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Whatcom Creek Bacteria Total Maximum Daily Load Study

Water Quality Improvement Report and Implementation Plan

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Whatcom Creek Bacteria Total Maximum Daily Load Study

Water Quality Improvement Report and Implementation Plan

by

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Washington State Department of Ecology

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Introduction

Water quality monitoring data for Whatcom Creek and its tributaries indicate these waters experience fecal coliform (FC) and *Escherichia coli* (*E. coli*) bacteria exceedances of Washington State Water Quality Standards (WQS). Fecal coliform and *E. coli* bacteria are also known as thermotolerant coliforms (APHA 2012). The presence of thermotolerant bacteria such as FC and *E. coli* often indicate fecal contamination from warm blooded animals has entered the water, increasing the risk that humans who contact the water may contract a waterborne illness.

The goal of this Total Maximum Daily Load (TMDL) study is to develop a plan to improve Whatcom Creek water quality to meet Washington WQS for bacteria. The TMDL addresses both FC and *E. coli* bacteria and uses the modeled relationship between *E. coli* and FC that was developed from paired samples collected in the watershed and other nearby urban areas in Bellingham. The TMDL goal will be achieved by assessing conditions and implementing best management practice (BMP) recommendations that reduce the pollution loading to fully support all beneficial uses.

This TMDL study identifies bacteria pollution sources in the watershed, sets limits on all pollution sources, and recommends necessary activities to achieve WQS. The Washington State Department of Ecology (Ecology), in partnership with local government agencies and the community, have developed measures to control and reduce pollution sources. This partnership involves a monitoring plan to assess effectiveness of the water quality improvement activities that are included in this Water Quality Improvement Report and Implementation Plan. Successful project outcomes are largely dependent on the collective efforts of all responsible parties involved.

Ongoing and future monitoring strategies will evaluate whether the water cleanup implementation measures are meeting the necessary bacteria pollution load reductions to achieve and maintain compliance with water quality standards. An adaptive management approach will provide the flexibility to efficiently change watershed implementation priorities as needed. Grants are expected to augment operating budgets necessary to achieve project goals and help provide a broad array of effective water quality improvement practices. Loans are expected to provide budget relief when implementing water quality improvement activities.

This report describes the Whatcom Creek watershed and stream reaches with known bacteria pollution, describes applicable WQS, evaluates bacteria levels throughout the watershed, and establishes TMDL elements to achieve clean water. The greatest *E. coli* pollution reductions are needed in Fever Creek, followed by Lincoln, Hanna, and Cemetery Creeks. The downstream reach of Whatcom Creek requires pollution reductions of both *E. coli* and FC.

This report identifies specific tasks and timelines for reducing or eliminating bacteria pollution sources. Additional funding sources for water quality improvement implementation are also identified. Details of the Federal Clean Water Act, TMDLs, water quality categories, and Whatcom Creek hydrology and water quality information can be found in Appendix A. Information about public participation can be found in Appendix B. The glossary and acronyms can be found in Appendix C. Details of the analytical framework for TMDL development can be found in Appendix D. Details of the TMDL analysis can be found in Appendix E.

Ecology updated the bacterial indicator from FC to *E. coli* in 2019 and phased out FC as the bacterial indicator in 2020 to protect freshwater designated uses. The bacteria translator that was developed for this *E. coli* TMDL study addresses this recent change in the WQS. Previous data collection efforts and water quality studies in this watershed — *e.g.,* Shannahan et al. (2004) and McCarthy (2020b) focused on FC sampling as summarized in the Scope section of this report. Because of the extent of the FC dataset and its use in previous water quality studies in the area, FC data were also analyzed as part of this study to evaluate water quality trends and conditions and calculate the TMDL to protect downstream designated uses in marine water.

Overview

Washington state WQS and numeric criteria are designed to protect, restore, and preserve water quality with respect to designated beneficial uses. Ecology is required by federal law to perform a statewide assessment of all readily available environmental data related to surface water quality every two years (Ecology 2018). When a lake, river, or stream fails to meet water quality standards, it is included on a list of impaired water bodies known as the 303(d) list. Information about the water quality assessment can be found at Ecology's Water Quality Assessment & 303(d) list webpage[1].

[1] https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d

Section 303(d) of the federal Clean Water Act requires that states develop TMDLs for impaired surface waters if timely implementation of technology-based pollution controls and other required controls do not result in water bodies meeting applicable WQS. The Water Quality Assessment process in Washington State assigns 303(d) listed impairments to Category 5 (Appendix A). TMDL studies include a quantitative assessment of water quality problems, a description of the pollutant sources that are causing the problem(s), and load allocation (LA) and waste load allocation (WLA) reductions necessary to meet WQS. When a TMDL and Implementation Plan is established for a given pollutant, the Category 5 impairment will be placed into Category 4a (Appendix A). Fulfilling the pollution prevention and control activities described in the Implementation Plan is expected to attain the TMDLs and meet the WQS for all water bodies in the study area.

The City of Bellingham Urban Streams Monitoring Program (USMP) has collected water quality data since 1990. Whatcom Creek has been listed as impaired for FC bacterial pollution since 1996. Recent monitoring data continues to confirm this assessment; however, recent reductions in bacteria pollution are demonstrating a positive trend at some sampling locations within the watershed (Appendix A). Whatcom Creek is a popular place for recreation, even though existing bacteria concentrations in the tributaries and lower reach of Whatcom Creek could pose a human health risk from recreational contact in the water.

Located in the center of the City of Bellingham, Whatcom Creek is accessible from many neighborhoods and businesses through a network of trails and parks. The Whatcom Creek watershed has, and continues, to receive increasingly focused efforts to improve water quality through stormwater BMPs, habitat restoration/protection, and education outreach. This TMDL will bolster continued efforts to improve water quality and habitat restoration in the watershed.

Ecology and interested parties, including the City of Bellingham (City), Whatcom County (County), Washington State Department of Transportation (WSDOT) jointly reviewed this TMDL Implementation Plan. The Implementation Plan describes necessary bacteria load reductions, as well as pollution control and prevention activities likely to achieve them, to meet WQS and details the roles of each responsible party. Water quality restoration and protection actions were prioritized based on:

1. Identification of significant bacteria potential pollution sources,
2. Locations in the watershed with the highest relative bacteria pollution concentrations,
3. Existing improvement programs,
4. Efficacy of improvement action, and
5. Most cost-effective approaches relative to the bacteria pollution magnitude.

Scope

Whatcom Creek TMDL Area

The Whatcom Creek study area and associated bacteria impairments (303(d) listings) are in Water Resource Inventory Area (WRIA) 1 in Whatcom County, northwest Washington (Figure 1). Whatcom Creek is fed primarily by Lake Whatcom through a flow control structure and travels 4.3 river miles (6.7 km) downstream to the Whatcom Waterway in the marine waters of Bellingham Bay (Hood et al. 2011). Whatcom Creek experiences inflows from numerous tributary streams including Hanna, Fever, Cemetery, and Lincoln creeks. Whatcom Creek and its tributaries flow through central Bellingham draining 5,790 acres (9 mi^2 (23.3 km^2)) (Appendix A). From 2002 through 2017, the annual average daily streamflow of Whatcom Creek was 137 cubic feet per second (cfs) according to the Dupont Street gage station (McCarthy 2020b). Fever, Lincoln, and Cemetery Creeks are perennial streams that have summer flows with less than one cubic foot per second (cfs). Hanna Creek is an intermittent stream that usually goes dry during August and September (Shannahan et al. 2004).

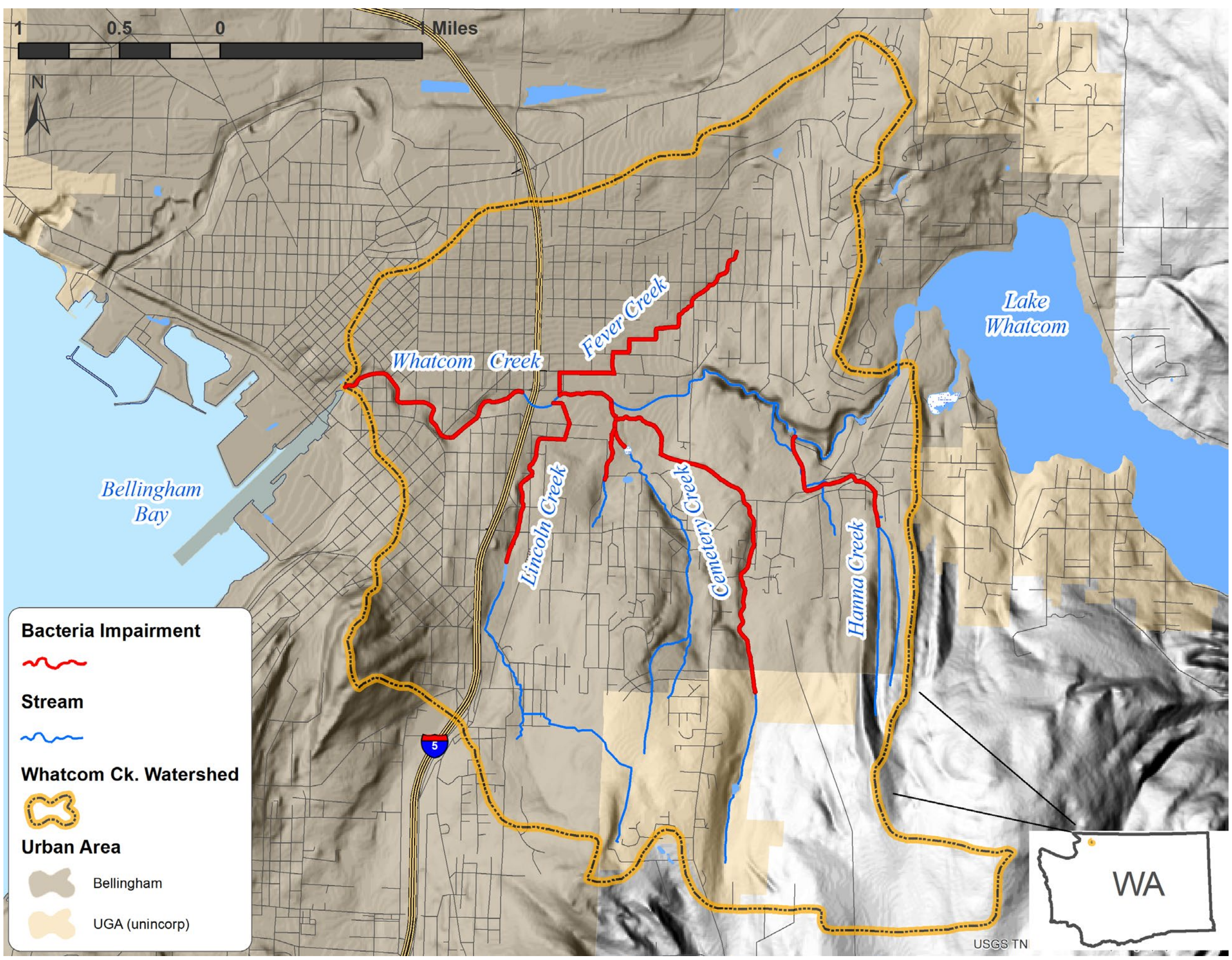


Figure 1. Whatcom Creek watershed bacteria TMDL study area and associated impaired (303(d) listed) stream segments (assessment units (AU))

Hanna Creek is also referred to as "Hannah Creek" in other data sources such as the USMP, though this TMDL uses the name Hanna exclusively based on the associated water body name given in the Clean Water Act IR. The USGS National Hydrography Dataset[2] (NHD) Version 2.3 represents the surface waters of the United States and does not resolve the Hanna Creek naming discrepancy (NHD 2001). The NHD is the standard hydrography for Washington State and is generally developed at a 1:24,000 scale resolution.

Land cover in the Whatcom Creek watershed includes parks, open spaces, and urban uses such as residential, commercial, and light industrial (Shannahan et al. 2004). Land cover along with the associated potential water quality impacts are discussed in the Implementation Plan section of this report under the Land Distribution subsection. Anthropogenic alterations to the Whatcom Creek watershed include channelization and flood control projects, loss of riparian vegetation, channel restrictions from road crossings, and stormwater runoff conduits (Shannahan et al. 2004).

The upper third of the watershed includes the heavily forested area of Whatcom Falls Park, a public greenspace that borders Whatcom Creek from river mile 4.3 at the flow control structure to river mile 2.5 at Woburn St (R2 Resources 2013). The Hanna Creek confluence with Whatcom Creek is roughly at river mile 3.2 near Arbor Street, approximately located in the center of Whatcom Falls Park. The Hanna Creek subbasin (0.75 mi^2 (1.9 km^2)) drains forested and residential areas (City of Bellingham 1995).

The lower portion of the watershed — river mile 2.5 to the mouth — includes commercial, industrial, forested, and urban residential areas. The Whatcom Creek Trail — multi-use pathway — follows the creek from Woburn Street to Meador Avenue near Interstate-5 and resumes between Ellis Street and Cornwall Avenue downstream to Maritime Heritage Park near the mouth. The Cemetery Creek confluence is roughly at river mile 2 and part of a wetland complex near Meador Avenue. The Cemetery Creek subbasin (2.5 mi^2 (6.6 km^2)) drains forested, commercial, and urban residential areas. Fever Creek flows through a series of ditches and culverts with a confluence near Nevada Street along the Whatcom Creek Trail. The Fever Creek subbasin (2 mi^2 (5.1 km^2)) drains a mix of industrial, commercial, and urban residential areas (Serdar et al. 1999). The Lincoln Creek confluence is roughly at river mile 1.8 near Meador Avenue along the Whatcom Creek Trail. The Lincoln Creek subbasins (1.2 mi^2 (3.2 km^2)) drains forested, commercial, and urban residential areas.

[2] https://www.usgs.gov/national-hydrography

Section 303(d) Listed Impairments Addressed by the TMDL

Ecology is establishing TMDLs for Whatcom Creek and its tributaries Hanna, Fever, Cemetery, and Lincoln creeks on a watershed scale. There are currently ten 303(d) listed Category 5 bacteria impairments in the Whatcom Creek watershed (Tables 1 and 2). All sampling data upstream of Listing ID 88957 on the mainstem of Whatcom Creek demonstrated that the bacteria WQS were consistently met. The FC and *E. coli* bacteria TMDLs established in this study incorporate a combination of water quality measurements, stream discharge measurements, and drainage area delineations at the sub-watershed level to account for all assessment units (AU) stream segments within the Whatcom Creek watershed (Appendix E). The AU is a water body segment or portion of a water body segment from which data are evaluated to determine compliance with WQS. Assessment units are typically delineated using the NHD reaches for fresh waters and grids for open water bodies. AUs are the basis for identifying water body listings in Tables 1 and 2.

Although these AUs presented in Tables 1 and 2 are listed based on FC data, this TMDL includes an *E. coli* component because the WQS have changed for freshwater — see the Uses of the Water Bodies and the Water Quality Criteria sections of this report for details. Ecology has not had a chance to reassess the listings using *E. coli* data, however, this TMDL is written to the new applicable WQS and employs the use of a bacteria translator — see Bacteria Translator under the TMDL Targets section of this report for details.

Table 1. Water bodies on the 1996 303(d) list addressed by the Whatcom Creek bacteria TMDL

Listing ID	Water body Name	Pollutant	Reach Code (Assessment Unit ID)
16408	Whatcom Creek	Fecal Coliform	17110004013762_001_002

While conducting this study, mainstem sections of Whatcom Creek, as well as additional water body segments comprising the tributaries to Whatcom Creek, did not meet water quality criteria for bacterial pollution (Table 2). Concerning FC 303(d) listings, the Water Quality Assessment placement dates for the tributaries are as follows: Cemetery (2004), Fever (2004), Hanna (2008), and Lincoln (2014). The *E. coli* TMDL component also addresses the 303(d) listed tributaries to Whatcom Creek. Ecology's Water Quality Assessment and 303(d) list[3] provides up to date information regarding the pollution status of sampled water bodies in Washington State.

Table 2. Additional water bodies on the current (2014 — 2018) 303(d) list addressed by the bacteria TMDL

Listing ID	Water body Name	Pollutant	Reach Code (Assessment Unit ID)
39061	Cemetery Creek	Fecal Coliform	17110004014628_001_001

[3] https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Assessment-of-state-waters-303d

88094	Cemetery Creek	Fecal Coliform	17110004013600_001_001
39089	Fever Creek	Fecal Coliform	17110004014207_001_001
45565	Hanna Creek	Fecal Coliform	17110004013829_001_001
88171	Hanna Creek	Fecal Coliform	17110004013979_001_001
39110	Lincoln Creek	Fecal Coliform	17110004013704_001_001
88254	Unnamed Creek (Trib to Cemetery W.F.)	Fecal Coliform	17110004018338_001_001
88957	Whatcom Creek	Fecal Coliform	17110004014447_001_001
89130	Whatcom Creek	Fecal Coliform	17110004013762_002_002

There are other 303(d) listed segments in the watershed, but this report does not address them since they are beyond the scope of this bacteria TMDL. The water bodies with temperature impairments are not shown in Table 3 because they are addressed by the Whatcom, Squalicum, and Padden Creeks Temperature TMDL: Water Quality Improvement Report (Hood et al. 2011).

Table 3. Additional water bodies on the current (2014 — 2018) 303(d) list not addressed by the bacteria TMDL

Listing ID	Water body Name	Pollutant	Reach Code (Assessment Unit ID)
38957	Cemetery Creek	Dissolved Oxygen	17110004014628_001_001
38963	Fever Creek	Dissolved Oxygen	17110004014207_001_001
9106	Fever Creek	Zinc	17110004014207_001_001
38981	Lincoln Creek	Dissolved Oxygen	17110004013704_001_001
39033	Whatcom Creek	Dissolved Oxygen	17110004014493_001_001
39034	Whatcom Creek	Dissolved Oxygen	17110004013762_001_002
78013	Whatcom Creek	Dissolved Oxygen	17110004013543_001_001

TMDL Development and Summary of Supporting Publications

This bacteria TMDL study and Implementation Plan is supported by previous TMDL-related assessments in the watershed and data collected by the City's USMP. This work is summarized in the following subsections. Initial project development occurred in early 2000 with a study conducted by the City and Ecology that was not submitted to the EPA for approval (Shannahan et al. 2004). Since publication of the Shannahan et al. (2004) report, the City's USMP has routinely monitored water quality in Whatcom Creek and its tributaries at monthly intervals. Follow up assessments include an updated TMDL calculation using a 2017 — 2018 USMP dataset and a trend analysis (McCarthy 2020b). Information detailed in Shannahan et al. (2004), along with subsequent analysis using more recent data *i.e.,* McCarthy (2020b), provide the general basis for this FC and *E. coli* bacteria TMDL.

Bacteria and streamflow datasets utilized in this TMDL and Implementation Plan:

- Primarily originate from the USMP,
- Include information from Shannahan et al. (2004) such as stream discharge and water quality results,
- Provide a FC bacteria trend analysis from 2002 through 2018 (McCarthy 2020b),
- Include paired samples collected locally from 2002 through 2003, and from 2018 through 2021, to build and define the relationship between FC and *E. coli* to develop the bacteria translator as explained in the TMDL Targets section of this report and in Appendix D,
- Establish TMDL allocations at the mouth of Whatcom Creek to protect downstream designated uses in marine water,
- Address the change to the freshwater WQS bacterial indicator of pollution from FC to *E. coli* using the translator to protect freshwater designated uses, and
- Forms the basis for the *E. coli* bacteria TMDLs, LCs, WLAs, LAs, and pollution reductions using the 2017 through 2018 two-year dataset coupled with the bacteria translator to represent contemporary watershed conditions and WQS.

Addressing water quality impairments through monitoring, data analysis, and adaptive management in the TMDL Implementation Plan provides the foundation to protect and preserve the designated beneficial uses of the Whatcom Creek watershed and receiving marine water. A combination of water quality and stream discharge measurements were used to analyze bacteria conditions and develop the TMDLs and associated allocations. Detailed descriptions of the methods, results, and conclusions of this TMDL can be found in the McCarthy (2020b) technical report and Appendices A, D, and E.

Whatcom Creek Fecal Coliform Total Maximum Daily Load Study (Shannahan et al. 2004)

The City partnered with Ecology in 2002 to conduct a watershed assessment to develop a fecal coliform bacteria TMDL to address impaired 303(d) listed water bodies. From January 2002 through February 2003, FC samples were collected every two weeks at five mainstem locations and each of the four tributaries to Whatcom Creek for a total of 28 to 31 samples per location (Appendix A). A subset of paired FC and *E. coli* bacteria samples were collected to examine their relationship. Bacteria sampling during storm events was conducted to assess the effects of stormwater runoff contributions. Continuous streamflow was recorded near the headwaters of Whatcom Creek and near the mouth. Instantaneous streamflow was measured at each tributary sampling location and related to the Euclid Creek continuous streamflow gage — USGS station 12202400. Streamflow and bacteria sample data were used to calculate loading and identify the load reductions necessary to meet WQS for freshwater.

This study used the Statistical Theory of Rollback (Ott 1995 and Appendix D) to determine FC benchmarks and percent reductions needed at each monitoring location to meet the WQS (Table 4). From highest to lowest, Fever Creek (88 percent) required the greatest bacteria reductions, followed by Cemetery Creek (86 percent), Lincoln Creek (78 percent), Hanna Creek (58 percent), and Whatcom Creek at Dupont St. (62 percent) and James St. (14 percent). All sampling locations on the Whatcom Creek mainstem above James St. met the WQS and did not require reductions. There were no additional sampling locations on the tributaries upstream of the mouth for those systems presented in Table 4 (Appendix A, Table A-18, and Figure A-11).

Table 4. Summary of the Whatcom Creek Fecal Coliform Study (Shannahan et al. 2004) including water quality, benchmarks, and percent reductions for each mainstem sampling location and for each tributary, colony forming units (cfu)

Site	Geometric Mean (cfu/100 mL)	90th Percentile (cfu/100 mL)	Geometric Mean Benchmark (cfu/100 mL)	90th Percentile Benchmark (cfu/100 mL)	Percent Reduction
Whatcom:					
Control Dam	18	107	18	90	0%
Water Plant	11	61	11	54	0%
Valencia St.	14	53	14	50	0%
James St.	44	235	38	200	14%
Dupont St.	93	647	29	200	62%
Hanna	45	361	25	200	58%
Fever	268	1918	28	200	88%
Cemetery	159	1622	20	200	86%
Lincoln	138	1211	23	200	78%

When compared to the mainstem, the relatively high bacteria concentrations observed in the tributaries contributed less than 3 percent of the total loading combined, while the mainstem below Valencia St. accounted for 80 percent of the loading. Allocations were based on the unit area covered by permitted sources and non-permitted pollution sources, however, were not assigned a numeric value. As an alternative, the use of narrative limitations was established as best management practices since numeric allocations were not determined.

The water quality calculations did not include a seasonal component. Seasonal variation on the mainstem was not identified because the WQS were exceeded throughout the year and discharge to Whatcom Creek was and continues to be manually regulated by the flow control structure near the outlet of Lake Whatcom, which masks the otherwise seasonal flow pattern of the creek. Higher bacteria concentrations, however, were observed during the dry season (May 1 — Oct. 31) when compared to the wet season (Nov. 1 — April 30). The greater bacteria concentrations observed during the dry season were attributed to; reduced streamflow that limited dilution or highlighted a pollution source that was not stormwater dependent. Storm event sampling — done when precipitation ≥ 0.5 inches in 24 hours — showed the highest bacteria concentrations when compared to routine monitoring.

Whatcom Creek Fecal Coliform Bacteria TMDL: Technical Report (McCarthy 2020b)

This technical report provides an analysis of the City's USMP ambient data collected from 2004 through 2018 and includes recommendations that update the Whatcom Creek FC TMDL. Since 2004, Whatcom Creek FC trends generally display significant improvements in water quality particularly in the lower reaches (Appendix A, Figure A-12). Cemetery Creek showed significant improving trends in FC concentrations while all other tributaries did not show a significant directional trend. The updated TMDL, LC, LA, and WLA were intended for use in this Whatcom Creek bacteria TMDL and Implementation Plan. The technical report did not develop or apply the use of the bacteria translator to usher a transition from the FC to the *E. coli* WQS pollution indicator.

The study used data from 2017 through 2018 to calculate FC percent reductions and establish target FC concentrations needed to meet water quality criteria using the Statistical Theory of Rollback (Ott 1995 and Appendix D). The pooled dataset produced 19 to 23 samples per site to represent recent conditions in the watershed. To meet the FC WQS at the monitoring locations, the tributaries required larger FC load reductions than the mainstem Whatcom Creek sites, with Fever Creek requiring the highest FC reductions (93 percent) followed by Lincoln Creek (73 percent), Hanna Creek (58 percent), and Cemetery Creek (41 percent) (Table 5). The three upper Whatcom Creek sampling sites met the FC WQS and did not require pollution reductions, while a minor reduction (10 percent) at the furthest downstream site at Dupont St. was needed to meet the FC WQS. The 2002 — 2003 bacteria dataset was compared to the 2017 — 2018 dataset. Greater reductions in bacteria pollution were determined to be necessary based on the Shannahan et al. (2004) dataset when compared to the McCarthy (2020b) dataset (Appendix A, Table A-19). There were no additional sampling locations on the tributaries upstream of those presented in Table 5 (Appendix D, Figure D-13 Whatcom Creek watershed).

Table 5. Summary of the Whatcom Creek Fecal Coliform Bacteria TMDL: Technical Report (McCarthy 2020b) including water quality, TMDL targets, and percent reductions for each mainstem sampling location and for each tributary, colony forming units (cfu)

Site	Geometric Mean (cfu/100 mL)	90th Percentile (cfu/100 mL)	TMDL Target Geometric Mean (cfu/100 mL)	TMDL Target 90th Percentile (cfu/100 mL)	TMDL Percent Reduction
Whatcom:					
Control Dam	10	48	10	48	0%
Valencia St.	13	36	13	35	0%
James St.	22	118	22	118	0%
Dupont St.	54	223	49	200	10%
Hanna	70	476	29	200	58%
Fever	406	2750	30	200	93%
Cemetery	82	342	29	200	41%
Lincoln	150	752	40	200	73%

Similar to Shannahan et al. (2004), seasonal variation showed greater bacteria concentrations during the dry season when compared to the wet season. Reductions in FC by season, however, were not determined. The dry season was defined as May through September and the wet season as October through April.

The McCarthy (2020b) technical report calculated numeric allocations for the entire watershed based on unit area at the most downstream sampling location on Whatcom Creek at Dupont Street. The unit area allocations were assumed to contribute equal quantities of loading. Allocations included a seasonal variation component based on the stream discharge averaged by season and the FC geometric mean WQS criterion of 100 cfu/100 mL to meet the loading capacity. The wet season FC loading capacity was 552 billion cfu/day (b.cfu/day) with equal parts allocated at 276 b.cfu/day to point and nonpoint pollution sources. The dry season FC loading capacity was 90 b.cfu/day with equal parts allocated at 45 b.cfu/day. The technical report did not calculate allocations for each tributary subbasin or translate allocations to *E. coli*.

Uses of the Water Bodies

Fresh Water Designated Uses

Designated uses assigned to fresh waters such as rivers and streams are listed in, WAC 173-201A-200, WAC 173-201A-600, and WAC 173-201A-602. Specifically, the waters of Whatcom Creek and its tributaries are addressed under:

Recreational – Primary contact is intended for waters where a person would have direct contact with water to the point of complete submergence where human exposure is likely to include exposure of the eyes, ears, nose, and throat. Since children are also the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection. Bacteria criteria are based on the presence of *E. coli* organisms and expressed as colony forming units (cfu) or most probable number (MPN).

Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. Thermotolerant bacteria such as FC or *E. coli* in water indicates the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. The former FC criteria and current *E. coli* criteria are based on concentrations that have been shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

Neither Whatcom Creek nor its tributaries have designated swimming areas, but swimming occurs, often in the upper reaches in Whatcom Falls Park. Canoeing, kayaking, fishing, and wading also take place. Mixed use trails that connect Lake Whatcom to Bellingham Bay follow Whatcom Creek and provide many access points.

Development of this TMDL was started when the WQS used FC bacteria as the indicator for protecting water contact recreation activities. In 2019 the WQS where changed to use *E. coli* as the fecal bacteria indicator. Details related to this change in bacterial indicator are presented in the following Water Quality Criteria section of this document under the Revised Water Quality Standard subsection. The *E. coli* TMDLs established in this report protect the fresh water primary contact recreation designate use.

Marine Water Designated Uses

While *E. coli* will be used to determine the attainment of recreational use in freshwater, the protection of marine water designated uses is based on the bacteria indicators Enterococci or FC depending on the specific use. Designated uses assigned to marine waters are listed in WAC 173-201A-210, WAC 173-201A-610, and WAC 173-201A-612. Whatcom Creek enters Bellingham Bay through the Whatcom Waterway, which is managed by the Port of Bellingham. The Whatcom Waterway has the designated use of recreation and shellfish harvesting, which is encompassed by the designated use of Bellingham Bay as stated in Table 612 of the WAC 173-201A-612.

As part of Bellingham Bay, the marine water near the mouth of Whatcom Creek is intended to be protected from bacterial pollution by the following guidelines:

Recreational – Primary contact is intended for waters where a person would have direct contact with water to the point of complete submergence where human exposure is likely to include exposure of the eyes, ears, nose, and throat. Since children are also the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection. Bacteria criteria are based on the presence of enterococci organisms and expressed as colony forming units (cfu) or most probable number (MPN).

Shellfish harvesting – Based on the presence of FC organisms and expressed as colony forming units (cfu) or most probable number (MPN).

Lummi Nation's Portage Bay Shellfish Growing Area is located on the west side of Bellingham Bay along the Lummi Peninsula and Portage Island (Appendix D, Figure D-14). Those shellfish beds are sensitive to bacteria contamination and important to the Lummi Nation (Hood 2002). The bacteria source that most heavily impact the shellfish growing areas comes from the Nooksack River watershed (Joy 2000, Hood 2002).

The WQS include the provision to protect downstream uses — "Upstream actions must be conducted in manners that meet downstream water body criteria" [WAC 173-201A-260(3)(b)]. The Nooksack River bacteria TMDL established targets for the mainstem and its tributaries to protect downstream designated uses of shellfish harvesting (Joy 2000, Hood 2002). After TMDL goals are met, the impact of FC pollution from the Nooksack River on the shellfish growing areas should support shellfish harvesting. The Nooksack River bacteria TMDL and Implementation Plan therefore addresses the impaired marine water segments near the mouth of the river and Portage Bay (Joy 2000, Hood 2002).

The mouth of Whatcom Creek is more remote from the Portage Bay Shellfish Growing Area than the mouth of the Nooksack River (Appendix D, Figure D-14). As described in the associated bacteria TMDL technical report, Joy (2000) determined that the Nooksack River had the major influence on water quality in the Portage Bay Shellfish Growing Area (Appendix D). The FC TMDL allocations established in the Whatcom Creek TMDL, however, protects the downstream shellfish harvesting designated use in the waters of the Whatcom Waterway and the greater Bellingham Bay (Appendix D). The TMDL allocations established in this report also protect downstream marine water primary contact recreation because both the fresh (*E. coli*) and marine (*enterococcus*) bacterial indicator criteria provide the same level of protection from associate pathogens (EPA 2012 and 2020) (Appendix D).

There are no shellfish growing areas or designated marine water swimming beaches near the mouth of Whatcom Creek. The Port of Bellingham Marine Beach at Boulevard Park is the nearest recreational beach, which is approximately 1.8 mile southwest of the Whatcom Waterway. The established bacteria TMDL allocations of this study were set to protect the downstream designated uses in the Whatcom Waterway and greater Bellingham Bay. The following provides a contextual summary of the interactions among Whatcom Creek, the receiving marine waters, and other relevant circumstances:

1. Whatcom Creek does not discharge within three miles of an assessed shellfish resource area,
2. Bacteria concentrations occurring near the mouth of Whatcom Creek experience harmful effects of saline marine water that cause significant attenuation before reaching the nearest shellfish resource area,
3. Given the relatively small discharge of Whatcom Creek, the high dilution factor of the fresh and marine water mixing zone is likely sufficient to yield minimal influence on the nearest shellfish resource areas,
4. Whatcom Creek's relative low discharge volume is far exceeded by the Nooksack River influence on Bellingham Bay shellfish resource areas,
5. The nearest shellfish growing area is in Portage Bay, which is addressed by the Nooksack River FC TMDL (Joy 2000),
6. The nearest marine water 303(d) impairment (ID: 87061) for FC bacteria is roughly 2.2 miles away, which is near the mouth of the Nooksack River and is addressed by the associated TMDL Implementation Plan (Hood and Joy 2000), and
7. The nearest marine water 303(d) impairment (ID: 84288) for enterococci bacteria is 1.8 miles away at Marine Beach.

Water Quality Criteria

Revised Water Quality Standards for Bacteria Indicators

In 2019, Ecology revised the Surface WQS for the protection of water contact recreation (Ecology 2018). Ecology arranged a transition period that allowed FC data to be used through December 31, 2020 (Ecology 2019a). TMDLs that protect water contact recreation approved after December 31, 2020, require the use of the new bacterial indicators. This Whatcom Creek bacteria TMDL and Implementation Plan is based on *E. coli* standards to protect primary contact recreation in freshwater as described below.

Water quality assessments using the revised indicator(s) include the follow key changes:

1. New bacterial indicators for contact recreation uses,
    a. Fresh water indicator – *Escherichia coli* (*E. coli)*
    b. Marine water indicator – Enterococci
2. All waters are now protected for primary contact recreation,
3. Extraordinary and secondary contact recreation uses were removed from the standards,
4. The averaging period to calculate the geometric mean for contact recreation bacterial indicators changed from 12 months to 3 months, and
5. The minimum number of samples needed to calculate the geometric mean changed from 5 to 3.

Ecology develops TMDLs to show what actions need to happen to meet WQS that protect the designated uses and meet numeric criteria. TMDLs are written to the current State WQS and criteria. For example, bacteria TMDLs written to protect shellfish harvesting beneficial use are based on the FC criteria, while TMDLs written to protect fresh water contact recreation are based on *E. coli*. When approving TMDLs, the EPA will consider current WQS using the provisions at 40 CFR § 130.7 and national EPA guidance.

This TMDL sets limits for shellfish harvesting marine water beneficial uses — see Marine Water Designated Uses Subsection and Appendix D. This TMDL also sets pollution limits to protect the downstream marine water primary contact recreation designated use. EPA (2012) suggests, where fresh waters protected for contact recreation flow into marine waters with the same designated use, the fresh water criteria are protective of downstream uses because both the fresh and marine WQS were developed using the same level of risk and illness rates for humans (Appendix D).

Fresh Water Contact Recreation

The Washington State Water Quality Standards[4] (WAC 173-201A) include designated beneficial uses for specific water bodies and their associated numeric water quality criteria. Respectively, the current and previous primary contact recreation standards in fresh waters are based on *E. coli* with FC organism concentrations being the standard prior to January 1, 2020 [WAC173-201A-200(2)(b)]. These WQS formed the basis to set TMDL targets for the Whatcom Creek watershed.

The current applicable fresh water quality criteria for ***E. coli*** are:

1. **Geometric mean** value within an averaging period not to exceed **100 cfu/100mL.**
2. **No more than 10 percent** of samples (or any single sample when less than ten samples exist) exceed **320 cfu/100mL** (percent exceedance or not-to-exceed criterion) obtained within the averaging period.

WAC 173-201A-200(2)(b)(i)(B) states "**Ambient water quality samples:** When averaging bacteria sample values for comparison to the geometric mean criteria, it is preferable to average by season. The averaging period of bacteria sample data shall be ninety days or less."

The former fresh water quality criteria for FC constituted the basis for the 303(d) listing which led to the initial water quality investigation (Shannahan 2004).

The former applicable fresh water quality criteria for **FC** are:

1. **Geometric mean** criterion not to exceed **100 cfu/100mL**.
2. **No more than 10 percent** of samples (or any single sample when less than ten samples exist) exceed **200 cfu/100mL** (percent exceedance or not-to-exceed criterion).

[4] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201a

The two-part water quality criteria are established to protect primary water contact recreation in fresh waters.

Marine Water Shellfish Harvesting and Contact Recreation

The water quality criteria and bacteria indicators of pollution include FC for shellfish harvesting and enterococci for primary contact recreation in marine water. This TMDL does address the shellfish harvesting designated use and the marine water contact recreation beneficial use.

The water quality criteria for **FC organisms** used to protect shellfish harvesting in marine waters are:

1. **Geometric mean** criterion not to exceed **14 cfu/100mL**.
2. **No more than 10 percent** of samples (or any single sample when less than ten samples exist) exceed **43 cfu/100mL** (percent exceedance or not-to-exceed criterion).

The water quality criteria for **Enterococci bacteria organisms** used to protect contact recreation in marine waters are:

1. **Geometric mean** criterion not to exceed **30 cfu/100mL**.
2. **No more than 10 percent** of samples (or any single sample when less than ten samples exist) exceed **110 cfu/100mL** (percent exceedance or not-to-exceed criterion).

Brackish Water

Application of fresh and marine water criteria vary depending on salinity concentrations in brackish waters of estuaries. When data are available, the fresh water or marine water criteria is selected and applied based on vertically averaged daily maximum salinity, referred to as "salinity." In these cases, the method to determine what standards apply can be found in the water quality standards at WAC 173-201A-260(3)(e):

i. "The fresh water criteria must be applied at any point where ninety-five percent of the salinity values are less than or equal to one part per thousand [(ppt)], except that the fresh water criteria for bacteria applies when the salinity is less than ten [ppt]; and"

ii. "The marine water criteria must apply at all other locations where the salinity values are greater than one [ppt], except that the marine criteria for bacteria applies when the salinity is ten [ppt] or greater."

If information is not available to determine the delineation between marine and fresh water criteria for brackish waters, then the more stringent of the two criteria will apply as described in WAC 173-201A-260(3)(c).

In brackish waters the 10 ppt salinity line is dynamic, changing constantly as a function of tidal movement and river flow near the fresh water and marine water interface. The exact location of the brackish water interface between Whatcom Creek and the Whatcom Waterway was not delineated. Water quality data collected by the USMP suggests that brackish water occurs somewhere downstream of the Dupont Street sampling location (WHA00.2) (Appendix A). The FC TMDL for Whatcom Creek was established using the WAC 173-201A-260(3)(e) criteria for the purpose of protecting the downstream designated use of shellfish harvesting (Appendices D and E). The mixing of fresh and marine water above 10 ppt salinity was used to establish water quality benchmarks that are protective of shellfish harvesting.

Antidegradation

The federal Clean Water Act requires that Washington's WQS protect existing designated uses by establishing the maximum level of pollutants Ecology can allow in surface water. Ecology requires extra protections for water that is already cleaner than the standards. Antidegradation rules help prevent unnecessary lowering of water quality (WAC 173-201A-300). Antidegradation rules also provide a framework to identify which water is designated as an "outstanding resource" by the state. The antidegradation policy is guided by chapter 90.48 RCW, Water Pollution Control Act, chapter 90.54 RCW, Water Resources Act of 1971, and 40 CFR § 131.12. Washington State's antidegradation rules follow the federal regulations, which set three tiers of protection for surface waters.

Tier I ensures existing and designated uses are maintained and protected applicable to all waters and sources of pollution (WAC 173-201A-310). Tier I focuses on fully applying the water quality criteria, and correcting problems using Ecology's existing regulatory and TMDL water cleanup processes, which applies to the water bodies of the Whatcom Creek watershed.

1. Existing and designated uses must be maintained and protected. No degradation may be allowed that would interfere with, or become injurious to, existing or designated uses, except as provided in "this chapter".

For waters that do not meet assigned criteria, or protect existing or designated uses, the department will take appropriate and definitive steps to bring the water quality back into compliance with the water quality standards.

2. Whenever the natural conditions of a water body are of lower quality than the assigned criteria, the natural condition constitutes the water quality criteria. Where water quality criteria are not met because of natural conditions, human actions are not allowed to further lower the water quality, except where explicitly allowed in "this chapter".

Tier II is used to ensure that waters that meet a higher quality than the limits set in the standards are not degraded (WAC 173-201A-320). Waters may still be degraded if impacting water quality is necessary and in the overriding public interest. Tier II applies only to new or expanded sources of pollution from specific types of activities Ecology directly regulate such as National Pollutant Discharge Elimination System (NPDES) permits.

Tier III is used when a high-quality water is designated as an outstanding resource water (WAC 173-201A-330). The water quality and uses of these waters must be maintained and protected against all sources of pollution. Ecology can request a Tier III designation or receive written public nominations. Public nominations must include sufficient information to show how the water body meets the appropriate conditions of an outstanding resource water.

TMDL Targets

The TMDL for Whatcom Creek and its tributaries sets limits for bacteria pollution to:

- Protect primary contact recreation designated uses in freshwater,
- Protect downstream designated uses in marine water including,
  - Primary contact recreation,
  - Shellfish harvesting, and
- Meet the associated WQS.

This TMDL used the statistical rollback method (Ott 1995) to determine bacteria load reductions necessary to attain the WQS using the dataset collected during years 2017 and 2018. The rollback method compares monitoring data to water quality criteria, and the difference is the percentage reduction needed to meet WQS (Appendix D). Ecology has applied and EPA has approved the rollback method in many other bacteria TMDLs (Hood and Joy 2000, Pelletier and Seiders 2000, Joy 2004, Joy and Swanson 2005, Schneider et al. 2007, Swanson 2008, Mathieu and James 2011, McCarthy 2020a, EPA 2020).

The rollback method is applied as follows:

> The geometric mean (approximate median in a log-normal distribution) and 90th percentile statistics are calculated and compared to the current water quality bacteria criteria. If one or both do not meet the criteria, the whole distribution is “rolled-back” to match the more restrictive of the two criteria. Load reductions based on the 90th percentile are usually the most restrictive.

The rolled-back geometric mean (geomean) or 90th percentile bacteria concentration then becomes the recommended target concentration for the reach code AU to meet WQS. The degree to which the distribution of bacteria counts are rolled-back to the target concentration represents the calculated percent of bacteria reduction required to meet the bacteria WQS and protect designated uses. The term “target” distinguishes rolled-back values from the TMDL allocations, which were both determined based on meeting the Washington State water quality numeric criteria and the WQS.

The bacteria targets assist water quality managers in assessing the progress toward compliance with the bacteria water quality criteria and help prioritize pollution cleanup activities. Compliance with the water quality criteria is ultimately measured by meeting both parts of the WQS for *E. coli*. The FC TMDL was established to meet the downstream designated use of shellfish harvesting based on the associated marine water criteria, while accounting for the mixing of Whatcom Creek and the Whatcom Waterway (Appendix D). The recommended percent reductions and target geomean concentrations are also useful for National Pollutant Discharge Elimination System (NPDES) permit development.

The 90th percentile is a statistical distribution measure that determines the value for which 90 percent of the data points are less than, and 10 percent are greater. While like the no more than 10 percent criterion, or statistical threshold value (STV), the 90th percentile provides a numeric value in terms of a concentration instead of a percentage. That is, the 90th percentile is expressed as bacteria colony forming units (cfu) per 100 mL (cfu/100 mL), while the percent exceedance STV criterion is expressed as a percentage of samples above a particular bacteria concentration.

As described in the Water Quality Criteria section in the Introduction of this TMDL report, the STV for *E. coli* is 10 percent of samples not to exceed 320 cfu/100 mL. The 90th percentile and percent not-to-exceed STV are relatable to one another, however, they are not interchangeable. For example, the 90th percentile is not used to determine compliance with the WQS. The 90th percentile STV for FC was calculated at 56 cfu/100 mL during the dry season and 53 cfu/100 mL during the wet season to address the protection of shellfish harvesting.

The *E. coli* concentrations estimated by the translator were used to evaluate the likelihood of exceeding *E. coli* water quality criteria and calculate *E. coli* loads, WLAs, and LAs. The two-year dataset (2017—2018) was not used to determine attainment of state WQS under the formative Water Quality Assessment process (Ecology 2018). When determining WQS attainment[5], data must be assessed within annual and seasonal blocks (WAC 173-201A). Future direct measurement and monitoring of *E. coli* will be necessary to determine the attainment of WQS.

[5] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201a

The 2017 — 2018 two-year dataset was utilized to represent and characterize more recent watershed conditions when compared to the Shannahan et al. (2004) study (McCarthy 2020b and Appendices A and D). The pooled 2017 — 2018 two-year dataset includes 174 samples total with a range of 19 to 23 samples per site. Pooling into a two-year dataset improves the certainty of the TMDL calculations when compared to using only one of the two annual datasets. All data were collected by the USMP for routine monthly ambient monitoring purposes. The data collection efforts conducted by the City's USMP was therefore integral to the development of this TMDL and will be essential for pollution control effectiveness monitoring.

Bacteria Translator

Fecal Coliform was the historic indicator of bacteria pollution in freshwater, which led to a larger dataset when compared to the limited *E. coli* bacteria dataset collected by the USMP. To account for the low number of *E. coli* samples, Ecology developed the bacteria translator specifically for the City of Bellingham urban streams using local watershed data (Appendix D). Paired FC and *E. coli* samples were used to develop the translator to characterize the relationship between the two organism concentrations. The bacteria translator allows the relatively robust FC dataset to be translated into *E. coli* organism concentrations using linear regression.

This TMDL used translated (forecasted) *E. coli* concentrations to calculate load contributions and assess the degree to which the WQS were either exceeded or attained (Appendices D and E) as well as to determine the TMDL targets and pollution reductions necessary to meet the WQS, and to guide pollution control implementation and monitoring efforts. Translated bacteria values, however, should not be used directly to determine the attainment of the WQS under Ecology's administration of the water quality assessment[6] (WAC 173-201A).

In 2018, the City's USMP re-initiated *E. coli* monitoring by collecting a subset of paired samples with FC. The bacteria translator used information obtained from additional paired sampling to increase the confidence in the characterizations between *E. coli* and FC concentrations. Regression analysis of paired samples collected within the Bellingham urban area demonstrated a significant linear relationship between FC and *E. coli* concentrations. Regression has been used in previous water quality and TMDL-related studies to demonstrate the relationship between FC and *E. coli* (EPA 2020, LimnoTech 2012, and Cude 2005).

[6] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201a

This TMDL and Implementation Plan address the recent bacterial indicator updates from FC to *E. coli* to determine the protection of contact recreation beneficial use. Functioning as a translator, the Type 2 linear regression, Major Axis Method, of paired samples (n = 47) collected within the Whatcom Creek and Lake Whatcom watershed urban areas expressed the relationship between FC and *E. coli* (Appendix D). FC concentration (cfu/100 mL) data points were translated to *E. coli* (EC) concentration data points using Equation 1:

$$EC = 0.776 \times (FC)^{1.037} \qquad (1)$$

$$FC = 1.277 \times (EC)^{0.965} \qquad (2)$$

The geomeans of the paired samples collected by the USMP and used to develop the regression were 42 and 38 cfu/100 mL for FC and EC respectively, with a ratio of 1:0.9 (FC:EC). Pearson's r correlation test demonstrated a positive relationship between FC and EC samples (r = 0.94). Translations made from the regression can be compared to observations to assess model quality, *i.e.,* model fitness. If the model slope is near 1 and the intercept near 0, then the model fits the data well. If the slope differs from 1-, or 45°-degree line, it indicates the difference between the observed and predicted values proportional to the observed values. The slope for the FC-to-EC translator was 1.04 and the intercept is -0.11, with an overall error of 3.7% used to derive Equation 1. The slope for the EC-to-FC translator was 0.97 and the intercept was 0.11, with an overall error of 3.5% used to derive Equation 2.

TMDL Implementation Targets and Seasonal Variation

To estimate a corresponding (forecasted) *E. coli* concentration, this TMDL uses the bacteria translator per individual FC sample (Appendix D). These translated *E. coli* concentrations were compared to water quality criteria to determine the load reductions and associated targets to meet the TMDL. The FC concentrations were compared to water quality criteria after accounting for the mixing of fresh and marine water in the brackish zone (Appendix D). The calculated FC load reductions and associated targets were established to meet the TMDL allocations. The TMDLs set the necessary limits for each 303(d) listed water body to meet WQS, protect designated uses, and includes an assessment of seasonal variation (Appendices D and E).

For the stream segments AUs that were not directly monitored at a corresponding sampling location, the same target geometric mean will be applied upstream of each sampling location to attain the TMDL. Assuming the stream flow and loading is relative to the land or catchment area, each TMDL is directly related to the proportion of the catchment area that drains to the identified pour point sampling location (Appendix E, Tables E-22 — 24, Figures E-29 and 30). The *E. coli* TMDL was calculated for each associated AU and applies to all other unlisted stream segment catchments. The FC TMDL was calculated for the downstream most AU on Whatcom Creek. The entire watershed is therefore covered by a TMDL and Implementation Plan where water quality clean up actions are expected to address all stream segments and listed AU ID reach codes.

Water Quality Results, TMDL Targets, and Percent Reductions

Analysis of the FC data collected near the mouth of Whatcom Creek (WHA00.2 — Dupont St.) indicate that freshwater pollution was at a level that does not protect downstream designated use (Table 6). Analysis of the translated *E. coli* concentrations indicated that the water quality criteria were likely not met at Whatcom Creek near the mouth during the dry season only. Translated *E. coli* concentrations demonstrated that the water quality criteria were likely not met at Fever, Hanna, and Lincoln Creek sampling sites generally during the dry season with some exceptions during the wet season. Geomean concentrations were higher at all sites during the dry season when compared to the wet season. Similarly, the percent exceedance STV criterion was greater during the dry season when compared to the wet season except for Cemetery and Hanna Creeks.

Table 6. FC and *E. coli* descriptive statistics, and target percent reductions and concentrations (cfu/100 mL) necessary to attain the TMDL using 2017 through 2018 data separated by season (Dry = May — Sept., Wet = Oct. — Apr.)

