Wilson Creek Sub-basin Bacteria

Total Maximum Daily Load

First Water Quality
Post TMDL Monitoring Report

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Study Codes

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Federal Clean Water Act 2004 303(d) Listings Addressed in this Study

Caribou Creek	*LLID: 1204591469529: Fecal Coliform*
Cascade Irrigation Canal	LLID: 12038882469702: Fecal Coliform
Cherry Creek	WA-39-1032: LLID: 1205084469164: Fecal Coliform
Coleman Creek	LLID: 1204991469477: Fecal Coliform
Cooke Creek	WA-39-1034: LLID: 1204591469539: Fecal Coliform
Ellensburg Water Company Canal	LLID: 1204659469835: Fecal Coliform
Johnson Drain	LLID: 1204499469450: Fecal Coliform
Mercer Creek	LLID: 1205541469864: Fecal Coliform
Naneum Creek	WA-39-1025: LLID: 1205030469443: Fecal Coliform
Turbine Ditch	LLID: 1204081469002: Fecal Coliform
Whiskey Creek	LLID: 1205354470480: Fecal Coliform
Wilson Creek	WA-39-1020: LLID: 1204996469292: Fecal Coliform
Wipple Wasteway (Badger Creek)	LLID: 1204966469272: Fecal Coliform

Cover photo: Cascade Irrigation Canal at Thrall Road (photo by Jenna Durkee)

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First Water Quality
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By

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October 2013

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Abstract

In 2005, the Washington State Department of Ecology (Ecology) completed the *Wilson Creek Sub-basin Bacteria Total Maximum Daily Load (TMDL)*, which is a water quality cleanup plan for fecal coliform (FC) bacteria in the Wilson Creek sub-watershed, near Ellensburg, Washington.

The Wilson Creek sub-basin is a highly agricultural area, irrigated by many canals and creeks that wind their way through valley. The TMDL found that the highest FC levels in the creeks occurred during the irrigation season.

This report summarizes a follow-up to the earlier TMDL, in which water samples were collected at most of the sites used in the TMDL and were then analyzed for FC. The new data was then compared to the data from the original study. A total of 16 sample sites – three background sites and 13 downstream (non-background) sites – were comparable between the TMDL and this study.

The TMDL identified two types of reduction targets for FC: a geometric mean target and a 90% value target. The current study found that all 16 comparative sites met the first interim TMDL target for the geometric mean. Additionally, 94% of the sampling sites complied with the TMDL's *second* interim geometric mean target, due in October 2015.

About 75% of the comparative sites complied with the first interim 90% value target. However, only 6 of 16 (37.5%) of the sites are in compliance with the corresponding second interim 90% value target, due in October 2015. This should accentuate the importance of continued implementation of best management practices (BMPs).

Acknowledgements

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- Washington State Department of Ecology staff:
    - Jenna Durkee and Kristin Carmack
    - Charlie McKinney

What is a Total Maximum Daily Load (TMDL)?

Federal Clean Water Act requirements

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

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

To develop the WQA, the Washington State Department of Ecology (Ecology) compiles its own water quality data along with data from local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data in this WQA are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the assessment. The WQA divides water bodies into five categories. Those not meeting standards are given a Category 5 designation, which collectively becomes the 303(d) list.

The Water Quality Assessment and the 303(d) List

The WQA is a list that tells a more complete story about the condition of the state's water bodies. This list divides water bodies into five categories:

- Category 1 – Clean water (meets water quality standards).
- Category 2 – Waters of concern.
- Category 3 – No data, or insufficient data, available.
- Category 4 – Polluted waters that do not require a TMDL since the problems are being solved in one of the following three ways:
    - 4a – Has an approved TMDL and it is being implemented,
    - 4b – Has a pollution control plan in place that should solve the problem,
    - 4c – Is impaired by a non-pollutant such as low water flow, dams, culverts, or
- Category 5 – Polluted waters that require a TMDL – the 303(d) list.

TMDL process overview

The CWA requires that a total maximum daily load (TMDL) be developed for each of the water bodies on the 303(d) list. The goal of a TMDL is to ensure that the impaired water body will attain state standards. A TMDL includes a written quantitative assessment of the specific water quality problem and the sources that cause, or contribute, to the pollution problem. The

Washington State Department of Ecology (Ecology) will subsequently develop, with local governmental and private entities, a strategy to control the pollution and a monitoring plan to assess the effectiveness of the water quality improvement activities. Those activities must include the implementation of specific best management practices (BMPs).

Elements required in a TMDL

Identification of the contaminant loading capacity for a water body is an important step in developing a TMDL. The U.S. Environmental Protection Agency (USEPA) defines the loading capacity as "the greatest amount of loading that a water body can receive without violating water quality standards" (USEPA, 2001). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with water quality standards.

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

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

Any amount of pollution that exceeds a water body's loading capacity must be eliminated in order to achieve compliance with state water quality standards. A TMDL must also include repeated evaluations of the progress toward reaching its goal (clean water) through effectiveness monitoring.

Background

What is post-TMDL monitoring?

Post-TMDL monitoring is the process of gathering and analyzing water quality information over the life of the TMDL. After a water cleanup plan (total maximum daily load, or TMDL) or other water quality improvement project is in place, we use post-TMDL monitoring to see if efforts are on track with meeting the goals of the TMDL implementation plan. Post-TMDL monitoring is used to identify additional pollutant sources and compare existing water quality to the desired water quality. Over time, this information is used as part of a TMDL effectiveness monitoring evaluation that is an important part of the adaptive management process.

Study area

The Wilson Creek Sub-basin is located in Central Washington, east of the Cascade Mountains in Watershed Resource Inventory Area (WRIA) 39, Upper Yakima. It is bordered by the Wenatchee Mountains, the Yakima River, Manastash Ridge, Colockum Mountains, and Boylston Mountains. The sub-basin encompasses 244,500 acres of land. Elevation ranges from 1,425 feet at Thrall Road (the confluence of Wilson Creek and the Yakima River) to 6,359 feet near the headwaters of Wilson Creek near Lion Rock.

