



**Nooksack River Transboundary
Water Quality
Sampling Program
June 2017–July 2018
Data Summary Report**

April 2019

Environmental Protection Division
Regional Operations Branch

Nooksack River Transboundary Water Quality Sampling Program: June 2017 to July 2018 Data Summary Report

Acknowledgements

This report was developed by the B.C. Ministry of Environment and Climate Change Strategy to provide an update on the project's progress. It includes detailed information on monitoring activities, sampling results, and future sampling plans and reporting.

We would like to thank the many people who contributed to this project's development and execution. Thank you to staff from the Washington State Department of Health, Washington State Department of Agriculture and Whatcom Conservation District who provided guidance related to sampling techniques and protocols used in Washington.

We are grateful to the Langley Environmental Partners Society (LEPS) and their staff who helped collect the aquatic ecosystem samples. Thank you also to Lisa Dreves and Pina Viola from LEPS.

We would like to acknowledge the authors of this summary report: Lyndsey Johnson, Environmental Impact Assessment Biologist, and Julie Porter, Water Technician, with senior reviews by Deb Epps, Section Head Provincial Water Quality, and Jillian Tamblyn, Senior Environmental Impact Assessment Biologist. Jennifer Wilson, Compliance, and Michael Dykes, Spatial Data Analyst, also contributed.

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Executive Summary

The Nooksack River is located south of the United States–Canada Border in the State of Washington and discharges primarily into Bellingham Bay through a wetland system. Bertrand Creek and Fishtrap Creek are two large sub-basins of the upper Nooksack River Watershed that straddle the international boundary. As part of the Nooksack Watershed Transboundary Project, both the B.C.'s Ministry of Environment & Climate Change Strategy (ENV) and Washington State's (WA) Department of Ecology are conducting sampling programs to monitor and address the high concentrations of microbiological indicators influencing the closure of shellfish production in Portage Bay in WA State. In particular, ENV is working on opportunities to reduce preventable sources of fecal coliform bacteria in the Canadian side of the tributaries.

Since 2017 water samples have been collected by the Monitoring, Assessment & Stewardship section of the B.C. ENV and the Langley Environmental Partners Society (LEPS). Based on the review of data collected monthly from 29 sample sites by both ENV and LEPS between June 2017 and July 2018, each of the three streams (Bertrand Creek, Fishtrap Creek and Pepin Brook, a tributary to Fishtrap Creek) sampled in the Nooksack River Watershed displays various issues with fecal coliform and *E. coli* concentrations. Fecal coliforms tend to be higher than *E. coli*, however *E. coli* exceeded applicable guidelines more often. The peaks tended to be seasonal, with the highest values observed in November and to a lesser degree in April. In addition, some of results in the upper sites tend to be higher than sites located closer to the border. More sampling is needed to further identify sources, through bacteria source tracking analysis, and to understand links to rainstorm events, the timing of manure spreading and overall annual trends.

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Project Background

Introduction

The Nooksack River is located south of the United States–Canada Border in the State of Washington and discharges primarily into Bellingham Bay through a wetland system. The watershed for this river spans both the United States and Canada (Figure 1). In recent years, this watershed has experienced a significant increase in urban and agricultural development, which has led to an overall decline in water quality and ecosystem health. At the mouth of the Nooksack River is the Lummi Indian Reservation. Since 1998, Lummi Nation shellfish beds in Portage Bay have been closed for harvesting up to six months of the year due to seasonally elevated fecal coliform bacteria levels in the marine water (British Columbia Ministry of Environment and Climate Change Strategy [B.C. ENV], 2018b). The closures typically last from April to June and from October to December, and May and November historically have the highest fecal coliform counts.

Bertrand Creek and Fishtrap Creek are two large sub-basins of the upper Nooksack River Watershed that straddle the international boundary. Pepin Brook flows into Fishtrap Creek south of the international border. About half the land areas of both Bertrand Creek and Fishtrap Creek Watersheds are located in British Columbia (B.C.), Canada, and half are in the State of Washington (WA), United States. Both B.C. and WA are working to understand the sources of fecal coliform pollution and to share best practices to reduce these sources and improve water quality.

The Nooksack River Water Quality Task Group (WQTG) began meeting in late 2016 to better understand water quality conditions and identify opportunities to reduce preventable sources of fecal coliform pollution in the transboundary area of the watershed. Water quality improvement efforts support mutual public and environmental health goals within the lower Nooksack River system and benefit shellfish harvest recovery efforts in the Nooksack River's receiving waters of Portage Bay (Portage Bay Shellfish Protection District Committee, 2014).

In August 2018, the WQTG recommended establishing a multi-agency Transboundary Technical Collaboration Group (TCG) for three years (August 2018 to August 2021). The TCG aims to deliver bacteria pollution reduction activities, as outlined in the Three-Year Work Plan and Terms of Reference. One of the WQTG's recommendations for the TCG was to continue long- and short-term ambient sampling in freshwater areas and to continue source identification sampling, including water quality monitoring, to identify fecal coliform sources.

Fecal coliforms are a subset of total coliform bacteria. Typically found in the gut and feces of warm-blooded animals, they are a better indicator of animal or human waste than total coliforms (U.S. Environmental Protection Agency, 2012). *Escherichia coli* (*E. coli*) is a species of fecal coliform that is specific to fecal material from humans and other warm-blooded animals, and is typically used by the U.S. Environmental Protection Agency as an indicator of the health risk from water contact during recreation. In B.C., *E. coli* is also the preferred indicator in freshwater environments (Warrington, 2001).

Land Use in the Area

On the Canadian side of the border, land uses in the Nooksack River Watershed include industrial, residential, parkland and agricultural (B.C. ENV, 2018b). Figure 1 provides an overview of the land use within the watershed, with details on the types of agriculture. The watershed spans the Township of Langley (which includes the community of Aldergrove) and the City of Abbotsford. Agricultural activities within the watershed include raising

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livestock (horses, beef cattle, dairy cattle, sheep, goats, llamas, donkeys, game, mink and chickens), providing forage and pasture, operating nurseries and greenhouses, and growing trees, berries, vine crops, mushrooms and other field vegetables or flowers. In the north end of the watershed around the Abbotsford city centre and Aldergrove, land use is more urban in nature, and the remaining area is primarily agricultural. The Nooksack River Watershed is located in the Fraser Valley Region, which receives upwards of 600 mm of rain annually from October 1 to April 1.

Currently, 15 known agricultural and compost operations are registered under a regulation or hold an authorization to discharge within the Nooksack River Watershed. The main industrial activities include composting, greenhouse operating, finfish farming and mushroom composting.

Water Quality Sampling in the Area

The Monitoring, Assessment & Stewardship section of the B.C. Ministry of Environment and Climate Change Strategy (ENV) has been collecting water samples from Bertrand Creek, Fishtrap Creek and Pepin Brook since June 2017. Langley Environmental Partners Society (LEPS), a non-profit partnership with core support from the Township of Langley, has also been collecting water samples in the watershed since 2017. LEPS has collected samples on Bertrand Creek and Pepin Brook on behalf of Whatcom County in WA. Figure 1 shows the locations where ENV and LEPS have collected water samples.

Compliance Activities in the Area

In 2017/18, the ENV Compliance staff audited 48 agricultural and compost operations within the Nooksack River Watershed to determine their level of compliance with the *Environmental Management Act*, as well as associated regulations including the Agricultural Waste Regulation, Land-based Finfish Waste Control Regulation, and Mushroom Compost Facilities Regulation (B.C. ENV 2018). These pieces of legislation specify waste discharge standards, terms and conditions.

The ENV's on-site inspections took place from October 2017 to March 2018. This timeframe captured the rainy season, which presents the greatest risk of environmental impact due to uncovered agricultural waste and compost. It also included the application of manure in blueberry operations, which typically occurs annually between mid-February and mid-April. A summary of the findings from the audits can be found [here](#), and several of the findings have been incorporated into this report.

Report Objective

The purpose of this report is to provide an analysis and summary of the sampling results collected by both ENV and LEPS in the B.C. portion of the watershed from June 2017 to July 2018. This report will also help form the basis of the future sampling program by highlighting areas of concern with high fecal coliform counts, identifying where further source tracking should occur, and offering overall sampling recommendations, such as frequency and site location(s).

