	
KRD	WW-2	7/14/99	330	79.70	7448443	2.5185	134.0	0.56	0.080	23	6	14.0	
KRD	WW-2	7/28/99	240	59.40	4037299	2.3802	200.0	0.96	0.158	14	4	15.0	
KRD	WW-2	8/9/99	620	62.10	10903766	2.7924	194.0	0.68	0.155	28	5	17.0	
KRD	WW-2	8/24/99	200	58.90	3336096	2.3010	172.0	0.59	0.146	15	4	16.0	
KRD	WW-2	9/8/99	120	168.40	5722906	2.0792	109.0	0.37	0.056	11	4	12.7	
KRD	WW-2	9/22/99	1100	73.90	23021328	3.0414	172.0	0.71	0.093	12	4	15.5	
KRD	WW-2	10/4/99	60	123.60	2100211	1.7782	133.0	0.44	0.067	8	3	11.5	
KRD	WW-2	11/3/99	54			1.7324	449.0	2.00	0.185	4	2	8.7	
KRD	WW-3	3/24/99	6	14.40	24468	0.7782	476.0	2.18	0.150	11	2	13.0	approx. 3 miles down from Cascade Canal enters the
KRD	WW-3	4/19/99	900	27.90	7111152	2.9542	217.0	0.89	0.220	53	15	9.5	
KRD	WW-3	5/19/99	120	117.40	3989722	2.0792	156.0	0.66	0.136	26	7	11.0	
KRD	WW-3	6/2/99	1000	115.00	32568000	3.0000	1000.0	0.78	0.145	22	9	12.0	
KRD	WW-3	6/14/99	1600	65.00	29452800	3.2041	201.0	0.69	0.188	30	10	18.5	
KRD	WW-3	6/28/99	430	183.00	22285008	2.6335	133.0	0.42	0.095	22	6	12.5	
KRD	WW-3	7/14/99	470	55.00	7320720	2.6721	167.0	0.87	0.102	20	6	14.0	
KRD	WW-3	7/28/99	290	45.80	3761462	2.4624	230.0	1.11	0.179	16	4	15.0	
KRD	WW-3	8/9/99	430	79.80	9717725	2.6335	223.0	0.73	0.190	30	8	17.5	
KRD	WW-3	8/24/99	600	79.80	13559616	2.7782	201.0	0.69	0.162	14	4	16.0	
KRD	WW-3	9/8/99	80	177.50	4021440	1.9031	130.0	0.46	0.068	12	4	12.6	
KRD	WW-3	9/22/99	22	79.80	497186	1.3424	192.0	0.71	0.119	13	3	15.0	
KRD	WW-3	10/4/99	70	145.00	2874480	1.8451	154.0	0.50	0.094	12	4	11.0	
KRD	WW-3	11/3/99	10	20.50	58056	1.0000	452.0	2.05	0.188	6	2	8.0	
KCCD	WW-4	3/24/99	4		0	0.6021		2.30	0.170	8	4	11.3	approx. 2 miles up from its discharge into Cherry Creek.
KRD	WW-4	3/24/99	14		0	1.1461	496.0	2.23	0.167	5	2	10.0	
Ecology	WW-4	4/13/99	28	22.10	175244	1.4472	380.0			50	25	7.8	
KCCD	WW-4	4/19/99	230		0	2.3617		0.90	0.400	69	23	9.5	
KRD	WW-4	4/19/99	220		0	2.3424	283.0	1.24	0.330	70	16	9.5	
Ecology	WW-4	5/4/99	300	85.50	7264080	2.4771	260.0			46	20	9.0	
KCCD	WW-4	5/4/99	700		0	2.8451		1.50	0.330	50	16	9.1	
KCCD	WW-4	5/19/99	130		0	2.1139		1.00	0.210	37	11	12.0	
KRD	WW-4	5/19/99	70		0	1.8451	202.0	0.81	0.169	30	9	12.3	
Ecology	WW-4	6/2/99	480	123.70	16815283	2.6812	220.0			65	23	10.2	
KCCD	WW-4	6/3/99	800		0	2.9031		1.10	0.240	40	17	12.2	
KCCD	WW-4	6/14/99	500		0	2.6990		1.10	0.300	40	12	17.2	
Ecology	WW-4	6/28/99	190	166.80	8975174	2.2788	148.0			37	110	12.5	
KCCD	WW-4	6/28/99	300		0	2.4771		0.60	0.160	35	11	15.1	
KCCD	WW-4	7/14/99	80		0	1.9031		1.40	0.210	23	10	16.1	
Agency	Sampling Site No.	Date	Fecal (cfu/100mL)	Flow (CFS)	FC Loading (cfu/sec)	Log FC	SC	NO3/ NO2 (mg/L)	Phos (mg/L)	TSS (mg/L)	NTU	Water Temp (C)	Notes
Ecology	WW-4	7/28/99	200	84.00	4757760	2.3010	329.0			24	9.5	17.3	
KCCD	WW-4	7/29/99	170		0	2.2304		1.60	0.290	27	5.3	14.9	
KCCD	WW-4	8/9/99	800		0	2.9031		0.70	0.340	57		18.1	
Ecology	WW-4	8/24/99	220	130.40	8124442	2.3424	300.0			25	9.9	19.9	