The cities of Ellensburg and Kittitas and their surrounding areas make up the majority of the land mass in the sub-basin. Land owned by the Washington Department of Fish and Wildlife and the US Bureau of Reclamation lies along the borders of the sub-basin. Ellensburg, with a population of 18,468 in 2011, is the largest city in Kittitas County. Ellensburg is home to Central Washington University, which adds around 11,000 students to the population of Ellensburg during the school year (September through June.) Kittitas is a small town in the Wilson Creek sub-basin and had a population of approximately 1,400 in 2011.

Most of the land in the Wilson Creek sub-basin is used for agriculture with additional land used for residential, urban, evergreen forest and shrub steppe. Figure 1 shows the distribution of land use throughout the sub-basin. Note: The labeled sampling sites in Figures 1 are the key sites used during the 2011 sampling.

Agriculture has been the mainstay of the 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 four to five years with one to 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 (AFOs) and hobby farms, with the principal livestock species being beef cattle.

The average annual rainfall is 8.9 inches, mostly (70%) occurring in October through March. 8% of total precipitation occurs during August through September. The average snowfall is 31.4 inches, and most of this accumulates from November through February. Because of minimal summer precipitation, irrigation water from outside of the basin is applied to croplands during the critical condition period (April through October). The amount of irrigation water applied to crops each year is about 4.5 times that of the annual rainfall.

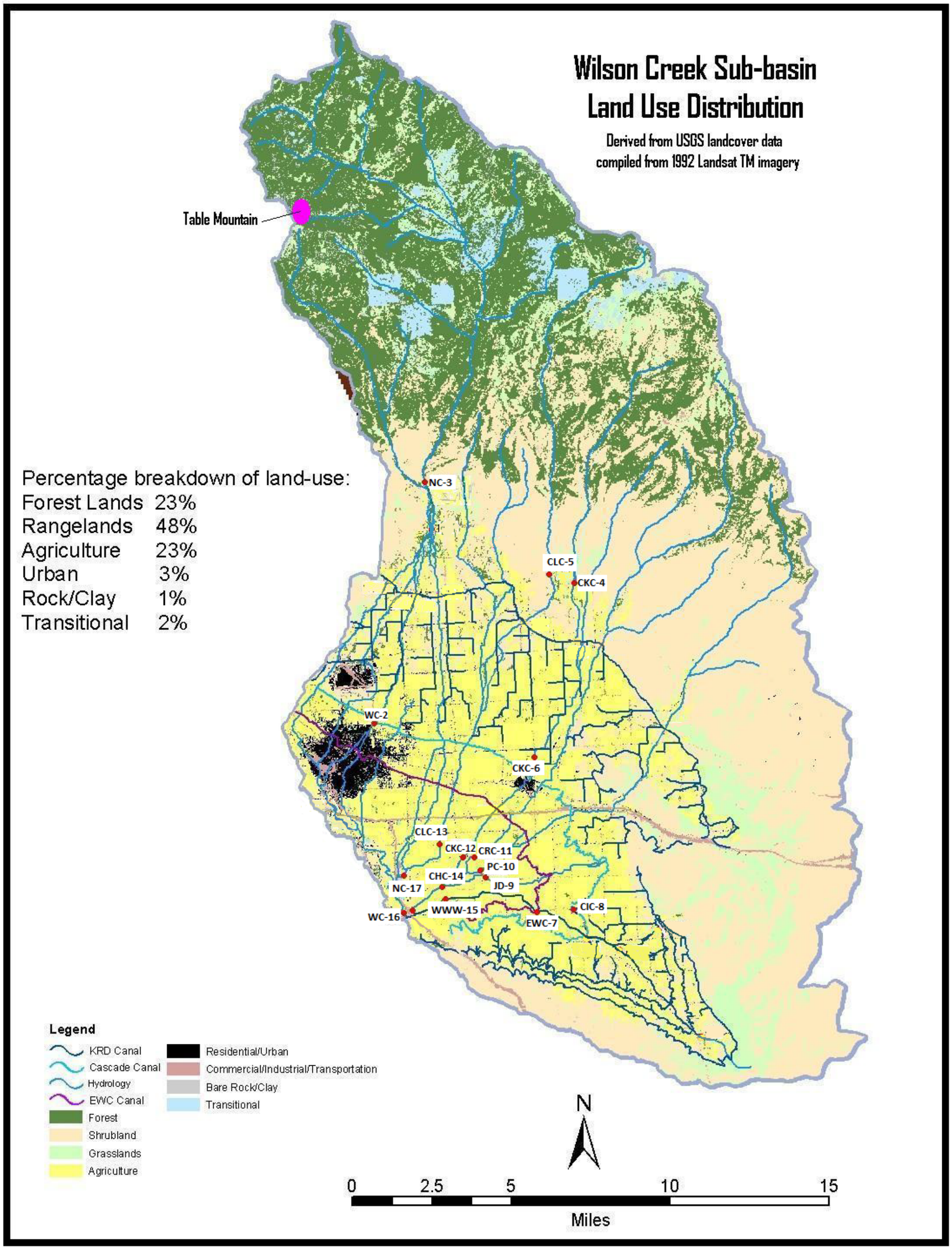

Figure 1: Land use in the Wilson Creek Sub-basin. Key 2011 sampling sites identified.

Wilson Creek, the sub-basin's principal water body, discharges into the Yakima River (River Mile 147.0) and is composed primarily of irrigation return flow during the irrigation season (the critical condition). According to the Kittitas Reclamation District (KRD), portions of many, water bodies in the Wilson Creek sub-basin sometimes go dry during the non-irrigation season. Figure 2, provided by the KRD, gives an overview of the various water bodies located in the Wilson Creek sub-basin. The only exception is Currier Creek, to the northeast, which is located outside of the sub-basin.