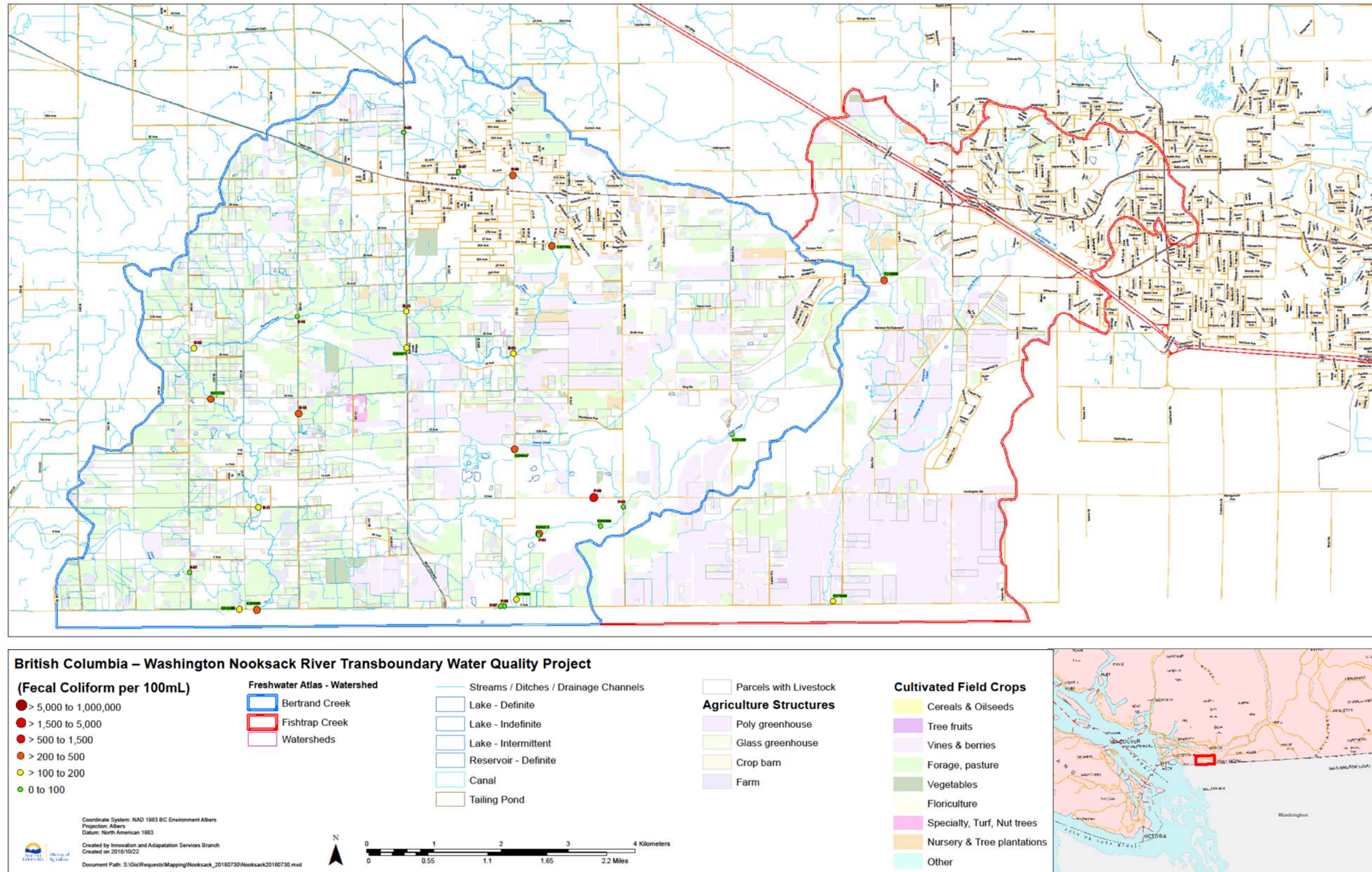


Figure 1. Nooksack River Watershed map with sampling locations.

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Methods

ENV Sampling Methodology

Discrete (or grab) water samples were collected monthly by ENV in accordance with the *B.C. Field Sampling Manual* (B.C. ENV, 2013) and the B.C. Ministry of Environment, Lands and Parks *Freshwater Biological Sampling Manual* (Cavanagh, Nordin, & Warrington, 1996). Water samples were collected in laboratory-supplied sample bottles.

Parameters collected *in situ* using a hand-held metre (typically from YSI) included:

- pH
- temperature
- specific conductivity
- dissolved oxygen (DO) (mg/L and %)

Water samples were analyzed for:

- General chemistry: total organic carbon, total suspended solids
- Nutrients: ammonia, chloride, nitrate and nitrite, total Kjeldahl nitrogen, total nitrogen (N), total organic nitrogen, dissolved ortho-phosphate, phosphorus
- Microbiological parameters: *E. coli* and fecal coliform bacteria

On the same day water samples were taken, they were delivered to ALS Laboratory in Burnaby for analysis. Quality assurance and quality control methods included replicate sampling (10% of samples, or 1 replicate sample, per sampling event).

Table 1 provides a summary of the sampling events and the number of water samples collected by ENV during each one.

Table 1. Summary of ENV water quality sampling events and number of samples collected.

Sampling date	Bertrand Creek	Pepin Brook	Fishtrap Creek	Total number of samples collected
June 16, 2017	4	3	2	9
July 24, 2017	5	3	2	10
August 14, 2017	3	5	2	10
October 2, 2017	3	4	2	9
October 19, 2017	4	4	2	10
November 14, 2017	4	4	2	10
December 21, 2017	5	6	2	13
January 16, 2018	6	6	2	15
February 28, 2018	6	6	2	14
March 13, 2018	5	6	2	13
April 17, 2018	5	6	2	13
May 5, 2018	7	6	2	15
June 11, 2018	7	5	2	13
July 17, 2018	7	5	2	14

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LEPS Sampling Methodology

LEPS conducted monthly water sampling on Bertrand Creek (including Cave Creek) and Pepin Brook between January 2017 and July 2018. Water samples were collected in laboratory-supplied sample bottles and delivered to Exova Labs in Surrey, B.C., for analysis of fecal coliforms and *E. coli*. Samples were collected using the methods described above; however, no *in situ* parameters were collected. Table 2 provides a summary of the sampling events and the number of water samples collected by LEPS during each one.

Table 2. Summary of LEPS water quality sampling events and number of samples collected.

Sampling date	Bertrand Creek	Pepin Brook	Total number of samples collected
January 9, 2017	5	5	10
February 22, 2017	9	5	14
March 6, 2017	9	5	14
April 4, 2017	8	6	14
May 2, 2017	8	6	14
June 20, 2017	8	6	14
July 17, 2017	7	6	13
August 29, 2017	6	4	10
September 17, 2017	4	6	10
October 24, 2017	8	6	14
December 12, 2017	8	6	14
January, 23, 2018	8	6	14
February 7, 2018	8	6	14
March 13, 2018	10	6	16
April 17, 2018	9	5	14
May 22, 2018	10	6	16
June 18, 2018	10	5	15
July 17, 2018	8	5	13

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Sampling Locations

Tables 3 and 4 provide the location and description of the ENV and LEPS sampling locations, respectively. Figure 1 shows the sampling locations.

Table 3. Summary of ENV sampling locations.

Watershed	EMS ID	Latitude	Longitude	Description
Bertrand	E207092	49.0506	-122.4628	About 50 m downstream of Aldergrove Lagoon, just off the end of 26B Ave.
	E273723	49.030456	-122.5325	Collected from east bank 15 metres south (downstream) of bridge on 16th Ave. between 248 St. and 250 St.
	E293977	49.03711	-122.4925	Collected on south bank, upstream (east) of 264 Ave. bridge
	E293980	49.00222	-122.5233	Collected underneath 0 Ave. bridge
	E206847	49.0235	-122.4707	Collected upstream of 272 St. on Howes Creek (tributary to Bertrand Creek)
	E312388	49.00238	-122.5271	Cave Creek at 0 Ave.
Pepin	E253209	49.0252	-122.4264	Collected on downstream (west) side of Bradner Rd.
	E253211	49.0122	-122.4658	Road crossing in Aldergrove Regional Park, accessed from 8th Ave.
	E279890	49.00333	-122.4705	Collected at 0 Ave. and 272 St. (NE corner).
	E208494	49.0131	-122.4533	Pepin Brook upstream in Aldergrove Regional Park, accessed from 8 Ave.
	E309447	49.015810	-122.455950	Pepin Brook tributary at Pepin Brook Trail bridge in Aldergrove Regional Park
Fishtrap	0300069	49.0242	-122.3953	Collected from south bank on east side of Echo St. bridge crossing
	E279889	49.00278	-122.4061	Collected upstream of 0 Ave. bridge crossing on west bank.
	E310908	49.04573	-122.3951	Collected on Waechter Creek near Simpson Rd.

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Table 4. Summary of LEPS sampling locations.

Watershed	LEPS ID	Latitude	Longitude	Description
Bertrand	B-02	49.037499	-122.535191	Main stem of Bertrand Creek in Otter Park, 1900 block of 248 St.
	B-03	49.036248	-122.470742	272 St. crossing just north of 18 Ave.
	B-06	49.065999	-122.492863	Headwaters crossing 264 St., south of 36 Ave.
	B-07	49.06115268	-122.4821827	Main stem of Bertrand Creek in Vanetta Park, NW corner of 32 Ave. and 268 St.
	B-09	49.06003978	-122.4708466	272 St. just south of 32 Ave.
	B-10	49.02587001	-122.514859	256 St. just south of 16 Ave.
	B-11	49.01586482	-122.5229979	Main stem of Bertrand Creek at 8 Ave., west of 256 St.
	C-01	49.00684	-122.53676	Cave Creek at 248 St. crossing north of 0 Ave.
Pepin	P-01	49.011992	-122.465871	Aldergrove Regional Park, entrance off 8 Ave. just east of 272 St.
	P-02	49.014476	-122.448769	Lefevre Rd. just south of 8 Ave. and Lefevre Rd. access to Aldergrove Regional Park
	P-03	49.025249	-122.426573	1281 Bradner Rd.
	P-05	49.013655	-122.455277	Pepin tributary entering Aldergrove Regional Park
	P-06	49.00239896	-122.4734947	Main stem of Pepin Brook, 0 Ave. and 272 St. Taken on downstream side of culvert
	P-07	49.0023468	-122.4738918	0 Ave. and 272 St. Taken between culverts that flow south to United States

Water Quality Guidelines

B.C. ENV developed ambient water quality guidelines (WQG) to assess and manage the health, safety and sustainability of B.C.'s aquatic resources. These WQGs were established to protect designated uses such as aquatic life, wildlife, agriculture, drinking water sources and recreation. They include guidelines for microbiological indicators, which are types of bacteria used to detect and estimate the level of fecal contamination in water. Bacteria often enter surface waters via point and non-point sources, including wild and domestic animal feces as well as seepage from leaking or failing septic systems.

