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Pussyfoot Creek and Second Creek Fecal Coliform Characterization Monitoring

Two Tributaries to the White River

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Two Tributaries to the White River

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Abstract

The Puyallup and White Rivers are in Water Resource Inventory Area (WRIA) 10 (Figure 1). Both rivers are on Washington State's list of impaired water bodies for not meeting contact recreation water quality standards for fecal coliform bacteria (FC). The federal Clean Water Act of 1972 requires that Washington State Department of Ecology (Ecology) develop a total maximum daily load study (TMDL) and implement activities that will bring the water bodies back into compliance with the Washington State Water Quality Standards.

Ecology conducted a FC bacteria TMDL study in the Puyallup River Watershed (which includes the White River) in October 2006 through September 2007 (Mathieu and James, 2011). The TMDL study demonstrated that Primary Contact Recreation was impaired in many areas of the Puyallup River watershed due to bacteria. The TMDL analyses determined that a 90% reduction in FC during the wet season would be required in order to meet the FC load allocations set for the White River and its tributaries. The TMDL recommended Ecology conduct additional source identification sampling in Pussyfoot Creek. Second Creek was not sampled in the TMDL but it was included in this FC characterization project due to concerns of elevated bacteria.

Data collected from this study (November 2012- June 2013) found that the mainstem sites on Pussyfoot Creek and Second Creek exceeded the Primary Contact Recreation standard. Many of the tributary and ditch sites exceeded the standards as well. Waters of the state are not meeting standards when entering the Muckleshoot Indian Tribe's Reservation.

During this study, a dairy in the Pussyfoot watershed was found to have manure management issues. Several other sites with direct livestock access to Pussyfoot Creek were identified. These sources of bacteria could be reduced with improved land and livestock management.

Second Creek also had elevated bacteria concentrations. The sources were not as evident. Further investigation of the watershed and ditches would be necessary to identify sources.

Introduction

The Puyallup and White Rivers are in Water Resource Inventory Area (WRIA) 10 (Figure 1). The White River enters the right bank (when looking downstream) of the Puyallup River at approximately RM 10.4 (Williams, et al, 1975). Both rivers are on Washington State's list of impaired water bodies for not meeting contact recreation water quality standards for fecal coliform bacteria (FC). The federal Clean Water Act of 1972 requires that Washington State Department of Ecology (Ecology) develop a total maximum daily load study (TMDL) and implement activities that will bring the water bodies back into compliance with the Washington State Water Quality Standards.

Ecology conducted a FC bacteria TMDL study in the Puyallup River Watershed (which includes the White River) in October 2006 through September 2007 (Mathieu and James, 2011). The TMDL study demonstrated that Primary Contact Recreation was impaired in many areas of the Puyallup River basin due to bacteria.

Some potential non-point sources within the watershed were identified as:

- Livestock with direct access to stream or with poor manure management.
- Failing or improperly constructed septic systems.
- Urban stormwater.
- Pet waste.

This study was conducted in response to Puyallup TMDL's implementation plan (Mathieu and James, 2011). The plan designated Ecology to conduct source ID sampling in Pussyfoot Creek.

The 2011 TMDL (Mathieu and James, 2011), referred to the sampling location on Pussyfoot Creek as *Unknown trib to White River at 180th* with the sampling station ID of *10-UNW-0.2*. The TMDL analyses determined that a 90% reduction in FC during the wet season would be required at this site in order to meet the FC load allocations set for the White River and its tributaries.

Second Creek was not sampled in the TMDL. However, it was included in this FC characterization project due to concerns of elevated bacteria entering the Muckleshoot Indian Tribe's (MIT) Reservation.

Water Quality Criteria

Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. In Washington State, Ecology water quality standards use FC as an *indicator bacteria* for the state's freshwaters. FC in water indicates the presence of waste from humans and /or warm-blooded animals. The FC criteria are set at levels that are shown to maintain low rates of serious intestinal illness in people.

The Washington State Water Quality Standards are documented in Chapter 173-201A of the Washington Administrative Code (WAC 173-201A). They include beneficial uses, as well as numeric and narrative water quality criteria for surface waters of the state. The numeric and narrative criteria are set at levels to protect the designated beneficial uses.

Pussyfoot and Second Creek must meet the *Primary Contact Recreation Use* since they flow into the Lower White River with this designated use. *Primary Contact* means activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

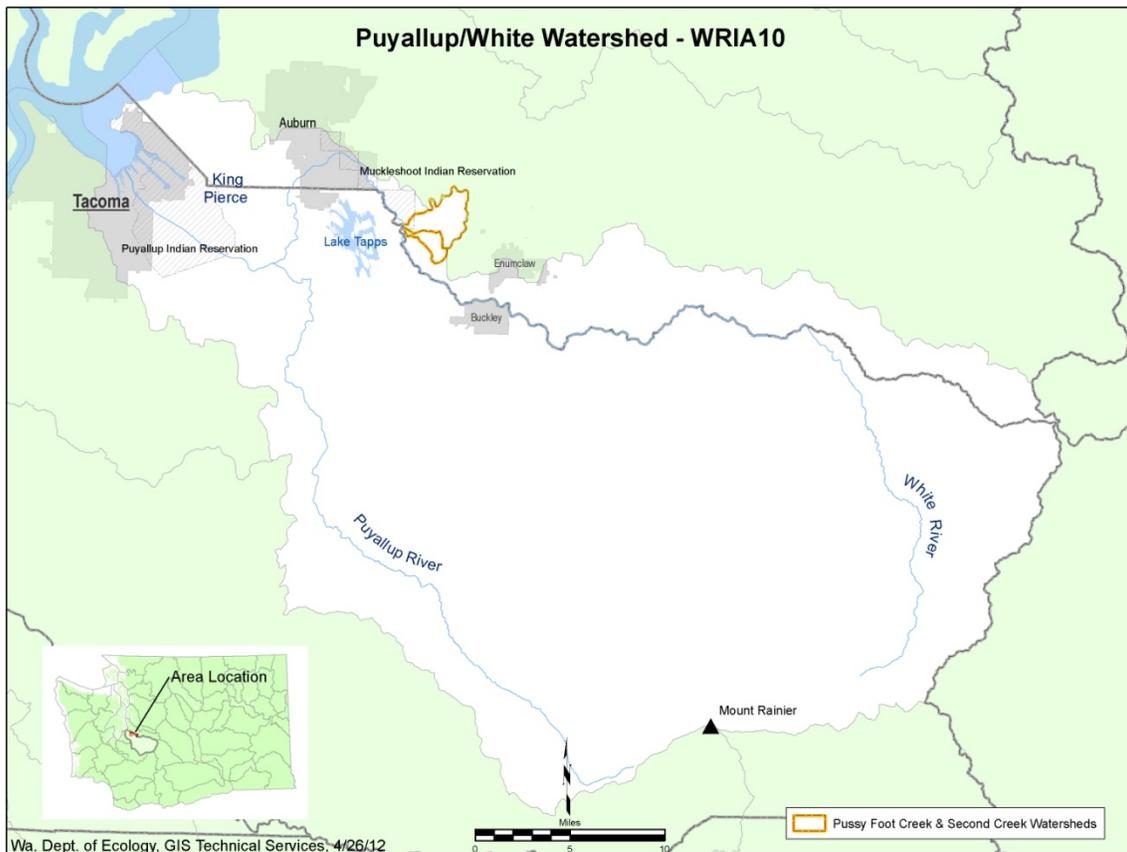


Figure 1. Overview map of WRIA 10 showing the locations of Pussyfoot and Second Creek watersheds.

The *Primary Contact Recreation* criterion for fecal coliform bacteria has two-parts:

Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean values exceeding 200 colonies/100mL (Ecology, 2006).

Goal and Objectives

The goal of this study was to reduce FC contamination to the 303(d)-listed Lower White River.

The objectives of the study were to:

- Characterize FC concentrations in Pussyfoot Creek and Second Creek and accessible ditches draining into them.
- Compare results to the Primary Contact Recreation criterion.
- Use study results to guide implementation activities for cleaner water.

Study Area

Pussyfoot and Second Creeks are located in King County south of the town of Auburn and north of the cities of Enumclaw and Buckley (Figure 1). Both enter the right bank of the White River. They are often mapped as unnamed tributaries. However, this study has used the names given by the local community. The Pussyfoot (stream number 10.0048, Williams, et al., 1975) enters at RM 15.45 and Second Creek (stream number 10.0050, Williams, et al., 1975) enters just upstream at RM 15.5.

The land use in the upper watersheds is rural residential. There are many farms pasturing livestock such as cattle, horses, alpaca, and sheep. There are also dairies in the area. The lower area of both streams are less developed.

The White River flows through the Muckleshoot Indian Tribe's Reservation between river mile (RM) 15.5 and RM 8.9. Surface waters that flow into the reservation boundaries are considered waters of the state upstream of the boundary and tribal waters downstream of the boundary. The opposite applies to waters flowing out of tribal land. The lower watersheds of Pussyfoot Creek and Second Creek are on tribal property.