Site	Season (n)	Geomean	Not-to-Exceed STV	90th percentile	Target Percent Reduction	Target Geomean	Target 90th percentile
WHA00.2[FC]	Dry (9)[FC]	128	78%[B]	272	87%[B]	17[B]	36[B]
	Wet (14)[FC]	31	21%[B]	111	40%[B]	18[B]	66[B]
WHA00.2	Dry (9)	119	11%	259	18%	97	212
	Wet (14)	27	0%	103	0%	27	103
WHA01.3	Dry (9)	50	0%	135	0%	50	135
	Wet (14)	10	0%	56	0%	10	56
WHA02.4	Dry (9)	20	0%	61	0%	20	61
	Wet (14)	7	0%	14	0%	7	14
WHA04.2	Dry (9)	28	0%	51	0%	28	51
	Wet (14)	4	0%	12	0%	4	12
CEMETERY	Dry (5)	107	0%	281	8%	99	281
	Wet (14)	66	7%	334	4%	63	320
FEVER	Dry (6)	1973	100%	3904	96%	76	320
	Wet (14)	196	21%	1030	69%	61	320
HANNA	Dry (5)	118	0%	261	17%	97	320
	Wet (14)	51	14%	471*	32%*	35*	320
LINCOLN	Dry (9)	215	33%	1526	79%	45	320
	Wet (14)	106	14%	441	27%	77	320

*Dataset not normally distributed, estimate may not be accurate
[FC]Fecal coliform dataset
[B]Brackish water mixing to protect downstream shellfish harvesting designated use
(n) Sample number
STV — Statistical threshold value

To attain the TMDL allocations, bacteria reductions were necessary for sites that did not meet the primary contact recreation WQS for *E. coli*, while reductions in FC were necessary to meet the downstream designated use of shellfish harvesting. For all sites that did not meet the WQS, the 10 percent of samples not-to-exceed STV criterion was the most restrictive for the Fever and Lincoln Creek water bodies, while Cemetery, Hanna, and Whatcom Creek near the mouth (WHA00.2 — Dupont St.) were restricted by the geomean criterion. All sampling sites that did not receive reductions met the water quality criteria according to the *E. coli* WQS using the translated bacteria concentrations. The observed geomean and 90th percentile became the TMDL targets where percent reductions were not necessary.

Seasonal Variation

Based on the Clean Water Act Section 303(d), the EPA suggests that TMDLs include an assessment of seasonal variation[7] (40 CFR § 130.7 (c)(1)) (EPA 1991). The Washington WQS[8] (WAC 173-201A-200) also recommends averaging by season when comparing bacteria concentrations to the geomean water quality criterion. While some discretion exists for selecting sample averaging periods, water quality criteria compliance considered in this TMDL, and Implementation Plan was evaluated for seasonal variation. Seasonal targets help avoid the potentially erroneous conclusion that when TMDL targets are met when averaged over the entire year they are also met during all seasons of the year. If bacteria pollution sources vary significantly by season to create distinct patterns, seasonal targets are required in the TMDL to set the most protective pollution limits during the critical period of the year. The seasonal targets form the basis of the water body assimilative capacity as detailed in the TMDL Allocations section in this document. This TMDL applied the Statistical Theory of Rollback method to each dataset grouped by season including an assessment of certainty of the rollback calculations (Ott 1995 and Appendix D).

Consistent with McCarthy (2020b), this TMDL study defines the wet season as October 1 through April 30, and the dry season as May 1 through September 30, based on monthly average precipitation data from the City's meteorological stations at City Hall and Bloedel (Figure 2 and Appendix A, Table A-15). The 15-year precipitation monthly average covers the time span from the Shannahan et al. (2004) study to the McCarthy (2020b) TMDL technical report, which includes years 2017 and 2018 (Appendices A and D). From 2003 through 2018, the May through September average precipitation was 1.6 inches per month, while the October through April period was 4.3 inches of average precipitation per month. According to the USDA Natural Resources Conservation Service (NRCS) National Water and Climate Center[9]:

[7] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-130
[8] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201a
[9] https://www.nrcs.usda.gov/wps/portal/wcc/home/climateSupport/agAcisClimateData/

- The total annual average precipitation in Bellingham from 2003 through 2018 was 37.0 inches, with a range of 29.9 to 42.3 inches per year,
- The total precipitation in 2017 was 40.5 inches, and
- The total precipitation in 2018 was 36.3 inches.

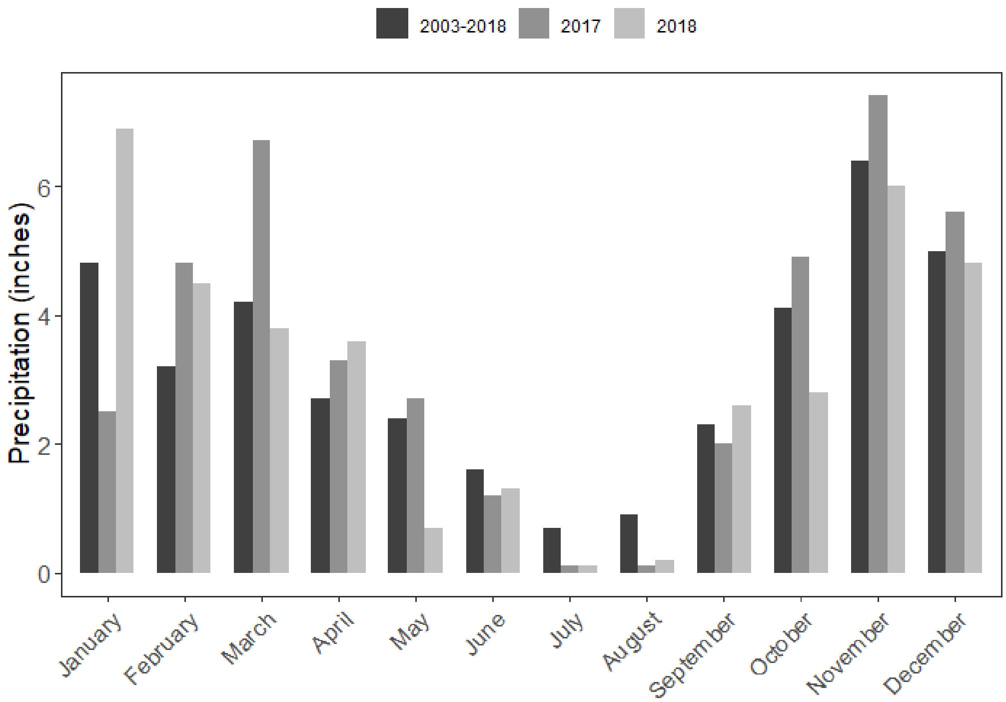


Figure 2. Monthly precipitation totals grouped by year and from 2003 — 2018 showing data from Bellingham City Hall and Bloedel

Seasonal variation in bacteria concentrations was observed where the dry season had higher concentrations than the wet season, which supports the conclusion that the critical period occurs during the dry season (Table 6). Additionally, people tend to make contact more often with Whatcom Creek and to a greater degree, *i.e.,* swimming, during the dry season when compared to the wet season. The dry season therefore poses a greater public health risk due to increased primary contact recreation when compared to the wet season.

TMDL Allocations

The TMDL allocations in this study are expressed as loads in billions of bacteria colony forming units (cfu) per day (b.cfu/day). The TMDL limiting assimilative capacities for each 303(d) listed water body are calculated using the geometric mean (geomean) of the WQS and mean streamflow discharge (Appendix E).

A water body's loading capacity (LC) is the amount of a given pollutant that a water body can receive and still meet water quality standards. The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with the standards. The LC assigned to a particular pollution source is a wasteload allocation (WLA) or load allocation (LA). If the pollutant comes from a discrete (point) source subject to a NPDES permit, such as a municipal or industrial facility's discharge pipe, that facility's share of the LC is called a WLA. If the pollutant comes from diffuse (nonpoint) sources not subject to an NPDES permit, such as general urban, residential, or forested run-off, the cumulative share of the LC is called a LA. Generally, the WLAs were developed based on either the proportional permitted area or the effluent discharge rates of permitted facilities, while the LAs were developed based on the proportional area not covered by a permit (Appendix E).

TMDL Formula

Once it is determined that a water body does not meet WQS, the goal of a TMDL is to provide a written, quantitative assessment of the water quality problems and of the pollutant sources that cause the problem, if known. This information is used to develop the TMDL of the water body. The TMDL provides a reference for calculating the amount of pollution reduction in terms of mass per unit time that is needed to bring a water body into compliance with the WQS. The TMDL is compared to the current amount of pollution entering the water body. If the pollutant levels are too high, the necessary reduction needed to bring a water body into compliance with the standards can be determined.

For this study, the TMDL may be proportioned using the relative percent of the catchment area that contributes to the receiving reach code AU stream segment after accounting for each effluent based WLA (Appendix E). Following this concept, the TMDL for each reach code AU may be determined using the relative proportion of contributing watershed area because land use activities largely influence the magnitude of bacteria loading. Improving land use practices that reduce bacteria loading will lead to TMDL attainment. The relative proportion of a catchment area is expected to contribute the same level of loading and therefore contribute similarly to the TMDL.

The TMDL must consider seasonal variations and critical conditions and include a margin of safety (MOS) that considers any lack of knowledge about the causes of the water quality problem. The reserve capacity for future pollutant sources is sometimes included as well. The TMDL is the sum of the wasteload and load allocations, any margin of safety, and any reserve capacity. The TMDL must be equal to or less than the LC. The short-hand formula that describes the TMDL is:

$$LC = \sum WLA + \sum LA + MOS$$

The summary (Table) provides the TMDL for *E. coli* (b.cfu/day) for each 303(d) listed water body and includes the FC TMDL established at the mouth of Whatcom Creek (Table 7). For example, the *E. coli* TMDL of 89.3 b.cfu/day at the mouth of Whatcom Creek will be achieved at an 18 percent reduction which equates to a target geomean of 97 cfu/100 mL when accounting for seasonal variability during the dry season, while no reductions were needed during the wet season because the WQS were met during this time of the year (Tables 6 and 7).

The TMDL was separated into,

1. Individual WLAs to address point source pollution for each permit holder — NPDES permit numbers provided below,
2. LAs per subbasin to address nonpoint source pollution, and
3. The MOS to address uncertainty.

Where the WLA or LA was not specified (—), the TMDL does not include that source because the identified allocation does not discharge to the given receiving water body. The MOS was explicit to comprise 10 percent of the TMDL for each tributary subbasin and the entire watershed. For method details and TMDLs at individual reach code AU IDs see Appendix E, which shows the TMDLs separated by 303(d) listed water body. The LC, WLA, LA, and MOS are detailed in the following subsections.

Table 7. Whatcom Creek watershed bacteria TMDL summary in of billions of colony forming units per day (b.cfu/day) separated by season: Dry is May — Sept. and Wet is Oct. — Apr.

NPDES permit and TMDL values (b.cfu/day)	Whatcom at Dupont St. (WHA00.2)	Whatcom at Dupont St. (WHA00.2)	Cemetery at mouth (CEMETERY)	Fever at Valencia St. (FEVER)	Hanna at mouth (HANNA)	Lincoln at Fraser St. (LINCOLN)
Season	**Dry**[FC]	**Dry**	**Dry**	**Dry**	**Dry**	**Dry**
WDFW Bellingham Fish Hatchery WAG994275	—	0.11	—	—	—	—
Brooks Manufacturing Co. WA0030805	—	0.09	—	—	—	—

NPDES permit and TMDL values (b.cfu/day)	Whatcom at Dupont St. (WHA00.2)	Whatcom at Dupont St. (WHA00.2)	Cemetery at mouth (CEMETERY)	Fever at Valencia St. (FEVER)	Hanna at mouth (HANNA)	Lincoln at Fraser St. (LINCOLN)
Season	**Dry[FC]**	**Dry**	**Dry**	**Dry**	**Dry**	**Dry**
Haskell Corporation WAR127009	—	0.09	—	—	—	—
City of Bellingham WAR045550	17.7	63.4	0.02	0.06	0.05	0.07
Whatcom County WAR045557	—	7.8	0.01	—	0.007	0.01
WSDOT WAR043000A	—	0.54	—	—	—	—
Dry WLA	17.7	72.0	0.03	0.06	0.06	0.08
Dry LA	0.0	8.4	0.01	0.0	0.02	0.0005
Dry MOS	2.0	8.9	0.005	0.007	0.008	0.009
Dry TMDL	19.6	89.3	0.05	0.07	0.08	0.09
NPDES permit and TMDL values (b.cfu/day)	**Whatcom at Dupont St. (WHA00.2)**	**Whatcom at Dupont St. (WHA00.2)**	**Cemetery at mouth (CEMETERY)**	**Fever at Valencia St. (FEVER)**	**Hanna at mouth (HANNA)**	**Lincoln at Fraser St. (LINCOLN)**
Season	**Wet[FC]**	**Wet**	**Wet**	**Wet**	**Wet**	**Wet**
WDFW Bellingham Fish Hatchery WAG994275	—	0.11	—	—	—	—
Brooks Manufacturing Co. WA0030805	—	0.09	—	—	—	—
Haskell Corporation WAR127009	—	0.5	—	—	—	—
City of Bellingham WAR045550	125.0	394.9	0.14	0.45	0.35	0.47
Whatcom County WAR045557	—	48.8	0.07	—	0.05	0.07
WSDOT WAR043000A	—	3.4	—	—	—	—
Wet WLA	125.0	448	0.21	0.45	0.39	0.55
Wet LA	0.0	52.3	0.09	0.0	0.11	0.003

NPDES permit and TMDL values (b.cfu/day)	Whatcom at Dupont St. (WHA00.2)	Whatcom at Dupont St. (WHA00.2)	Cemetery at mouth (CEMETERY)	Fever at Valencia St. (FEVER)	Hanna at mouth (HANNA)	Lincoln at Fraser St. (LINCOLN)
Season	**Dry[FC]**	**Dry**	**Dry**	**Dry**	**Dry**	**Dry**
Wet MOS	13.9	55.6	0.03	0.05	0.06	0.06
Wet TMDL	138.9	555.7	0.33	0.5	0.56	0.61

— No allocation because the identified source does not discharge to the receiving water
[FC]Fecal coliform loading

The TMDL was roughly six times greater during the wet season when compared to the dry season for all 303(d) listed water bodies combined (Table 7). The greater TMDL during the wet season was likely driven by the greater streamflow when compared to the dry season streamflow. The dry season was the critical period due to the greater bacteria concentrations observed and the greater TMDL percent reductions needed when compared to the wet season (Table 6).

During 2017 and 2018, the USMP conducted routine ambient monitoring. These ambient monitoring data were used to develop the bacteria target reductions and TMDLs. At the time, the primary objective of the USMP did not include a specific investigation to develop a TMDL. Information provided by the USMP, however, offers the best available contemporary data for TMDL development to represent up-to-date conditions of the watershed. The USMP sampling strategy did not typically did not account for the separation of point sources and nonpoint sources of bacteria in terms of area loading. For example, separating contributions from the urban stormwater infrastructure — Municipal Separate Storm Sewer System (MS4) — from ambient water quality data would require sampling each outfall to Whatcom Creek and its tributaries throughout the entire watershed.

In this TMDL study, estimating urban stormwater loading was difficult due to limited available data, and the high costs associated with sampling to the spatial degree necessary to reduce uncertainty and isolate MS4 contributions. When the following circumstances applied, the Whatcom Creek watershed bacterial WLAs were apportioned based on 1) the permitted MS4 proportional jurisdictional area, 2) the permitted industrial facility stormwater area, or 3) the average reported discharge from the permitted facility point source (Table 7 and Appendix E).

The nonpoint source contribution to the TMDL comprised the LAs, which were based on the proportional area of each subbasin not covered by a permit that contributes to the watershed. When present, both point and nonpoint sources were assumed to contribute to bacteria loads within jurisdictions covered by NPDES stormwater permits. Since data were not available to distinguish between specific point-source and nonpoint-source contributions, the same percent reduction needed to meet the target concentrations was applied to both point and nonpoint discharges to attain the TMDL.

Both the WLAs and the LAs were set to meet the TMDL and therefore the LC. Developed land which contributes runoff to the WLA or LA was estimated to contribute pollutants at the same concentration per unit of surface area, which is therefore expected to contribute equally to the TMDL. Shannahan et al. (2004) indicated that stormwater runoff was a conveyor of contamination in the watershed Stormwater runoff falls into both point source (WLA) and nonpoint source (LA) categories separated only by whether the NPDES permit coverage is required for the discharge.

Persistent pollution sources such as failing onsite sewage systems (OSS) or illicit discharges may also contribute given the high bacteria concentrations observed under non-storm event, or dry conditions. Other persistent pollution sources may come from an improperly functioning sewer conveyance system or cross connections. These persistent pollution sources may be exacerbated by stormwater conveyance through runoff or flushing of the MS4 infrastructure system. Runoff and system flushing occurs regardless of season, which causes difficulty when attempting to separate the exact source of pollution by allocation type — WLA or LA — in the Whatcom Creek watershed.

Each separately evaluated discharge was expected to meet WQS through the means of source control measures to attain the WLA and LA. Providing reasonable assurance that nonpoint source control measures will meet the expected load reductions increases the probability that the pollution reduction levels specified in the TMDL will be achieved and the WQS attained. Reasonable assurance in the context of the Whatcom Creek bacteria TMDL is explained in the Reasonable Assurance section below along with details in the Implementation Plan chapter of this report.

Loading Capacity

Identifying the LC is the crucial step in developing TMDLs for a specific watershed. The LC is the greatest amount of pollutant a water body can receive and still meet WQS. The LC also provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with water quality standards. In a conventional mass based TMDL, the LC is determined for specific streamflow conditions, by calculating the mass that can be assimilated for the given condition. The critical period was determined by assessing seasonal variation. The LC is expressed in mass units per day to form the basis of the TMDL to address the associated AU impairments and all other reach code stream segments at the watershed scale that do not indicate a water quality impairment at this time. The LC is the sum of the WLA, LA, and MOS components in which the TMDL must not exceed.

The LCs for each 303(d) listed water body in the Whatcom Creek watershed were calculated using continuous stream discharge data and the bacterial geomean water quality criterion of 100 cfu/100 mL (Appendices D and E). Similarly, brackish water mixing near the mouth of Whatcom Creek was used to determine the FC LC using a combination of fresh and marine water criteria. Whatcom Creek flow data from the City's continuous gage station at Dupont St. was used to calculate the mainstem LC at the furthest downstream sampling location. The USGS continuous streamflow gage on Euclid Creek at Euclid Ave. (Station # 12202400) was used to estimate tributary discharge from flow rating curve relationships developed by Shannahan et al. (2004) (Appendices D and E).

The daily LCs were calculated using streamflow data averaged by the wet and dry seasons to establish seasonal bacterial TMDLs expressed in b.cfu/day. The critical flow conditions occurred during the dry season when bacteria concentrations were greater than those observed during the wet season (Table 6). Greater bacterial loading, however, was observed during the wet season when compared to the dry season likely driven by the relatively greater stream discharge during the wet season (Appendix D, Table D-21).

To meet the LC, the TMDL for Whatcom Creek at the mouth was roughly 308 times greater than the combined TMDLs for the tributaries during the dry season, and 278 times greater during the wet season (Table 7). The large difference between Whatcom Creek and the combined tributaries was influenced by the relative streamflow magnitude. Whatcom Creek comprises 96 percent of the total streamflow in the watershed, while the tributaries produce a combined 4 percent of total streamflow (Shannahan et al. 2004). When the TMDLs for all water bodies are summed, Whatcom Creek comprises 99.7 percent during the dry season and 99.6 percent during the wet season, while the tributaries combined total the remaining TMDL. Under dry and wet season conditions respectively, Whatcom Creek contributed 98.4 percent and 98.6 percent of the total observed bacterial loading, while the combined tributaries contributed the remainder (Appendix D, Table D-21).

When parsing out the *E. coli* TMDL for Whatcom Creek at the mouth (WHA00.2) by allocation type, the total WLA was roughly 81 percent, the LA was 9 percent, and the explicit MOS was assigned 10 percent. The WLAs assigned to the mainstem included the permitted MS4 areas and permitted industrial facilities. The FC TMDL allocations were assigned to the City MS4 because it is sole permitted area that discharges directly to the mouth of Whatcom Creek and into marine water. The *E. coli* TMDL for Cemetery Creek had a WLA totaling 61 percent of the TMDL, which includes the MS4 permitted areas of the City and County, while the LA was roughly 29 percent of the TMDL, along with a 10 percent MOS. The *E. coli* TMDL for Hanna Creek was comprised of 81 percent WLA, which includes the MS4 permitted areas of the City and County, 9 percent LA, and the 10 percent MOS. The *E. coli* TMDL for Lincoln Creek was comprised of 89 percent WLA, which includes the MS4 permitted areas of the City and County, roughly 0.5 percent LA, and 10 percent MOS. After accounting for the 10 percent MOS, the Fever Creek *E. coli* TMDL was entirely apportioned to a WLA because this subbasin is essentially covered by the City's MS4 permit.

Wasteload Allocations

The largest point source came from the City's MS4, which includes 71.1 percent of the *E. coli* TMDL, followed by the County MS4 at 8.8 percent, and the WSDOT permitted jurisdiction at 0.6 percent (Figure 3 and Table 14 — Reasonable Assurance subsection). The City and County are covered by the Western Washington Phase II Municipal Stormwater NPDES permit, which includes the MS4 infrastructure, and the WSDOT is covered by a similar stormwater permit. The remaining WLAs are addressed by other NPDES permits held by; the Washington State Department of Fish and Wildlife (WDFW) Bellingham Hatchery, Brooks Manufacturing, and the Haskell Corporation. Unless the permitted facility produced effluent, each WLA and LA was determined using the relative proportional area covered under permit as a point source and the relative proportional area not covered by a permit as a nonpoint source respectively (Appendix E). The WLA was effluent-based in the event the permitted facility produced effluent that discharged to surface water.

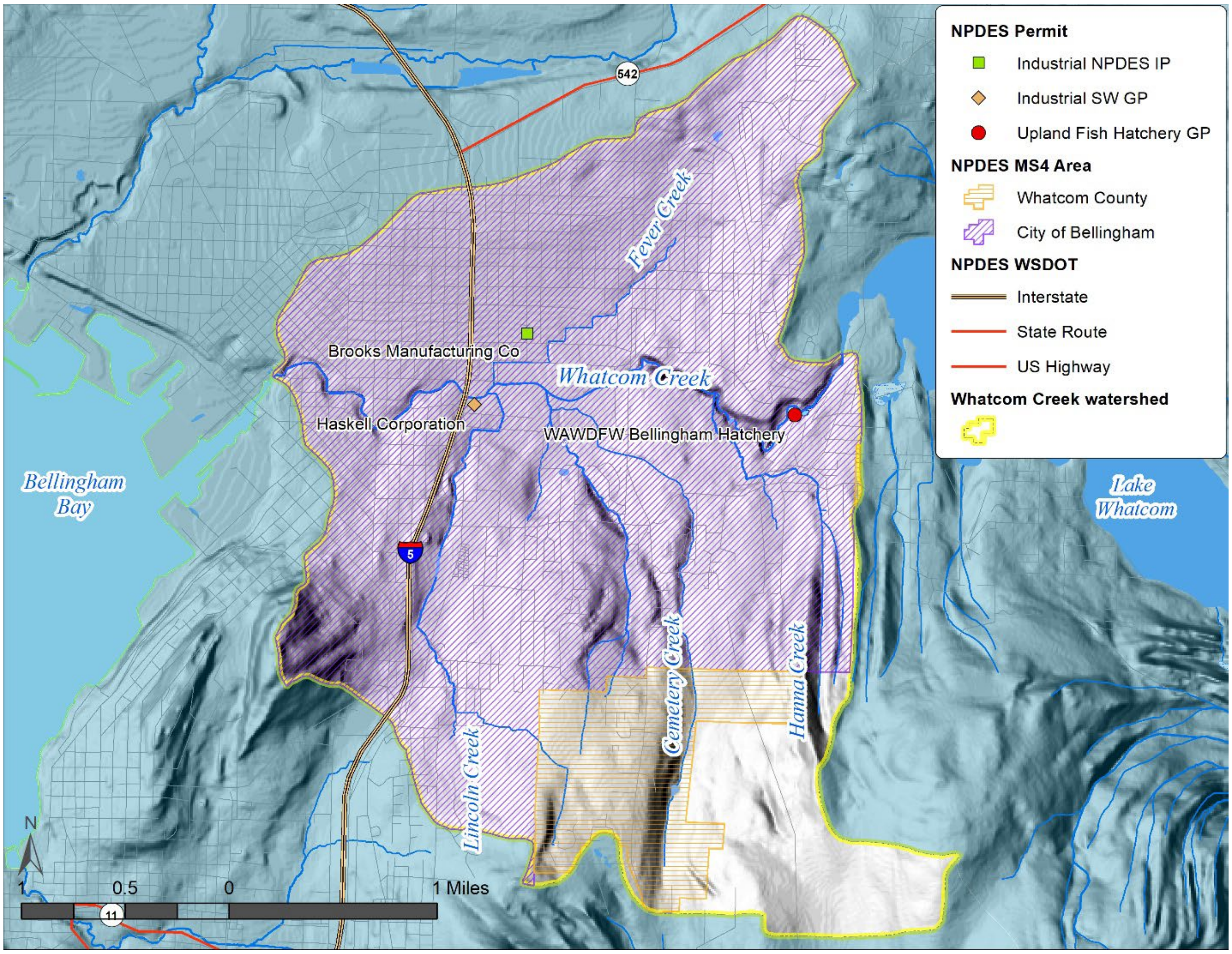


Figure 3. National Pollution Discharge and Elimination System (NPDES) permitted sources in the Whatcom Creek watershed TMDL area

Areal-based allocations were used to describe the relative amount of both point and nonpoint source inputs to the receiving water bodies using watershed catchment area (Appendix E, Table E-24). The following areal-based allocations were proportioned after accounting for the 10 percent MOS and any applicable effluent-based allocation. The areal-based allocations contributing to the Whatcom Creek watershed *E. coli* TMDL included 89.5 percent WLA with the remaining 10.5 percent identified as LA. The areal-based allocations contributing to the Lincoln Creek subbasin TMDL included 99.4 percent WLA with the remaining 0.6 percent identified as LA. The areal-based allocations contributing to the Fever Creek subbasin TMDL included 100 percent WLA with 0 percent identified as LA. The areal-based allocations contributing to the Cemetery Creek subbasin TMDL included 82.9 percent WLA with the remaining 17.1 percent identified as LA. The areal-based allocations contributing to the Hanna Creek subbasin TMDL included 90.5 percent WLA with the remaining 9.5 percent identified as LA. Any area that discharges directly to Whatcom Creek or one of its tributaries without passing through a municipal storm sewer system is a nonpoint source.

The NPDES permits are directly enforceable and regulatory mechanisms. Implementation actions specified within each permit are expected to contribute to the attainment of the WLA and TMDL. The TMDL WLAs will be used to inform NPDES permit development and renewal. Permit limits and pollution prevention actions must be written in a manner consistent with the assumptions and requirements of this TMDL that will contribute to the attainment of the WQS. The WLAs incorporated seasonal variation. The dry season required a greater degree of protection, *i.e.*, percent reduction, than those determined for the wet season. During the wet season, however, the WLAs were generally much larger than those of the dry season.

Entities under permit that do not have water quality-based effluent limit requirements will continue to require pollution control and prevention actions that minimize bacterial pollution to attain the TMDLs. Routine water quality information collected by the USMP represent the most readily available way to estimate the efficacy of pollution prevention actions in the greater watershed area. Additional information is needed and therefore sampling for *E. coli* to some degree shall be incorporated into the NDPES permit when the entity under permit is determined to be a significant source. When assessing pollution control and prevention activities, bacteria sampling shall occur on an as needed basis to confirm attainment of the assigned WLA. When a receiving water body reach fails to meet the WQS, the permitted organization that discharges to the receiving stream reach shall sample for bacteria from pertinent outfalls upon request or based on permit requirements.

All NPDES discharges including MS4, general industrial stormwater, and general industrial will receive a WLA aggregated to attain the TMDL reductions necessary near the mouth of Whatcom Creek and at each tributary (Table 7 and Appendix E, Table E-22). Permits for stormwater discharge may use mandatory activities as the means of meeting the WLAs, instead of only requiring direct water quality monitoring measurements at representative outfalls. Each general municipal stormwater permit covers the discharge to the surface water from the MS4s maintained by the County, City, and WSDOT.

Individual and general permits for industrial activities include Brooks Manufacturing Co. (Brooks) and Haskell Corporation respectively. The WDFW Bellingham Fish Hatchery operates under the general upland finfish hatchery permit. The aggregated WLAs where compiled and then separated based on jurisdictional area or effluent depending on the facility. The calculated stormwater discharge for Brooks was based on the information provided in the permit and monthly reporting. The effluent discharge from the WDFW Bellingham Fish Hatchery was based on the permit and monthly reporting.

In this TMDL, the point and nonpoint sources both have diffuse discharge locations except for the WDFW Bellingham Fish Hatchery, Brooks, and the Haskell Corporation as detailed in this section below. When the WLA is attributed to MS4 permitted areas, both the LAs and WLAs are assumed to produce equal rates of loading to the system, which have been disaggregated and portioned by their relative area of the watershed subbasin (Appendix E, Tables E-22 — 24, and Figures E-31 and 32). The WLAs assigned to each MS4 and general industrial stormwater permitted discharger were separated by the percent jurisdictional area relative to the area of the Whatcom Creek watershed and each tributary watershed. Each permitted area will include stormwater discharge points as an aggregate to address the multiple outfalls of each individual MS4 permit holder. The WLAs covered by facility permits will be separated based on each facility's reported discharge rate or stormwater catchment area. Future urban growth or new facilities that require NPDES permits shall use similar methods to develop WLAs to ensure that the TMDL does not exceeded the LC (Appendix E).

General Construction Stormwater Permits

General construction stormwater NPDES permits cover construction activities that disturb more than one acre. General construction stormwater permits in the watershed did not receive explicit WLAs because they typically represent an insignificant source of bacteria pollution due to the minimal potential to pollute and are temporary in nature by being active only for the duration of the construction project (EPA 2020). For purposes of attaining TMDL goals, however, general construction permits shall receive a performance-based limit associated with nearest downstream WLA based on meeting the WQS.

WDFW Bellingham Hatchery

The WDFW Bellingham Hatchery has authorization under the Washington State's Upland Finfish Hatching and Rearing NPDES General Permit to discharge near the headwaters of Whatcom Creek (permit WAG994275). The hatchery is a small facility and since 1990 has had occasional permit coverage as fish production ceased or was beneath the production threshold requirement. Since 2013, the hatchery has typically raised trout from October to April in conjunction with Bellingham Technical College Fish Hatchery Technician education program. The 2021-2026 permit cycle planned maximum fish production on station in one month is 19,500 pounds in April. The hatchery's primary influent is surface water from Lake Whatcom and, very rarely, Whatcom Creek. The water flows through the fish rearing structures (i.e., self-cleaning circular ponds) and eventually discharges effluent to Whatcom Creek at the average rate of approximately 1.5 million gallons per day (2.3 cfs).

Considering the pollutants associated with fish hatching and rearing facilities, Ecology has determined that discharges to waterbodies listed for fine sediment, temperature, pH (phosphorus-controlled), and dissolved oxygen must comply when approved TMDLs apply[10]. Overall, the pollutants of concern in hatchery effluent includes nutrients, temperature (heat load), polychlorinated biphenyls, disease control chemicals, and chlorine. Ecology does not usually develop permit limits for pollutants not reported in the permit application but that may be present in the discharge. For example, *E. coli* does not have a reasonable potential to cause a water quality violation because hatcheries are not considered a likely source[11]. The permit does not authorize discharge of non-reported pollutants, which are pollutants that exist or have potential to exist in the discharge at concentrations that could cause or contribute to a violation of a WQS.

Up through the late 1970's, trout and salmon fish feed often consisted of offal from cows, pigs, and chickens (i.e., remnants from slaughter for human consumption) that contained incidental bacteria that could pollute receiving water bodies when used. The potential of fish feed as a bacteria pollution source, however, has since been addressed as the industry no longer uses offal as a protein source. Hatchery-reared trout and salmon are now fed a controlled diet of dry, pelletized fish feed that is processed under heat and pressure to remove bacterial pathogens. Fish feed is regulated by the Washington State Department of Agriculture and U.S. Food and Drug Administration. The WDFW Bellingham Hatchery does not likely discharge the pollutant of concern because fish do not produce *E. coli* or FC bacteria, and the historic issues with bacteria contaminated feed as a pollution source has been remedied.

Performance-based limitations known as source controls, however, shall be implemented to ensure bacteria loading does not occur. Specifically, as a component of permit compliance the hatchery must implement strategies to discourage wildlife from congregating when attracted to any aspect of facility operation because high counts or frequent occurrences of wildlife are potential sources of bacteria pollution.

[10] https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Upland-finfish-permit
[11] https://www.epa.gov/system/files/documents/2022-09/R10-NPDES-Washington-Aquaculture-GP-WAG130000-Fact-Sheet-2022.pdf

The Bellingham Fish Hatchery is not considered to be a likely source of pathogens that affect human health. As such, when in operation, an effluent based WLA was assigned using the bacterial concentration of 2 cfu/100mL, which is the increment where water quality change to a receiving water body can be measured in the discharge based on the state WQS for Antidegradation: Tier II protection for existing dischargers. In other words, discharges below this concentration will not cause measurable change to existing water quality. The WLA for the WDFW Bellingham Fish Hatchery is 0.11 b.cfu/day (Table 8), which totals approximately 0.1% of the TMDL during the dry season, and 0.02% during the wet season (Table 14). The discharge is expected to be well below the 100 cfu/100mL WQS criterion. *E. coli* monitoring may be requested, as specified under G3(4) of the permit, to ensure the facility is effectively following BMPs that prevent and control *E. coli* pollution.

Brooks Manufacturing Co. WLA

The Brooks industrial individual permit covers the proper handling and storage of wood preservation materials used for the onsite production of treated wood. The individual permit addresses treated wood process wastewater and stormwater runoff from buildings and property that covers 11.2 acres. The onsite treatment of process wastewater prevents chemical contaminants from entering Whatcom Creek to achieve zero discharge of process wastewater to surface water. Stormwater treatment is accomplished by retention, sedimentation, and biological and photo degradation in the stormwater collection ponds.

Stormwater discharge from the pond enters a nearby drainage ditch that appears to flow into a branch of Fever Creek at Iowa Street, which ultimately discharges to Whatcom Creek near Nevada Street. The permit states that the treated stormwater discharges to a ditch that drains into Whatcom Creek. The stormwater discharge outfall from Brooks is downstream of the USMP routine water quality sampling site on Fever Creek. The WLA for the Brooks facility is based on attaining the TMDL established at the downstream most sampling location on Whatcom Creek at Dupont Street. The permit requires the development and implementation of a Stormwater Pollution Prevention Plan (SWPPP) to assure that stormwater discharges do not degrade the water quality of Whatcom Creek.

Brooks, however, was not considered to be a significant source of bacterial pollution because 1) operations do not produce or handle bacterial waste, 2) routine sweeping throughout the property occurs as a BMP, and 3) stormwater is treated in settling ponds. Establishing the WLA for Brooks to address treated stormwater runoff allows discharge at or below the *E. coli* WQS. Brooks received a WLA of 0.09 b.cfu/day based on their calculated stormwater discharge of 0.0227 million gallons per day (0.035 cfs), which accounts for the intermittent characteristic of stormwater discharge (Table 9). The Brooks WLA totals approximately 0.1 percent of the TMDL during the dry season, and 0.02 percent during the wet season (Table 14). The BMP-based approach, which includes additional stormwater treatment already in the permit will satisfy the attainment of the WLA and ensure permit compliance. Stormwater outfall monitoring, however, may be required upon request to ensure the Brooks facility does not discharge above the *E. coli* WQS in the future.

Haskell Corporation WLA

The Haskell Corporation industrial stormwater general permit covers metal product manufacturing at the facility located downstream of the Lincoln Creek and Whatcom Creek confluence. The permit regulates the discharge of contaminated stormwater to Whatcom Creek. The permit requires the development and implementation of a Stormwater Pollution Prevention Plan SWPPP, which includes BMPs to minimize the impacts to Whatcom Creek. The Haskell Corporation received a WLA of 0.09 b.cfu/day during the dry season and 0.5 b.cfu/day during the wet season (Table 10). Approximately 0.1 percent of the TMDL was apportioned to the Haskell Corporation based on the facility area that is proportional to the total watershed area covered by all other NPDES permits to the receiving water body (Table 14). When stormwater sampling, the Haskell Corporation should meet the geometric mean of 97 cfu/100 mL to attain the WLA in the TMDL and for the purpose of permit related development. The WLA for the Haskell Corporation facility was based on attaining the TMDL established at the downstream most sampling location on Whatcom Creek at Dupont Street.

Municipal Stormwater WLAs

The central means of controlling pollution discharged within the municipal stormwater infrastructure are the actions conducted under the Stormwater Management Program (SWMP) of each permittee. Many of the SWMP actions, however, are equally applicable to reducing pollution discharges from nonpoint sources that have an associated LA. Program elements such as public education and outreach have essentially the same impact on all stormwater discharges regardless of whether they enter a municipal stormwater system or are discharged directly to a receiving water body as a nonpoint source.

The City and the County are permitted under the Western Washington Phase II NPDES for the discharge of stormwater from their MS4 system to surface water bodies of the state. The WSDOT has a permit to discharge stormwater to surface water bodies under its specific municipal stormwater permit. The WLAs for each permitted jurisdiction were established for the mainstem of Whatcom Creek and its primary tributaries (Table 7). The City's permitted MS4 received the WLA for FC because it is the only entity that discharges directly to the downstream most reach of Whatcom Creek before it enters marine water. All other point sources do not directly discharge to the downstream most reach of Whatcom Creek and therefore did not receive an associated FC WLA. Tables 11 — 13 show permit WLAs for the City, County, and WSDOT respectively. When including the entire watershed based on permitted area, the City will receive 71.1 percent of the TMDL, followed by the County at 8.8 percent, and the WSDOT at 0.6 percent (Table 14).

Table 8. Wasteload allocation for the WDFW Bellingham fish hatchery NPDES general permit

Permittee Name	**Washington Department of Fish and Wildlife - Bellingham Hatchery**
Permit Number	WAG994275
Permit Type	Upland Finfish Hatching and Rearing General Permit
Water body Names	Whatcom Creek
Listing IDs of Receiving Water	88957
WLA (billion cfu/day)	***E. coli* Bacteria Concentration-based Limit (cfu/100 mL)**
0.11	Dry or Wet season: 100 maintains the WQS
Other Load Limits and Requirements	Critical Period: Dry season (May — Sept)
	Do not allow unusually high densities of birds or mammals to congregate at the facility (i.e., deter and prevent fish predation) Incorporate pollution control and prevention activities in support of the bacteria TMDL
	Monitor for *E. coli* in effluent or other hatchery locations upon request
	Current permit cycle dates: effective 10/1/2021, expiration 9/30/2026

Table 9. Wasteload allocation for the Brooks Manufacturing Company NPDES individual permit

Permittee Name	**Brooks Manufacturing Company**
Permit Number	WA0030805
Permit Type	Industrial Individual Permit
Water body Names	Drainage ditch to Whatcom Creek
Listing IDs of Receiving Water	89130
WLA (billion cfu/day)	***E. coli* Bacteria Concentration-based Limit (cfu/100 mL)**

Dry season: 0.09	Dry season: 97 attains the target and percent reduction
Wet season: 0.09	Wet season: 27 maintains the observed concentration
Other Load Limits and Requirements	Critical Period: Dry season (May — Sept)
	Monitor for *E. coli* in effluent or other locations upon request
	Current permit cycle dates: effective 1/1/2021, expiration 12/31/2025
	Incorporate TMDL WLA, concentration-based limits into next permit cycle

Table 10. Wasteload allocation for the Haskell Corporation NPDES general permit

Permittee Name	Haskell Corporation
Permit Number	WAR127009
Permit Type	Industrial Stormwater General Permit
Water body Names	Whatcom Creek
Listing IDs of Receiving Water	89130
WLA (billion cfu/day)	***E. coli* Bacteria Concentration-based Limit (cfu/100 mL)**
Dry season: 0.09	Dry season: 97 attains target and percent reduction
Wet season: 0.5	Wet season: 27 maintains observed concentration
Other Load Limits and Requirements	Critical Period: Dry season (May — Sept)
	Monitor for E. coli in effluent or other locations
	Current permit cycle dates: effective 1/1/2020, expiration 12/31/2024
	Incorporate TMDL WLA, concentration-based limits, and percent reductions into next permit cycle

Table 11. Wasteload allocations for the City of Bellingham MS4 NPDES general permit

Permittee Name	City of Bellingham
Permit Number	WAR045550
Permit Type	Municipal separate storm sewer systems (MS4) Phase II, Western WA
Water body Names	Whatcom, Hanna, Fever, Cemetery, Lincoln Creeks
Listing IDs of Receiving Water	39061, 88094, 39089, 45565, 88171, 39110, 88254, 16408, 88957, 89130
WLA (billion cfu/day)	***E. coli* and FC Bacteria Concentration-based Limit (cfu/100 mL)**
Whatcom Creek	Whatcom Creek
Dry season: 63.4	Dry season: 97 attains target and percent reduction
Wet season: 394.9	Wet season: 27 maintains observed concentration
Whatcom Creek$^{\text{Fecal Coliform}}$	Whatcom Creek$^{\text{Fecal Coliform}}$

Dry season: 17.7	Dry season: 22 attains target and percent reduction
Wet season: 125.0	Wet season: 25 attains target and percent reduction
Cemetery Creek	Cemetery Creek
Dry season: 0.02	Dry season: 99 attains target and percent reduction
Wet season: 0.14	Wet season: 63 attains target and percent reduction
Fever Creek	Fever Creek
Dry season: 0.06	Dry season: 76 attains target and percent reduction
Wet season: 0.45	Wet season: 61 attains target and percent reduction
Hanna Creek	Hanna Creek
Dry season: 0.05	Dry season: 97 attains target and percent reduction
Wet season: 0.35	Wet season: 100 maintains the WQS
Lincoln Creek	Lincoln Creek
Dry season: 0.07	Dry season: 45 attains target and percent reduction
Wet season: 0.47	Wet season: 77 attains target and percent reduction
Other Load Limits and Requirements	Critical Period: Dry season (May — Sept)
	Focus Illicit Discharge Detection Elimination (IDDE) in catchments draining to creeks with elevated bacterial concentrations and prioritize source control inspections
	Participate in monitoring and trend assessments
	Current permit cycle dates: effective 8/1/2019, expiration 7/31/2024
	Incorporate TMDL WLA, concentration-based limits, and percent reductions into next permit cycle

Table 12. Wasteload allocations for the Whatcom County MS4 NPDES general permit

Permittee Name	Whatcom County
Permit Number	WAR045557
Permit Type	Municipal separate storm sewer systems (MS4) Phase II, Western WA
Water body Names	Whatcom, Cemetery, Hanna, Lincoln Creeks
Listing IDs of Receiving Water	89130, 88957, 88171, 39061, 88094, 39110
WLA (billion cfu/day)	***E. coli* Bacteria Concentration-based Limit (cfu/100 mL)**
Whatcom Creek	Whatcom Creek
Dry season: 7.4	Dry season: 97 attains target and percent reduction
Wet season: 48.3	Wet season: 27 maintains observed concentration
Cemetery Creek	Cemetery Creek
Dry season: 0.01	Dry season: 99 attains target and percent reduction
Wet season: 0.07	Wet season: 63 attains target and percent reduction
Hanna Creek	Hanna Creek
Dry season: 0.007	Dry season: 97 attains target and percent reduction
Wet season: 0.05	Wet season: 100 maintains the WQS

<u>Lincoln Creek</u>	<u>Lincoln Creek</u>
Dry season: 0.01	Dry season: 45 attains target and percent reduction
Wet season: 0.07	Wet season: 77 attains target and percent reduction
Other Load Limits and Requirements	Critical Period: Dry season (May — Sept)
	Focus Illicit Discharge Detection Elimination (IDDE) in catchments draining to creeks with elevated bacterial concentrations and prioritize source control inspections
	Participate in monitoring and trend assessments
	Current permit cycle dates: effective 8/1/2019, expiration 7/31/2024
	Incorporate TMDL WLA, concentration-based limits, and percent reductions into next permit cycle

Table 13. Wasteload allocations for the Washington State Department of Transportation NPDES general stormwater permit

Permittee Name	Washington State Department of Transportation
Permit Number	WAR043000A
Permit Type	General stormwater permit
Water body Names	Whatcom Creek
Listing IDs of Receiving Water	16408 and 89130
WLA (billion cfu/day)	***E. coli*** **Bacteria Concentration-based Limit (cfu/100 mL)**
Dry season: 0.54	Dry season: 97 attains target and percent reduction
Wet season: 3.4	Wet season: 27 maintains observed concentration
Other Load Limits and Requirements	Critical Period: Dry season (May — Sept)
	Focus Illicit Discharge Detection Elimination (IDDE) in catchments draining to creeks with elevated bacterial concentrations
	Current permit cycle: effective 4/5/2019, expiration 4/5/2024
	Incorporate TMDL WLA, concentration-based limits, and percent reductions into next permit cycle

Load Allocations

Load allocations are allowable pollutant loads attributed to nonpoint pollution or natural background sources. A portion of the total TMDL was determined using areal-based allocations, which was based on the relative percent watershed area either covered by a permit or not (Appendix E). The nonpoint source LAs were therefore set in this TMDL based on the proportional area of the watershed, or subbasin, not covered under an NPDES permit. The ambient monitoring sample design by the USMP that informed the development of this TMDL did not distinguish nonpoint sources from the point sources in the permitted MS4. If nonpoint sources are later mapped and segregated, success in meeting the TMDL target will still depend on effective control of stormwater pollutants and all other sources.

After accounting for the 10 percent MOS, the Whatcom Creek mainstem will receive the greatest relative LA at 8.4 b.cfu/day during the dry season and 52.3 b.cfu/day during the wet season followed by all other tributary subbasins combined (Table 7). Proportionally, the LA for Whatcom Creek will receive 9.4 percent of the TMDL, while the areal-based WLA will receive the remaining 80.6 percent along with a minimal contribution from the WDFW Bellingham Fish Hatchery and Brooks (Appendix E). Similarly, all tributaries to Whatcom Creek will receive allocations based on the proportional subbasin area either covered under permit or not. The tributaries did not receive an effluent based WLA because this type of permitted discharge does not occur and therefore does not apply.

The LA for the Lincoln Creek subbasin will receive roughly 0.5 percent of the TMDL, while the WLA will receive roughly 90 percent after accounting for the MOS. The Cemetery Creek subbasin will receive roughly 26.5 percent of the TMDL as a LA, while the remaining 63.5 percent will receive a WLA after accounting for the MOS. The Hanna Creek subbasin will receive roughly 20 percent of the TMDL as a LA, while the remaining 70 percent will receive a WLA after accounting for the MOS. The Fever Creek subbasin did not receive a LA because it is entirely covered under the City's MS4 permit and loads associated with nonpoint sources were not isolated by routine water quality sampling methods.

Load allocations for the Whatcom Creek bacteria TMDL were associated with each specific receiving water body monitoring location within the AU. The TMDLs were established to account for nonpoint source land uses within each catchment that drains to and therefore influences the water quality of the receiving AU. Load allocations are often addressed through a variety of pollution control and prevention activities, educational programs, and other means. Many of the same pollution control activities that address LAs are like those used to address WLAs, however, the legal and regulatory mechanisms of enforcement differ.

Because nonpoint pollution comes from diffuse sources, all upstream activities within the drainage area have the potential to affect downstream water quality. Other potential sources of bacteria pollution in the watershed not currently under NPDES permit include failing onsite sewage systems (OSS) or direct deposit of bacteria pollutant to the receiving water body outside of a permitted area. The allocations for such sources are expressed as the LAs contingent on the source remaining unpermitted by the MS4 NPDES. The same percent reduction needed to meet the TMDLs are applied to both the WLA and LA as previously described (Tables 6 and 7).

Margin of Safety

The federal Clean Water Act requires that TMDLs include a margin of safety (MOS). The MOS can be stated explicitly by setting a specific allocation as a MOS, or as an implicit MOS by using conservative assumptions in the use of data, analysis, and the effectiveness of proposed management practices. Similar to EPA (2020), the explicit ten percent MOS was allocated in each TMDL to account for uncertainty in these bacteria TMDLs. Additionally, an implicit MOS was applied because the TMDL did not consider bacteria die-off using a natural decay rate coefficient. Although sunlight and temperature reduce bacteria survival, it was assumed that FC and *E. coli* bacteria entering the watershed will stay active and suspended in the water column to the mouth of the water body with no die-off.

Reserve Capacity

The reserve capacity was not included in the TMDL because:

1) Additional point sources to the receiving water bodies in terms of individual or general industrial permits will require minimal WLAs. For example, Table 14 indicates that industrial permits comprise roughly 0.2 percent of the TMDL for Whatcom Creek. In the future, if an area of land is converted to a use that requires coverage under an NPDES permit, the associated LA will be retired and an equal WLA will be available to the permitted point source. Based on the watershed unit area conversion for the TMDL, this new permitted area will receive an area-based (areal) WLA following the example in Appendix E using Tables E-22 through E-24, and Equation 18.

2) Another type of effluent based WLA may include the addition of a new wastewater treatment facility, however this is not likely. The Post Point facility, which discharges to marine waters, has the capacity to treat associated discharges from the receiving infrastructure of the urban areas from the city of Bellingham including the adjacent urban growth areas. Considering future urban growth, the existing Post Point facility will be expanded as needed to treat additional discharges, which is not located in the Whatcom Creek watershed.

3) Bacteria pollution has generally decreased over time despite increased urban growth in the Whatcom Creek watershed. Future population growth has the potential to exert water quality degradation stressors unless pollution control efforts remain effective. McCarthy (2020b), however, demonstrated decreasing trends in bacteria concentrations along Whatcom Creek and Cemetery Creek from 2002 through 2018, while during this time, the city of Bellingham has experienced a 25% population growth determined using the Washington State Office of Financial Management[12] statistics (Appendix A).

Reasonable Assurance

Ecology believes that the pollution identification and control activities described in the Implementation Plan section of this report support the TMDL and addresses both the WLAs and LAs. Ecology assumes that the implementation activities are continued and maintained to reduce bacteria pollution to attain the TMDL and associated WLAs and LAs. When establishing a TMDL, reductions of a particular pollutant are allocated among the pollutant sources — both point and nonpoint sources — in the water body. The TMDL must show reasonable assurance that these sources shall be reduced to their allocated amount.

[12] https://ofm.wa.gov/washington-data-research/population-demographics

The point sources expressed as WLAs shall be addressed by fulfilling the established regulatory permit requirements and pollution control strategies as informed by this TMDL. The nonpoint sources expressed as LAs shall be addressed using similar pollution control strategies under cooperative management of these areas, which includes state and local code enforcement along with responsible public conduct. Adaptive management shall provide the foundation for evolving water quality improvement strategies based on the development of new information and pollution control activities. Documenting sufficient reasonable assurance increases the probability that regulatory and voluntary mechanisms will be applied to the level of pollution reduction identified in the TMDL to attain the WQS.

Allocations by Source and Watershed Area

The City, County, WSDOT, and Haskell Corporation shall receive stormwater based WLAs using each entity's relative managed area in the watershed (Appendices D and E). The total stormwater based WLA for the watershed was roughly 80.6 percent of the TMDL (Table 14). The remaining allocations of the TMDL include 9.4 percent LA and the 10 percent MOS. The total stormwater based WLA was therefore roughly eight times greater than the LA, and the LA was slightly less than the MOS.