Fecal coliforms have been used extensively for many years as indicators to determine the sanitary quality of surface, recreational and shellfish-growing waters. However, more recent studies have shown that *E. coli* is the main thermo-tolerant coliform species present in fecal samples (94 percent) from humans and other endotherms, such as birds and mammals (Tallon, Magajna, Lofranco, & Leung, 2005). In addition, where fecal coliform concentrations are higher than those of *E. coli*, it's highly likely that non-fecal sources have contributed. Current B.C. WQGs are based on *E. coli* as the freshwater indicator and enterococci as the marine indicator for microbial contamination. However, the Environment and Climate Change Canada shellfish program and Washington State still use fecal coliforms as indicators of risk in marine water. Therefore, this study monitored both fecal coliforms and *E. coli* in order to provide appropriate resource management recommendations to both B.C. and WA decision makers.

Table 5 provides the relevant guidelines for *E. coli* and fecal coliforms used in this report. Note that the updated 2017 B.C. Recreational WQGs document archived the fecal coliform guideline for recreation (≤ 200 colony-forming units (CFU)/100 mL geometric mean, based on the 2001 B.C. ENV report [Warrington, 2001]) and identified *E. coli* as the preferred indicator (B.C. ENV, 2017). Also, note that the primary contact recreation fecal coliform criteria for Washington State is 100 CFU/100 mL, based on the geometric mean, with no more than 10% of the samples exceeding 200 CFU/100 mL (Washington State Department of Ecology, 2019). This report provides the archived B.C. WQG and Washington State recreational guidelines for fecal coliform bacteria for comparative purposes only.

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Table 5. Applicable water quality guidelines

ENV-approved water quality guidelines	<i>E. coli</i>	Fecal coliform
Primary recreation	<p>≤ 200 CFU/100 mL geometric mean (based on a geometric mean of a minimum of 5 samples collected weekly within 30 days);</p> <p>or</p> <p>< 400 CFU/100 mL (single-sample maximum concentration)</p>	<p>No B.C. guideline</p> <p><i>For comparative purposes:</i> <i>Archived B.C. WQG = ≤ 200 CFU/100 mL geometric mean (based on a geometric mean of a minimum of 5 samples collected weekly within 30 days)</i></p> <p><i>Washington State Primary Contact Recreation Criteria: 100 CFU/100 mL (based on the geometric mean), and not more than 10% of the samples exceeding 200 CFU/100 mL.</i></p>
Irrigation crops eaten raw	77 CFU/100 mL geometric mean (based on minimum of 5 samples collected weekly within 30 days)	≤ 200 CFU/100 mL geometric mean (based on minimum of 5 samples collected weekly within 30 days)
General irrigation	$\leq 1,000$ CFU/100 mL geometric mean (based on minimum of 5 samples collected weekly within 30 days)	$\leq 1,000$ CFU/100 mL geometric mean (based on minimum of 5 samples collected weekly within 30 days)

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Results

ENV and LEPS collected water quality data from a total of 29 sample sites from June 2017 to July 2018. Where appropriate, ENV and LEPS sampling results have been combined. Typically, geometric means are calculated based on 5 samples collected within a 30-day period; however, due to the lack of weekly data sets, in this report, we calculated the geometric means seasonally and used the monthly sampling results (n=3). These geometric means were compared to the applicable guidelines to provide an initial screening assessment.

The data were grouped by season using the Equinox calendar:

- Winter: December 21 to March 20
- Spring: March 21 to June 21
- Summer: June 22 to September 22
- Fall: September 23 to December 20

The data in this report are presented by watershed, moving west to east (Bertrand Creek, Pepin Brook and Fishtrap Creek). Within each watershed, the data are summarized by parameter (i.e., fecal coliforms, then *E. coli*). Results above the WQGs are called exceedances. The data are followed by a discussion section that provides insight into the potential sources of contamination for each watershed. Recommendations, including any changes to future monitoring programs, are proposed at the end of the report.

Criteria for determining actual sites of concern (termed “hotspots”) included three qualifiers:

- high geometric means (over the guideline limits for recreation and irrigation)
- the number of times the sites exceeded the guidelines (above 50 percent of sample dates)
- extremely high maximum grab sample results (anything above 1,000 CFU/100 mL)

Bertrand Creek

Bertrand Creek Watershed is a fish-bearing tributary to the Nooksack River in the United States, with its headwater in the top northwest end of the Nooksack River Watershed in Aldergrove and Langley. It flows south through Aldergrove and Langley and across the border just south of 0 Avenue. Bertrand Creek drains approximately 113 km² of land, making it the largest of the three watersheds. Bertrand Creek and its many tributaries, including Cave Creek and Howes Creek, flow through both urban and agricultural areas, which directly influence the type and amounts of microbiological contamination entering the system. Bertrand Creek and its tributaries typically lack riparian buffers.

Tables A.1 and A.2 in Appendix A provide a summary of the data on Bertrand Creek, which are presented starting at sites B-07 and B-09 (furthest upstream) and extending to E293980 and E312388 (located at 0 Avenue near the border on Bertrand Creek and Cave Creek, respectively).

Bertrand Creek Fecal Coliform

Figure 2 provides the Bertrand Creek seasonal fecal geometric means and compares them to the guidelines. The sites are arranged to show the flow from upstream to downstream, ending at the United States–Canada border at 0 Avenue. Sites with extremely high results include the result number above the graph bar.

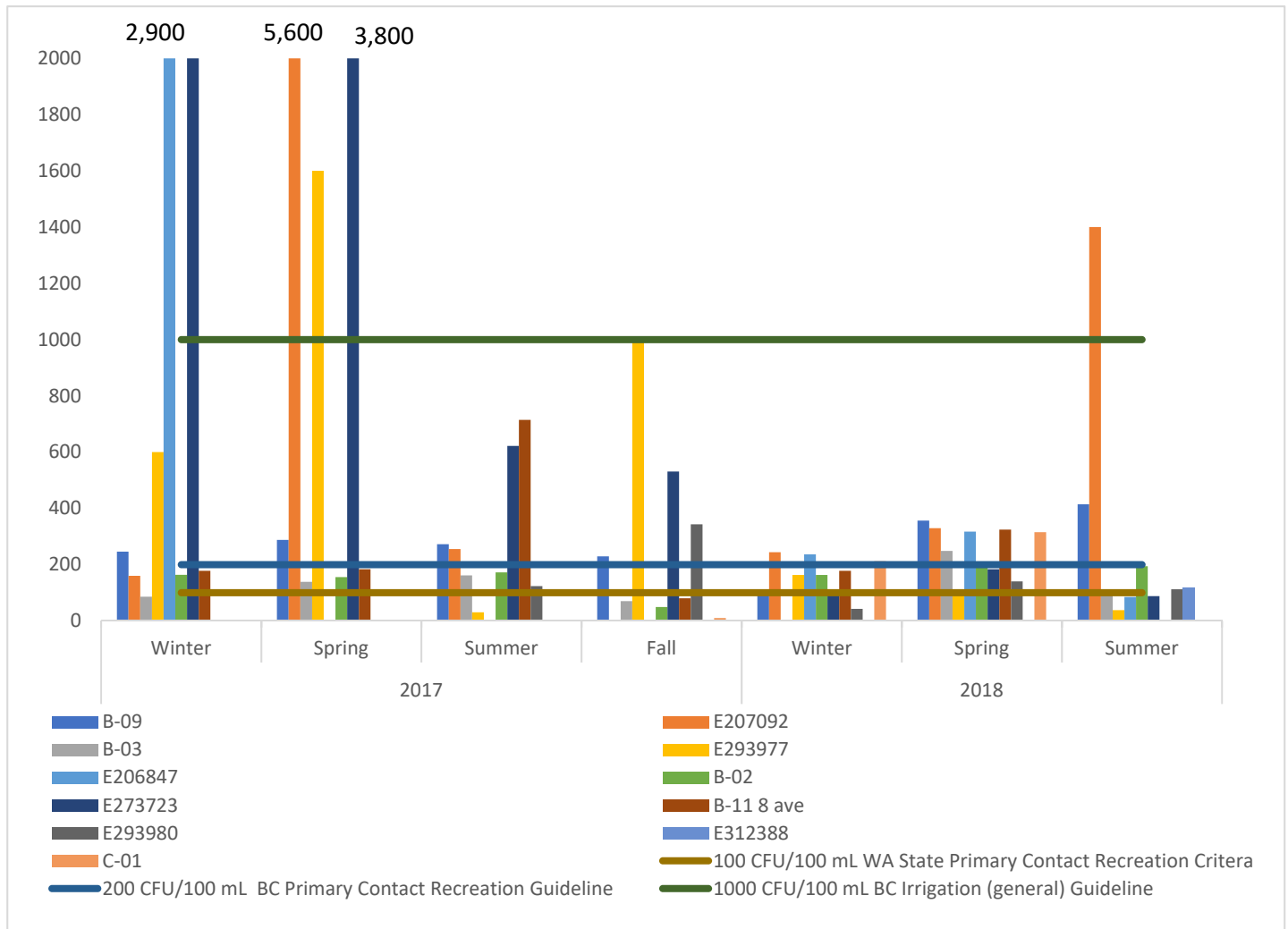


Figure 2. Bertrand Creek fecal coliform results (seasonal geometric means, CFU/100 mL)

In 2017, the seasonal geometric means frequently exceeded all three water quality guidelines, in particular the 1,000 CFU/100 mL general irrigation guideline in winter and spring of 2017. In addition, the 2017 results were generally higher than those from 2018 (at least prior to July), most likely due to precipitation events. The 2018 results frequently exceeded the 100 and 200 CFU/100 mL guidelines in all seasons. Site E207092, located at 266 Avenue, had the highest exceedances, reaching 5,600 CFU/100 mL in Spring 2017 and 1,400 CFU/100 mL in Summer 2018.