Ecology does not regulate waters within the boundaries of the MIT Reservation, but two sampling sites, P0.19 and P0.2, were located on MIT property. Permission for Ecology to access these specific sites was obtained contingent on the presence of MIT staff at each sampling event.

Access was also obtained from a property owner to access the sampling location for the site at approximately creek mile (CM) 1.12 (P1.12). All other sites were accessed within the public right-of-way.

Methods

Water Quality field staff collected bacteria samples for this study following established and documented Ecology protocols (Ward and Mathieu, 2011). All bacteria samples were analyzed at the Manchester Environmental Laboratory (MEL) using the membrane filter method (SM9992D, APHA, et al., 1998).

A Quality Assurance Project Plan was prepared to guide project activities (Dicke, 2012). The details for field, laboratory, and quality control can be reviewed at <https://fortress.wa.gov/ecy/publications/SummaryPages/1210032.html>.

Streamflow was not measured. We eliminated streamflow to have more time available to sample additional sites for source identification.

Study design

The initial sampling sites were located on the mainstem of Pussyfoot and Second Creeks as well as the South Fork (SF) Pussyfoot main channel. Sample sites were selected based on: access to the sampling location; quality of sample location for representative water collection; and potential sources.

Pussyfoot Creek, the priority watershed in this study, was sampled twice a month. Second Creek was sampled once a month. We expected to catch rain events within the routine sampling schedule. The assumption of this study was that sample size would be adequate to characterize bacteria concentrations in the watersheds and would identify potential problem areas for implementation activities.

The one sampling site used in the original Puyallup TMDL, 10-UWN-0.2 (Unnamed trib to White River at 180th), was eliminated from this study. This site was replaced with a site downstream just below the SE 408th St. road-bridge. The name for this new site is P0.2. There are no known tributaries between the upstream culvert site (10-UWN-0.2) and the new P0.2, but access was easier. The new site was also on MIT property. An MIT escort was always present when samples were taken here.

Opportunistic sites were added to improve source identification. For example, a site would be added when stormwater would be flowing in an otherwise dry ditch. Another example of these opportunistic sites is the addition of P0.19, a site added just downstream of P0.2 to reflect any impacts from the manure slurry (PS0.2, also added later) that occasionally flowed across 180th St SE and down the embankment into the creek.

Due to the small size of the watersheds, samples were collected from downstream to upstream to prevent potential contamination.

Sampling Dates

The sampling dates for this study are provided in Table 1.

Table 1. Sampling dates for Pussyfoot Creek and Second Creek.

Sample Date	Pussyfoot Creek	Second Creek
2012		
Sept	<i>dry</i>	<i>dry</i>
Oct	<i>dry</i>	<i>dry</i>
Nov	6	28
Dec	4, 19	19
2013		
Jan	8, 22	23
Feb	5, 19	20
Mar	5, 19, (20)	20
Apr	9, 23	24
May	7, 21	22
Jun	4, 18	19
Jul	9, <i>dry</i>	8
Aug	<i>dry</i>	<i>dry</i>

Sampling Locations

Naming Convention for Sites

The formal site names in EIM depict the WRIA (10) and the creek name abbreviated and the creek mile. However, in the results section for this report the site names are abbreviated. For example, 10-PUS-0.2, as identified in in EIM, will be shown in the graphs tables and text in this document as P0.2. This naming convention refers to the fact that it is in Pussyfoot Creek (P) at approximate creek mile 0.2. Additionally, sites identify whether the site is a ditch, and what bank it enters the mainstem. For example, 10-SECD-1.50DR will be the site name in EIM. In the report it will be abbreviated to SD1.50DR. This states that the site is in Second Creek (S), it is a ditch site (D) located at the approximate creek mile 1.50, and enters into Second Creek mainstem on the downstream side of the road (D) and on the right bank (R).

Pussyfoot Creek Watershed

The sample locations in the Pussyfoot watershed can be seen in Figure 2 and the identifying site number can be cross-referenced to Table 2 and Table 3.

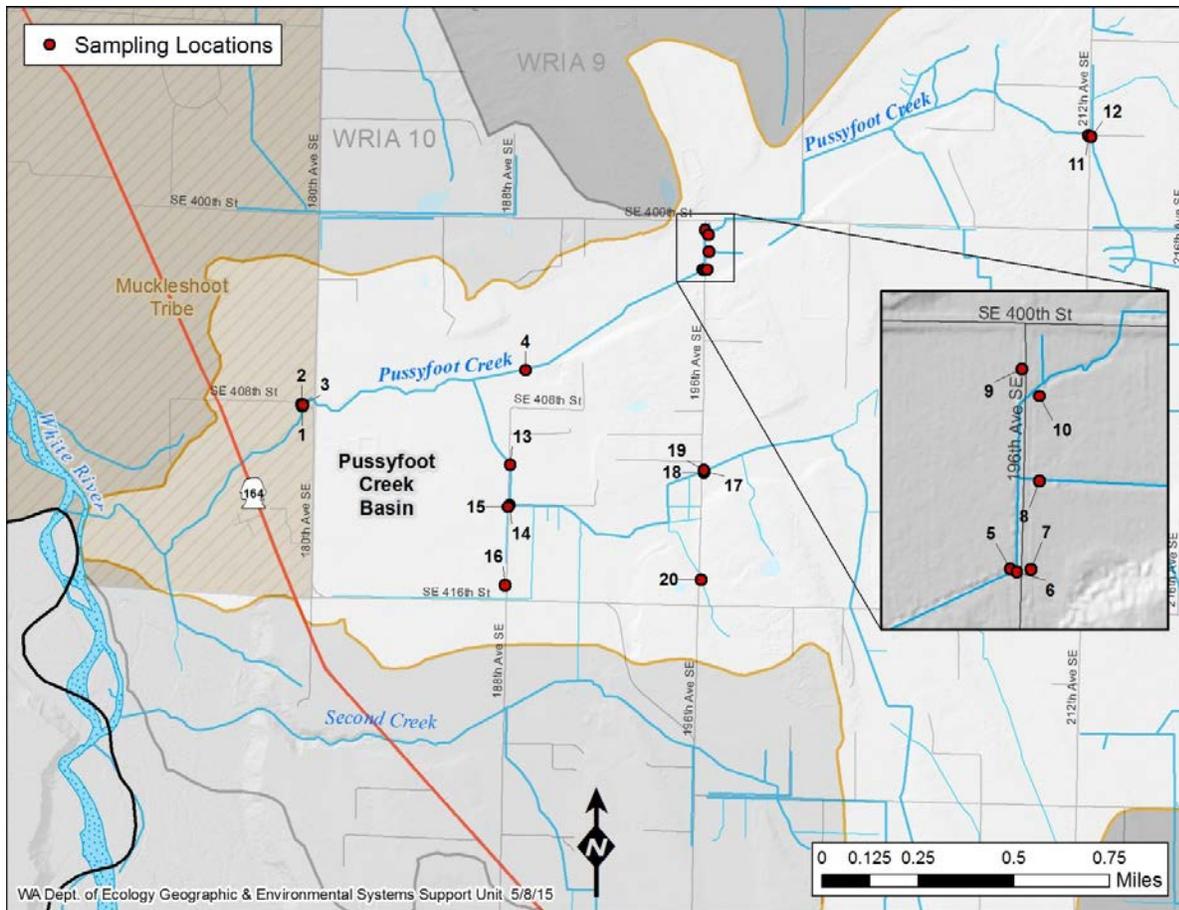


Figure 2. Map of sampling locations for Pussyfoot Creek.

Table 2. Map ID with associated location ID and descriptions for Pussyfoot Creek mainstem area sites. (CM= creek mile)

# ID	Field Location ID	Pussyfoot Creek Location Description	Latitude	Longitude
1	P0.19	Pussyfoot Creek downstream of bridge at SE 408th St and 180th Ave SE at approx. CM0.19, 10 - 15 m downstream of bridge at large riffle.	47.23547	-122.10237
2	P0.2	Pussyfoot Creek on MIT property collected just downstream of bridge at SE 408th St and 180th Ave SE. at approx. CM0.2.	47.23554	-122.10241
3	PS0.2	Runoff from the vicinity of the dairy at 180th Ave SE. Discharge typically crossed from the SE to the west across 180th and enters a roadside swale that enters creek.	47.23552	-122.10233
4	P1.12	Pussyfoot Creek from private property at the end of 188th Ave SE. Collected midstream at field crossing. At approximate CM1.12.	47.23699	-122.09005
5	P2.10	Pussyfoot Creek at 196th Ave SE. at CM2.10, downstream side of road and culvert at bend in creek. At Approximate CM2.10.	47.24092	-122.08032
6	PD2.10DL	Ditch at Pussyfoot CM2.10 downstream side of road on left bank.	47.24090	-122.08025
7	PD2.10UC	Small culvert across 196th Ave SE from the mainstem Pussyfoot site at CM2.10. Collects water from both sides of the ditch.	47.24092	-122.08009
8	PT0.01	Mouth of small tributary to Pussyfoot Creek at 196th, upstream side of road (E). Crosses the pasture with narrow riparian. Enters from E at around CM2.15 via culvert some water may also go down ditch line.	47.24159	-122.08002
9	PD2.22DR	Collected from the roadside ditch across from Pussyfoot Creek CM2.22 on 196th Ave SE. The ditch flows into the right bank of the mainstem after the MS has crossed under the road. The MS flows under the road and turns left and looks like a roadside ditch until below CM2.10.	47.24243	-122.08024
10	P2.22	Pussyfoot Creek at 196th Ave SE. at CM2.22, upstream side of road, above ditches and culvert	47.24223	-122.08004
11	P3.46	Pussyfoot Creek at 212th Ave SE at CM3.46 (north of 400th St.) on downstream side of road below culvert mouth	47.24627	-122.05909
12	PD3.46UC	Collected from small roadside ditch culvert (from under 396 Road) across from site CM3.46. The sample is collected before it enters the right bank MS Pussyfoot. (UC means upstream culvert).	47.24622	-122.05893

Table 3. Map ID with associated location ID and descriptions for SF Pussyfoot Creek area sites.

