Pierre Creek and Burns Creek Fecal Coliform Bacteria Water Quality Monitoring Study

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Pierre Creek and Burns Creek Fecal Coliform Bacteria Water Quality Monitoring Study

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303(d) Listings Addressed in this Study
Pierre Creek WA-14-1190 fecal coliform bacteria
Burns Creek WA-14-1195 fecal coliform bacteria

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Abstract

Water quality monitoring for fecal coliform bacteria (FC bacteria) was conducted in the Pierre Creek and Burns Creek watersheds during spring 2007and fall 2007. The objectives of the study were to assess compliance with Washington State's Extraordinary Primary Contact Recreational water quality standards for FC bacteria and to identify potential sources of FC bacteria. Results show that FC bacteria levels are not meeting the Extraordinary Primary Contact standard for FC bacteria in either Pierre or Burns Creek. Areas draining livestock pasture have the highest FC bacteria concentrations.

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Introduction

Pierre Creek and Burns Creek are small watersheds in the lower reach of Totten Inlet, Thurston County (Figure 1). Both creeks have been on Ecology's list of impaired water bodies (303(d) list) for many years. They were on the 303(d) list in 1996, 1998, and 2004 for fecal coliform (FC) bacteria violations. They are now listed for bacteria in the proposed 2008 Water Quality Assessment. FC bacteria are used as an indicator of bacterial contamination from humans and other warm-blooded animals such as livestock, pets, and wildlife. Elevated concentrations in water may result in unhealthy conditions for primary contact during recreation and unsafe shellfish consumption. Resources have been focused on these watersheds in efforts to clean up bacterial pollution. See Appendix A for additional information on federal Clean Water Act requirements such as the 303 (d) list and Water Quality Assessment.

Washington State Department of Ecology (Ecology) monitored these creeks from 1992 through 2002 as part of the comprehensive National Monitoring Project (NMP) in Totten and Eld Inlets (Batts and Seiders, 2003a and 2003b). Pierre and Burns Creeks violated water quality standards for FC bacteria every year of the investigation. Ecology developed a Total Maximum Daily Load (TMDL) study for tributaries to Totten Inlet (Ahmed and Hempleman, 2006) using historic data collected by staff from Ecology, Thurston County, Squaxin Island Tribe, and Mason County. Pierre Creek and Burns Creek were part of that TMDL study. The TMDL concluded that these two creeks still violated water quality standards for FC bacteria and concentrations needed to be reduced. The 2008 Water Quality Assessment listed both creeks under Category 4a. This means that a TMDL has been conducted, approved, and is being implemented. However, these creeks continue to be out of compliance with state water quality standards for FC bacteria.

Pierre Creek and Burns Creek are classified as Extraordinary Primary Contact Recreational waters (Appendix B). Under this classification, FC bacteria levels must not exceed a geometric mean value of 50 colonies (cfu/100 mL). Additionally, not more than 10 percent of all samples obtained for calculating the geometric mean value may exceed 100 cfu/100 mL. If the sample size is less than 10 at a particular site it takes one sample to exceed 100 cfu/100 mL to render the site out of compliance with the standard.

Shellfish harvesting is an important commercial and non-commercial activity in Totten Inlet. Though Burns Cove is designated as '*Unclassified*' (not open to commercial harvesting) by the Washington State Department of Health (DOH) the waters are used for recreational activities and private shellfish harvesting. Additionally, waters in Burns Cove mix with Totten Inlet. Totten Inlet is not on Ecology's 303(d) list for FC bacteria and is categorized as *Approved* for shellfish harvesting. However, recently DOH has determined that concentrations of bacteria in the Inlet increase to unhealthy levels after heavy rain events. Therefore, the shellfish beds in Totten Inlet will enter an emergency closure whenever three inches or more of rain falls in 24 hours as measured at the Olympia Airport (Cleland, 2008, personal communication, and Appendix C).

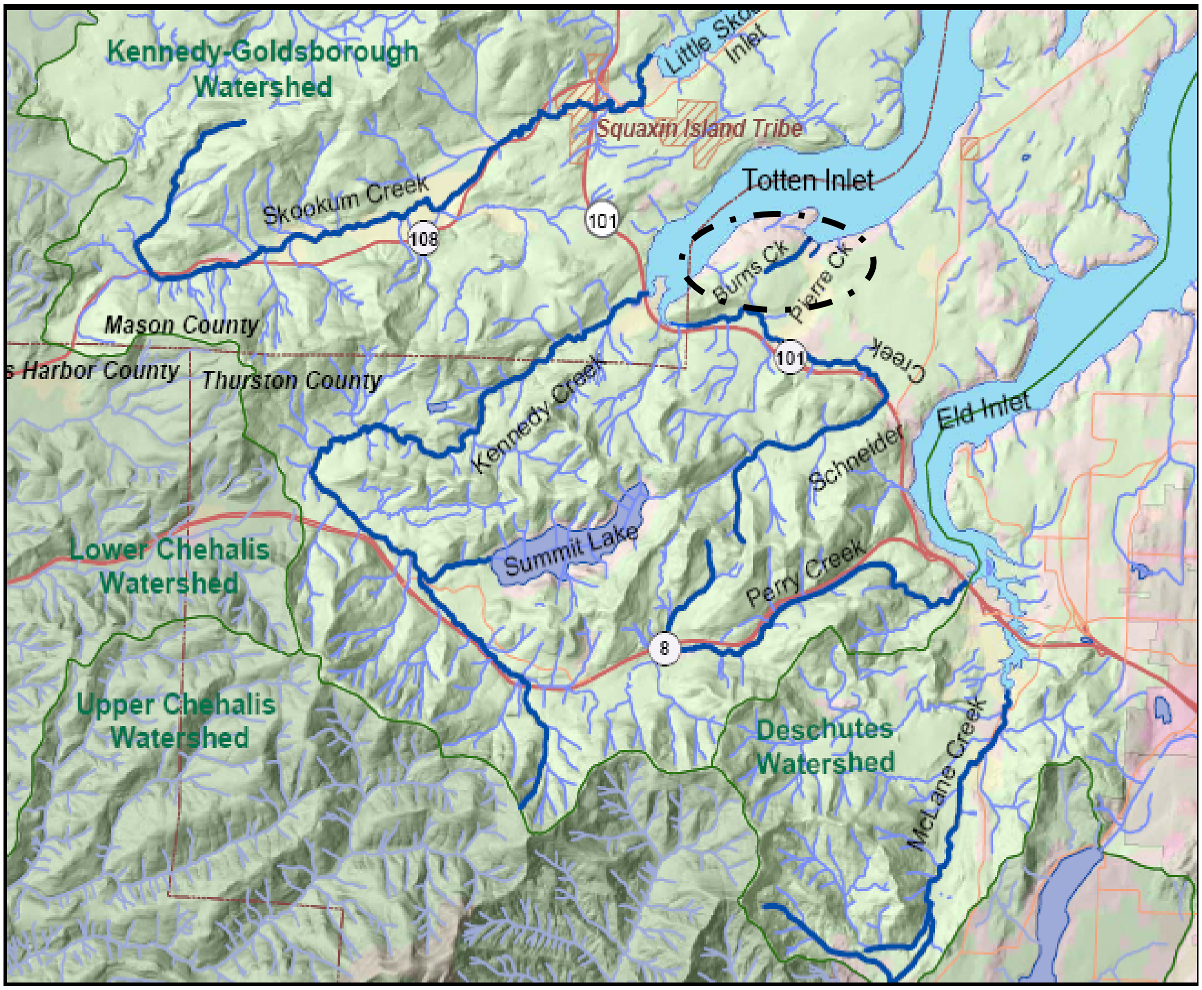


Figure 1. Map of study area.

Study Area

Burns and Pierre Creeks are small adjacent watersheds. Burns Creek is 0.26 square miles and Pierre Creek is 0.16 square miles (Ahmed and Hempleman, 2006). The creeks drain into Burns Cove near the southern end of Totten Inlet. During certain years the creeks are dry or very low from May/June through August/September.

The Pierre and Burns Creek watersheds include a mixture of rural residential, agricultural, and forested lands. Possible sources for bacterial pollution include livestock, other domestic animals, wildlife, and on-site septic systems. Most of the sites for this project are located on Oyster Bay Farm. Best management practices (BMPs) have been implemented over the course of many years. Examples of some of the improved management activities include: rotating livestock between pastures, reduction of livestock numbers during the wet season, and creek fencing. BMP implementation and effectiveness are not quantified in this study.

Methods

Objectives and Study Design

The objectives of the study were to:

- Collect weekly water quality samples to assess compliance with state Extraordinary Primary Contact Recreational water quality standards for FC bacteria.
- Identify areas of elevated FC bacteria concentrations to assist in locating potential bacteria sources.