Overall hotspot sites in the Bertrand Creek Watershed include sites B-09, near downtown Aldergrove off Fraser Highway; E207092, downstream of Aldergrove lagoon; B-2, in Otter Park; E273723, at 16 Avenue; E293977, at 264

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Avenue; and E293980, at 0 Avenue. Insight into potential sources of fecal contamination at these sites is provided in the Discussion section.

Bertrand Creek *E. coli*

The data suggest that *E. coli* concentration geometric means decrease from the upper watershed sites (i.e., B-09 and E207092) downstream toward the border site at 0 Avenue (E293980). The majority of the Bertrand Creek sites exceeded the *E. coli* guideline for irrigation crops eaten raw (77 CFU/100 mL).

The Bertrand Creek site at the border (E293890) had the lowest overall percentage of results exceeding the 200 CFU/100 mL primary recreation guideline. However, at least 50 percent of the results from each of the Bertrand Creek sample sites exceeded the 77 CFU/100 mL raw crop irrigation guideline. The Aldergrove Lagoon site (E207092), located near Fraser Highway, had the highest percentage of exceedances for both the 77 CFU/100 mL and 200 CFU/100 mL guidelines, as well as one of the higher geometric means in 2017. This was also the only site that exceeded the 1,000 CFU/100 mL WQG in 2018 (summer geometric mean).

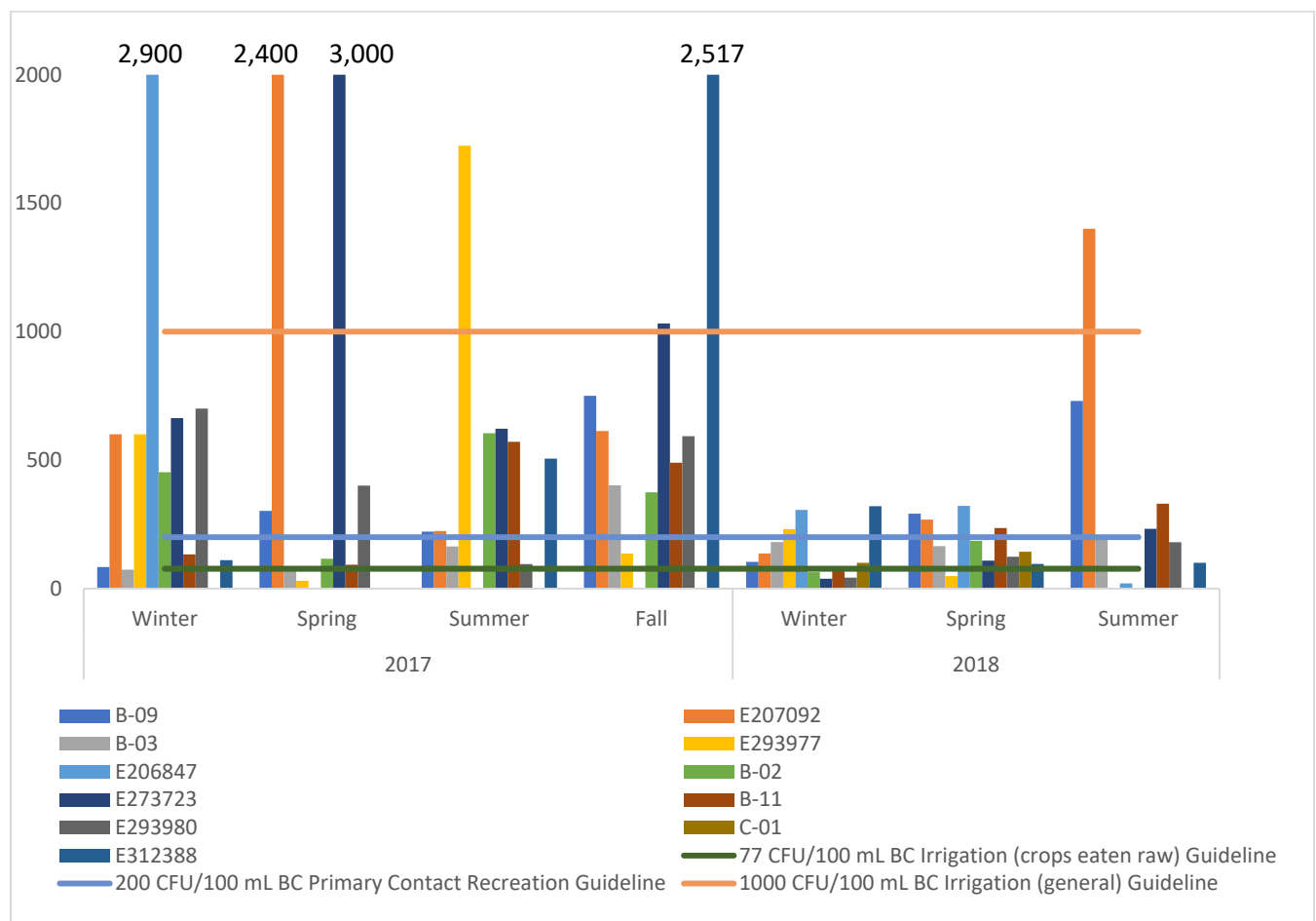


Figure 3. Bertrand Creek *E. coli* results (seasonal geometric means, CFU/100 mL)

Sites B-02, E207092 and E273273 are considered hotspots for *E. coli* on Bertrand Creek. Insight into potential sources of microbial contamination at these sites is provided in the Discussion section.

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Pepin Brook

Pepin Brook is a fish-bearing stream located to the east of the Bertrand Creek Watershed. It covers approximately 16.5 km² on the Canadian side of the border, flowing south through East Aldergrove and into the United States. Pepin Brook's watershed mainly comprises berry farms and cattle-grazing agricultural land. A tributary to Pepin Brook is located inside the private property of a large composting facility, and then connects to Pepin Brook inside Aldergrove Regional Park. The lower portion of Pepin Brook flows through a series of wetland complexes, meadows and mixed forests in Aldergrove Regional Park, where four of the ENV sample sites are located, including the border site on 0 Avenue. Tables A.3 and A.4 in Appendix A provide a summary of the data on Pepin Brook, which are presented starting at site E253209 (furthest upstream) to E279890, and P-07 (located at 0 Avenue near the border).

Pepin Brook Fecal Coliform

Similar to the Bertrand Creek results, samples collected in the Pepin Brook Watershed also had more frequent exceedances in 2017 than in 2018. Figure 4 shows the Pepin Brook seasonal fecal geometric means and compares them to the guidelines. The sites are arranged to show the flow from upstream to downstream, ending at the United States–Canada border at 0 Avenue. Sites with extremely high results include the result number above the bar.

Both ENV sites in Aldergrove Regional Park (E253211 and E309447) and the LEPS site in Aldergrove Regional Park (P-05) had high and frequent concentrations of fecal coliforms that exceeded the WA State criteria of 100 CFU/100 mL, the B.C. recreational guideline of 200 CFU/100 mL, and the B.C. irrigation guideline of 1,000 CFU/100 mL. A compost facility is located upstream of these sampling locations on the Pepin Brook tributary. This area is considered a hotspot and will be discussed in further detail in the Discussion section.

The border stations on Pepin Brook (E272890 and P-07) showed extremely high fecal coliform counts during the winter and spring of 2017. However, the 2018 fecal coliform levels are substantially lower. It will be interesting to see the results from winter 2018/2019 and spring 2019, as these time frames include the rainy period when fecal coliform levels tend to increase. Site P-02 has no data for the summer of 2017 due to a sampling error that occurred either at the lab or during sample collection.