Map ID #	Field Location ID	SF Pussyfoot Creek Location Description	Latitude	Longitude
13	SF0.23	South Fork Pussyfoot Creek at 188th Ave SE at CM0.23, upstream side of road in straight stretch upstream of culvert.	47.23341	-122.09076
14	SF0.24	SF Pussyfoot on 188th Ave SE upstream of CM0.23 at approx. CM.24 downstream of large culvert at corner (but above where 188D enters from left bank).	47.23189	-122.09077
15	188D	Ditch draining in front of residential properties along west side of 188th Ave.SE. Sample taken just before going under the road and entering SF Pussyfoot. The ditch water drains into SF Pussyfoot just below site SF0.24.	47.23181	-122.09087
16	188D_UP	Same ditch as site 188D but UP stream. Taken 3-5m above the last house on 188th Ave SE residential ditch before reaching SE 416th St.	47.22886	-122.09092
17	SF0.92	SF of Pussyfoot Creek at 196th Ave SE CM0.92, upstream side of road and fence.	47.23331	-122.08001
18	SFD.092UL	Left bank ditch at SF0.92 upstream side of road.	47.23326	-122.08002
19	SFD0.92UR	Right bank ditch at SF0.92 upstream side of road.	47.23334	-122.08003
20	SFT0.35	Small tributary to SF Pussyfoot at 196th Ave SE near SE 416 St, at CM0.35, at upstream side of road just upstream of culvert.	47.22922	-122.08008

Second Creek Watershed

The sample locations in the Second watershed can be seen in Figure 3 and the identifying site number can be cross-referenced to Table 4. (Note: The hydrology at the mouth of Second Creek may be different than that available in the GIS database used by Ecology).

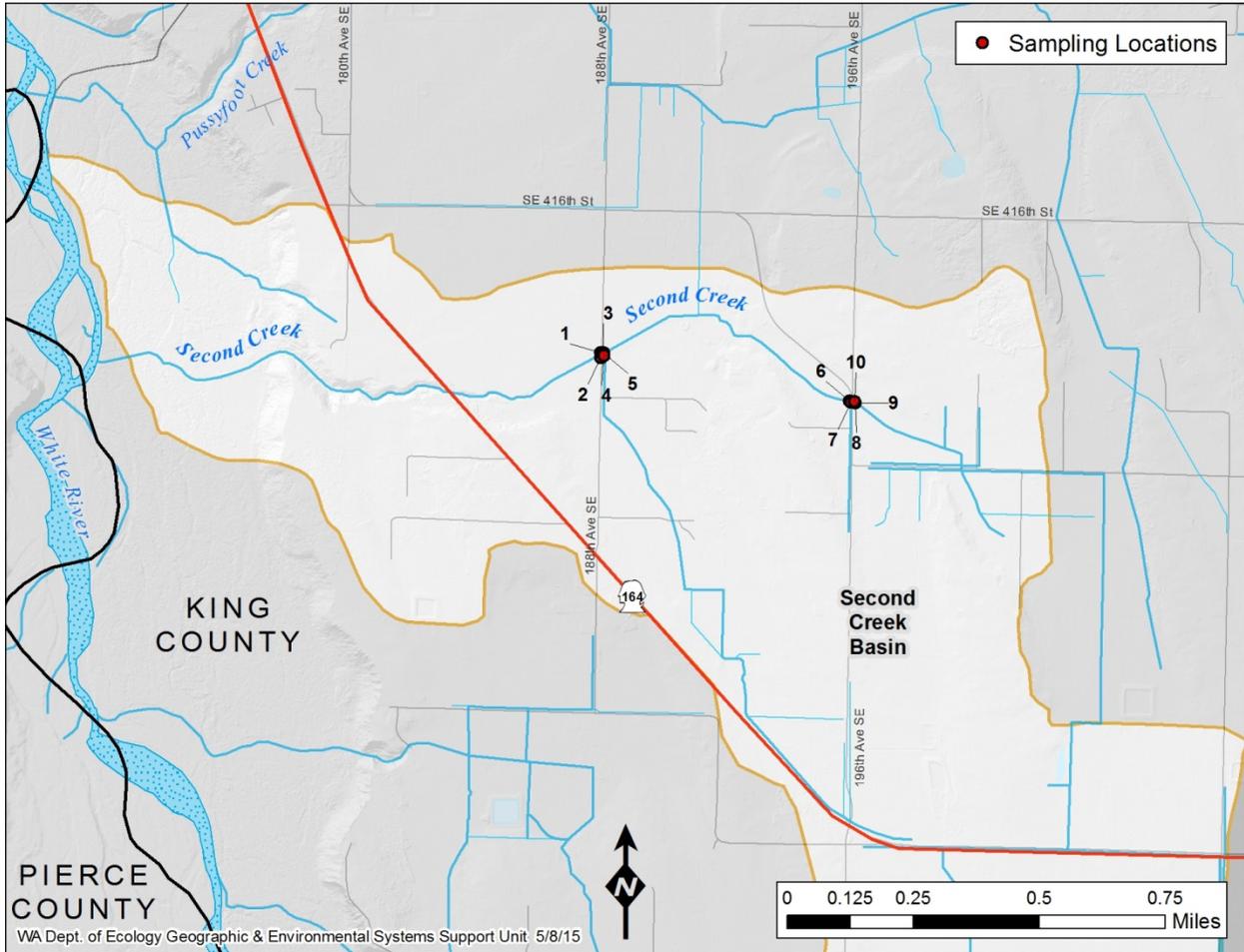


Figure 3. Map of sampling locations for Second Creek.

Table 4. Map ID with associated location ID for the Second Creek area sites.

Map ID #	Field Location ID	Second Creek Location Description	Latitude	Longitude
1	SD1.50DR	Ditch on Second Creek at CM1.50 downstream side of 188th St. on right bank.	47.22417	-122.09090
2	SD1.50DL	Ditch on Second Creek at CM 1.50 downstream side of 188th St. on left bank.	47.22404	-122.09090
3	SD1.50UR	Ditch on Second Creek at CM 1.50 upstream side of 188th St. on right bank.	47.22417	-122.09079
4	ST0.01	Mouth of tributary to Second Creek at 188th St., enters upstream side of road from left bank.	47.22409	-122.09076
5	S1.50	Second Creek at 188th St. at CM1.50, upstream side of road.	47.22414	-122.09075
6	S2.07	Second Creek at CM 2.07 196th St. downstream side of road below ditches.	47.22291	-122.08037
7	SD2.07DL	Ditch at Second Creek at CM 2.07 on the downstream side of 196th St. from the left bank just before it enters the mainstem.	47.22288	-122.08031
8	S2.08	Second Creek at CM 2.08 upstream side of 196th St. above influence of ditch and pipe.	47.22287	-122.08013
9	SD2.08UL	Ditch at Second Creek CM 2.08 upper side of 196th St. Left bank.	47.22287	-122.08013
10	SD2.08UPR	Hanging black pipe at Second Creek CM 2.08 upper side of 196th St. Right bank.	47.22290	-122.08016

Data Quality

Ecology evaluated the study data and determined that the data are useable for the project objectives. Data quality issues are described in more detail in the following sections.

Precision

Precision is the measure of variability in the results of replicate measurements due to random error. The random error includes error inherently associated with field sampling and laboratory analysis. Bacteria sample precision for this study was assessed through 10 - 20 percent replication. The samples were collected one-right-after the other.

The Method Quality Objectives (MQOs) set for precision were based on an analysis conducted by Mathieu, 2006, using replicate data from TMDLs in much larger watersheds. However, we used the criteria for assessing these smaller watersheds. Under this MQO, 50% of the replicate pairs must be at or below 20% RSD, and 90% of the pairs must be at or below 50% RSD.

As seen in Table 5, precision results for Pussyfoot Creek (N=29 pairs) met both parts of the MQO. Second Creek (N=10 pairs), however, exceeded the low limit by having a 25% RSD instead of falling at or below 20% RSD. This may result from the smaller sample size, smaller watershed size and poor mixing after sources enter the water.

Table 5. Precision MQO for field replicate samples in Pussyfoot and Second Creeks. This is for concentrations over 20 cfu/100mL.