Table 14. Whatcom Creek watershed permitted areas and discharge allocations expressed as a percentage of the total TMDL

NPDES permit	Area (acres)	Proportion of Watershed-wide Allocation and MOS (%)
WDFW Bellingham Hatchery WAG994275	—	(dry / wet) 0.1 / 0.02%
Brooks Manufacturing Co. WA0030805	—	(dry / wet) 0.1 / 0.02 %
Haskell Corporation WAR127009	6.2	0.1%
City of Bellingham WAR045550	4562	71.1%
Whatcom County WAR045557	565	8.8%
WSDOT WAR043000A	51.8	0.6%
Total watershed area	5790	
Total permitted stormwater area and WLA	5185	80.6%
Total non-permitted area and LA	605	9.4%
Margin of Safety (MOS)	—	10%

— does not apply to the given allocation

Managing LAs

The central means of controlling pollution discharged within the municipal stormwater infrastructure are the actions conducted under the Stormwater Management Program (SWMP). Many of the SWMP actions, however, are equally applicable to reducing pollution discharges from nonpoint sources that have an associated LA. Program elements such as public education and outreach have essentially the same impact on all stormwater discharges regardless of whether they enter a municipal stormwater system or are discharged directly to a receiving water as a nonpoint source.

The LAs shall be addressed by working with homeowners that have OSS to safeguard the importance of system maintenance and the associated water quality impacts under system failure. Other actions include the use of pet waste stations along with responsible citizen involvement that equally apply to the WLAs and LAs as pollution prevention measures. For example, the cooperative management of the Galbraith Mount Recreational Area is largely outside of the permitted MS4 area and shall receive a LA for that portion of the Whatcom Creek watershed and receiving tributaries such as the Hanna and Cemetery Creek subbasins. Extending pet waste programs and public education provides reasonable assurance that the LA will be met.

State and local ordinances also provide reasonable assurance that the LAs will be met — see Implementation Plan chapter of this report. For example, Ecology is authorized under Chapter 90.48 RCW to impose strict requirements or issue enforcement actions to achieve compliance with state WQSs. It is, however, the goal of all participants in the TMDL process to achieve clean water through cooperative efforts. For example, the Environmental Reporting and Tracking System (ERTS)[13] is a statewide forum that connects local governments and state agencies when responding to an immediate pollution concern. Each reported issue is assigned a tracking number along with follow up personnel. Each governmental agency has a plan in place to address pollution concerns that can be coordinated through the ERTS. Local jurisdictions have similar environmental reporting forums that address water quality pollution.

Some known bacteria-related issues reported in the Whatcom Creek include fecal waste pollution in the riparian areas that may be address through the ERTS or other local forums. Follow up pollution prevention actions may be authorized under Chapter 90.48 RCW or other local ordinances that address nonpoint source pollution associated with the LAs. Other nonpoint sources may include OSS, which has a set of regulatory rules to address pollution prevention and routine maintenance that is the responsibility of the owner.

[13] https://ecology.wa.gov/Footer/Report-an-environmental-issue

Monitoring Trends

The City's USMP is a long-term status and trends, and effectiveness monitoring program spanning over 30 years. Water quality monitoring data indicates significant decreasing trends in bacteria pollution on Whatcom and Cemetery Creeks from 2002 through 2018, while Hanna, Lincoln, and Fever Creeks show no significant trends in bacterial concentrations (McCarthy 2020b and Appendix A). The decreasing bacteria concentrations suggests that pollution identification and control efforts lead by the City have been effective.

Continued pollution control efforts, however, are necessary to attain the TMDL. Water quality trend analysis may be extended to include future monitoring efforts and determine water quality improvement progress. Measuring FC near the mouth of Whatcom Creek will determine TMDL attainment to protect downstream shellfish harvesting. Measuring FC and using the bacteria translator is one option when assessing the attainment of the *E. coli* TMDL. The direct measurement of *E. coli* concentrations, however, must be used to determine the attainment of the WQS for fresh waters, Ecology (2018), and is another way to determine the attainment of the TMDL allocations. Education, outreach, technical and financial assistance, permit administration, and enforcement shall also provide the means to ensure that the goals of this TMDL are met.

TMDL Calculation

Water quality sampling stations located along Whatcom Creek and at the most downstream location feasible for each tributary provided the information for TMDL calculations using 2017 through 2018 two-year dataset collected by the USMP. The seasonal variation assessment included a dry season from May through September, and a wet season from October through April to determine the potential of a critical period — see Seasonal Variation Subsection and Figure 2 for details.

The *E. coli* LC was determined based on the mean seasonal stream discharge and meeting the geomean *E. coli* WQS criterion of 100 cfu/100 mL (Appendices D and E). The FC LC was determined using 22 and 25 cfu/100 mL, which accounts for the mixing of fresh and marine waters and seasonal variation (Appendices D and E). The TMDL for each 303(d) listing — reach code AU — was determined using the weighted catchment drainage area and each contributing allocated source to account for the entire watershed (Appendix E, Tables E-22 — 24).

The TMDL included a 10 percent MOS that was determined for each reach code AU. Accounting for seasonal variation, the percent reductions and TMDL target geometric means were established for each of the eight sampling sites (Table 6). The TMDL targets and percent reductions quantify the amount of pollution reduction necessary to achieve or be within the LC.

The TMDL represents a distribution of bacteria counts over time that has a geomean when attainted, will meet water quality criteria (Table 6). The TMDLs, LCs, WLAs, and LAs were expressed in terms of mass unit-per-time (b.cfu/day) as loads (Table 7). Washington State water quality criteria for bacteria, however, are expressed as concentration such as mass-per-volume (cfu/100 mL) and the 10 percent not to exceed the STV. The Washington State water quality criteria are therefore not expressed as loads.

Washington State bacteria TMDLs typically use a combination of loads and percent reductions to define the LCs and load allocations (Lawrence and Swanson 2013, Lawrence 2009, Mathieu and James 2011, McCarthy 2020a, Hood and Joy 2000, Pickett 1997, Swanson 2008). All target geometric means were set below the geometric mean portion of the criterion, ensuring that the full LC will not be used. Further, when all allocations and the MOS are summed the underlying count distributions are combined and the sum of the allocations will not exceed the LC. When the TMDLs are attained, it is assumed that the WLAs and LAs will be met for each AU to establish the protection of designated uses.

The LC, WLAs, and LAs were updated from 2002 — 2003 conditions using 2017 — 2018 data, following methods consistent to those described in the Shannahan et al. (2004) report along with the dataset update from McCarthy (2020b) and applying the *E. coli* and FC WQS. The more recent dataset characterizes existing watershed conditions, which accounts for pollution control activities that likely improved water quality in many catchments since 2003 (Appendix D). The TMDL was based on the 2017 — 2018 two-year USMP dataset to reduce uncertainty in the load calculations and seasonal variation analysis. The two-year dataset provided an acceptable level of certainty based the data distributions used to calculate the target geometric means and percent reductions for implementation purposes and TMDL establishment (Appendix D, Figures D-20 — 27).

The data collected by the USMP has been instrumental for TMDL development. Uncertainty in the TMDL calculation was attributed to the variability associated with limited temporal and spatial sampling frequency conducted by the USMP and the inherent variability associated with discrete bacteria sampling and lab analysis. Discrete sampling for bacteria, however, is the most common and cost-effective approach when assessing water quality conditions. Watersheds are inherently continuous systems that are difficult to characterize using discrete information, or sample data points. By utilizing the USMP datasets, the information provided in this TMDL represents the best available assessment of the pollution reduction needed to meet the WQS.

Implementation Plan

Introduction

Ecology worked with interested parties including the City of Bellingham (City), Whatcom County (County), and Washington State Department of Transportation (WSDOT) to develop this TMDL and Implementation Plan. The Implementation Plan describes what needs to be done to improve water quality and details the roles of each project partner governmental organization. The goal is for the Whatcom Creek system to be at or below the TMDL, which allows each water body in the watershed to consistently meet the Washington State Water Quality Standards (WQS) for bacteria that supports designated uses. The expected outcome is to attain the TMDL and meet the WQS when activities described in this Implementation Plan are fulfilled. Grants are identified to help fund existing water quality improvement programs and future innovative projects. Loans are identified to provide budget relief when implementing water quality improvement activities.

Water quality cleanup and protection actions are prioritized based on 1) the locations in the watershed with the highest relative pollution levels, 2) identification of potential pollution sources, and 3) working within the existing improvement programs — such as stormwater NPDES permits. The progress of this TMDL implementation effort will be measured by documenting pollution control activities underway or completed and the direct measurement of in-stream or effluent water quality. Many pollution control activities are covered by NPDES permits that require control, prevention, and documentation to reduce and eliminate sources.

For added flexibility in water quality monitoring strategies that guide implementation actions, the Whatcom Creek TMDL is expressed in three ways to meet the WQS:

1. Mass-based (b.cfu/day),
2. Concentration-based (cfu/100 mL), and
3. Percent reduction.

Ecology anticipates that if state and local coordination proceed as expected and resources remain available, by December 2042 each of the sampling stations within the watershed will follow the state primary contact recreation standards. Continued water quality monitoring, protection, and preservation is necessary to inform the adaptive management process. Ecology will not use FC samples collected after 2020 to determine the protection of freshwater contact recreation beneficial (Ecology 2018). Water quality effectiveness monitoring and comparison to the Washington State WQS shall be done using *E. coli* data and is recommended in this Implementation Plan. Determining the protection of shellfish harvesting shall be done using FC data collected near the mouth of Whatcom Creek.

There is a significant degree of interest in the Whatcom Creek watershed evident by the number of public and private organizations with established programs for monitoring, protection, and restoration. The City, the County, and the WSDOT are already proactive at identifying and addressing water quality issues. For example, the City and Ecology worked together to identify the sources of pollution as part of activities funded by a Centennial Clean Water Fund grant that was applicable before the MS4 NPDES permit was actuated. Water quality data from the City's USMP and dry weather outfall sampling, Geographic Information System (GIS) analysis, and windshield surveys were used to identify potential bacteria sources to develop the initial phase this TMDL (Shannahan et al. 2004). Effectiveness monitoring was conducted in 2012 — EIM[14] Study ID G0800132a — by sampling FC in Whatcom Creek and the four tributary subbasins following wet weather storm events, and to follow up with source control actions. This TMDL and Implementation Plan builds off previous work and has been updated by using more recent data. Support for protecting water quality is vital to maintain the beneficial uses of the water bodies covered by this TMDL.

The two primary sources of known pollution loading to the Whatcom Creek watershed include 1) bacteria-contaminated stormwater discharge either directly into the receiving water bodies or the MS4, and 2) non-stormwater discharges (Shannahan et al. 2004 and McCarthy 2020b). Subbasins with a relatively high percent of impervious surface areas, however, showed no correlation with FC concentrations measured in the receiving waterways (Shannahan et al. 2004). Urbanized areas associated with impervious surface area were likely not the primary source of bacterial contamination. Bacteria contamination may also occur under non-storm related, or dry conditions. Additional information to further identify the sources of bacteria pollution in the watershed is needed. Based on current knowledge, the sources of bacteria pollution to the Whatcom Creek watershed are likely a combination of the following:

- Failing sewer mains, laterals, or junctions,
- MS4 cross connections,
- Pet waste in riparian and urban areas,
- Human waste in riparian and urban areas,
- Failing onsite sewage systems (OSS) along creeks or associated ditches,
- Domestic animal and livestock wastes, and
- Wildlife waste or carcasses.

[14] https://apps.ecology.wa.gov/eim/search/Default.aspx

There is no single solution to improving water quality in the Whatcom Creek watershed. Local governments, permittees and the public will need to work together to solve the problem. Federal, state, and local organizations will need to coordinate on TMDL implementation with the goal of attaining the WQS. State and local codes, and NPDES permits are designed to reduce detrimental impacts to water quality, which align with the Implementation Plan goals. The public plays a crucial role in preventing bacteria pollution by acting responsibly and following codes.

After accounting for the MOS, the WLA comprise the permitted NPDES sources and total roughly 80 percent of the TMDL for the entire watershed. Approximately 90 percent of the watershed area is controlled by Phase II Municipal Stormwater NPDES permits, where the City received roughly 88 percent of the WLA, the County received 11 percent, WSDOT received 0.75 percent, and the remaining 0.25 percent was divided among the other permit holders. Permitted stormwater systems and MS4 represent the largest potential conveyor of bacteria to Whatcom Creek watershed. Updated 2019 permits for the City and County also require jurisdictional implementation of Stormwater Management Action Planning (SMAP) to reduce MS4 related pollution (Ecology 2019c). Correct operation and maintenance of the MS4 will be necessary to protect water quality in Whatcom Creek watershed.

The City, County, and WSDOT shall coordinate and share Whatcom Creek watershed information as required by their respective municipal stormwater NPDES permits. At a minimum, the WSDOT and the County are expected to share the results of outfall and best management practices (BMP) mapping, and pollution control and prevention activities with the City and share monitoring data about the watershed following permit protocols. Ecology will maintain the responsibility for issuing NPDES permits that meet the established WLAs and coordinate with permittees. This collaborative approach provides reasonable assurance that reductions necessary to meet LAs will be achieved that allow the WLAs to be made for the permitted stormwater discharges.

This TMDL water quality Improvement Plan identifies several existing activities that will help control bacteria pollution in the watershed, which primarily involves addressing the MS4 and nonpoint sources of pollution. Programs and activities that improve and protect water quality require effective stormwater systems, source control actions, private storm sewer inspections, OSS inspections and maintenance, hobby farm planning, cleanups of unauthorized encampments, and pet waste campaigns.

Maintaining pollution prevention practices while prioritizing areas in the watershed that have the highest bacteria levels is paramount to the goal of this TMDL. The top pollution reduction priority is to control sources once identified. Due to the observed persistent elevated bacteria levels, the Fever and Lincoln Creek subbasins and the catchments that drain into the lower reaches of Whatcom Creek are recommended as priority areas to focus initial implementation efforts. Cemetery and Hanna Creeks also have high bacteria levels and shall be address through the suite of pollution control activities.

General Types of Implementation Actions

The Implementation Plan in this report includes four general types of actions: 1) source tracking, 2) source control, 3) education/public outreach, and 4) water quality monitoring. Specific pollution problems and corrective actions are detailed in the Nonpoint Sources of Pollution section of this report. Corrective actions are already being implemented throughout the watershed in full support of this TMDL implementation plan. Adaptive management to prevent sources from degrading water quality should focus on stream reaches with chronic bacterial exceedances. Proposed actions to be implemented by each entity in support of the Whatcom Creek bacteria TMDL are summarized in Table 15 and briefly described below.

- Source Tracking
  - Maintain updated map/database of land uses and commercial animal handling facilities in the basin,
  - Investigate and repair sewer leaks and failing on-site septic systems,
  - Identify and eliminate illicit connections to the stormwater drainage system, and
  - Identify bacteria pollution sources through observation and monitoring.
- Source Controls
  - Implement structural and non-structural stormwater operation and maintenance procedures, and
  - Manage domestic animal and livestock wastes in a manner the prevents pollution.
- Education and Public Outreach
  - Educate businesses owners and the public on bacteria pollution issues and the associated sources, and
  - Encourage proper pet waste cleanup and disposal on public and private areas.
- Water quality monitoring
  - Continue water quality monitoring and expand to address data gaps as funding allows,
  - Consider transitional monitoring of bacteria indicators from FC to *E. coli*, and
  - Augment existing bacterial indicator comparison datasets as needed.

Table 15. Summary of recommended and required pollution control and prevention activities in the Whatcom Creek watershed

Entity and (Component)	Actions
Ecology (Stormwater)	• Issue permits and ensure compliance (required) • Administer ERTS and share information (required)

<table>
<tr><td>City of Bellingham (Stormwater)</td><td>Continue to implement Phase II Municipal Stormwater NPDES Permit and Stormwater Management Program (SWMP) that includes (required):
Stormwater Planning
Public education and outreach
Public involvement and participation
MS4 mapping and documentation
Illicit Discharge Detection Elimination (IDDE)
Runoff/flow controls for new development, redevelopment, and construction
Prevent pollution from municipal operations and maintenance
Source control for existing development
Annual reporting
Share IDDE and monitoring data with other watershed stakeholders on request; notify Whatcom County or WSDOT if illicit discharges or exceedances drain to physically interconnected stormwater systems (required)
As funds allow, continue the Urban Streams Monitoring Program (USMP) to assess pollution prevention and reduction effectiveness (recommended)</td></tr>
<tr><td>Whatcom County (Stormwater)</td><td>Continue to implement Phase II Municipal Stormwater NPDES Permit and Stormwater Management Program (SWMP) that includes (required):
Stormwater Planning
Public education and outreach
Public involvement and participation
MS4 mapping and documentation
Illicit Discharge Detection Elimination (IDDE)
Runoff/flow controls for new development, redevelopment, and construction
Prevent pollution from municipal operations and maintenance
Source control for existing development
Annual reporting
Share IDDE and monitoring data with other watershed stakeholders on request; notify the City of Bellingham if illicit discharges or exceedances drain to physically interconnected stormwater systems (required)</td></tr>
<tr><td>Washington State Department of Transportation (WSDOT) (Stormwater)</td><td>Continue to implement NPDES Stormwater Permit (required)
Conduct Stormwater Management Program (SWMP) (required)
Illicit Discharge Detection Elimination (IDDE) (required)
Runoff/flow controls for new development, redevelopment, and construction
Highway Maintenance (required)
Share monitoring data with the City of Bellingham on request. Notify the City of Bellingham if illicit discharges or exceedances drain to physically interconnected stormwater systems (required)</td></tr>
<tr><td>Commercial Businesses (Stormwater)</td><td>Maintain, operate, and repair the stormwater facilities in compliance with the city/county ordinances and the Ecology Manual (current edition) (required)
Annual inspection/clearing of stormwater facilities
Inspect grassy swales
Maintain facilities consistent with conditions of approval, and recorded agreements against subject properties, and city or county standards as enacted at the time of approval
Where lack of maintenance is causing or contributing to a water quality problem or violation, action shall be taken by the property owner to correct the problem</td></tr>
</table>

Private property owners (Stormwater)	• Maintain, operate, and repair the stormwater facilities in compliance with the city/county ordinances and the Ecology Manual (current edition) (required) o Annual inspection/clearing of stormwater facilities o Inspect grassy swales o Maintain facilities consistent with conditions of approval, and recorded agreements against subject properties, and city or county standards as enacted at the time of approval o Where lack of maintenance is causing or contributing to a water quality problem or violation, action shall be taken by the property owner to correct the problem
Ecology (Wastewater)	• Issue permits and ensure compliance (required) • Administer ERTS and share information (required)
City of Bellingham (Wastewater)	• Continue to conduct periodic surveys of stormwater system pipes using a video scanner to check for illicit connections (required) • Conduct source identification water quality monitoring as needed (recommended) • Cooperate with the County Health Department On-site Sewage System (OSS) program
Whatcom County (Wastewater)	• Conduct the On-site Sewage System (OSS) program and work with the City (required) • Conduct source identification water quality monitoring as needed (recommended) • Enforce Health Department codes (required)
Commercial Businesses (Wastewater)	• Comply with relevant permit requirements and city/county ordinances (required)
Private property owners (Wastewater)	• Comply with relevant permit requirements and city/county ordinances (required)
Ecology (Pets)	• Administer ERTS and share information (required)
City of Bellingham (Pets)	• Continue Pet Waste Education Program (required) • Continue to share educational information with the public (required) • Continue the installation/maintenance of pet waste stations along City trails, parks, and off-leash areas with continued programmatic actions and planning (required) • Continue to review and update city ordinances governing pet waste to improve enforcement capability (recommended) • Continue to enforce relevant ordinances (required) • Continue to share resources and educational materials with the County (recommended)
Whatcom County (Pets)	• Continue Pet Waste Education Program (required) • Continue to share educational information with the public (required)Continue the installation/maintenance of pet waste stations within County jurisdiction with continued programmatic actions and planning (required) • Continue to review and update county ordinances governing pet waste to improve enforcement capability (recommended) • Continue to enforce relevant ordinances (required) • Continue to share resources and educational materials with the City (recommended)
Private property owners (Pets)	• Collect and dispose of pet waste deposited on public lands (required) • Properly dispose of pet waste deposited in residential areas (required) • Ensure that contaminated runoff from animal pens/exercise facilities does not enter stormwater system (required)

City of Bellingham (Commercial businesses handling animals)	• Continue periodic inspection by source control specialists or other qualified staff (recommended) • Sample the receiving water ways or infrastructure when determined necessary for informational gathering purposed (recommended) • Continue to review and update city ordinances as needed to improve enforcement capability (recommended) • Continue to enforce relevant ordinances (required)
Whatcom County (Commercial businesses handling animals)	• Continue periodic inspection by source control specialists (recommended) • Sample the receiving water ways or infrastructure when determined necessary for informational gathering purposed (recommended) • Continue to review and update county ordinances as needed to improve enforcement capability (recommended) • Continue to enforce relevant ordinances (required)
Commercial Businesses (Commercial businesses handling animals)	• Cooperate with City, County, and State administration of good housekeeping (required) • Regularly clean animal holding areas to collect and properly dispose of waste and prevent delivery to stormwater system (required) • Do not hose down areas of potential fecal contamination to storm drains or to receiving waters (required) • Verify that drains used for this purpose go to the sanitary sewer (required) • Do not allow any wash waters to be discharged to storm drains or to natural drainage ways (required) • Maintain vegetative ground cover or mulch where animals are kept in unpaved and uncovered areas (recommended) • Fence animal holding or exercise areas, or use a leash when necessary to control potential waste related pollution issues (required) • Commercial facilities that store bulk compost should ensure that runoff from the storage sites does not drain to the stormwater system or natural drainage ways (required)
Ecology (Domestic livestock)	Administer ERTS and share information (required)

City of Bellingham (Domestic livestock)	• Provide info on BMPs to residences with domestic livestock identified as being potential bacteria sources (recommended)
	• Refer livestock owners to technical assistance providers such as the Whatcom County Conservation District for information on developing and implementing a plan to prevent pollution discharges (recommended)
	• Utilize Ecology's Voluntary Clean Water Guidance and may include the following recommendations:
	    • Riparian Buffers
	    • Setbacks from ditches and other conduits to surface water
	    • Covered Waste Storage
	    • Heavy use area protection to minimize pollutants leaving these areas
	    • Gutters and downspouts, and other practices to divert water around heavy use areas and waste storage areas
	    • Grazing plans
	• Continue to review and update city ordinances as needed to improve enforcement capability (recommended)

	• Continue to enforce relevant city ordinances (required)

Whatcom County (Domestic livestock)	• Refer livestock owners to technical assistance providers such as the Whatcom County Conservation District for information on developing and implementing a plan to prevent pollution discharges (recommended)
	• Utilize Ecology's Voluntary Clean Water Guidance and may include the following recommendations:
	  • Riparian Buffers
	  • Setbacks from ditches and other conduits to surface water
	  • Covered Waste Storage
	  • Heavy use area protection to minimize pollutants leaving these areas
	  • Gutters and downspouts, and other practices to divert water around heavy use areas and waste storage areas
	  • Grazing plans
	• Continue to review and update County ordinances as needed to improve enforcement capability (recommended)
	• Continue to enforce relevant county ordinances (required)

Whatcom Conservation District (Domestic livestock)	• Work with property owners to implement BMPs in accordance with Ecology's Voluntary Clean Water Guidance for Agriculture to reduce bacteria inputs (recommended)
Commercial Businesses (Domestic livestock)	• Determine whether livestock operations require a permit (recommended) • Work with technical assistance providers (e.g., Whatcom Conservation District) to implement BMPs (recommended) • Comply with relevant city and county ordinances and the State Water Pollution Control Act (required)
Private property owners (Domestic livestock)	• Determine whether livestock operations require a permit (recommended) • Work with technical assistance providers (e.g., Whatcom Conservation District) to implement BMPs (recommended) • Comply with relevant city and county ordinances and the State Water Pollution Control Act (required)
City of Bellingham (Critical Areas waste management)	• Continue to enforce relevant city ordinances (required) • Continue to follow adopted procedures in addressing camps identified in streamside areas (recommended) • Continue to share resources and educational materials with the County and WSDOT (required)
Whatcom County (Critical Areas waste management)	• Continue to enforce relevant county ordinances (required) • Continue to follow adopted procedures in addressing camps identified in streamside areas (recommended) • Continue to share resources and educational materials with the City and WSDOT (required)
WSDOT (Critical Areas waste management)	• Continue to share resources and educational materials with the City and County (required) • Continue to follow adopted procedures in addressing camps identified in streamside areas (recommended)

Commercial Businesses (Critical Areas waste management)	• Comply with relevant city and county ordinances (required)
Private property owners (Critical Areas waste management)	• Comply with relevant city and county ordinances (required)
City of Bellingham (Wildlife)	• Enforce ordinances dealing with rodent control and garbage/refuse accumulations (required)
Whatcom County (Wildlife)	• Enforce relevant ordinances (required)
Washington State Department of Fish and Wildlife (Wildlife)	• Respond and manage issues regarding wildlife pollution due to human influences
Ecology/WDNR (Forest Practices)	• Implement and enforce Forest Practices Regulations

Land Distribution

From its headwater, Whatcom Creek is surrounded by Whatcom Falls Park down to Woburn Street (City of Bellingham 2011). Downstream of Woburn Street, the Whatcom Creek Trail continues along a narrow protected riparian area. The trail departs the Whatcom Creek under Interstate-5 (I-5) and later rejoins near Maritime Heritage Park for a short reach before emptying into Bellingham Bay.

The National Land Cover Database (NLCD) provides nationwide information on land cover at a 30m resolution with 16 classes based on a modified Anderson Level II classification system (Wickham et al. 2021, Homer et al. 2020, Jin et al. 2019, Yang et al. 2018). The NLCD indicates the land cover in the Whatcom Creek watershed is primarily developed (68 percent) with the remainder consisting of forests (27 percent) and other (5 percent) (Figures 4 and 5). The developed area is comprised of Medium intensity (26 percent), Low intensity (23 percent), High intensity (10 percent), and Open Space (9 percent). The NLCD for the Whatcom Creek watershed was quantified by the proportional area within the City, County, and unpermitted areas (Figure 5).

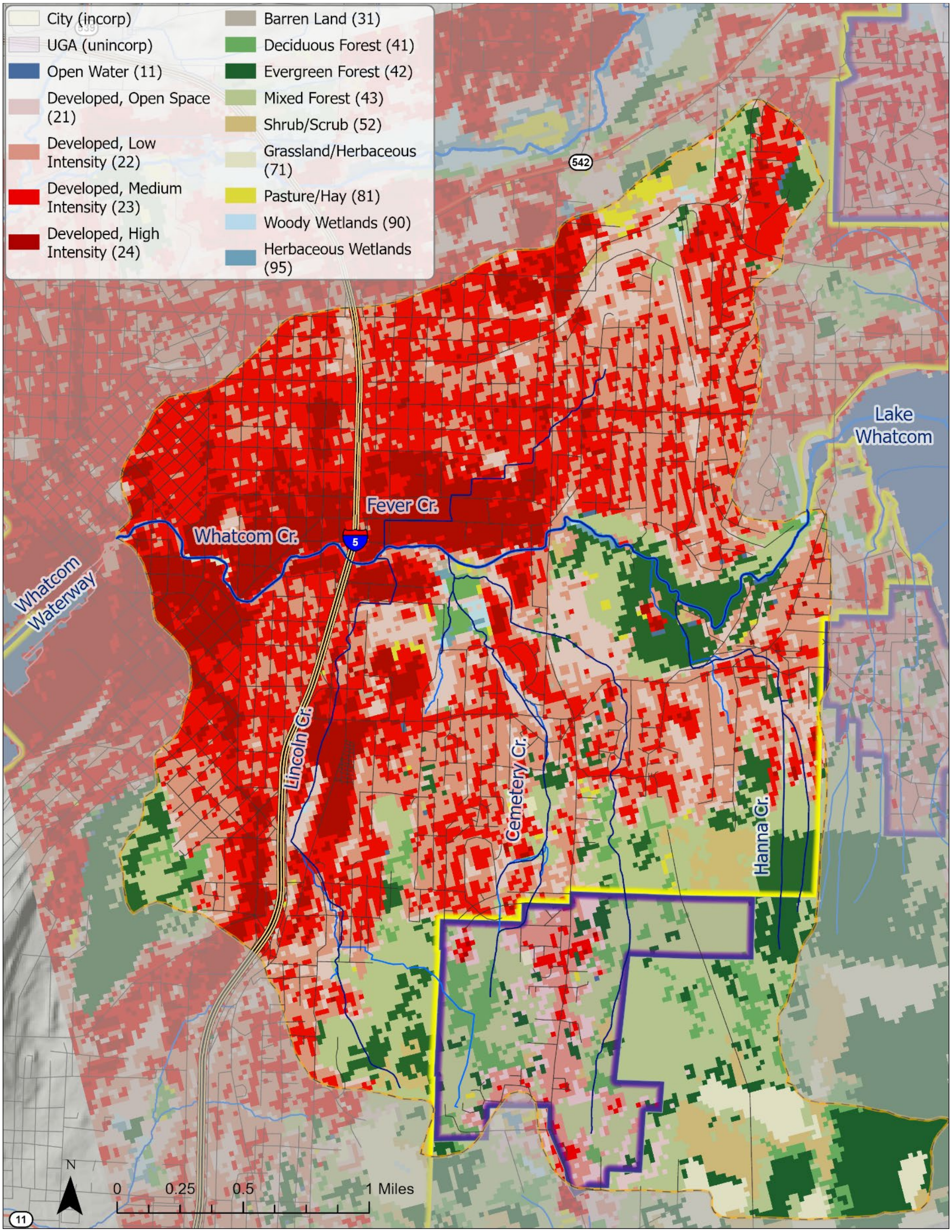
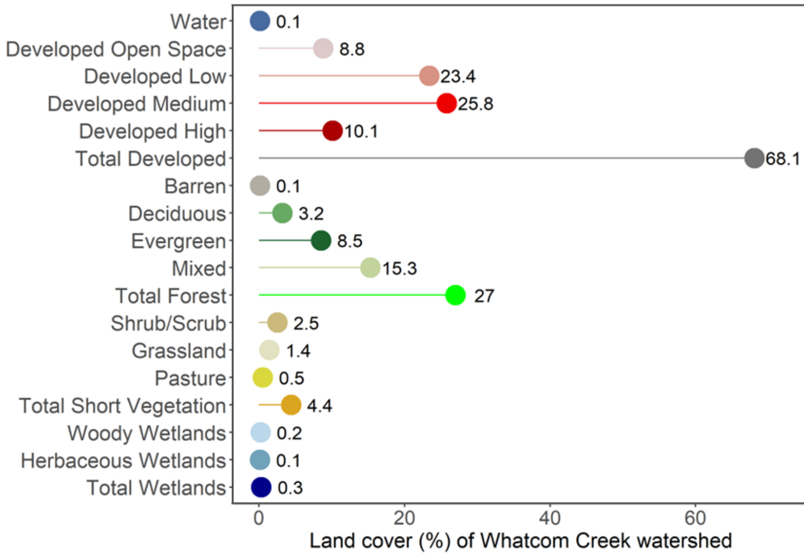


Figure 4. The National Land Cover Database (NLCD) showing the 2019 land cover in the Whatcom Creek watershed along with the City (incorp) and County (UGA (unincorp)) permitted areas



Coverage Area (%)		
City	County	Nonpoint
96.7	3.3	0
84.8	12.7	2.5
92.1	7.6	0.3
98.4	1.5	0.1
99.8	0.2	0
94.7	4.8	0.5
100	0	0
34.0	40.3	25.7
59.0	6.1	34.9
44.8	29.5	25.7
48.0	23.4	28.6
50.1	3.9	46.1
6.9	1.7	91.4
96.0	4.0	0
41.7	3.2	55.1
100	0	0
100	0	0
100	0	0

Figure 5. The National Land Cover Database (NLCD) percent coverage by land use in the Whatcom Creek watershed along with totals for Developed, Forest, Short Vegetation, and Wetland areas, and Coverage Area by City, County, and nonpermitted areas using the 2019 dataset

Urban development tends to occur within the lower two-thirds of the Whatcom Creek watershed, and in nearly all the Fever Creek subbasin and the Lincoln Creek subbasin with minimal exceptions near its headwaters (Figure 4). The lower two-thirds of the Whatcom Creek watershed particularly in the northern areas, and the Fever and Lincoln Creek subbasins have the relative greatest urban densities.

As a component of the developed areas category, residential density is the ratio of homes to land area expressed as housing units per acre. The city-wide residential density in Bellingham is 6.3 units per acre with a range of 77.4 in the lower watershed to 3.3 in the upper watershed (City of Bellingham 2020). The City Planning and Community Development Department encourages infill to reduce urban sprawl. Some undeveloped locations, however, continue to be developed including the UGA. The adverse effects on water quality often caused by urban development could be mitigated by sufficiently implementing the wide suite of stormwater pollution control and prevention activities, retrofits, careful MS4 infrastructure planning and maintenance, and public participation.

The upper third of watershed is forested including Whatcom Falls Park. The upper portions of the Cemetery Creek subbasin and intermittently throughout the Hanna Creek drainage are also forested. The upper areas of the Cemetery Creek are mostly within the County's jurisdictional area. The upper portions of the Hanna Creek subbasin and eastern branches of the Cemetery Creek subbasin are managed for recreation and industrial timber harvest through the consortium of the City of Bellingham, Whatcom County Land Trust, and Galbraith Tree Farm LLC. This land management consortium follows rules and regulations under an agreement that was made official in July, 2018[15]. This agreement protects the watershed and greater area from development under a recreation easement. Managing the recreation area to reduce pollution inputs is essential for improving the water quality of the receiving water bodies.

Point Sources of Pollution

The TMDL WLAs shall be implemented through the administration of the NPDES permit program under the Clean Water Act section 402. The Whatcom Creek TMDL Implementation Plan Lead will work with Ecology permit managers and each permittee to ensure that new TMDL-related requirements become permit conditions during the renewal process as described in the Wasteload Allocations Section of this report. Each NPDES permittee performs a suite of actions to reduce bacteria pollution in the Whatcom Creek watershed. One important objective is to reduce bacteria loading to meet the specified TMDL and associated target geometric means within 20 years of the Detailed Implementation Plan final publication.

The TMDL target geometric mean bacteria concentrations and percent reductions form the basis of the WLAs (b.cfu/day) calculated by season, which are developed to protect designated uses. Interim targets may be established to guide adaptive management plans ensuring that progress is made toward meeting the target geometric means. The target geometric means will continue to function as a guide for adaptive management to maintain the water quality.

Stormwater Pollution Source

Stormwater can be a significant source of bacterial inputs to the Whatcom Creek watershed. Stormwater that is generated within the basin reaches the surface water through a system of ditches, culverts, and pipes as part of the permitted MS4 infrastructure. Stormwater starts as precipitation that either infiltrates into the ground, which is beneficial, flows in shallow interflow which exits into ditches or as groundwater springs, or accumulates and flows over impervious surfaces. Stormwater includes 1) precipitation that hits the ground and does not infiltrate at that location, and 2) other discharges that are collected in stormwater collection systems and is conveyed to local surface waters.

[15] https://cob.org/news/2018/city-enters-agreement-to-secure-recreational-use-of-galbraith-mountain

Paved surfaces typically do not allow water to infiltrate into the ground where it can be naturally filtered and treated before entering streams or aquifers. The lack of infiltration results in excess stormwater running off urban areas each year. Land uses and activities in urban areas, coupled with an increase in impervious surfaces and accumulation of contaminants, often result in polluted stormwater. Stormwater systems allow pollutants to move from drainage surfaces to local waters, where pollutants are delivered quickly and in high concentrations.

Pollution Control Effectiveness Monitoring (2012)

In 2012, the City conducted a pollution control effectiveness monitoring study that was partially funded by an Ecology grant — EIM[16] Study ID G0800132a. Study objectives included sampling FC throughout the Whatcom Creek watershed following wet weather storm events. Sampling results were used to inform follow up source control work and provide education to potentially liable parties. Roughly 12 sampling events were conducted at varying degrees of spatial resolution and temporal frequency for a total of 145 samples collected. Depending on source identification objectives, sampling events often focused on one subbasin at a time, while other subbasins were not sampled, or were sampled during a different event. The watershed was therefore not entirely sampled during each monitoring event and did not include routine ambient monitoring.

The FC samples collected during the wet weather sampling (Study ID G0800132a) event were translated to *E. coli* concentrations using Equation 1 (Figures 6 and 7). At a subbasin-wide scale, the drainage area of Cemetery Creek had the highest geometric mean *E. coli* concentrations (cfu/100 mL) at 220 (236 FC) followed by the drainages of Fever Creek at 164 (176 FC), Hanna Creek at 48 (52 FC), Lower Whatcom Creek at 45 (49 FC), Lincoln Creek 35 (40 FC), and Upper Whatcom Creek 16 (18 FC). These reported geometric means represent the combined sampled discharge from the specified water body and the associated MS4 infrastructure. Comparisons to the geometric mean criterion on a subbasin-level gives a rough estimate of the likelihood of meeting the WQS following wet weather events at the subbasin scale and is not intended for a formal Water Quality Assessment (Ecology 2018). The study may be used to inform work such as IDDE or operations and maintenance of the MS4.

[16] https://ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database

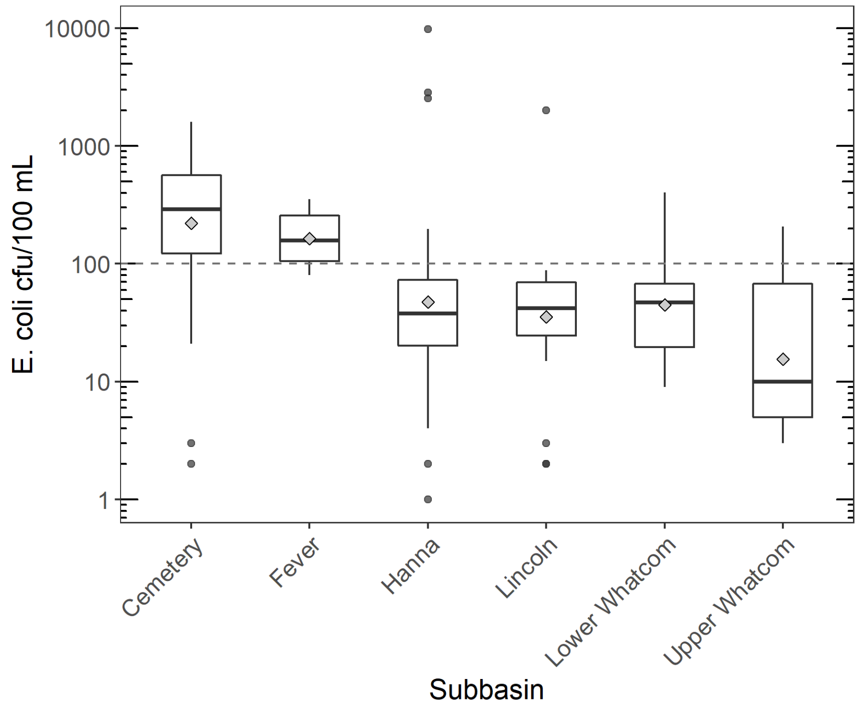


Figure 6. Translated E. coli wet weather sampling results segregated by subbasin in the Whatcom Creek watershed using the 2012 dataset. --- geomean water quality criteria, ◊ geometric mean, — median

During 2012, the City's pollution control and effectiveness monitoring efforts (EIM[17] Study ID G0800132a) wet weather sampling in the Whatcom Creek watershed included both in-stream and outfall monitoring (Figure 7). Stormwater outfall (canal/ditch or source-manmade) sampling throughout the Whatcom Creek watershed produced a geomean of 56 *E. coli* cfu/100 mL (61 FC), with a high of 2004 (n = 23). Sampling from surface water (stream/river) produced a geomean of 101 *E. coli* cfu/100 mL (111 FC) with a maximum value of 9762 (n = 122). The *E. coli* values were calculated using the bacteria translator (Equation 1). The geometric mean was 93 *E. coli* cfu/100 mL (101 FC) on the watershed-wide scale during wet weather sampling in 2012 (n = 145). For comparison, the geometric mean was 68 *E. coli* cfu/100 mL (75 FC) on the watershed-wide from ambient samples collected by the USMP in 2012 (n = 96). This rudimentary comparison indicated that wet weather sampling conducted in 2012 had greater bacterial levels on average when compared to routine ambient sampling during the same year at the watershed-wide scale.

[17] https://ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database

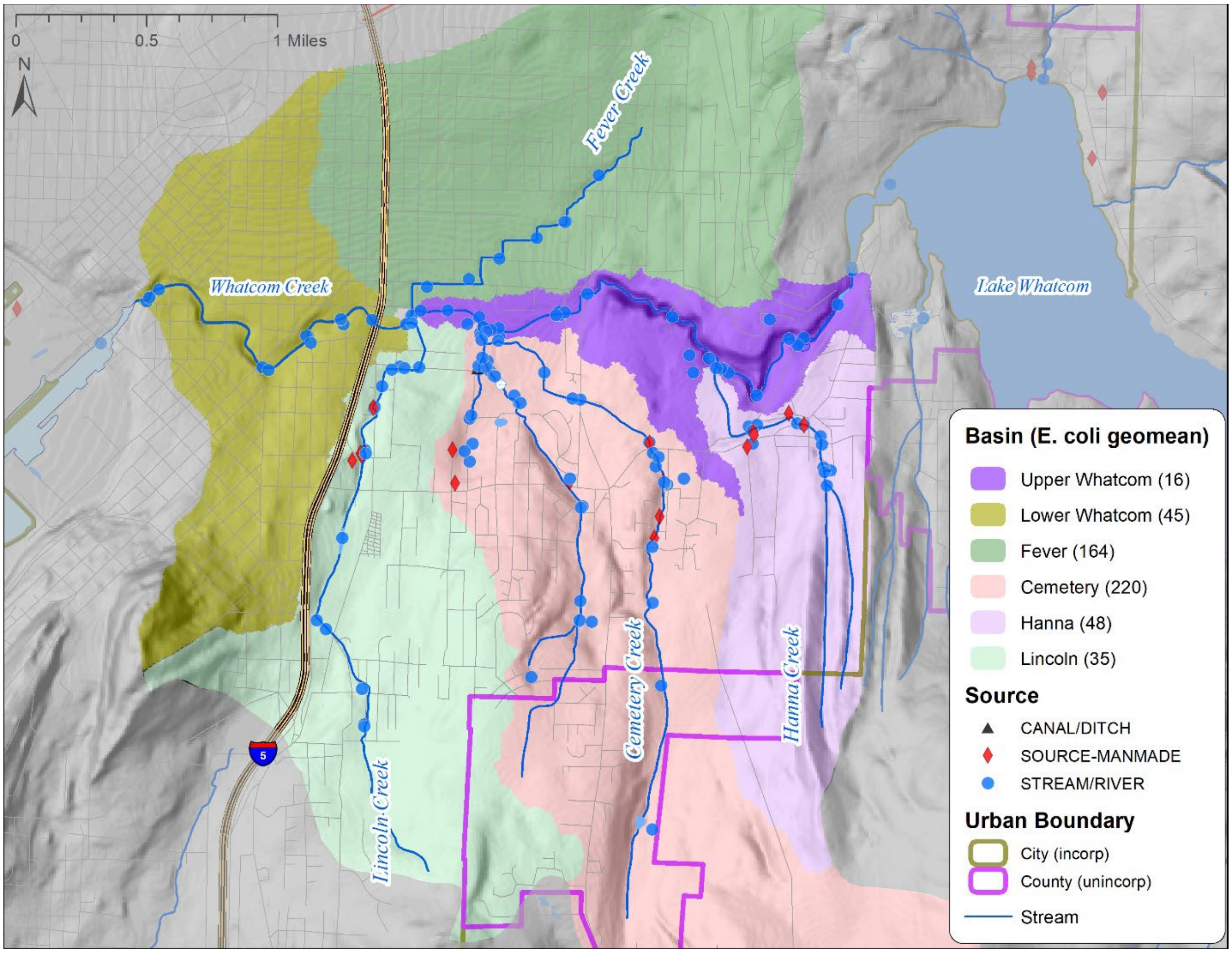


Figure 7. 2012 wet weather sampling sources and E. coli geometric means (cfu/100 mL) for each delineated basin the Whatcom Creek watershed

Bacteria in Urban Stormwater Research

Other studies have shown that bacteria concentrations in stormwater range from approximately 1,000 to over 100,000-organisms/100 mL in urban areas around Puget Sound and elsewhere across the country (Center for Watershed Protection, 1999, Doran et al. 1981, Pitt 1998, Varner 1995). The Center for Watershed Protection (1999) found that mean FC concentrations in urban stormwater were 15,000 cfu/100 mL. That same study showed that nearly every individual stormwater runoff sample exceeded bacterial standards, usually by a factor of 75 to 100. The FC concentrations reported from these studies are far greater than those observed during wet weather sampling in the Whatcom Creek watershed.

An evaluation of stormwater monitoring data from the National Stormwater Quality Database (NSQD) characterized associated pollution from specific urban land uses (Pitt et al. 2004). The mean concentrations of FC bacteria (MPN/100 mL) discharge via stormwater by land use category indicated that residential land use had the highest observed FC concentrations followed by all land uses combined including, commercial, open space, industrial, and freeways land use/land code (LULC) (Figure 8).

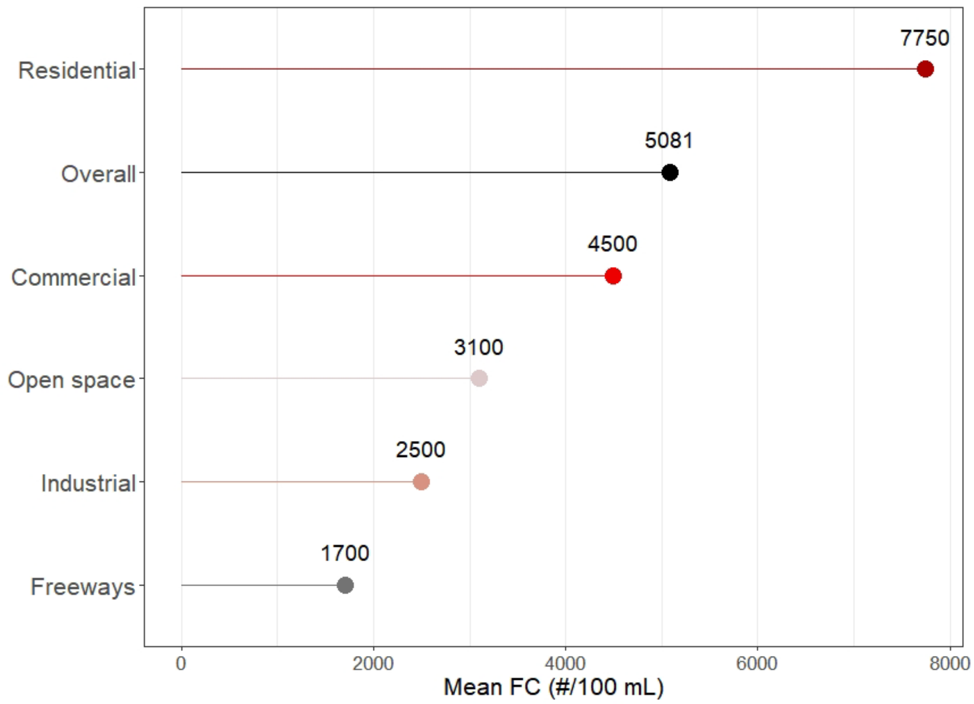


Figure 8. Mean fecal coliform (FC) concentrations in stormwater by land use — data source: Pitt et al. 2004

When accounting for urban land uses, developed watersheds tend to have greater bacterial concentrations than watersheds with comparatively reduced amount of development (Schueler 1999). Developed areas cover 68 percent of the Whatcom Creek watershed, however, the FC levels presented in Figure 8 are much greater than those typically seen in the Whatcom Creek watershed. These developed areas include the MS4 network infrastructure and nonpoint source land use activities. The forested land use areas in the Whatcom Creek watershed include portions developed as parks. Sources of bacterial pollution may come from public and private areas from human activities that are not necessarily attributed to the MS4 contributions.

Bacteria can be directly deposited into waterways or transported by stormwater that produces runoff flow or MS4 flushing. Stormwater can carry bacteria from pet waste on the ground, surfacing wastewater from failing septic tanks, manure associated with livestock operations or businesses that manufacture or supply compost, and activities such as right-of-way and sidewalk cleaning. Bacteria may persist outside of the originating host much longer in sediment, biofilms, and organic litter than in the water column. Therefore, sediment and organic litter mobilized by stormwater represents an important source of bacteria pollution (Clary et al. 2010, and Pachepsky and Shelton 2011). Further, bacteria populations may increase under conducive environmental conditions even with no additional loading to the waterway.

Stormwater Corrective Actions and Pollution Prevention

Several sources of stormwater discharged to Whatcom Creek and its tributaries are covered by NPDES discharge permits. Federal regulations address urban stormwater through the Phase I and Phase II Municipal Stormwater NPDES Permit programs. The City and the County currently implement their Phase II permits that address the Municipal Separate Storm Sewer Systems (MS4s) infrastructure and pollution prevention activities.

The WSDOT NPDES and State Waste Discharge Municipal Stormwater Permit addresses jurisdictional infrastructure and pollution prevention activities. Discharges covered include those from WSDOT's highways, ferry terminals, rest areas, park-and-ride lots, maintenance facilities, vactor decant and street sweepings facilities, and winter chemical storage facilities when the discharges are conveyed through a MS4 owned or operated by WSDOT.

The City BMC prohibits illicit discharges to stormwater drainage systems (BMC 15.42.050) and includes the necessity to periodically survey stormwater system pipes using video to check for illicit connections, which are typically cover by an MS4 permit as well. When illicit connections are identified, corrective actions are required immediately. Whatcom County is also required to implement an Illicit Discharge Detection and Elimination (IDDE) Program within unincorporated Urban Growth Areas (UGA) and census defined Urban Areas (UA) of Whatcom County as part of it Phase II NPDES permit requirements. Whatcom County UGA in the watershed includes the headwaters of Cemetery Creek. The IDDE Program shall be coordinated with the City, County, WSDOT, and Ecology. In some instances, the sharing of IDDE information has largely been automated, for example, through Ecology ERTS or spills notification and reporting.

Stormwater NPDES Permits

The basic provisions of the stormwater NPDES permit programs contribute substantially to the objectives of this TMDL. When fully implemented, the existing stormwater management plans fulfilled by the City, County, WSDOT, Brooks, and Haskell will meet the bacteria TMDL WLAs. The industrial stormwater permits shall include actions that prevent bacteria discharges from the given source. Permit compliance is sufficient to make progress toward WLA attainment, where adaptive management is essential as new information is obtained to address bacteria pollution.