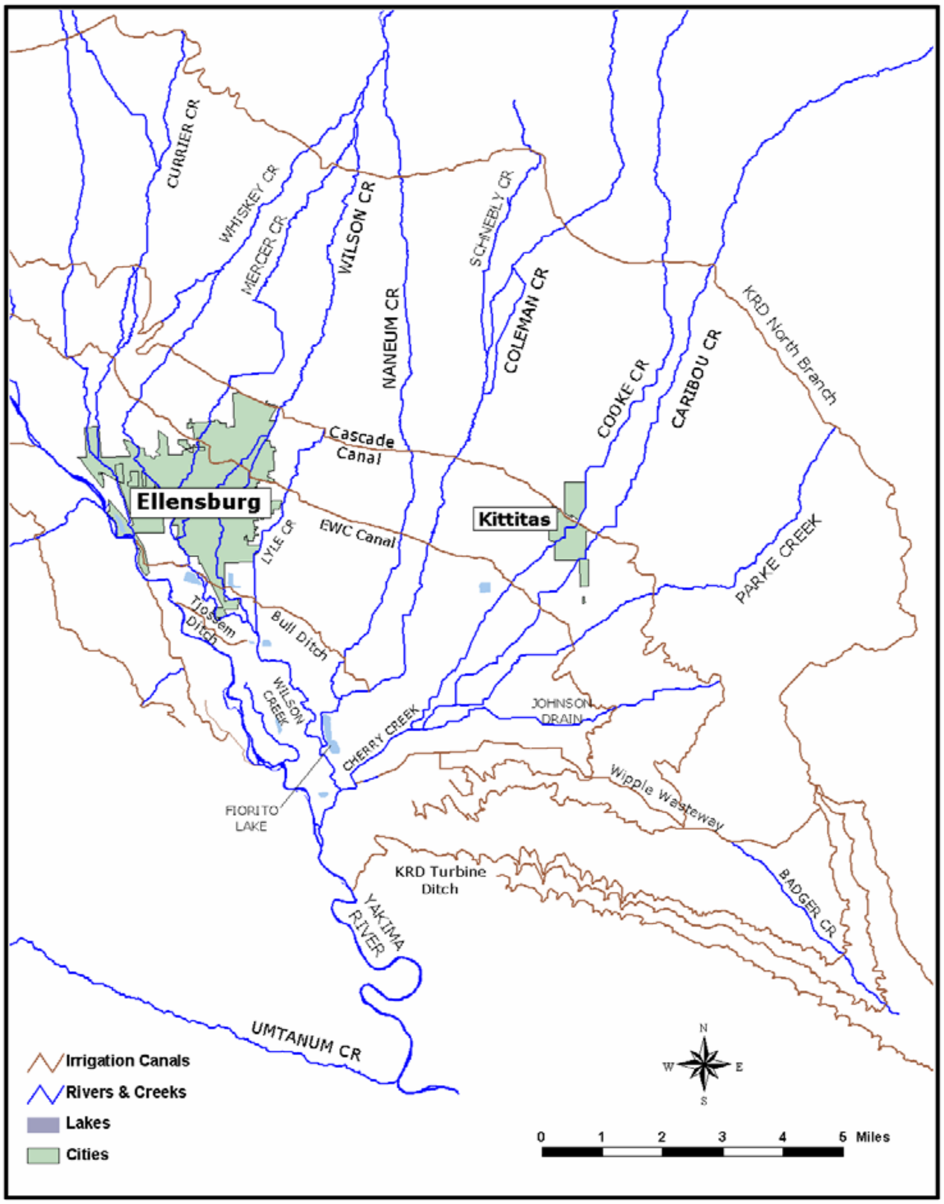

Figure 2: Water bodies in the Wilson Creek sub-basin (map courtesy of KRD).

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

In addition to the previously mentioned water bodies, three large man-made irrigation water supply canals transect the sub-basin from the northwest to the southeast. These canals divert irrigation water from the Yakima River at various upstream locations. There are various smaller irrigation ditches that are also located in the sub-basin.

Pollutant addressed by this monitoring

The 2011 post-TMDL monitoring project addresses only the pollutant of fecal coliform bacteria (FC). Excessive FC will potentially cause impairments of primary contact recreation. In state law, the designation of "primary contact recreation" is intended for water bodies "where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and waterskiing." In practice, however, primary contact recreation is designated for water bodies where human exposure is likely to include exposure of the eyes, ears, nose, and throat.

Children are considered the most sensitive group for waterborne pathogens. During the summer, Ecology staff has often observed children playing in numerous water bodies within the Wilson Creek sub-basin.

Watershed implementation or restoration activities

The *Wilson Creek Sub-basin Bacteria TMDL: Detailed Implementation Plan* (Creech, 2006) was divided into three categories:

- Implementing BMPs where possible to reduce FC densities.
- Education/outreach.
- Effectiveness monitoring.

Non-point source discharges and overland transport are the main contributors to FC pollution in the various water bodies located within the Wilson Creek sub-basin. Post-TMDL monitoring will be conducted every five years until 2020 to determine if FC densities are improving and where additional work is needed.

The Detailed Implementation Plan (DIP) outlined specific BMPs that will be implemented in order to decrease FC densities. The DIP focused on addressing failing and improperly connected septic systems, pet waste disposal, livestock waste disposal, irrigation practices, revegetation, wildlife management, responsible recreation practices, and public education.

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Water Quality Standards and Designated Uses

The state water quality criteria are set to protect people who work and play in and on the water from waterborne illnesses. FC is utilized as an "indicator bacteria" for the state's surface waters (e.g., lakes and streams). In other words, FC "indicates" the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is likely to contain pathogens that will cause illness in humans.