Creek	50% ≤ 20 %RSD	90% ≤ 50 % RSD
Pussyfoot	13	42
Second	25	43

Completeness

The goal of the project was to collect and analyze 100 % of the samples planned for the project. This expectation was not met. However, the number of samples collected and analyzed are adequate to characterize the watershed. Samples were not collected and or analyzed due to the following situations:

- The intended sampling design planned for samples to be collected on both creeks starting in September 2012 and extend through August 2013. However, Pussyfoot Creek was dry in September 2012 through October 2012 and went dry again in late July 2013. The creek volume was quite reduced starting in June with some of the ditch sites going dry.

- Second Creek was also dry in September 2012 through October 2012. All sites on the Second Creek mainstem were able to be sampled through May 2013. But in June the lower sites on 188th Ave. went dry and only the upper reach of the study area (S2.08) could be sampled. Site S2.07 may have had water but, was totally inundated with vegetation.
- The sampling event scheduled for November 20, 2012, was cancelled for Pussyfoot due to an unexpected conflict with work schedules.
- Two samples collected at site P3.46 on February 19, 2013, were not analyzed. They had been placed in a second cooler due to lack of space in the first cooler. However, the second cooler was overlooked and never made it to MEL.
- Several samples were taken on Pussyfoot Creek on March 20, 2013, during a rain event. The sample date was not a routine date for Pussyfoot but the rain was harder than previously seen so several samples were collected. These data were not analyzed with the routine data; they were kept separate (see Table 9 in the Results section).

Bias and Representativeness

Fecal coliform concentrations in the environment are known to be highly variable over space and time. Standard sampling protocols (Ward and Mathieu, 2011) were followed to ensure data were representative of site conditions and to minimize bias.

MEL analyzed duplicate samples (an aliquot taken in the lab from a well-mixed field sample) from each sampling event to determine the presence of bias in analytical methods. MEL's MQO for duplicates is a relative percent difference (RPD) of 40 colony forming units (cfu) when concentrations are above 20 cfu. There were a few laboratory duplicates that did not meet the MQO. MEL qualified the appropriate samples as estimates.

On March 20, 2013, one filter blank (out of two) was contaminated (cfu/100 mL). Data that were less than ten times the contamination were qualified as an estimate by MEL.

Over holding time

Some fecal coliform samples were qualified by MEL with a J (estimate) to acknowledge that analysis occurred over the 24-hour holding time. However, all analyses were completed within 30 hours of sample collection. An Ecology holding time study has shown that FC samples analyzed by MEL within 30 hours were comparable to samples analyzed within 6-8 hours (Mathieu, 2005). The qualified results were used in calculating statistics.

Too Numerous to Count (TNTC)

Some sample results were reported as TNTC. The result values were later recalculated using the maximum countable value of 200 colonies and then multiplied by its dilution factor. The value was then given a G qualifier to signify that the actual FC concentration of the sample was greater than that reported. These values underestimate the conditions of bacteria in the system.

For example, On April 10, 2013, a field replicate was collected at site P0.2. The initial concentration was TNTC. Later the dilution was recalculated and a value of 2000 cfu/100 mL G was reported. The routine sample collected was 45000 J. These data were used in the analysis for precision, but the

2000 G value was not used in subsequent data analysis; only the 45000 cfu/100 mL was used to represent bacteria concentrations for this site on April 10, 2013.

Results and Discussion

Ecology loaded all data in its online Environmental Information Management (EIM) database. EIM also contains information about the study and sampling stations.

To access the data:

- Go to www.ecy.wa.gov/eim/
- Enter BEDI0020 into the Study ID field
- Click the arrow under the Studies tab. Then click the List of results tab.

Precipitation for this study was obtained using the Enumclaw Rain gauge (44u) (Hydrologic Information Center Gauge Map <http://green2.kingcounty.gov/hydrology/gaugemap.aspx>).

To depict the distribution with boxplots the 90th percentile is used. This is used as an equivalent expression to the “no more than 10%” criterion found in the second part of the water quality standard for fecal coliform bacteria. The 90th percentile was calculated as the antilog of the mean of the log-transformed data plus 1.28 times the standard deviation of the log-transformed data.

Pussyfoot Creek

Precipitation

FC concentrations often increased with rain events, however, only weak statistical correlations were identified between FC concentrations and previous 12 hour (hr.), 24 hr. or 48 hr. precipitation in the watershed. The R^2 at the various sites for the varying time periods ranged from 0.1 to 0.3. This is indicative of a system that is not totally influenced by runoff. That is, there are sources entering the creek without the runoff effects of precipitation e.g. direct animal access. Figures 4 and 5 show the FC concentration and associated precipitation at a downstream and upstream sampling site, respectively, in the Pussyfoot Creek study area. The precipitation in tabular form can be reviewed in Appendix A.

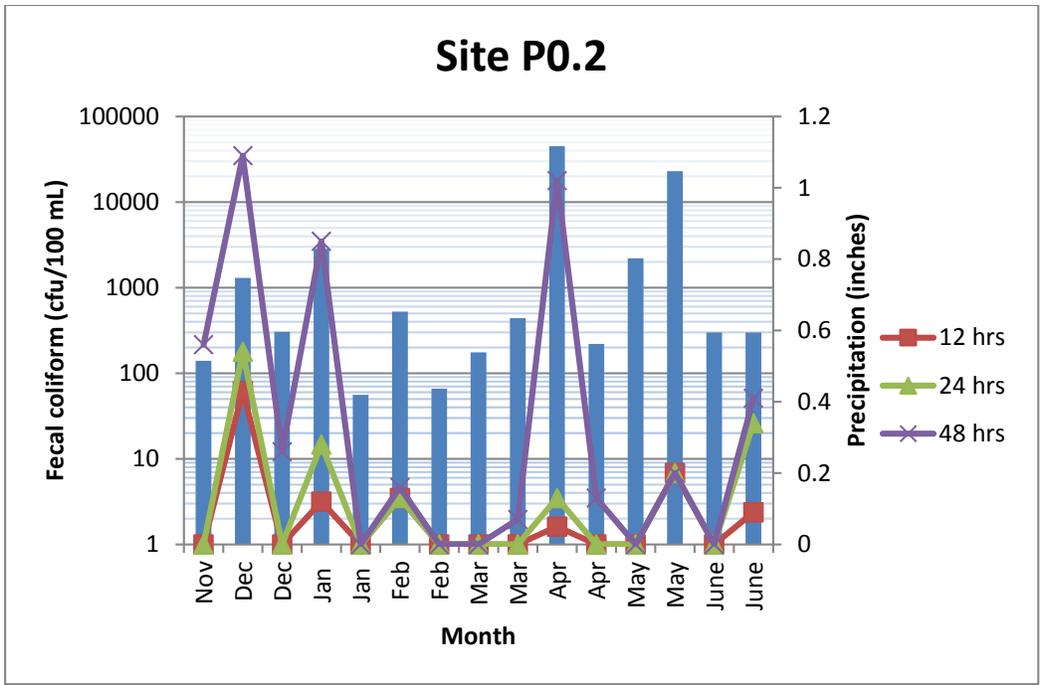


Figure 4. Pussyfoot Creek at P0.2 in the lower end of the study area with the associated precipitation.

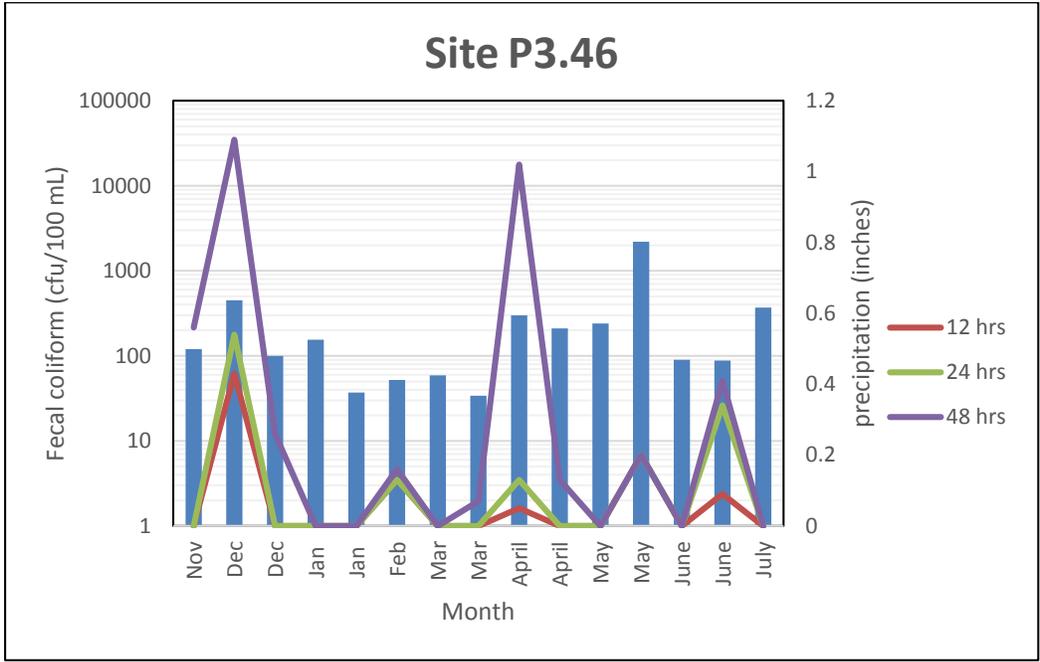


Figure 5. Pussyfoot Creek at site P3.46 in upper end of the study area with the associated precipitation.