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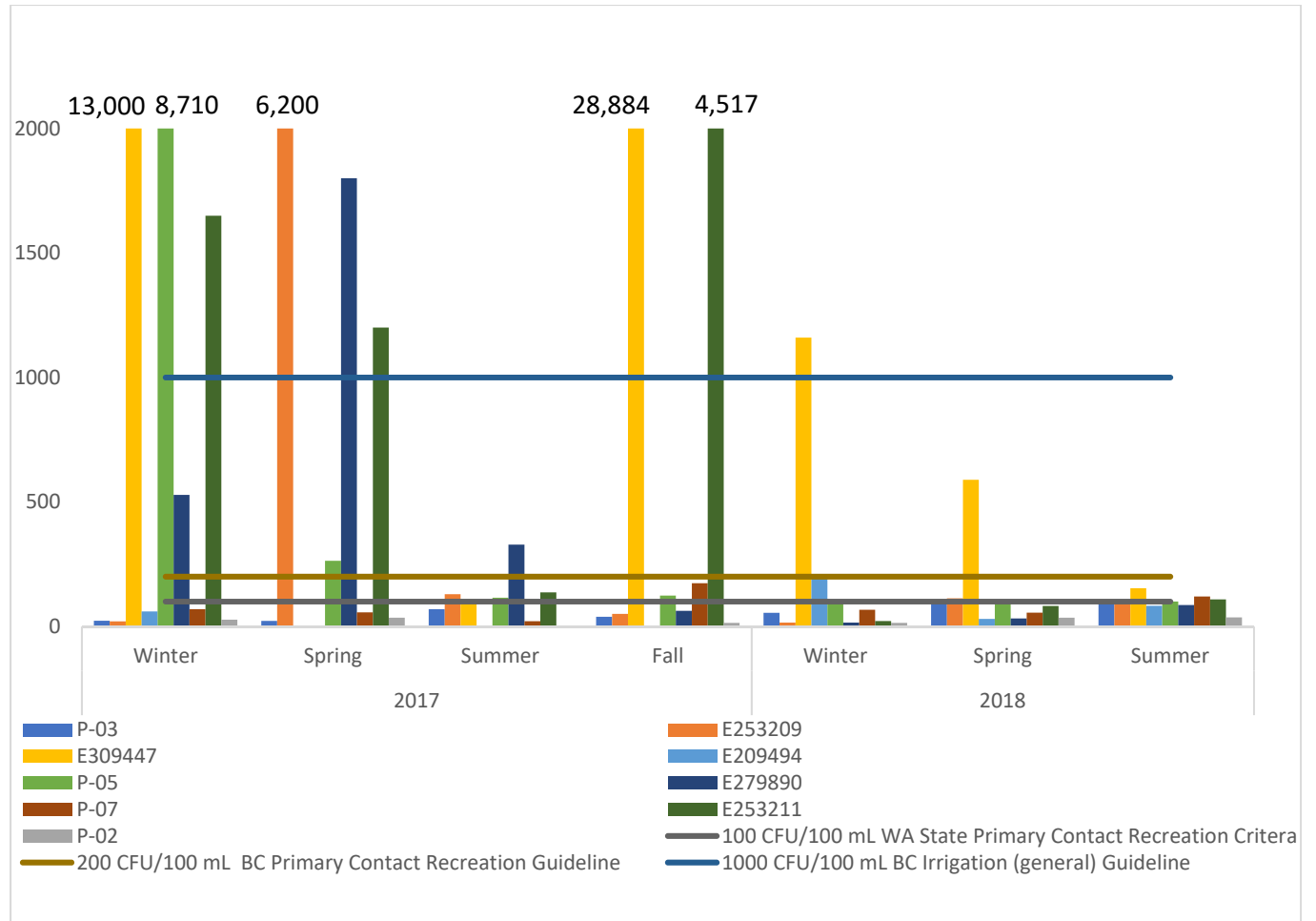


Figure 4. Pepin Brook fecal coliform results (seasonal geometric means, CFU/100 mL)

Pepin Brook E. coli

Figure 5 shows the *E. coli* results from Pepin Brook. Sites with extremely high results include the result number above the bar. Overall, there appear to be fewer exceedances in 2018 compared to 2017, and in fact there were no exceedances of the irrigation WQG in 2018. The *E. coli* results mirror the fecal results at sites E309447, P-05 and E253211, the hotspots. Site E253209 had a high exceedance in spring 2017, but levels have not been elevated to that extent since then.

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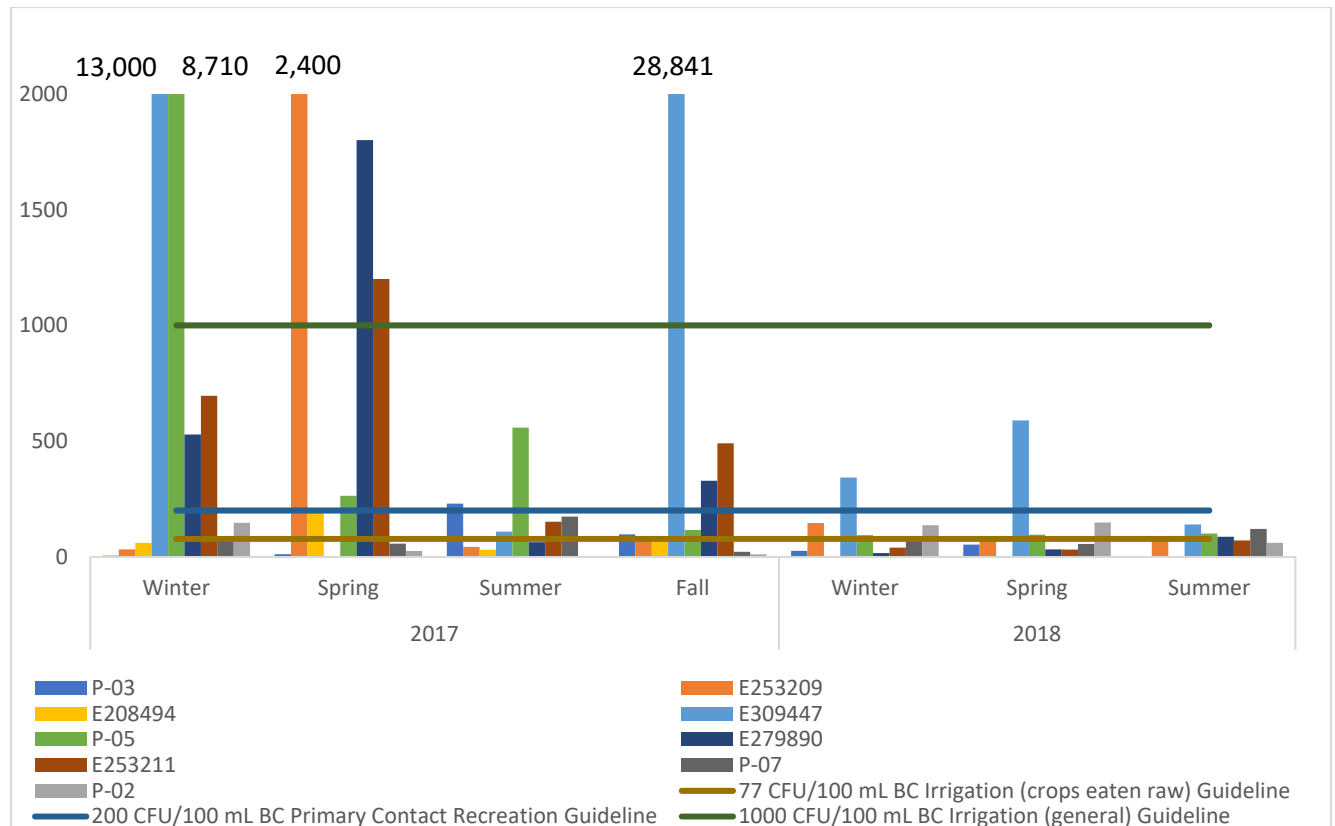


Figure 5. Pepin Brook *E. coli* results (seasonal geometric means, CFU/100 mL)

Fishtrap Creek

Fishtrap Creek is a fish-bearing stream approximately 30 km² in size. It flows south through West Abbotsford to the United States–Canada border. Waechter Creek is a significant tributary to Fishtrap Creek. Tables A.5 and A.6 in Appendix A provide a summary of the data on Fishtrap Creek, which are presented starting at site E310908 (furthest upstream on Waechter Creek) and moving downstream to E279889 (located at 0 Avenue near the border).

Fishtrap Creek Fecal Coliform

Figure 5 shows the Fishtrap Creek seasonal fecal geometric means and compares them to the guidelines. The sites are arranged to show the flow from upstream to downstream, ending at the United States–Canada border at 0 Avenue. Sites with exceedingly high results include the result number above the bar. Waechter Creek was added to ENV’s sampling sites in winter 2017/2018.

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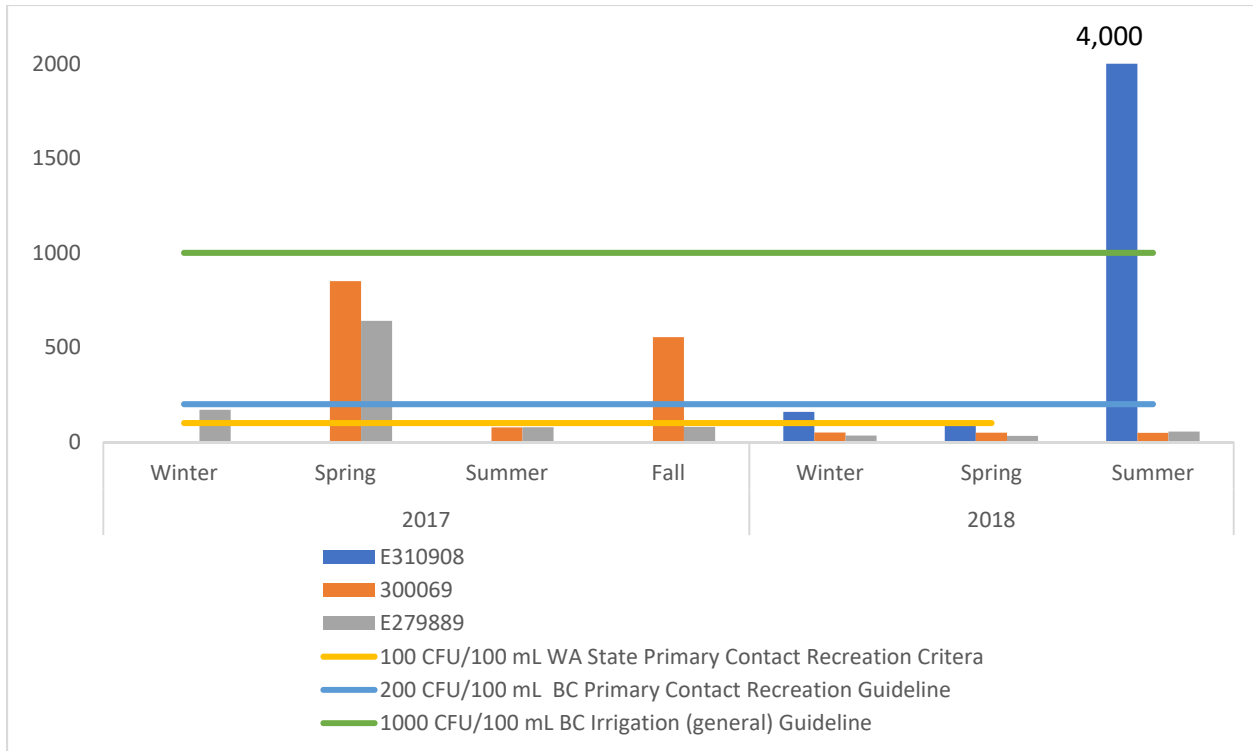


Figure 5. Fishtrap Creek fecal coliform results (seasonal geometric means, CFU/100 mL)

In general, fecal coliform counts were higher in 2017 than 2018, with the exception of Waechter Creek (E310908) in summer 2018. During the sampling period in 2018, site E279889 near the border did not exceed either the 100 CFU/100 mL or the 200 CFU/100 mL fecal coliform primary recreational guidelines. Fecal counts were generally higher at site E310908, located at Waechter Creek upstream from the border. Waechter Creek (E310908) had several large exceedances in the summer of 2018. Insight into potential sources of fecal contamination at these sites is provided in the Discussion section.