To attain the goals of the TMDL, permit requirements shall be specified and incorporated into Appendix 2 of the Western Washington Phase II MS4 permit for the City and County. Where TMDLs have assigned WLAs for MS4 stormwater discharges from the City and County infrastructure, compliance with the action items listed in Appendix 2 constitutes compliance with the WLAs. Similarly, permit requirements shall be specified and incorporated into Appendix 3 of the WSDOT stormwater permit. Where TMDLs have assigned WLAs to WSDOT stormwater discharges, compliance with the action items listed in Appendix 3 of the WSDOT permit constitutes compliance with the WLAs.

Ecology may establish TMDL-related permit requirements through future permit modification for TMDLs that are approved by EPA after the permit is issued. Permittees are encouraged to participate in development of TMDLs within their jurisdiction and continue permit pollution control activities. Ecology recognizes that many jurisdictions are already actively planning stormwater investments and actions to accommodate future growth in a way that minimizes impacts to receiving waters and designated uses.

Receiving Water Conditions Assessment

Topographical catchment delineations are useful for determining the locations of potential bacteria pollution sources generated by stormwater runoff (Figure 9). The high resolution NHD[18] was used to determine the catchments, which formed the basis for the watershed subbasin delineations. In Figure 9, the catchments are shown along with the Whatcom Creek watershed and tributary subbasins. Catchments may be delineated at a finer resolution to improve source control information or to better understand the efficacy of pollution control efforts. Catchment delineations may be useful when determining MS4 jurisdictional boundaries relative to the topographical drainage area and the relative contributions to the TMDL AUs.

[18] https://www.usgs.gov/core-science-systems/ngp/national-hydrography/nhdplus-high-resolutionNHDPlusHR

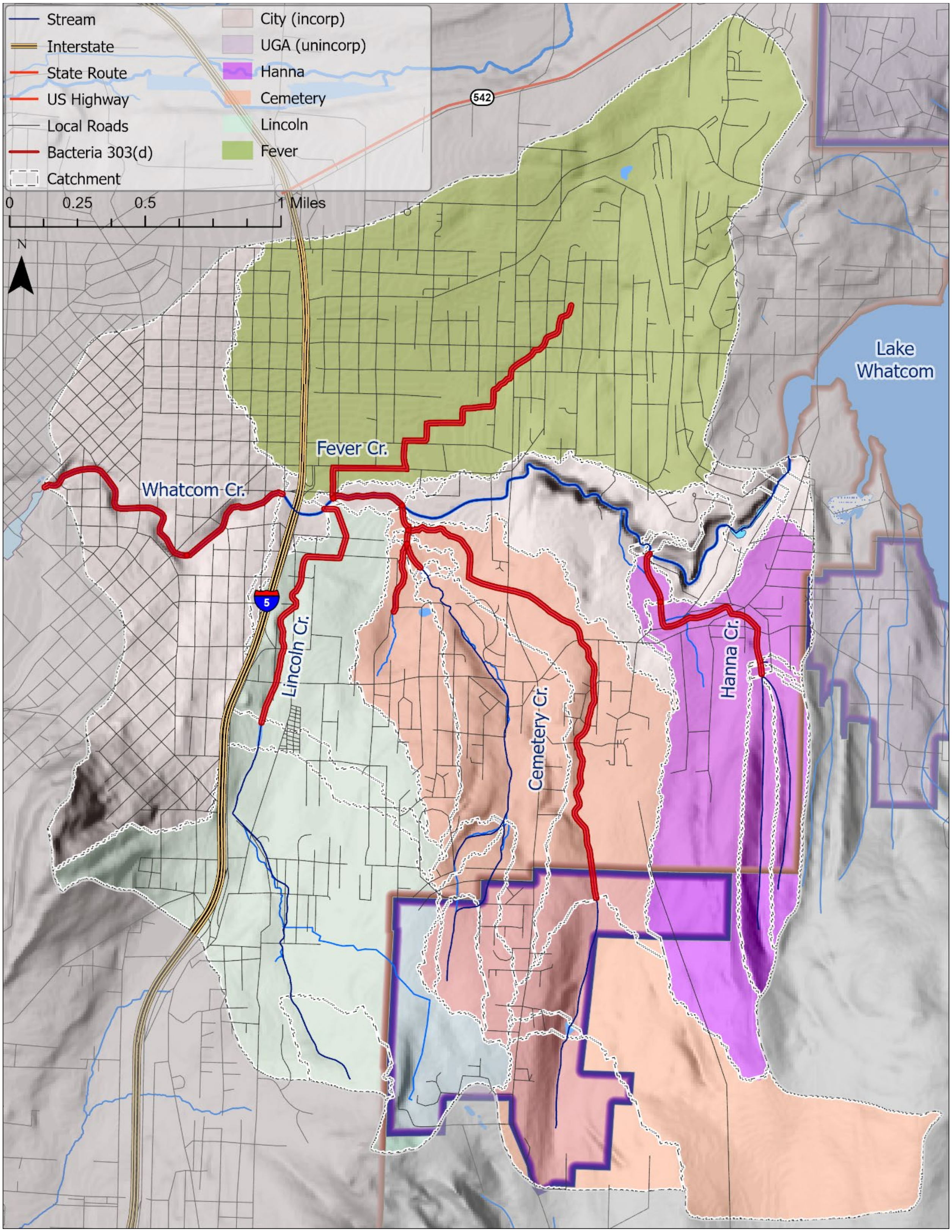


Figure 9. Topographical catchments within the Whatcom Creek watershed

For practical purposes of assessing the receiving waters, the MS4 network usually follows the topography of the watershed and subbasins. In some instances, however, the artificial pathways of the MS4 infrastructure alter the natural drainages of a delineated subbasin. Mapping of the MS4 is routinely conducted by the City, County, and WSDOT under the respective NPDES permit duties.

Establishing and updating the MS4 inventory is crucial for IDDE work and operations and maintenance BMPs.

S5.C.1.d.i of the Western Washington Phase II MS4 permit states:

> "Permittees shall document and assess existing information related to their local receiving waters and contributing area conditions to identify which receiving waters are most likely to benefit from stormwater management planning."
>
> "By March 31, 2022, Permittees shall submit a watershed inventory and include a brief description of the relative conditions of the receiving waters and the contributing areas. The watershed inventory shall be submitted as a table with each receiving water name, its total watershed area, the percent of the total watershed area that is in the Permittee's jurisdiction, and the findings of the stormwater management influence assessment for each basin. Indicate which receiving waters will be included in the S5.C.1.d.ii prioritization process. Attach a map of the delineated basins with references to the watershed inventory table."

The watershed assessment will help gain an understanding of receiving waters, the relative impacts of urbanization and land use activities on those receiving waters, and what existing information is most useful to guide prioritization (S5.C.1.d.ii of the Phase II Permit).

Four steps are included in this overall assessment:

Step 1: Delineate basins and identify receiving waters,

Step 2: Assess receiving water conditions,

Step 3: Assess stormwater management influence, and

Step 4: Assess relative conditions, and contributions.

The outcome of the Receiving Water Conditions Assessment is a watershed inventory that identifies the list of candidate basins and includes the information you need to support your prioritization process. Although these steps are presented in consecutive order, they may be implemented concurrently if it is practical for the jurisdiction.

Source Control is the first and foremost focus which requires the clear identification of bacterial pollution sources. Isolating and identifying the source of bacterial pollution can be challenging when considering the many types of land use activities that interface with the MS4 and drain to a particular location. Operation and maintenance and IDDE are common types of source control BMPs. Particularly, sources of human origin are paramount, such as failing or cross connected sewer lines, failing OSS, and public defecation, followed by pet waste as another substantial concern. Concentrated wildlife populations such as nesting birds or raccoon latrines may also pose a threat to water quality, however, are difficult to detect and address. Once pollution sources have been identified in the watershed, corrective and preventative measures are recommended that can be tailored for each specific issue. The Phase II NPDES permit includes the requirement of conducting pollution source control of the MS4. The Whatcom County Health Department has the responsibility and authority to address the OSS on private property. Source control alone, however, may not be sufficient to meet ambient water quality standards (Pitt 2004, Clary et al. 2009).

Flow controls that reduce the rate of direct stormwater runoff to the receiving surface water will reduce the volume of sediment resuspension by mimicking natural hydrology. Stream sediments are the dominant reservoir for bacteria when compared to the water column (Pachepsky and Shelton 2011). Additional bacteria loading from upland sources is likely to increase the accumulation of bacteria in sediments that provide a suitable environment for bio-persistence (Pachepsky and Shelton 2011). Addressing the instream sediment source of bacteria is done by addressing the upland pollutant inputs. Once bacteria are in the streambed sediment, there is no feasible way to remove it and flow control BMPs specific to bacteria pollution have not been developed to do so. Source control BMPs are therefore the most understood and effective way to reduce bacteria pollution of surface water.

Structures and practices that reduce flow volume through infiltration may be effective at reducing bacteria loads to the system (Clary et al. 2017). Addressing the altered hydrology from urbanization may be used as a presumptive approach at reducing bacteria concentrations in the water column by reducing the rate of sediment resuspension. Since bacteria concentrations can be higher in the sediment than in the water column, reducing instream sediment resuspension using flow controls could lead to a decrease in bacteria concentrations in the water column. The best available science, however, is limited and currently does not demonstrate the added benefits of bacterial reductions by addressing the instream sediment source. This concept does not address the primary source of bacteria pollution.

Stormwater Management Programs (SWMP)

Phase II Municipal permittees, including the City and the County, are required to have developed Stormwater Management Programs (SWMP) that include the following components:

- Compliance with water quality standards and TMDL requirements including an evaluation of program compliance,
- Stormwater planning,
- MS4 mapping and documentation,
- Public education and outreach on stormwater impacts,
- Public involvement and participation in the SWMP decision making process,
- Illicit discharge detection and elimination (IDDE), such as illegal sanitary sewer connections, or improper storage or disposal of potential pollutants,
- Control of runoff from construction sites,
- Post-construction stormwater management in new development and re-development,
- Pollution prevention from municipal operation and maintenance activities,
- Source control from existing development, and
- Monitoring and assessment including annual reports.

The City has mapped all stormwater outfalls greater than 12 inches in diameter to Whatcom Creek or its tributary streams in support of their Phase II Permit. The City provides GIS data and an online mapping tools that shows the MS4 infrastructure. The Whatcom County MS4 has additional outfalls that deliver to the Whatcom Creek system , some of which has been mapped.

The potential for unknown outfalls exits, where continued and additional mapping will address insufficient information. Information generated from stormwater mapping shall continue to be shared among all organizations that have municipal stormwater NPDES permits. Ecology encourages, and may enforce through NPDES permits, the fulfillment of jurisdictional SWMP to prevent or reduce pollution associated with stormwater runoff.

Permittees are also required to implement applicable TMDLs, complete annual program evaluation and reporting, and prepare to participate in effectiveness monitoring. Under the current permitting cycle, the Phase II MS4 permits for the City and the County became effective on August 1, 2019, and expire July 31, 2024, with periodic renewals.

The WSDOT has a separate general permit for stormwater discharges in areas covered by Phase II stormwater permits. The current permitting cycle for WSDOT became effective on April 5, 2019, and expires April 5, 2024, with periodic renewals. Among other mandates, this permit requires WSDOT to:

- Participate in watershed planning and TMDL development where WSDOT identifies itself as a key stakeholder,
- Inventory and document all known municipal separate storm sewer outfalls and structural stormwater treatment and flow control BMPs WSDOT owns, operates, or maintains, and
- Track all illicit discharges and illegal connections discovered by maintenance and construction staff and contractors and seek remediation when necessary.

The WSDOT has mapped all known stormwater outfalls within its permit coverage area (phase I and II) and is in the process of mapping MS4 features. The WSDOT makes these mapping data available upon request. An Action Plan is developed by a permittee to inform Ecology and the public of the selected actions the permittee will conduct to reduce pollution associated with a TMDL. In contrast to Ecology specifying the necessary stormwater management activities in Appendix 2, it gives the Permittee the opportunity to identify the BMPs, or actions they will take to reduce the discharge of the TMDL-related pollutant. The Action Plan is a permit requirement and does not necessarily come from the TMDL implementation plan, but can be used if the TMDL language is not clear on which first actions should be taken, or if a TMDL has been implemented for a long period time – in this case, an Action Plan may be useful for determining new actions that are needed, to replace actions that are no longer relevant or completed.

Private Stormwater Systems

Private stormwater systems are subject to the same pollution sources as publicly owned systems. Following Bellingham Municipal Code (BMC), the City SWMP requires that all privately owned stormwater systems within the city limits that discharge to the city's MS4 comply with Ecology's Stormwater Management Manual (BMC 15.42.070). Similarly, Whatcom County Code (Title 20.80.630 WCC) gives the County authority to control and regulate stormwater management activities. Both the City and County ensure that stormwater systems are inspected annually and cleared of debris, sediment, and vegetation when they affect the functioning and/or design capacity of the facility. Grassy swales and other biofilters must be inspected, mowed, or replanted as necessary.

Pollution Prevention Assistance

Many routine business activities can pollute stormwater runoff or groundwater. Businesses are responsible for keeping polluted runoff from their property or worksite from damaging local waterways. In 2007, Washington State Legislature established the Local Source Control (LSC) Partnership that funds interagency coordination among Ecology and local jurisdictions that participate in the voluntary program. The LSC Partnership started in the Puget Sound and Spokane watersheds and expanded the Columbia River basin. The LSC was rebranded as Pollution Prevention Assistance (PPA) in 2016. This new name was part of an effort to emphasize the benefits of the program to the public and businesses (Ecology 2020). The PPA encourages business owners and neighborhood associations to examine their land use and maintenance strategies to improve local water quality.

The PPA relies on local voluntary participation from the City and County. The Whatcom County Health Department and the City established Specialists — formally called Local Source Control Specialists — to assist business owners with proper waste management and to diagnose and fix stormwater-related issues. Ecology's 2016 biennium report indicated that Whatcom County Health Department LSC visited 194 businesses and found 136 issues. The City visited 206 businesses and found 118 issues (Orme 2016). Since 2007, the PPA has increased from 13 to 21 local jurisdictional partnerships making a total of 7,602 visits to businesses and resolving 3,963 (85%) of the issues found (Ecology 2020).

Specialists offer businesses help with complicated regulatory issues including technical assistance and education to prevent stormwater contaminants and hazardous waste from entering public waterways. Specialists educate business owners about this bacteria TMDL, how their activities may contribute to the bacteria load, and steps they can take to reduce inputs. For example, PPA Specialists helped correct runoff from leaking trash compactors that polluted nearby streams with FC bacteria from rotting organic matter (Orme 2016). Local PPA Specialists should continue to visit pet-related businesses (e.g., veterinarians, kennels, and pet stores), and other businesses identified as potential bacteria sources.

Wastewater Pollution Sources

The WDFW's Bellingham Fish Hatchery is the only permitted source of non-stormwater discharge into Whatcom Creek. Numeric criteria will not be identified in the Upland Finfish Hatchery General permit. The hatchery is not a likely source of thermotolerant bacteria. Narrative criteria, however, such as BMPs and source controls to prevent the congregation of mammals and birds attracted to the rearing of fish shall be identified in the next iteration of the general permit. While not required, *E. coli* monitoring may be requested, as specified under G3(4) of the permit, to ensure the hatchery facility is effectively using deterrents and preventing mammals and birds from congregating.

Unpermitted wastewater discharge may inadvertently reach the waterways and come from a variety of sources. For example, unpermitted wastewater discharges generally come from showers, toilets, and sinks, and are defined as "domestic wastewater." Domestic wastewater can be generated in private residences or commercial businesses and is either conveyed to a wastewater treatment facility through a regional sewage conveyance system or is treated by an OSS.

The City currently operates the only sewage conveyance system in the Whatcom Creek watershed. The City first provided primary wastewater treatment in 1947, discharging effluent into a shallow part of Bellingham Bay, from a treatment plant located near the mouth of Whatcom Creek. In 1974, Bellingham replaced the Whatcom Creek treatment plant with the Post Point Wastewater Treatment Plant, which is located outside of the Whatcom Creek watershed. In 1993, Post Point was upgraded to include secondary treatment.

Centrally conveyed sewage could enter surface waters under several scenarios such as sanitary sewer line breakages, illicit cross-connections to stormwater sewers, or overflows. These can be significant sources of pathogenic bacteria contamination with concentrations in the tens of thousands of bacteria colonies per 100 mL and pose great human health risk to people in contact with the water. Bellingham's MS4 does not currently receive from or discharge to the sewer system; however, illegal cross-connections between domestic wastewater sources and the city's stormwater system are occasionally detected. One such source was identified in the Lincoln Creek subbasin in 2009. When such sources are identified, they should continue to be corrected as soon as possible.

Nonpoint Sources of Pollution

Land use activities in the Whatcom Creek watershed have potential to produce sources of bacteria loading. Shannahan et al. (2004) suggested that potential nonpoint sources of bacteria and other pathogens within the Whatcom Creek watershed include stormwater, hobby farms, wildlife, domesticated-pet waste, septic systems, illegal sewer connections, and unsanctioned camps. Septic systems can also contribute bacterial contamination to streams through surface or groundwater flows when they are improperly installed, improperly located, inadequately sized, and when systems are not maintained or are failing. The watershed does have many older homes, some of which may not have been hooked up to the sanitary sewer and may contribute bacterial loads into the watershed.

Pets and waterfowl are often the primary sources of bacteria pollution in urbanized areas (Glenn 2001). Pet waste is typically conveyed by stormwater surface runoff to the receiving water body. As the human population of Bellingham increases, so will the number of pets in the watershed. The control of pet waste pollution may develop into a challenging issue unless pet owners remain educated and follow through with waste cleanup responsibly. Waterfowl waste is typically deposited directly to the water and may also be conveyed by stormwater. The low bacteria concentrations observed below the Derby Pond sampling location on Whatcom Creek (WHA04.2) indicates minor contributions from waterfowl that does not elevate bacteria levels above the WQS.

Growth Management Act (GMA) (RCW 36.70A) requires the City and designated Urban Growth Areas (UGA) of Whatcom County continue to develop while incorporating proactive plans for careful growth. Environmental protection is one of the many mandates of the GMA that must consider reducing the effects of urban growth on water quality. For example, natural area preservation, stormwater BMPs, retrofits, and low impact development (LID) should be implemented in order protect water quality. In addition to GMA protections, the Critical Area Ordinances for City and County jurisdictions are also enacted to protect natural systems, including wetlands, frequently flooded areas, fish and wildlife habitat conservation areas, geologically hazardous areas, and aquifer recharge areas. Tier I antidegradation protection of Whatcom Creek is recommended when enacting GMA requirements.

Onsite Sewage Systems (OSS)

Whatcom County Health Department data indicates there are 182 parcels in the Whatcom Creek watershed with suspected onsite sewage systems (OSS) as of October 31, 2022. Within these parcels there are 210 suspected OSS, which means some of the identified parcels may have multiple OSS (Figure 10). Suspected OSS on each parcel is defined by any of the following features: 1) a recordable OSS activity has been associated with the site, e. g., historical evaluation, 2) an active permit has been recorded without any OSS decommissioning paperwork, 3) pumping has been recorded, or 4) a suspected system like an OSS may be serving the site based on the types of structures on the parcel and the absence of a sewer connection. Within their respective MS4 permitted areas, the City has 27 suspected OSS and the County has 167. The remaining 16 suspected OSS are located on parcels outside of these MS4 permitted areas.

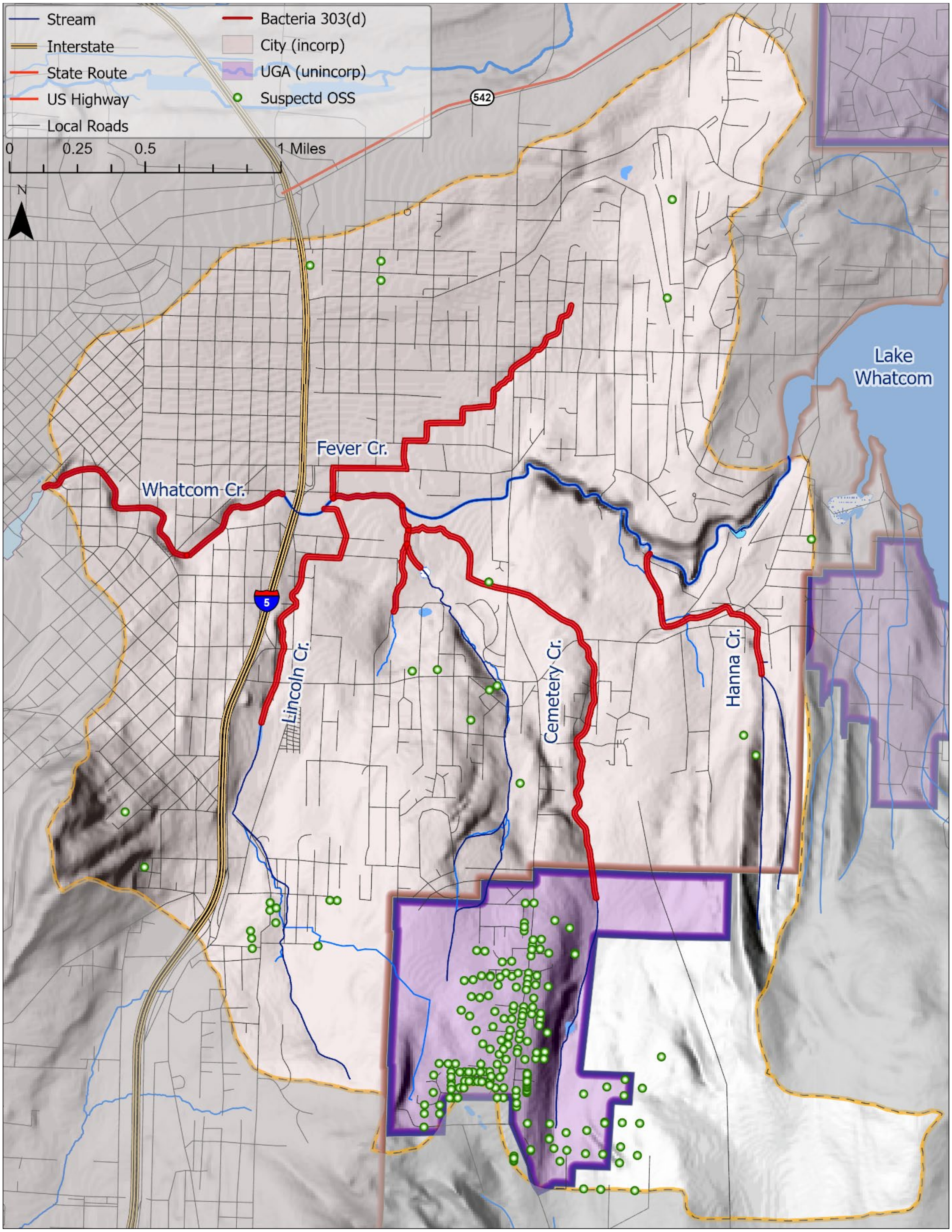


Figure 10. Suspected onsite sewage systems (OSS) in the Whatcom Creek watershed — data source: Whatcom County Health Department (10/31/2022)

Onsite sewage systems, both community-based and individual systems, are not a problem when designed, sited, evaluated, maintained, and operated properly. Properly functioning OSS uses the soil surrounding the drainfield to remove bacteria and some nutrients from the wastewater. Soil compaction, clogging of the soil with solids, and hydraulic overload, however, can all cause a failure of the system to adequately treat wastewater. Signs of OSS failure include:

- Odors, surfacing sewage, wet spots, or unusually lush vegetation in the drainfield area
- Plumbing or septic tank backups,
- Slow draining fixtures, and
- Gurgling sounds in the plumbing system.

If wastewater surfaces it is possible that it could drain directly to a nearby stream, or it could be carried by stormwater runoff. Another problem observed in some older OSS is the subsurface movement of wastewater through extremely porous soils. Unwanted subsurface movement of OSS discharges, however, can be difficult to detect.

Wastewater Corrective and Preventative Actions

The proximity of an OSS to the receiving water bodies offers the greatest priority for identifying potential pollution sources. Catchments with the greatest number of OSS such as the upper portions of the Cemetery Creek subbasin should be prioritized, followed by parcels within a serviceable distance to the sewer mains to determine the feasibility of connecting to the City's sewage conveyance infrastructure. The Whatcom County Health Department is the local authority that typically takes the lead on the OSS regulatory oversite. Cooperation from the City and County will sufficiently address the OSS in the watershed. Incentives to connect an OSS to the municipal sewage system is encouraged as needed, which involves the City, County, and the local Health Department authority working together to determine the most feasible option for wastewater treatment.

The local Health Department's OSS Program provides regulatory oversight for septic systems throughout Whatcom County including OSS within the Bellingham city boundary. Onsite sewage systems must be periodically inspected and maintained to ensure proper function. The local Health Department manages an OSS database to track mandatory maintenance and inspection schedules. Homes with OSS are mapped to inform bacteria source ID actions and illustrate potential pollution sources (Figure 10). Proper monitoring, correct operation and maintenance is the responsibility of the OSS owner. Homeowners in the Whatcom Creek watershed should contact the Whatcom County Health Department for assistance if they suspect problems with their OSS or need routine inspection and maintenance.

Pet Waste Pollution Sources

Ribotyping DNA studies of bacteria found in streams and creeks in urban Puget Sound streams consistently show the presence of bacteria from dogs and cats (Svrjcek 2006). In a watershed containing 100,000 people, it is estimated that dog populations alone generate over two-and one-half tons of feces each day, equating to almost 2 million pounds per year. Although current methods do not allow for quantification of sources, the consistent presence of pet waste in regional studies indicates that controlling these sources are particularly important.

According to the United States Census Bureau[19] the number of households in Bellingham was 38,664 in 2019. Based on the number of households, the estimated dog population in Bellingham was 14,847 in 2019 (American Veterinary Medical Association 2018). On average, one dog produces ¾ pounds (340 grams) per day (USDA 2005), which amounts to an estimated 11,135 pounds of dog waste generated every day based on Bellingham demographics. According to the EPA pet waste factsheet[20], one gram of pet waste contains 23 million FC bacteria on average. Pet waste management is therefore strongly needed on private properties near streams and stormwater conveyances. Public locations that experience pet and owner use may also have a particularly high potential for stormwater contamination due to the presence of storm sewer systems adjacent to sidewalks and roadways, as well as the proximity of parks and trails to natural streams.

Pet Waste Corrective and Preventative Actions

The City and County administer campaigns to reduce pet waste pollution by implementing several activities and continue to develop effective strategies. Public rights-of-way and recreational areas such as City and County Parks should be prioritized when addressing pet waste related pollution. People that recreate in these areas have the responsibility to follow protocols and clean up after their pets.

When people recreate with accompanying pets, the increased public use in areas such as Galbraith Mtn. also increases the potential of pet waste pollution entering Hanna and Cemetery Creeks, which will adversely affect the water quality of Whatcom Creek. Enforcing leash rules and pet waste pick up and proper disposal are highly recommended as pollution prevention activities. All jurisdictions that cooperatively manage the Galbraith Mtn. recreational area should conduct pollution preventative measures within their ability to interact with the public and provide opportunity through education and maintenance of facilities and trails. The following activities have or shall be undertaken to address pet waste in the Whatcom Creek watershed.

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[19] https://www.census.gov/

[20] https://cfpub.epa.gov/npstbx/files/cwc_petwastefactsheet.pdf

Withing their respective authority, the City and County will:

- Work collaboratively on pet waste corrective actions, and
- Share pet waste education and outreach materials with other governmental and non-governmental organizations.

The pet waste education program should include:

- Dog waste door hangers/posters,
- Dog waste information packet,
- Presentations to local dog training classes and neighborhood groups,
- Distribution of information at local festivals, and
- Installation of signs identifying local ordinances governing pet waste along public trails and at off leash areas.

Pet waste station and public area practices will include:

- Review of the station locations around streamside trails and public properties,
- Work toward installing and maintaining bag dispensers/waste disposal stations evenly dispersed along existing and future sanctioned trails including the Galbraith Recreation Area,
- Install or maintain pet waste stations within public parks or sanctioned public pathways as deemed feasible to address this potential pollution source,
- Work with local groups to “adopt” a station/trail and take on responsibility for maintenance,
- Develop pet waste management plans for all new trails/parks or public spaces,
- Locate all future off-leash areas away from streams and wetlands, and
- Develop citywide or countywide policy for off-leash use areas located near shorelines.

Home and business owner information packets on pet waste should be developed to contain:

- Background info on bacteria contamination,
- Suggestions for preventing bacteria inputs,
- Copy of relevant local ordinances governing the cleanup of pet waste, and
- Contact info for additional assistance.

The BMC contains several ordinances that govern disposal of pet waste, thereby requiring pet owners to remove fecal matter deposited by their animal on public property before leaving the area. Bellingham Municipal Code also requires that dogs be kept on leash in city parks (not including off-leash areas), and that horses are allowed only on paved roads or designated bridle paths, while stipulating that owners or handlers are responsible for cleaning up their animals' waste deposits left on park property. For example, BMC 10.60.100 prohibits deposit of litter in water, or allowing of drainage of any unauthorized substance, including animal waste, into any surface water drainage course or body of water. City Municipal Codes will be reviewed and modified as needed to improve the ability to enforce relevant ordinances. Other jurisdictions such as the County with regulatory authority over land use in the Whatcom Creek watershed shall implement comparable regulations.

Hobby Farms and Livestock

The Whatcom Creek watershed does not have agricultural lands that include large livestock or horse boarding facilities. The urbanized watershed, however, does include households that have ruminant animals, chickens, or ducks as livestock. Manure from these livestock may inadvertently pollute a receiving water body when it is either directly deposited or flushed into the system by improper handling, stormwater runoff, or by not following prescribed BMPs. When not properly managed, animal waste may build up over time and thus increase the loading potential to the receiving water bodies.

Hobby Farm Pollution Prevention

Preventing pollution from small hobby farms or livestock is addressed through local ordinances, farm planning, and statewide codes. Local codes and ordinances, and statewide codes should be updated, administered, and followed when managing livestock and a permit may need to be obtained depending on the situation. The Whatcom Conservation District[21] offers farm planning services with a suite of BMPs. Once a farm plan is complete and implemented with the Whatcom Conservation District, the recipient may be eligible for a small reimbursement grant. Ecology has a Voluntary Clean Water Guidance for Agriculture[22] that includes a phased approach for developing guidelines to address specific components related to farming and livestock. Useful guidelines in development include stormwater control and diversion, animal confinement, manure handling and storage, riparian areas and surface water protection, and suites of recommended practices, which may be applied to prevent bacterial pollution to the watershed.

Forest Practice Rules

Managed timberlands are present in the upper reaches of Hanna and Cemetery Creeks in the Galbraith Mount area. Timber harvest is not a likely source of bacteria pollution; however, people and pets are allowed to recreate within these managed forests. Negligence or improper disposal of human and pet waste represent the greatest potential source of bacteria pollution in these areas of the watershed.

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[21] https://www.whatcomcd.org/

[22] https://apps.ecology.wa.gov/publications/SummaryPages/2010008.html

The Forest Practices Rules establish protection standards for forest practices activities such as timber harvest, pre-commercial thinning, road construction and maintenance, fertilization, forest chemical application, required reforestation, and specific riparian and wetland protection measures. They give direction on how to implement the Forest Practices Act and the Stewardship of Non-industrial Forests and Woodlands. The rules are designed to protect public resources, such as water quality and fish habitat while maintaining a viable timber industry. Forest Practice Rules are under constant review through an adaptive management program. An approved Forest Practices Application from the state Department of Natural Resources (DNR) is required for any forest practices activities on forestlands in the state meeting certain criteria. Washington State DNR is authorized to inspect operations and enforce all rules related to forest practices. Ecology is also authorized to take enforcement action if needed to prevent damage to water quality.

The state's forest practices regulations will be relied upon to bring waters into compliance with the load allocations established in this TMDL on private and state forest lands. This strategy was established as a formal agreement to the 1999 Forests and Fish Report (Department of Natural Resources 1999). Consistent with the directives of the 1999 Forests and Fish agreement, Ecology conducted a formal 10-year review of the forest practices and adaptive management programs in 2009[23] and with a 2019 Clean Water Act Assurances two-year extension[24] (Ecology 2009).

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

To ensure the rules are as effective as assumed, a formal adaptive management program was established to assess and revise the forest practices rules, as needed. The agreement to rely on the forest practices rules in lieu of developing separate TMDL load allocations or implementation requirements for forestry is conditioned on maintaining an effective adaptive management program.

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[23] https://apps.ecology.wa.gov/publications/SummaryPages/0910101.html

[24] https://ecology.wa.gov/Water-Shorelines/Water-quality/Runoff-pollution/Forestry-runoff

Pollution Source and Corrective Actions Associated with Camping

Surveys conducted by the City Public Works Department's Stormwater Division frequently encountered encampments along undeveloped sections of Whatcom Creek and its tributaries; human waste was observed in those areas. People are responsible for their own waste, however when neglected, the City often takes on the challenge of clean up and code enforcement. The City frequently addresses the pollution sources associated with unsanctioned camping, but the issue is overwhelming and folds into broader social constructs. Unsanctioned camps are often adjacent to receiving waters, and undeveloped riparian buffers provide concealment and access to water. High bacteria concentrations have been documented in areas with unsanctioned camps, which potentially serve as a pollution source.

Eliminating fecal matter generated by campers is a unique challenge. Installations of port-a-potties or bathroom facilities are often unsuccessful because these structures are frequently damaged by vandals. Conversion of undeveloped riparian areas to restoration sites with native vegetation has not been proven to reduce the number of encampments. Currently, the Bellingham Police Department is the primary entity that address unsanctioned camping. Coordinated camp cleanup activities may help reduce bacteria pollution associated with unsanctioned camping.

The City is in the process of reviewing the BMC to ensure that the proper tools exist to hold landowners accountable for encampments on private property that threaten water quality and produce litter. The City shall develop an information packet explaining the problem, relevant city ordinances, and landowner responsibilities for distribution to property owners. The City continues to address the unsanctioned camping community in a variety of ways including outreach and works with organizations that assist this population segment to identify innovative solutions to this multi-faceted problem.

Wildlife Pollution Source and Corrective Actions

Unless wildlife populations have increased artificially or have been concentrated due to anthropogenic activities, wildlife contributions are considered natural background conditions which may be quantified in a TMDL but not assumed to be decreased. Source control investigations should consider for example, raccoon latrines or concentrated bird nesting under bridges as potential sources. Increases in bacterial pollution has been observed downstream of dead and decaying wildlife, but this is typically not common and often temporary. It is also likely that waterfowl do not contribute excess bacteria to the system since Whatcom Creek meets water quality criteria below the headwater ponds where aquatic birds congregate. Birds, however, may nest under bridges that can cause excessive bacterial loading to the waterways below. The WDFW is the lead organization when dealing with excessive wildlife pollution that is found to be related to human-caused activities.

State Environmental Policy Act and Land Use Planning

Responsible State Environmental Policy Act (SEPA) officials must consider TMDLs during SEPA and other local land use planning reviews. If the land use action under review is known to potentially impact bacteria loading as addressed by this TMDL, then the project may have a significant adverse environmental impact. State Environmental Policy Act lead agencies and reviewers are required to look at potentially significant environmental impacts and alternatives, and to document that the necessary environmental analyses have been made. Land use planners and project managers from the City, the County, and WSDOT shall use findings and actions prescribed in this TMDL and Implementation Plan to help prevent new land uses from violating water quality standards. Information about the SEPA[25] is available at Ecology's website.

Organizations that Implement TMDL

The City, the County, WSDOT, and Ecology are responsible for implementing TMDL control measures. Ecology will work with responsible entities to develop and administer the Clean Water Act NPDES municipal stormwater permits which regulates MS4 dischargers as point sources. The Whatcom Creek watershed is covered by general municipal stormwater Phase II permits that requires local governments to manage and control stormwater runoff so that it does not pollute downstream waters. Implementing source control strategies by identifying and correcting pollution sources is recommended prior to relying on treatment from stormwater best management practices (BMPs).

Ecology will work cooperatively with the local jurisdictions, and other parties involved in the TMDL Implementation Plan. In many instances, Ecology's ERTS shall serve to share information regarding illicit discharges and generate follow up corrective actions. Under the Costs section, this Implementation Plan identifies financial assistance for TMDL-related projects, such as water quality monitoring and BMPs that cover both nonpoint and point source pollution identification and correction activities. Ecology administers financial assistance to local organizations to fund water quality cleanup activities. Ecology will assist in tracking the progress toward meeting the TMDL goals to achieve the WQS that are protective of beneficial uses.

[25] https://ecology.wa.gov/regulations-permits/SEPA-environmental-review

The City manages approximately 90 percent of the land in the Whatcom Creek watershed; 89 percent of this managed area is incorporated and 11 percent is unincorporated UGA (Figure 11). The City's USMP is a voluntary program that samples at eight locations in the Whatcom Creek watershed and is essential for water quality data collection, water quality trend analysis, effectiveness monitoring, and pollution source tracking. The Phase II stormwater NPDES permit requires the City to manage and control stormwater runoff using BMPs so that it does not pollute downstream waters. The City conducts periodic surveys of stormwater system pipes using a video scanner to check for illicit connections.

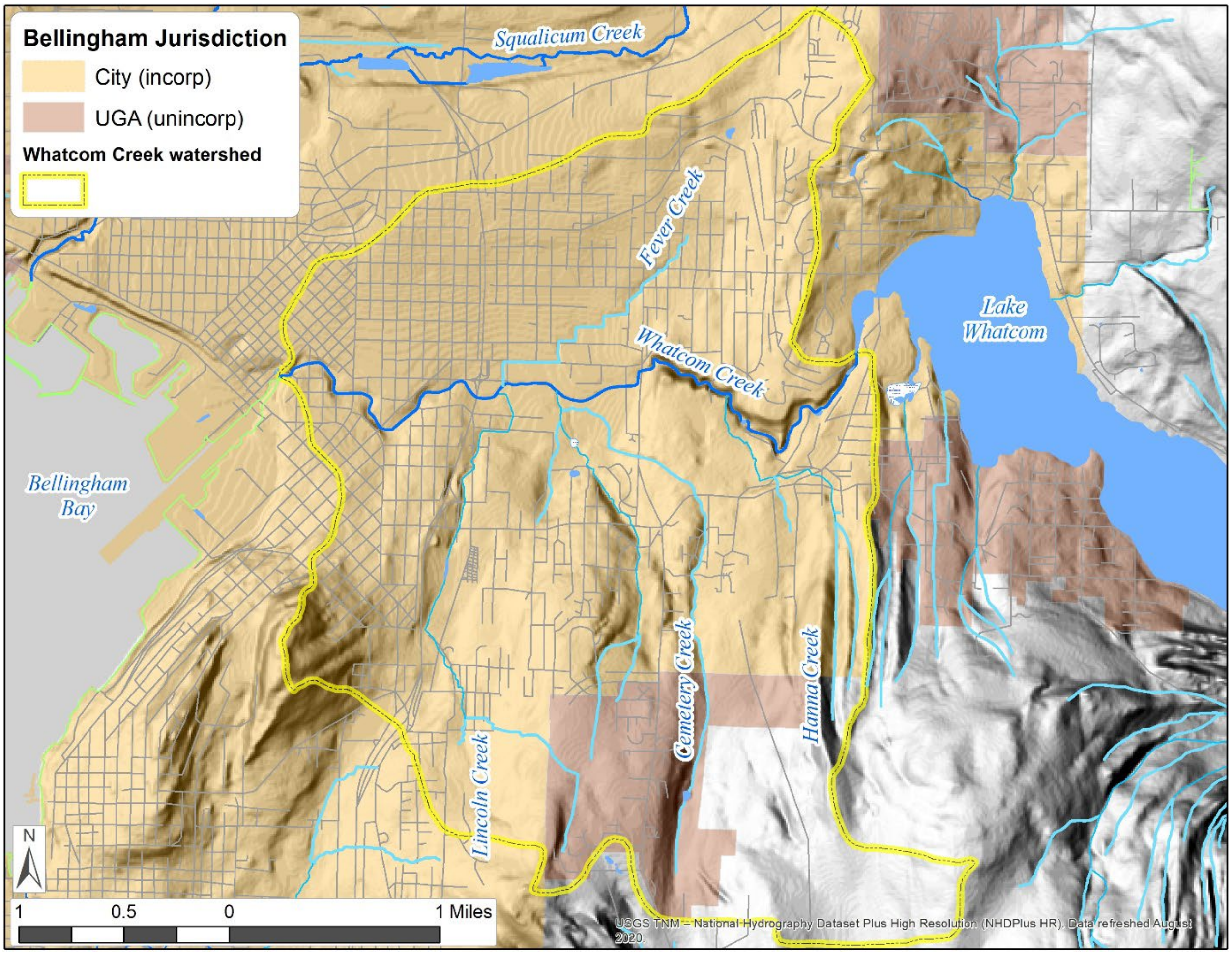

Figure 11. City of Bellingham incorporated jurisdiction and urban growth area (UGA) in the Whatcom Creek watershed

The County manages roughly 10 percent of the watershed area in the UGA (Figure 11). The County UGA in the watershed covers the headwaters of the Cemetery Creek subbasin. The County is responsible for Phase II stormwater activities that reduce and control watershed pollution. Whatcom County Health Department also manages their OSS program to maintain OSS and reduce failure (Figure 10).

The WSDOT manages approximately less than 1 percent of the watershed area in the form of infrastructure and adjacent right-of-way along I-5. The WSDOT manages stormwater runoff from facilities and infrastructure under their NPDES permit. The WSDOT will engage in pollution control and prevention activities or perform corrective remediation in compliance with permit obligations.

Priorities and Timeline

Priorities

Implementation shall start as soon as possible with a focused priority on problematic catchments that show relatively high FC or *E. coli* levels in the MS4 or receiving waterways. The tributaries to Whatcom Creek consistently do not meet water quality criteria, while Whatcom Creek generally meets criteria except for at Dupont St. (WHA00.2) during the dry season. Water quality improvement activities should be prioritized in locations that have the greatest relative geometric mean bacteria levels and require the greatest relative percent reductions to meet the TMDL recommendations.

For example, Fever Creek shows the greatest bacteria levels followed by Lincoln, Cemetery and Hanna Creeks. Further, the relatively high bacteria concentrations observed during the dry season suggest a steady source of pollution that may be attributed to direct-deposit, illicit discharges, illicit cross-connections to stormwater sewers, failing OSS contamination, or municipal sewer entering surface waters through sanitary sewer line breakages. As a priority, correcting the pollution problems in the Fever and Lincoln Creek subbasins will not only reduce the observed bacteria concentrations in these tributaries, it will also likely improve downstream water quality in the mainstem of Whatcom Creek and the Whatcom Waterway.

Whatcom Creek generally showed a decreasing trend in FC concentrations from 2002 through 2018, with the greatest magnitude observed at Dupont St. (WHA00.2 sampling site farthest downstream) (Appendix A) (McCarthy 2020b). Documenting the water quality improvement activities conducted in the watershed from approximately year 2000 through 2018 will help identify activities that led to the improving trends in bacteria levels. Cemetery Creek is the only tributary with a significant decreasing trend in FC concentrations (2002 – 2018), while all other tributaries showed no trend (McCarthy 2020b). The City and County should continue effective water quality improvement actions that were conducted in the Cemetery Creek subbasin and continue to implement or expand these effective practices throughout the Whatcom Creek watershed when applicable.

Seasonal patterns of FC concentrations may be difficult to detect because the hydrology of Whatcom Creek is primarily influenced by the management of Lake Whatcom water levels (Shannahan et al. 2004). Shannahan et al. (2004) and McCarthy (2020b), however, showed increased FC concentrations under stormwater runoff conditions, which suggest the conveyance of FC pollutants to the system with possible resuspension due to stream sediment scouring under increased stream velocities. Assessment of the 2012 effectiveness monitoring field data suggests Cemetery and Fever Creek subbasins experienced the highest FC concentrations relative to all other subbasins in the watershed under wet weather conditions. Wet weather and stormwater runoff likely represents a critical condition and occurs during both the wet and dry season. Additional information, however, such as a combination of streamflow, storm event magnitude, and frequencies is needed to better understand the critical condition.

Timeline

Effective pollution control efforts were already underway well before the completion of this TMDL Implementation Plan. For example, the SWMPs of the City and County detail many of the existing management actions that improve and protect water quality from excessive bacteria pollution. Many pollution control efforts already underway led to improved trends (McCarthy 2020b), which align with the goals of this TMDL Implementation Plan. Pollution control efforts shall be maintained or expanded at any point during the implementation phase of this TMDL. The additional work necessary to attain the TMDL or WQS will require planning, prioritization, and water quality monitoring through an iterative process.

After TMDL approval, local organizations shall use the Implementation Plan to inform development initial strategies and budgets by the end of 2024. Sufficient time will be necessary to finalize the initial TMDL implementation strategies and budgets. Local organizations will work with Ecology to finalize implementation strategies by 2025.

Organizations will work with Ecology on an as need basis to assess attainment of the TMDL and WQS, develop implementation strategies, apply for grants, report environmental concerns, or fulfill permit requirements. Information gathered during each phase of TMDL implementation will be used to develop follow up actions.

The area-based WLA NPDES permit requirements account for roughly 80 percent of the TMDL, after accounting for the effluent-based WLA and the MOS. Annual NPDES permit reporting requirements align with most implementation activities and shall therefore serve as one component of tracking actions and progress toward TMDL attainment. Additional actions beyond the NPDES permit reporting requirements to attain the TMDL is encouraged to be documented and shared with Ecology by 2028.

NPDES Permit

The general stormwater NPDES permits for the City, County, and WSDOT were renewed in 2019 and expire in 2024. Updated versions of the MS4 permits in the next cycle (i.e., after 2024) will include applicable TMDL WLAs, recommendations for permit writers and holders, and other implementation activities designed to ensure Whatcom Creek, its tributaries, and downstream marine waters meet WQSs. Source identification is a high priority and essential activity to address the consistently high bacterial concentrations in the tributaries. The Brooks Manufacturing facility and WDFW Bellingham Fish Hatchery NPDES permits are scheduled for renewal in 2026 and will incorporate TMDL recommendations and implementation activities applicable to their permits. Haskell Corporation holds a general stormwater permit scheduled for renewal in 2025.

All permit holders within the watershed that have assigned WLAs will work with Ecology to incorporate TMDL-related requirements before each respective permit is due for renewal (Tables 8 — 13). For example, using the most protective pollution limit indicated by the TMDL seasonal variation assessment, the NPDES permits shall include an *E. coli* target geometric mean of 97 cfu/100 mL based on the downstream most sampling site of Whatcom Creek at Dupont St. (WHA00.2) during the dry season unless otherwise stated. Monitoring for *E. coli* is recommended to be incorporated under the NPDES permit renewals since it supports this TMDL and the updated WQS. Ecology is currently updating the MS4 NPDES permit manuals while considering the updated WQS, and how it affects TMDLs approved both before and after December 31, 2020. Ecology recently completed the Upland Finfish Hatching and Rearing permit[26]. The NPDES permits shall also include language protective of the dry season (May — September) as the critical period when most of the primary contact recreation occurs.

Technical Feasibility

Since 2002, trends show a decline in bacteria levels at the Whatcom Creek sampling locations that were known to exceed water quality criteria. The proactive water quality improvement activities conducted by the City and County have therefore proven effective despite the increased pressures of urban growth and development. Continuing efforts to improve water quality and protect beneficial uses are also likely to be effective at reducing fecal indicator bacteria loading to the system.

[26] https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Upland-finfish-permit

Focusing pollution control activities on the tributaries to Whatcom Creek will improve conditions in the mainstem while addressing the impairments of each tributary. Assessing catchment specific conditions and potential pollution sources, followed by BMPs and IDDE is a requirement for NPDES permit compliance. The actions described in each NPDES permit provide the means necessary to improve water quality in an iterative process. Education outreach, pet waste stations, and PPA activities are also implementation strategies that have likely improved water quality in the Whatcom Creek watershed.

Costs

The City and the County have been proactive at reducing bacteria pollution in the Whatcom Creek watershed using existing budgets. However, additional funds may be needed to bolster efforts when examining and isolating sources of bacteria pollution (Table 16). Ecology encourages the use of funding opportunities by applying for state-run grants and loans. Funding opportunities offered through Ecology include the Centennial Clean Water Fund, Section 319, State Revolving Fund, and Stormwater Grants. Ecology grant and loan officers are available for consultation throughout the application process. Ecology's TMDL Water Quality Lead for the Whatcom Creek watershed should also be informed of all relevant grant applications. This bacteria TMDL Water Quality Improvement Plan lends impetuous for successful acceptance of the sought grant or loan. Ecology's Grant and Loan Program[27] webpage provides the information needed for the application process. Ecology also offers application workshops.

Table 16. Summary of potential funding opportunities for water quality improvement projects

Sponsoring Entity	Funding Source	Funding Uses
Washington State Department of Ecology	Centennial Clean Water Program	Facilities and water pollution control-related activities; implementation, design, acquisition, construction, and improvement of water pollution control
	Clean Water Act Section 319 Program	Priorities include implementing water cleanup plans; keeping pollution out of streams and aquifers; modernizing aging wastewater treatment facilities; reclaiming and reusing waste water
	Washington State Water Pollution Control Revolving Fund Program (EPA-state partnership)	The State Legislature has periodically made funding available for Municipal Stormwater permittees

[27] https://ecology.wa.gov/About-us/Payments-contracts-grants/Grants-loans/Find-a-grant-or-loan/Water-Quality-grants-and-loans

	Stormwater Financial Assistance Program	Allows local governments to provide loans for repairing and replacing private systems, such as fixing a failed septic system (OSS)
	Stormwater Capacity Grants Program	
	Stormwater Grants of Regional or Statewide Significance	
City of Bellingham	Stormwater Utility Fee	Control stormwater runoff and provide pollution reduction
Whatcom County	Real Estate Excise Tax	Capital investments
	OSS Annual Fee	Support the Operation and Maintenance (O&M) Program for OSS
Washington State Recreation and Conservation	Salmon Recover Funding Board	Habitat restoration, habitat assessment, monitoring, and land acquisition
Environmental Protection Agency	Watershed Funding	Provides tools, databases, and information on funding sources that can be used to protect watersheds
	National Estuary Program (NEP)	Protect and restore the Salish Sea, Puget Sound Region including upland land use that influences habitat, water quality, and stormwater runoff

Ecology's Water Quality Combined Funding Program[28] is an integrated funding program for projects that improve and protect water quality throughout the state using state and federal funding sources. Ecology awards grants and loans on a competitive basis to eligible applicants for high-priority water quality projects. Ecology provides technical assistance and an annual guidance document (Ecology 2019b) to Combined Funding Program applicants. Allocated funds support local communities by helping them upgrade sewage treatment systems, manage polluted stormwater runoff, and complete a variety of other projects to prevent and cleanup pollution. More than $100 million of our combined funding is for new projects that will help support Puget Sound recovery. These projects are a high priority, as they help improve water quality and create a healthy habitat for the endangered Southern Resident Orca, salmon, and the food web they rely on. State financial managers calculate that 11 direct and indirect jobs are created in Washington for every $1 million spent on building clean water infrastructure.