Aware that the creeks go dry during the critical period set by the TMDL (May –June), sampling was initiated as soon as resources could be deployed. Water samples were collected weekly from March 2007 until the creeks went dry in late May 2007. Sampling was initiated again in the fall to characterize conditions once the creeks started to flow again. Samples were delivered to Ecology's Manchester Environmental Laboratory (MEL) for analysis.

Mouth sites are the same used for the TMDL analyses (Ahmed and Hempleman, 2006) and during NMP monitoring (Batts and Seiders, 2003a):

- P1 was previously PIE at the mouth of Pierre Creek
- B1 in this study was BUR at the mouth of Burns Creek
- B2S in this study was BUR2 at the south side of Oyster Bay Road

Additional upstream monitoring sites were selected for this study to identify potential sources of FC bacteria (Figure 2 and Table 1). See the project's Quality Assurance Project Plan (QAPP) (Dickes, 2007) for additional study design information.

Effort was made to collect at least ten samples during the study period. However, various complications prevented this from happening including tidal cycle, adequate water depth, and access issues. It only takes one sample that exceeds 100 cfu/100 mL to violate the 90^{th} percentile criterion when less than 10 samples are collected at a site. Compliance with both parts of a two-part standard must be attained to achieve compliance.

Pierre Creek

Site P4 was dropped after realizing it was located too far into the pasture and did not reflect background conditions. This site was replaced with the sampling site named *PFOREST*. PFOREST is located about 300 feet upstream of the pasture. There is little human activity in this area.

Site P1 was located at the lower reach of Pierre Creek. It is the same location used for NMP monitoring and TMDL data analyses. The location is upstream from the Hofman residence. Sampling results, therefore, do not reflect bacterial contributions, if any, from this residence. Discharge was measured at this site to match what was done in the NMP study and used in the TMDL analyses. But, a bacterial loading analysis was not part of the project objectives. Flow data will be available in Ecology's Environmental Information Management (EIM) database (http://www.ecy.wa.gov/eim/).

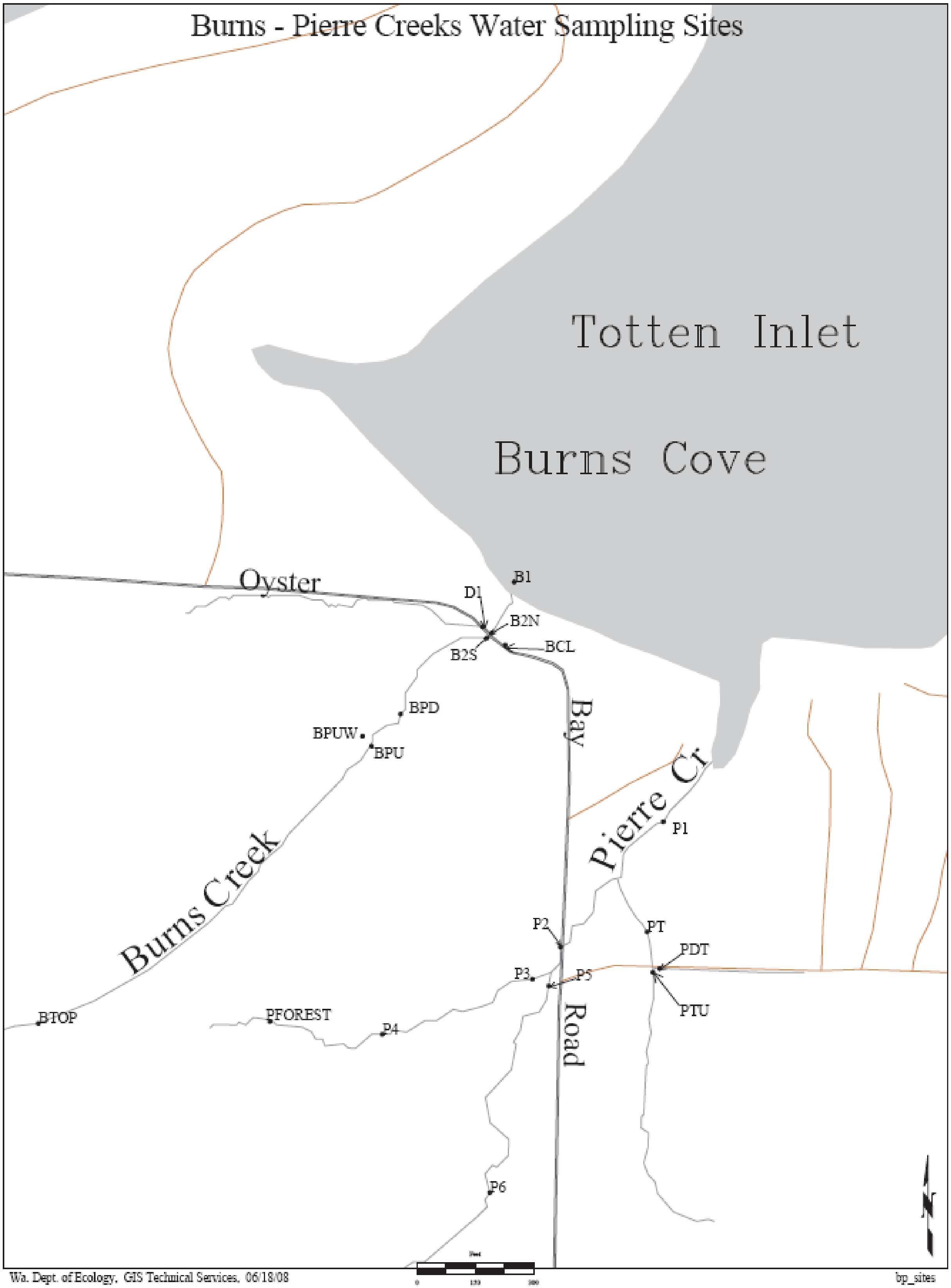


Figure 2. Location of sample sites on Pierre Creek and Burns Creek.

Table 1. Site location descriptions for Burns Creek and Pierre Creek.

SITE NAME	LATITUDE	LONGITUDE	DESCRIPTION [1]
BURNS CREEK			
B1	N 47 º 06' 22.2 "	W123° 02' 39.1"	Mouth located on tidal flat
B2N	N 47 º 06' 21.8 "	W123° 02' 39.5"	Below culvert on north side (beach side) of Oyster Bay Road
B2S	N 47 º 06' 21.4 "	W123° 02' 40.8"	Culvert on south side of Oyster Bay Road above confluence with D1
BCL	N 47 º 06' 21.3 "	W123° 02' 38.6"	Culvert draining lower NE pasture - where well house is located
BPD	N 47 º 06' 18.6 "	W123° 02' 43.4"	Downstream end of pond
BPU	N 47 º 06' 17.8 "	W123° 02' 44.7"	Upstream end of pond
BPUW	N 47 º 06' 17.8 "	W123° 02' 45.7"	Run-off rivulet from upper wet pastures
BTOP	N 47 º 06' 11.0 "	W123° 02' 55.5"	SW property line of Oyster Bay farm
D1	N 47 º 06' 21.6 "	W123° 02' 41.1"	Mouth of ditch flowing east down Oyster Bay Road. Just upstream of confluence with Burns.
PIERRE CREEK			
P1	N 47 º 06' 16.4 "	W123° 02' 33.1"	Pierre 250 feet above mouth
P2	N 47 º 06' 13.1 "	W123° 02' 36.3"	North on creek NE side of intersection of Oyster Bay Road and 49th Ave
P3	N 47 º 06' 12.7 "	W123° 02' 37.5"	SW tributary just west of Oyster Bay Road
P4	N 47 º 06' 11.1 "	W123° 02' 42.8"	SW tributary west of Oyster Bay Road at forest line
PFOREST	N 47 º 06' 11.7 "	W123° 02' 48.8"	Above pasture in the forest.
P5	N 47 º 06' 12.5 "	W123° 02' 37.0"	SW tributary just west of Oyster Bay Road
P6	N 47 º 06' 08.7 "	W123° 02' 39.7"	SW tributary west of Oyster Bay Road below adjacent properties pond
PT	N 47 º 06' 14.1"	W123° 02' 33.0"	Tributary to Pierre coming in from the SE, sampled north of 49th Ave
PTU	N 47 º 06' 12.6 "	W123° 02' 33.1"	Tributary to Pierre south of 49th Ave above influence of PDT
PDT	N 47 º 06' 12.9 "	W123° 02' 32.9"	Ditch flowing west along 49th into PTU

1 Visual location see Figure 2

Burns Creek

Site B1 and B2N are tidally influenced. As a result, these sites were not routinely sampled. A relationship was not developed between bacterial concentrations at B1 and the B2S culvert for this study. Flow measurements could not be taken at B2N due to thick and overhanging stream side vegetation.