Fishtrap Creek E. coli

Figure 6 shows Fishtrap Creek *E. coli* results as seasonal geometric means. These results show the same overall trend as those for fecal coliform counts.

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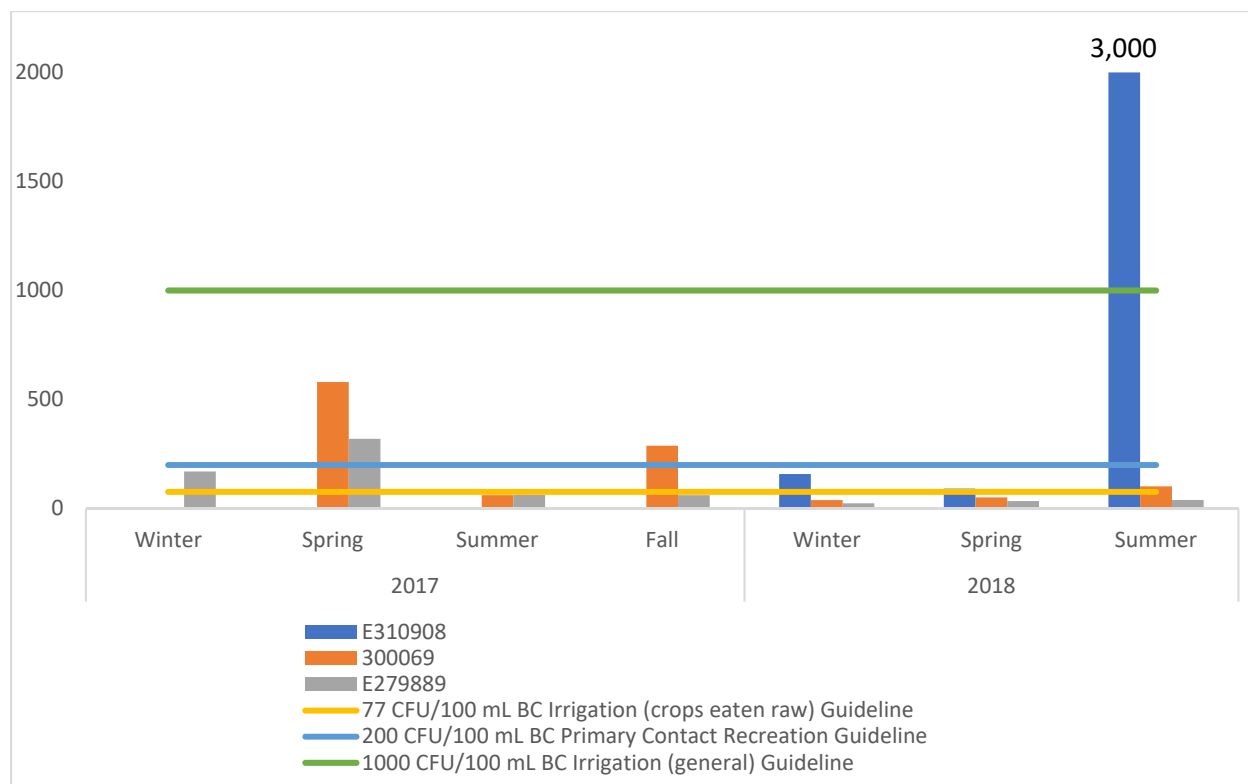


Figure 6. Fishtrap Creek *E. coli* results (seasonal geometric means, CFU/100 mL)

Figure 6 shows site E310908 at Waechter Creek again had the highest geometric means in Summer 2018, as it did for the fecal coliform results. The data show that maximums for *E. coli* were once again higher in 2017. The site at Echo Road (300069) also had high maximum fecal counts, but those counts decreased as they reached the border site (E279889).

Nutrient Results

Samples from all ENV sites at Bertrand Creek, Pepin Brook and Fishtrap Creek were also tested for physical water parameters and nutrients. As described in the Methods section, water samples were analyzed for nutrients and general chemistry parameters, including temperature, dissolved oxygen (DO), pH and conductivity. Each of these parameters was compared to the B.C. Approved WQGs for Aquatic Life, Wildlife and Agriculture (B.C. Ministry of Environment and Climate Change Strategy, 2018a), and only parameters that exceeded the applicable guidelines are provided in the nutrient summary tables. Each parameter is presented per sampling event (approximately monthly).

Bertrand Creek Nutrients

Table 7 summarizes several short-term (acute) exceedances for pH and nitrite on Bertrand Creek. These exceedances occurred at sites including E207092 (Aldergrove Lagoon), E293977 (at 264 Avenue), W293980 (0 Avenue at the border) and E206847 (Howes Creek). The months of June and October 2017 had the most exceedances, and also corresponded to high fecal coliform counts across all sample sites. These elevated counts

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could have been due to rainfall events on those days, resulting in runoff from agricultural operations or sewage overflows. No longer-term guidelines (chronic) were exceeded.

Table 7. Bertrand Creek nutrient data exceedances

Site	Date	pH	Nitrite (mg/L)
		6.5 to 9	Guideline varies, depending on chloride ¹
E207092 Aldergrove Lagoon	June 16, 2017	6.12	
	October 2, 2017	6.42	0.0226
	October 19, 2017	6.22	0.0228
	November 14, 2017	6.22	
	January 16, 2018	6.44	
	June 11, 2018		0.0239
E293977 264 Ave.	October 19, 2017	6.14	
	November 14, 2017	6.46	
	January 16, 2018	6.37	
E293980 Border	June 16, 2017		0.0303
E206847 Howes Creek	January 16, 2018		0.0412
	May 3, 2018		0.0417
	June 11, 2018		1.4

¹ The nitrite guidelines range from 0.02-0.20 mg/L, depending on the chloride values. See Table 26B in B.C. WQG for nitrite guidelines. Only values that exceeded the applicable guideline are shown in this table.

Pepin Brook Nutrients

No long-term water quality guidelines for physical or nutrient data were exceeded on Pepin Brook. However, there were some short-term exceedances for DO, nitrite and total N, as shown in Table 8. The months of October, November and December 2017 and January and February of 2018 had high N and fecal coliform counts at three sites sampled on Pepin Brook. This timing also coincided with precipitation events and with the high microbiological exceedances located downstream from the compost facility (at site E308447) on the Pepin Brook tributary. The low DO values noted at site E253209 can likely be attributed to the wetland located just upstream of Bradner Road, where the lack of a defined channel and extensive in-stream vegetation may reduce the amount of dissolved oxygen (or flow) in the water.

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Table 8. Pepin Brook nutrient data exceedances.

Site	Date	DO (mg/L)	Nitrite (mg/L)	Total N (mg/L)
		Guideline: at least 5	Guideline: varies depending on chloride ²	Guideline: 3
E253209 Bradner Rd.	June 17, 2017	3.3		
	October 2, 2017	3.3		
E279890 Border	October 19, 2017		1.09	
	November 14, 2017		0.71	
	December 21, 2017		1.48	
	January 16, 2018		1.75	
	February 28, 2018		1.96	
E309447 Pepin Tributary	October 19, 2017			5.58
	November 14, 2017			4.25
	December 21, 2017			5.53
	January 16, 2018			4.61
	February 28, 2018			7.28

² The nitrite guidelines range from 0.02-0.20 mg/L, depending on the chloride values. See Table 26B in B.C. WQG (B.C. ENV, 2018a) for nitrite guidelines. Only values that exceeded the applicable guideline are shown in this table.

Fishtrap Creek Nutrients

Fishtrap Creek had exceedances in nitrate rather than nitrite. No acute water quality guidelines for physical or nutrient data were exceeded. The border site had slight chronic exceedances of nitrate and total N from May to June 2018, which corresponded to low DO in July. There was no correlation to high fecal coliform or *E. coli* counts during these exceedances. Waechter Creek had exceedances in nitrate from December 2017 to January 2018, and in total N from December 2017 until March 2018. Unlike the border site, Waechter Creek had fecal coliform and *E. coli* exceedances on December 21, 2017, of 5,800 and 4,800 CFU/100 mL, respectively, and on March 13, 2018, of 2,000 CFU/100 mL for both. Lastly, site 0300069 at Echo Road had low DO on July 17, 2018, which was also reflected at the border site (E279889).

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Table 9. Fishtrap Creek nutrient data exceedances.