The designation of "primary contact recreation" applies to all water bodies where human exposure is likely to include exposure of the eyes, ears, nose, and throat. The state water quality FC criteria are set at levels that have been shown to maintain low rates of serious intestinal illness (gastroenteritis) in people. Since children have been observed playing in several of the sub-basin's water bodies, all of the water bodies within the Wilson Creek sub-basin must be protected for the beneficial use of primary contact recreation. To protect primary contact recreation, the state water quality standards stipulate that FC densities must meet the following two criteria:

- Not exceed a "geometric mean (geomean) value" of 100 cfu/100 mL,
- Not have more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 cfu/100 mL. This second criterion is estimated by a "90% value".

Compliance with state water quality standards is based on meeting both of the above FC criteria. These two measures, used in combination, ensure that FC pollution in a water body will be maintained at levels that will not cause substantial risk to human health. The water quality standards are designed to allow seven or fewer illnesses out of every 1,000 people engaged in primary contact recreation activities. While some discretion exists for selecting sample averaging periods, compliance with state water quality standards will be evaluated for annual critical condition data sets.

Once the density of FC in a water body increases to either of the state water quality numeric criteria, human activities that would further increase FC pollution are prohibited. If natural levels of FC pollution (from wildlife) cause either of the criteria to be exceeded, no allowance exists for human sources to measurably increase FC pollution further.

Table 1 presents a list of all of the water bodies addressed by the *Wilson Creek Sub-basin Bacteria TMDL* (Creech and Bohn, 2005) and this monitoring report.

Table 1. Wilson Creek sub-basin water bodies previously on 303(d) list for FC pollution.

Water body	WQA Listing ID
Badger Creek	6934
Caribou Creek	10052
Cascade Irrigation District Canal	45673
	45931
Cherry Creek	10035
Coleman Creek	6925
Cooke Creek	6721
	6722
	6923
	10038
	10039
	45806
	46830
	46831
	46833
	46870
	46871
	46872
Ellensburg Water Company Canal	45674
	10046
	10045
Johnson Drain	10040
Mercer Creek	6930
Naneum Creek	10041
	45241
Turbine Ditch	45683
Whiskey Creek	6931
Wilson Creek	6719
	6929
	10047
	10048
	16814
Wilson Creek, west	45822
Wipple Wasteway	6922
	6932
	6933
	45186

Project Goal

The goal of this monitoring project is to determine if the water bodies addressed by the *Wilson Creek Sub-basin Bacteria TMDL* have met the TMDL's first interim target, which was required to be met at the end of October 2010 (Creech, 2005). For each site, the first interim target is stipulated as the more stringent of the following:

- Not exceed a geomean of 500 cfu/100 mL, and a 90% value of 1,500 cfu/100mL, or
- Not to exceed the initial geomean and 90% value as presented in the TMDL submittal report.

Compliance, or non-compliance, with the above 2010 first interim target (Table 4) will support the adaptive management portion of the TMDL.

Study Design

Overview

Monitoring for FC was purposely conducted during the "critical condition" (April through October) of 2011. Sample collection occurred on: April 5, April 20, May 11, May 17, June 1, June 14, June 27, July 12, July 27, August 8, August 22, September 7, September 19, October 3, and October 31, all in 2011.

Sampling procedures for FC followed the Ecology's Environmental Assessment Program's Standard Operating Procedure (SOP) EAP-030 for the collection of FC samples in surface waters. Duplicate FC samples were collected for 10% of the samples.

After collection, all samples were placed on ice to cool. Just before shipping, the samples were placed in a cooler with eight-ten blue ice blocks and packing material to prevent damage while in transport. The samples were shipped via Horizon Air from the city of Yakima to the city of Seattle where a Manchester Laboratory courier transported the samples to Manchester Laboratory.

Samples were processed by Manchester Environmental Lab (MEL) using method SM9222D for FC (MEL, 2008).

Sampling locations

Table 2 presents the 2011 monitoring sampling sites by ID, location description, lat/long coordinates, and their respective 2005 site IDs.[1] The sampling sites are also presented in Figure 3.

[1] Note that Table 1 in *Wilson Creek Sub-basin Fecal Coliform Bacteria Effectiveness Monitoring – Water Quality Study Design* (Durkee, 2012) incorrectly listed Crystal Creek as being located in the Wilson Creek sub-basin. That

Table 2: Sampling locations for Wilson Creek sub-basin monitoring.