Discharge was measured at the lowest site in the watershed, B1, when possible. Bacterial loading analysis was not part of the project objectives. Flow data will be available in Ecology's EIM database.

Field and Laboratory Methods

Field protocols followed those described in Cusimano, 1993, and MEL 2005. Laboratory methods followed those documented in MEL 2006. See Figure 2 for a map of sampling sites. Site locations are described in Table 1.

Data Analysis Methods

Field and laboratory data were compiled and managed using Microsoft Excel® software. The average of the field replicate pair value was used in data analyses. Laboratory duplicate values were used to provide with-in laboratory quality assurance information. The non-parametric Wilkoxon paired sample test was used to compare bacteria concentrations between upstream and downstream sites (two-tailed test with significance level of α=0.05).

Quality Assurance Data

Quality assurance data and additional discussion can be reviewed in Appendix D and E.

Laboratory Duplicates

Results of laboratory duplicate pairs were accepted and reflect quality laboratory analyses.

Field Replicates

Method Quality Objectives (MQOs) for bacteria set by Ecology's Environmental Assessment Program (Ecology, 2006) were used to analyze field replicate samples (Appendix E). The 28 replicate pair sub-set from this study did not meet the two-part MQO. Fifty percent of the replicates were below a 22% relative standard deviation (RSD) instead of below 20% RSD. Ninety percent of the samples *were* below a RSD of 50%. Both of these creeks are small and shallow and extreme care was taken to avoid sample contamination. It was concluded that all data were acceptable.

Results & Discussion

A summary of laboratory and field data can be found in Appendix D and precipitation (as recorded at Olympia Airport) can be found in Appendix F.

Sample size needs to be considered when reviewing the water quality results. With bacteria, for example, sample size influences whether a site will be in compliance with the state's water quality standard. It is a two-part standard as mentioned in the Introduction. Therefore, even if the site meets the first part of the standard (geometric mean less than 50 cfu/100 mL) it only takes one sample over 100 cfu/100 mL (second part of the standard) to result in it being out of compliance with the state standard.

Pierre Creek Results

In general, bacteria concentrations in Pierre Creek are not meeting designated state water quality standards for Extraordinary Primary Contact Recreational waters, as can be seen in Table 2. Data are visually represented with box plots in Figure 3 and summarized in Appendix G.

FC bacteria concentrations are not in compliance with water quality standards in the southwest pasture of Oyster Bay Farm. FC bacteria concentrations increase significantly as Pierre Creek water flows across the southwestern pasture from sampling site P6 through the pasture to site P5 (Figure G- 1) and from the mainstem site PFOREST to site P3 toward Oyster Bay Road (Figure G- 2). The pasture is wet and supports wetland plants. It may be that water flows easily across the pasture picking up remnant and fresh manure before discharging to the creek.

The southeast tributary of Pierre Creek was not in compliance with water quality standards. Samples were collected both from water running west along the ditch (site PDT) as well as water from the primary tributary channel running north across the field (PTU) before crossing under 49^{th} Avenue. Data reflect that sources of bacteria are draining into the culvert at the 49^{th} Avenue sampling sites. This basin includes livestock pasture, an independent business for cat boarding, as well as rural residential development. A site representing background conditions was not identified for this tributary.

Sites P6 and PFOREST are the two sites that did comply with state water quality standard for Extraordinary Primary Contact Recreational waters. Sample site PFOREST is located in a forested area above agricultural lands and above other consistent human influence. Site P6 characterizes water flowing from a constructed pond on rural residential property. On April 9, 2007, sampling occurred during a notable rain event (0.35 inches preceded by 0.83 over previous two days). This storm resulted in a watershed-wide run-off event with most sites experiencing the highest concentrations of bacteria for the study. However, bacteria concentrations at PFOREST stayed relatively unaffected during the storm. Bacteria concentrations increased at P6, but not to the extent seen at the downstream sites.

Table 2. Pierre Creek site data and compliance with the state water quality standard for FC bacteria.

Site Name	# of samples	# of samples > 100	First part of Standard (cfu/100 mL)			Second part of Standard (cfu/100 mL)		Compliance with WQ Standard?
			Geometric Mean (GM)	GM <50		90th percentile	<100	
P1	13	4	71	N		434	N	No
P2	11	4	114	N		653	N	No
P3	9	2	70	N		336	N	No
PFOREST	8	0	2	Y		10	Y	Yes
P5	9	4	113	N		590	N	No
P6	9	0	8	Y		43	Y	Yes
PT	11	5	104	N		961	N	No
PTU	8	3	87	N		477	N	No
PDT	6	3	168	N		1509	N	No

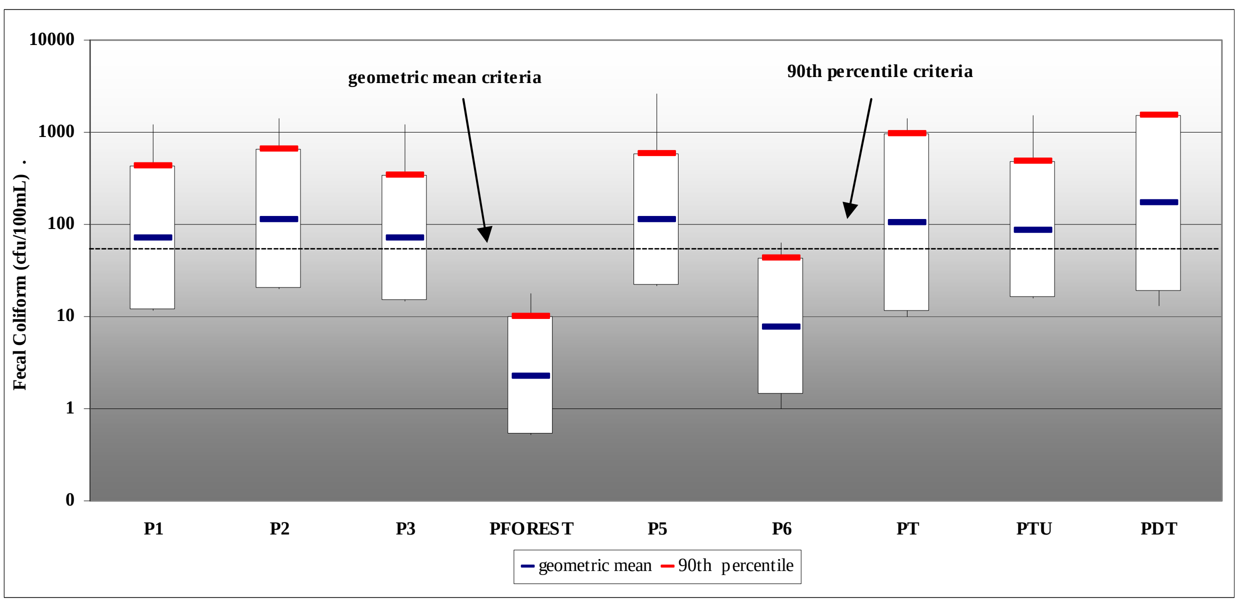


Figure 3. Pierre Creek Bacteria concentration data described with box plots. Note the logarithmic scale.

Burns Creek Results

In general, FC bacteria concentrations in Burns Creek are not attaining state designated water quality standard for Extraordinary Primary Contact Recreational waters as can be seen in Table 3 and Figure 4, and summarized in Appendix G.

There is a pond in Burns Creek that is frequented by ducks and most likely other wildlife. FC concentrations at the downstream site were noticeably higher during the April 9, 2007 storm event (Figure G-3), but in general concentrations upstream and downstream of the pond were similar.
There was a small run-off rivulet flowing into the pond from the west (site BPUW). It was often dry or too shallow to obtain a quality sample. This rivulet drains the hillside pastures. The seven samples taken had a geometric mean (GM) of 118 cfu/100 mL exceeded only by the culvert BCL (described below). The water from this small channel had elevated bacteria concentrations relative to other sites sampled on the same day.

Bacteria concentrations were usually higher at site B2S when compared to site BTOP (Figure G-4), and was found to be statistically significant. This reflects that there are sources of bacteria entering Burns Creek as it flows from upper forested property down through the pastures toward the roadway. Examples of land use in this area include pasture, chicken yard, livestock shelter, a pond, a residence, and a septic drain field.

Two sites in Burns Creek watershed were in compliance during this study period, sites D1 and BTOP. Both site D1 and site BTOP are not directly influenced by intense human influence. The D1 samples are taken from the roadside ditch and characterize a small wetland area having minimal residential or agricultural activities. The ditch also transports run-off from the adjacent Oyster Bay Road. The sampling location was located at the mouth of the ditch just above the confluence with Burns Creek (Figure 2). Water from site BTOP flows on to Oyster Creek Farm from the west. There are rural residential and livestock influences upstream. Both responded to the April 9, 2007 rain event, but not to the extent of other sites. Easy site comparisons can be made with Appendix G data summaries.