Water Quality Criterion

Bacteria criteria are set to protect people who work, fish, and play in and on the water from waterborne illnesses. Pussyfoot and Second Creek must meet the *Primary Contact Recreation Use* since they flow into the Lower White River with this designated use. The *Primary Contact Recreation* criterion for fecal coliform bacteria has two-parts:

Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean values exceeding 200 colonies/100mL (Ecology, 2006).

Mainstem Pussyfoot Creek

Table 6 shows FC summary statistics for the mainstem Pussyfoot Creek. The highlighted cells indicate that the site exceeded the water quality criteria during the study time 2012-2013. As can be seen, all of the mainstem sites exceeded both parts of the Primary Contact criterion. This can also be seen graphically with the box plots in Figure 6.

Table 6. Pussyfoot Creek mainstem sites with FC summary statistics. The highlighted cells indicate that the water quality criterion was not met.

	P0.19	P0.2	P1.12	P2.10	P2.22	P3.46
10th percentile	50	52	35	42	45	34
Minimum	57	56	20	46	53	34
Geometric mean	730	634	188	250	244	154
Maximum	39000	45000	2600	4900	3200	2200
90th percentile	10592	7719	998	1497	1329	632
# of samples (N)	12	15	15	16	16	15
# > 200	10	11	6	7	7	7
>200	83%	73%	40%	44%	44%	47%

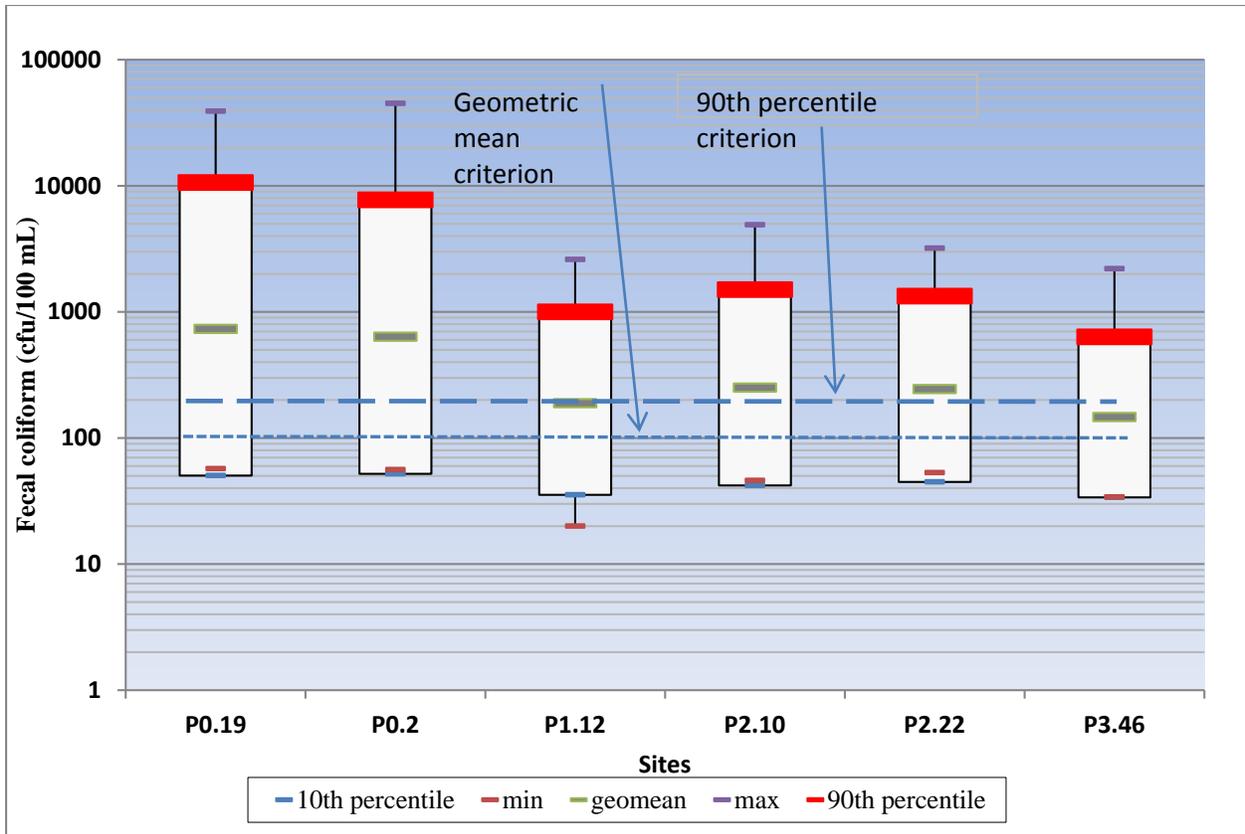


Figure 6. Boxplots depicting the distribution of the FC concentrations for the mainstem Pussyfoot sites.

Tributary and ditch sites that flow into the Pussyfoot mainstem

Table 7 shows that four of five sites exceeded the Primary contact criterion for FC. The three sites on 196th Ave SE that exceeded the water quality criterion are downstream of pastured livestock. They are described in the sub-section “Direct Animal Access”. It is not directly apparent what impact was affecting waters collected at PD3.46UC on April 23, 2013, but that one sample was over 200 cfu/100 mL.

Table 7. Pussyfoot Creek mainstem ditch sites with FC summary statistics. The highlighted cells indicate that the water quality criterion was not met.

	PD2.10UC	PT0.01	PD2.10DL	PD2.22DR	PD3.46UC
10th percentile	5	8	x	13	3
Minimum	3	3	9	3	3
Geometric mean	41	78	x	245	30
Maximum	960	4000	x	34000	430
90th percentile	354	745	x	4487	267
#of samples (N)	15	15	1	14	8
# > 200	3	3	0	6	1
>200	20%	20%	0	43%	13%

SF Pussyfoot Creek and Ditches

Five of the eight sites sampled on the South fork (SF) tributary to Pussyfoot Creek and ditches exceeded the Primary contact water quality criterion for FC bacteria (Table 8.). Site SF0.24 reflects all the SF watershed including SF0.35. Site SF0.23 includes the SF watershed *and* the 188th Ave SE ditch. Though the concentrations were high from the ditch, impacts were not clearly seen in downstream concentrations since the volume of ditch water was so low. The 188th Ave SE ditch site is described in more detail in the sub-section named as such. Site SF0.35 had animal access issues described further in the ‘Direct Animal Access’ sub-section of the results section.

Table 8. SF Pussyfoot Creek sites with FC summary statistics. The highlighted cells indicate that the water quality criterion was not met.

	SF0.23	SF0.24	SFT 0.35	SF0.92	SFD0.92 UL	SFD0.92 UR	188D	188D_UP
10th percentile	55	30	8	5	2	3	196	2
Minimum	31	20	6	3	3	3	96	3
Geometric mean	201	151	130	27	14	13	824	37
Maximum	2500	2400	6700	490	460	130	5700	2000
90th percentile	735	754	2110	157	112	60	3476	818
# of samples (N)	15	11	16	15	11	7	10	5
# > 200	6	5	6	1	1	0	9	1
>200	40%	45%	38%	7%	9%	0	90%	20%

The ditch sites at SF Pussyfoot creek mile 0.92 are located downstream of a wetland complex and some horses. There were a few high FC concentrations, but these three sites met the water quality criterion.

Fecal Coliform Sources Identified

Manure Impacts

A stream of manure was found flowing across the street, near the 408th St Bridge, during three sampling events in Pussyfoot Creek. The manure stream originated from a dairy located along 180th Avenue SE. and directly impacted Pussyfoot Creek waters flowing in the MIT reservation. The events were shared with the TMDL lead who then followed up with local jurisdictions. A representative of the MIT was also present during these events. The sample taken on March 20, 2013, was taken only from the public roadway only. Additional creek samples in this area were not collected since there was not a MIT representative present.

The manure slurry (See PS0.2 in Figures 7 and 8) was sampled where it was observed flowing across 180th Avenue SE. It originated from a dairy located along 180th Avenue SE and entered Pussyfoot Creek near the 408th St Bridge, just below site P0.2 and above P0.19. The first event witnessed occurred on December 4, 2012 (Figure 7). The concentration was reported as 10,000 but was

qualified as TNTC. Another spill was seen on January 8, 2013 (Figure 8) with light rain at the time, but 0.85 had fallen in the past 48 hours.