[28] https://ecology.wa.gov/About-us/Payments-contracts-grants/Grants-loans/Find-a-grant-or-loan/Water-Quality-Combined-Funding-Program

The Final List[29] presents the offered distribution of funding for the State Fiscal Year 2021 (SFY21) Funding Cycle (Ecology 2020). The Final List also discusses the goals and objectives for meeting water quality priorities and state and federal funding requirements. There are four major funding programs under the Water Quality Combined Funding Program with an annual funding cycle. The Final List describes how Ecology intends to use and administer the four major funding sources from 1) the Centennial Clean Water Program (Centennial), 2) the federal Clean Water Act (CWA) Section 319 Program (Section 319), 3) the Stormwater Financial Assistance Program (SFAP), and 4) the Washington State Water Pollution Control Revolving Fund, nationally referred to as the Clean Water State Revolving Fund (CWSRF). The Final List also serves as the Intended Use Plan (IUP) required by the federal EPA for providing information on how Ecology will administer the CWSRF. Due to the integrated nature of the funding programs, Ecology publishes one combined document.

The **Centennial Clean Water Program (Centennial)** is a state funding program established by the State Legislature in 1986. The Centennial provides grants to eligible public bodies for wastewater facility preconstruction, construction in qualified hardship communities, and for nonpoint source pollution control activity projects. Nonpoint source pollution control projects include:

- Stream restoration and buffers
- Water quality-focused agricultural best management practices (BMPs)
- Onsite sewage system (OSS) repair and replacement
- Stormwater activities
- TMDL support.

Congress established **Section 319** as part of the CWA amendments of 1987 to address nonpoint sources of water pollution. Based on Congressional appropriations, EPA offers an annual grant to Washington State to implement Washington's Water Quality Management Plan to Control Nonpoint Sources of Pollution. The grant from EPA requires a 40 percent state match. Ecology provides this match by awarding Centennial grants to nonpoint source pollution control projects. Section 319 provides grants for a variety of projects such as:

- Stream restoration and buffers
- Water quality focused agricultural BMPs
- TMDL support.

Projects that implement BMPs are required to collect and report data that estimate load reductions of nitrogen, phosphorus, and sediments. Ecology must report the reductions to EPA annually. Eligible applicants include public bodies and not-for-profit groups. There are no specific state laws or rules for Section 319, but Ecology uses a combination of federal laws, rules, and guidelines and the Centennial law and rule to govern the program.

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[29] https://apps.ecology.wa.gov/publications/SummaryPages/2010017.html

The **Clean Water State Revolving Fund (CWSRF)** is a low-interest rate loan program established by Congress under Title VI of the CWA Amendments of 1987 to fund water quality related projects. The CWSRF provides funds for a broad range of facility and activity projects, including:

- Planning, design, and construction of wastewater facilities, stormwater facilities, and large onsite sewage systems (OSS)
- Planning and implementation of nonpoint source pollution control activities
- Planning and implementation of estuary conservation and management activities
- Onsite sewage system repair and replacement programs
- TMDL support.

Ecology also uses CWSRF to provide special funding for financially challenged (hardship) communities and for projects or portions of projects that meet one or more of EPA's criteria for green project reserve.

The **Stormwater Financial Assistance Program (SFAP)** is a state grant program established through legislative appropriation. The SFAP funds facilities and activities that have been proven effective at reducing adverse water quality impacts from existing urban infrastructure and development. Cities, counties, and ports are eligible for SFAP grants per Chapter 173-323 WAC. In addition, Ecology must implement the program in accordance with any conditions in the SFAP funding appropriation. Funding for the SFAP may come from various state sources that in the past included Model Toxics Control Act (MTCA) and State Building Construction Account. Recent updates to the MTCA statute established the MTCA Stormwater Account that addresses the funding of the SFAP.

Other stormwater grants administered by Ecology include the **Grants of Regional or Statewide Significance and Stormwater Capacity Grants.** Grants of Regional or Statewide Significance (GROSS) are competitive grants that assist Phase I and Phase II NPDES permittees in completing projects that will benefit multiple permit holders. Stormwater Capacity Grants are non-competitive and awarded to Phase I and Phase II NPDES municipal permittees for activities and equipment necessary for permit implementation. Ecology formed a Stormwater Financial Assistance Stakeholder group that developed guidelines for program implementation. Total funding available to each eligible recipient is $50,000. Ports, universities, school or drainage districts, state agencies covered by municipal stormwater permits, or other secondary permittees are not eligible to directly receive this funding.

Outreach

The detrimental impacts of unabated stormwater runoff on water quality are important outreach topics. Webpages, storm drain labels, and informational signs about stormwater and pollution prevention helps raise public awareness. Public education and outreach that stresses the importance of eliminating bacterial pollution is one of the many ways to address the TMDL. The City, County, and Ecology have education and outreach information on their webpages about bacterial pollution prevention. The public is responsible and must get involved by cleaning up after their pets. Cleaning up pet waste litter in public places is required according to local and state code. Utilizing pet waste stations and following the recommendations posted on signs or informational webpages are effective approaches which encourage the prevention of bacterial pollution.

For example, the City and County commonly post informational signs at pet waste stations while providing bags and trash containers. The pet waste programs provide webpage and flyer information about the pollution problems associated with unmanaged waste and how to take preventative actions that reduce the threat of bacterial pollution. The link between stormwater flushing pet waste litter into surface waters offers a connection between litter, stormwater runoff, and water quality. The Whatcom County Health Department provides educational outreach to OSS owners on the importance of maintenance and how to detect a failing system. The local Health Department mails reminders of OSS maintenance and manages a database to track inspections and maintenance schedules. The local Health Department also administers loans to address OSS repair, which requires informational education and outreach.

Tracking Progress

Ecology shall schedule TMDL follow up meetings with the City, County, and local the Health Department to discuss implementation activities and water quality monitoring results. This stakeholder group will determine the optimal time and frequency of meetings. Meetings shall be extended to additional organizations for example, the WSDOT or WDFW, to develop pertinent strategies as needed. Comparisons to the recommended target reductions in bacteria concentrations and trend analysis are measurable milestones to track the efficacy of implementation actions.

Achieving the recommended target reductions is one goal of this TMDL Implementation Plan. The City's Urban Streams Monitoring Program[30] (USMP) is voluntary, however, it offers the existing best option to track the status of water quality, given its continuation. Collaboration with Ecology and project partners will determine the methods used to share water quality information in relation to TMDL cleanup implementation and progress to a broader audience including the EPA. Ecology shall share the TMDL progress and adaptive management actions on their webpage or fact sheet and work with stakeholder to develop the content.

Stakeholders are responsible for documenting their implementation activities and enforcing their legal authority within their jurisdiction under associated codes or permits. If enforcement actions are required, the issuing authority shall be responsible for follow up on any necessary actions. Stormwater permittees shall be responsible for meeting the requirements of their permits. Restoration projects, pollution control and prevention activities, and routine maintenance shall be tracked by the responsible managing party and should include documenting the type and location of water quality improvement actions.

Effectiveness Monitoring

Effectiveness monitoring uses a combination of monitoring types to evaluate whether specified activities have achieved the desired effect. The goals of TMDL effectiveness monitoring can determine if 1) WQS and TMDLs are being met, 2) water quality improvements are linked to water cleanup activities, 3) the current implementation strategy is sufficient, and 4) progress is being made towards meeting these goals (Collyard and Onwumere 2013).

Effectiveness monitoring plans should be developed to assess the efficacy of BMPs and pollution control activities. To evaluate the effectiveness pollution control activities and the attainment of the TMDL, monitoring types may be defined to address questions as follows (Collyard and Onwumere 2013):

Baseline — what are the current water quality conditions?
Status — what is the overall condition of the watershed?
Trends — are conditions changing over time?
Compliance — are WQS or NPDES requirements being met?
Implementation — are BMPs or pollution control and prevention activities leading to the attainment the TMDL goals?
Source Identification — are additional source controls needed?
Effectiveness — are changes in water quality linked to pollution control activities?

[30] https://cob.org/services/environment/water-quality/urban-streams-monitoring

Leveraging local monitoring programs is integral to the success and efficiency of TMDL effectiveness monitoring. Existing monitoring efforts such as the City's USMP serves to provide effectiveness monitoring information to meet the goals of the TMDL Implementation Plan, while maintaining the Program's primary objectives. Depending on available resources, the USMP is encouraged to continue, however, remains at the City's discretion. Additional funding or monitoring efforts may be necessary to continue or temporarily expand efforts to investigate the causes of water quality exceedances observed on the tributaries and the lower reach of Whatcom Creek.

Whatcom Creek at Dupont Street is an important monitoring site because it has a long history of routine sampling and is the most downstream site that may be used to generally characterize the water quality of the watershed. The sampling records indicate that the City's USMP typically samples FC at this site every month along with the recent reintroduction of *E. coli* sampling at a subset of locations. The Dupont Street sampling location is important when assessing the attainment of TMDL allocations to determine the protection of shellfish harvesting in the downstream marine waters. For added flexibility, monitoring for FC at the mouth of Whatcom Creek becomes optional because the bacteria translator offers a way to estimate FC loading from *E. coli* sampling results (Equation 2). In any event, either these translated FC values or direct FC measurements shall be used to determine TMDL components and the protection of downstream shellfish harvesting.

Likewise, *E. coli* TMDL components may be calculated using either direct measurement or FC measurement. The FC samples collected may be used to estimate *E. coli* concentrations using the bacteria translator (Equation 1). Either translated or direct *E. coli* measurements may therefore be used to assess the attainment of the TMDL allocations, which addresses primary contact recreation. Epidemiology of people in contact with water bodies using *E. coli* and enterococci fecal indicator bacteria provide the same level of protection from associate pathogens (EPA 2012).

Because this TMDL and long-term monitoring conducted by the USMP indicates continued exceedances in the bacteria WQS along the tributaries and Whatcom Creek at Dupont Street, source identification and control should be focused on the immediate contributing catchments. Source identification and control is important by lending the capability of isolating the location of pollution sources and confirming the effectiveness of pollution control activities. For example, source identification and control conducted when stormwater runoff is not occurring may indicate a cross-connection in the MS4, direct-deposit, failing sewage infrastructure, or an OSS that contributes to elevated bacteria concentrations. Alternatively, source identification when stormwater runoff is occurring may indicate conveyance from the MS4 or nonpoint sources to the receiving waterways.

When including seasonal variability, the dry season (May through September) indicates the period of the year with the observed greatest bacteria pollution levels, where source identification and control may be tailored based on this information. For example, the connection between increased outdoor recreation with pets during the dry season may lead to increased pet waste issues as a potential pollution source. Once pollution sources are identified, water quality clean up actions may be tailored to address each specific cause of pollution.

Identifying the exact source of bacteria pollution using source identification methods is difficult in urban environments given the wide variety of potential origin, which may be temporary in nature, and the complexity of tracking the MS4 infrastructure circuits in relation to topographic catchments back to the source of pollution. Any one of the identified pollution sources may be contributing, where isolating one from another becomes possible once the cause-and-effect relationship is established. Documentation of corrective actions and BMPs along with water quality sampling allows involved parties to assess the efficacy of these activities or identify other potential influences.

Assessing the Attainment of the TMDL and WQS

Currently, water quality monitoring discretion is largely determined by the USMP objectives and available funding. Additional funds or monitoring programs may be necessary to address the TMDL and prevent bacteria pollution. Efforts that focus resources on locations with chronic bacteria impairments should be maintained or increased, while sites that consistently meet the WQS could be sampled less frequently. For example, Whatcom Creek at the control dam and at Valencia Street consistently meet the WQS, which may be monitored based on the USMP objectives, or monitored approximately once every two months starting in January of each year to provide flexibility while providing sufficient data to address the WQS (Ecology 2018).

Priority sampling sites and minimum recommendations that address the TMDLs and 303(d) listed impaired AUs include:

- Whatcom Creek at Dupont St. — paired FC and *E. coli*
- Lincoln Creek at Fraser St. — transition from FC to *E. coli*
- Fever Creek at Valencia St. — transition from FC to *E. coli*
- Cemetery Creek at mouth — transition from FC to *E. coli*
- Hanna Creek at mouth — transition from FC to *E. coli*

Improving the FC to *E. coli* Relationship Characterization

Reduced monitoring frequency away from sites that consistently meet the WQS could shift time and resources toward the paired sampling of FC and *E. coli* or promote the transition to primarily sampling *E. coli* at locations upstream of Dupont Street. The bacteria translator is based on 47 paired samples collected throughout the urban areas of Bellingham, which was used to develop the TMDL (Appendix D). Continued paired sampling of Whatcom Creek at Dupont Street as well as ongoing local paired sampling efforts may be used to update the bacteria translator model. The USMP planning and sampling efforts remain at the discretion of the City, which currently serves as a robust program.

The decision to update the bacteria translator model shall be made by Ecology and local stakeholders, which collectively serve as a technical advisory group. If the group decides to update the model, Ecology will use the best available data and share the outcome and methods used to develop the model following methods described in Appendix D. Future TMDL calculations using an updated translator, however, is not anticipated to produce significantly different outcomes than those calculated in this study; given the existing close agreement between the paired samples as indicated by model performance (Appendix D — Bacteria Translator). The City and County may request Ecology's assistance when addressing the FC to *E. coli* relationship on an as need basis, when considering monitoring strategies, trend analysis, the WQA, and applications to TMDLs.

Adaptive Management

Natural systems are complex and dynamic. The way a system will respond to human management activities is often unknown and can only be described as probabilities or possibilities. Adaptive management involves testing, monitoring, evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings or field observations. Quantifying the effects of applied pollution prevention activities or BMPs in terms of actual bacteria reductions is not well understood for urban environments. Pollution prevention activities described in this Implementation Plan are based in practical and scientific knowledge. Ultimately, measuring the efficacy of the collective pollution control activities is reflected in ambient water quality data collected over time. The effectiveness of site specific pollution control activities, however, may be assessed by sampling outfalls, ditches, or isolated stream reaches, for example, near the source of activity.

In the case of TMDLs, Ecology uses adaptive management to assess whether the actions identified to solve the pollution problems are the correct ones and whether they are working. As actions are implemented, the system should respond as indicated by an improvement in water quality. Effectiveness monitoring can be applied to adaptive management to highlight the progress of implementation actions, help identify new strategies, promote accountability, and increase participation. Adaptive management may fine-tune actions to make them more effective, and to try new strategies if evidence that a new approach could help achieve WQS or permit compliance.

If implementation actions are effective, bacteria reductions should be achieved, and the WQS for bacteria should be met and thereby fulfill project goals. Project partners will work together to monitor progress towards these goals and evaluate successes, obstacles, and changing needs. Adjustments to the implementation strategy may be necessary as new information is discovered or if the WQS are not attained. If the WQS are achieved, but wasteload and load allocations are not, the TMDL will be considered satisfied. Following the requirements of the WQA, sampling for *E. coli* will be necessary to evaluate the data with the *E. coli* WQS (Ecology 2018 and WAC 173-201A). Either FC or *E. coli* data may be used to determine the attainment of the TMDL relative to the designated use of the water body.

Ecology and stakeholders shall use adaptive management when water monitoring data show that the TMDL targets are not being met or implementation activities are not producing the desired result. Full implementation of water quality cleanup actions will require time to coordinate as strategies, workplans, and monitoring activities are developed and tailored. As implementation develops, the attainment of the WQS is anticipated to be achieved by 2042 or sooner. Many of the pollution control efforts are already underway and implemented by the City and County respective SWMPs under regulation, or cooperative nonpoint source control activities under local codes and voluntary activities. Additional pollution control efforts are necessary to meet WQS because elevated bacteria levels have been and continue to be observed. Water quality monitoring data should be assessed annually to track progress toward meeting the TMDL goals. Ecology shall assess water quality data in relation to the goals of this TMDL at its discretion, or upon request from local stakeholders or the EPA.

Adaptive management is expressed in the following steps (Figure 12):

Step 1. The activities in the water quality Implementation Plan are put into practice starting with data analysis and drafting grant proposals. Priority areas include the Fever and Lincoln subbasins and the downstream catchments of Whatcom Creek.

Step 2. Programs and pollution control and prevention activities are evaluated for adequacy or use by 2024. Time will be needed to develop and review the planned implementation activities.

Step 3. The effectiveness of the activities is evaluated by assessing new monitoring data and comparing it to the data used to set the TMDL targets. Ecology will analyze data at the request of stakeholders. The USMP is the most likely data source given the long-term involvement in the watershed, however, other credible data are also practical for use.

Step 3a. If the goals and objectives are achieved, the implementation efforts are adequate as designed, installed, and maintained. Project success and accomplishments should be publicized and reported to continue project implementation and increase public support.

Step 3b. If not, then supporting activities the implementation plan will be modified or new actions identified every five years after Step 2, starting in 2029. The new or modified activities are then applied as in Step 1.

Additional monitoring may be necessary to better isolate the pollutant sources so that new supporting activities can be designed and implemented to address all sources of bacteria to the streams. It is ultimately Ecology's responsibility to assure that implementation is being actively pursued and WQS are achieved. If the WQS are not achieved, more stringent permit requirements or innovative approaches to control pollution sources may be necessary to reach the TMDL project goals.

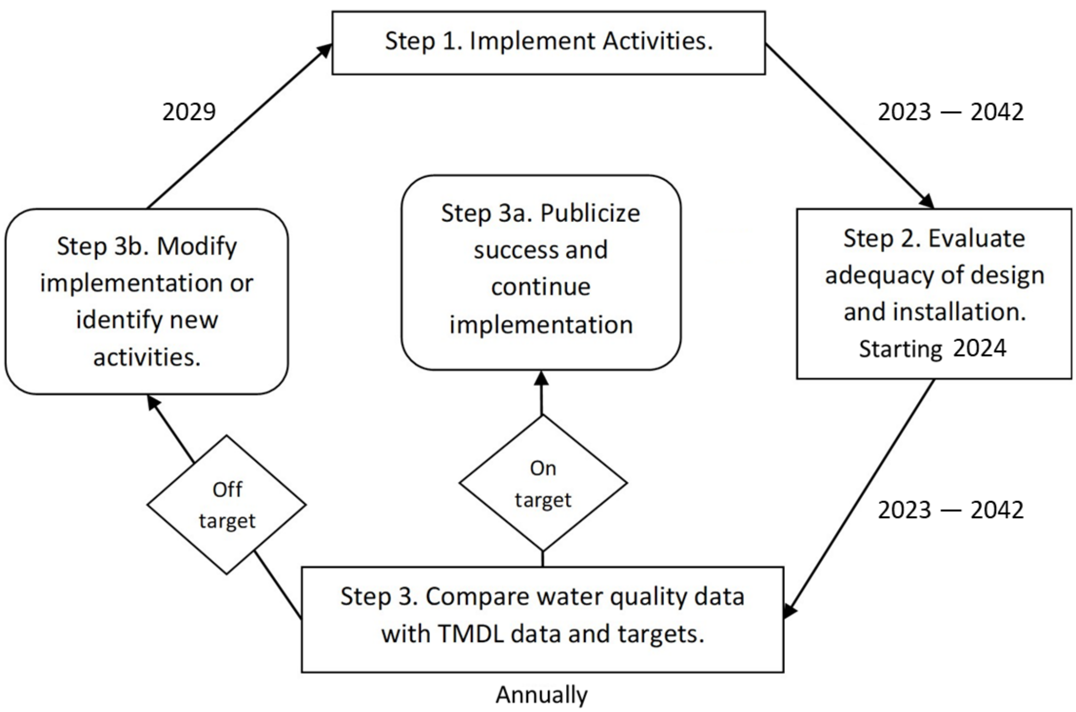

Figure 12. Feedback loop for determining need for adaptive management. Dates are estimates and may change depending on resources and implementation status

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Appendices

Appendix A. Background

Clean Water Act and TMDLs

Federal Clean Water Act requirements

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

The Water Quality Assessment and the 303(d) List

Every two years, states are required to prepare a list of water bodies that do not meet water quality standards that are set by the state for each type of pollutant. Section 303(d) of the Clean Water Act establishes a process to identify and clean up polluted waters. In Washington State, this list is part of the Water Quality Assessment process. The Clean Water Act requires that a TMDL be developed for each of the water bodies on the 303(d) list.

To develop the Water Quality Assessment, 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 Water Quality Assessment are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the assessment. The Water Quality Assessment divides water bodies into five categories. Waters with pollutants that impair beneficial uses such as for drinking, recreation, aquatic habitat, and industrial use are placed in the polluted water category (category 5) of the water quality assessment.

- **Category 1** — Meets standards for parameter(s) for which it has been tested.
- **Category 2** — Waters of concern.
- **Category 3** — Waters with no data or insufficient data available.
- **Category 4** — Polluted waters that do not require a TMDL because they:
  - **4a** — Have an approved TMDL being implemented.
  - **4b** — Have a pollution control program in place that should solve the problem.
  - **4c** — Impaired by a non-pollutant such as low water flow, dams, or culverts.
- **Category 5** — Polluted waters that require a TMDL – the 303(d) list.

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

Total Maximum Daily Load (TMDL) process overview

Ecology uses the 303(d) list to prioritize and initiate Total Maximum Daily Load (TMDL) studies across the state. The TMDL study identifies pollution problems in the watershed and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology, with the assistance of local stakeholders, develops a plan to control and reduce pollution sources as well as a monitoring plan to assess effectiveness of the water quality improvement activities. This comprises the water quality improvement report and implementation plan.

The TMDL report goes through a public comment period followed by changes and adjustments as needed. The final report is submitted to the Environmental Protection Agency (EPA) for approval and includes the TMDL, project plan, and implementation plan. After EPA approval, the TMDL water quality improvement plan is implemented and the Category 5 — 303(d) listing will be placed into Category 4a — has an approve TMDL. During that process, monitoring will indicate how well water quality is improving. If the water body health is not improving as expected, Ecology and local stakeholders adjust in the process, where needed. When the water body meets water quality standards, its assessment status is changed to Category 1: Meets tested standards for clean waters. Continued periodic monitoring ensures that the water body maintains state water quality standards. The biennial Water Quality Assessment process determines the most recent status of 303(d) listed water bodies.

Watershed Hydrology

Whatcom Creek is in northwestern Washington State and runs through the City of Bellingham (Figure 1), originating from Lake Whatcom and draining into Bellingham Bay. Whatcom Creek is the only natural surface water outlet of Lake Whatcom, a glacially formed lake located in Whatcom County. Whatcom Creek is 4.3 miles (6.7 km) long with a drainage basin of approximately 9 mi^2 (23.3 km^2 (5,790 acres)) in addition to the 486 mi^2 (1,259 km^2 (31,180 acres)) of the upstream Lake Whatcom watershed (City of Bellingham 2011 and 1982, Hood et al. 2011). The annual average streamflow of Whatcom Creek is 137 cfs, with a wet season average of 214 cfs, and a dry season average of 60 cfs. The stream discharge reported here quantifies the period of record from 2002 through 2017 and is measured by a continuous flow gage at Dupont Street (McCarthy 2020b). Whatcom Creek has four tributaries: Hanna, Cemetery, Fever, and Lincoln creeks. Fever, Lincoln, and Cemetery Creeks are perennial streams that have summer flows with less than one cubic foot per second. Hanna Creek is an intermittent stream that usually goes dry during August and September (Shannahan et al. 2004).

Lake Whatcom supplies drinking water for more than 100,000 residents in Bellingham and Whatcom County, as well as process water for several industries. The City diverts flow from river mile 7 of the Middle Fork of the Nooksack River into Lake Whatcom. Water is diverted through a tunnel under Bowman Mountain to Mirror Lake. Water from Mirror Lake flows to Lake Whatcom via Anderson Creek. The City operates a control dam at the outfall of Lake Whatcom as it enters Whatcom Creek. Operational considerations include minimization of downstream flooding, utility storage for water quantity and water quality considerations, maximizing salmonid habitat, and maintaining lake level within the legal limitation to prevent lakefront properties from flooding (City of Bellingham 2011).

Shannahan et al. (2004) estimated that the Whatcom Creek watershed discharge is largely controlled by the headwater dam operation. Whatcom Creek comprises approximately 96 percent of basin's total streamflow followed by the Cemetery Creek basin (1.8 percent), Lincoln Creek basin (0.9 percent), Fever Creek basin (0.9 percent), and Hanna Creek basin (0.5 percent). The impacts to the watershed that alter stream discharge include channelization and flood control projects, loss of riparian vegetation, channel restrictions from road crossings, and the addition of many point sources of stormwater runoff. The Department of Fish and Wildlife, Bellingham fish hatchery located in Whatcom Falls Park near the head of the creek, discharges water after it has been cycled through rearing ponds and raceways.

Fever and Lincoln creeks are flashy due to the basin topography and soil conditions. These conditions are compounded by the increase in impervious surfaces and loss of riparian buffer strips associated with development in these watersheds (City of Bellingham 2011). Cemetery Creek is comprised of four tributaries that drain residential areas and small wetlands. Fever, Lincoln, and Cemetery creeks are perennial streams that have summer flows with less than one cubic foot per second. Hanna Creek is an intermittent stream that usually goes dry during August and September.

Long-term meteorological data indicates that Bellingham averages 36 inches of precipitation annually with a distinct seasonality according to the National Oceanic and Atmospheric Administration meteorological station at the local airport (Network ID: GHCND:USW00024217). The technical study designated May – September as the dry season and October – April as the wet season (Shannahan et al. 2004) with average precipitation of 12 and 24 inches respectively. The City maintains rain gages at City Hall and Bloedel Donovan Park (Table A-17).

Table A-17 Average total monthly and annual precipitation (inches) from the City of Bellingham's City Hall and Bloedel Donovan Park site rain gages

Month	2003-2018	2017	2018
January	4.8	2.5	6.9
February	3.2	4.8	4.5
March	4.2	6.7	3.8
April	2.7	3.3	3.6
May	2.4	2.7	0.7
June	1.6	1.2	1.3
July	0.7	0.1	0.1

August	0.9	0.1	0.2
September	2.3	2.0	2.6
October	4.1	4.9	2.8
November	6.4	7.4	6.0
December	5.0	5.6	4.8
Annual	38.3	41.3	37.3

Water Quality Issues

Since 1990, the City of Bellingham's Urban Streams Monitoring Program[32] has monitored water quality of Whatcom Creek and its tributaries. The City typically monitors Whatcom Creek at four locations and has one sampling station on each of the tributaries: Cemetery, Lincoln, Fever, and Hanna creeks (Table A-18 and Figure A-13). For the latest sampling locations visit the City's USMP website, see link above. Sampling parameters include temperature dissolved oxygen, pH, conductivity, turbidity, and fecal coliform (FC). Sampling schedules varied from monthly (1990 to 1995), a minimum of four times per year (1996 to 2001), to monthly (2002 to present).

Table A-18 City of Bellingham's Urban Stream Monitoring Program sampling locations in the Whatcom Creek watershed — data source: Shannahan et al. 2004

Group	Site	Description
Whatcom Creek	WHA00.2	Whatcom Cr at Dupont St
Whatcom Creek	WHA01.3	Whatcom Cr at James St
Whatcom Creek	WHA02.4	Whatcom Cr at Valencia St
Whatcom Creek	WHA04.2	Whatcom Cr at Headwaters/ Control Dam
Tributary	CEMETERY	Cemetery Cr at mouth
Tributary	FEVER	Fever Cr at Valencia St
Tributary	HANNA	Hanna Cr at mouth
Tributary	LINCOLN	Lincoln Cr at Fraser St

[32] https://cob.org/services/environment/water-quality/urban-streams-monitoring

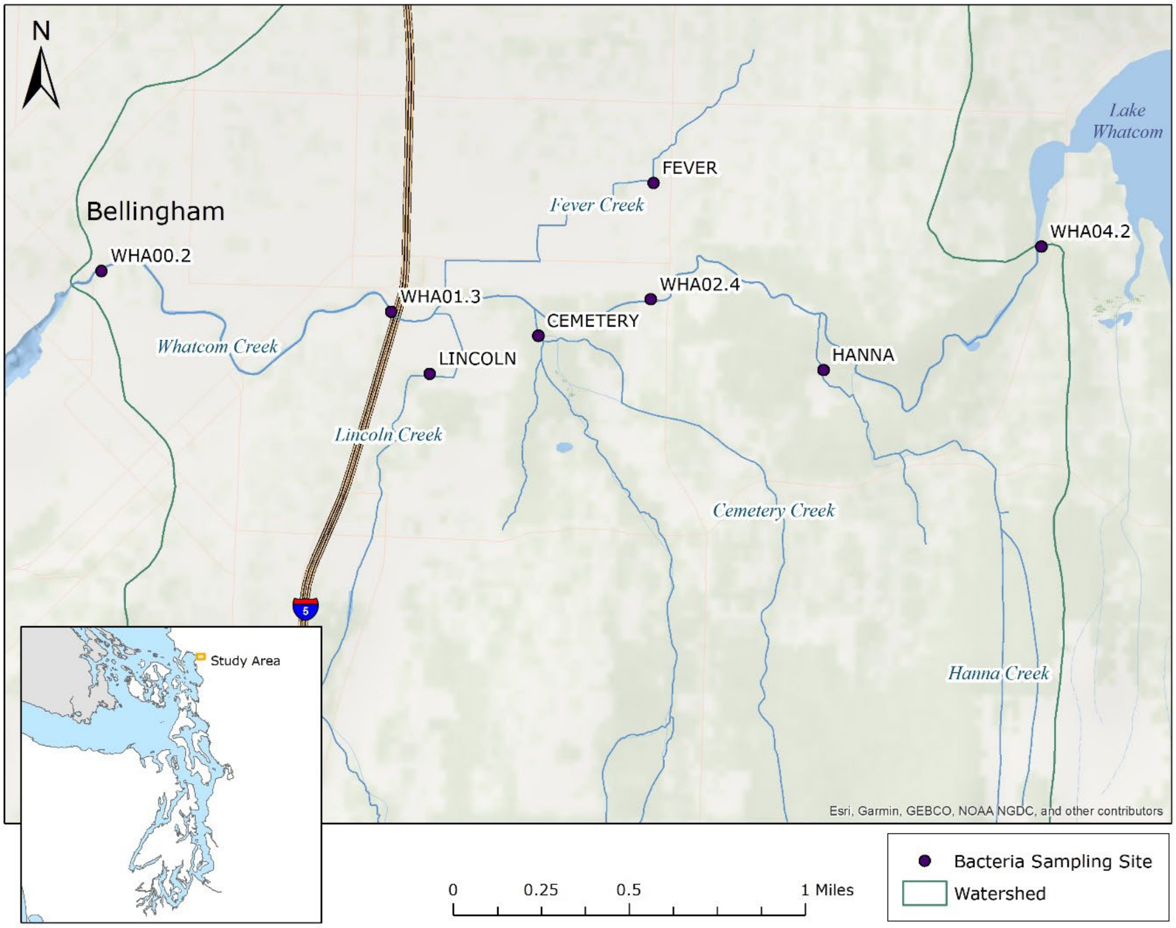


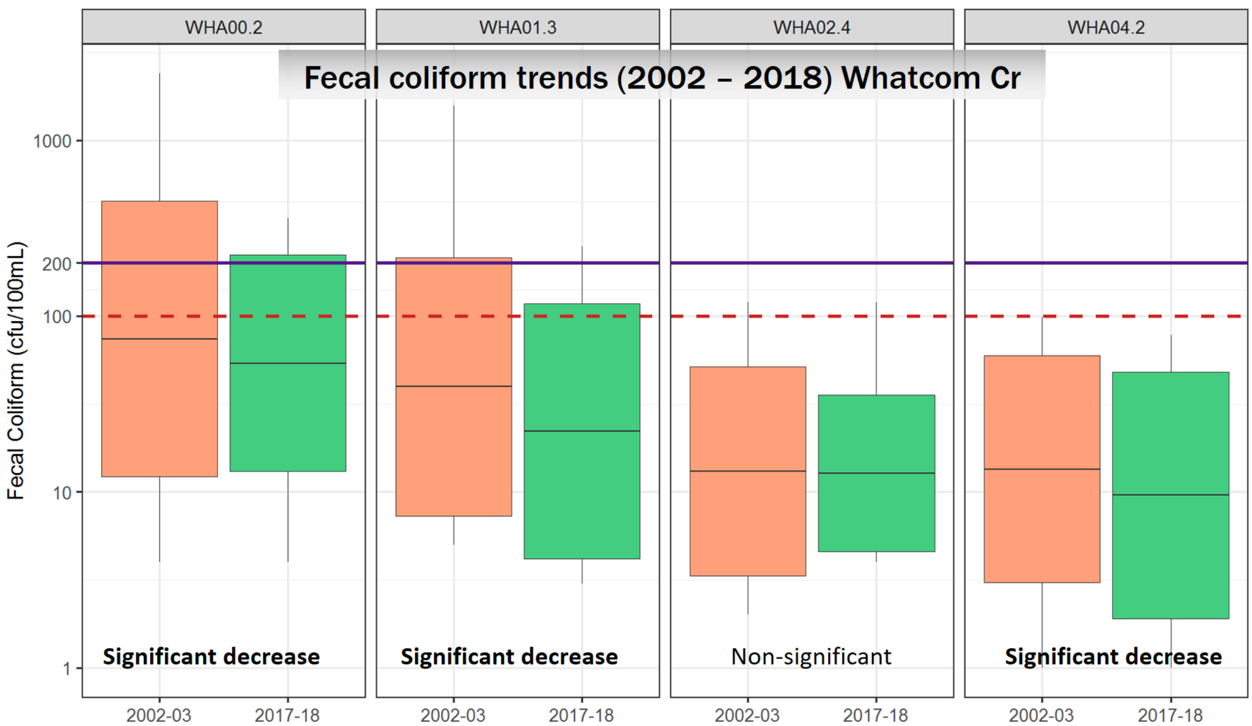
Figure A-13. City of Bellingham's Urban Stream Monitoring Program sampling locations in the Whatcom Creek watershed — data source: Shannahan et al. 2004

Whatcom Creek is a polluted urban stream system where historically the water quality did not meet the standards for FC bacteria and temperature. Data collected by the City's USMP since 1990 indicate that bacteria concentrations have exceeded standards both in Whatcom Creek and its tributaries for several years. Between September 1991 and September 1996, Ecology's ambient water quality monitoring found 3 excursions out of 12 samples in the lower reach of Whatcom Creek. These data led to the listing of Whatcom Creek on Washington's 1998 303(d) list for FC bacteria. Follow up monitoring led to the tributaries Cemetery, Lincoln, Fever, and Hanna creeks to be included on 303(d) list for FC bacteria as well based on the former FC WQS for freshwater contact recreation. FC has since then been replaced by *E. coli* as the freshwater fecal bacteria indicator in the WQS.

Like many municipalities, the City utilizes Whatcom Creek and its tributaries as part of the stormwater conveyance system. Watershed and resource managers are challenged by the encroachment of development and associated pollutant loads. In areas with a high percentage of impervious surfaces, stormwater runoff is a major source of bacteria pollution in streams. Approximately 23.6 percent of the total Whatcom Creek watershed area is covered with impervious surface (Shannahan et al. 2004); however, it is likely that the amount of impervious surface has increased during the past 20 years.

Water Quality Trends

Despite the expected increase in impervious surface cover, McCarthy (2020b) demonstrated that bacteria concentrations have declined at many long-term sampling locations (Figure A-14). Increased urbanization typically deteriorates water quality; however, the Whatcom Creek watershed has improved water quality in terms of observed bacteria concentrations while simultaneously experiencing potentially harmful urban development. One possible explanation of the observed decreasing trend in bacteria concentrations is the efficacy of the mandatory pollution control actions described in the MS4 general NPDES permit and stormwater management plans.



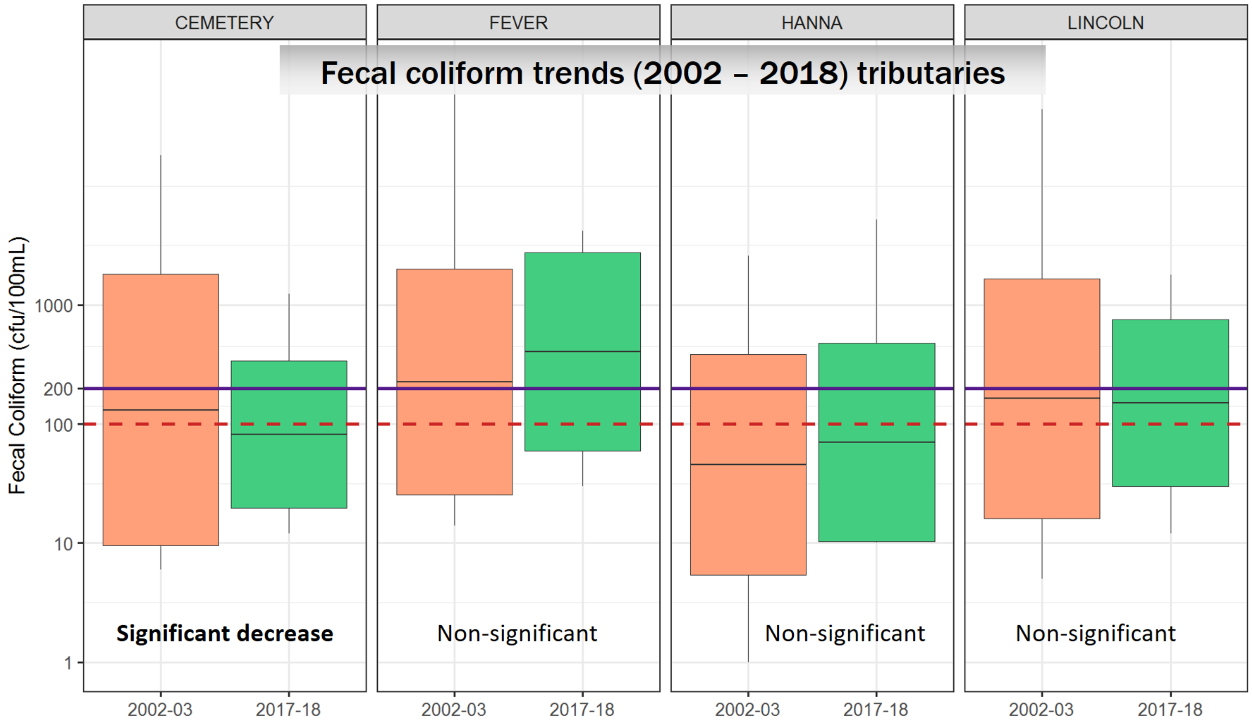


Figure A-14. FC distribution during original TMDL period (2002-2003) and more recent data (2017-2018). Boxplots indicate maximum, 90th percentile, geometric mean, 10th percentile, and minimum and are compared with water quality criteria — solid line (10% STV) and dashed line (geometric mean). Significant trends were determined using Seasonal Kendall tests — data source: McCarthy (2020b).

Comparison with Shannahan et al. (2004)

The Shannahan et al. (2004) study included FC percent reductions using the 2002 — 2003 dataset. Reductions from Shannahan et al. (2004) were compared with the updated FC percent reductions that incorporated data from 2017 through 2018 (Table A-19) (McCarthy 2020b). Based on the updated 2017–2018 FC data, additional FC reductions are needed at the lower Whatcom Creek sites (WHA00.2 and WHA01.3). Like Shannahan et al. (2004), no reductions were required at either in the upper reaches of Whatcom Creek (WHA02.4 or WHA04.2). Tributary reductions are similar between both study time-periods except for Cemetery Creek that currently requires a higher FC reduction to meet criteria based on the 2017 — 2018 data when compared to 2002 — 2003 data. Dataset comparisons provide an examination of the potential effectiveness of BMPs and education outreach programs that were enacted between 2002 and 2018.

Table A-19. Fecal Coliform percent reductions and TMDL target geometric means needed to meet water quality criteria from the 2004 TMDL technical study (2002–2003 data) and updated data (2017–2018) — data source: McCarthy (2020b)

Site	FC % Reduction 2002 — 2003	Target Geomean (cfu/100mL) 2002 — 2003	FC % Reduction 2017 — 2018	Target Geomean (cfu/100mL) 2017 — 2018
WHA00.2	62%	29	10%	49
WHA01.3	14%	38	0%	22
WHA02.4	0%	14	0%	13
WHA04.2	0%	18	0%	10
CEMETERY	86%	20	41%	48
FEVER	88%	28	93%	30
HANNA	58%	25	58%	29
LINCOLN	78%	23	73%	40

Protection of Designated Uses

The Whatcom Creek bacteria TMDLs were established to address impairments to the designated uses of shellfish harvesting and primary contact recreation, which were caused by excessive bacteria concentrations. The *E. coli* TMDLs were established using the bacteria translator (Appendix D). Addressing water quality impairments through monitoring, data analysis, and adaptive management using the TMDL Implementation Plan and NPDES permit requirements provides the foundation to protect and preserve the designated uses of the Whatcom Creek watershed and the downstream marine waters. The WLAs, LAs, and MOS have been incorporated using conservative assumptions. The LC accounts for the WQS by incorporate the water quality criteria.

Appendix B. Public Participation

Public Comment

During project development, Ecology received input from the City, County, Whatcom County Health Department, WSDOT, EPA, and members of the public. The draft TMDL and Implementation Plan was posted on Ecology's website and shared with the public and governmental organizations following Washington's public participation statute requirements. Ecology held an online public presentation workshop on April 12, 2023, from 3:00 pm to 4:00 pm. The 30-day public comment period for this TMDL and Implementation Plan was from April 1 through 30, 2023. Ecology sent a news release local stakeholders and to all local media and work groups in the watershed. Ecology announced the workshop using online outreach platforms through listserv and on the Washington State Department of Ecology's homepage.

Ecology welcomes and appreciates public involvement, which is integral to improving and protecting water quality in the Whatcom Creek watershed. Collaboration with governmental and non-governmental organizations is essential for TMDL development and implementation. The comments received during the public comment period are provided below along with Ecology's responses. This Comment and Response section is organized starting with those received from the members of the public, followed by those received from governmental organizations.

Comments and Response

I-1: Comment I-1-1

Using Bloedel Donovan as an off leash dog park for the majority of the year seems to me like a large contributor to bacteria. Has anyone considered temporarily halting that activity to see if water quality improves? I also would consider keeping dogs a good distance away from the tributary creeks at the whatcom falls off leash trail area near the water treatment plant. Not sure if the non housed people can be effectively regulated but encampments along the creek are obvious contributors as well.

Response to I-1-1

Thank you for your comment. Although your consideration to temporarily halt off leash dog park activities at Bloedel Donovan is not directly stated in the Implementation Plan, the concept of developing or updating City and County policies for off leash dog parks is recommended to protect water quality. Starting on page 88 of the Implementation Plan, we have recommendations to address off leash dog parks and siting future dog parks in the Whatcom Creek watershed are as follows:

- Locate all future off-leash areas away from streams and wetlands, and
- Develop citywide or countywide policy for off-leash use areas located near shorelines.

The Implementation Plan does not use the terms "non housed", however, Ecology recognizes similarities by using the terms "unsanctioned camping", see — Pollution Source and Corrective Actions Associated with Camping (page 91). Unsanctioned camping and the littering of fecal waste are identified as potential sources of pollution. Ecology acknowledges the need to address this potential pollution source. The many factors that contribute to unsanctioned camping, *e.g.*, socioeconomic, go beyond the confines of the Clean Water Act. Despite the complexity of this issue, pollution control and prevention are possible through community participation and following local codes and regulations.

I-2: Comment I-2-1

I strongly support any effort to improve the water quality of Whatcom creek and four of its tributaries that are on the state's list of impaired water bodies, known as the 303(d) list. Whatcom Creek has been on the impaired list since 1996.

However, Whatcom creek originates in Lake Whatcom, which is the primary water source for Bellingham (where I live) which is also rated as an impaired water body. If it is important to support recreation, and shellfish commerce, is it not even more important to force the city of Bellingham and Whatcom county to an providean[sic] unimpaired water source for its citizens? Isn't it within the scope of the department of Ecology to enforce such responsibility?

Unless the Department of Ecology sues (or otherwise legally forces) the county and the city to immediately stop letting people swim, boat and land planes in a public reservoir, the water quality of Lake Whatcom (the source of Whatcom creek) will continue to degrade until it is no longer usable. The consistent degradation of Lake Whatcom has been well documented, and yet no substantial state level enforcement has occurred. The situation has become absurd as Whatcom county (that manages the majority of the Lake and its watershed) continues to build luxury homes on the banks of the lake with boat docks and continues to allow old septic tanks and the use of pesticides in the watershed. The county also still allows clear cuts in the watershed which consistently degrades water quality. And there are unremediated[sic] toxic waste locations in the watershed including an old toxic waste dump and a heavy contaminated shooting range to name just a couple.

This is the only locality in Washington state that has these dangerous water management policies in a public reservoir. Yes, it is vital to clean up the tributaries that carry the impaired water from Lake Whatcom to the coastline. But that is the result of the dangerous and likely illegal neglect of public health and the right of the public to have access to clean water. Forcing the county and the city to immediately stop recreational use of the lake/reservoir and stop development and remediate waste in the watershed should be the first step in this project.

It is sad that Whatcom county and the city of Bellingham have no regard for their citizens access to clean water, but it is even more egregious that the department of Ecology is willing to allow this to continue. The environmental degradation in Whatcom county has led to a cancer rate that is higher than Alameda county in California that includes the city of Oakland. The cancer rate is higher than King county--this is unacceptable.

And let's not forget that Climate Change and the extreme weather it brings will only accelerate the impaired water in both Lake Whatcom and its tributaries. Please take action now.

Response to I-2-1

Thank you for your comment. The Lake Whatcom Dissolved Oxygen and Bacteria TMDL addresses nutrients and bacteria pollution to the lake. The Whatcom Creek bacteria Implementation Plan acknowledges the hydrologic connection between the lake and Whatcom Creek and how this pertains to water quality, see — Scope, Seasonal Variation, and Appendix A Background sections.

I-3: Comment I-3-1

Geese and ducks are a big problem. Human beings swimming on the beach is a problem. Critters in general are a "problem".

The watershed rules end at Dakin. That's a problem.

You must know the breakdown of the DNA.

Let me know.

Response to I-3-1
Thank you for your comment. The TMDL and Implementation Plan acknowledges throughout the report your identified potential pollution sources.

I-4: Comment I-4-1
The statement (p. 24):

"There are no shellfish growing areas or designated marine water swimming beaches near the mouth of Whatcom Creek"

is perhaps legally correct but in practice untrue. The beach at Waypoint Park (at the head of Whatcom Waterway and right at the mouth of Whatcom Creek) is heavily frequented by swimmers and bathers (particularly children) during the summer months, and during the past few years there has been (illicit, gray-market) commercial harvest of oysters from the beds at the mouth of the creek.

Response to I-4-1
Thank you for your comment. By establishing the TMDL, Ecology's goal is to protect the designated uses in the area which you refer including the mouth of Whatcom Creek, the Whatcom Waterway, and the greater Bellingham Bay. The TMDL and Implementation Plan establishes bacteria loadings and concentration targets that are protective of downstream designated uses — see the sections titled Marine Water Designated Uses (page 25), Marine Water Shellfish Harvesting and Contact Recreation (page 28) and Table 6, TMDL Targets (page 30) and Table 7, Appendix A, Protection of Designated Uses (page 121), Appendix D, Protecting Downstream Uses (page 139), Rollback Target Concentrations and Percent Reductions (page 152), and Appendix E Loading Calculation (page 167). Achieving the bacteria TMDLs will result in the protection of shellfish harvesting and contact recreation according to the applicable water quality standards.

I-5: Comment I-5-1
Creek Pollution Alert

Model: Default (GPT-3.5)

Dahvid Hill

Please write a comment for me to provide to the ecology council on bacteria in the creek . Let them know I have fished the creek for 15 years and in the past 5 have seen its demise. I've witnessed tents and fecal waste in the creek by people camping on the creek as well as added pollution with shopping carts and other debris . I have pulled out machinery and bicycles . People dump their septic from rvs directly into the creek . This is the unspoken ecological impact of unpermitted waste dumping and unpermitted camping on the creek. We use to organize clean ups but the problem is too great. Please consider the problem of open defecation into the creek and sorrounding[sic] areas as a contributer[sic]

Dear Ecology Council,

I am writing to bring your attention to the deteriorating state of the creek that I have been fishing in for the past 15 years. Over the past five years, I have witnessed a significant decline in the water quality and overall health of the creek. The main contributing factors to this decline are unpermitted waste dumping and unpermitted camping on the creek.

During my fishing expeditions, I have seen tents and fecal waste in the creek, which I suspect are from people camping on the creek. Additionally, there has been an increase in pollution, including shopping carts and other debris, machinery, and bicycles. People have even been known to dump their septic from RVs directly into the creek, causing further harm to the environment.

Despite our efforts to organize clean-up efforts, the problem has become too great to handle. Therefore, I urge the Ecology Council to consider the problem of open defecation into the creek and surrounding areas as a significant contributor to the deteriorating state of the creek. Immediate action needs to be taken to address this problem to ensure that the creek can be restored to its former state.

Areas of dumping include under Meador Ave Bridge, by railroad ave parking lot .[sic] Down by the lower falls and fish hatchery .[sic] Plenty of unpermitted waste under every bridge from state on down .[sic]

Thank you for your attention to this matter.

Sincerely,

Dahvid Hill

Response to I-5-1

Thank you for your comment. Please see — Pollution Source and Corrective Actions Associated with Camping (page 91) and Response I-1-1. The TMDL and Implementation Plan acknowledges and addresses the potential for pollution to originate from human waste in the context of camping and illicit discharges (direct deposit). The TMDL report highlights that state and local ordinances and codes can be used to address nonpoint source bacteria pollution.

Efforts to address litter in the watershed is beyond the scope of the bacteria TMDL. Local ordinances and codes prohibit this type of littering in public spaces. Public responsibility plays a major role when preventing litter including waste associated with bacterial pollution.

I-6: Comment I-6-1

Please see attachment.

I am a writer and historian and for the past few years, I have been researching and writing about an epidemic that hit Bellingham in the last summer/early fall of 1913. Most of the victims who died were children although other people became sick. Newspapers from all over the country reported on the story around Oct. 8, 1913. Oddly enough, there were many different "diagnoses" cited as the possible cause. Here is the story the Sept. 29, 1913 Bellingham Herald wrote about the situation. You will note that at the end of the story they address the idea of water pollution from Lake Whatcom as a possible cause of illness.