Of particular note is the sampling station identified as BCL. The location of this culvert was not previously known and thus was not sampled in previous studies. This sample site characterized water from the northeast pasture of Oyster Bay Farm. The water is carried under Oyster Bay Road in a concrete culvert. The sample was collected as the water dropped toward the channel below. The flow from this tributary joins Burns Creek as it flows in its tide flat channel. Bacteria levels were often elevated at BCL relative to other sites. The first opportunity to get a water sample at BCL in the fall was October 8, 2007. An estimated bacteria concentration of 60,000 cfu/100 mL resulted from sample analyses. The high values may reflect high concentration due to low volume, however, the exceptionally high bacteria level also indicates that there is a source of bacteria coming from the basin discharging into the culvert. The pasture contains a well house, a mobile trailer residence, and usually about four sheep during the winter months. The pasture may also collect run-off from the chicken yard and areas upslope to the west.

Table 3. Burns Creek data and compliance with the state water quality standard for FC bacteria.

Site Name	# of samples	# of samples > 100	First part of Standard (cfu/100 mL)			Second part of Standard (cfu/100 mL)		Compliance with WQ Standard?
			Geometric Mean (GM)	GM <50		90th percentile	<100	
B1	9	2	40	Y		142	N	No
B2N	10	2	38	Y		225	N	No
B2S	10	3	58	N		652	N	No
BPD	9	1	36	Y		274	N	No
BPU	9	2	19	Y		124	N	No
BPUW	7	4	118	N		508	N	No
BTOP	9	1	9	Y		48	Y	Yes
BCL	12	8	319	N		6187	N	No
D1	11	0	7	Y		38	Y	Yes

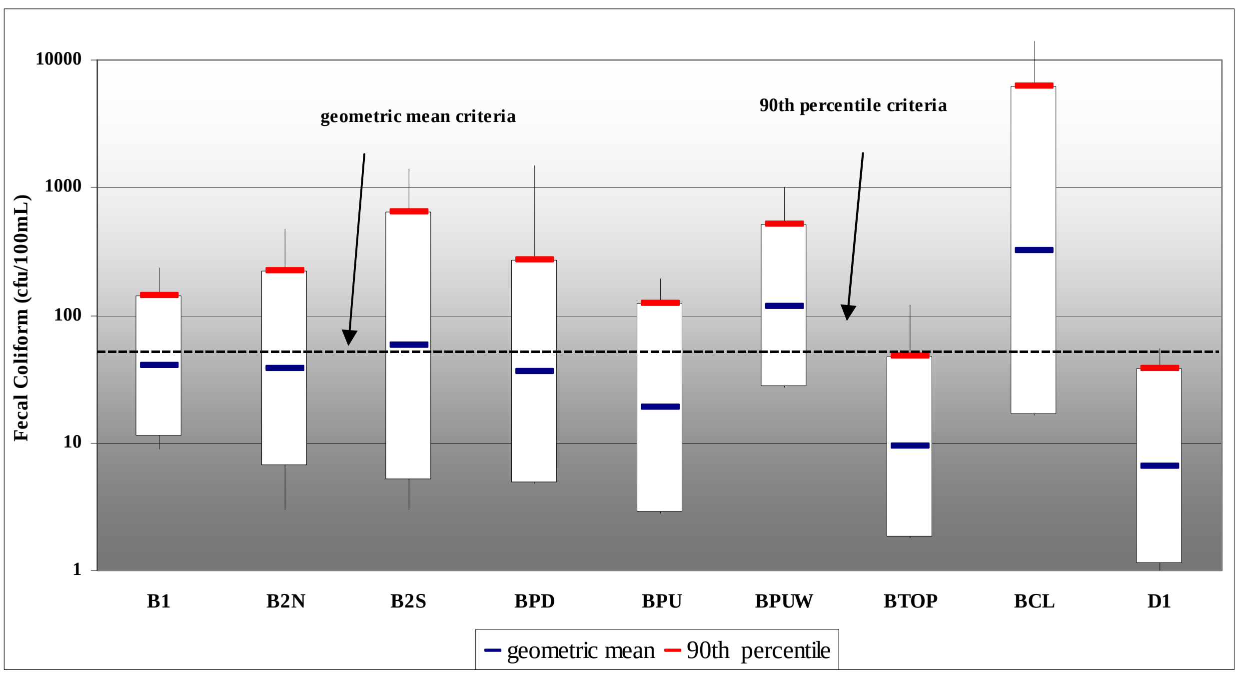


Figure 4. Burns Creek FC bacteria concentration data described with box plots. Note the logarithmic scale.

Conclusions

- Water quality in Pierre Creek was not in compliance with designated water quality standards for FC bacteria during the period of this study March 2007 into November 2007.
  - Bacteria concentrations increase as water flows downstream across the upper pasture mainstem (PFOREST to P3) as well as downstream across the southwest tributary (P6 to P5) toward Oyster Bay Road. It appears that new and or remnant manure is entering Pierre Creek in these areas.
  - Results from sites PTU and PDT suggest that there are sources of bacteria entering the creek from the area south of 49^{th} Avenue. This area includes pasture, an independent business for cat boarding, as well as rural residential development.
- Water quality in Burns Creek was not in compliance with designated water quality standards for FC bacteria during the period of this study March 2007 into November 2007.
  - Bacteria concentrations increase as water flows down from the upper forested area (BTOP) north toward Oyster Bay Road (B2S). Land use in this area includes pasture, livestock holding areas, a residence, and a septic field.
  - There was a small run-off rivulet flowing into the pond from the west, site BPUW. It drains the hillside pastures. This run-off water had elevated concentrations of FC bacteria.
  - The northeast field, as represented by site BCL, had elevated FC bacteria concentrations. Land use includes pasture and potential livestock influences, a residence, and an old well house.
- FC bacteria concentrations in both Pierre and Burns Creeks increase in response to run-off events.
- The Pierre and Burns Creek watersheds include a mixture of rural residential, agricultural, and forested lands. Possible sources for bacterial pollution include livestock, other domestic animals such as dogs and cats, wildlife, and on-site septic systems.
- Pierre Creek and Burns Creek are typically dry June through September.

Recommendations

- Contributions of FC bacteria to the upper reaches of the Pierre Creek watershed must be reduced. Restoring riparian vegetation and fencing the creek through this area may be effective. The Thurston Conservation District should be contacted for assistance in determining measures for effective management.

- Investigate the sources of bacteria entering the 49^{th} Avenue roadside ditch and entering the tributary of Pierre Creek crossing 49^{th} Avenue. FC bacteria sources must be identified and reduced.

- Determine if there is ground water continuity impacting water quality from west to east across the upper Pierre Creek basin.

- The source for the elevated FC bacteria concentrations seen at site BCL must be identified. Impacts from the well house and the residential trailer should be looked at as well as livestock influences. This could include sampling the water from the well house as well as checking the sanitary system used by the trailer.

- The Thurston Conservation District should be contacted for assistance in determining measures for effective agricultural land management.

- The Thurston County Environmental Health Division should be contacted to ensure all sanitary systems in the basin are adequately maintained and continue to work properly. Dye testing should be considered.

- Continue to implement and maintain BMPs to reduce bacterial contamination to the creeks.

- Review pasture and livestock management practices to ensure water quality is being protected.

- Records of annual land management activities could assist in understanding the sources for bacterial contamination in the water. This would include tracking structural BMPs, number of animals grazing in which pasture and when, acreage moving into or out of agriculture, as well as other changes in land use throughout the seasons.

- Effectiveness monitoring should be considered after source identification is complete and BMPs installed. Monitoring for bacteria should be conducted during an entire year to include effects of run-off in a sequential fall/winter season. Recommendations for that study would include but should not be limited to:
    - Discharge should be measured at all sites, if possible, so that loading calculations can further assist in source identification and effectiveness monitoring.
    - Add sites in the upper watersheds to identify what is coming in from the upper areas.
    - Storm events should be targeted, especially initial storms in the fall.

- Re-evaluate the critical season as defined in the TMDL.

- Calculate bacterial loading using the 2007 data and review the TMDL targets for these sites.

- Compare 2007 data with historic data to document water quality over time.

- Investigate water quality of other drainages and seeps entering Burns Cove. This would provide a more complete view of impacts from the rural residential area draining into the cove and ultimately impacting waters in the larger Totten Inlet.