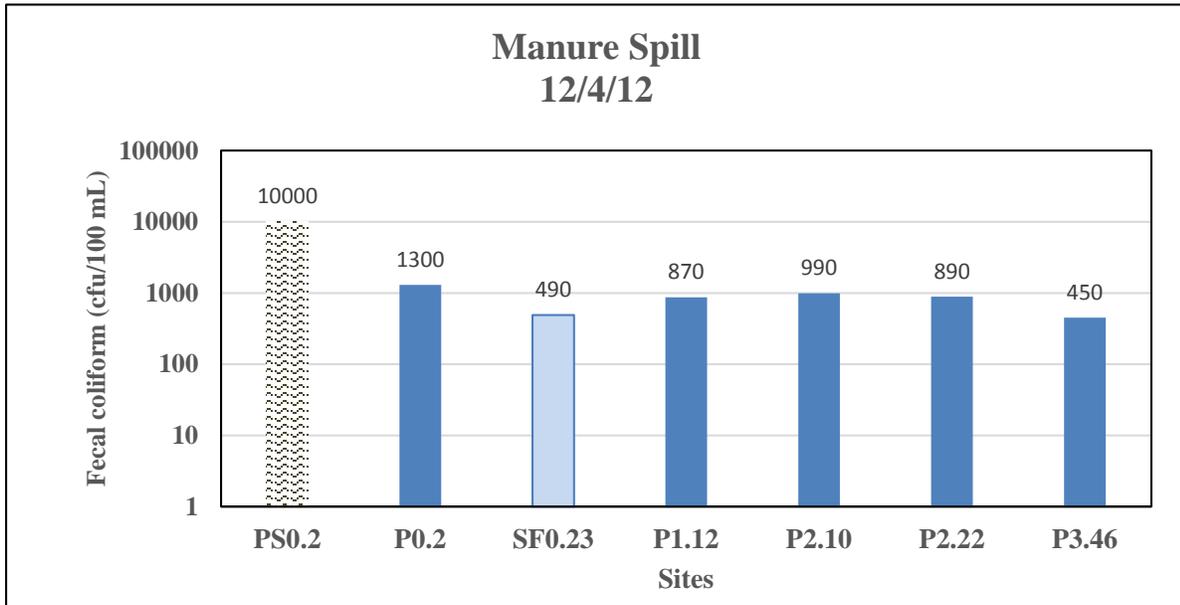


Figure 7. Pussyfoot Creek watershed FC concentrations on December 4, 2012. Note manure slurry sampled (PS0.2) as it headed toward Pussyfoot Creek.

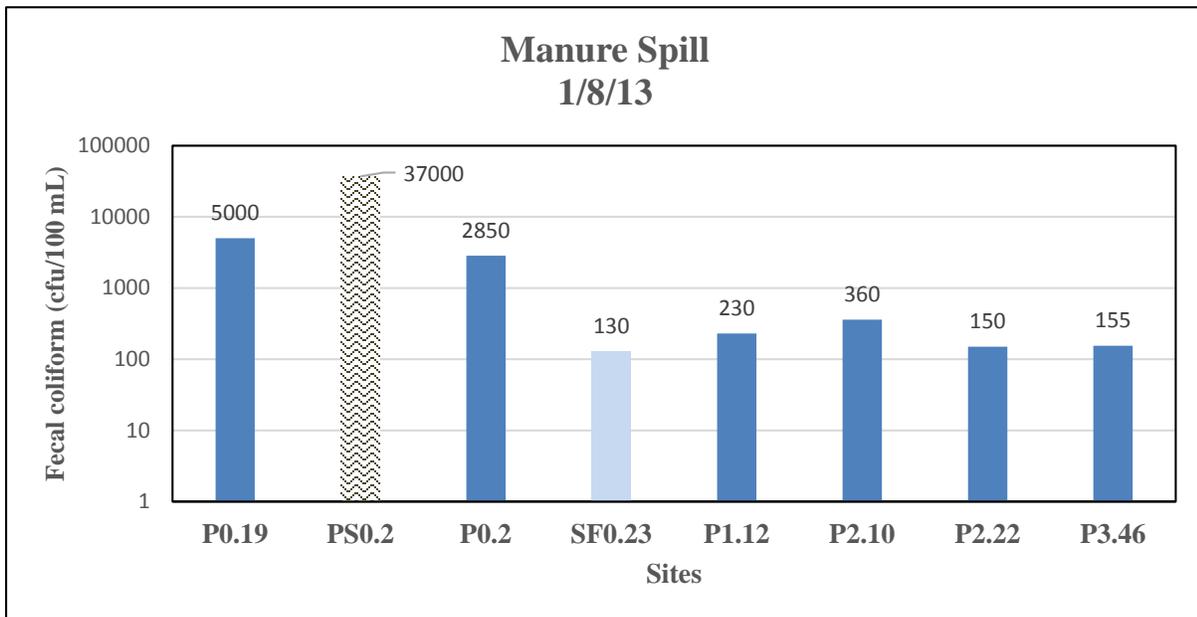


Figure 8. Pussyfoot Creek watershed FC concentrations on January 8, 2013. Note manure slurry sampled (PS0.2) as it headed toward Pussyfoot Creek. Sampling site P0.19 was added to capture effects of the manure after entering the creek.

On March 20, 2013, while sampling Second Creek, a large rain event was occurring. We collected a few samples from Pussyfoot Creek. This was the third time we saw manure flowing into Pussyfoot

Creek from the 180th Avenue SE location. A sample was taken of the slurry from where it ran along the roadway, but since there was no MIT representative, the mainstream was not sampled at P0.2. These data were not included in the data analysis, as mentioned in the Data Quality section of this report, but are included in Table 9. These data support that there are potential problems in the lower study area as well as in the roadside ditch along 188th Ave. SE (this site is discussed later).

Table 9. Pussyfoot sample data collected on March 20, 2013.

Sample Site	(FC cfu/100 mL)
PS0.2	TNTC
P1.12	740
188D	1200
188D (lab duplicate)	TNTC
SFPO.24	420

Even when no manure slurry was evident at the P0.2 sampling location, FC concentrations often were elevated downstream of the mainstream site P1.12 and the confluence of the SF tributary, SF0.23. This is illustrated in Figures 9 and 10 on April 9, 2013, and May 21, 2013, respectively.

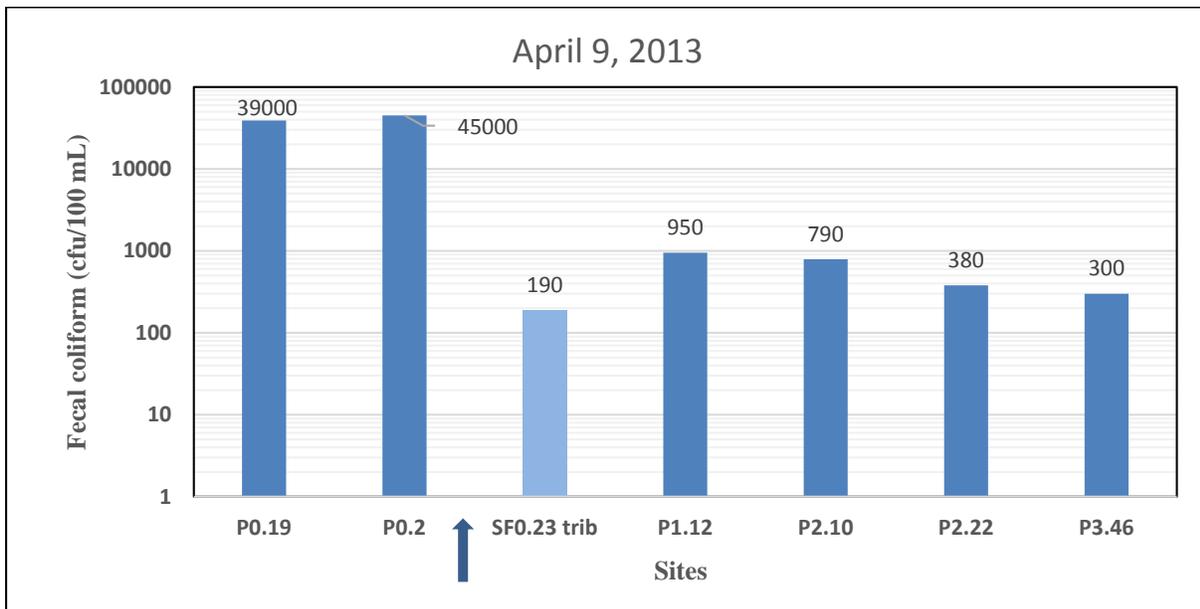


Figure 9. FC concentrations in the Pussyfoot Creek watershed. The arrow is to point out the increase in concentration at site P0.2 indicating a source.