Site	Date	DO (mg/L)	Nitrate (mg/L N)	Total N (mg/L)
		Guideline: at least 5	Chronic 3.0 Acute 32.8	Guideline: 3
E279889 Border	May 3, 2018		3.03	3.46
	June 11, 2018		3.04	3.07
	July 17, 2018	1.8	3.02	3.22
E310908 Waechter Creek	December 21, 2017		3.57	6.15
	January 16, 2018		3.29	4.50
	February 28, 2018			4.98
	March 13, 2018			3.05
0300069 Echo Rd	July 17, 2018	1.4		

Summary of Border Sampling Locations

ENV sampled four border sites along O Avenue:

- E293980 (Bertrand Creek)
- E312388 (Cave Creek)
- E279890 (Pepin Brook)
- E279889 (Fishtrap Creek)

Figure 7 summarizes the data as seasonal geometric means between 2017 and 2018 for three of the border sites located at Bertrand, Pepin and Fishtrap Creeks. Sampling by ENV on Cave Creek at the border began in Spring 2018 and is therefore omitted until more sampling events have occurred, since there were only three prior to July 2018.

Overall, it appears that all three sites had more exceedances in 2017 than in 2018, particularly in spring and winter. Pepin Brook (E293890) had very high concentrations and exceeded 1,000 CFU/100 mL in spring 2017 and was the only border site that exceeded this guideline. While we do not yet have data for fall 2018, Bertrand Creek (E293980) exceeded over the 100 CFU/100 mL guideline in spring and summer months. Pepin Brook (E279890) only exceeded over 100 CFU/100 mL guideline in summer and Fishtrap Creek (E279889) has not exceeded any guideline in 2018.

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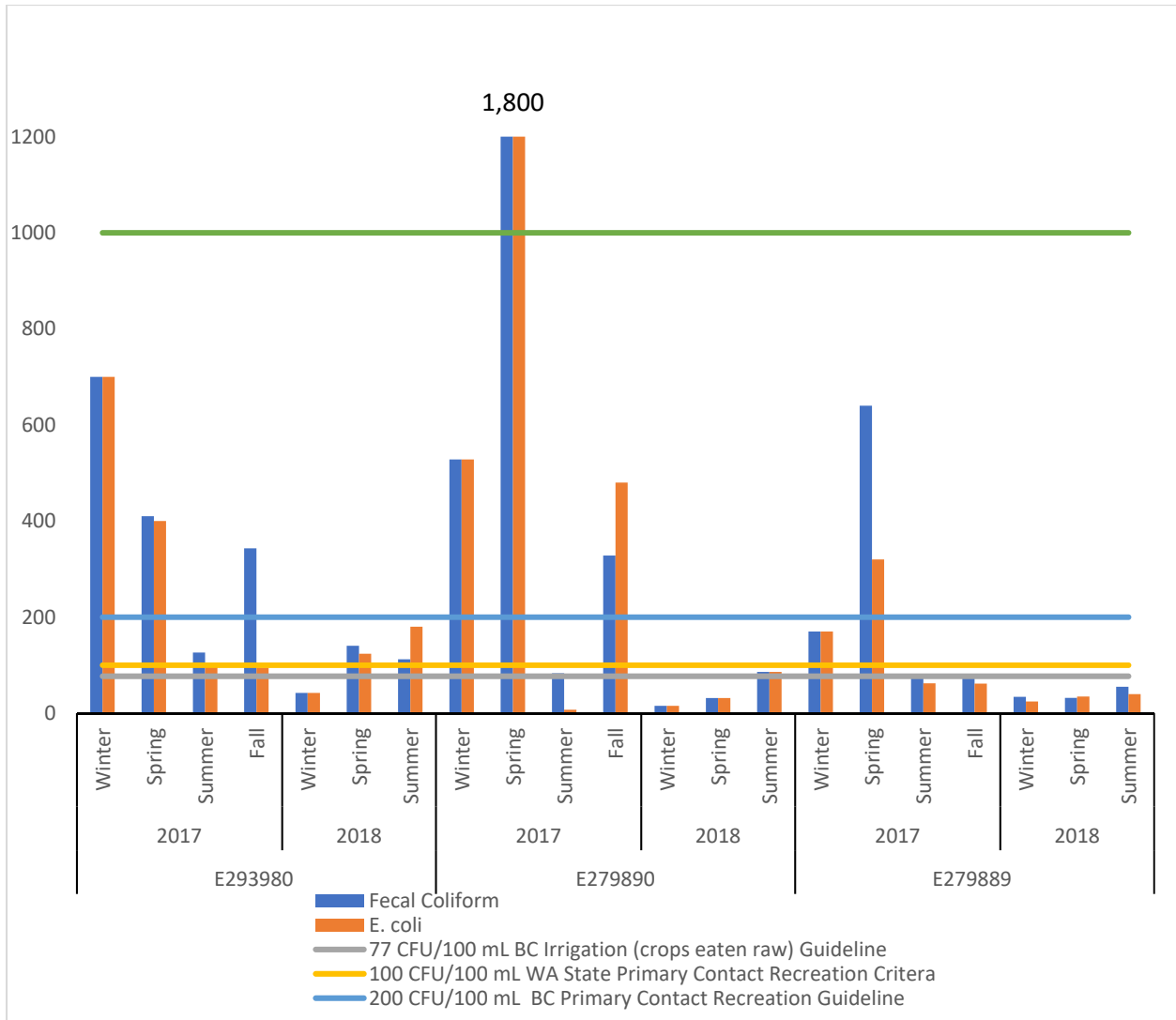


Figure 7. Summary of *E. coli* and fecal coliform at border sites on Bertrand Creek, Pepin Brook and Fishtrap Creek (seasonal geometric means, CFU/100 mL).

Discussion of Results

In general, the water quality results in this study indicate that Bertrand Creek had the highest concentrations of *E. coli* and fecal coliforms, as well as the most exceedances of the applicable guidelines of the three streams sampled. Bertrand Creek is the largest system in the Nooksack River Watershed; it accounts for more area than both Pepin Brook and Fishtrap Creek watersheds combined, and potentially contributes the highest load. In Pepin Brook, the highest concentrations and most exceedances were at the sampling locations located in or exiting Aldergrove Regional Park. Fishtrap Creek had the fewest sample sites, and its few exceedances were of a lesser degree.

In general, higher concentrations of *E. coli* and fecal coliforms were found in surface water samples collected during or just after rainfall events, which indicates contamination is likely from runoff. Sources could include uncovered manure piles, uncovered field storage, runoff from agricultural waste applied to the land, and sewage overflow events.

A more detailed discussion of each of these watersheds is provided below, starting with the uppermost sites and working downstream to the border sites.

Bertrand Creek

Sites B-09 and E207092 are both in the top quarter of the watershed, which is mostly residential and commercial. Site B-09 is located near a manicured park, and has a small riparian zone of less than 10 m. Because of its proximity to sewer overflows and dog parks, we suspect that the fecal input may be caused by human sewage and dog feces. Site E207092, located at 26B Avenue, is in an urban area of Aldergrove and is surrounded mainly by residences, a school and shopping complex. Again, human and dog fecal matter may be the contributing source. While unconfirmed, sanitary pipes in the area may still be combined for overflow storm events, and leaking or illegal sewer hookups may be present. This potential source requires further investigation and discussion with local governments.

Site E207092 had some minor pH exceedances, which may be a reflection of the lagoon, where dissolved humic substances can reduce pH levels. If there are more organics, typically indicated by coloured water, these pH levels would naturally be lower, and could affect the lower pH observed downstream at site E293977. The nitrite exceedances could also be related to the suspected human sewage, dog feces and manure spreading close to this site.

Another hotspot is site B-02 in Otter Park, because it is consistently near the 200 CFU/100 mL *E. coli* primary recreation guideline. This location is surrounded by several upstream and adjacent hobby farms, so possible fecal sources include cow, horse, goat and chicken. Downstream from this site is another hotspot, located near 16 Avenue (E273723); this site had high exceedance events, such as in spring 2017 when the fecal coliform count measured 3,800 CFU/100 mL. Presumed fecal input may be from upstream hobby farms, berry production and a dog-boarding facility. Berry production is a source of concern as manure can be spread in both fall and spring.

Continuing downstream, another hotspot is Howes Creek (E206847). Flows at this site vary by season, and typically are very low or absent in the summer and high in the fall and winter. Fecal sources are most likely from the berry farms and cattle-grazing fields that border Howes Creek with minimal riparian buffers.

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The last hotspot site is located on 0 Avenue at the United States–Canada border (E293980), which exceeds the 200 CFU/100 mL guideline 65% of the time. This site does have a riparian area on both sides, but also has several farms and horse-breeding facilities directly upstream. During the compliance audit in this area, horse ranch facilities had a low compliance rate of proper manure storage. During rain events, uncovered manure piles have the potential to create overland flows and contaminate the creek.

Although not included in the results graph because of a lack of sample events, site B-15 has had high exceedances in the past, most notably of fecal coliforms at 7,000 CFU/100 mL in June 2018. This site is a tributary to Bertrand Creek and is directly downstream from an organic vegetable farm.

Pepin Brook

Based on the water quality data, sites of concern are the Pepin tributary in Aldergrove Regional Park (E309447 and P-05), and Pepin Brook itself in Aldergrove Regional Park (E253211). These sites exceeded the irrigation guideline of 1,000 CFU/100 mL in winter, spring and fall more often than the other sites. The high fecal counts in this tributary most likely also influence the data at the Pepin Brook site in Aldergrove Regional Park (E253211). One likely contributor of fecal contamination is the compost facility located at the headwater of the Pepin tributary. This tributary flows across the compost facility and near its effluent retention ponds before flowing south under 8 Avenue. Elevated nitrite and total N were also observed at sites on Pepin Brook, and these results are indicative of manure sources. In addition, dog owners frequent Aldergrove Regional Park's trails and dog park, which is located adjacent to Pepin Brook. The visiting dogs may be a contributing source of fecal contamination, along with the compost facility and berry fields further upstream.