References

Ahmed, A and Hempleman, C., 2006. Tributaries to Totten, Eld, and Little Skookum Inlets: Fecal Coliform Bacteria and Temperature Total Maximum Daily Load - Water Quality Improvement Report. Washington State Department of Ecology, March 2006. Publication No. 06-03-007. Olympia, WA http://www.ecy.wa.gov/biblio/0603007.html

Batts, D. and K. Seiders, 2003a. Totten and Eld Inlets Clean Water Projects: Final Report. Washington State Department of Ecology, Olympia, WA. Publication No. 03-03-010. www.ecy.wa.gov/biblio/0303010.html

--------- 2003b. Appendixes B, C, and D. Totten and Eld Inlets Clean Water Projects: Final Report. Washington State Department of Ecology, Olympia, WA. Publication No. 03-03-011. http://www.ecy.wa.gov/pubs/0303011.pdf

Cleland, B., 2008. Personal communication. Washington State Department of Health. April 25, 2008.

Cusimano, B. 1993. Field Sampling and Measurement Protocols for the Watershed Assessments Section. Publication Number 93-e04. Washington State Department of Ecology, Olympia, Washington. http://www.ecy.wa.gov/pubs/93e04.pdf

Dickes, B. 2007. Water Quality Sampling for Fecal Coliform Bacteria in Pierre Creek and Burns Creek. Publication Number 07-10-036. Washington State Department of Ecology, Olympia, Washington. http://www.ecy.wa.gov/pubs/0710036.pdf

Ecology, 2006. Replicate Precision for 12 TMDL Studies and Recommendations for Precision Measurement Quality Objectives for Water Quality Parameters. Washington State Department of Ecology, Olympia, WA. Publication No. 06-03-044. www.ecy.wa.gov/biblio/0603044.html

Manchester Environmental Laboratory (MEL). 2005. Manchester Environmental Laboratory Users Manual. 8th Edition. Washington Department of Ecology, Manchester, WA.

MEL, 2006. Manchester Environmental Laboratory Quality Assurance Manual. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

Appendices

Appendix A

Federal Clean Water Act requirements Water Quality Assessment

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

Every two years, states are required to prepare a list of waterbodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list. To develop the list, Ecology compiles its own water quality data along with data submitted by local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before the data are used to develop the 303(d) list. The 303(d) list is part of the larger Water Quality Assessment.

The Water Quality Assessment is a list that tells a more complete story about the condition of Washington's water. This list divides waterbodies into one of five categories:

Category 1 – Meets standards for parameter(s) for which it has been tested.

Category 2 – Waters of concern.

Category 3 – Waters with no data available.

Category 4 – Polluted waters that do not require a TMDL because:

- 4a. – Has a TMDL approved and it's being implemented
- 4b. – Has a pollution control plan in place that should solve the problem
- 4c. – Is impaired by a non-pollutant such as low water flow, dams, culverts

Category 5 – Polluted waters that make up the **303(d)** list and require a TMDL.

TMDL process overview

The Clean Water Act requires that a Total Maximum Daily Load be developed for each of the waterbodies on the 303(d) list. A TMDL identifies how much pollution needs to be reduced or eliminated and still meet Washington State's Water Quality Standards, Chapter 173-201A of the Washington Administrative Code. Then Ecology works with the local community to develop (1) a strategy to control the pollution and (2) a monitoring plan to assess effectiveness of the water quality improvement activities.

Elements required in a TMDL

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant that can be discharged to the waterbody and still meet standards (the loading capacity) and allocates that load among the various sources.

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

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

TMDL = Loading Capacity = sum of all wasteload allocations + sum of all load allocations + margin of safety

Total Maximum Daily Load Analyses: Loading capacity

Identification of the contaminant loading capacity for a waterbody is an important step in developing a TMDL. The Environmental Protection Agency (EPA) defines the loading capacity as "the greatest amount of loading that a waterbody can receive without violating water quality standards" (EPA, 2001). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a waterbody into compliance with standards. The portion of the receiving water's loading capacity assigned to a particular source is a load or wasteload allocation. By definition, a TMDL is the sum of the allocations, which must not exceed the loading capacity.

Appendix B

Water Quality Criteria for Fecal Coliform Bacteria.

Table B1. Water Contact Recreation Bacteria Criteria in Freshwater

Water Contact Recreation Bacteria Criteria in Freshwater	
Category	Bacteria Indicator
Extraordinary Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.
Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies /100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for Calculating the geometric mean value exceeding 200 colonies /100 mL.
Secondary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 200 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 400 colonies /100 mL.

Bacteria, Fresh Waters

Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. In the Washington State water quality standards, fecal coliform is used as an “indicator bacteria” for the state’s freshwaters (e.g., lakes and streams). Fecal coliform in water “indicates” the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. The fecal coliform criteria are set at levels that have been shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

Use Categories

There are three use categories related to the freshwater bacteria criteria in Washington:

(1) The *Extraordinary Primary Contact* use is intended for waters capable of "providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas." To protect this use category: Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 100/colonies mL" [WAC 173-201A-200(2)(b), 2003 edition].

(2) The *Primary Contact* use is intended for waters "where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and waterskiing." More to the point, however, the use is to be designated to any waters where human exposure is likely to include exposure of the eyes, ears, nose, and throat. Since children are also the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection. To protect this use category: "Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 200/colonies mL" [WAC 173-201A-200(2)(b), 2003 edition].

(3**)** The *Secondary Contact* use is intended for waters "where a person's water contact would be limited (e.g., wading or fishing) to the extent that bacterial infections of the eyes, ears, respiratory or digestive systems, or urogenital areas would be normally avoided." To protect this use category: "Fecal coliform organism levels must not exceed a geometric mean value of 200 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 400/colonies mL" [WAC 173-201A-200(2)(b), 2003 edition].

Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than 10 total samples) limit. These two measures used in combination ensure that bacterial pollution in a waterbody will be maintained at levels that will not cause a greater risk to human health than intended. While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both monthly (if five or more samples exist) and seasonal (summer versus winter) data sets.

Appendix C

Emergency Closure Letter for Totten Inlet

October 4, 2007

«FirstName» «LastName»
«Organization»
«Address1»
«Address2»
«City», «State» «Zip»

Dear «Salute» «LastName»:

During the heavy rain storms we experienced in November of 2006, we collected water samples in Totten Inlet. The fecal coliform results from November 6, 2006 were very poor from Oyster Bay to Arcadia.

Although Totten Inlet is classified as Approved, it's obvious that heavy rains can rapidly transport pollution into the inlet, creating a health risk to shellfish consumers. As a result, we want to alert you that we plan to close all of Totten Inlet as shown on the enclosed maps whenever three inches or more of rain falls in 24 hours as measured at the Olympia Airport. National Weather Service records indicate such heavy rains happen in Totten Inlet about once every two years. Our experience indicates that we would need to close the area for a period of one week; however, a longer closure may be required depending on the circumstances.

These closures comply with the National Shellfish Sanitation Program requirements that shellfish growing areas must be closed when:

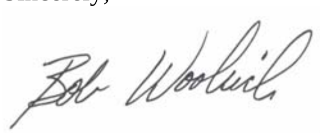
- An emergency condition or situation exists; or
- Pollution conditions exist that were not included in the data set used to classify the area.

In addition to protecting shellfish consumers, closing the area after extreme rain events may also help protect the Approved classification of Totten Inlet. Water samples collected after heavy rains often show very high fecal coliform bacteria results. When we close an area, water samples collected during the closure are not included in the data used to classify the area. However, if the area is left open, the water sampling results must be included.

We recognize the hardship that closures place on shellfish operations. However, we believe that such closures are needed to assure the safety of the shellfish and to maintain the Approved classification status of Totten Inlet.

We welcome any questions or suggestions you may have about this safety measure. Please contact Bill Cleland at (360) 236-3306 or by e-mail at bill.cleland@doh.wa.gov
by October 19, 2007.

Sincerely,



Bob Woolrich, Manager
Growing Area Section

Enclosures

Appendix D

Laboratory and Field Data

Table D-1: Laboratory and Field data for FC bacteria samples collected in Pierre and Burns Creeks.