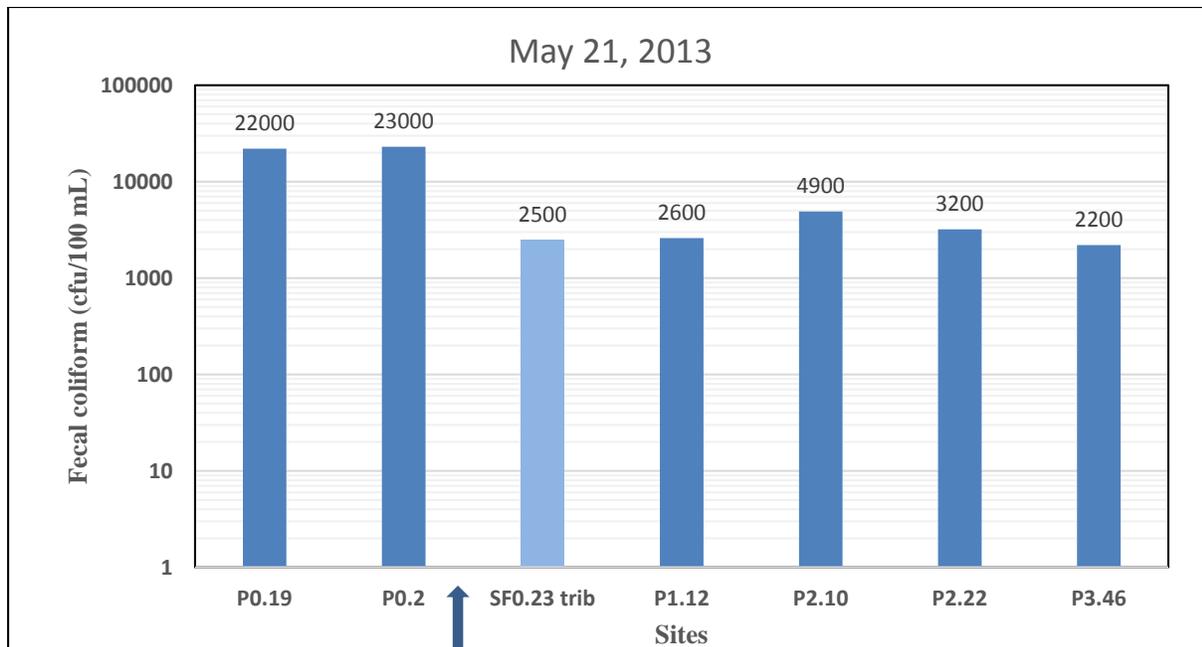


Figure 10. FC concentrations in the Pussyfoot Creek watershed. The arrow is to point out the increase in FC concentration at the site P0.2 indicating a source.

The entire watershed responded to the May 21, 2013 rain event when 0.2 inches of rain fell in the previous 12 hours; with most falling between 0400 and 0800 that morning before samples were collected. Many sites had their highest FC concentrations on this day.

However, on May 21, 2013, the water was noticeably turbid in Pussyfoot Creek at sites P0.2 and P0.19, the lower most sites sampled in this study (waters were not turbid at sample sites upstream). The MIT staff called Washington State Department of Agriculture (WSDA) based on their previous knowledge of this site and water quality. Subsequent investigation by WSDA and MIT identified poor management practices at the local dairy. A Notice of Correction was issued by WSDA in August 2013.

Direct Animal Access

Additional areas in the Pussyfoot watershed were identified as having priority concerns for sources of FC bacteria. One is the area near P2.22 where the creek crosses 196th Ave. SE. and the other is on the SF tributary area near SF0.35 also on 196th Ave. SE.

Pussyfoot Creek at 196th Ave SE.

The mainstem was sampled (P2.22) on the upstream side of 196th Ave. SE. This is an area where cows were not fenced out of the creek and the banks were trampled from use. There were a few cows and occasionally horses. These animals directly impacted waters at P2.22 as well as potentially impacting the small tributary PT0.01, see Table 10. Both of these sites had their highest FC concentrations on May 21, 2013 (0.2 inches in 12 hr.) and May 7, 2013 (1.02 inches in 48 hrs.). Cows were seen in the pasture on these days. It is noteworthy that the water volume in the tributary was lower than that of the mainstem. PD2.10UC is influenced by roadside drainage including the possibility of waters from the small tributary (PT0.01) draining the pasture.

Table 10. FC concentrations at animal access areas above site P2.22 at 196th Ave, SE.

Date	Site FC (cfu/100 mL)	
	P2.22	PT0.01
5/21/2013	3200	4000
5/7/2013	2000	1100

Another source area was seen in the ditch PD2.22DR. This is the ditch that enters downstream of P2.22 (on the opposite of road of P2.22) and enters the mainstem on its right bank. There are cattle in the fields across the main road SE 400th St. This site had a concentration of TNTC on May 21, 2013 (though 2000 cfu/100 mL was later reported with a G qualifier – this 2000 cfu/100 mL used in the summary stats), and 34000 cfu/100 mL on 4/9/13. These were both days that had increased rain.

Site SF0.35 – a tributary to SF Pussyfoot Creek

This site is another where concentrations were high and the volume of water was low. This site had a geometric mean of 130 cfu/100 mL with 6 out of 16 samples exceeding 200 cfu/100 mL. The highest concentration (an estimated 6700 cfu/100 mL) was seen on July 9, 2013 when the cows were actually in the creek just above 196th Ave. SE.

Cows and horses were also pastured downstream of SFT0.35 and on the west side of the road most if not every visit to the area. The tributary has little riparian vegetation other than grass and is open to access from livestock. This area could not be accessed for sampling until farther downstream at site SF0.24 on 188th Ave. SE, which is after the tributary water enters the SF.

Horses were pastured upstream of this SFT0.35 site across the road (on the south of SE 416th St.). Sampling off this road was deemed to be too dangerous so upstream samples were not obtained. It is unclear if these horses have access to the creek.

Roadside ditch at 188th Ave. SE

Another area of concern was the roadside ditch along 188th Ave. SE. It is unclear if the FC originate from human sources or dogs and horses – or both. There are drainage pipes discharging into the ditch from the properties as well as dogs and occasional pastured horses. Figure 11 illustrates the difference between an upstream site (188D_UP) at the top of the road and the downstream site (188D). The data for this boxplot only includes the 5 days that both sites were sampled. It is quite evident that there is a source of FC entering this ditch. It is important to note that the flow in this ditch is very low and thus the loading into the SF Pussyfoot and the mainstem is also relatively low.

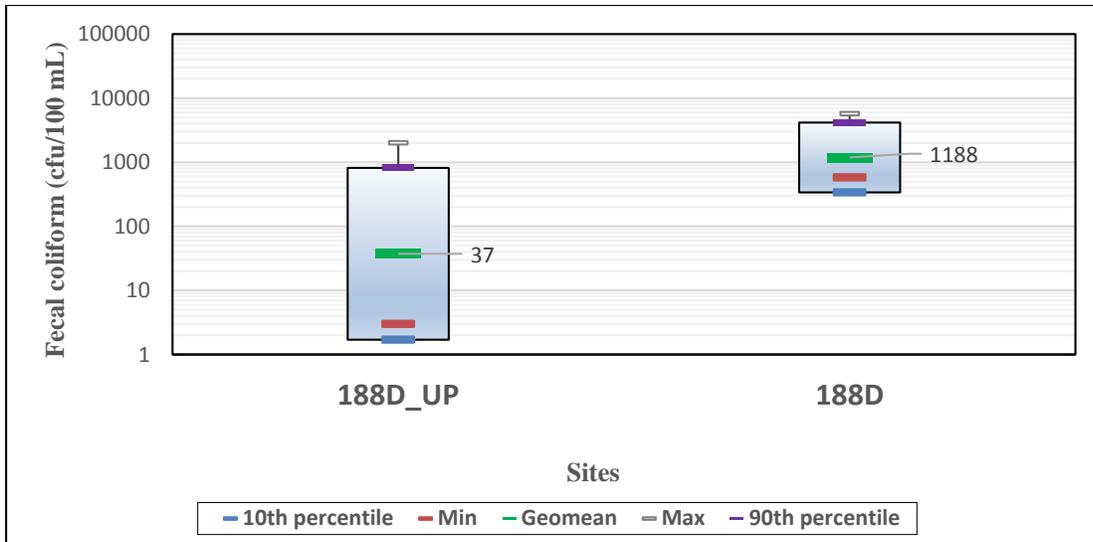


Figure 11. Boxplots depicting the distribution between the upstream and downstream sites in the roadside ditch on 188th Ave SE.

Second Creek

Precipitation

FC concentrations often increased with rain events, however only weak statistical correlations were identified between FC concentrations and previous 12 hour (hr.), 24 hr. or 48 hr. precipitation in most of the watershed. The response to precipitation and FC concentrations at the downstream site (S1.50) is seen in Figure 12. Most of the creek was dry by June. See appendix B for precipitation data.

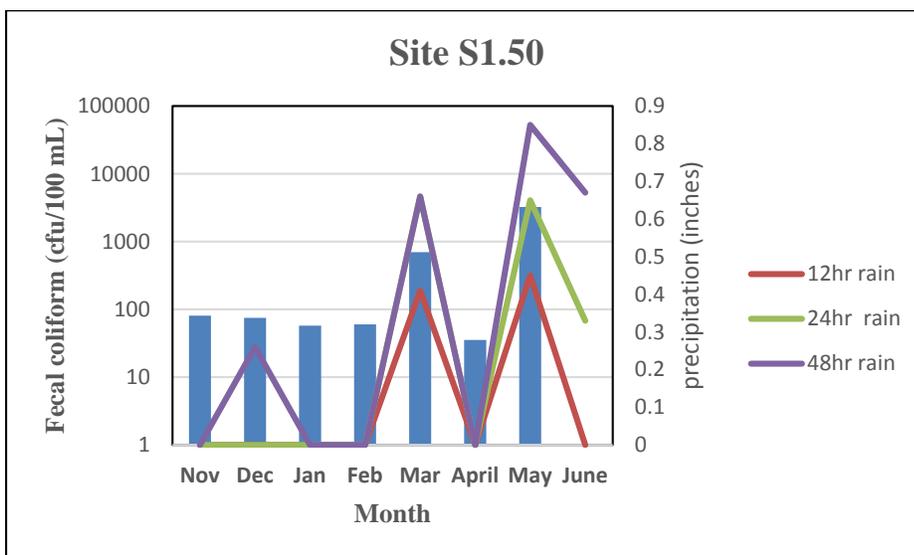


Figure 12. Second Creek and its response to precipitation seen at site S1.50.