2005 Site ID	2011 Site ID	Location Description	Latitude	Longitude
n/a	BC-19	Badger Creek at Thrall Rd., upstream of WWW-15	46.92658861	-120.4135653
WW-4	WWW-15	Wipple Wasteway at Moe Rd., upstream of check dam	46.93367317	-120.4763895
n/a	CRC-22	Caribou Creek at Denmark Rd., upstream of CRC-11	46.96250863	-120.4348728
CR-2	CRC-11	Caribou Creek at South Ferguson Rd.	46.9524527	-120.452258
n/a	VCIC-1	Cascade Irrigation Canal at Vantage Hwy., upstream of CIC-8	47.00014	-120.43970
CID-1	CIC-8	Cascade Irrigation Canal at Thrall Rd.	46.92706323	-120.3892261
CH-1	CHC-14	Cherry Creek at Moe Rd., upstream side of check dam	46.93957621	-120.4765627
CL-1	CLC-5	Coleman Creek at first bridge on Coleman Canyon Rd.	47.08469018	-120.3987994
n/a	VCLC-10	Coleman Creek at Vantage Hwy., upstream of CLC-13	47.00028	-120.46107
CL-3	CLC-13	Coleman Creek at Moe Rd. (RM 4.2)	46.96296	-120.47723
CK-1	CKC-4	Cooke Creek at Cooke Canyon Rd.	47.08231169	-120.3820760
n/a	VCC-2	Cooke Creek at Vantage Hwy., upstream of CKC-6	47.00080	-120.40572
CK-3	CKC-6	Cooke Creek on #81 Rd., upstream of VCC-13	46.99087128	-120.4124746
n/a	VCC-13	Cooke Creek at I-90, upstream of VCC-12	46.97187	-120.44116
n/a	VCC-12	Cooke Creek at Tjossem Rd., upstream of CKC-12	46.96353	-120.45115
CK-5	CKC-12	Cooke Creek at South Ferguson Rd.	46.95326	-120.45983
n/a	CKCDTCHBT	CC Ditch at Vantage Hwy., upstream of CKCD-871	46.0002119	-120.4122671
n/a	CKCD-871	CC Ditch at House #871, upstream of CKCDTCHVH	46.99390742	-120.4123888
n/a	CKCDTCHVH	CC Ditch, upstream of CKCD-731	46.99293097	-120.4124495
n/a	CKCD-731	CC Ditch at House #731, upstream of CKCD-680	46.99239991	-120.4124531
n/a	CKCD-680	CC Ditch at House #680, upstream of CKCDTCHNAL	46.99203401	-120.4124746
n/a	CKCDTCHNAL	CC Ditch north of Alpine Dr., upstream of CKCD-23	46.99168689	-120.4125246
n/a	CKCD-23	CC Ditch at #81 Rd., south of Alpine Dr. & above confluence	46.99099897	-120.4125139
EWC-3	EWC-7	Ellensburg Water Company Canal at Thrall Rd.	46.92672619	-120.4134625
n/a	VJD-3	Johnson Drain at Badger Pocket Rd., upstream of VJD-4	46.94382045	-120.4016957
n/a	VJD-4	Johnson Drain at Sorenson Rd., upstream of JD-9	46.94427004	-120.4504495
JD-1	JD-9	Johnson Drain at South Ferguson Rd.	46.94427004	-120.4504495
n/a	KRD-18	Kittitas Reclamation District Canal at Cooke Canyon Rd.	47.04915802	-120.3859645
n/a	VMC-16	Mercer Creek at East Helena Ave., upstream of MC-1	47.01338091	-120.5434164
n/a	MC-1	Mercer Creek at Kiwanis Park	47.00542265	-120.5488525
NC-1	NC-3	Naneum Creek at Naneum Rd.	47.12347	-120.48006
n/a	VNC-5	Naneum Creek at Rader Rd., upstream of VNC-6	47.05890	-120.47327
n/a	VNC-6	Naneum Creek at Game Farm Rd., upstream of VNC-7	47.01467	-120.47605
n/a	VNC-7	Naneum Creek at Vantage Hwy., upstream of NC-17	47.9996	-120.4727
NC-4	NC-17	Naneum Creek at Fiorito Ponds off #6 Rd.	46.93685	-120.50547
n/a	PC-23	Parke Creek at Denmark Rd., upstream of PC-10	46.956343	-120.4347441
PC-2	PC-10	Parke Creek at South Ferguson Rd.	46.94630789	-120.4500371
n/a	VWC-14	Wilson Creek at Brick Mill Rd., upstream of WC-2	47.03652855	-120.5014881
WL-2	WC-2	Wilson Creek at Sanders Rd., upstream of VWC-8 and VWC-9	47.01733433	-120.5169441
n/a	VWC-8	Wilson Creek (East) at Lincoln School	46.99035625	-120.540323
n/a	VWC-9	Wilson Creek at West Umtanum Rd., upstream of WC-16	46.98110216	-120.5515793
WL-5	WC-16	Wilson Creek at Thrall Rd., upstream of WC-20	46.92634	-120.50164
n/a	WC-20	Wilson Creek at Canyon Rd., above confluence	46.91731	-120.50817

n/a means no corresponding sampling was conducted for the original *Wilson Creek Sub-basin Bacteria TMDL*.

same table also incorrectly listed Unnamed Ditch (Trib to Cooke Creek) and Parke Creek as being previously 303(d) listed for FC, even though they never were.