During winter 2018, ENV observed a thick mat of sewage fungus lining the substrate of the tributary downstream of 8 Avenue; sample data from this site revealed fecal coliform counts between 64,000 and 120,000 CFU/100 mL. The ENV compliance team was notified and upon further investigation was able to confirm that this facility was contributing to the high exceedances. The facility is cooperating with ENV to reduce their effluent discharge, which is evident in the recent 2018 results.

Fishtrap Creek

Fishtrap Creek has three sampling locations along its length, and is mainly surrounded by berry fields. In addition to these potential sources of contamination, there are mushroom farms, cow and horse pastures, and a poultry facility. Fishtrap Creek at Echo Road (300069) also had high maximum fecal coliform counts, but these counts decreased as they reach the border site. The site on Waechter Creek (E310908) is located in the headwaters of Fishtrap Creek and had very high microbial results in 2018. This site is located near the effluent ponds from a large mushroom compost facility, and the creek then flows south through multiple berry fields with minimal riparian buffers to eventually join Fishtrap Creek.

Next Steps

Based on the review of data collected from 29 sample sites by both ENV and LEPS between June 2017 and July 2018, each of the three streams sampled in the Nooksack River Watershed displays various issues with fecal coliform and *E. coli* concentrations. Of the data analyzed, the highest concentrations were observed in the fall months; however, ENV samples only provided one year of fall data. As noted, there were generally peaks in the data set in November (2017) and April (2017 and 2018), which will need to be compared to 2018 fall and 2019 spring samples to determine any trends. More sampling is needed to further identify sources and understand links to rainstorm events, the timing of manure spreading and overall annual trends.

For proper comparison to the B.C. WQGs, future research should collect the requisite five weekly samples over 30 days, especially during these peak periods. Based on the review of seasonal geometric mean results for sites in each watershed, we recommend sampling at additional sites to further investigate sources of contamination, both spatially and temporally. Furthermore, LEPS will no longer be sampling in 2019, so we recommend that ENV take over some of the key sampling locations identified in this report. In addition, ENV should continue to collaborate with Whatcom County to develop a bacteriological source-tracking program for sites that frequently exceed fecal and *E. coli* maximums.

Our WA State partners are not yet submitting their water quality samples for *E. coli* analysis as part of this project. To make proper comparisons between the two data sets, we recommend that WA State also analyse for *E. coli* beginning in August 2018.

To address these recommendations, ENV developed a two-year sampling plan that was implemented in August 2018. This continued water quality sampling program will confirm and expand upon the findings described in this report. Monitoring, Assessment & Stewardship staff will also continue to collaborate with the Compliance staff in ENV on areas of concern and those with potential for further investigation or inspection. We also recommend taking a proactive approach by implementing an outreach and education program, led by the Compliance team, but supported through the data collected in this program.

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Table A.1. Summary of fecal coliform (CFU) water quality data at Bertrand Creek.

ENV/LEPS ID and location description	Min.	Median	Max.	Geometric mean	% of samples exceeding U.S. fecal guideline (100 CFU/100 mL)	% of samples exceeding fecal coliform guideline (200 CFU/100 mL)	% of samples exceeding fecal coliform guideline (1,000 CFU/100 mL)	Number of samples
B-07 Vannetta Park	2	86	2,170	96	50	35	6	18
BC-B-09 Heritage Park	20	250	2,000	214	68	65	12	17
E207092 Bertrand Creek downstream of Aldergrove Lagoon	70	165	5,600	353	93	50	25	16
BC-B-03 Bertrand Creek at 272 St.	20	120	450	117	65	35	0	17
BC-B-13 Highway 13 Tributary	10	148	2,200	102	69	42	8	12
E206847 Howes Creek	80	245	2,900	289	75	44	22	9
E293977 Bertrand Creek at 264 St.	30	160	3,600	175	46	25	17	12
B-02 Otter Park by 248 St.	40	132	3,200	168	50	39	10	16
E273723 Bertrand Creek at 16 Ave.	10	375	4,000	334	86	62	19	16
B-15** 256 St. and 16 Ave.	10	465	7,000	346	86	67	17	6
B-11 Bertrand Creek at 8 Ave.	42	150	1,900	184	81	47	6	16
C-01 Cave Creek at 248 St.	10	90	560	86	40	8	0	5
E312388 Cave Creek at 0 Ave.	42	42	650	190	33	33	0	3
E293980 Bertrand Creek at 0 Ave	10	200	700	210	68	65	5	17

** not enough sample sites per season

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Table A.2. Summary of *E. coli* water quality data at Bertrand Creek.

ENV/LEPS ID and location description	Min.	Median	Max.	Geometric mean	% of samples exceeding <i>E. coli</i> guideline (77 CFU/100 mL)	% of samples exceeding <i>E. coli</i> guideline (200 CFU/100 mL)	% of samples exceeding <i>E. coli</i> guideline (1,000 CF/100 mL)	Number of samples
B-07 Vanetta Park	10	120	2,300	127	64	36	14	22
E207092 Bertrand Creek downstream of Aldergrove Regional Park	70	60	4,000	286	93	47	27	15
B-03 Bertrand Creek at 272 St.	20	125	2,300	132	65	35	10	20
B-13 Tributary	10	170	2,700	94	54	46	15	13
E206847 Howes Creek	30	180	2,900	229	89	44	22	9
E293977 Bertrand Creek at 264 St.	30	95	3,300	154	50	42	8	12
B-02 Otter Park by 248 St.	50	230	1,400	238	80	60	10	20
E273723 Bertrand Creek at 16 Ave.	10	430	3,900	295	79	57	21	14
C-01 Cave Creek	80	140	260	138	100	20	0	5
E312388 Cave Creek at 0 Ave.	42	96	250	102	71	50	38	14
E293980 Bertrand Creek at 0 Ave.	10	150	700	143	71	29	0	17

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Table A.3. Summary of fecal coliform (CFU) water quality data at Pepin Brook.

ENV/LEPS ID and location description	Min.	Median	Max.	Geometric mean	% of samples exceeding U.S. fecal coliform guideline (100 CFU/100 mL)	% of samples exceeding fecal coliform guideline (200 CFU/100 mL)	% of samples exceeding fecal coliform guideline (1,000 CFU/100 mL)	Number of samples
E253209 Bradner Rd.	5	70	6,200	76	25	23	10	20
P-02 8 Ave and Lefeuve Rd.	8	30	24	24	0	0	0	16
E208494 Pepin Brook upstream	8	29	124	35	8	0		36
E309447 Pepin Tributary	1	1,000	64,000	739	85	69	46	31
P-05 Pepin Tributary	70	590	861	861	78	76	41	18
P-06 Pepin at 272 St.	10	35	33	33	0	0	0	8
P-01 Aldergrove Regional Park	10	70	85	85	41	18	6	17
E253211 Aldergrove Regional Park	10	83	6,000	176	46	53	27	44
E279890 0 Ave. near border	6	86	1,800	113	26	27	13	23
P-07 Pepin Brook at 0 Ave.	20	50	63	65	21	8	8	14

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Table A.4. Summary of *E. coli* water quality data at Pepin Brook.

ENV/LEPS ID and location description	Min.	Median	Max.	Geometric mean	% of samples exceeding <i>E. coli</i> guideline (77 CFU/100 mL)	% of samples exceeding <i>E. coli</i> guideline (200 CFU/100 mL)	% of samples exceeding <i>E. coli</i> guideline (1,000 CFU/100 mL)	Number of samples
E253209 Brader Rd.	5	75	2,000	79	54	23	7	13
P-02 8 Ave and Lefevre Rd.	10	25	3,500	42	20	15	0	20
E208494 Pepin Brook upstream	10	34	114	28	11	0	0	9
E309447 Pepin Tributary	1	400	13,000	467	92	62	53	13
P-05 Pepin Tributary	30	375	20,000	703	80	60	35	20
E253211 Aldergrove Regional Park	12	70	4,000	132	47	33	13	15
P-07 Pepin Brook at 0 Ave	10	60	1,200	57	47	11	0	19
E279890 Pepin Brook at 0 Ave.	6	60	1,900	89	47	27	13	15

Table A.5. Summary of fecal coliform (CFU) water quality data at Fishtrap Creek.

ENV/LEPS ID and location description	Min.	Median	Max.	Monthly geometric mean	% of samples exceeding U.S. fecal coliform guideline (100 CFU/100 mL)	% of samples exceeding fecal coliform guideline (200 CFU/100 mL)	% of samples exceeding fecal coliform guideline (1,000 CFU/100 mL)	Number of samples
E310908 Waechter Creek at Simpson Rd.	20	120	4,000	226	67	33	33	6
300069 Fishtrap Creek at Echo Rd.	10	110	5,800	533	64	39	8	14
E279889 Fishtrap Creek at O Ave.	3	100	7,900	103	50	13	13	16

Table A.6. Summary of *E. coli* water quality data at Fishtrap Creek.

ENV ID and location description	Min.	Median	Max.	Geometric mean	% of samples exceeding <i>E. coli</i> guideline (77 CFU/100 mL)	% of samples exceeding <i>E. coli</i> guideline (200 CFU/100 mL)	% of samples exceeding <i>E. coli</i> guideline (1,000 CFU/100 mL)	Number of samples
E310908 Waechter Creek at Simpson Rd.	20	120	4,000	226	67	66	33	6
300069 Fishtrap Creek at Echo Rd.	6	77	4,800	88	43	21	7	14
E279889 Fishtrap Creek at O Ave.	2	100	7,900	89	53	20	13	15