Water Quality Criterion

Tables 11 and 12 show the summary statistics for FC in the Second Creek watershed. The highlighted cells indicate that the site exceeded the water criteria during the months of the study 2012-2013. All but one site, SD2.08UPR, exceeded both parts of the Primary Contact criterion. Figure 13 shows the distribution of FC concentrations for those sites that had a sample size greater than 5. The ditch sites often had enough water to collect a representative sample after a recent rain event. The sample size is quite small and the volume of water was low. However, from the data it appears that they are carrying rainwater contaminated by FC bacteria.

Table 11. Second Creek sites with FC summary statistics. The highlighted cells indicate that the water quality criterion was not met.

	Mainstem sites			Tributary
	S1.50	S2.07	S2.08	ST0.01
10th percentile	18	16	14	46
Minimum	36	27	26	43
Geometric mean	150	167	163	232
Maximum	3250	5400	6200	2000
90th percentile	1257	1415	1210	1164
# of samples (N)	7	8	9	7
# > 200	2	3	3	3
>200	29%	38%	33%	43%

Table 12. Second Creek Ditch sites with FC summary statistics. The highlighted cells indicate that the water quality criterion was not met.

	Ditches					
	SD1.50DL	SD1.50DR	SD1.50UR	SD2.07DL	SD2.08UL	SD2.08UPR
10th percentile	70	530	55	13	52	1
Minimum	88	800	85	27	46	6
Geometric mean	318	1327	578	177	294	53
Maximum	1200	2200	3300	2000	1200	470
90th percentile	1435	3318	6082	2415	1671	2763
# of samples (N)	4	2	3	4	7	2
# > 200	2	2	2	2	5	1
>200	50%	100%	67%	50%	71%	50%

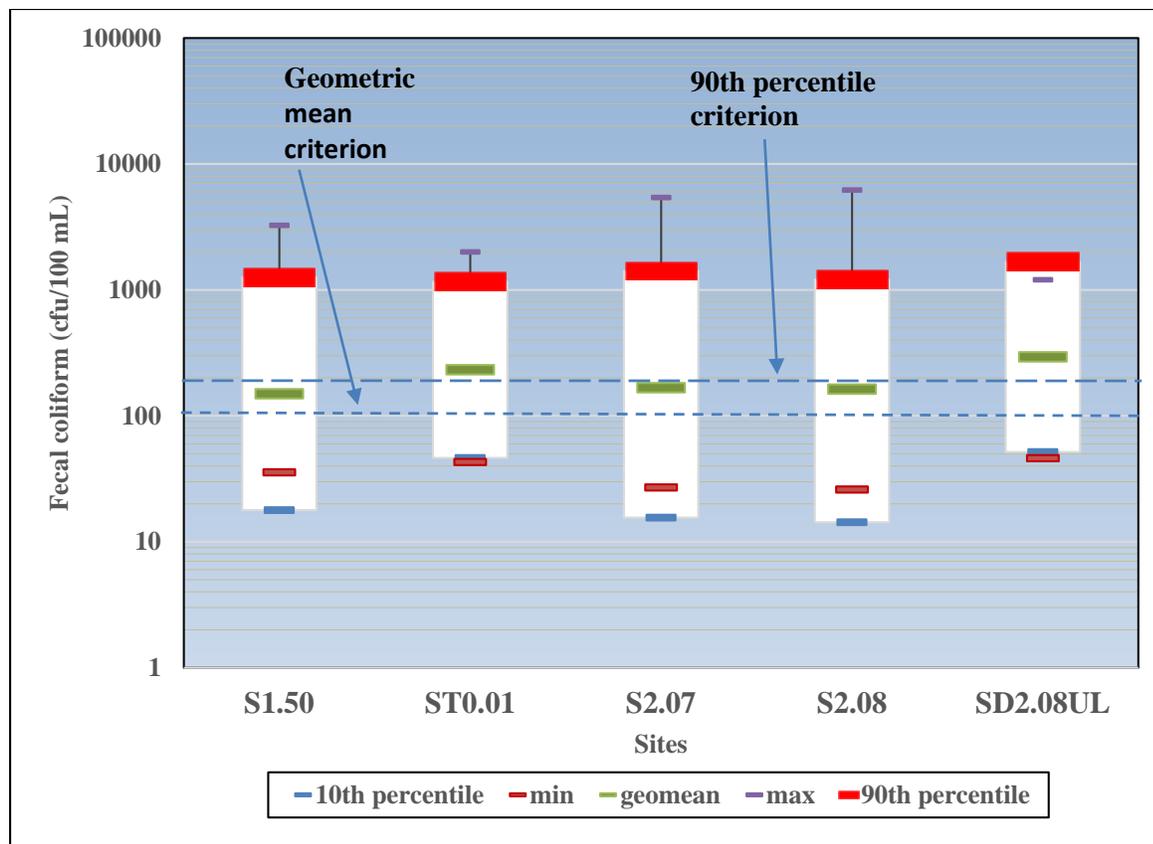


Figure 13. Boxplots depicting the distribution of the FC concentrations for select sites sampled in the Second Creek watershed. Only sites that had a sample size (N) >5 are illustrated.

There are humans, dogs, horses, cattle, and wildlife in the watershed. It is hard to determine where the sources are entering the ditches, tributary and creek.

Conclusions

The water quality monitoring conducted in Pussyfoot Creek watershed and Second Creek watershed during 2012-2013 found that the majority of sites exceeded the Primary Contact water quality criterion for fecal coliform bacteria. None of the mainstem sites were in compliance with the standard.

Pussyfoot Creek did not meet the primary contact standard when entering the MIT land. Based on results, Second Creek most likely did not meet these standards when entering MIT lands either, though the most downstream site was above the MIT boundary.

Elevated FC concentrations in the Pussyfoot Creek watershed are primarily caused by livestock with direct access to waterbodies and poor manure management. The waters in the ditch along 188th Ave SE may be impacted by pet waste, livestock, and perhaps failing septic.

Recommendations

Non-point sources within the Pussyfoot Watershed and Second Creek Watershed should be prioritized for review and follow-up implementation activities should follow.

Non-point sources may include, but are not limited to:

- Livestock with direct access to stream or with poor manure management.
- Failing or improperly constructed septic systems.
- Pet waste.

Pussyfoot Watershed

Priority management activities in the basin should begin with:

1. Follow-up with WSDA on manure management at the dairy on 180th Ave SE.
2. Work with appropriate entities to eliminate direct access of livestock in areas near site P2.22 on 196th Ave SE.
3. Work with appropriate entities to eliminate direct access of livestock near site SFT0.35 on 196th Ave SE.
4. Investigate the sources of bacteria entering the ditch on 188th Ave SE.

Second Creek

It is unclear where the sources are specifically originating in the watershed.

- The ditching system in Second Creek needs to be further investigated to identify where sources of bacteria may be entering the roadside ditches and the creek.
- Livestock and manure management should be reviewed. Best management practices should be established and maintained.
- Clarify whether there are dairies in the area that may drain into Second Creek watershed and ditching system. Ensure best management practices are established and being maintained.

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Appendices

Appendix A. Precipitation for Pussyfoot Creek Watershed Sampling Dates

Pussyfoot Creek	Precipitation (inches)		
	12 hrs.	24 hrs.	48 hrs.
Sample Date			
11/6/12	0	0	0.56
12/4/12	0.43	0.54	1.09
12/19/12	0	0	0.26
1/8/13	0.12	0.28	0.85
1/22/13	0	0	0
2/5/13	0.13	0.13	0.16
2/19/13	0	0	0
3/5/13	0	0	0
3/19/13	0	0	0.07
4/9/13	0.05	0.13	1.02
4/23/13	0	0	0.13
5/7/13	0	0	0
5/21/13	0.2	0.2	0.2
6/4/13	0	0	0
6/18/13	0.09	0.34	0.41
7/9/13	0	0	0

Appendix B. Precipitation for Second Creek Watershed Sampling Dates

Second Creek	Precipitation (inches)		
Sample Date	12 hrs.	24 hrs.	48 hrs.
11/28/12	0	0	0
12/19/12	0	0	0.26
1/23/13	0	0	0
2/20/13	0	0	0
3/20/13	0.41	0.66	0.66
4/24/13	0	0	0
5/22/13	0.45	0.65	0.85
6/19/13	0	0.33	0.67
7/8/13	0	0	0