Bacteriological Data

Addendum To:

Habitat Limiting Factors and Reconnaissance Assessment Report. Green/Duwamish and Central Puget Sound Watersheds Part II: Factors of Decline/Conditions Chapter 1.2 Water Quality

June 2002

Prepared for:

Green Duwamish Watershed Water Quality Assessment

Prepared by:

King County
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1. Introduction

This report is an addendum to the Water Quality Chapter (1.2) of the Green/Duwamish Habitat Limiting Factors and Reconnaissance Assessment (Kerwin and Nelson 2000). The Reconnaissance Report provided an assessment of the water quality conditions in the Green/Duwamish watershed focusing on water quality concerns for anadromous and resident salmonids. This addendum presents results of bacteriological sampling and analysis and compares the results to current and proposed water quality standards. To ensure that this summary accurately reflects existing and not historical conditions, only the last four years of available data were evaluated (i.e., 1996 through 1999).

As with the main text of the Reconnaissance Report, the scope of this addendum includes an assessment of water quality in the mainstem of the Green River and Duwamish Estuary, as well as the major tributaries to the Green River. These tributaries include the Newaukum Creek subbasin, Crisp Creek, Soos Creek subbasin, Mill/Hill Creek subbasin, and Black River (Springbrook Creek) subbasin (Figures 1 and 2). The scope does not include an assessment of tributaries in the upper Green River or the Duwamish Estuary, nor does it include the independent tributaries to Puget Sound or Elliott Bay.

1.1. Available Bacteriological Data

The water quality data used in this report for the Green/Duwamish watershed were collected by King County Department of Natural Resources (previously Metro), the Washington State Department of Ecology (Ecology), and the Muckleshoot Indian Tribe Fisheries Department (MITFD). The samples collected by MITFD were analyzed by the King County Environmental Laboratory, and the data results are incorporated into the King County water quality database.

King County (Metro) has been sampling in the Green/Duwamish watershed for a variety of water quality parameters since 1970. In the mid-1970s, it was recommended that Metro institute an ongoing program to monitor water quality in the 26 subbasins within the western third of King County (Metro 1978). The goal of the monitoring program was to provide information about local surface waters in the Seattle Metropolitan area in support of programs designed to protect water quality and abate water pollution. King County has been monitoring 14 stations in the Green River basin as part of this program since the mid-1970s. Under King County's program, the sampling frequencies and types of indicators measured have varied over the years, but samples have been consistently collected on at least a monthly basis.

Similarly, the Department of Ecology has been actively monitoring the Green/Duwamish Watershed for a variety of water quality parameters since 1959 under Ecology's statewide "Ambient Monitoring Program". Ten monitoring stations have been active in the Green/Duwamish Watershed during various time periods over the past 40 years.

Figure 1. Bacteriological sampling stations. Duwamish and Lower Green River and tributaries.

Figure 2. Bacteriological sampling stations. Lower and Middle Green River and tributaries.

Ecology currently monitors three stations for conventional parameters in the Green River Basin on a monthly basis.

Samples for the King County Streams Monitoring Program were collected beneath the water surface, in the top meter and as close to the center of the channel as possible. For the Duwamish River Water Quality Assessment (King County 1999), King County also collected samples at depth (one meter above bottom to a maximum depth of 20 meters) and near the banks in the Duwamish River. Ecology's Ambient Monitoring Program collects freshwater samples in accordance to established sampling protocols (Ecology 2001).

1.2. Sampling Locations and frequency

Bacteriological data were available from 55 locations throughout the Green River basin, excluding the upper Green River, as part of the King County/ MITFD Streams Monitoring Program for the time period investigated (1996-1999). Ecology's Ambient Monitoring Program provides three additional sampling locations in the basin over the same time period.

All sampling occurs routinely as part of monthly monitoring, typically during ambient flow conditions. King County also conducts specific sampling to target storm conditions. Storms are characterized by at least 0.25 inches of rain within a 24-hour period with at least 24 hours of dry antecedent conditions. Although the non-storm samples did not target storm conditions, these regularly sampled sites, by coincidence, contain samples taken during periods of precipitation or during storm generated impacts to the sampled stream.

Figures 1 and 2 identify all of the sampling locations analyzed in this report from the King County and Muckleshoot Indian Tribe Streams Program. These figures also include Ecology's current ambient monitoring stations. All data analyzed were from samples collected between October 1996 and December 1999.

1.3. State Water Quality Designations and Beneficial Uses

The Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC) provide a set of classifications for water bodies in the state, ranging from Class AA (extraordinary) to Class C (fair) based on the "beneficial uses" of the water, or what uses the water might support. The beneficial uses describe allowable water uses (domestic, industrial, agricultural), salmon fishery uses (migration, rearing, spawning, harvesting) and contact recreation (swimming, wading) for each classification. Table 1 summarizes the state water quality beneficial uses for each classification.

Table 1. Water quality beneficial uses for surface waters of the State of Washington.

Characteristic/ WQ Parameter	**Class AA (extraordinary) (Upper Green R.)**	**Class A (excellent) (Lower Green R.)**	**Class B (good) (Duwamish R.)**
Allowable Water Uses	Domestic Industrial Agricultural	Domestic Industrial Agricultural	Industrial Agricultural
Salmonid Uses	Migration Rearing Spawning Harvesting	Migration Rearing Spawning Harvesting	Migration Rearing Harvesting
Contact Recreation	Primary (swimming)	Primary (swimming)	Secondary (wading)

The Duwamish River, from its mouth at Elliott Bay to the confluence with the Black River (river mile 11.0) is designated Class B. The lower and middle Green River is designated Class A from river mile 11.0 to river mile 42.3 at Flaming Geyser State Park. From river mile 42.3 to the headwaters, the Green River is designated Class AA. The Black River, Mill Creek, Soos Creek, Crisp Creek, and Newaukum Creek subbasins are all designated Class A. All tributaries to the Green River above river mile 42.3 are designated Class AA (see Figures 1 and 2 for river mile markings).