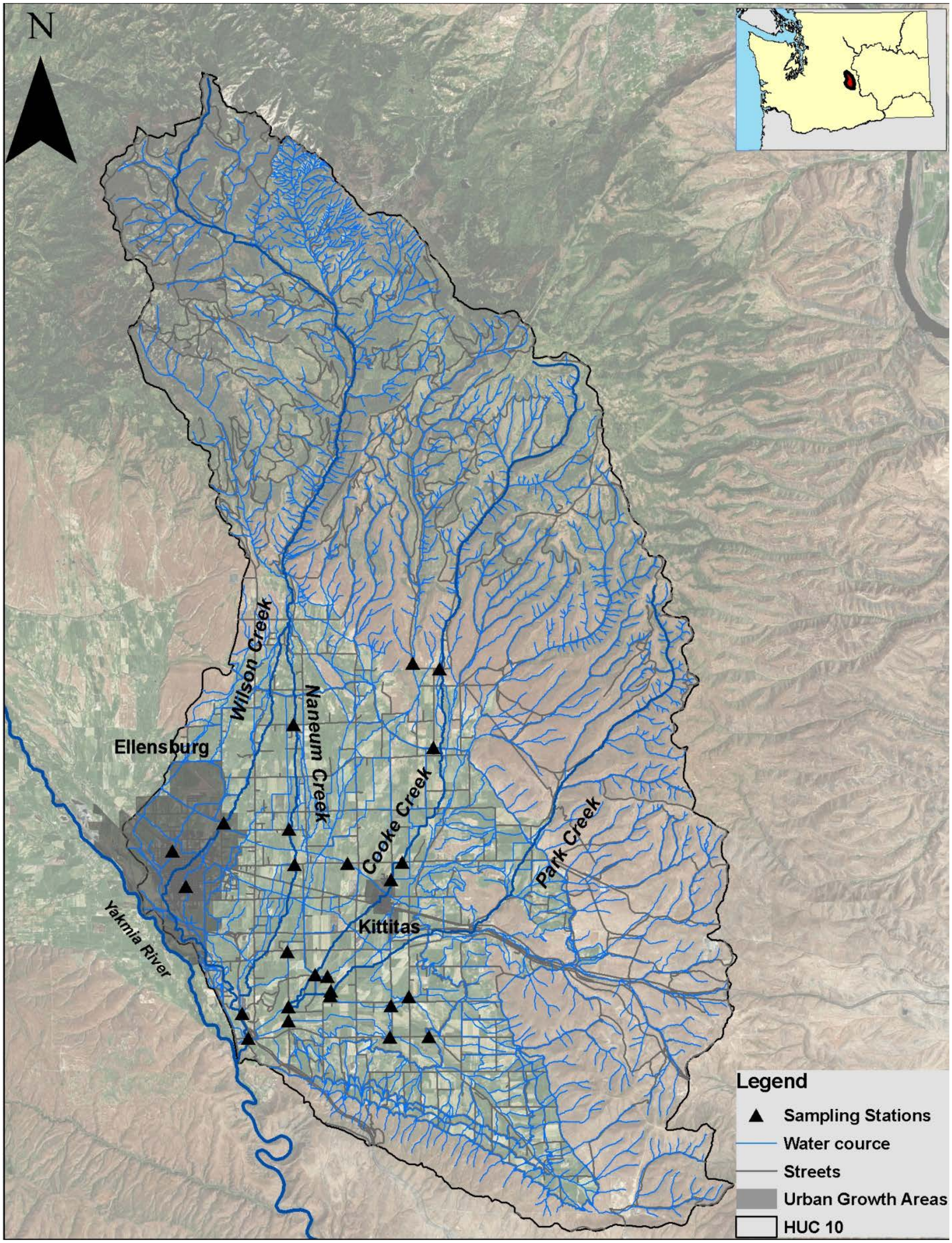

Figure 3: Wilson Creek sub-basin 2011 monitoring locations.

Nineteen sites were sampled during the 2011 monitoring project; however, only 16 of them were actually comparable to similar site locations used for the *Wilson Creek Sub-basin Bacteria TMDL*. Three of the comparable sites (NC-3, CKC-4, and CLC-5) were considered background sites, as they represented the portion of the creeks that is mainly free from anthropogenic factors. The sites were described by the TMDL to be upstream of homes, cropland, and grazing activity, which are suspected of being the predominant sources of FC pollution in the sub-basin.

Statistical analysis methods

Methods used in this study for statistical analysis include linear regressions and non-parametric Kruskal-Wallis tests. Methods are described further as appropriate in the next section.

Results and Discussion

Monitoring data

Pollutant reductions required in the 2005 TMDL

The 2005 *Wilson Creek Sub-basin Bacteria TMDL* required FC target reductions ranging from 58.9% to 84.3% at the 13 non-background sites that were sampled in 2011. The average required target reduction was 74.2%.

One of the three background sites, (CKC-4), had a required target reduction of 3.3%. Two of the background sites already met state water quality standards in the TMDL.

Comparison of 2011 data to 2005 data

All of the 13 non-background sites had significant FC reductions, which ranged from 1.4% (WC-16) to 70.2% (EWC-7). Significance was determined by the non-parametric Kruskal-Wallis test. The average site FC reduction was calculated to be 41.1%.

The FC reduction for the background site that exceeded standards in the TMDL (CKC-4) was -3.8%, which indicates that FC pollution had actually *increased* slightly at that site. Further analysis showed that this was the only background site that had an increase of the 90% value of FC. The other two background sites still meet state water quality standards (as they did in the original TMDL), even though site CLC-5 did have a slight increase in the 90% value FC.

Comparison of FC densities to TMDL's first interim target

In order to determine the effectiveness of BMP implementation and restoration activities associated with the *Wilson Creek Sub-basin Bacteria TMDL,* the individual sampling site FC density statistics were compared to the TMDL's first interim target.

Table 3 presents the 2011 FC density data obtained from all 16 sampling sites that were comparable to the TMDL's sites. The table also presents the FC statistics and, in the last column, the percentage of FC pollution reduction that has occurred since USEPA approval of the TMDL.

Table 3: 2011 monitoring FC data (cfu/100mL) and statistics during the TMDL critical condition.

2011 Site ID	Corresponding TMDL Site ID	4/5/2011	4/20/2011	5/11/2011	5/17/2011	6/1/2011	6/14/2011	6/27/2011	7/12/2011	7/27/2011	8/8/2011	8/22/2011	9/7/2011	9/19/2011	10/3/2011	10/18/2011	10/31/2011	2011 Geomean	2011 90% Value	2011 Total % Reduction Required	TMDL Geomean	TMDL 90% Value	TMDL Total % Reduction Required	Actual % Reduction since 2005
WC-2	WL-2	39	28	250	920	300	470	830	550	330	970	970	4,000	200	390	140	46	316	4,000	71.1	552	1,000	81.7	10.6
NC-3*	NC-1	3	1	4	9	11	4	18	7	7	6	11	12	5	11	3.5	4	6	18	0.0	9	42	0.0	0.0
CKC-4*	CK-1	4	2	91	680	8	39	32	32	690	290	390	150	210	420	54	150	76	690	7.1	90	300	3.3	**-3.8**
CLC-5*	CL-1	2	7	8	9	110	11	27	11	11	13	68	15	51	93	3	51	17	110	0.0	22	91	0.0	0.0
CKC-6	CK-3	34	25	700	570	250	640	700	350	370	830	370	390	510	410	110	31	259	830	62.9	492	5,900	81.4	18.5
EWC-7	EWC-3	1	200	170	180	370	62	230	340	630	190	190	220	260	240	8	8	105	630	11.1	499	3,000	81.3	70.2
CIC-8	CID-1	3	750	730	350	630	390	2,300	1,700	230	220	1,100	180	160	220	6	8	204	2,300	55.1	570	2,300	83.3	28.2
JD-9	JD-1	1	100	92	75	310	100	1,200	370	420	440	970	560	420	280	34	240	177	1,200	47.4	616	1,800	84.3	36.8
PC-10	PC-2	1	4	63	130	370	110	130	84	250	160	120	210	63	180	84	57	74	370	4.6	328	5,940	72.2	67.6
CRC-11	CR-2	42	36	120	390	310	230	560	130	240	470	490	350	260	340	23	23	166	560	42.2	428	4,000	78.5	36.3
CKC-12	CK-5	23	15	650	610	210	220	150	300	220	190	740	490	150	130	17	8	134	740	30.4	300	1,140	68.2	37.9
CLC-13	CL-3	36	91	240	350	730	390	1,400	400	180	280	650	480	260	390	160	140	282	1,400	66.6	378	1,400	74.8	8.1
CHC-14	CH-1	16	110	660	230	210	110	330	330	110	180	430	370	210	200	41	110	168	660	43.4	402	1,200	75.9	32.6
WWW-15	WW-4	1	41	40	68	330	130	270	200	120	74	63	80	100	54	6	3	49	330	3.9	235	720	58.9	55.0
WC-16	WL-5	67	170	270	430	210	180	320	220	240	430	770	210	370	160		69	224	770	57.2	248	720	60.9	1.4
NC-17	NC-4	42	29	88	250	300	290	300	150	160	420	420	380	580	210	12	77	156	580	39.0	265	620	62.8	23.8