The families that were affected lived near the Whatcom Falls Trolley Station. I was not able to find a final definitive government or official report in terms of the epidemic and the individual death certificates also had varying causes ranging from cholera infantum to ileo colitis.

This certainly doesn't address the situation you are trying to solve today but I thought it might be interesting to have in the records. I can go into much more depth if that might be helpful in your research.

CONFERENCE REPORT ON TARIFF BILL COMPLETED TODAY

TIDES TOMORROW

THE BELLINGHAM HERALD

FULL ASSOCIATED PRESS AND UNITED PRESS SERVICES.

WEATHER

VOL. XXIV. THE BELLINGHAM HERALD, BELLINGHAM, WASHINGTON, MONDAY, SEPTEMBER 29, 1913. NO. 64.

Death Lurks In Over-Ripe Fruit

Great Britain Withdraws From Chinese Loan Agreement

PRESIDENT CASTING VOTE AND DEMOCRATIC AND REPUBLICAN CHOICE FOR GOVERNOR ... JERSEY

J. F. FIELDER. PRESIDENT WILSON CASTING HIS VOTE. E. C. STOKES.

MANY CHANGES IN UNDERWOOD BILL SINCE PASSAGE

Conference Report Representing Final Adjustment of Disputes Between Senate and House Made Public Today When Democratic Managers Submit It for First Time to Colleagues.

FOUR PER CENT REDUCTION

Numerous Articles Are Placed on Free List—Reductions Insisted Upon by President Appear in Completed Measure.

COLWELL READY TO TESTIFY IN SULZER TRIAL

Much Wanted Witness Is Ill in Sanitarium But Is Willing to Make Appearance in Court Provided He Is Not Arrested by Board of Managers for Having Previously Refused to Testify.

POINT UNDER ADVISEMENT

Dozen Detectives Busy Today Serving Subpoenas for Prosecution and Defense—Fifty Persons Called by Governor.

BRITAIN HOLDS AGREEMENT IS VIOLATED BY POWERS

British Government Announces Dissolution of Chinese Loan Agreement From Which United States Withdrew Some Time Ago—Has Not Worked to Satisfaction of Any of Powers.

OBJECT IS NOT ACHIEVED

Purpose Was to Prevent International Scramble to Land China Money But It Fails—English Financiers Get Worst of It.

Reformer Has Himself Jailed to Determine Psychological Effect

FRENCH AVIATOR MAKES LONGEST FLIGHT EVER TAKEN OVER THE SEA.

ROLAND GARROS

Leaving St. Raphael, on the Riviera coast, Roland Garros, a French aviator, flew across the Mediterranean without a stop and landed at the French naval station at Bizerta, covering the 750 kilometres (about 470 miles) in approximately eight hours, his speed being ninety-seven kilometres (60 miles) an hour, or nearly twice as fast as the fastest torpedo boat.

His flight to-day was the longest journey in an aeroplane overseas that has ever been carried out. He declined the offer made by the French naval authorities to station torpedo boat destroyers at intervals along the route from France to Tunis.

10 CHILDREN KILLED BY DECAYED FRUIT

Cholera Infantum Has Caused Wholesale Mortality Among Children During Past Two Weeks—Health Officer Says Over-Ripe Fruit Is Responsible and Lake Water Not to Blame.

LETHAL ACID IN PEACHES

Young Especially Affected by Ferment—Fruit Subjected to Ripening Process Dangerous—Several Families Decimated.

A succession of mortalities which can be traced direct to the eating of so-called over-ripe fruit have occurred in Bellingham and the Lake Whatcom district during the past two weeks, resulting in a general public warning from City Health Officer W. W. Ballaine. The health officer has reports of ten deaths occurring from cholera infantum or similar ailment during this period and a number of other fatal cases attended by private physicians have been laid at the door of the over-ripe fruit. An agent of one of the big national insurance companies says he has been directed to make a special investigation in a couple of cases where claims for insurance followed short illness and death.

Right at this time the market is flooded with peaches, and this fruit especially, according to Dr. Ballaine, should be kept from the children at this time of year, although all varieties of fruit are harmful to the young in quantities at this time. When the fruit is picked green elsewhere and shipped in, the ripening process, according to the physician, is nothing more than a period of slow decomposition, when the fruit assimilates acids which act seriously upon the human system. In at least a dozen deaths reported it has been found that the persons afflicted had partaken of fruit immediately prior to the first symptoms of the attack. The form of illness comes with sudden fever, followed by chronic dysentery, which cannot be stopped.

Water Not Responsible.

When the fatalities began to assert themselves a rigid investigation was commenced by the health office. Skeptics laid the blame to the Lake Whatcom water because the majority of cases seem to have originated in the Whatcom Falls section. This phase was subjected to the most rigid examination but it was found that the water supply is pure, and not in any way responsible for the epidemic of cholera. In some of the cases it was found that the children had been given milk to drink after eating fruit and these cases were more severe and entailed more suffering than those where the fruit alone was held responsible for the condition.

Two children and two adults have died in the family of Mr. and Mrs. L. Cummings, on Idaho street, within the last two weeks, and Mrs. Cummings is said to be in a precarious condition at this time. The four were all buried within a short time of each other. One-year-old Bernice Cummings, her grandparents, John and Mrs. Jane Bannerman, all died in rapid succession last week, while 14-year-old Violet Cummings passed away early yesterday morning.

(Continued on Page Six.)

Investigation of Charges Lodged Against Hardin and Bixby Will Be Started At Once

ESTATE WORTH $250,000 IN COURT

Quarter Million Dollar Estate of Fred Myers, Rich Timber Owner on Nooksack, Contested—Wife Wants to Be Executrix.

QUARREL OVER CRAP GAME IS CAUSE OF 11 DEATHS

Race Riot Breaks Out in Mississippi Town—Eleven Dead, Five Probably Fatally Hurt and Sixteen Are Seriously Wounded in Fight Between Whites and Negroes—Militia Patrol Streets.

FRANCHISE IS OPPOSED BY TELEPHONE PEOPLE

President of Farmers' Mutual Appears Before County Board and Urges Refusal of Franchise for Fifty Years to Sumas Electric Light Company Unless Line Is Protected—Life Too Long.

(Continued on Page Six.)

LOGGER IS HELD ON FORGERY CHARGE

W. N. Adair Arrested by Deputy Sheriff in Seattle to Answer Charges Filed by Bolcom-Vanderhoof Logging Company.

(Continued on Page Three.)

JUDGES REVOKE GRAND JURY ORDER

Veniremen Ordered Not to Appear October 6—Judge Pemberton Said to Be Too Busy—Hardin Accused and Can't Preside.

(Continued on Page Three.)

INDIANS RETURN FROM THE HOP FIELDS

Carload of Tribesmen Back From British Columbia—Jingle Coin in Pockets and Are Happy—Season's Work Is Finished.

(Continued on Page Six.)

GOVERNOR FELKER OF NEW HAMPSHIRE

GOVERNOR S. D. FELKER.

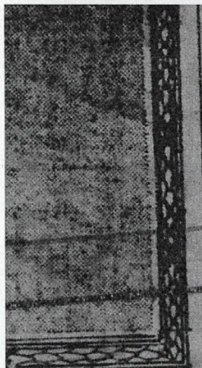
The fight by Harry K. Thaw's counsel to resist the extradition of their client from the State of New Hampshire is being heard by Governor Felker in the Senate Chamber of the State Capitol at Concord.

Four Women In Jury On Its Way To Enterprise Cranberry Marsh

GREECE MUST YIELD, IS SENTIMENT IN TURKEY

CONSTANTINOPLE, Sept. 29. "The menacing language of the newspapers representing the Turkish military element, which virtually occupies the government while at the present moment, confirms the uncompromising attitude adopted by Turkey in her demands on Greece. One paper declares that if Greece fails to yield "she is doomed to be driven from Saloniki and Epirus within the limits of her old frontier." Another says: "Greece is bound to yield on the question of the islands in the Aegean sea before the united Bulgarian and Turkish armies."

CONSTANTINOPLE, Sept. 29. —The treaty of peace between Turkey and Bulgaria was signed by the plenipotentiaries here today.



French aviator, he French naval roximately eight , or nearly twice

ne overseas that he French naval g the route from

ISE IS ED BY HONE PLE

ers' Mutual Ap- ounty Board and of Franchise for Sumas Electric Unless Line Is Too Long.

was made to the rs this morning by ... of the Farmers'

infantum or similar ailment during this period and a number of other fatal cases attended by private physicians have been laid at the door of the over-ripe fruit. An agent of one of the big national insurance companies says he has been directed to make a special investigation in a couple of cases where claims for insurance followed short illness and death.

Right at this time the market is flooded with peaches, and this fruit especially, according to Dr. Ballaine, should be kept from the children at this time of year, although all varieties of fruit are harmful to the young in quantities at this time. When the fruit is picked green elsewhere and shipped in, the ripening process, according to the physician, is nothing more than a period of slow decomposition, when the fruit assimilates acids which act seriously upon the human system. In at least a dozen deaths reported it has been found that the persons afflicted had partaken of fruit immediately prior to the first symptoms of the attack. The form of illness comes with sudden fever, followed by chronic dysentery, which cannot be stopped.

Water Not Responsible.

When the fatalities began to assert themselves a rigid investigation was commenced by the health office. Skeptics laid the blame to the Lake Whatcom water because the majority of cases seem to have originated in the Whatcom Falls section. This phase was subjected to the most rigid examination but it was found that the water supply is pure, and not in any way responsible for the epidemic of cholera. In some of the cases it was found that the children had been given milk to drink after eating fruit, and these cases were more severe and entailed more suffering than those where the fruit alone was held responsible for the condition.

Two children and two adults have died in the family of Mr. and Mrs. L. Cummings, on Idaho street, within the last two weeks, and Mrs. Cummings is said to be in a precarious condition at this time. The four were all buried within a short time of each other. One-year-old Bernice Cummings, her grandparents, John and Mrs. Jane Bannerman, all died in rapid succession last week, while 3-year-old Violet Cummings passed away early yesterday morning.

(Continued on Page Six.)

Response to I-6-1

Ecology appreciates the addition of historical events that occurred in the Whatcom Creek watershed.

A-1: WA Dept Transportation

Comment A-1-1

The Washington State Department of Transportation (WSDOT) seeks to work collaboratively with the Department of Ecology (Ecology) and other partners to improve water quality across the state. We appreciate your efforts to collaborate with WSDOT on the development of this TMDL and implementation plan.

Draft TMDL comment and recommendation:

1. (p. 62, Table 15)

Draft TMDL language: *Share IDDE and monitoring data with the City of Bellingham; notify Department of Public Works Stormwater manager if illicit discharges or exceedances that drain to physically interconnected stormwater systems (required)*

Comment: We appreciate the importance of sharing data with watershed partners. As written, this action doesn't acknowledge that the sharing of IDDE data has largely been automated based on existing permit requirements. If specific individuals wish to receive all WSDOT related IDDE notifications, they must be on the Washington State Patrol Spills Notification listserv and set up to receive notifications from Ecology's ERTS notification system. WSDOT does not own these notification systems but uses them to ensure appropriate notifications are made.

Recommendation: Consistent with the draft TMDL language for other municipal permittee actions, please include the words, "on request" in this action for monitoring data. Please also consider editing this action to acknowledge the automated procedures developed to meet IDDE notification requirements.

*Share ~~IDDE and~~ monitoring data with the City of Bellingham **on request**. **N**otify ~~Department of Public Works Stormwater manager~~ **the City of Bellingham** if illicit discharges or exceedances ~~that~~ drain to physically interconnected stormwater systems (required)*

Response to A-1-1

Thank you for your comment and recommendations. Table 15 has been updated to reflect the WSDOT recommendations. These changes offer consistency among stormwater permit holder required actions identified in the report and are consistent with permit language. Ecology also recognizes the utility of ERTS for information sharing purposes and has added in the text under the Stormwater Corrective Actions and Pollution Prevention section (p. 75) *"The IDDE Program shall be coordinated with the City, County, WSDOT, and Ecology. In some instances, the sharing of IDDE information has largely been automated, for example, through Ecology ERTS or spills notification and reporting."*

A-2: U.S. Environmental Protection Agency, Region 10

Comment A-2-1

1. The draft TMDL appears written to be protective of downstream uses, such as the shellfish harvesting use that is applicable to Whatcom Creek. However, some of the information in the document is inconsistent about this- for example, p.27 states "this TMDL does not address the shellfish harvesting designated use." EPA recommends that Ecology review the document so that language is consistent in referencing the protection of downstream uses.

Response A-2-1

Ecology appreciates EPAs review and corrective edits. This TMDL does address shellfish harvesting. The error on page 27 was corrected and the remainder of the document was reviewed for consistency. No additional errors were found.

Comment A-2-1.2

2. The designated use section discusses where recreation and shellfish harvesting are located. While this is helpful background information, EPA recommends that Ecology be clear that the designated uses for a particular assessment unit within a waterbody apply to the entirety of that assessment unit. For example, as indicated in Table 6102 of Ecology's water quality standards (WAC 173-201A-612), all of Bellingham Bay has shellfish harvesting as a designated use.

Response A-2-1.2

Ecology appreciates the intended clarification and acknowledges that the Whatcom Waterway is within Bellingham Bay and therefore has the same designated use for all assessment units within. The text on page 25 has been updated as follows:

> "*The Whatcom Waterway has the designated use of recreation and shellfish harvesting, which is encompassed by the designated use of Bellingham Bay as stated in Table 612 of the WAC 173-201A-612.*
>
> *As part of Bellingham Bay, the marine water near the mouth of Whatcom Creek is intended to be protected from bacterial pollution by the following guidelines:".*

Comment A-2-1.3

3. With regards to reasonable assurance, p.40 states "It was therefore assumed that the WLA is dependent upon reductions in LAs being met, and reasonable assurance must be provided that the reductions necessary to meet the LAs will be made" and p.54 similarly states, "The point sources expressed as WLAs will be met based on the assumption that the LAs will be met using similar pollution control strategies that may be voluntarily extended to address nonpoint sources expressed as LAs." With the exception of effluent-based WLAs, reductions to all other sources are equally applied based on contributing land area, so it does not appear that the WLAs being met are dependent on the LAs. However, by providing reasonable assurance that nonpoint source control measures will achieve expected load reductions, Ecology increases the probability that the pollution reduction levels specified in the TMDL will be achieved, and therefore, that applicable standards will be attained. In addition, p.52 says "To avoid more stringent requirements being placed in NPDES permits, the SWMP must provide reasonable assurance that LAs will be met." Since Stormwater Management Plans are only a required component for MS4s permitted under the NPDES program, it is unclear how they are expected to provide reasonable assurance that load allocations for nonpoint sources outside their jurisdiction will be met.

Response A-2-1.3

The document has been revised to express that reasonable assurance does not rely on extending the regulatory framework of the Western Washington Phase 2 stormwater NPDES permit beyond the permitted MS4 area to attain the load allocations (LAs). The LAs, however, will be attained through similar pollution control strategies by enforcing local codes and regulations, and by cooperative management in areas with nonpoint sources of pollution. The following text reflects the general concept of pollution control similarities between LAs and WLAs — see Reasonable Assurances section.

> *"The point sources expressed as WLAs will be met based on the established regulatory permit requirements and pollution control strategies as informed by this TMDL. The nonpoint sources expressed as LAs will be met using similar pollution control strategies under cooperative management of these areas, which includes state and local code enforcement or other measures. Documenting sufficient reasonable assurance increases the probability that regulatory and voluntary mechanisms will be applied to the level of pollution reduction identified in the TMDL to attain the WQS."*

Comment A-2-1.4

4. P.153 states "If a future Water Quality Assessment concludes that a new stream segment AU ID does not meet the WQS, then it will be placed into a Category 4a," and that is followed by calculations showing how future TMDLs will be calculated. EPA commends Ecology for being transparent about its intended process for calculating TMDLs for future bacteria impairments in the watershed but notes that this does not necessarily negate the need for submission and review of future TMDLs in the watershed by EPA in accordance with federal regulations at 40 CFR § 130.7. EPA requests that Ecology coordinate with EPA if bacteria impairments are identified for AUs in the Whatcom Creek watershed that are not currently identified as impaired as the options for addressing the impairments may vary depending on the location of the impairments and status of implementation activities.

Response A-2-1.4

Ecology acknowledges and agrees that consulting with the EPA on category determinations is a required formal process by law. The intent of the TMDL is to provide sufficient information in the event a future impairment (AU ID) requires a TMDL. In Appendix E, Loading Capacity section the text has been updated as follows:

> *"If a future Water Quality Assessment concludes that a new stream segment AU ID does not meet the bacteria WQS, in accordance with federal regulations at 40 CFR § 130.7, Ecology will coordinate with EPA to make the correct Category determination — see Appendix A, Clean Water Act and TMDLs. The following methods, tables, and equations shall be used to establish the TMDL for any future bacteria impairment based on 2017 and 2018 conditions. These methods are consistent with the methods used to establish the TMDLs in this report."*

Comment A-2-1.5

5. To review the TMDLs, EPA must be able to understand and evaluate the basis for the TMDLs. Therefore, EPA requests that seasonal average flows be added to the document that were used in Equation 14 for each TMDL presented in Table E-23.

Response A-2-1.5

Ecology has updated the text to emphasize and further clarify the use of seasonally averaged streamflow to calculate TMDLs — see Appendix E, Loading Calculation. During the Public Comment period, one table was removed from the document — see Response A-2-1.7. The correct table reference to this comment has therefore been update from Table E-23 to Table E-22.

Comment A-2-1.6

6. The concentration basis for the hatchery allocation is unclear. Using a flow of 2.3 cfs and a concentration of 2 cfu/100 mL as cited as on p. 44/45 and the conversion factor in Equation 14, the resultant concentration is 0.11 b.cfu/day. Please clarify the basis for the Bellingham Hatchery WLA. Also, Table 8 indicates a concentration limit of 100 cfu/100 mL but does not indicate that concentration should be incorporated into the permit, and the narrative on p.45 indicates a concentration below 2 cfu/100 mL may be needed to avoid triggering antidegradation requirements. EPA recommends that Ecology clarify the basis and any intent for concentration-based limits for the hatchery.

Response A-2-1.6

The initial WLA for the Bellingham Fish Hatchery was calculated correctly, however, Table 8 and the WDFW Fish Hatchery subsection under the Wasteload Allocations section included typographical errors, which did not reflect the correct WLA. Ecology appreciates EPA's correction and has updated the text and relevant tables indicating the WLA of 0.11 b.cfu/day.

Comment A-2-1.7

7. EPA requests that Ecology clarify their intended distinction between TMDL and loading capacity, because the terms are often used interchangeably. P.37 says the TMDL can be equal to or less than the LC, but some portions of the document like Tables D-21, E-22, and E-23, use the terms interchangeably (i.e., same loads are referred to as TMDL or LC).

Response A-2-1.7

Ecology appreciates the comment to add or otherwise correct the distinction between the LC and TMDL as recommended by the EPA. The text throughout the TMDL and Implementation Plan has been updated with the distinction between the LC and TMDL, where the two are no longer used interchangeably or otherwise misused.

Comment A-2-1.8

8. TMDL targets are typically water quality concentrations used to calculate the TMDL, however, Table E-22 has "TMDL Target Loading" values that differ from those used to calculate the TMDLs. Using the rollback method, it appears the target concentration varies based on the variability of sampling data, but that the target concentration is intended to be the implementation goal to attain the TMDL/LC. The discussion of Equation 14 indicates the water quality geometric mean-based criterion is used to calculate the TMDL, and then the allocation discussion on p.51 indicates allocations are generally aerially based on the LC. However, the WLA tables have concentrations that it says are to be implemented as effluent limits, even where the target is based on existing conditions below the criterion. The implementation portion of the TMDL discusses the criteria will be used to assess progress towards the TMDLs. EPA recommends Ecology clarify if the concentration-based targets are intended to be water quality based effluent limits for point sources.

Response A-2-1.7

Ecology appreciates EPA's comment to bring clarity and avoid erroneous conclusion around the established TMDLs. Ecology reaffirms that the use of TMDL target concentrations and percent reductions shall be used to prioritize the implementation processes and express the degree to which the TMDL is not being achieved. These target concentrations apply to both point and nonpoint sources and shall be used as a way to measure TMDL attainment. The TMDL target concentrations were established by using the two-year dataset and the Statistical Theory of Rollback to measure the degree to which the WQS are not being met.

The geometric mean water quality criterion was used to calculate the LC and bridge the conversion of a concentration-based unit of measurement to a mass-based unit of measurement. The TMDL was expressed as a mass-based load to establish allocations for both effluent and areal types of pollution sources, and thereby offers a direct comparison to the LC. TMDL targets below the existing geometric mean criterion are the results of the Statistical Theory of Rollback analysis, where the most stringent of the two-part water quality criteria dictate the degree of rollback and associated TMDL target concentration. TMDLs may be established at or below the LC.

Approximately 99.9 percent of the WLA is areal-based with the reminder as effluent-based allocations (Table 7). The concentration-based targets shall be applied to the Brooks Manufacturing Company effluent limits (NPDES permit number WA0030805) and Washington Department of Fish and Wildlife - Bellingham Hatchery effluent limits (NPDES permit number WAG994275), which contribute to the attainment of the TMDL as water quality-based effluent limits to address effluent-based point sources.

Table E-22 is not essential to clarify and establish the TMDL and has been removed to avoid confusion and redundancy. For example, sufficient information is provided in Tables 6, which clearly shows each TMDL target as concentrations using the rollback method for each listed water body. Table 7 shows each TMDL in terms of pollutant loading separated by allocation type and margin of safety. Table D-21 clearly shows the loading capacity and observed loading.

Comment A-2-1.9

9. The WLA tables for Hanna Creek state "inconclusive dataset" for concentration for the wet season. Regardless of whether the concentrations are intended to be benchmarks or effluent limits, EPA recommends including a concentration as a starting point and/or denote how a value is intended to be derived.

Response A-2-1.8

The wet season WLAs for Hanna Creek have been updated using the 100 cfu/100 mL geometric mean water quality criterion and the modeled streamflow to maintain the WQS. These WLAs apply to the permitted MS4 of the City and County (Tables 11 and 12 respectively), while the LAs were developed similarly and apply to the nonpermitted areas of Hanna Creek. Meeting the 100 cfu/100 mL will attain the wet season TMDL for Hanna Creek established in the report, which is also expressed as a mass-based limit, *i.e.*, Tables 7, 11, and 12. The wet season data were not normally distributed and therefore the statistical theory of rollback does not provide conclusive evidence when calculating TMDL target concentrations and percent reductions. The TMDL in Table 7 shows the loading necessary to attain the TMDL and water quality standards for Hanna Creek during the wet season, while the water quality-based concentration in Table 11 and 12 will result in attaining the water quality standards.

Comment A-2-1.10

10. Table 12 of the TMDL does not provide dry and wet season fecal coliform WLAs in billion cfu/day ("not applicable"; column 1, rows 11 and 12) for Whatcom Creek but does provide dry and wet season concentration-based fecal coliform WLAs in the adjacent column. While the assumption from p.47 for why dry and wet season fecal coliform WLAs would be listed as "not applicable" here is because the allocation is not for the city, there is some language that still seems unclear. The concentration-based values that are provided here seem to differ from a WLA, and it is not clear what their intended use is. EPA recommends Ecology further clarify why these WLAs are listed as "not applicable" and provide additional context in the TMDL narrative regarding the concentration-based values provided, or provide applicable WLAs in billion cfu/day.

Response to A-2-1.10

The concentration-based values for FC were removed since the County permitted MS4 does not directly discharge to the downstream most AU of Whatcom Creek. This resulted in the removal of the FC WLA only for the County MS4 permitted area for the mainstem of Whatcom Creek since it does not apply to the entities stormwater permit. For added clarity, the narrative on page 47 includes the following:

> *"The City's permitted MS4 received the WLA for FC because it is the only entity that discharges directly to downstream most reach of Whatcom Creek before it enters marine water. All other point sources do not directly discharge to the downstream most reach of Whatcom Creek and therefore did not receive an associated FC WLA."*

Appendix C. Glossary and Acronyms

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

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 organisms may vary anywhere from 10- to 10,000-fold over a given period. The calculation is performed by either: (1) taking the n^{th} root of a product of *n* factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

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

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

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

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 where more than 5 acres of land have been cleared.

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

Reach Code: A reach code is a unique 14-digit code that identifies a continuous piece of surface water with similar hydrologic characteristics. It is assigned to each receiving water body by the United States Geological Survey's (USGS) National Hydrography Dataset (NHD).

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

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

Total Maximum Daily Load (TMDL): Water cleanup plan. A distribution of a substance in a water body designed to protect it from not meeting 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.

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

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

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

Acronyms and Abbreviations

AU	assessment unit
BMC	Bellingham Municipal Code
BMP	Best Management Practice
CFR	Code of Federal Regulations
City	City of Bellingham
County	Whatcom County
CWSRF	Clean Water State Revolving Fund
DMR	Discharge Monitoring Report
E. coli	*Escherichia coli*
EC	*Escherichia coli*
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency

ERTS Environmental Reporting and Tracking System
FC fecal coliform
geomean geometric mean
GIS Geographic Information System
GMA Growth Management Act
LA load allocation
LC loading capacity
LSC Local Source Control Program
LULC land use/land code
MS4 Municipal separate storm sewer systems
NHD National Hydrography Dataset
NLCD National Land Cover Database
NPDES National Pollutant Discharge Elimination System (see glossary)
NSQD National Stormwater Quality Database
PPA Pollution Prevention Assistance
RCW Revised Code of Washington
SFAP Stormwater Financial Assistance Program
SMAP Stormwater Management Action Planning
STV statistical threshold value
SWMP Stormwater Management Programs
SWPPP Stormwater Pollution Prevention Plan
TMDL Total Maximum Daily Load (see glossary)
UGA Urban Growth Area
USDA United States Department of Agriculture
USGS United States Geological Survey
USMP City of Bellingham's Urban Stream Monitoring Program
WAC Washington Administrative Code
WDFW Washington State Department of Fish and Wildlife
WLA wasteload allocation
WSDOT Washington State Department of Transportation

Units of Measurement

b. cfu/day billion colony forming units per day (bacteria loading)
cfs cubic feet per second (stream or effluent discharge)
cfu colony forming units (number of bacteria on an agar plate)
cfu/100 mL colony forming unit per 100 mL (bacteria sample concentration)
mL milliliters (volume)
MPN most probable number (bacteria sample concentration)
ppt parts per thousand (mixing ratio)

Appendix D. Analytical Framework

Approach Summary

Data utilized for this TMDL Improvement Plan was collected at a fixed-network of routine sampling sites throughout the Whatcom Creek watershed (Table A-18 and Figure A-13). Data from 2002 through mid-2021 formed the basis for TMDL assessment and pollution characterization in the watershed.

Shannahan et al. (2004) included approximately 31 sampling events collected from January 2002 through February 2003 that also included: 1) paired subsets of *E. coli* samples, 2) modeled estimates of stream discharge from the tributaries, and 3) targeted storm sampling.

The City's USMP dataset from 2017 through 2018 includes approximately 12 sampling events per fixed-network site used to estimate bacteria loadings and rollback. The USMP conducted paired FC and *E. coli* sampling in and adjacent to the Whatcom Creek watershed that was used to develop the bacteria translator and establish *E. coli* TMDL targets and allocations. Paired samples used for this TMDL were collected from 2002 through 2003, and from 2018 through 2021, which represent the comprehensive dataset from local water bodies with similar land cover. The paired bacteria samples were all collected in the Bellingham urban areas and believed to accurately represent the ambient conditions of the assessed water bodies throughout the years and across urban landscapes. Paired sampling was conducted at the same locations used to develop this TMDL, and at other USMP locations (Figure D-15).

The continuous streamflow gage at Dupont St. was used to develop loading metrics and establish the LC and TMDL of the watershed. Target geometric means, percent reductions, and FC bacteria loads were compared between the Shannahan et al. (2004) report and the dataset recently available during the project planning process. Trend analysis was used to detect significant changes in bacteria concentrations from 2002 through 2018.

Figure D-15. Bellingham USMP water quality locations — data source: City of Bellingham

Protecting Downstream Uses

The WQS are provisioned to protect downstream uses — "Upstream actions must be conducted in manners that meet downstream water body criteria" [WAC 173-201A-260(3)(b)]. Whatcom Creek flows into marine water where the Port of Bellingham is located within Bellingham Bay. The marine water designated uses included primary contact recreation and shellfish harvesting.

Primary Contact Recreation

The Whatcom Creek TMDL allocations set pollution limits to protect downstream estuarine and marine water primary contact recreation, which follows the example set in the Deschutes River TMDL (EPA 2020). The *E. coli* and enterococci fecal indicator bacteria criteria were developed using the same level of risk and illness rates for humans (EPA 2012). EPA (2012) demonstrated that the enterococci acceptable illness rate analyses were used to derive the acceptable risk level of *E. coli* in freshwater. Setting the TMDL allocations in the Whatcom Creek watershed therefore provides the same level of protection from associate pathogens in the receiving marine water. Note that states and tribes may select either enterococci or *E. coli* for fresh waters, as adopting one indicator is sufficient and only enterococci may be selected for marine waters (EPA 2021).

Shellfish Harvesting

Shellfish harvesting criteria requires lower bacteria values than for fresh water primary contact recreation. An analysis of Whatcom Creek's effect on the shellfish harvesting designated use was applied following methods in the Lower Skagit River TMDL (Pickett 1997), and the Skagit Bay FC loading assessment (Kardouni 2012). Similarly, the Whatcom Creek FC TMDL was established using a combination of water quality data and the mixing ratio for the brackish water interface at 10 ppt salinity (Appendix D — Downstream Designated Used Targets). The target geometric mean to attain the Whatcom Creek FC TMDL was 22 and 25 cfu/100 mL for the dry and wet seasons respectively (Table 6). These targets protect shellfish harvesting starting at the estuarine marine water of the Whatcom Waterway.

Portage Bay is the nearest shellfish growing area to the mouth of Whatcom Creek (Figure D-16). The Nooksack River has an EPA approved FC bacteria TMDL with targets for the mainstem and tributaries that is supportive of the shellfish harvesting designated use in Bellingham Bay and the Portage Bay shellfish growing areas (Joy 2000). Using a Monte Carlo simulation, the Nooksack River TMDL demonstrated that the target geometric mean of 39 cfu/100 mL was protective, which required a robust dataset covering both fresh and marine waters. The Nooksack River is the largest freshwater tributary to Bellingham Bay and has a substantial water quality impact on nearby Portage Bay (Joy 2000, Hood 2002).

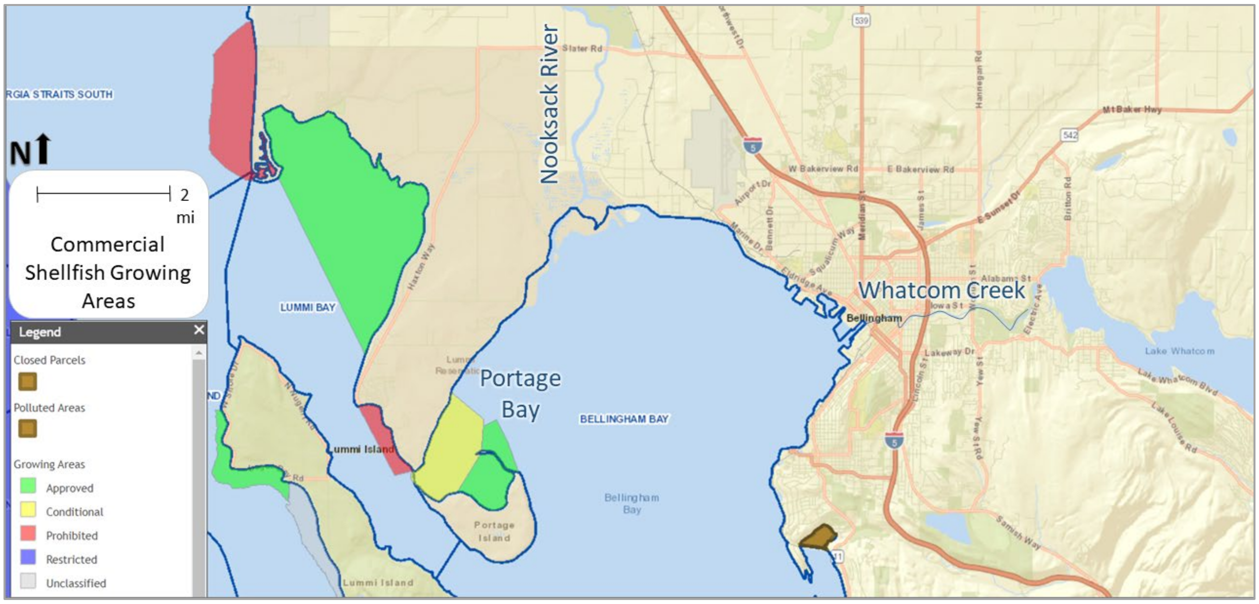


Figure D-16. Shellfish growing areas in and near Bellingham Bay — data source: Washington State Department of Health Shellfish Program (Jan. 6, 2022)

Both the Whatcom Creek and Nooksack River TMDLs flow into the same downstream designated use, however, the Nooksack River is directly upstream of the shellfish growing areas and dominates the receiving marine water quality. The Nooksack River at Ferndale (USGS monitoring location 12213100) has an annual mean discharge of 3,853 cfs (Joy 2000), while the annual mean discharge of Whatcom Creek is 137 cfs (McCarthy 2020b). The relatively low discharge of Whatcom Creek compared to the Nooksack River limits its influence on the Portage Bay shellfish growing area. There are no other shellfish resource areas near the vicinity of the mouth of Whatcom Creek (> 5 – 10 miles) and the bacterial die-off in marine waters will likely result in minimal impacts to the nearest shellfish resource area. A separate analysis of Whatcom Creek's impact on shellfish growing areas has therefore not been pursued, however, the TMDL allocations were set to protect downstream designated uses in marine waters.

Washington state shellfish resources are managed by the State Department of Health Shellfish Program and the State Department of Fish and Wildlife. There are no assessed shellfish resource areas within three miles of the outflow of Whatcom Creek. The creek enters the Whatcom Waterway along the industrial and commercial areas of the Port of Bellingham adjacent to mixed use urban areas. Post Point is the nearest assessed shellfish beach approximately three miles south of the mouth of Whatcom Creek. This beach is within the closure zone of the Post Point wastewater treatment plant outfall and therefore considered unsafe for shellfish harvest year-round. Approximately two miles south of Post Point, the recreational shellfish resource areas of Chuckanut Bay remains closed year-round, followed by Teddy Bear Cove that is intermittently closed due to bio toxin contamination. Approximately six miles away from the Whatcom Creek's mouth, the western shoreline of Bellingham Bay has shellfish growing areas including Portage Bay, which are important to the Lummi Nation.

Bacteria Translator

Water quality criteria were recently updated from FC to *E. coli* (EC) as the bacterial indicator to determine the protection of the fresh water contact recreation beneficial use. For this study, the TMDLs and trend analysis required translation between the two bacterial indicators as water quality monitoring selected in favor of the WQS update. The initial Whatcom Creek watershed bacteria pollution technical studies (Shannahan et al. 2004, McCarthy 2020b) were based on FC data, which will require the update to *E. coli*. Functioning as a translator, the Type 2 regression of paired samples collected within the urbanized watershed areas of Bellingham expressed the relationship between FC and *E. coli*.

Purpose

The bacteria translator illustrates the relationship between paired FC and *E. coli* samples collected within the urban watersheds of Bellingham, WA. The bacteria translator may be applied to the TMDL or other types of water quality analysis. The translator plays a critical role when establishing the *E. coli* TMDL component that was initially based on the FC datasets.

The functional relationship between the FC and *E. coli* bacteria groups serve to:

- Forecast (translate) between bacterial indicators
- Determine applicable targets and allocations for the Whatcom Creek bacteria TMDL
- Bridge long-term trend analysis upon changing bacterial indicators
- Provide the basis to estimate the probability of exceeding water quality criteria
- Illustrate relationship characteristics
- Lend insight into the type of bacterial pollution source, *i.e.* vegetative or animal

Generally, water body AUs within the Whatcom Creek watershed not meeting Washington State Water Quality Criteria for FC will remain on the 303(d) list as impaired until:

- Ecology's Water Quality Assessment of *new E. coli* data indicates that standards are met for fresh water contact recreation, or
- An *E. coli* TMDL or pollution control program is activated following EPA approval.

Data Source

Data sources include the Ecology's Environmental Information Management (EIM) database and sample results shared by the City. Information gathering produced 47 paired samples representing the Whatcom Creek watershed that were collected from:

- 2002 through 2003 (Shannahan et. al 2004) (EIM Study ID G0200178), and
- 2018 through 2021 (Table D-20).

The City routinely samples FC, with the reintroduction of *E. coli* subset pairs beginning in 2018. Samples were collected across a variety of climactic conditions throughout the urbanized areas of Bellingham. Lab sample analysis methods included SM 9222D for FC, and SM 9223B and 9213D for *E. coli* (APHA 2000).

Table D-20. Paired sample data from EIM in WRIA 01 used to develop the bacteria translator, duplicate sample average indication *

EIM Location ID/Site Name	Date	FC (cfu/100 mL)	*E. coli* (cfu/100 mL)
CE1(CEMETARY)	1/23/02	310	300
FE5(FEVER)	1/23/02	1900	1600
LI1(LINCOLN)	2/6/02	100	50
LI1(LINCOLN)	2/19/02	7*	13
WH3(WHATCOM)	2/19/02	24	11
WH2(WHATCOM)	2/21/02	370	300
HA1(HANNA)	3/5/02	9	17
WH1(WHATCOM)	3/18/02	12	11
WH1(WHATCOM)	4/2/02	720	900
WH2(WHATCOM)	4/23/02	19	30
LI1(LINCOLN)	5/7/02	180	130
LI1(LINCOLN)	5/21/02	140	70
FE5(FEVER)	6/18/02	940	900
WH5(WHATCOM)	8/27/02	4	2
WH1(WHATCOM)	9/10/02	280	290
WH1(WHATCOM)	9/24/02	75	95
CE1(CEMETARY)	10/8/02	50	70
WH1(WHATCOM)	10/29/02	55	56
WH4(WHATCOM)	11/12/02	17	7
WH2(WHATCOM)	11/26/02	18	28
LI1(LINCOLN)	12/31/02	280	430
WH5(WHATCOM)	1/2/03	28	10
WH5(WHATCOM)	1/12/03	31	15
HA1(HANNA)	1/14/03	26	42
WH1(WHATCOM)	1/28/03	4	8
LI1(LINCOLN)	2/11/03	46	59
LI1(LINCOLN)	2/25/03	72	23
Silver Beach	11/13/18	130	80
Mill Wheel	1/15/19	50	85
CD	1/15/19	2	3
Euclid	2/19/19	35	39
Silver Beach	8/11/20	380	550
Park Place	12/16/20	80	67
Euclid	1/13/21	32	28
Silver Beach	1/13/21	44	16
Control Dam	2/23/21	5	1
Dupont	2/23/21	8	4
CD	3/10/21	3	1
Hanna	3/30/21	130	76
Lincoln	3/30/21	110	80
Dupont	3/30/21	60	74
Control Dam	4/27/21	1	4
Hanna	4/27/21	50	32
Valencia	4/27/21	14	20
Dupont	4/27/21	44	56
Mill Wheel	5/11/21	180	170

EIM Location ID/Site Name	Date	FC (cfu/100 mL)	*E. coli* (cfu/100 mL)
CD	5/11/21	3	4

Methods

Paired bacteria samples (n =47) were examined for normal distribution, equal variance, and correlation. The normal distribution of $\log_{10}$ transformed data was verified by the Shapiro-Wilks test, and the Levene's test for homoscedasticity verified equal variance among sample populations. The geometric means were 42 and 38 cfu/100 mL for FC and *E. coli* respectively with a ratio of 1:0.9 (FC:EC) (Figure D-17). Pearson's r correlation coefficient demonstrated a positive relationship between FC and *E. coli* samples (r = 0.94) (Figure D-18).

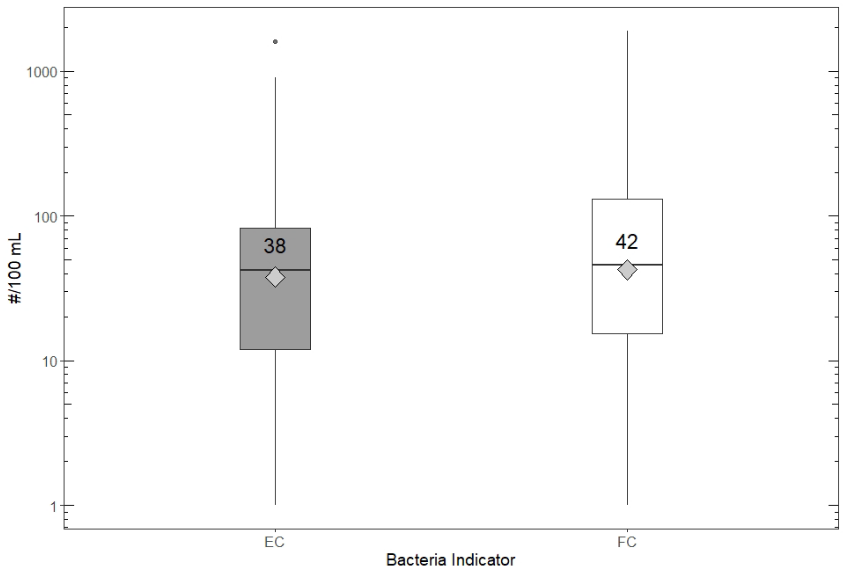


Figure D-17. Fecal Coliform (FC) and E. coli (EC) $\log_{10}$ scale sample distribution counts (#) collected throughout Bellingham urban watersheds (2002 — 2003 and 2018 — 2021), — median, ◊ geometric mean, boxplot edges are first and third quartiles, whiskers are the smallest or largest values 1.5 times beyond the interquartile range

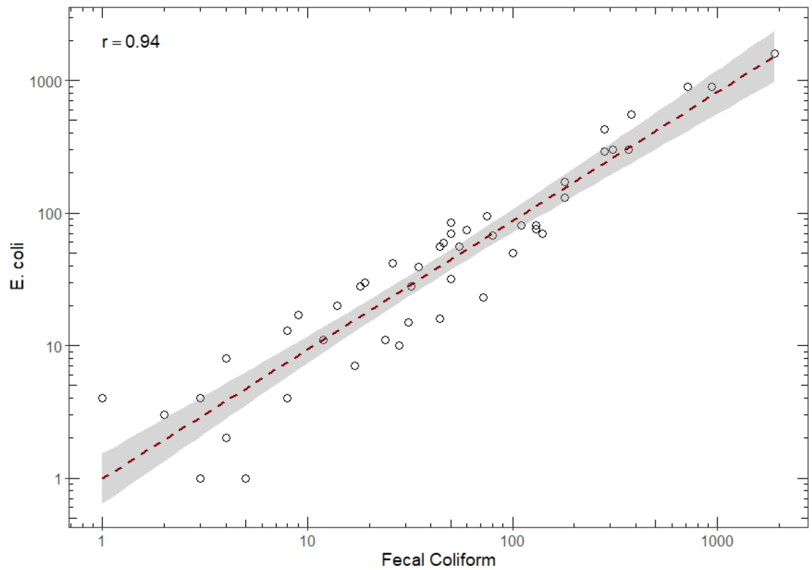


Figure D-18. Log_{10} Fecal Coliform and E. coli (#/100 mL) Pearson's r correlation
- - - best fit line and 95% confidence interval, ∘ observed values

Type 2 (Model 2) Linear Regression Selection

Type 2 linear regression expressed the relationship between the two bacterial indicators using paired sampling data points. Because measurement error was inherent in both types of sample methods, a Type 2 linear regression was done using the Least Normal Squares (Major Axis) method (Legendre 2018, Helsel et al 2020). Type 2 regression should be used when the two variables in the equation are random, which applies to the circumstance where the water quality investigator has no control over either bacterial indicator. Conditional assumptions and use of the regression as a bacteria translator include:

- Bivariate normal distribution for each bacterial indicator sample population
- Bacterial indicators are of the same unit or dimensionless, *e.g.* log-transformed
- Similar variance error for each bacterial indicator sample population
- Comparisons among observed and forecasted (translated) values are possible

Two separate regressions were done where either *E. coli* (EC) or FC served as the response (dependent) variable of the other. For example, when EC was designated as the response variable, FC was the explanatory variable, and these variables may be swapped (Equations 3 and 4).

$$\log_{10} EC = -0.110 + (1.037 \times \log_{10}(FC)) \qquad (3)$$

$$\log_{10} FC = 0.106 + (0.965 \times \log_{10}(EC)) \qquad (4)$$

Translations made from the Major Axis regression can be compared to observations to assess model quality, *i.e.*, model fitness. If the model slope is near 1 and the intercept near 0, then the model fits the data well. If the slope differs from 1, or 45° degree line, it indicates the difference between the observed and predicted values proportional to the observed values. Both regression models fit the data with an overall error of 3.7 percent when EC is dependent (Equation 3), and with a 3.5 percent error when FC is dependent (Equation 4) (Figure D-19). Visual inspection of the bacteria translations (forecasts) indicates a slight underestimation using Equation 3 (FC to EC) and slight overestimation using Equation 3 (EC to FC).

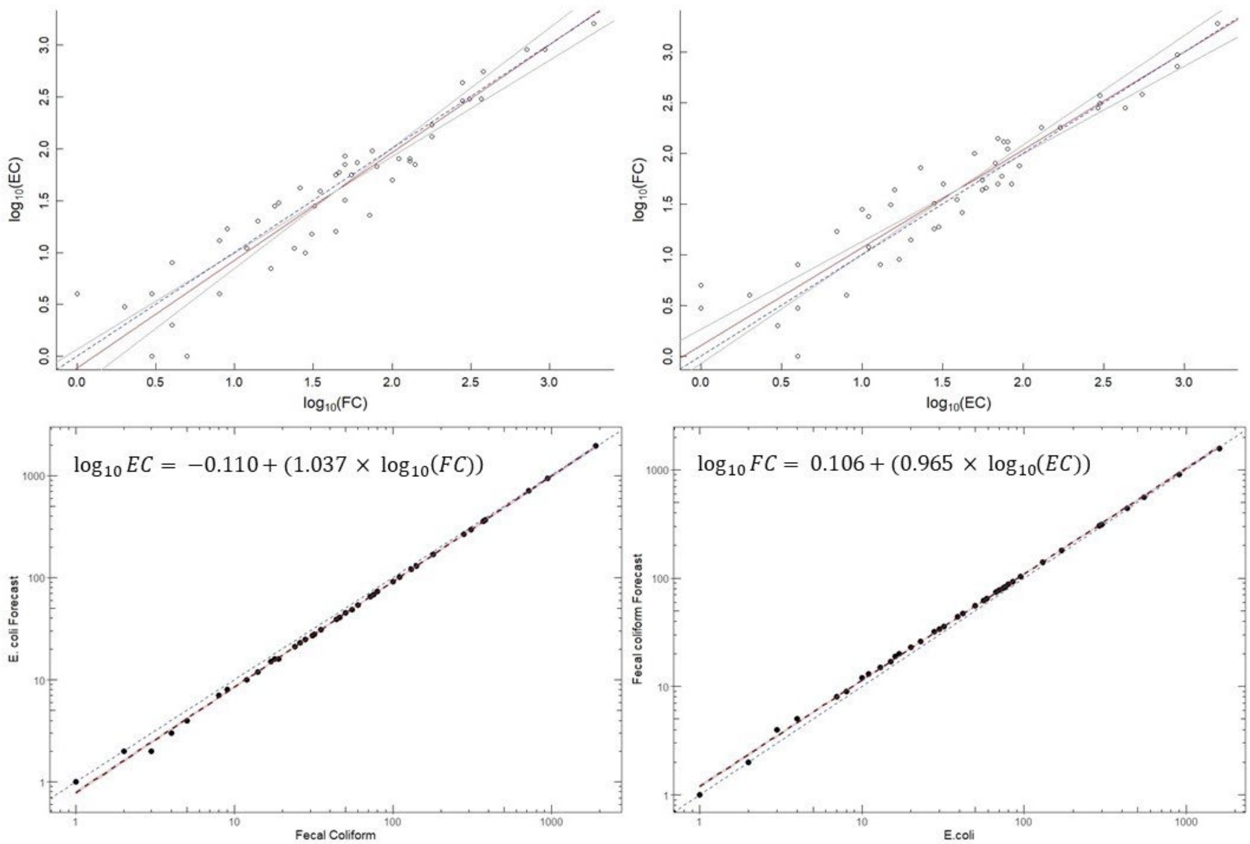


Figure D-19. Type 2 regression Major Axis method showing observed data on top and forecasted data on bottom

— regression line, — confidence interval, --- 45° reference, ∘ observed, • forecasted

Equations 3 and 4 may be simplified by taking the antilogarithm (inverse logarithm) to produce the simplified translator Equations 1 and 2 that are presented below and in the TMDL Targets section of this report. All equations presented require only the raw, *i.e.*, untransformed bacterial concentration values as input.

$$EC = 0.776 \times (FC)^{1.037} \qquad (1)$$

$$FC = 1.277 \times (EC)^{0.965} \qquad (2)$$

Applying the Translator to Develop the Whatcom Creek *E. coli* TMDLs

Updates to the Shannahan et al. (2004) Whatcom Creek FC bacteria study include trend analysis, load capacities, load allocations, and TMDL targets using data collected from 2002 through 2018 described in this TMDL and the McCarthy (2020b) technical report. McCarthy (2020b) based the TMDL FC, which was the accepted water quality indicator at the time. Recent water quality revisions, effective at the beginning of 2020, necessitate the use of *E. coli* to establish protective TMDLs for freshwater contact recreation. The functional relationship characterized by Type 2 regressions demonstrates the translation between FC and *E. coli* bacteria concentrations that was used to update the elements of previous Whatcom Creek bacteria studies and compensate for the current WQS.

Equation 1 was used to translate FC data into forecasted *E. coli* data to determine Whatcom Creek *E. coli* TMDL targets and to help guide actions in the Implementation Plan. Specifically, the 2017 through 2018 FC dataset collected by the City was translated to *E. coli* concentrations for the following applications:

- Compare to the WQS for *E. coli* to estimate the likelihood of meeting the geomean and ten percent not-to-exceed STV criteria,
- Characterize seasonal variation in the Whatcom Creek watershed,
- Calculate *E. coli* loading for each water body and compare to the TMDL,
- Develop the *E. coli* TMDL rollback to meet WQS,
- Establish TMDL target geomean concentrations for *E. coli* that are protective of beneficial uses and guide implementation efforts,
- Establish TMDLs, and associated LCs, allocations (WLAs and LAs), and the MOS,
- Develop NPDES general permits,
- Inform TMDL effectiveness monitoring and adaptive management, and
- Bridge long-term datasets and gain perspective on effectiveness monitoring.