2. Standards for Bacteria

The U.S. EPA establishes and/or recommends water quality criteria for surface waters nation-wide. The original U.S. EPA criteria for bacteria were based on disease studies conducted at bathing beaches in the 1940s and 1950s by the U.S. Public Health Service. At that time "total coliform bacteria" was the measured indicator organism (USEPA 1986), and total coliform densities less than 2,300/100 ml were considered protective. In the 1960s the "total coliform" criterion was changed to "fecal coliform" to become more feces-specific and to provide a more appropriate measure to protect public health.

Studies conducted by the U.S. EPA in the 1970s examined marine and freshwater bathing beaches and concluded that fecal coliform was a poor indicator of swimming-related illnesses. The U.S. EPA further suggested that E. coli was the best indicator of disease in freshwaters and enterococcus was the best indicator for marine waters. Enterococci was also noted as a good indicator in both marine and fresh waters. This provides the basis for U.S. EPA's current bacteria standard recommendation: E. coli as the freshwater indicator and enterococci as the marine water indicator, or enterococci for both.

The Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC) uses fecal coliform organisms as the indicator organism for the protection of human health (Table 2).

Table 2. Water Quality Standards for Fecal Coliforms in Freshwater.

Water Body Classification	River Stretch	Standard (colonies/100 ml)
Class AA	Upper Green River (RM 42.3 to headwaters)	Geometric Mean < 50, not more than 10% over 100
Class A	Middle Green River (RM 11 to 42.3)	Geometric Mean < 100, not more than 10% over 200
Class B	Duwamish River (mouth to RM 11)	Geometric Mean < 200, not more than 10% over 400

The U.S. EPA has proposed the following criteria based on the E. coli and enterococci indicator organisms (Table 3).

Table 3. U.S. EPA National Recommended Bacteriological Ambient Water Quality Criteria in Freshwater.

Parameter	Recommended Criterion
E. coli	not to exceed a geometric mean of 126 colonies/100 ml
Enterococci	not to exceed a geometric mean of 33 colonies/100 ml

Since monitoring data were available for fecal coliforms, E. coli, and enterococci, both the current Washington State standards and the U.S. EPA recommended criteria were used for comparisons in this analysis.

2.1. Use of Indicator Organisms Versus Pathogen Analysis

Water quality standards are based on the measure of indicator organisms (e.g., fecal coliform, enterococci) instead of quantifying the direct presence of pathogenic bacteria and viruses. The reasons for relying on the use of indicator organisms are many (Cabelli 1983), including:

- There are a large number of different pathogenic bacteria and viruses potentially present in municipal sewage, and each has its own associated probability of illness for a given dose;
- Because of the shear numbers, and compounded by the fact that these pathogens vary independently of each other over space and time, routine monitoring for each would be an enormous task;
- Reliable quantification methods for many of the pathogens of concern are either unavailable or technically difficult;
- Pathogen data are often difficult to interpret because methodologies can be inaccurate and there may be limited availability of dose-response data; and
- The intent of the water quality standards is to define a quantifiable relationship between the density of the indicator in the water and the potential for unacceptable human health risks, not to index the presence of individual pathogenic bacteria and viruses.

2.2. Designation of 303(d) Listed Water Bodies

Numerous stream segments throughout the Green/Duwamish watershed are listed on the State's 1998 303(d) list of impaired water bodies for violations of water quality standards for fecal coliform bacteria. Section 303(d) of the Clean Water Act (CWA) requires the State to identify those water bodies that do not meet water quality standards. The State is then responsible for prioritizing the list and developing Total Maximum Daily Loads

(TMDLs) for every water body and pollutant on the list. The water bodies on the 1998 303(d) list for fecal coliform are shown in Figure 3.

The water bodies on the 1998 303(d) list for bacteria mostly reflect exceedances where water quality data have been collected. It should not be inferred that all other segments meet water quality standards. Some segments have been regularly monitored and meet water quality standards; however, other segments may exceed standards, but are not on the 303(d) list because they have never been monitored.

The majority of 303(d) listings for fecal coliform were based on sampling conducted by King County over the past decade. It is important to note that the sampling dates responsible for the 1998 303(d) list are not as current as the data evaluated for this addendum. The first step in TMDL development is to review existing data and conduct additional sampling, if necessary, to better define the spatial and temporal character of the water quality impairment. This bacteriological data addendum is the first step in that process. Ecology is scheduled to issue an updated 303(d) list in October 2002 (though it may be delayed).