* Background site (yellow highlight) according to *Wilson Creek Sub-basin Bacteria TMDL*.

The first interim TMDL target was required to be met at the end of the 2010 irrigation season, and required compliance "*with the more stringent of either (1) a maximum geometric mean FC density of 500 cfu/100mL and a maximum 90% value FC density of 1,500 cfu/100mL, or (2) existing original conditions*." Table 4 presents the comparison of the 2011 monitoring FC statistics with the first interim TMDL target.

Table 4: Comparison to first interim TMDL target.

Sampling Site ID	Original Geomean	2011 Geomean	Is 2011 Geomean >, <, or = to original Geomean?	Geomean meets first interim target?	Original 90% Value	2011 90% Value	Is 2011 90% Value >, <, or = to original 90% value?	90% value meets first interim target?
WC-2	552	316	<	**Yes**	1,000	4,000	>	**No**
NC-3*	9	6	<	**Yes**	42	18	<	**Yes**
CKC-4*	90	76	<	**Yes**	300	690	>	**No**
CLC-5*	22	17	<	**Yes**	91	110	>	**No**
CKC-6	492	259	<	**Yes**	5,900	830	<	**Yes**
EWC-7	499	105	<	**Yes**	3,000	630	<	**Yes**
CIC-8	570	204	<	**Yes**	2,300	2,300	=	**Yes**
JD-9	616	177	<	**Yes**	1,800	1,200	<	**Yes**
PC-10	328	74	<	**Yes**	5,940	370	<	**Yes**
CRC-11	428	166	<	**Yes**	4,000	560	<	**Yes**
CKC-12	300	134	<	**Yes**	1,140	740	<	**Yes**
CLC-13	378	282	<	**Yes**	1,400	1,400	=	**Yes**
CHC-14	402	168	<	**Yes**	1,200	660	<	**Yes**
WWW-15	235	49	<	**Yes**	720	330	<	**Yes**
WC-16	248	224	<	**Yes**	720	770	>	**No**
NC-17	265	156	<	**Yes**	620	580	<	**Yes**

* Background site (yellow highlight) according to *Wilson Creek Sub-basin Bacteria TMDL*.

All 16 comparative sites (both background and non-background) met their respective first interim geomean target.

While 12 of the 16 comparative sites complied with their first interim 90% value target, four sites did not comply with this target FC. Two of the four sites (CKC-4 and CLC-5) that did not meet the 90% value target were background sites. The other two sites (WC-2 and WC-16) were located along the mainstem of Wilson Creek.

TSS vs. FC density

The 2011 monitoring project also included limited sampling of total suspended solids (TSS) and turbidity. Although that data was not collected specifically for the *Wilson Creek Sub-basin Bacteria TMDL*, an analysis of it may still show some relationship to FC pollution. This is hypothesized because studies in other state watersheds (e.g., Granger Drain, Sulphur Creek Wasteway) found a significant relationship between TSS/turbidity and FC densities.

TSS, turbidity, and FC density data were collected from the furthest downstream sampling site on Wilson Creek (WC-20) as well as the furthest upstream background site on Naneum Creek (NC-3). Comparison of the relationship between TSS vs. FC pollution at those two sites may provide insight as to the FC pollution throughout the entire Wilson Creek sub-basin.

Table 5 presents the correlation coefficients for the analyses of turbidity vs. TSS concentrations and of FC density vs. TSS concentration, at both of the above sites.

Table 5: Correlation results for TSS, turbidity and FC at NC-3 and WC-20.

Site ID	Correlation Coefficient for Turbidity vs. TSS	Correlation Equation for Turbidity vs. TSS	Correlation Coefficient for TSS vs. FC	Correlation Equation for FC vs. TSS
NC-3	R = 0.9949	Turbidity = 0.735865 + (0.484075*TSS)	R =0.3251	log FC = 0.54846 + (0.260501*log TSS)
WC-20	R = 0.9926	Turbidity = 0.793834 + (0.335135*TSS)	R =0.8743	log FC = 1.25625 + (0.863447*log TSS)

The information presented in Table 5 indicates that there is a “very strong” correlation (>0.99) between turbidity and TSS at both sites. These nearly identical correlations are not unexpected, as turbidity in surface waters is primarily caused by TSS. The *Upper Yakima Suspended Sediment, Turbidity and Organochlorine Pesticide TMDL* has overwhelmingly determined that overland runoff produces the majority of TSS in local surface waters. Additionally, the *Granger Drain Fecal Coliform Bacteria TMDL* has determined that overland runoff of manure-contaminated (wildlife and livestock) soil is a predominant source of FC pollution.