Model Updates

Additional paired sampling data collected by the City may be incorporated to strengthen the relationship between the two bacterial indicators; thereby informing the regressions to minimize model uncertainty. Legendre (2018) suggests that the Type 2 model regression is ideally developed with a dataset of 60 or more data points to minimize model uncertainty. Datasets smaller than 60 data points may be modeled at the expense of an increasing confidence interval. The dataset for this study (n = 47) are paired bacteria samples used to develop a model with reasonable certainty because of the following:

- High correlation was exhibited,
  - Pearson's correlation coefficient r = 0.94
  - Ordinary Least Squares (OLS) coefficient of determination r^2 = 0.88
- The model fit the data well and error was low for Equation 1 at 3.7%, and
- *E. coli* are a subgroup of FC thermotolerant organisms that exhibited a 1:0.9 ratio of FC to *E. coli*.

Deming and Ordinary Least Squares (OLS) regressions were not selected methods primarily due to the severe under-prediction of slope. The Deming and OLS forecasts over-estimated of *E. coli* as the response variable, and an under-estimation of FC as the response variable. Applying the OLS regression is typically appropriate when random variation is greater for the response variable (y-axis) when compared to the explanatory variable (x-axis), or when the explanatory variable is assumed to have no associated error.

Loading Summary

Loading is defined as the mass of a substance that passes through a particular point of a river or stream (e.g., monitoring site) in a specified amount of time (e.g., daily) (Meals et al. 2013). A load is mathematically defined as the product of stream or effluent discharge and the concentration of a substance in the water. Load calculations require both bacteria concentrations and discharge measurements to quantify loading at a particular location in the Whatcom Creek watershed.

Bacteria concentration data were collected by the USMP during routine water quality sampling and used to develop the loading summary based on the 2017 through 2018 two-year dataset (McCarthy 2020b). The FC concentrations were translated to *E. coli* using Equation 1 to calculate *E. coli* loading. Whatcom Creek flow data from the City's continuous gage station at Dupont St. was used to calculate the mainstem loading at the furthest downstream sampling location. The USGS continuous streamflow gage on Euclid Creek at Euclid Ave. (Station # 12202400) was used to estimate tributary discharge from flow rating curve relationships developed by Shannahan et al. (2004) using simple linear regression as follows:

$$Cemetery(Q) = 0.2334 \times Euclid_{(Q)} \qquad r^2 = 0.79 \qquad (5)$$

$$Fever(Q) = 0.3557 \times Euclid_{(Q)} \qquad r^2 = 0.98 \qquad (6)$$

$$Hanna(Q) = 0.3994 \times Euclid_{(Q)} \qquad r^2 = 0.76 \qquad (7)$$

$$Lincoln(Q) = 0.4309 \times Euclid_{(Q)} \qquad r^2 = 0.34 \qquad (8)$$

Discharge (Q) for each tributary was estimated by multiplying the slope by the Euclid Creek continuous streamflow — cubic feet per second (cfs) discharge rates (Equations 5 — 8). Euclid Creek discharge severed as the best predictor for Fever Creek, followed by Cemetery, Hanna, and Lincoln Creeks indicated by the r^2 coefficient of correlation. The modeled stream discharge for each tributary was used to determine loading at each confluence with Whatcom Creek.

Using Equation 1, the translated *E. coli* bacteria concentrations were multiplied by the daily averaged stream discharge to determine daily loadings using the 2017 and 2018 datasets collected by the USMP. The daily loading (b.cfu/day) was averaged by the wet and dry seasons to estimate the seasonal bacteria loading for both FC and *E. coli* (Appendix E). Note that loading is expressed in mass per unit time, *i.e.*, billions of colony forming units per day (b.cfu/day). The daily LC was calculated using the 100 cfu/100 mL water quality criterion for *E. coli* and the mean seasonal discharge of each stream. Similarly, the FC LC occurring at the mouth of Whatcom Creek was calculated using mean seasonal discharge, and 22 cfu/100 mL for the dry season or 25 cfu/100 mL for the wet season, which accounted for freshwater and marine water mixing — see the Downstream Designate Use Targets subsection in this Appendix for details. These calculated LCs form benchmarks to attain the TMDLs and meet the WQS.

The *E. coli* load contribution at the downstream most pour point was expressed as a proportion in terms of the relative percent total loading from all tributaries (Table D-21). Whatcom Creek made up roughly 98.5 percent of the total *E. coli* loading while all other tributary creeks combined constituted the remaining 1.5 percent. Of the tributaries, Fever Creek contributed the highest loading, followed by Lincoln, Hanna, and Cemetery Creeks. Wet season loading was generally greater than dry season loading except for Fever Creek where the dry season loading was 1.4 times greater than that of the wet season with a relative percent difference (RPD) of 35 percent. The Whatcom Creek wet season loading was 1.4 times greater than that of the dry season with a RPD of 34 percent. The Cemetery Creek wet season loading was 4.4 times greater than that of the dry season with a RPD of 125 percent. The Hanna Creek wet season loading was 3.1 times greater than that of the dry season with a RPD of 103 percent. The Lincoln Creek wet season loading was 3.5 times greater than that of the dry season with a RPD of 111 percent. The wet season bacterial loading for Whatcom Creek at the mouth was 1.5 times than that of the dry season. The TMDLs were established at or below the LCs to protect designated uses and meet the WQS.

Table D-21. FC and *E. coli* TMDLs and loading (b.cfu/day) using 2017 — 2018 data for Whatcom Creek at Dupont St. and each tributary near the confluence

Site	Season	TMDL	Average Loading	Total Load
WHA00.2^{FC}	Dry^{FC}	19.6	114.3	100%
	Wet^{FC}	138.9	172.2	100%
WHA00.2	Dry	89.3	106.3	98.4%
	Wet	555.5	150.0	98.6%
CEMETERY	Dry	0.046	0.050	0.05%
	Wet	0.328	0.216	0.14%
FEVER	Dry	0.071	1.400	1.30%
	Wet	0.502	0.983	0.65%
HANNA	Dry	0.078	0.092	0.09%
	Wet	0.563	0.287	0.19%
LINCOLN	Dry	0.086	0.184	0.17%

	Wet	0.607	0.643	0.42%

Statistical Rollback Analysis

The Statistical Theory of Rollback (STR) (Ott 1995) was used to calculate *E. coli* reduction targets for Whatcom Creek and tributaries to protect the contact recreation designated use in both fresh and marine waters. Reductions targets for FC at the mouth of Whatcom Creek were calculated to protect the downstream designated use of shellfish harvesting. The STR compares monitoring data to the numeric water quality criteria, and the difference is the percentage change needed to meet the WQS. The rollback method has been applied by Ecology in many other bacteria TMDL studies (Hood and Joy 2000, Pelletier and Seiders 2000, Joy 2004, Joy and Swanson 2005, Schneider et al. 2007, Swanson 2008, Mathieu and James 2011, McCarthy 2020a, EPA 2020).

Ideally, at least 20 bacteria observations per site taken throughout the year are needed from a broad range of hydrologic conditions to determine the sample population distribution. Fewer data provide less confidence when determining bacteria reductions. The rollback method, however, is robust enough to calculate percent reductions and the associated geomean sampling targets for planning implementation actions using smaller datasets that follow normal distribution. If seasonal variation in bacteria pollution is observed, then seasonal TMDLs and reductions may be required, which was applied to the Whatcom Creek and tributary bacteria TMDLs.

Target reductions were estimates generally based on the water quality criteria for *E. coli* — see the 'Water Quality Criteria' section of this report or WAC 173-201A[33] for details. Attaining the most restrictive of the dual bacteria water quality criteria — *i.e.*, the geometric mean or 10 percent exceedance STV portions — was used to estimate the pollution reduction needed at each stream sampling site. To express the 10 percent exceedance STV as a concentration, the 90th percentile of the sample population distribution may be used.

The FC marine standard target values were established in brackish water conditions. The FC target values represent the bacteria levels in the river that would meet marine standards when the mixture of fresh and marine water reached 10 ppt salinity (Kardouni 2012, Pickett 1997). These calculated marine standard target values were used to determine the FC target reductions for Whatcom Creek (Equations 17 and 18).

Descriptive Statistics

The geometric mean is the n'^{th} root of the product of all n observations. The bacteria geometric mean $\bar{x}_G$ was calculated using Equation 9 where x is the sample concentration (cfu/100 mL) and n is the sample population count:

$$\bar{x}_G = \sqrt[n]{x_1 x_2 \dots x_n} \qquad (9)$$

[33] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201a

Equation 10 calculates the bacteria 90th percentile $\left(\bar{x}_{90^{th}}\right)$, where μ is the mean of the log_{10} data, σ is the standard deviation of the log_{10} transformed data, and the 90th percentile standardized normal score is 1.282:

$$\bar{x}_{90^{th}} = 10^{(\mu_{log10}+1.282\sigma_{log10})} \qquad (10)$$

Statistical Theory of Rollback

The STR (Ott 1995) involves the calculation of the geometric mean (approximate median in a log-normal distribution) and 90th percentile statistics, which were compared to the *E. coli* water quality criteria — 100 and 320 cfu/100 mL (Equations 11 and 12 respectively). If one or both do not meet the criteria, the whole distribution is "rolled-back" to match the more restrictive of the two criteria. After applying the STR method to calculate the final rollback, the 90th percentile criterion is usually the most restrictive (Equation 16). The rolled-back geometric mean or 90th percentile bacteria value then becomes the recommended target bacteria value for the site to meet the TMDL limits. The STR was also used to calculate the FC reductions needed to protect the downstream designated use of shellfish harvesting as described below. This method was also used to establish FC reductions at the mouth of Whatcom Creek — see the Downstream Designate Use Targets subsection in this Appendix for details.

The initial step in the STR method was to calculate the reduction needed to meet the primary contact WQS for *E. coli* using the geometric mean of 100 cfu/100 mL (Equation 11) and STV of 320 cfu/100 mL (Equation 12) and select the greater of the two outputs.

$$Geomean\ Reduction\ (log_{10}) = \left[\frac{\mu_{log10}(E.coli) - log_{10}(100)}{\mu_{log10}(E.coli)}\right] \qquad (11)$$

$$90^{th}\ Reduction\ (log_{10}) = \left[\frac{\bar{x}_{90^{th}}(log_{10}(E.coli)) - log_{10}(320)}{\bar{x}_{90^{th}}(log_{10}(E.coli))}\right] \qquad (12)$$

Next, the greater of the two reductions from Equations 11 and 12 in terms of the log_{10} of the geomean and 90th percentile, was used to calculate the log_{10} rollback for both terms. The log_{10} greatest reduction is used in Equation 13 to calculate the log_{10} bacteria rollback target mean:

$$Target\ Mean(log_{10}) = \mu_{log10}(E.coli) - \left(\mu_{log10}(E.coli) \times Greatest\ Reduction\right) \qquad (13)$$

The rollback $Target\ Mean(log_{10})$ output and standard deviation $`\sigma_{(Target\ Mean(log_{10}))}$ was used in Equation 14 to calculate the $Target\ 90^{th}(log_{10})$:

$$Target\ 90^{th}(log_{10}) = Target\ Mean(log_{10}) + \left(1.2816 \times `\sigma_{(Target\ Mean(log_{10}))}\right) \qquad (14)$$

Finally, the values from Equations 13 and 14 were back transformed to the original units of bacteria cfu/100 mL to determine the greatest percent reduction for the final rollback. The greatest percent reduction from either the STR geomean or 90th percentile was used to calculate the final rollback using Equations 15 and 16:

$$STR\ Geomean\ Reduction\ (\%) = \left[\frac{\bar{x}_G - Target\ (`\bar{x}_G)}{\bar{x}_G}\right] \times 100 \qquad (15)$$

$$STR\ 90^{th}\ Reduction\ (\%) = \left[\frac{\bar{x}_{90^{th}} - Target\ (`\bar{x}_{90^{th}})}{\bar{x}_{90^{th}}}\right] \times 100 \qquad (16)$$

Where $\bar{x}_G$ and $\bar{x}_{90^{th}}$ were the calculated *E. coli* concentrations before rollback, and the $\grave{\bar{x}}_G$ and $\grave{\bar{x}}_{90^{th}}$ are the concentrations after rollback.

The major theorems and corollaries for the STR from Environmental Statistics and Data Analysis by Ott (1995) may be summarized as follows:

1. If $Q =$ the concentration of a contaminant at a source, and $D =$ the dilution-diffusion factor, and $x =$ the concentration of the contaminant at the monitoring site, then $x = Q \times D$.
2. Successive random dilution and diffusion of a contaminant Q in the environment often result in a lognormal distribution of the contaminant x at a distant monitoring site.
3. The coefficient of variation (CV) of Q is the same before and after applying a "rollback" (i.e., the CV in the post-control state will be the same as the CV in the pre-control state). The rollback factor $= r$, a reduction factor expressed as a decimal — a 70 percent reduction would be a rollback factor of $r = 0.3$. The random variable Q represents a pre-control source output state, and Q_r represents the post-control state.
4. If D remains consistent in the pre-control and post-control states (long-term hydrological and climatic conditions remain unchanged), then $CV(Q) \times CV(D) = CV(x)$, and $CV(x)$ will be the same before and after the rollback is applied.
5. If x is multiplied by the rollback factor r, then the variance in the post-control state will be multiplied by r^2, and the post-control standard deviation ($\grave{\sigma}$) will be multiplied by r.
6. If x is multiplied by r, the quantiles of the concentration distribution will be scaled geometrically.
7. If any random variable is multiplied by r, then its expected value and standard deviation also will be multiplied by r, and its CV will be unchanged. Ott uses "expected value" for the mean.

Downstream Designated Use Targets

The STR was also applied to address downstream designated use of shellfish harvesting while accounting for fresh and marine water mixing at 10 ppt salinity. Equations 11 through 16 were used to calculate the FC target reductions at the mouth of Whatcom Creek when the fresh and marine water mixture reaches 10 ppt salinity in accordance with WAC 173-201A-260(3)(e). The STR target reduction for FC was based on meeting the geomean of 25 cfu/100 mL and the STV of 66 cfu/100 mL during the wet season. The STR target reduction during the dry season was based on meeting the geomean of 22 cfu/100 mL and the STV of 64 cfu/100 mL. Equations 17 and 18 were developed to calculate protective water quality targets to meet the WQS. Following the STR method, the more restrictive of the two targets — geomean or STV — formed the basis of the maximum amount of FC reduction necessary to attain the TMDL.

$$Target_{GM} = \frac{WQS_{GM} - (Salinity_{MW} \times FC_{GM})}{Salinity_{FW}} \qquad (17)$$

$$Target_{STV} = \frac{WQS_{STV} - \left(Salinity_{MW} \times FC_{90^{th}}\right)}{Salinity_{FW}} \qquad (18)$$

Where,

$Target_{GM}$ (cfu/100 mL) is the protective geomean concentration in the brackish mixing zone,

$Target_{STV}$ (cfu/100 mL) is the protective 90th percentile concentration in the brackish mixing zone,

WQS_{GM} (cfu/100 mL) is the geomean criterion of 14 for marine waters,

WQS_{STV} (cfu/100 mL) is the STV criterion of 43 for marine waters,

$Salinity_{MW}$ is the mixed marine water portion at 10 ppt salinity where the value of 45.4 percent was calculated for the dry season and 54.0 percent for the wet season,

$Salinity_{FW}$ is the mixed freshwater portion at 10 ppt salinity where the value of 54.6 percent was calculated for the dry season and 46.0 percent for the wet season,

FC_{GM} is a value of either 4 or 5 cfu/100 mL geomean fecal coliform concentrations representing the background marine water quality based on the dry and wet season respectively, and

FC_{90}^{th} is the value of either 18 or 23 cfu/100 mL 90th percentile fecal coliform concentrations representing background marine water quality based on the dry and wet season, respectively.

Salinity and FC data were collected by the Washington State Department of Health Shellfish Program in Portage Bay during shellfish growing areas sampling events for years 2017 and 2018. Data collected in Portage Bay represents the most comprehensive dataset available in proximity to the Whatcom Waterway. Median salinity values used to quantify the contribution of marine water mixing with freshwater were determined using the pooled two-year dataset. The median salinity in Portage Bay was 22 practical salinity units, or ppt, during the dry season and 18.5 ppt during the wet season, which were used to determine the $Salinity_{MW}$ term. Note that practical salinity units and ppt are very similar and either may be reasonably applied in the WQS. The FC values representing background marine concentrations that were calculated for the pooled two-year dataset by season, represented the FC_{GM} and FC_{90}^{th} terms. Marine water quality data coincided with the USMP freshwater dataset utilized for the TMDL calculations. Whatcom Creek had 0.02 ppt salinity based on the USMP specific conductance data. Freshwater salinity values were calculated following the Intergovernmental Oceanographic Commission (IOC) (2010) guidelines.

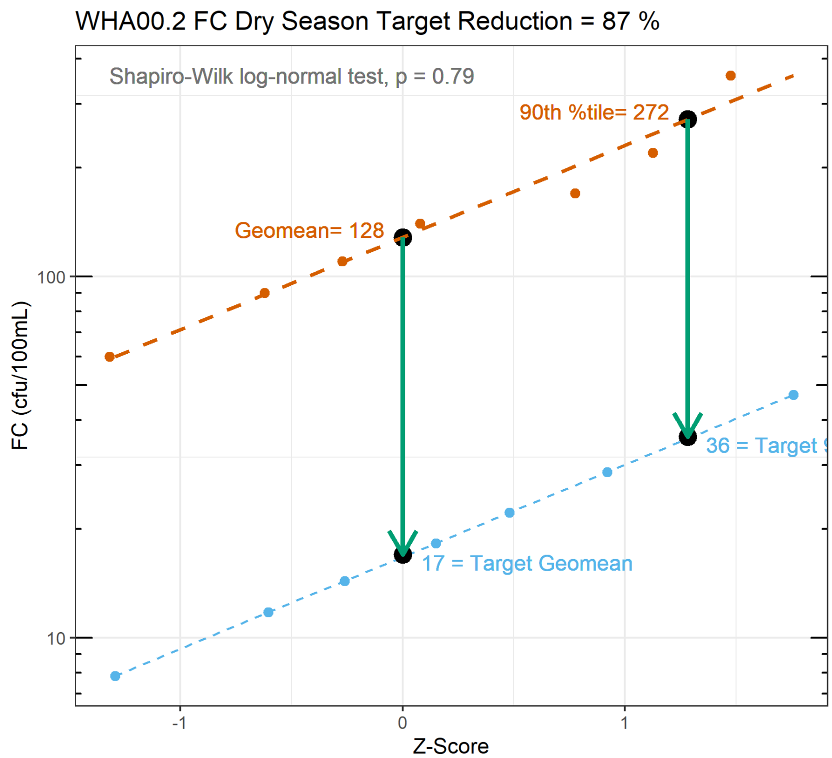
Rollback Target Concentrations and Percent Reductions

The term "target" is used to distinguish these estimated numbers from the actual water quality criteria. The degree to which the distribution of bacteria counts is rolled-back (rollback factor — r), to the target value represents the estimated percent of bacteria reduction required to meet the WQS, and TMDL limits. The bacteria targets are used to assist water quality managers in assessing the progress toward compliance with the bacteria water quality criteria. Compliance is ultimately measured as meeting both parts of the water quality standards criteria.

The rollback method assumes log-normal distribution for each sample site population. Prior to the use of the roll-back method, bacteria concentrations from each site were examined for lognormality using the Shapiro-Wilk test. In all instances, the data at each site met the lognormality test. When separated by the dry and wet seasons, the data distribution met the lognormality test except for Hanna Creek during the wet season (Table 6). The Hanna Creek 90th percentile and rollback estimate for the wet season has been qualified as an exception and should be used with caution, or not used at all.

The statistical rollback analyses were performed using the FC dataset from 2017 — 2018, which were translated to *E. coli* bacteria concentrations using Equation 1 for each data point. The two-year pooled dataset provided a large enough sample size to adequately characterize the watershed and offer sufficient certainty to the roll-back analysis. The sample population ranged from 5 to 9 samples per site collected during the dry season, while the wet season included 14 samples per site. Seasonal estimates were used to determine TMDL limits and target reductions. Figures D-20 through D-28 from the statistical rollback analysis include:

- Reduction in FC bacteria to meet the TMDL accounting for seasonal variation and the mixing of fresh and marine waters downstream of Whatcom Creek at Dupont Street (Figure D-20 only),
- Reductions in *E. coli* bacteria to meet the TMDL accounting for seasonal variation,
- Current water quality conditions represented by data points, 90th percentile, and geometric mean per season (orange),
- Target values for the 90th percentile and target geometric mean to attain the TMDL (blue),
- Greatest target percent reduction needed to attain the TMDL (green), and
- Shapiro-Wilk Test for normal distribution, $\alpha = 0.05$.



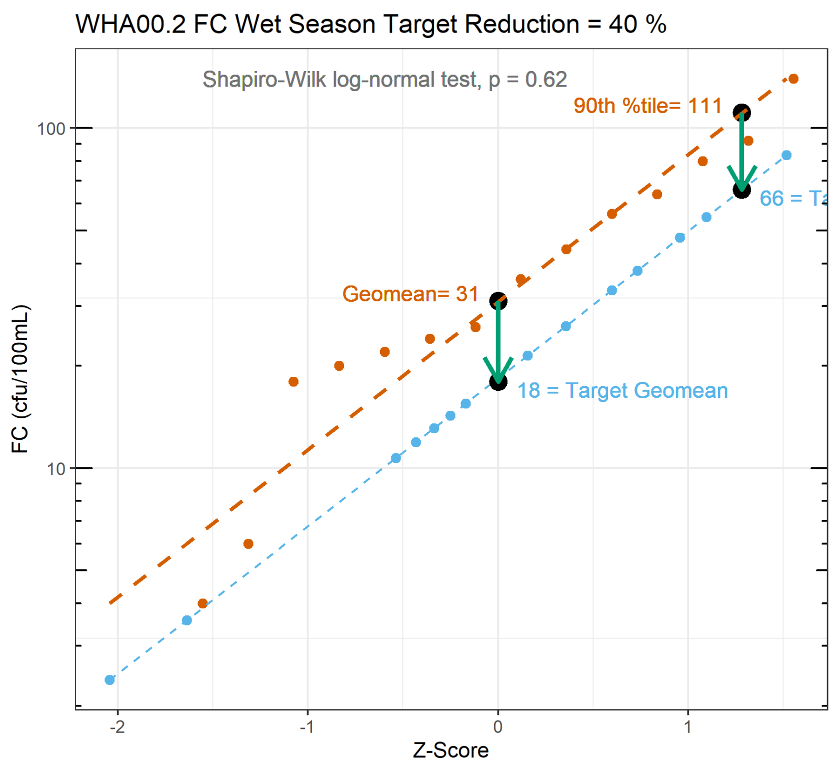
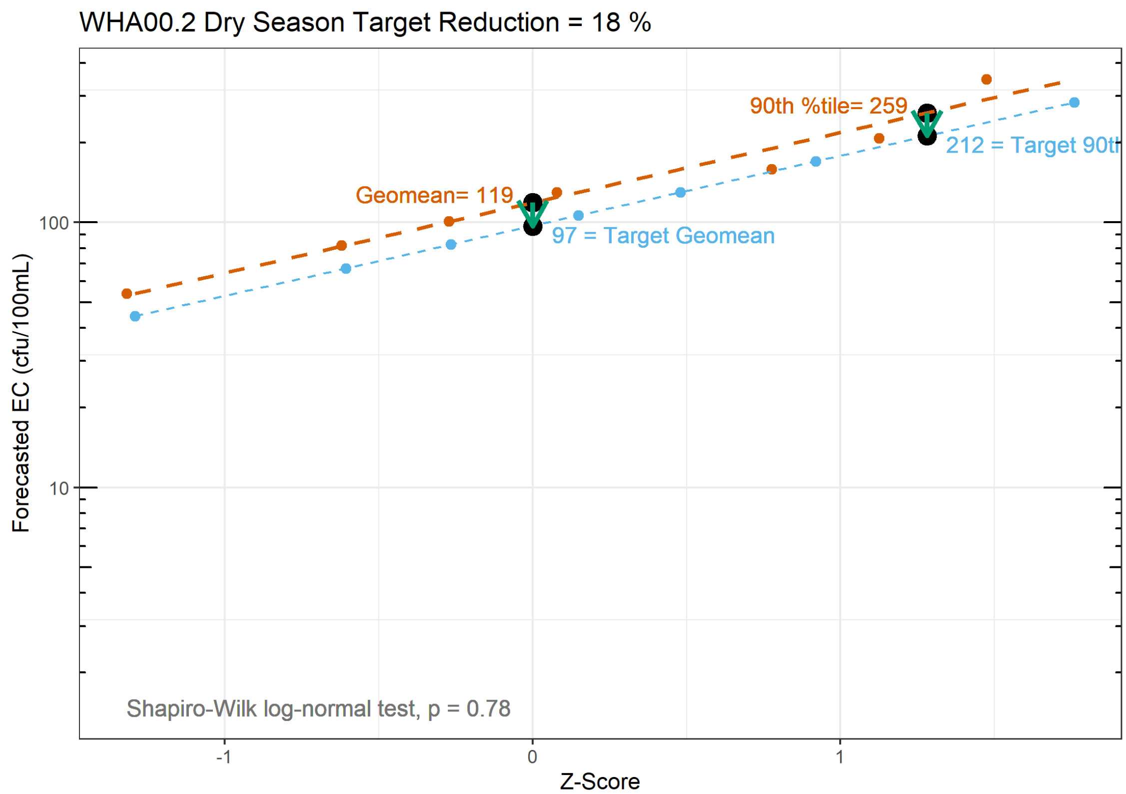


Figure D-20. Fecal Coliform (FC) TMDL target reductions for Whatcom Creek (WHA00.2) at Dupont St. 2017 — 2018 pooled data using the statistical rollback method, accounting for seasonality and brackish water mixing between fresh and marine waters



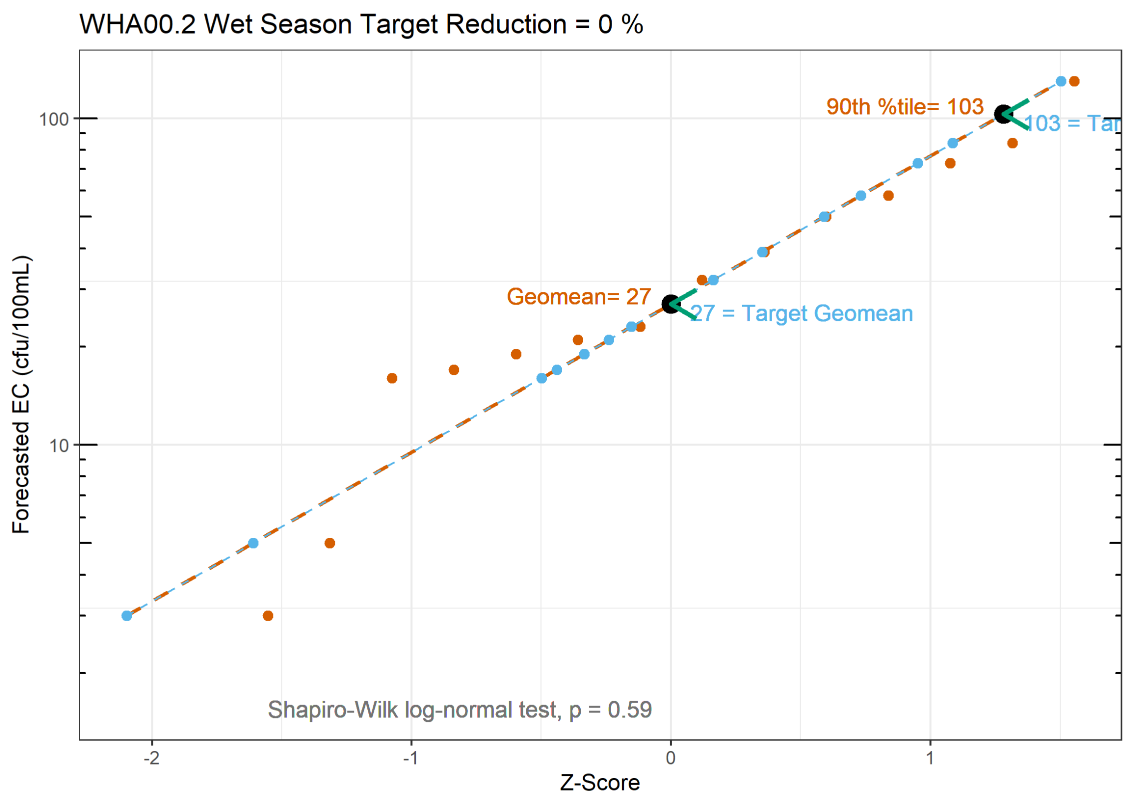
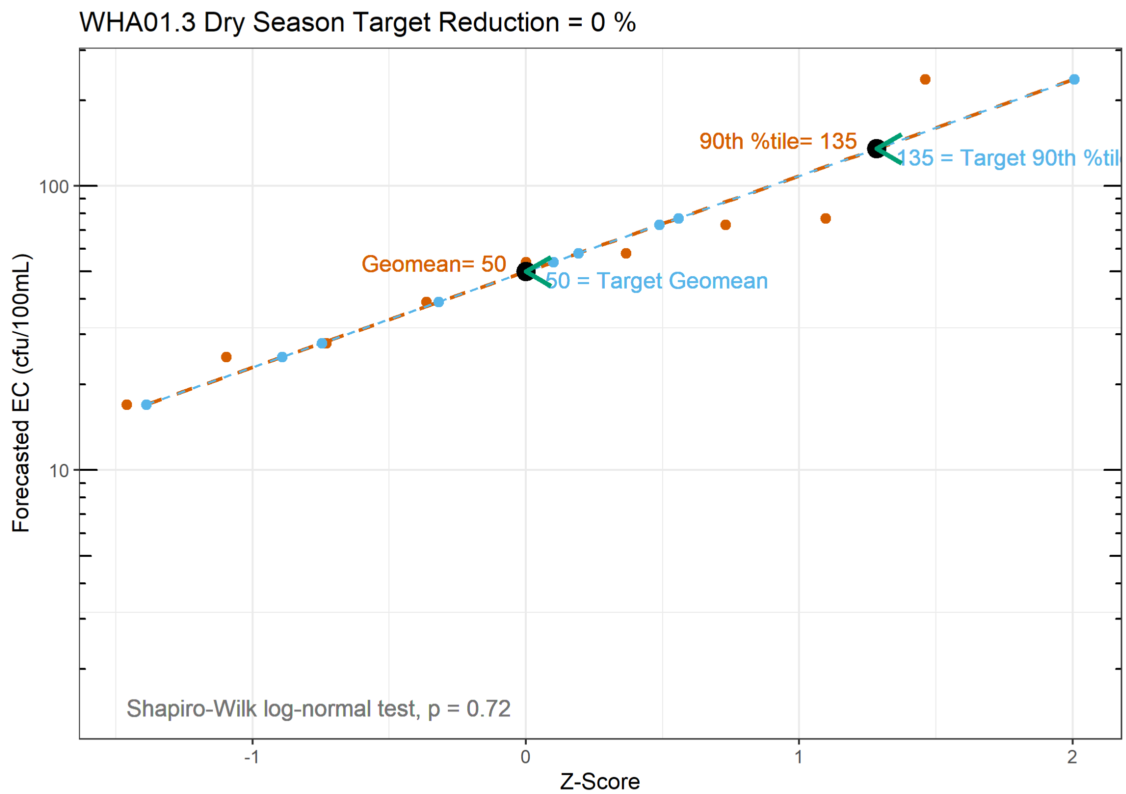


Figure D-21. *E. coli* TMDL target reductions accounting for seasonal variability using the statistical rollback method for Whatcom Creek (WHA00.2) at Dupont St. 2017 — 2018 pooled data



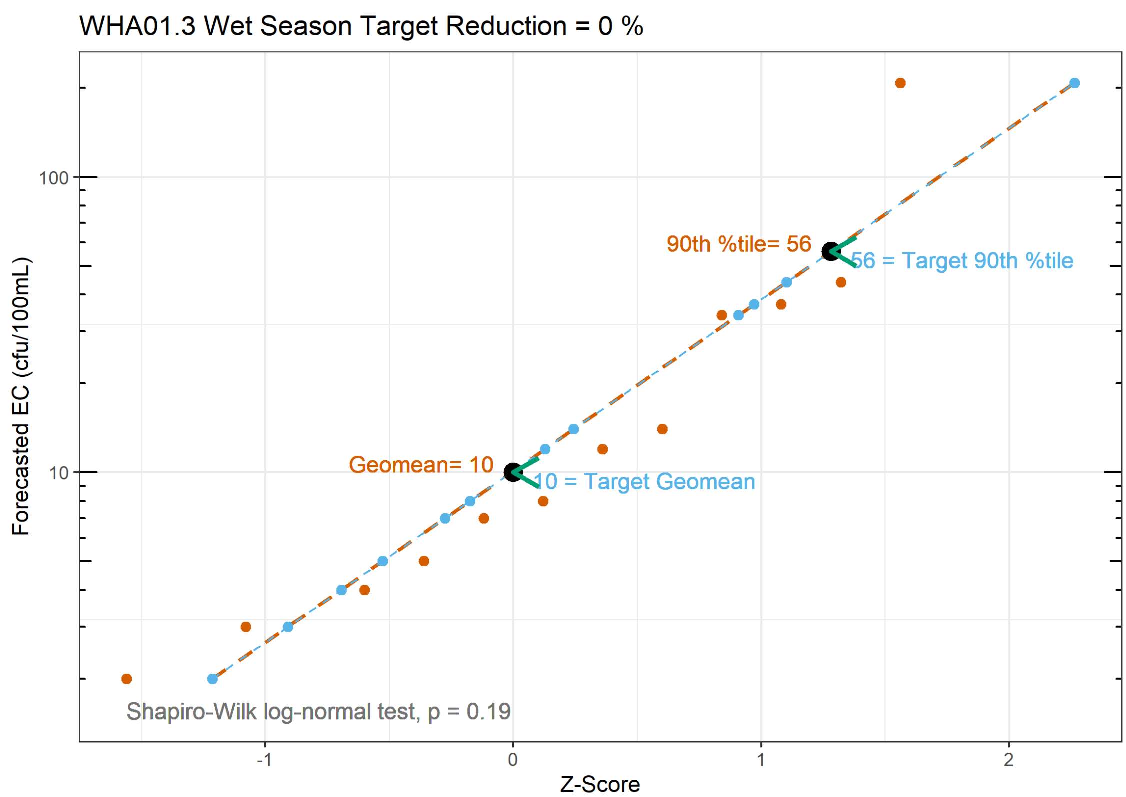
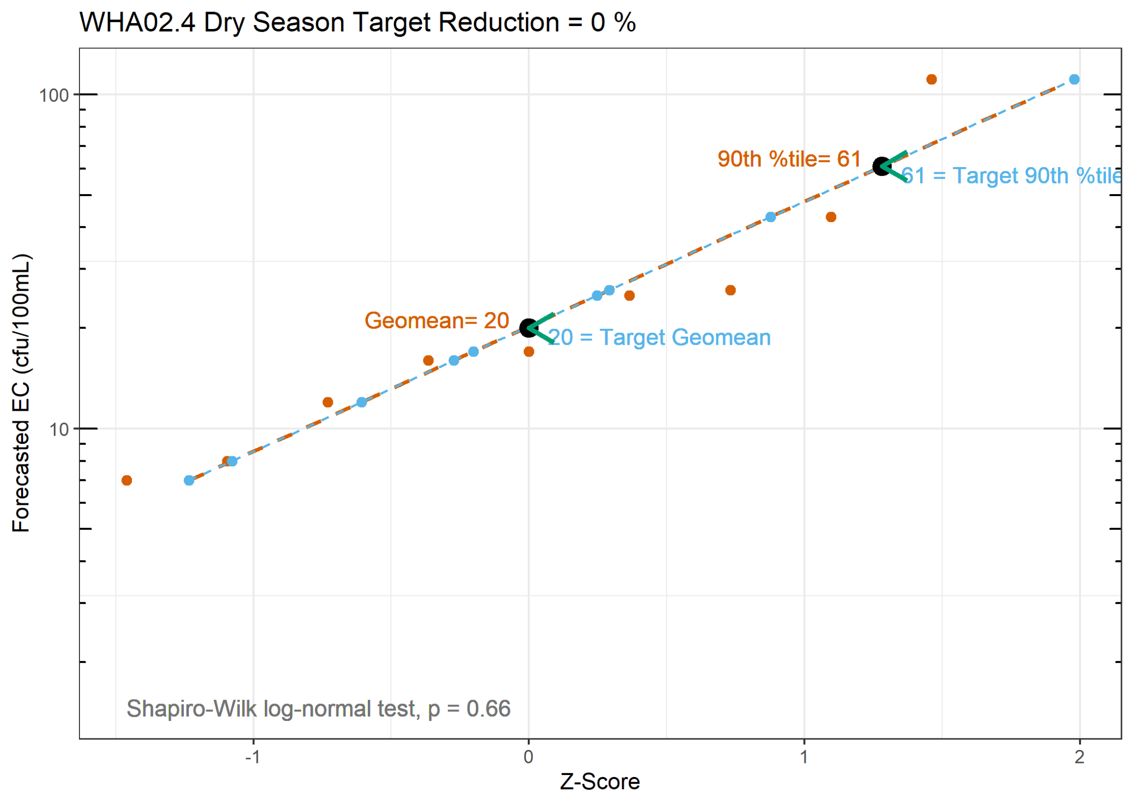


Figure D-22. *E. coli* TMDL target reductions accounting for seasonal variability using the statistical rollback method for Whatcom Creek (WHA01.3) at James St. 2017 — 2018 pooled data



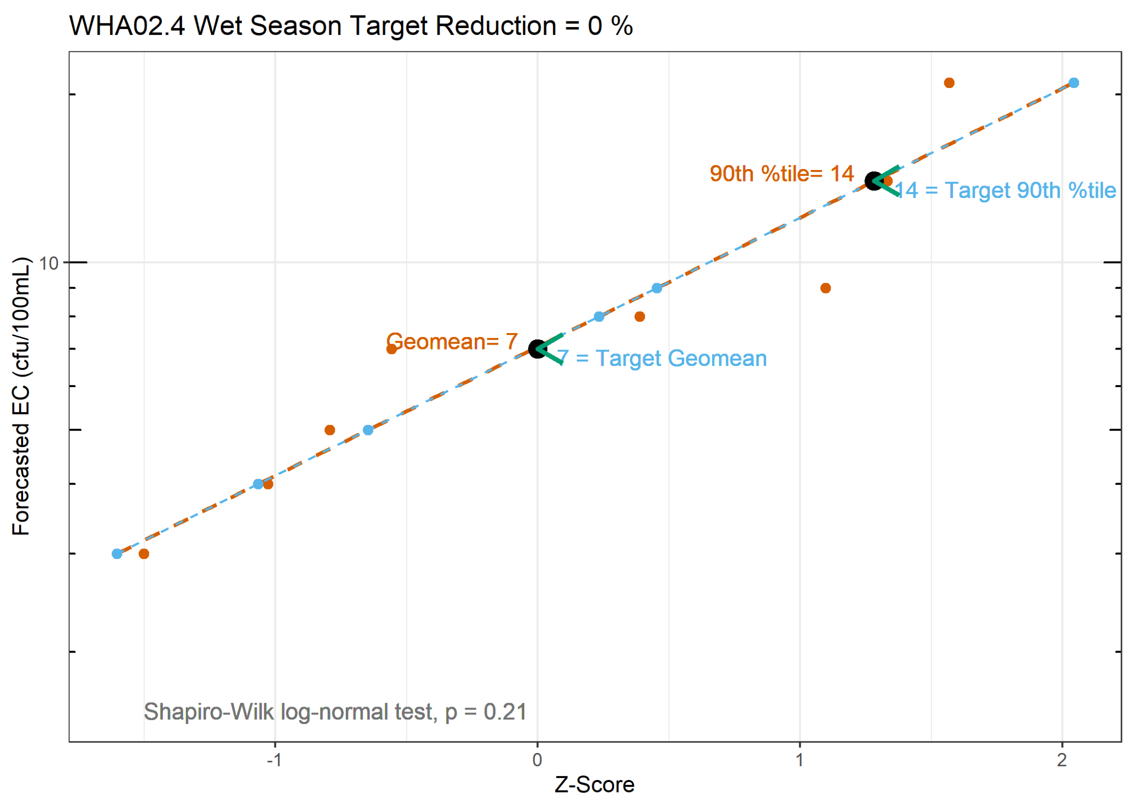
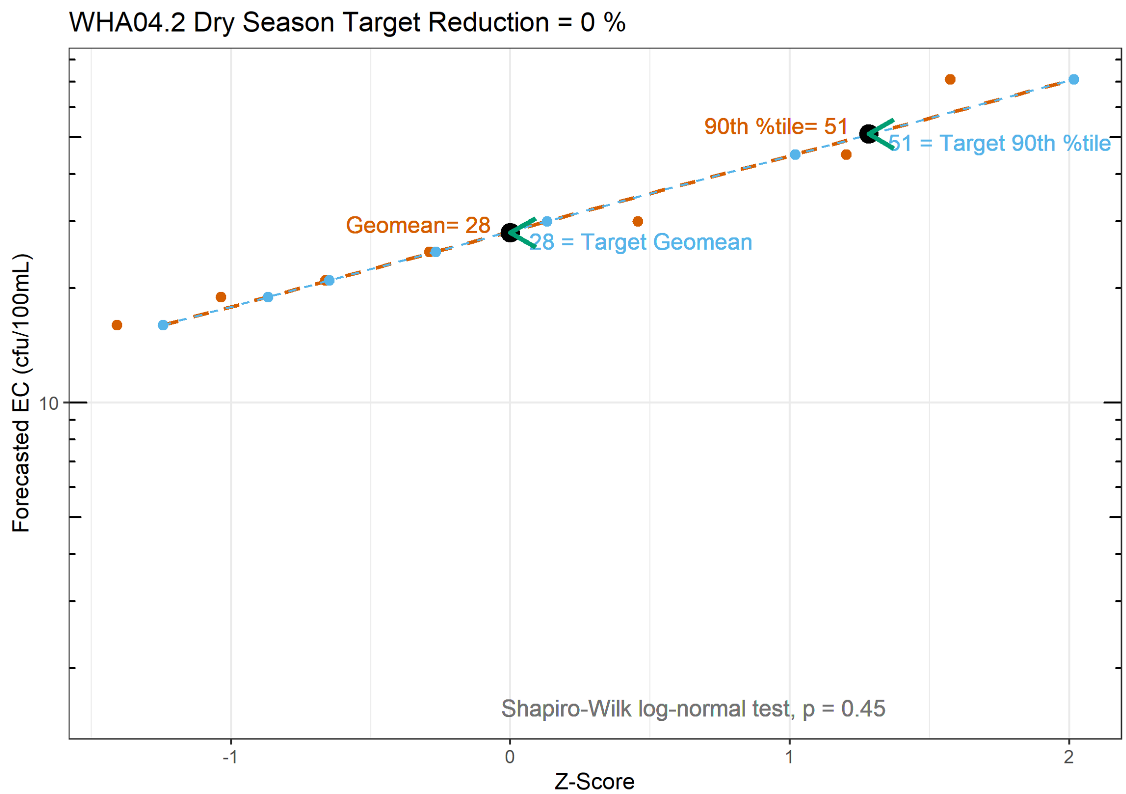


Figure D-23. *E. coli* TMDL target reductions accounting for seasonal variability using the statistical rollback method for Whatcom Creek (WHA02.4) at Valencia St. 2017 — 2018 pooled data



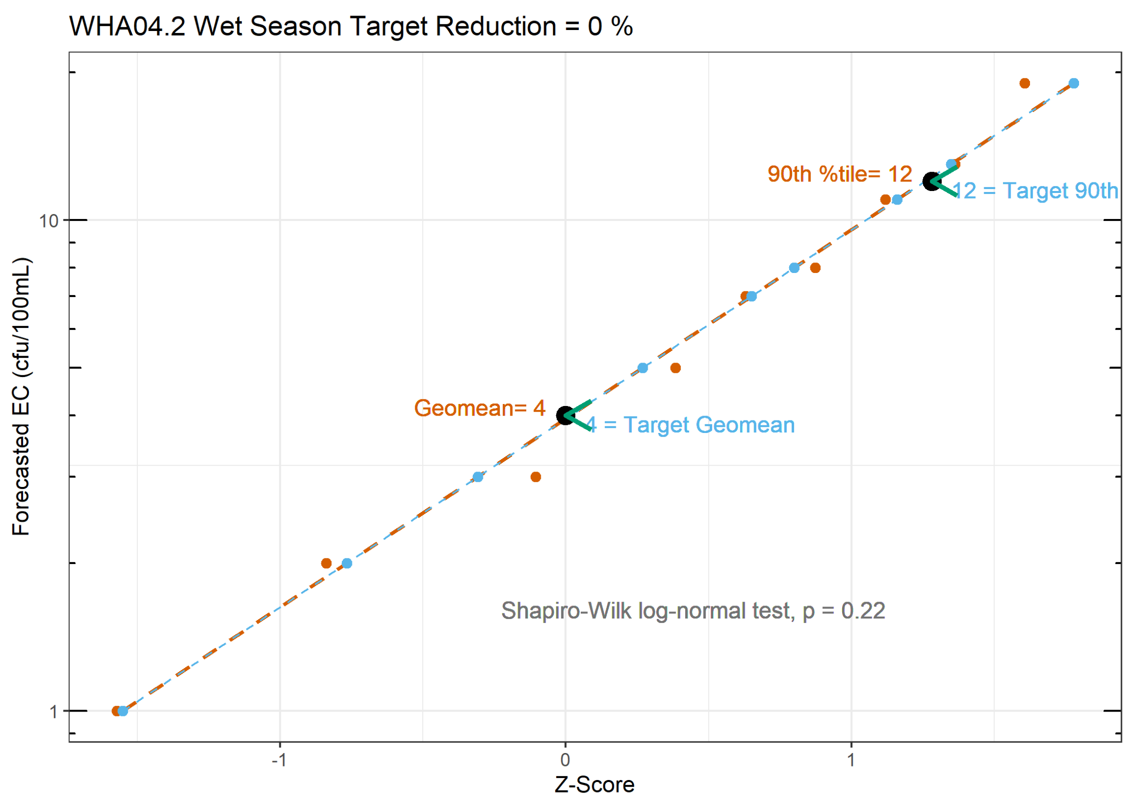


Figure D-24. *E. coli* TMDL target reductions accounting for seasonal variability using the statistical rollback method for Whatcom Creek (WHA04.2) at control dam 2017 — 2018 pooled data

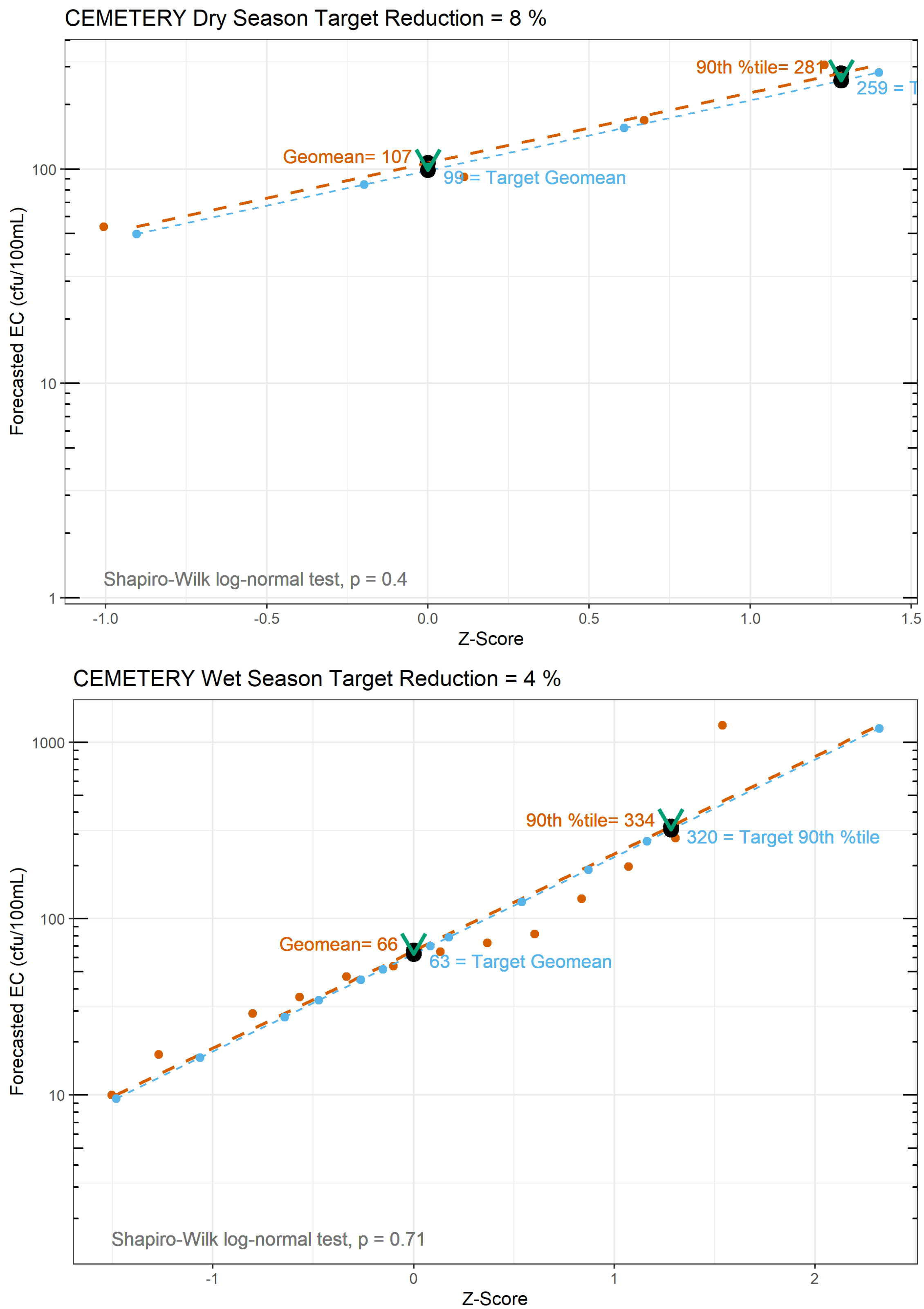


Figure D-25. *E. coli* TMDL target reductions accounting for seasonal variability using the statistical rollback method for Cemetery Creek at mouth 2017 — 2018 pooled data