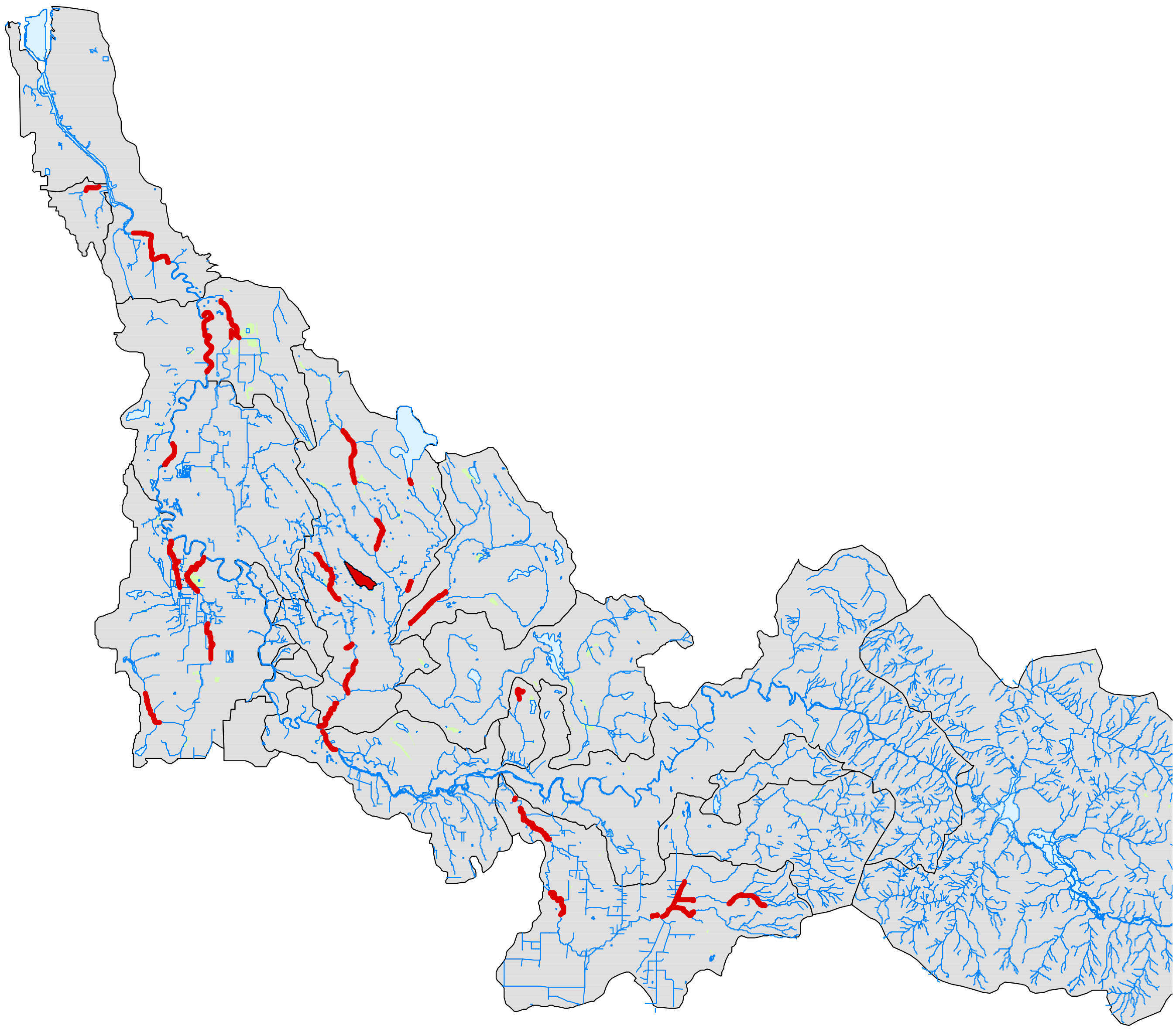

Figure 3. Water bodies on the 303(d) list (in red) in the Green-Duwamish River watershed (fecal coliform only).

3. Comparisons To Standards/Criteria by Subbasin

The following section provides a summary by subbasin of the bacteriological conditions in the Middle and Lower Green River, the Duwamish River, and five subbasins. No King County/MITFD bacteriological data were available in the Upper Green River. A description of each subbasin's physical information including location, watershed area, and land use, is detailed in Kerwin and Nelson (2000). Figures 4, 5 and 6 depict sampling stations for fecal coliform, E. coli, and enterococcus, respectively. Furthermore, stations are color coded to indicate whether or not the non-storm and storm data combined (when storm data were available) exceed the standard or recommended criteria. Summary tables of the data used for the comparisons are included in Appendices A – E.

3.1. Middle Green River

3.1.1. Fecal Coliform

Fecal coliform data were available for three stations (A319, B319, and 09A190) in the Middle Green River Subbasin (Appendix A). For the King County stations, 35 and 36 non-storm samples and one and 15 storm samples were collected at Station A319 (approximately RM 34) and Station B319 (approximately RM 41), respectively. Forty-one non-storm samples were collected at Ecology station 09A190. At Station A319, the highest geometric mean of the non-storm samples (30 colonies/100 ml) was less than the Class A standard of 100 colonies/100 ml, but four of the 35 samples (11%) were greater than 200 colonies/100 ml. The single storm sample at Station A319 (180 colonies/100 ml) was below 200 colonies/100 ml. Taken together, the fecal coliform data exceed the class A standards at Station A319 because greater than 10% of the samples exceed 200 colonies/100 ml. At the further upstream stations B319 and 09A190, Class A standards are not exceeded.

The Middle Green River is on the State's 303(d) list for failure to meet fecal coliform standards at station A319.

3.1.2. E. coli

Data for eleven non-storm samples at Station A319 and 12 non-storm and five storm samples at Station B319 were available. The geometric means for these stations ranged from 5 to 29 colonies/100 ml (Appendix B), which is well below the EPA recommended criterion of 126 colonies/100 ml.