Site Name	Date	time	Result (cfu/100mL)	Q	Field Replicate (cfu/100mL)	Q	Laboratory Duplicate (cfu/100mL)	Q
Burns Creek								
B1	*3/5/2007*	*1230*	*310*		*160*			
	3/12/2007	*1515*	*29*					
	3/19/2007	*1147*	*28*					
	4/2/2007	*1248*	*22*		*9*			
	4/16/2007	*1139*	*40*					
	4/23/2007	*1505*	*9*					
	4/30/2007	*1129*	*34*					
	5/7/2007	*1418*	*55*					
	5/22/2007	*1430*	*120*		*130*			
B2N	*3/5/2007*	*1327*	*140*					
	3/12/2007	*1315*	*31*					
	3/19/2007	*1040*	*24*					
	4/2/2007	*1310*	*3*					
	4/16/2007	*1152*	*32*		*32*			
	4/23/2007	*1507*	*3*		*17*			
	4/30/2007	*1133*	*40*		*29*			
	5/7/2007	*1420*	*59*		*67*			
	6/5/2007	*1513*	*51*		*80*			
	10/8/2007	*1220*	*570*		*380*		*400*	
B2S	*3/12/2007*	*1325*	*48*					
	3/19/2007	*1046*	*30*					
	3/26/2007	*1128*	*14*		*13*			
	4/2/2007	*1318*	*3*					
	4/9/2007	*0951*	*940*	*J*	*730*	*J*	*870*	*J*
	4/16/2007	*1201*	*120*					
	4/23/2007	*1536*	*11*					
	4/30/2007	*1203*	*45*					
	5/7/2007	*1251*	*100*					
	11/13/2007	*1317*	*1400*	*J*			*1600*	*J*
BCL	*3/12/2007*	*1305*	*210*					
	3/19/2007	*1035*	*57*		*59*			
	3/26/2007	*1120*	*76*		*75*			
	4/2/2007	*1240*	*23*					
	4/9/2007	*0942*	*3700*	*J*	*2100*	*J*		
	4/16/2007	*1136*	*220*					
	4/23/2007	*1500*	*120*					
	4/30/2007	*1125*	*35*					
	5/7/2007	*1412*	*250*					
	6/5/2007	*1525*	*220*					
	10/8/2007	*1236*	*60000*	*J*				

BCL	*11/13/2007*	*1313*	*5800*					
BPD	*3/12/2007*	*1355*	*29*		*25*			
	3/19/2007	*1056*	*25*					
	3/26/2007	*1143*	*20*					
	4/2/2007	*1330*	*9*					
	4/9/2007	*1002*	*1500*	*J*				
	4/16/2007	*1208*	*43*					
	4/23/2007	*1545*	*6*					
	4/30/2007	*1211*	*43*					
	5/7/2007	*1500*	*55*					
BPU	*3/12/2007*	*1410*	*27*					
	3/19/2007	*1102*	*16*					
	3/26/2007	*1150*	*10*					
	4/2/2007	*1339*	*8*					
	4/9/2007	*1007*	*120*					
	4/16/2007	*1214*	*3*					
	4/23/2007	*1558*	*3*					
	4/30/2007	*1218*	*38*	*J*				
	5/7/2007	*1505*	*220*	*J*	*170*	*J*		
BPUW	*3/12/2007*	*1402*	*130*					
	3/19/2007	*1100*	*110*					
	3/26/2007	*1148*	*77*					
	4/16/2007	*1212*	*210*					
	4/2/2007	*1337*	*40*					
	4/23/2007	*1555*	*34*					
	4/9/2007	*1005*	*1000*	*J*				
BTOP	*3/12/2007*	*1435*	*27*					
	3/19/2007	*1117*	*5*					
	3/26/2007	*1203*	*7*				*9*	
	4/2/2007	*1354*	*2*					
	4/9/2007	*1025*	*120*					
	4/16/2007	*1225*	*5*					
	4/23/2007	*1610*	*3*					
	4/30/2007	*1232*	*7*					
	5/7/2007	*1525*	*23*					
D1	*3/5/2007*	*1310*	*1*	*U*				
	3/12/2007	*1320*	*4*				*12*	
	3/19/2007	*1044*	*5*					
	3/26/2007	*1125*	*4*					
	4/2/2007	*1319*	*5*				*3*	
	4/9/2007	*0950*	*47*					
	4/16/2007	*1200*	*44*					
	4/23/2007	*1534*	*2*					
	4/30/2007	*1201*	*2*					
	5/7/2007	*1250*	*5*					
	11/13/2007	*1318*	*55*					
Pierre Creek								
P1	*3/5/2007*	*1340*	*88*					
	3/12/2007	*1040*	*61*		*47*			
	3/19/2007	*1216*	*130*		*88*			
	3/26/2007	*1255*	*54*		*33*			
	4/2/2007	*1420*	*80*		*40*			

P1	*4/9/2007*	*1055*	*620*	*J*	*570*			
	4/16/2007	*1005*	*18*					
	4/23/2007	*1308*	*14*		*10*			
	4/30/2007	*1258*	*10*		*13*			
	5/7/2007	*1145*	*20*		*23*			
	5/22/2007	*1525*	*190*	*J*	*270*	*J*	*200*	*J*
	6/5/2007	*1443*	*51*		*120*		*36*	
	11/13/2007	*1304*	*900*		*1500*			
P2	*3/5/2007*	*1415*	*200*				*190*	
	3/12/2007	*1155*	*66*					
	3/19/2007	*1328*	*140*					
	3/26/2007	*1356*	*88*					
	4/2/2007	*1525*	*67*					
	4/9/2007	*1140*	*1400*	*J*				
	4/16/2007	*1051*	*51*		*26*			
	4/23/2007	*1402*	*34*		*40*			
	4/30/2007	*1337*	*36*		*31*			
	5/7/2007	*1320*	*33*		*45*			
	11/13/2007	*1259*	*1400*					
P3	*3/12/2007*	*1218*	*48*					
	3/19/2007	*1337*	*130*					
	3/26/2007	*1405*	*84*					
	4/2/2007	*1532*	*59*		*67*			
	4/9/2007	*1150*	*1200*	*J*				
	4/16/2007	*1104*	*15*		*27*			
	4/23/2007	*1410*	*60*					
	4/30/2007	*1343*	*20*					
	5/7/2007	*1325*	*39*	*J*				
P4	*3/12/2007*	*1226*	*15*					
	3/19/2007	*1341*	*44*					
	3/26/2007	*1416*	*29*					
P5	*3/12/2007*	*1203*	*29*					
	3/19/2007	*1345*	*130*					
	3/26/2007	*1410*	*130*					
	4/2/2007	*1536*	*120*					
	4/9/2007	*1151*	*2600*	*J*				
	4/16/2007	*1107*	*38*					
	4/23/2007	*1412*	*80*					
	4/30/2007	*1346*	*79*					
	5/7/2007	*1328*	*84*					
P6	*3/12/2007*	*1210*	*29*					
	3/19/2007	*1350*	*9*					
	3/26/2007	*1412*	*6*					
	4/2/2007	*1540*	*5*					
	4/9/2007	*1155*	*63*					
	4/16/2007	*1110*	*2*				*3*	
	4/23/2007	*1419*	*1*					
	4/30/2007	*1351*	*25*					
	5/7/2007	*1337*	*4*					
PDT	*3/12/2007*	*1147*	*100*					
	3/19/2007	*1326*	*300*					
	3/26/2007	*1353*	*60*					

PDT	*4/16/2007*	*1057*	*13*					
	4/2/2007	*1520*	*1300*	*J*				
	4/9/2007	*1143*	*750*					
PFOREST	*3/19/2007*	*1125*	*2*				*1*	*U*
	3/26/2007	*1209*	*18*					
	4/2/2007	*1550*	*1*	*U*				
	4/9/2007	*1202*	*10*					
	4/16/2007	*1116*	*2*					
	4/23/2007	*1426*	*1*	*U*			*1*	
	4/30/2007	*1358*	*1*	*U*			*1*	*U*
	5/7/2007	*1347*	*1*	*U*			*1*	*U*
PT	*3/5/2007*	*1425*	*220*					
	3/12/2007	*1140*	*84*					
	3/19/2007	*1322*	*190*					
	3/26/2007	*1351*	*60*					
	4/2/2007	*1518*	*410*					
	4/9/2007	*1146*	*1300*					
	4/16/2007	*1055*	*40*					
	4/23/2007	*1354*	*11*					
	4/30/2007	*1333*	*9*		*10*			
	5/7/2007	*1312*	*23*					
	11/13/2007	*1253*	*1400*					
PTU	*3/12/2007*	*1146*	*100*					
	3/19/2007	*1324*	*130*					
	3/26/2007	*1352*	*120*					
	4/2/2007	*1522*	*54*					
	4/9/2007	*1141*	*1800*	*J*	*1200*	*J*		
	4/16/2007	*1057*	*37*					
	4/23/2007	*1359*	*34*					
	5/7/2007	*1315*	*20*					

J=estimate
U= below detection limit

Appendix E

Quality Assurance for Field and Laboratory

Laboratory Duplicates

The measurement quality objective (MQO) used by MEL for FC bacteria samples is 40% relative percent difference (RPD). RPD is the percent difference between the duplicate sample concentrations. MEL takes two aliquots (duplicates) from a field replicate sample. Results from the duplicate samples provide quality assurance by measuring with-in laboratory precision. Duplicate sample concentrations 20 cfu/100 mL and less are close to the detection limit and thus RPD analyses result in artificially escalated values. Duplicate RPD in this range do not meet the MEL MQO, due to this artificially escalation. This does not reflect poor analytical technique, however. Microbiology samples were analyzed within 24 hours of collection. Using a 24 hour holding time versus the typical 6 hours has been field tested (Mathieu, 2005) and is standard procedure for MEL.