The most interesting aspect of Table 5 regards the difference in correlation coefficients for TSS vs. FC at the two sites. The upstream background site showed a “weak” correlation (R<0.5) between the two parameters; whereas, the downstream Wilson Creek site showed a “strong” correlation (R>0.8). This difference could be interpreted as:

1. The background site receives little overland runoff of manure-contaminated soil; and
2. The downstream site receives substantial overland runoff of manure-contaminated soil.

Another possible interpretation is that ag-influenced lands (such as the downstream site) simply have multiple sources of pollution.

Miscellaneous data

During the 2011 monitoring project, some high FC densities were found in an irrigation drainage ditch that parallels #81 Road near its confluence with Cooke Creek. A limited amount of FC density data was collected during October and November 2011 from the general site locations of "upstream", "adjacent" and "downstream" from two mobile home subdivisions located to the north of the city of Kittitas.

At first glance, it appeared that significantly higher FC densities occurred downstream of the two subdivisions. This situation suggested a potential problem with sewage disposal at those residences. Therefore, a Kruskal-Wallis (K-W) non-parametric statistical analysis was conducted on the FC density data. The analysis determined that no significant difference (K-W = 5.470; p = 0.0649) actually occurred between the three general locations.

The above determination is primarily due to the high natural variability of bacterial populations, as well as due to the limited number of samples that were collected during the 2011 monitoring. Additional sampling should be performed in order to conclusively determine if FC pollution downstream of the sub-divisions is higher than that found upstream.

A cursory review of parcel descriptions showed that most of these properties are connected to the city of Kittitas sewer system. The January 13, 2000 issue of the Ellensburg Daily Record stated that "sewer line problems (are) being found in (this) development." The problem was described as aging lines allowing groundwater to infiltrate into the collection system of the POTW. In these situations, sewage can also flow *out* of the sewer lines, causing FC pollution.

Therefore, more downstream samples need to be collected in order to determine whether or not the two mobile home subdivisions are actually causing an increase in FC densities in the irrigation return ditch that parallels road #81.

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Conclusions

As a result of this study, the following conclusions are made regarding the 2011 monitoring associated with the *Wilson Creek Sub-basin Bacteria TMDL*:

- The two main transport mechanisms of FC in the sub-basin are overland runoff and direct deposition. Overland runoff is the movement of water across the surface of the ground, and may be caused by precipitation, snowmelt, and irrigation water. Direct deposition includes manure deposition by wildlife, pets and livestock, as well as direct discharges from inadequate or failing on-site septic systems.
- Every sampling site comparable to the original TMDL sites, except CKC-4, had a reduction in overall FC pollution between 2005 and 2011.
- Two of the three original TMDL background sites (NC-3 and CLC-5) have remained in compliance with both of the state water quality FC criteria, even though one site has shown a minimal increase in 90% value FC levels.
- The third background site (CKC-4) remained in compliance with state water quality FC geomean criterion, but not with the 90% value criterion. An aerial view of this background site (also conducted in 2011) identified approximately 20 residences with some livestock corrals upstream of the sampling site. Due to those potential sources of FC pollution, this site should not continue to be considered as representative of background conditions.
- All of the 13 non-background sites complied with the TMDL's first interim geomean target. This indicates that the long-term FC pollution has been significantly reduced.
- Two of the non-background sites (WC-2 and WC-16), however, did not comply with the TMDL's first interim 90% value target. This indicates that the short-term worst-case FC pollution at those sites actually increased from 2005, especially at site WC-2. The reason for the latter's increase in FC pollution should be investigated.
- A possible reason that the downstream Wilson Creek site (WC-16) had the least improvement among all the non-background sites was because that site represented the accumulation of pollution from all upstream tributaries and sources. Further BMP implementation and restoration activities throughout the Wilson Creek sub-basin should correspondingly effect a greater FC reduction from 2005 than the present 1.4% reduction.
- Additionally, 94% of the sampling sites (all except WC-2), are also presently in compliance with the TMDL's second interim (2015) geomean target due, which is due at the end of the 2015 irrigation season. However, only 6 of 16 (37.5%) of the sites are in compliance with the corresponding second interim 90% value target. This should accentuate the importance of continued implementation of BMPs.

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Appendix

Glossary and Acronyms

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

Anthropogenic: Human-caused.

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

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

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

Effectiveness monitoring: Monitoring to determine whether, after a significant portion of the recommendations in a water quality implementation plan have been implemented, is adequate in meeting the targets, objectives and goals of the corresponding TMDL project.

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

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

Load allocation (LA): The portion of a receiving waters' loading capacity attributed to one or more of its existing or future sources of non-point pollution or to natural background sources.
Loading capacity: The greatest amount of a substance that a water body can receive and still meet state water quality standards.

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

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

Non-point source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities. This includes, but is not limited to, atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES Program. It generally refers to any unconfined and diffuse source of contamination. Legally, it refers to any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the CWA.

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

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

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

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

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

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

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

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

Critical condition: When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses.

90% value: A number obtained from a distribution of a data set, above which 10% of the data exists and below which 90% of the data exists. It is performed according to Appendix E contained in the *Wilson Creek Sub-basin Bacteria TMDL – Submittal Report* (Creech and Bohn, 2005).

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

BMPs	Best management practices
Ecology	Washington State Department of Ecology
FC	Fecal coliform bacteria
KRD	Kittitas Reclamation District
NPDES	National Pollutant Discharge Elimination System
POTW	Wastewater treatment plant
TMDL	Total maximum daily load
USEPA	U.S. Environmental Protection Agency
WRIA	Water Resources Inventory Area

Units of Measurement

cfu	colony forming unit
mg/L	milligrams per liter (parts per million)