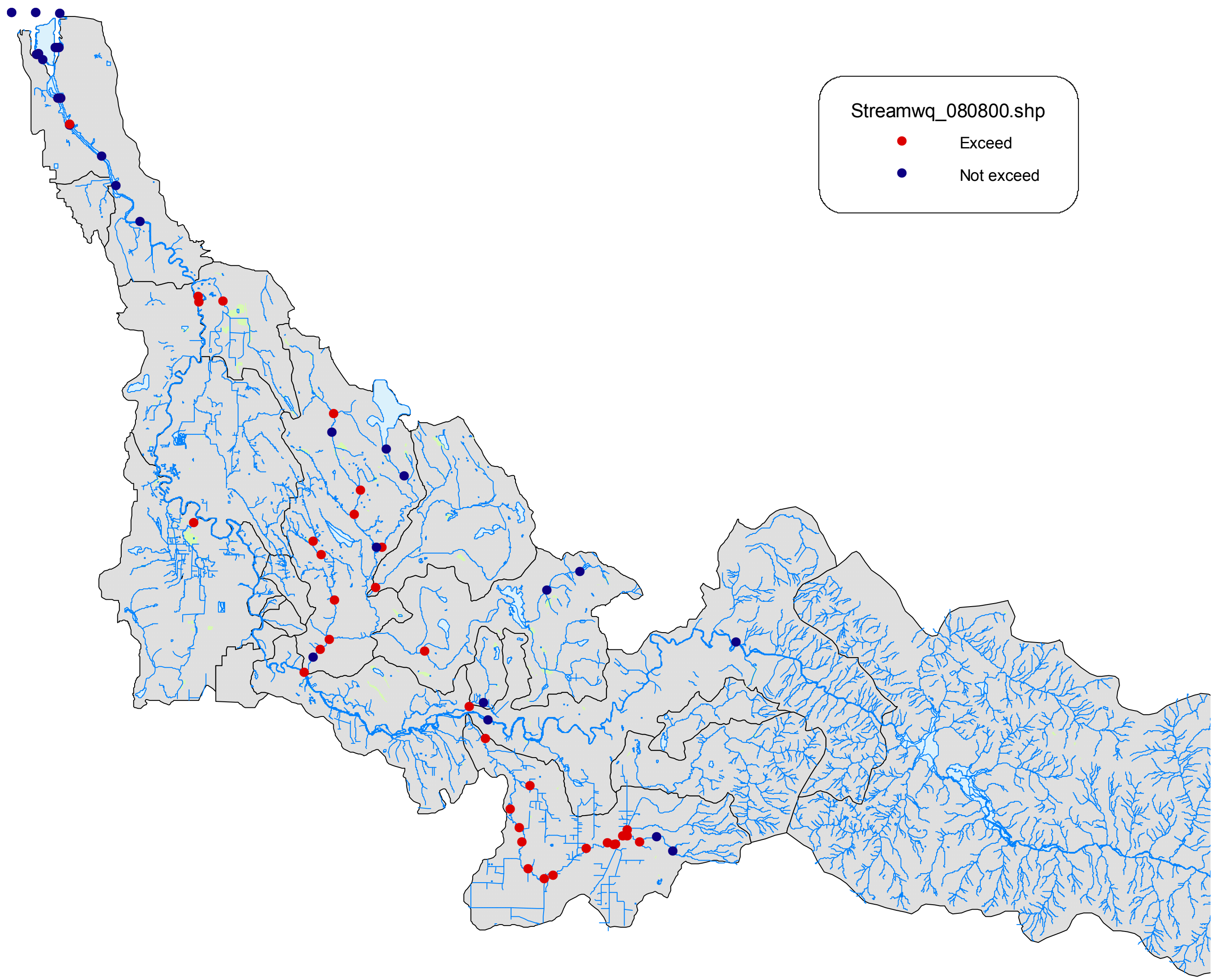

Figure 4. Fecal coliform sampling sites and sites with exceedances of standards for non-storm and storm (where available) data combined.

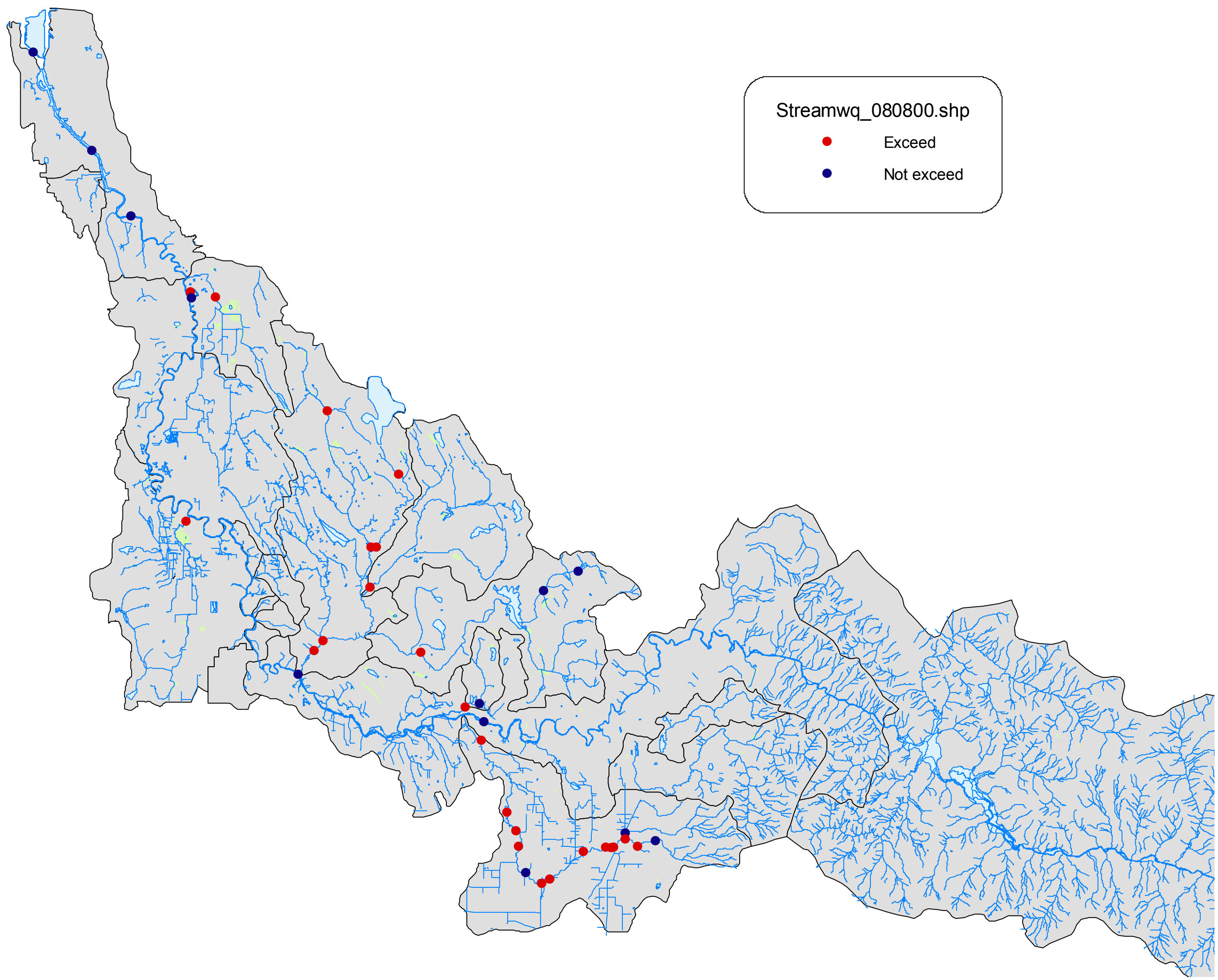

Figure 5. Enterococcus sampling sites and sites with exceedances of recommended criteria for non-storm and storm (where available) data combined.