Field Replicates

Field quality assurance samples **(**replicates) are samples taken one right after the other in the same location in the stream. Field replicates were collected at approximately 20% of the total number of sites. Replicate results reflect total variability associated with the laboratory, field, and transport. Relative standard deviation (RSD) is used to analyze field replicates (Ecology, 2006). RSD is calculated by dividing the standard deviation of the replicate pairs by their mean and multiplying by 100

Six of the 34 replicate pairs were equal to or below 20 cfu/100 mL and thus were not used in determining compliance with the MQO. These concentrations are too close to the method detection limit resulting in artificially escalated RPD values.

Twenty eight replicate pairs had a mean greater than 20 cfu/100 mL and were used for measuring quality assurance in the field**.** MQO for field replicate samples is to have 50% of the replicates below a 20% RSD and 90% of the samples below a RSD of 50% (Ecology, 2006). Figure E- 1 shows 50% of the replicates were below a 22% RSD (versus 20% RSD) and 90% of the samples were below a RSD of 50%.

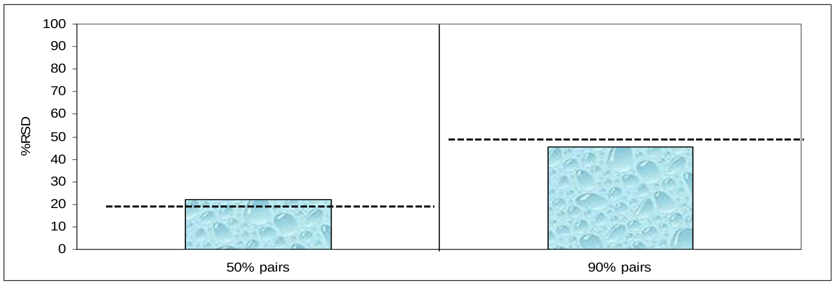


Figure E -1. RSD for field replicate samples (cfu>20cfu) in Pierre and Burns watershed, spring and fall, 2007.

Only one part of the two part MQO was met. I am confident in the field procedure followed and see no reason to eliminate any of the data.

Appendix F

Precipitation

Table F-1. Inches of precipitation recorded at the Olympia airport. Estimate for study site. Bolded entries represent inches of rain on the sample day.

DAY	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.001	0.01	0.16	0	0	0	0	0.16	0	0.6
2	0.27	**0.001**	0.24	0	0	0	0	1.06	0	2.12
3	0.001	0	0.25	0	0	0	0.39	0.11	0	3.19
4	0.001	0	0.001	0.07	0	0	0.31	0.13	0.001	0.16
5	**0.03**	0	0	**0.02**	0	0	0.001	0.01	0	0.001
6	0	0	0.001	0	0	0	0	0.07	0	0.06
7	0.3	0.47	**0**	0	0	0.01	0	0.21	0.03	0.001
8	0.28	0.36	0	0	0	0.001	0	**0**	0.01	0
9	0.001	**0.35**	0	0.25	0	0	0	0.001	0.19	0.07
10	1.18	0.08	0	0.03	0	0.001	0	0.12	0.33	0.001
11	1.28	0.06	0	0.05	0	0	0	0	0.15	0.001
12	**0.09**	0.02	0	0	0.001	0.001	0	0.04	0.74	0
13	0.05	0.22	0	0.001	0	0	0	0	**0.04**	0.01
14	0.02	0.02	0	0	0.001	0	0	0	0.12	0.12
15	0.01	0	0	0.01	0.001	0	0	0.1	0.79	0.42
16	0.001	**0.09**	0	0.01	0	0.001	0.15	0.14	0.12	0.01
17	0.23	0.04	0	0	0.61	0.001	0.09	0.34	0.61	0.06
18	0.04	0.04	0.02	0	0.19	0.23	0.02	0.41	0.01	0.63
19	**0.36**	0	0.09	0	0.36	0.12	0.001	1.26	0.03	1.14
20	0.16	0	0.42	0	0.29	0.05	0.06	0.64	0.001	0
21	0	0.22	0.04	0.001	0.32	0.14	0.01	0.07	0	0
22	0.06	0.04	**0**	0.001	0.08	0.001	0.07	0	0	0.4
23	0.73	**0**	0	0.01	0.001	0	0	0	0	0.86
24	1.31	0.05	0	0.31	0.001	0	0	0.001	0	0.06
25	0	0.02	0	0.001	0	0.01	0.02	0	0	0.37
26	**0.28**	0.05	0	0	0	0	0	0.001	0.3	0.001
27	0.16	0	0	0	0	0	0.13	0	0.001	0.43
28	0	0	0	0.45	0	0	0.001	0	0.32	0.49
29	0	0	**0**	0.09	0	0	0.03	0.01	0.25	0.23
30	0.03	**0.19**	0	0	0	0	0.96	0	0.001	0.28
31	0.13		0			0.001		0		

Trace replaced with 0.001 inches

Appendix G

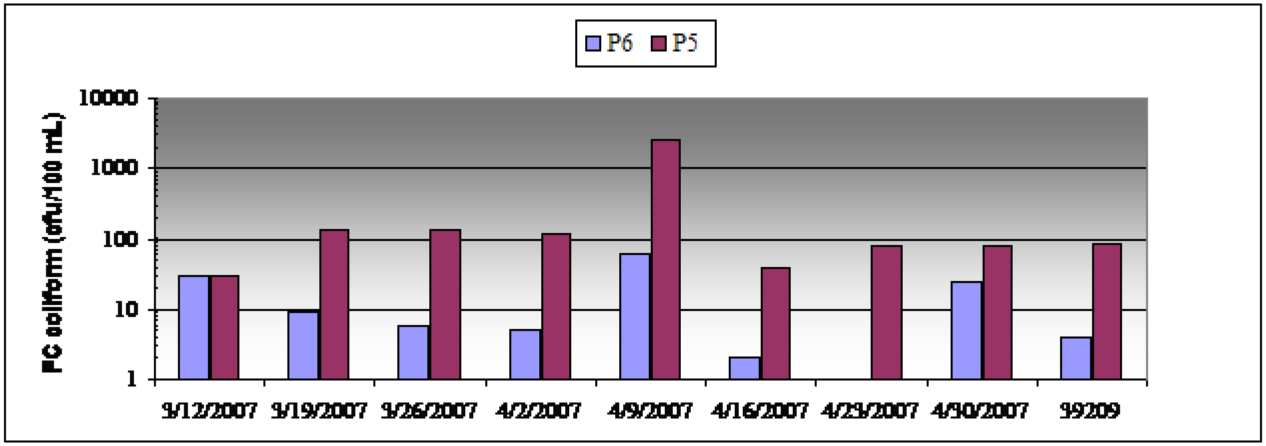
Data Summary

Table G-1. Pierre Creek FC bacteria data as represented by box plots in report.

Summary Statistics	P1	P2	P3	PFOREST	P5	P6	PT	PTU	PDT
10th percentile	12	20	14	1	22	1	11	16	19
minimum	12	34	20	1	29	1	10	20	13
geometric mean	71	114	70	2	113	8	104	87	168
maximum	1200	1400	1200	18	2600	63	1400	1500	1300
90th percentile	434	653	336	10	590	43	961	477	1509
No. of samples	13	11	9	8	9	9	11	8	6