KCCD	WW-4	8/24/99	300		0	2.4771		1.10	0.230	26	5.2	19.8	
KCCD	WW-4	9/8/99	800		0	2.9031		0.70	0.080	21	3	12.7	
KRD	WW-4	9/8/99	100		0	2.0000	166.0	0.57	0.140	16	5	11.9	
Ecology	WW-4	9/22/99	170	96.70	4655525	2.2304	243.0			21	8.2	15.0	
KCCD	WW-4	9/23/99	220		0	2.3424		1.10	0.150	16	3.1	15.0	
KCCD	WW-4	10/4/99	140		0	2.1461		0.90	0.170	22	8.3	12.2	
KRD	WW-4	10/4/99	50		0	1.6990	203.0	0.70	0.130	22	5	11.1	
Ecology	WW-4	10/19/99	69	39.50	771862	1.8388	440.0			5	2.7	8.4	
KCCD	WW-4	11/3/99	23		0	1.3617		2.40	0.280	2	2.5	8.5	
KRD	WW-4	11/3/99	6		0	0.7782	493.0	2.34	0.199	5	2	7.5	
Ecology	WW-4	11/17/99	23	30.80	200619	1.3617	500.0			5	2.5	9.1	
KRD	WW-4	3/22/00	2	26.32	14908	0.3010	518.0	2.33	0.165	4	2	8.3	
KRD	WW-4	4/18/00	236	163.16	10904809	2.3729	169.4	0.48	0.330	238	52	9.7	sunny
KRD	WW-4	5/2/00	110	116.18	3619331	2.0414	269.0	0.91	0.230	43	12	12.6	
KRD	WW-4	5/16/00	280	112.85	8948646	2.4472	279.0	0.83	0.260	31	12	11.9	
KRD	WW-4	5/31/00	700	147.37	29214407	2.8451	269.0	0.86	0.260	42	12	11.6	wildlife droppings near water
KRD	WW-4	6/13/00	270	181.26	13860033	2.4314	215.0	0.48	0.170	31	10	12.9	
KRD	WW-4	6/27/00	182	144.82	7464519	2.2601	204.0	0.58	0.140	24	5	15.1	
KRD	WW-4	7/11/00	180	94.02	4792696	2.2553	306.0	1.35	0.222	51	12	16.0	
KRD	WW-4	7/24/00	260	91.07	6705886	2.4150	385.0	1.50	0.340	44	13	14.3	
KRD	WW-4	8/8/00	500	68.67	9723729	2.6990	367.0	1.45	0.260	26	8	15.5	
KRD	WW-4	8/22/00	660	109.57	20480794	2.8195	311.0	1.04	0.220	47	12	14.9	
KRD	WW-4	9/6/00	144	220.57	8995200	2.1584	198.3	0.51	0.118	37	9	14.7	
KRD	WW-4	9/19/00	120	131.26	4460674	2.0792	229.0	0.69	0.166	27	8	15.5	
KRD	WW-4	10/3/00	96	137.33	3733672	1.9823	245.0	0.79	0.167	31	8	10.7	

KRD	WW-4	11/7/00	26	35.36	260333	1.4150	499.0	2.07	0.150	3	2	8.2	
KRD	WW-4	3/28/01	6	26.52	45063	0.7782	513.0	2.31	0.212	8	4	8.6	
KRD	WW-4	4/18/01	94	38.91	1035682	1.9731	296.0	1.04	0.160	50	16	10.1	
KRD	WW-4	5/2/01	112	85.79	2721122	2.0492	231.0	0.96	0.200	32	10	9.2	
KRD	WW-4	5/16/01	200	124.93	7076035	2.3010	231.0	0.81	0.190	50	9	9.9	
KRD	WW-4	5/30/01	188	145.07	7723759	2.2742	238.0	0.69	0.170	34	9	11.7	
KRD	WW-4	6/13/01	200	162.22	9188141	2.3010	254.0	0.71	0.170	53	9	11.6	integrated grab sample
KRD	WW-4	6/27/01	400	182.05	20622624	2.6021	168.4	0.63	0.122	38	10	14.0	
KRD	WW-4	7/11/01	240	60.25	4095072	2.3802	314.0	1.47	0.176	22	5	17.4	
KRD	WW-4	7/25/01	170	65.38	3147655	2.2304	334.0	1.54	0.191	26	8	16.0	
KRD	WW-4	8/8/01	200	86.78	4915219	2.3010	281.0	1.06	0.156	22	5	16.3	
KRD	WW-4	8/22/01	244	94.16	6506531	2.3874	290.0	1.01	0.171	26	6	16.5	overcast & light rain
KRD	WW-4	9/5/01	140	145.01	5749356	2.1461	201.0	0.59	0.106	27	6	14.6	cool & windy
KRD	WW-4	9/19/01	720	31.12	6345492	2.8573	486.0	2.13	0.190	7	4	14.3	sunny, warm & breezy
KRD	WW-4	10/3/01	296	23.35	1957365	2.4713	550.0	2.27	0.222	6	3	12.0	
KRD	WW-4	11/7/01	20	20.55	116395	1.3010	493.0	2.20	0.212	3	2	7.0	

Shaded cells indicate non-critical condition period data.