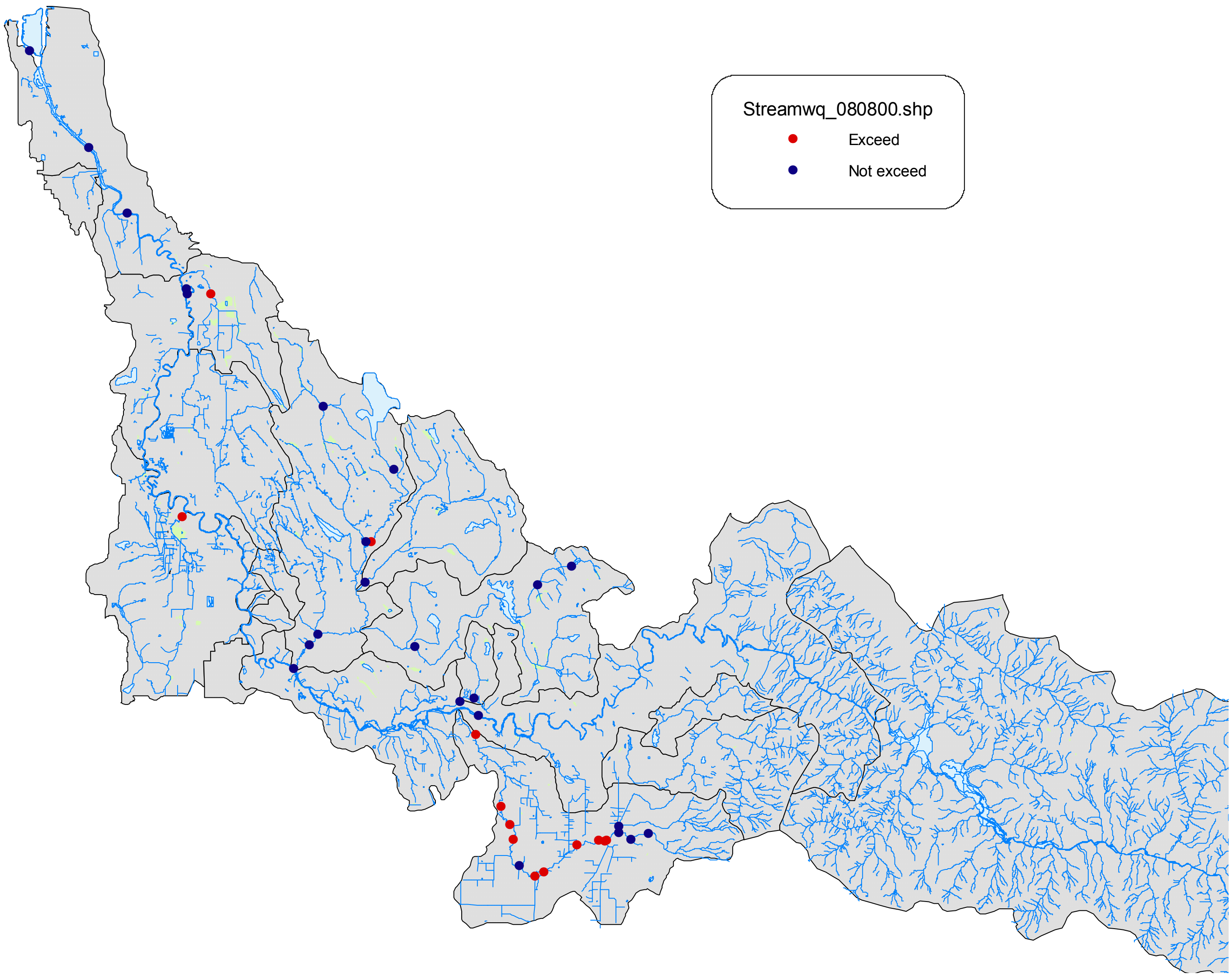

Figure 6. E. coli sampling sites and sites with exceedances of recommended criteria for non-storm and storm (where available) data combined.

3.1.3. Enterococci

The number of enterococci samples was equivalent to the number of fecal coliform samples at Stations A319 and B319. However, the range of geometric mean enterococci concentrations (4 – 14 colonies/100 ml, see Appendix C) do not exceed the EPA recommended criterion (33 colonies/100 ml), with one exception; the single storm sample at Station A319 was 170 colonies/100 ml. When data from the storm sample is combined with the non-storm data at this station, the resulting geometric mean (15 colonies/100 ml) is still below the recommended criterion.

3.2. Lower Green River

3.2.1. Fecal Coliform

Fecal coliform data were available for three stations (0311, 3106, and 09A080) in the Lower Middle Green River Subbasin (Appendix A). At the King County stations 34 and 40 non-storm samples and one and 14 storm samples were collected at Stations 0311 and 3106, respectively (approximately RM 12). Ecology station 09A080 contributed 36 non-storm samples. Geometric means for these stations ranged from 57 to 270 colonies/100 ml, with the highest geometric means for samples collected under storm conditions (260 and 220 colonies/100 ml for Stations 0311 and 3106, respectively). Although the geometric mean for these stations under non-storm conditions were below the Class A standard (100 colonies/100 ml), 13%, 14%, and 15% of these samples exceeded 200 colonies/100 ml. Therefore, Class A standards are exceeded at all these stations.

Fecal coliform data from King County and Ecology at all three stations were used to place the Lower Green River on the 1998 303(d) list.

3.2.2. E. coli

Data for 11 non-storm samples at Station 0311 and 12 non-storm and four storm samples at Station 3106 were available. The geometric means for these stations were 34 and 35 colonies/100 ml for Station 0311 and 3106, respectively, during non-storm conditions. Only the geometric mean of the storm samples at Station 3106 (215 colonies/100 ml) exceed the EPA recommended criterion of 126 colonies/100 ml. However, when the geometric mean for this station is calculated using all of the data (storm and non-storm), the recommended criterion is not exceeded.

3.2.3. Enterococci

Data for 34 non-storm and one storm sample at Station 0311 and 35 non-storm and 14 storm samples at Station 3106 were available. Geometric means under non-storm conditions at Stations 0311 and 3106 (24 and 22 colonies/100 ml, respectively) were below EPA recommended criterion (33 colonies/100 ml), whereas geometric means under storm conditions (190 and 218 colonies/100 ml, respectively) exceeded the criterion. When the non-storm and storm data are combined, the recommended criterion is exceeded at Station 3106 but not at 0311.

3.3. Duwamish River and Estuary

3.3.1. CSO Water Quality Assessment

Beginning in 1996, the King County Department of Natural Resources studied the existing conditions in the Duwamish, as well as the County's combined sewer overflows (CSOs) and their effects on water quality in the Duwamish River, using a risk assessment approach (King County 1999). A summary of the conclusions regarding fecal coliform concentrations collected in 1996 and 1997 is provided below.