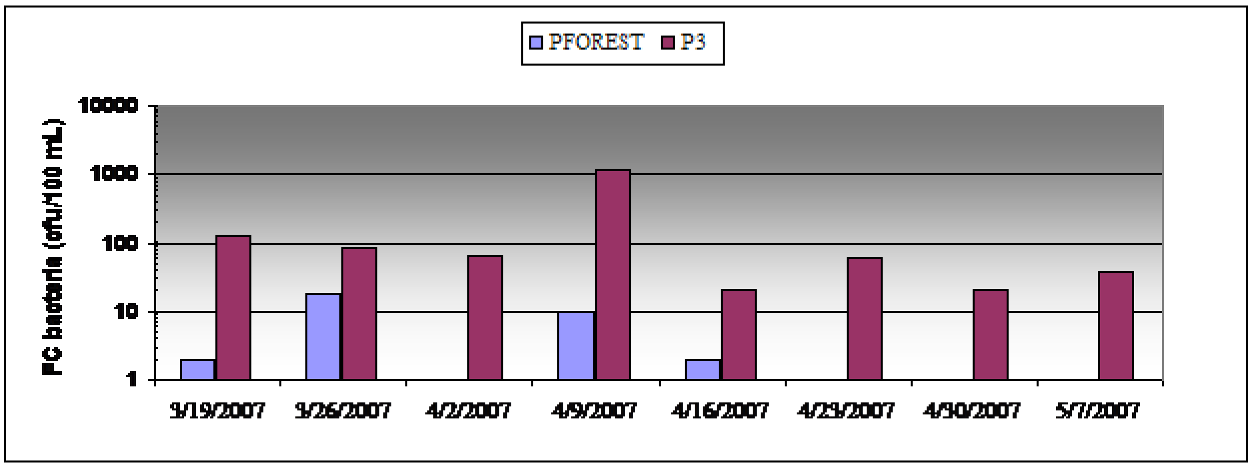
Date	P1	P2	P3	PFOREST	P5	P6	PT	PTU	PDT
3/5/2007	88	200	nd	nd	nd	nd	220	nd	nd
3/12/2007	54	66	48	nd	29	29	84	100	100
3/19/2007	109	140	130	2	130	9	190	130	300
3/26/2007	44	88	84	18	130	6	60	120	60
4/2/2007	60	67	63	1	120	5	410	54	1300
4/9/2007	595	1400	1200	10	2600	63	1300	1500	750
4/16/2007	18	39	21	2	38	2	40	37	13
4/23/2007	12	37	60	1	80	1	11	34	nd
4/30/2007	12	34	20	1	79	25	10	nd	nd
5/7/2007	22	39	39	1	84	4	23	20	nd
5/22/2007	230	nd	nd	nd	nd	nd	nd	nd	nd
6/5/2007	86	nd	nd	nd	nd	nd	nd	nd	nd
10/8/2007	nd*	nd	nd	nd	nd	nd	nd	nd	nd
11/13/2007	1200	1400	nd	nd	nd	nd	1400	nd	nd

*nd = no data



Date	P6	P5
3/12/2007	29	29
3/19/2007	9	130
3/26/2007	6	130
4/2/2007	5	120
4/9/2007	63	2600
4/16/2007	2	38
4/23/2007	1	80
4/30/2007	25	79
5/7/2007	4	84

Figure G-1. Pierre Creek above and below agricultural activity in southwest pasture.



Date	PFOREST	P3
3/19/2007	2	130
3/26/2007	18	84
4/2/2007	1	63
4/9/2007	10	1200
4/16/2007	2	21
4/23/2007	1	60
4/30/2007	1	20
5/7/2007	1	39

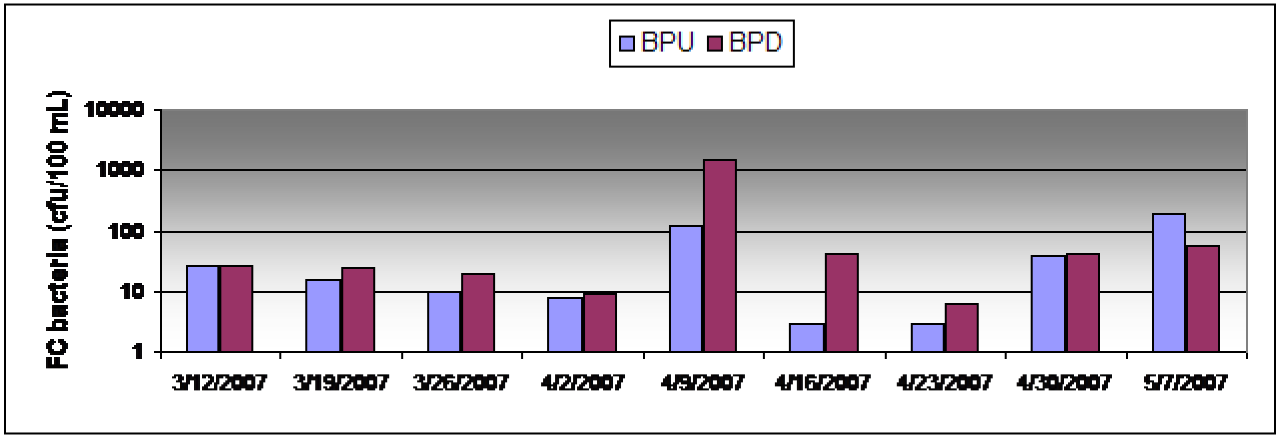
Figure G-2. Pierre Creek above and below agricultural activity in southwest pasture.

Table G-2. Burns Creek FC bacteria data as represented by box plots in report.

Summary Statistics	B1	B2N	B2S	BPD	BPU	BPUW	BTOP	BCL	D1
10th percentile	11	7	5	5	3	27	2	16	1
minimum	9	3	3	6	3	34	2	23	1
geometric mean	40	38	58	36	19	118	9	319	7
maximum	235	475	1400	1500	195	1000	120	60000	55
90th percentile	142	225	652	274	124	508	48	6187	38
No. of samples	9	10	10	9	9	7	9	12	11

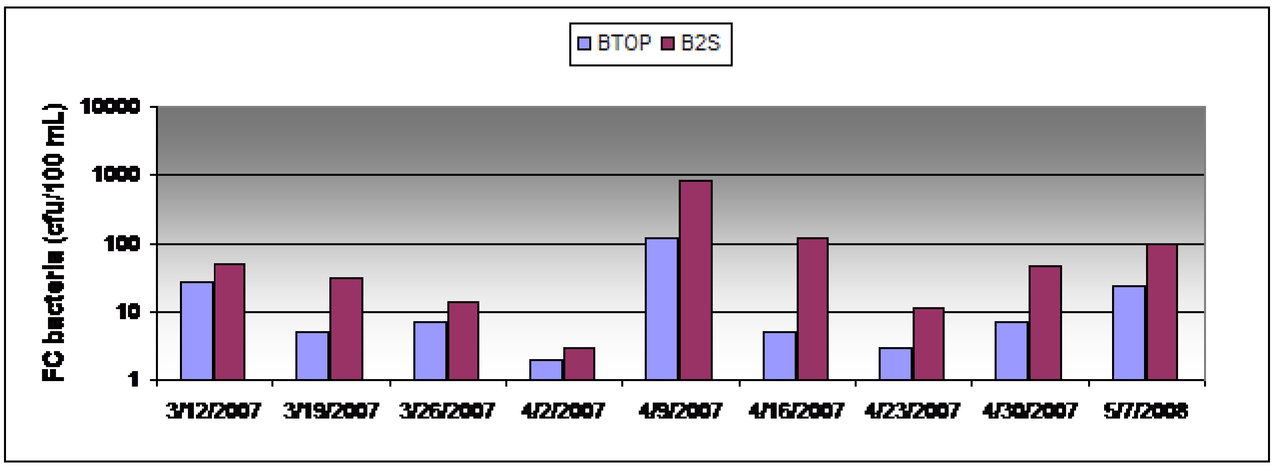
Date	B1	B2N	B2S	BPD	BPU	BPUW	BTOP	BCL	D1
3/5/2007	235	140	nd*	nd	nd	nd	nd	nd	1
3/12/2007	29	31	48	27	27	130	27	210	4
3/19/2007	28	24	30	25	16	110	5	58	5
3/26/2007	nd	nd	14	20	10	77	7	76	4
4/2/2007	16	3	3	9	8	40	2	23	5
4/9/2007	nd	nd	835	1500	120	1000	120	2900	47
4/16/2007	40	32	120	43	3	210	5	220	44
4/23/2007	9	10	11	6	3	34	3	120	2
4/30/2007	34	35	45	43	38	nd	7	35	2
5/7/2007	55	63	100	55	195	nd	23	250	5
5/22/2007	125	nd	nd	nd	nd	nd	nd	nd	nd
6/5/2007	nd	66	nd	nd	nd	nd	nd	220	nd
10/8/2007	nd	475	nd	nd	nd	nd	nd	60000	nd
11/13/2007	nd	nd	1400	nd	nd	nd	nd	5800	55

*nd = no data



DATE	BPU	BPD
3/12/2007	27	27
3/19/2007	16	25
3/26/2007	10	20
4/2/2007	8	9
4/9/2007	120	1500
4/16/2007	3	43
4/23/2007	3	6
4/30/2007	38	43
5/7/2007	195	55

Figure G-3. Burns Creek above and below pond.



DATE	BTOP	B2S
3/12/2007	27	48
3/19/2007	5	30
3/26/2007	7	14
4/2/2007	2	3
4/9/2007	120	835
4/16/2007	5	120
4/23/2007	3	11
4/30/2007	7	45
5/7/2008	23	100

Figure G-4. Burns Creek above and below agriculture.