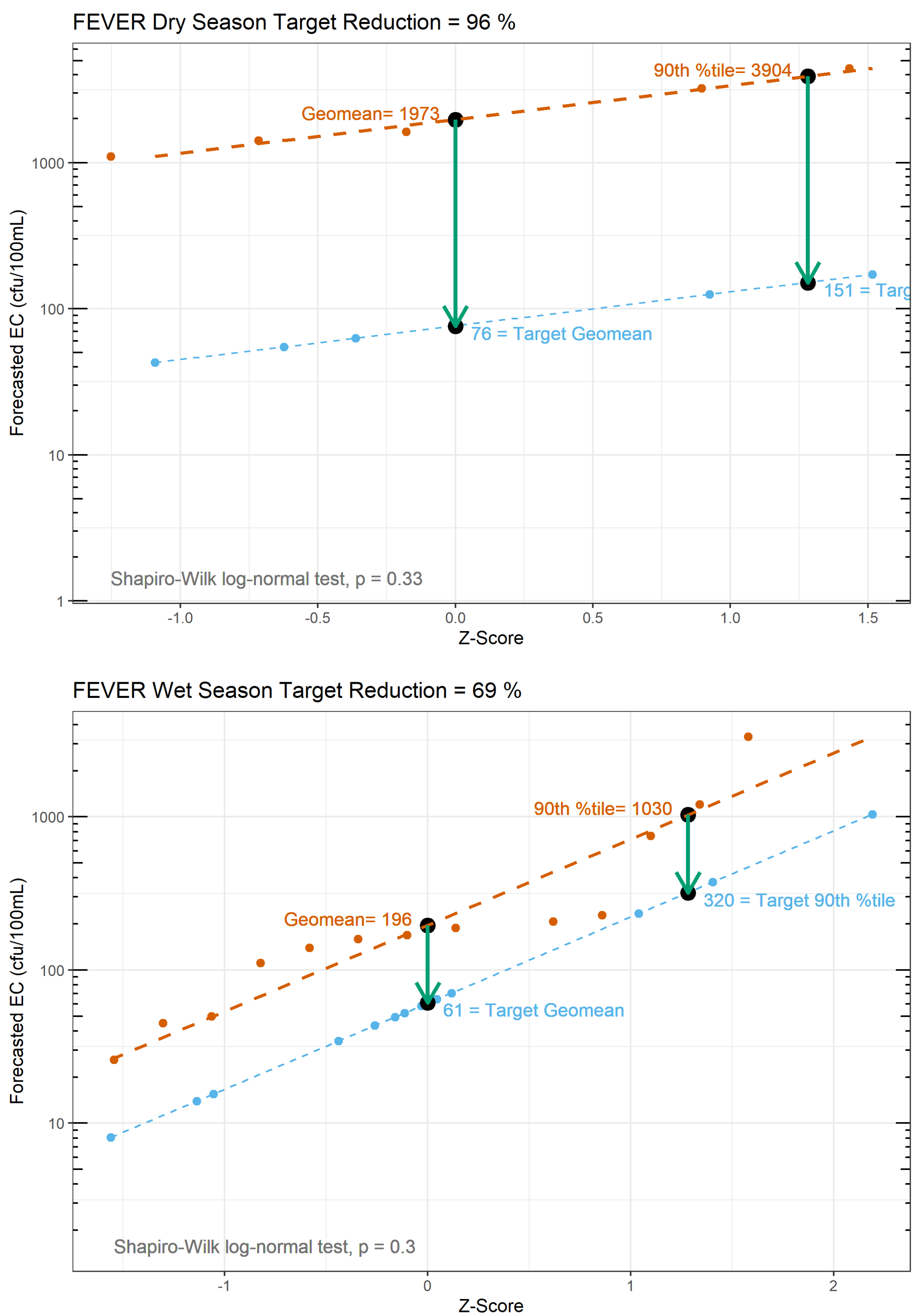


Figure D-26. *E. coli* TMDL target reductions accounting for seasonal variability using the statistical rollback method for Fever Creek at Valencia St. 2017 — 2018 pooled data

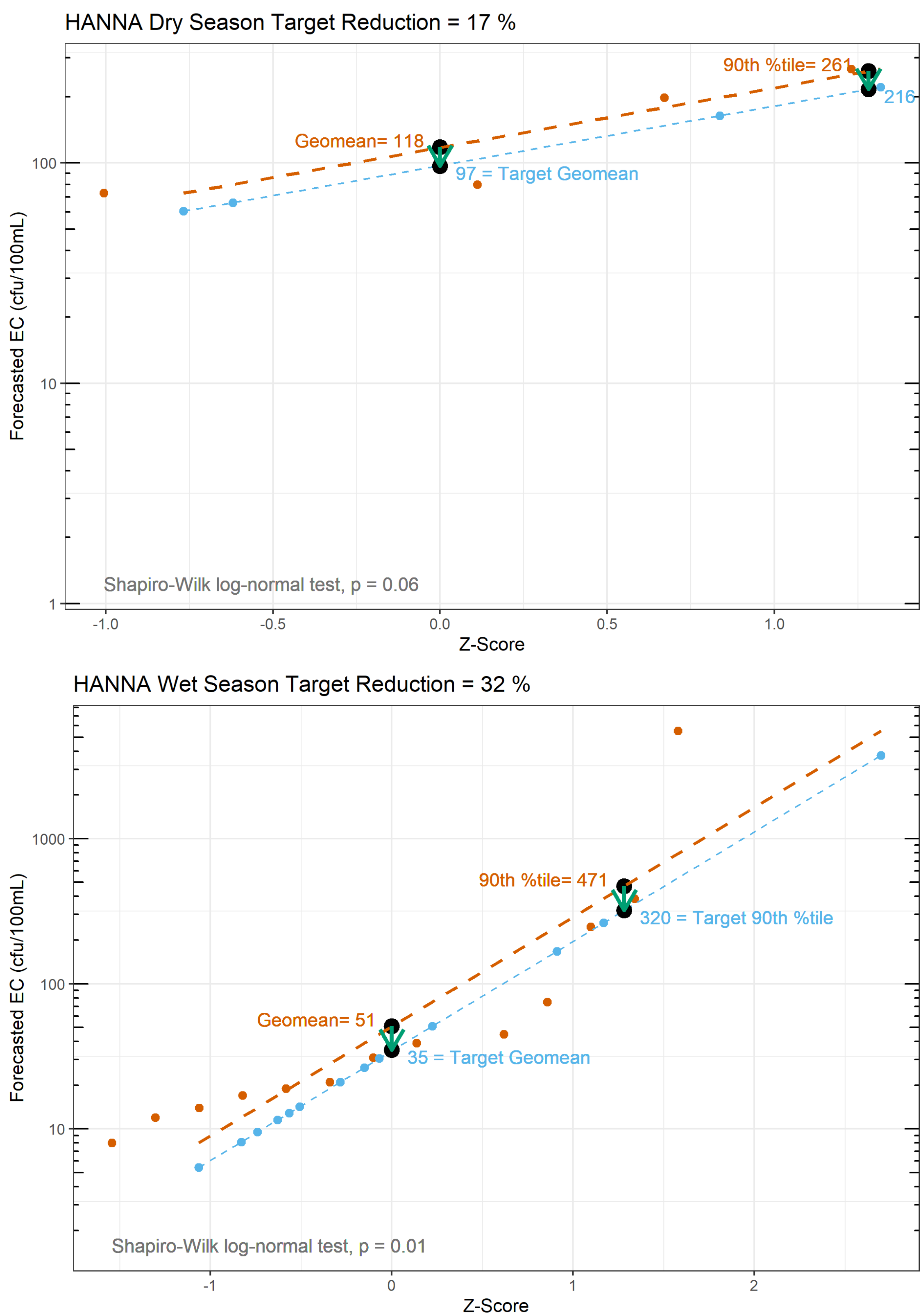


Figure D-27. *E. coli* TMDL target reductions accounting for seasonal variability using the statistical rollback method for Hanna Creek at mouth 2017 — 2018 pooled data

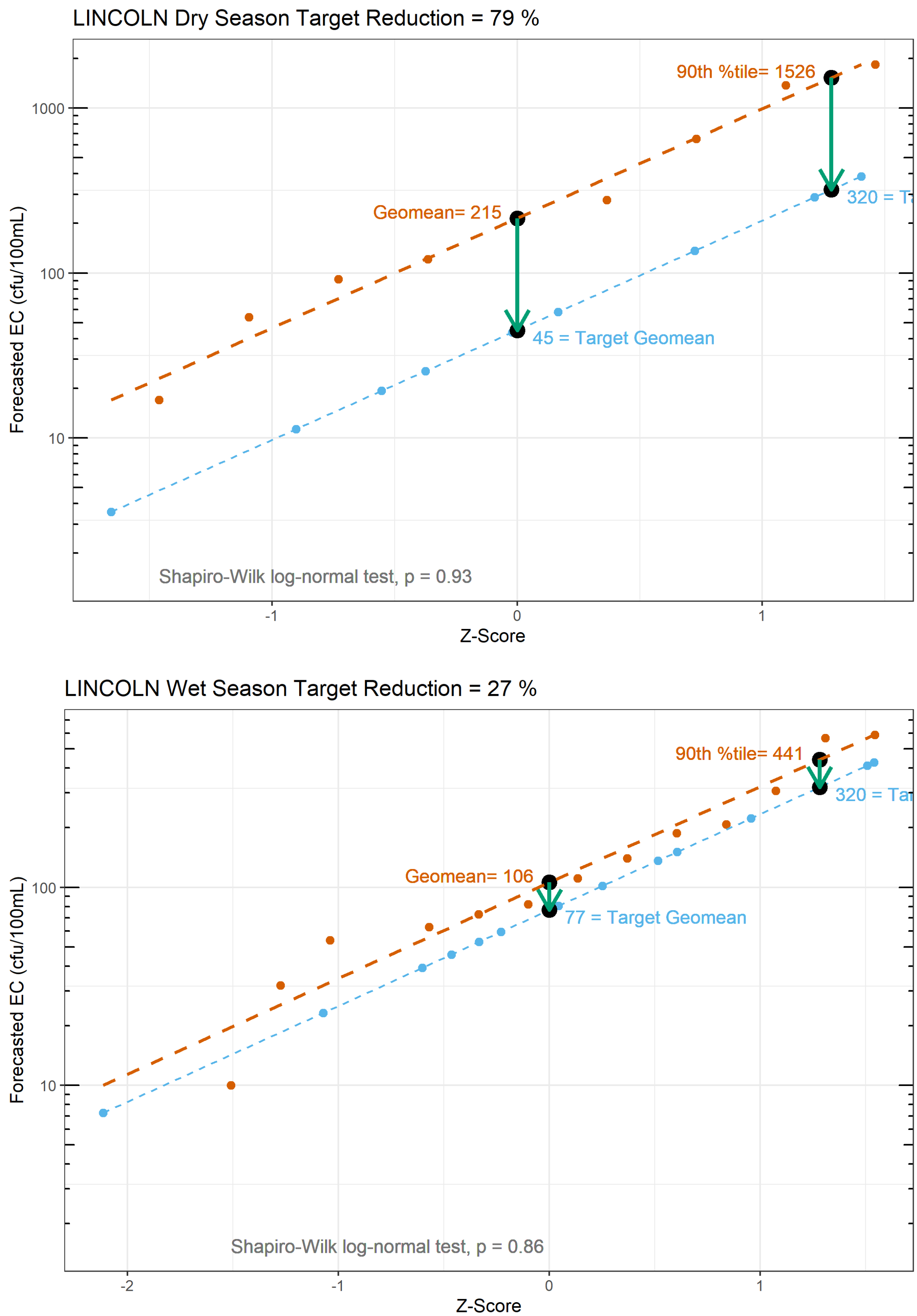


Figure D-28. *E. coli* TMDL target reductions accounting for seasonal variability using the statistical rollback method for Lincoln Creek at Fraser St. 2017 — 2018 pooled data

Seasonal Variation

McCarthy (2020b) examined FC data from 2017—2018 to evaluate more recent water quality conditions in the Whatcom Creek watershed and to compare with results presented in the Shannahan et al. (2004) study (Appendix A, Table A-19). To evaluate seasonal variations of bacteria concentrations, data were summarized seasonally. Each season was determined using 2003 through 2018 meteorological data averaged by month (Figure 2) and (McCarthy 2020b). The average monthly precipitation patterns were used to determine each season where the wet season is defined as October 1 through April 30 and the dry season as May 1 through September 30. The average precipitation during the wet season was 4.3 inches with a sum of 30.4 inches. The average precipitation during the dry season was 1.6 inches with a sum of 7.9 inches. Wet season monthly averages ranged from 2.7 to 6.4 inches, and the dry season monthly averages ranged from 0.7 to 2.4 inches.

E. coli geometric mean exceedances above the WQS occur in both the wet and dry seasons, with a general tendency of higher geometric means occurring during the dry season months Table 6 and Figure D-29). The FC WQS were not met during both the wet and dry seasons after accounting for the mixing of fresh and marine waters in the brackish zone. The higher concentrations during the dry season can be explained by reduced flows that limit the dilution of samples and highlight a bacteria pollution source that is not stormwater dependent. The FC concentration data from McCarthy (2020b) was translated to *E. coli* to produce the seasonality assessment — see the 'TMDL Targets' section for *E. coli* discussion (Tables 6 and 7). During a two-year period, a greater number of samples were collected during the seven-month wet season when compared to the five-month dry season due to:

- The inherent routine monthly sampling potential
  - Wet (n = 14)
  - Dry (n = 10)
- One sampling event did not occur during the dry season in June 2018, and
- Hanna, Fever, and Cemetery Creeks often do not have surface water flow at the sampling location during the dry season in the months of July and August

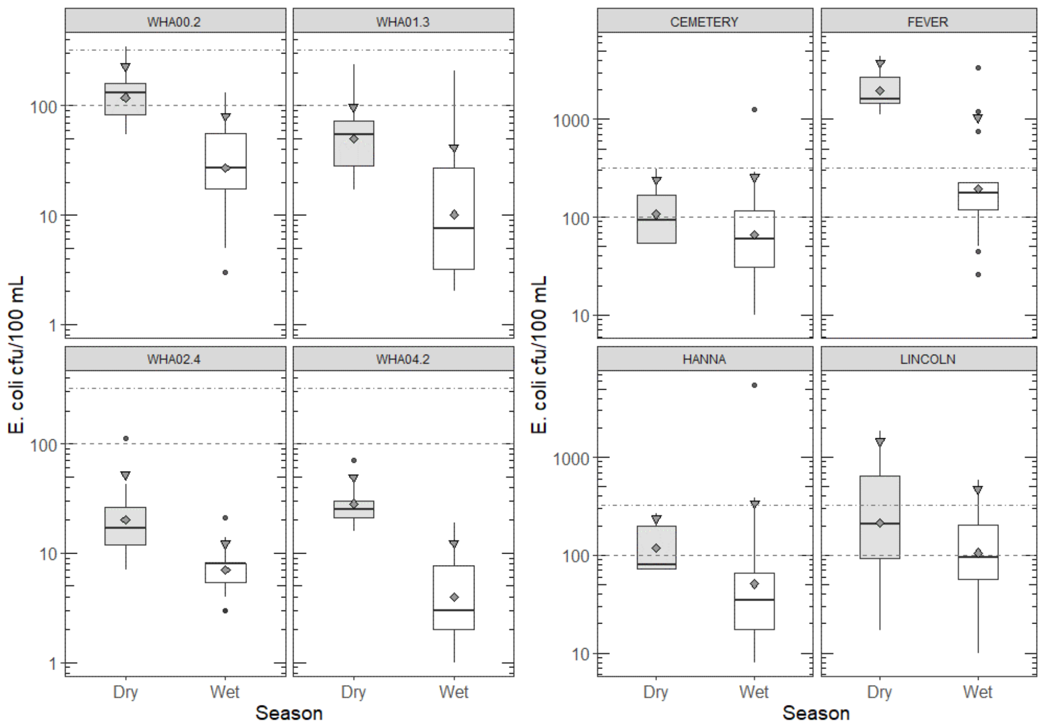


Figure D-29. Boxplot by wet and dry season for each sampling location where ♦ is the geomean, ▼ is the 90th percentile, - - - is the E. coli 100 m geomean criterion, and — - — is the not to exceed 320 STV

While higher loads may be expected during the wet season due to increased flow, there is not a strong seasonal pattern in bacteria loading (Figure D-30) and (McCarthy 2020b). Annual variation includes some years with much higher wet season loading (2002, 2004–2006, 2008, 2017) and other years with much higher loading during the dry season (2009, 2011, and 2013). The remainder of the years do not show a strong seasonal difference in bacteria loading. Water quality exceedances can occur under any flow and in any season; however, the critical period established in this TMDL and Implementation Plan is the dry season, which is primarily based on observed relative higher bacteria concentrations than that of the wet season.

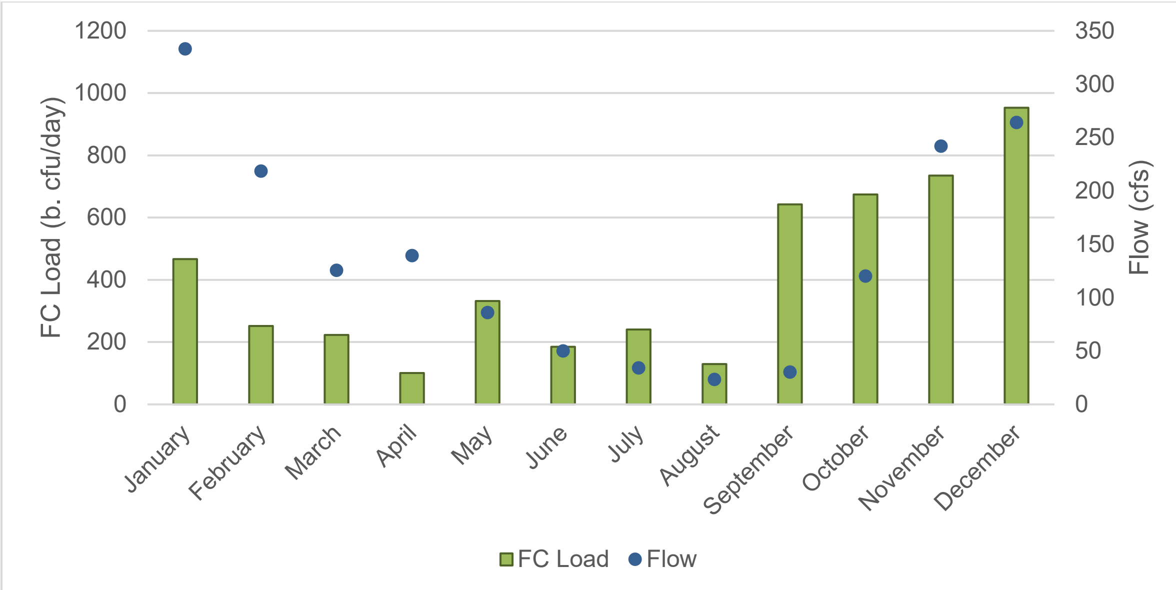


Figure D-30. Average monthly FC loading and stream discharge for Whatcom Creek at Dupont St. (2002-2018) — data source: McCarthy (2020b)

Critical Condition

Critical conditions differ from critical seasons (periods) since the critical condition could occur at any time during the year with no associated seasonal variability. Storm events generally showed the highest relative temporal bacteria concentrations in the sampled waterways (Shannahan et al. 2004 and McCarthy 2020b). Storm events are defined as measurable rainfall equal to or greater than 0.5 inches in a 24-hour period. High bacteria concentrations observed during storm events suggests that runoff and resuspension are two possible driving mechanisms as stormwater conveys pollution to the receiving water bodies.

Pollution associated with stormwater runoff presents a possible critical condition that demonstrates the greatest potential for elevated bacteria loading throughout the Whatcom Creek watershed. A better understanding of the combination of streamflow, storm event magnitude, and the frequency of these factors is necessary to improve the understanding and characterization of the critical condition.

Data Quality Assessment (McCarthy 2020b)

Data quality assessment procedures and measurement quality objectives (MQOs) for the USMP are described in detail in the most recent QAPP (City of Bellingham 2012). Additionally, annual water quality monitoring reports provide a review of data quality and are available on the USMP website[34]. Quality control procedures for the City of Bellingham's USMP for FC samples include a laboratory duplicate (one sample, two measurements) and a field replicate (two samples collected from the same sampling location) analyzed monthly along with regular stream samples. The laboratory duplicates serve to check the reproducibility of the instruments and analysis technique. The purpose of the field replicate is to indicate site heterogeneity or how representative the measurement is for a particular site.

USMP precision MQOs (City of Bellingham 2012):

- For values that are greater than 5 times the reporting limit (1 cfu/100 mL), the relative percent difference (RPD) of laboratory and field duplicates will be ≤ 30 percent using the following formula:

$$RPD = \frac{|(C_1 - C_2)|}{(C_1 + C_2)/2} \times 100 \qquad (13)$$

  Where C_1 and C_2 correspond with FC sample and replicate.

- For values that are less than or equal to 5 times the reporting limit, duplicate values will be within ± 2 times the reporting limit.

Because the USMP monitors a network of water bodies, FC data quality records are reported with all sites collectively. Although this TMDL study is focused on Whatcom Creek sites, the data quality results are presented for the full dataset for 2017–2018, the focus years for the analysis.

Samples with field replicates were collected for at least 1 out of 10 samples, (average of 13 percent for both 2017 and 2018) meeting the USMP MQO (10 percent). The range of bacterial variation were like those reported in the Shannahan et al. (2004) study. The average coefficient of variation (CV) calculated by Shannahan et al. (2004) using a 2002—2003 dataset was 26 percent and the CV for the 2017—2018 FC dataset was 29 percent.

Field sampling follows protocols described in the USMP Quality Assurance Project Plan (City of Bellingham 2012). Water quality samples are collected six inches below the surface of the water in clean, sterile 250-mL polypropylene bottles. Samples are kept on ice for transportation to the laboratory. In the lab, samples are handled according to SM9060B until analyzed. Analysis for FC (SM9222D) is completed within six hours of collection. All sample analyses are performed by staff of the city of Bellingham's state accredited laboratory.

[34] https://cob.org/services/environment/water-quality/urban-streams-monitoring

Appendix E. TMDL Analysis

Loading Capacity

The FC and *E. coli* LCs were determined for the mainstem of Whatcom Creek at Dupont Street. The *E. coli* LCs were determined for each tributary near the confluence with Whatcom Creek and further established for each AU ID to account for each contributing NHD catchment. Establishing the bacteria TMDLs at or below the associated LCs addresses each Category 5 — 303(d) listed impairment and the watershed for a basin-wide Implementation Plan approach. Information provided by Shannahan et al. (2004) and McCarthy (2020b) was used to determine the LCs. The bacteria translator (Equation 1) was used to convert individual FC concentrations to *E. coli* concentrations when necessary. The TMDLs and reductions necessary to meet WQS were based on the pooled 2017 and 2018 datasets and expressed as mass per unit time (b.cfu/day).

After calculating the FC and *E. coli* seasonal loading, the TMDL for each 303(d) listed reach code (AU ID) stream segment was determined based on the delineated contributing catchment area as described below in the following sections. All contributing stream segments with unique AU IDs were accounted for when determining each TMDL. If a future Water Quality Assessment concludes that a new stream segment AU ID does not meet the bacteria WQS, in accordance with federal regulations at 40 CFR § 130.7, Ecology will coordinate with EPA to make the correct Category determination — see Appendix A, Clean Water Act and TMDLs. The following methods, tables, and equations shall be used to establish the TMDL for any future bacteria impairment based on 2017 and 2018 conditions. These methods are consistent with the methods used to establish the TMDLs in this report.

Loading Calculation

Calculating bacteria loads require the measurement of stream flow (discharge) and bacteria concentrations. Shannahan et al. (2004) generated a water balance using continuous flow data on the mainstem and simulated hydrographs for the tributaries described in the Loading Summary subsection in Appendix D. Similarly, McCarthy (2020b) relied on continuous flow data collected at Dupont Street to calculate FC loading, the LC, and TMDL at this pour point, which was assigned to the entire watershed. McCarthy (2020b), however, did not determine the loadings, LCs, and TMDLs for the tributary drainages. The *E. coli* TMDL component of this updated study, however, fills in the data gaps by quantifying the *E. coli* loads, LCs, and TMDLs for each tributary and the mainstem of Whatcom Creek. The FC load, LC, and TMDL were further established at the mouth of Whatcom Creek by accounting for the downstream designated use based on water quality criteria and standards. The loads, LCs, and TMDLs were separated by wet and dry season.

The following equation calculates the LC and TMDL used to assess the attainment of the FC and *E. coli* TMDLs:

$$Load\ \left(\frac{cfu}{day}\right) = \ Bacteria\ \left(\frac{cfu}{100mL}\right) \times Flow\ (cfs) \times Conversion\ Factor\ (2.447 * 10^7) \qquad (14)$$

Equation 14 calculates the LC, where the bacteria concentration was the *E. coli* geometric mean criterion of 100 (cfu/100 mL) and streamflow discharge was averaged by season. The FC LC for Whatcom Creek near the mouth was established by using the geometric mean concentrations of 25 and 22 (cfu/100 mL) averaged by the wet and dry seasons, respectively and the seasonally averaged streamflow discharge (Appendix D — Downstream Designated Use Targets). Whatcom Creek flow data (2017 — 2018) from the City's continuous gage station at Dupont St. was used to calculate the mainstem loads, which represents the furthest downstream sampling location. Regression (Shannahan et al. 2004) with the Euclid Creek continuous gage station operated by the USGS was used to calculate tributary loading (Appendix D, Equations 5 – 8). Finally, each TMDL, LC, WLA, and LA were all expressed as billion cfu per day (b.cfu/day) — total number divided by one billion — to effectively show very large bacteria load numbers.

Equation 14 was used to calculate the observed conditions such as seasonal loading at each tributary sampling location and at the mouth of Whatcom Creek using 2017 through 2018 data. The streamflow was averaged by season for each tributary and the mainstem Whatcom Creek. The bacteria concentrations measured at each sampling location were averaged by season using the geometric mean value. These seasonally averaged streamflow values and geometric mean bacteria concentrations were multiplied along with the conversion factor to calculate the seasonal loading, which was expressed as daily loads based on the average seasonal loading.

Equation 14 may also be used to calculate instantaneous loads, known as flux, using the measured bacteria concentration and average daily streamflow discharge observed at the time of sampling, or effluent-based loading from measured "end-of-pipe" discharges. When measured, the instantaneous discharge may be used instead of average daily streamflow values that are often associated with these time series data from continuous gage stations.

TMDLs for Each Reach Code Assessment Unit ID Catchment

The *E. coli* TMDL for each impaired Category 5 reach code — AU stream segment was established (Tables E-22). The FC TMDL was established for the downstream most AU (ID 17110004013762_001_002) of Whatcom Creek to protect the designated use of shellfish harvesting. An area-weighted calculation was used to determine the TMDL for each AU ID, which included the WLA and LA components of the LC for each AU ID stream segment (Equations 15 and 16 — see below). Depending on the type of WLA, the effluent-based calculation was also applied and included in the total sum of the TMDL —see Tables 7 and 14 of the TMDL report. The area-weighted allocations, which are relative to each delineated watershed area, cover areal loadings that are proportional to both the NPDES stormwater permitted area to calculate WLAs, and the non-permitted areas to calculate LAs (Tables E-23 and 24). The TMDL determined at each sampling location was therefore weighted to each contributing reach code AU based on the proportion of catchment area that flows into the given AU. Once the TMDL was established, the areal-based WLAs and LAs were calculated for the Whatcom Creek watershed as a whole and for each tributary using the relative contributing area. Each TMDL was establish at or below the associated LC. Figures E-31 and 32 show the TMDLs in relation to the size of each AU ID catchment area for Whatcom Creek and tributaries, respectively.

Table E-22. Bacteria TMDLs (b.cfu/day) separated by season and reach code Assessment Unit (AU ID) for the Whatcom Creek watershed

Listing ID	Water Body Name	Reach Code (Assessment Unit ID)	Dry Season TMDL	Dry Season WLA	Dry Season LA	Dry MOS (10%)	Wet Season TMDL	Wet Season WLA	Wet Season LA	Wet MOS (10%)	Bacteria Indicator
16408	Whatcom Creek	17110004013762_001_002	19.6	17.7	—	1.96	138.9	125.0	—	13.9	FC
16408	Whatcom Creek	17110004013762_001_002	8.5	7.6	—	0.8	52.8	47.5	—	5.3	*E. coli*
89130	Whatcom Creek	17110004013762_002_002	42.1	37.8	0.09	4.2	261.7	235.0	0.55	26.2	*E. coli*
88957	Whatcom Creek	17110004014447_001_001	38.7	26.6	8.3	3.9	241.0	165.2	51.7	24.1	*E. coli*
		Total:	89.3	72.0	8.4	8.9	555.5	447.7	52.3	55.6	*E. coli*
39110	Lincoln Creek	17110004013704_001_001	0.09	0.08	0.0005	0.009	0.61	0.54	0.003	0.06	*E. coli*
39089	Fever Creek	17110004014207_001_001	0.07	0.063	—	0.007	0.50	0.45	—	0.05	*E. coli*
39061	Cemetery Creek	17110004014628_001_001	0.013	0.012		0.001	0.09	0.077		0.009	*E. coli*
88094	Cemetery Creek	17110004013600_001_001	0.033	0.016	0.013	0.003	0.22	0.105	0.089	0.022	*E. coli*
88254	Unnamed Creek (Trib to Cemetery W.F.)	17110004018338_001_001	0.005	0.004	—	0.0005	0.03	0.027	—	0.003	*E. coli*
		Total:	0.05	0.03	0.013	0.005	0.33	0.21	0.089	0.033	*E. coli*
45565	Hanna Creek	17110004013829_001_001	0.003	0.003		0.0003	0.02	0.02		0.002	*E. coli*
88171	Hanna Creek	17110004013979_001_001	0.077	0.054	0.016	0.0077	0.54	0.38	0.11	0.05	*E. coli*
		Total:	0.08	0.06	0.016	0.008	0.56	0.39	0.11	0.06	*E. coli*

— indicates the allocation type does not discharge to the Assessment Unit ID

Table E-23. TMDL reach code Assessment Unit (AU ID) catchment area and pour point locations in the Whatcom Creek watershed

Listing ID	Water Body Name	Reach Code (Assessment Unit ID)	Catchment Area (acres)	TMDL Contribution Catchment Area (%)	Delineation Pour Point (Latitude)	Delineation Pour Point (Longitude)
16408	Whatcom Creek	17110004013762_001_002	582	9.5%	48.75499	-122.48238
89130	Whatcom Creek	17110004013762_002_002	2656	47.1%	48.75150	-122.47088
88957	Whatcom Creek	17110004014447_001_001	2490	43.4%	48.75477	-122.45915
39110	Lincoln Creek	17110004013704_001_001	1024	100%	48.75413	-122.45982
39089	Fever Creek	17110004014207_001_001	1306	100%	48.75474	-122.45923
39061	Cemetery Creek	17110004014628_001_001	1542	25.8%	48.75426	-122.45360
88094	Cemetery Creek	17110004013600_001_001	1005	65.2%	48.75316	-122.45307
88254	Unnamed Creek (Trib to Cemetery W.F.)	17110004018338_001_001	140	9.1%	48.75241	-122.45313
45565	Hanna Creek	17110004013829_001_001	243	3.5%	48.75220	-122.43354
88171	Hanna Creek	17110004013979_001_001	173	96.5%	48.74964	-122.43257

Table E-24. Whatcom Creek watershed and subbasin areal allocations based on total permitted area (WLA) and non-permitted area (LA) after accounting for the 10% margin of safety

Listing ID	Water Body/Basin	Reach Code (Assessment Unit ID)	Total Areal WLA	Total Areal LA	Area (acres)
16408	Whatcom Creek	17110004013762_001_002	100%	0%	582
89130	Whatcom Creek	17110004013762_002_002	99.8%	0.2%	2656
88957	Whatcom Creek	17110004014447_001_001	76.2%	23.8%	2490
	Whatcom Basin		89.5%	10.5%	5728
39110	Lincoln Creek	17110004013704_001_001	99.4%	0.6%	1024
39089	Fever Creek	17110004014207_001_001	100%	0%	1306
39061	Cemetery Creek	17110004014628_001_001	100%	0%	1542
88094	Cemetery Creek	17110004013600_001_001	54.2%	45.8%	1005
88254	Unnamed Creek (Trib to Cemetery W.F.)	17110004018338_001_001	100%	0%	140
	Cemetery subbasin		82.9%	17.1%	2687
45565	Hanna Creek	17110004013829_001_001	100%	0%	243
88171	Hanna Creek	17110004013979_001_001	77.2%	22.8%	173
	Hanna subbasin		90.5%	9.5%	416

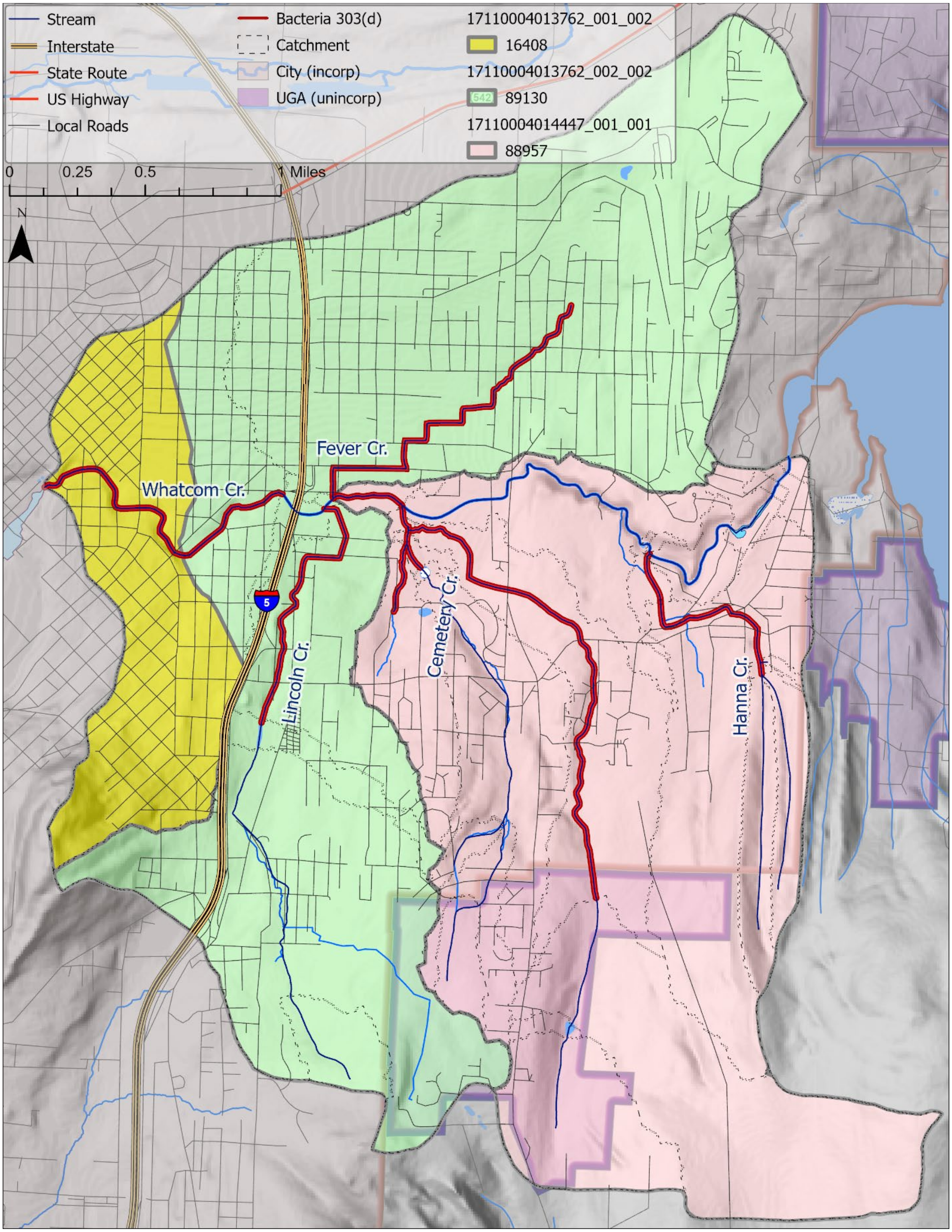


Figure E-31. Whatcom Creek delineated catchment area separated by AU ID/303(d) listing all of which contribute to the TMDL

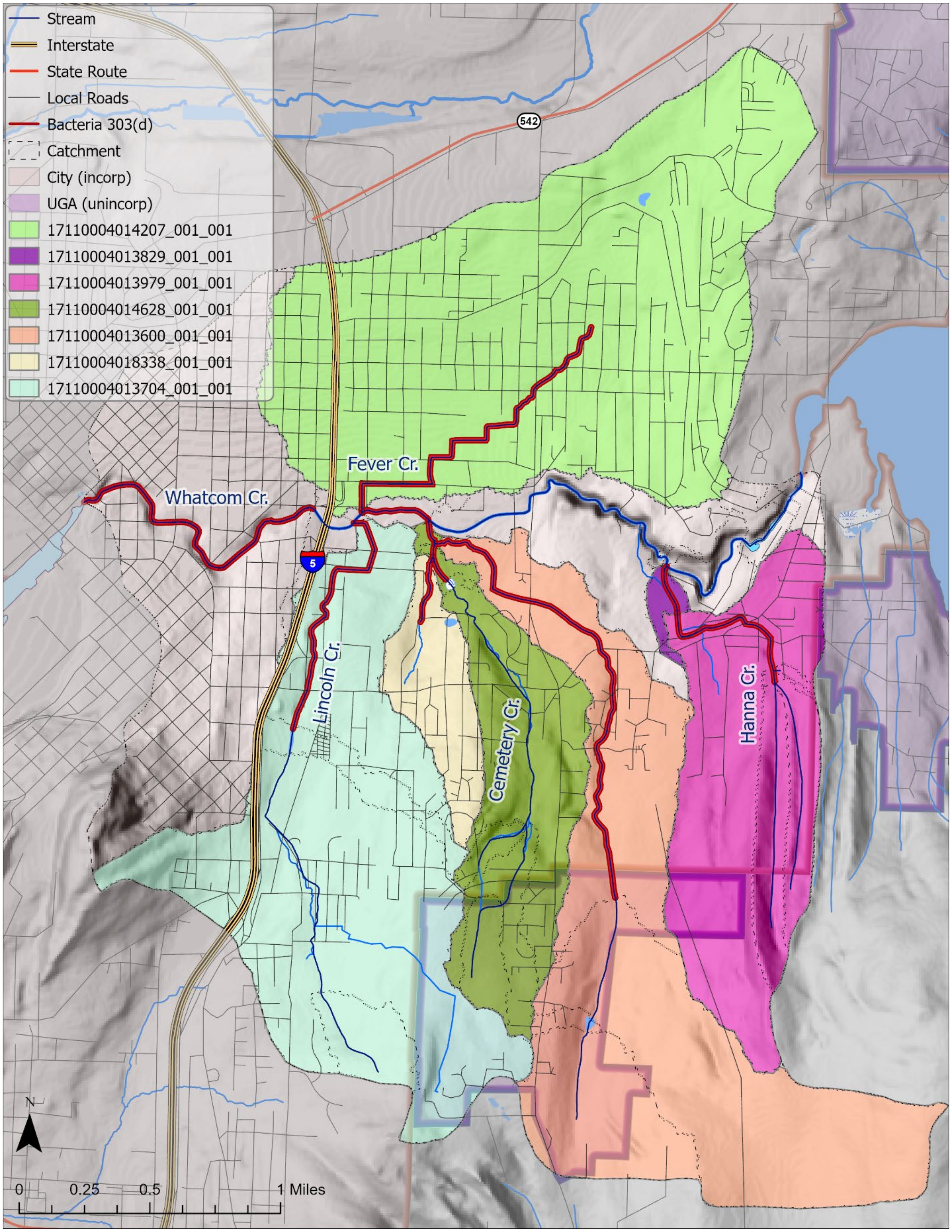


Figure E-32. Tributaries to Whatcom Creek delineated catchment area separated by AU ID/303(d) listing all of which contribute to the TMDL

Effluent-based WLAs were applied to permitted entities that discharge to the mainstem Whatcom Creek because this is the only water body that receives direct discharge from these NPDES permitted sources. The NPDES permitted effluent based WLA for the WDFW Bellingham Fish Hatchery (WAG994275) amounts to 0.11 b.cfu/day, which was included in the dry and wet season WLA for the mainstem of Whatcom Creek (Listing ID: 89130, AU ID: 17110004013762_002_002) because it is the nearest 303(d) listed reach of the receiving water body (Tables 7 and 9). The NPDES permitted effluent based WLA for Brooks Manufacturing Co. (WA0030805) amounts to 0.09 b.cfu/day, which was included in the dry and wet season WLA for the mainstem of Whatcom Creek (Listing ID: 89130, AU ID: 17110004013762_002_002) since it is the 303(d) listed reach of the receiving water body (Tables 7 and 9).

Based on the established FC and *E. coli* TMDLs, all impaired reach code AU stream segments shall be moved from Category 5 to Category 4a. In the event a future Water Quality Assessment (WQA) indicates that a stream segment does not meet the WQS (Category 5) that was previously not impaired, the TMDL may be calculated for the new stream segment AU. Table E-25 includes all NHD reach codes currently not impaired (unlisted), that are addressed by this TMDL by using the watershed-scale approach to reduce bacterial pollution and meet the WQS. If a reach code (Table E-25) does not meet the WQS under a future WQA, each reach code shall receive a TMDL using Equations 15 and 16, based on the contributing catchment area, which accounts for the proportional contributions of the WLAs, LAs, and the MOS.

Table E-25. All unlisted water bodies addressed by this bacteria TMDL as indicated by the National Hydrography Dataset (NHD)

Row Number	NHD Reach Code	Length (km)	Row Number	NHD Reach Code	Length (km)
1	17110004013543	0.32	20	17110004014447	0.44
2	17110004013600	3.01	21	17110004014474	1.30
3	17110004013605	1.15	22	17110004014493	0.08
4	17110004013704	1.65	23	17110004014628	0.16
5	17110004013762	1.98	24	17110004014628	0.08
6	17110004013797	0.04	25	17110004014628	0.16
7	17110004013821	1.69	26	17110004014651	0.24
8	17110004013829	0.94	27	17110004014651	1.22
9	17110004013947	0.16	28	17110004014692	0.07
10	17110004013979	0.72	29	17110004014739	0.87
11	17110004013979	0.07	30	17110004014779	1.50
12	17110004013988	0.10	31	17110004014839	0.56
13	17110004013993	0.36	32	17110004015011	0.76
14	17110004014072	0.08	33	17110004015057	0.08
15	17110004014207	2.30	34	17110004015102	0.09
16	17110004014209	1.70	35	17110004018337	0.04
17	17110004014236	0.56	36	17110004018338	0.85
18	17110004014411	1.62	37	17110004018349	0.45
19	17110004014411	0.27			

Equation 15 shows the interim step to establish the LC using the proportional contributing catchment area to the reach code AU after accounting for the MOS.

$$LC_{AU} = AU_A \times (TMDL - MOS) \qquad (15)$$

Where:

LC_{AU} is the bacterial loading capacity (b.cfu/day) for the reach code assessment unit (AU),

AU_A is the proportional contributing catchment area (%) of the reach code AU delineated between the downstream most pour point of the given AU to the next upstream AU pour point,

TMDL is the total maximum daily load of bacteria (b.cfu/day) established using data collected at the downstream most sampling location, which is at or below the LC_{AU}, and

MOS is the margin of safety (b.cfu/day) comprised of 10 percent of the TMDL.

Once the LC_{AU} is calculated, the final $TMDL_{AU}$ for the given AU is calculated by accounting for the proportional contributions from the WLAs, LAs, and the MOS (Equation 16). The sum of all $TMDL_{AU}$ calculated for a given AU is equal to the TMDL for the listed water body.

$$TMDL_{AU} = LC_{AU}(WLA_A + LA_A) + MOS_{AU} \qquad (16)$$

Where:

$TMDL_{AU}$ is the bacterial total maximum daily load (b.cfu/day) for the AU,

LC_{AU} is the loading capacity (b.cfu/day) of the AU from Equation 15,

WLA_A is the proportional areal contribution (%) from point sources within the AU catchment after accounting for all applicable effluent based WLA contributions,

LA_A is the proportional areal contribution (%) from nonpoint sources within the AU catchment, and

MOS_{AU} is the margin of safety (b.cfu/day) that is standardized by the AU_A, which is calculated using the TMDL and the 10 percent MOS: $AU_A(TMDL \times 0.1)$

Wasteload and Load Allocations

Consistent with Shannahan et al. (2004) and McCarthy (2020b), both point sources and nonpoint sources were assumed to contribute equal amounts of bacteria pollution per unit area (acre). Water quality sampling data used to establish these bacteria TMDLs did not separate the MS4 infrastructure's interface with ambient streamflow discharge and direct pollution deposit. The WLAs and LAs, however, were apportioned to determine the contribution from each pollutant source and assigned an allocation type. Areal WLAs and LAs were assigned based on whether the area is covered by an NPDES permit plus the permitted entity's jurisdictional area for WLAs when applicable. The WLAs that apply to the WDFW Bellingham Fish Hatchery and Brook Manufacturing, however, were isolated from ambient loading given the WLA is effluent-based. The FC and *E. coli* TMDL was made up of the contributing WLA and LA for each watershed and 303(d) listed AU, while the MOS was 10 percent of the total TMDL. The TMDLs were established at a level that does not exceed the LC.

The area weighted WLAs and LAs were calculated using the concept of areal loading. The effluent based WLA was calculated for the WDFW Bellingham Fish Hatchery and Brooks using Equation 14, where the discharge (flow) was determined by the permittee and reported in the facility's Discharge Monitoring Reports (DMR) confirmed by Ecology's permit mangers. For the watershed areas not under permit, the LA was applied, while all other remaining permitted areas received a WLA. Each unit area of the watershed was assumed to contribute the same quantity of the pollutant and the same quantity of water as other units of area regardless of allocation type — WLA or LA. After subtracting the effluent based WLAs from the TMDL, the WLAs and LAs for Whatcom Creek watershed and its tributaries were calculated using Equations 17 and 18 respectively.

$$WLA_{AU} = (LC_{AU} - MOS_{AU}) \times A_{WLA} \qquad (17)$$

$$LA_{AU} = (LC_{AU} - MOS_{AU}) \times A_{LA} \qquad (18)$$

Where:

WLA_{AU} is the sum of all wasteload allocations (b.cfu/day), that contribute to the immediate downstream assessment unit (AU),

LA_{AU} is the load allocation (b.cfu/day) that contribute to the immediate downstream AU,

LC_{AU} is the loading capacity (b.cfu/day) of the AU,

MOS_{AU} is the margin of safety (b.cfu/day) of the AU, and

$A_{WLA\ or\ LA}$ is the proportional area (%) of the allocations relative to the specific AU catchment area, which collectively sum to 1 (Tables E-23 and 24).

In the future, if an area of land is converted to a use that requires coverage under an NPDES permit, the associated LA should be retired and an equal WLA should be available to the permitted point source, which would not require TMDL resubmittal and associated approval.

"If any sources currently assigned load allocations are later determined to be point sources requiring NPDES permits, the portion of the load allocations applied to those sources are to be treated as wasteload allocations for purposes of determining appropriate water quality-based effluent limitations pursuant to 40 CFR 122.44(d)(1)."

The following equation calculates the unit area allocation conversions for area-based allocations that are typically associated with newly permitted stormwater areas:

$$Unit\ Area\ Allocation\ \left(\frac{b.cfu}{day \times acre}\right) = LA\ or\ WLA\ \left(\frac{b.cfu}{day}\right)\ \div Area\ (acre) \qquad (19)$$

The unit area allocation, LA or WLA, and area is relative to the sum of the TMDL for each receiving water body (Tables E-22 — 24). For example, using Equation 19 and the values provided in Tables E-22 and 23, when a 12-acre area within the Cemetery Creek catchment (AU

ID 17110004013600_001_001, listing 88094) requires a new WLA under the NPDES permitting requirements, the unit area allocation for the wet season is calculated as follows:

$$0.000219\left(\frac{b.cfu}{day \times acre}\right) = 0.22\left(\frac{b.cfu}{day}\right) \div 1005\ (acre)$$

$$0.0026\left(\frac{b.cfu}{day}\right) = 0.000219\left(\frac{b.cfu}{day \times acre}\right) \times 12\ (acre)$$

The primary conveyance of contamination in the Whatcom Creek watershed includes (1) stormwater runoff directly into the receiving waterways and (2) non-stormwater discharges into the storm drainage system (Shannahan et al. 2004, McCarthy 2020b). These avenues of conveyance fall into both point source and nonpoint source categories, and therefore, the same WLA and LA apply to discharges from sources covered by an NPDES permit as those sources that are not covered by an NPDES permit. Other potential non-stormwater sources of bacterial pollution can include leaking sewer lines, failing OSS, or direct deposit.

As NPDES permits are written or revised to implement the TMDL, they should be conditioned to attain the FC or *E. coli* target geometric means and therefore the associated TMDL. By meeting the target geometric means in the ambient receiving water bodies, it is assumed the percentage reduction allocations will have been met. Bacteria sampling either immediately downstream from the AU, or within the AU will confirm that the WQS are met, while sampling permitted effluent will assess the performance of the facility. The WLAs and LAs established in the Whatcom Creek watershed are inherent in the WQS geometric mean to meet the TMDL, which is based on the STR using the most stringent of the two-part water quality criteria. Target geometric means, percent reductions, and loadings are presented to guide water quality practitioners under clean up and pollution prevention effort such as NPDES development and other strategies.

Upstream Conditions

For this study, the upstream inflow conditions are represented by the translated *E. coli* concentrations found at the most upstream sampling location on Whatcom Creek (WHA04.2) at the control dam:

- Annual geometric mean — 9 cfu/100 mL, with
- No samples above the 320 cfu/100 mL STV, and
- The 90th percentile of 41 cfu/100 mL.

It is possible that human-caused pollution influences the upstream most sampling location because there are residential land uses and public access from Whatcom Falls Park and Bloedel Donovan Parks with nearby trail systems. . While wildlife may also contribute to locally elevated counts, it often occurs near background levels according to available data that were used in this study. Wildlife contributions shall be addressed by source control actions when sufficient information is available that illustrates an elevated pollution source. Human-caused activity that elevate bacterial pollution are, however, subject to pollution control and prevention activities to reduce or eliminate these detrimental impacts on water quality.