The analysis of fecal coliform concentrations indicates that there is risk of exposure to pathogens from direct exposure to the waters of the Duwamish River under baseline (i.e., existing) and without CSO conditions. Fecal coliform concentrations in surface water were used as an indicator of the presence of fecal contamination and an increased likelihood of infection by human pathogens. It is acknowledged that fecal coliforms may originate from many non-human sources and hence may not accurately predict concentrations of pathogenic organisms. However, it was assumed that fecal coliform concentrations may be used as a general indicator of water quality, and hence as a general indicator of potential exposure to pathogenic organisms.

Fecal coliform concentrations were assessed using a variety of methods. First, geometric mean and 90th percentile fecal coliform concentrations under baseline and without CSO conditions were modeled using the Environmental Fluids Dynamic Computer Code (EFDC) model, and compared to the state water quality standards on a monthly basis. Each EFDC model cell's compliance with state standards for any given month was assumed if the cell's monthly geometric mean and 90th percentile concentrations were both below the appropriate standards. Second, the percent of time during the year that fecal coliform concentrations under baseline and without CSO conditions exceed various numerical standards were determined. Finally, peak concentrations at specific locations were assessed to estimate the magnitude of any potential risks.

Using the 1996 –1997 data, the model predicted that the geometric mean and/or the 90th percentile fecal coliform concentrations in the surface layers for most of the Duwamish River were above the state standards for over nine months of the year, both baseline and without CSO discharges. In general, more model cells were predicted to exceed state standards during wet months than dry months.

If the state standards truly represent the thresholds for risk of infection from exposure to pathogens, comparisons of monthly fecal coliform concentrations to standards would indicate frequent potential risks of infection from direct contact with surface water from the Duwamish River under baseline and without CSO conditions. These results also indicate that fecal coliforms from other sources are of such a magnitude that the complete removal of CSO discharges would not allow for the Duwamish River to frequently meet the fecal coliform standards, although the other sources of fecal coliforms and the actual concentrations of human pathogen organisms remains uncertain.

Fecal coliform concentrations in surface waters were further investigated to identify the fraction contributed by CSOs, and whether the CSO contribution, without considering any other sources, would result in an exceedance of the state standards. The modeling analysis predicted that in the Duwamish River, monthly geometric mean and 90th percentile fecal coliform concentrations were not attributable to the CSO discharges predicted to frequently exceed standards. These observations support the conclusion that sources other than CSOs contribute substantially to the fecal coliform concentrations in the Duwamish River. The potential for risks under both baseline and without CSO conditions is also obtained from the observation that fecal coliform concentrations in the Duwamish River exceed 400 organisms per 100 ml between 10 and 25 percent of the year both under baseline and without CSO conditions, thus exceeding the state standards.

Worst-case estimates of risk were assessed by reviewing peak fecal coliform concentrations. Peak fecal coliform concentrations in the Duwamish River during January (a month with many CSO discharges) were found to frequently exceed 1,000 organisms per 100 ml both under baseline and without CSO conditions. These results indicate that there are periods when fecal coliform concentrations indicate the potential for substantial risk.

3.3.2. Existing Conditions

Recent King County data were available for a total of 19 stations in the Duwamish River. Sixteen of these stations were sampled from nine sites in 1996 and 1997 for the Duwamish River and Elliott Bay WQA, and represent either east bank, center channel or west bank sampling within the Duwamish River channel at six sites (CSO locations). At each station, samples were collected both one meter under the surface and one meter above the bottom (or at 20 meters depth if bottom depth was greater than 20 meters). Table 4 below describes the site abbreviations used for the Duwamish River WQA, and sampling locations are depicted in Figure 1.

Table 4. Site abbreviations from the Duwamish River WQA.

Site	East Bank (1,2)	Center Channel (1,2)	West Bank (1,2)
Norfolk		NFKBLB	
S/W Michigan	SWM/E	SWM/C	SWM/W
Brandon	BRN/E	BRN/C	BRN/W
Chelan	CHE/E	CHE/C	CHE/W
Hanford	HNF/E	HNF/C	HNF/W
Connecticut	HNF/E	HNF/C	HNF/W

1 = surface and 2 = depth (e.g., SWM/E1 and SWM/E2)

Data were also available between 1996 and 1999 for three other stations (0305, 0307, 0309) sampled as part of the Streams Monitoring Program (see Figure 1). Appendices D, E, and F summarize the number of samples analyzed for fecal coliforms, E. coli and enterococci at all locations in the Duwamish River (WQA and Streams Monitoring Program) between 1996 and 1999. Comparisons to State standards and EPA recommended criteria are also presented in Appendices D, E and F.

3.3.2.1. Fecal Coliform

In general, samples collected at depth (both non-storm and storm) did not exceed the Class B freshwater standards. The only exception was at Station SWM/W2, where 3 of 10 storm samples (30%) exceeded 400 colonies/100 ml. When the storm data are combined with the non-storm data at this station, the standard is not exceeded. At the surface, however, samples often exceeded Class B standards (Appendix D). Standards were exceeded at more locations (16 stations, 7 sites) during storm conditions than during non-storm conditions (3 stations, 2 sites). If the storm data are combined with the non-storm data, the standards would still be exceeded at six stations (4 sites). In general, inclusion of the more recent data would not change the conclusions of the WQA that standards are frequently exceeded.

The Duwamish River is on the 303(d) list for violations of fecal coliform standards at two of Ecology's ambient monitoring stations (09A060 and ELB010). However, the data from these stations are considered out of date (1984-1990) and will be replaced by newer King County data during Ecology's next 303(d) listing cycle in 2002.

3.3.2.2. E. coli

Data from 11 to 21 non-storm samples were available at three stations in the Duwamish River sampled as part of the routine streams monitoring program (Appendix E). The geometric means of these data ranged from 16 to 51 colonies/100 ml, well below the EPA recommended criterion of 126 colonies/100 ml. No storm *E. coli* concentration data in the Duwamish River were available.

3.3.2.3. Enterococci

Data from 35 to 55 samples were available at three sites in the Duwamish River, mostly collected during non-storm conditions (Appendix F). The geometric means under non-storm conditions ranged from 4 to 27 colonies/100 ml, which is below the EPA recommended criterion of 33 colonies/100 ml. However, the geometric means for the relatively few storm samples (one or two samples per site) did exceed this criterion, ranging from 247 to 416 colonies/100 ml. When the storm and non-storm data are combined, however, the recommended criterion is not exceeded.

3.4. Crisp Creek

3.4.1. Fecal Coliform

Data from 37 to 41 non-storm samples and 17 storm samples were available in Crisp Creek (Appendix A). At Station 0321, the geometric mean of the non-storm samples was below the Class A standard (100 colonies/100 ml); however, greater than 10% (11%) of the samples were greater than 200 colonies/100 ml. The geometric mean of the 17 storm samples at Station 0321 was 142, and 41% of the samples exceeded 200 colonies/100 ml, which exceeds both Class A standards. In contrast, further upstream at Station F321, the geometric mean of the non-storm samples was 6 colonies/100 ml; only one of 41 samples exceeded 200 colonies/100 ml. No storm sample data were available at Station F321. Crisp Creek is not on the state's 303(d) list.

3.4.2. E. coli

Data from 11 to 13 non-storm and five storm samples were available in Crisp Creek (Appendix B). The geometric means of the non-storm samples were 36 and 6 colonies/100 ml at Stations 0321 and F321, well below the EPA recommended criteria of 126 colonies/100 ml. However, the geometric mean of the five storm samples collected at 0321 was 263 colonies/100 ml. If the 11 non-storm and five storm data are combined, the geometric mean is 68 colonies/100 ml, which is below the recommended criterion.

3.4.3. Enterococci

Data from 37 to 41 non-storm and 17 storm samples were available in Crisp Creek (Appendix C). Both the non-storm and the storm geometric means at Station 0321 (35 and 129 colonies/100 ml, respectively) exceeded the EPA recommended criteria of 33 colonies/100 ml. However, further upstream at Station F321, the geometric mean of the non-storm data was only 6 colonies/100 ml. No storm sample data were available at Station F321.

3.5. Newaukum Creek

3.5.1. Fecal Coliform

Data from nine to 68 non-storm and zero to 16 storm samples were available at 18 stations throughout Newaukum Creek and its tributaries (Appendix A). Class A standards were exceeded at nearly every site under both non-storm and storm conditions. The only exceptions included four stations in the upper Newaukum; three under storm conditions (N322, AI322, and AJ322) and one under both non-storm and storm conditions (T322). In addition, the standards were met in the tributaries Spring Creek (AC322) under non-storm conditions, and Stonequarry Creek (AG322) under storm conditions. When the non-storm and storm data are combined, standards are met at only two stations (AJ322 and T322). At only the uppermost, forested station (T322) were standards met under both non-storm and storm conditions. This greater degree of exceeding standards in the Newaukum basin likely results from the extensive agricultural activities (including livestock) in this watershed. In contrast to other basins, geometric means were greater under non-storm conditions than under storm conditions for eight of the 18 sites in the Newaukum basin. Again, this is probably an effect of the agricultural activity in this basin.

The 303(d) list included Newaukum Creek for several segments based on the King County data.

3.5.2. E. coli

Data from seven to 11 non-storm and one to four storm samples were available at 15 stations throughout Newaukum Creek and its tributaries (Appendix B). EPA recommended criteria were met under non-storm, storm, and combined conditions at only five of 15 stations (three stations in the upper Newaukum (AI322, AJ322 and N322) and in the tributaries Spring Creek (AC322) and Stonequarry Creek (AG322)). At the other 10 stations, EPA recommended criteria were exceeded either under non-storm conditions, storm conditions, or both.

3.5.3. Enterococci

Data from seven to 35 non-storm and one to 14 storm samples were available at 15 stations throughout Newaukum Creek and its tributaries (Appendix C). EPA recommended criteria were exceeded at nearly every site under both non-storm and storm conditions. The only exceptions were at the uppermost station sampled for enterococci on the Newaukum Creek (AJ322) under both non-storm and storm conditions, and in the tributaries Spring Creek (AC322) and Stonequarry Creek (AG322) under non-storm conditions. When the non-storm and storm data are combined, standards are met at these three stations.

3.6. Soos Creek

3.6.1. Fecal Coliform

<u>Big Soos Creek</u> – Data from 7 to 47 non-storm and one to 16 storm samples were available from seven stations in Big Soos Creek (Appendix A). Class A standards were exceeded at all stations except M320 and 09B090, which were only sampled under non-storm conditions. In addition, data from Station Q320 under non-storm and combined conditions also met standards; however, the single storm sample from this station exceeded standards with 300 colonies/100 ml.

<u>Little Soos Creek</u> – Data from 14 to 43 non-storm and zero to two storm samples were available from three stations in Little Soos Creek (Appendix A). At the uppermost station (T320), Class A standards were met under non-storm conditions; no storm data were available. Further downstream at U320, standards were met under non-storm conditions, and exceeded under storm conditions. When the non-storm and storm data are combined at this station, the standards are not exceeded. At the mouth of Little Soos Creek (G320), standards are exceeded under both non-storm and storm conditions.

<u>Jenkins Creek</u> – Data from 36 non-storm and two storm samples were available at one station (D320) in Jenkins Creek (Appendix A). Although Class A standards were met with the two storm samples at this station, 11% of the non-storm samples exceeded 200 colonies/100 ml, which is greater than the 10% limit required for compliance with the Class A standards. Combining the storm with the non-storm data still results in exceeding the Class A standards.

Covington Creek – Data from 33 to 43 non-storm samples and one to two storm samples were available at three stations in Covington Creek (Appendix A). Class A standards were met at all stations under both non-storm and storm conditions except at Station C320, where 16% of the non-storm samples exceeded 200 colonies/100 ml. Combining the storm with the non-storm data still results in exceeding the Class A standards.

Soosette Creek – Data from 17 to 34 non-storm samples were available at four stations in Soosette Creek (Appendix A). In addition, one storm sample was collected at one station (B320) in Soosette Creek. The geometric mean of the non-storm data is less than the Class A standard of 100 colonies/100 ml; however, 26% of the samples are greater than 200 colonies/100 ml. Class A standards were exceeded at all four stations during both non-storm and storm conditions.

Big Soos, Little Soos, Jenkins, and Soosette Creeks are all present on the 1998 303(d) list due to fecal coliform standard exceedances. Covington Creek is not currently listed.

3.6.2. E. coli

Big Soos Creek – Data from 10 to 14 non-storm and one to six storm samples were available at three stations in Big Soos Creek (Appendix B). The EPA recommended criterion was met under non-storm conditions at all three stations, but exceeded under storm conditions at two of the stations (L320 and Q320). When the non-storm and storm data are combined, the recommended criterion is not exceeded at either station.

Little Soos Creek – Data from 11 non-storm samples were available at two stations (G320 and U320) in Little Soos Creek (Appendix B). One storm sample was also collected at Station U320. The EPA recommended criterion was exceeded at the downstream station (G320) under non-storm conditions, and at the upstream station (U320) under storm conditions. When this single storm datum is combined with the non-storm data, the recommended criterion is not exceeded.

Jenkins Creek – Data from 12 non-storm samples were available at one station (D320) in Jenkins Creek (Appendix B). The geometric mean of these data (26 colonies/100 ml) did not exceed the EPA recommended criterion (126 colonies/100 ml).

Covington Creek – Data from nine to 15 non-storm samples at three stations and one storm sample at two locations were available in Covington Creek (Appendix B). The EPA recommended criterion was met at all three locations.

Soosette Creek – Data from nine non-storm and one storm sample was available at one location in Soosette Creek (Appendix B). The EPA recommended criterion was met under non-storm conditions, but exceeded under storm conditions. When the non-storm and storm data are combined, the recommended criterion is not exceeded at either station.

3.6.3. Enterococci

Big Soos Creek – Data from 11 to 36 non-storm and one to 16 storm samples were available at three stations in Big Soos Creek (Appendix C). Under non-storm conditions, the EPA recommended criterion is met at Stations L320 and Q320, but not at Station A320, the furthest downstream station. The criterion was exceeded at all three locations under storm and combined (non-storm and storm) conditions.

Little Soos Creek – Data from 12 to 34 non-storm samples and one to two storm samples were available from two stations in Little Soos Creek (Appendix C). Under non-storm conditions, the EPA recommended criterion was exceeded at the downstream station (G320), but met at the upstream station (U320). The criterion was exceeded under storm and combined conditions at both stations.

Jenkins Creek – Data from 36 non-storm and two storm samples were available at one station (D320) in Jenkins Creek (Appendix C). The mean of the non-storm samples (47 colonies/100 ml) exceeded the EPA recommended criterion (33 colonies/100 ml), but the mean of the two storm samples (32 colonies/100 ml) was just below the criterion. When the non-storm and storm data are combined, the recommended criterion is exceeded.

Covington Creek – Data from 10 to 43 non-storm samples and one to two storm samples were available at three stations in Big Soos Creek (Appendix C). The EPA recommended criterion was met at all three stations under non-storm conditions, but exceeded at Stations C320 and S320 under storm conditions. The single storm sample collected at the furthest upstream station (R320) was below the criterion. When the non-storm and storm data are combined, the recommended criterion is met at the upstream stations (R320 and S320), but exceeded at the downstream station (C320).

Soosette Creek – Data from 11 non-storm and one storm sample were available at Station B320 in Soosette Creek near the confluence with Big Soos Creek (Appendix C). The geometric mean of the non-storm data (67 colonies/100 ml) and the single storm datum (3300 colonies/100 ml) exceeded the EPA recommended criterion.

3.7. Mill Creek

3.7.1. Fecal Coliform

Data from 35 non-storm and 14 storm samples were available at Station A315 in Mill Creek (Appendix A). Under non-storm conditions, the geometric mean (316 colonies/100 ml) was greater than the Class A standard (100 colonies/100 ml). In addition, 60% of the non-storm samples were greater than 200 colonies/100 ml. Under storm conditions, the geometric mean was 1,029 colonies/100 ml, and 79% of the samples were greater than 200 colonies/100 ml. Therefore, Class A standards are exceeded under both non-storm and storm conditions. Mill Creek is on the state's 303(d) list for water quality impairments due to exceedances of fecal coliform standards.

3.7.2. E. coli

Data from 11 non-storm and four storm samples were available at Station A315 in Mill Creek (Appendix B). The geometric mean was 330 colonies/100 ml under non-storm conditions and 1,095 colonies/100 ml under storm conditions, both of which are well above the EPA recommended criterion of 126 colonies/100 ml.

3.7.3. Enterococci

Data from 35 non-storm and 14 storm samples were available at Station A315 in Mill Creek (Appendix C). The geometric mean was 126 colonies/100 ml under non-storm conditions and 771 colonies/100 ml under storm conditions, both of which are well above the EPA recommended criterion of 33 colonies/100 ml.

3.8. Springbrook Creek (Black River)

3.8.1. Fecal Coliform

Data from 36 non-storm and 13 storm samples were available at Station 0317 in Springbrook Creek (Appendix A). Under non-storm conditions, the geometric mean (115 colonies/100 ml) was greater than the Class A standard (100 colonies/100 ml). In addition, 22% of the samples were greater than 200 colonies/100 ml. Under storm conditions, the geometric mean was 513 colonies/100 ml, and 85% of the samples were greater than 200 colonies/100 ml. Therefore, Class A standards are exceeded under both non-storm and storm conditions. King County station 0317 as well as two old Ecology ambient monitoring stations provided the basis to place Springbrook Creek on the 1998 303(d) list for fecal coliform.

3.8.2. E. coli

Data from 13 non-storm and three storm samples were available at Station 0317 in Springbrook Creek (Appendix B). Under non-storm conditions, the geometric mean (121 colonies/100 ml) was below the EPA recommended criterion (126 colonies/100 ml). However, under storm conditions the geometric mean was 513 colonies/100 ml, well above the criterion. When the non-storm and storm data are combined, the geometric mean (158 colonies/100 ml) exceeded the recommended criterion.

3.8.3. Enterococci

Data from 35 non-storm and 13 storm samples were available at Station 0317 in Springbrook Creek (Appendix C). The geometric mean was 71 colonies/100 ml under non-storm conditions and 567 colonies/100 ml under storm conditions, both of which are above the EPA recommended criterion of 33 colonies/100 ml.

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