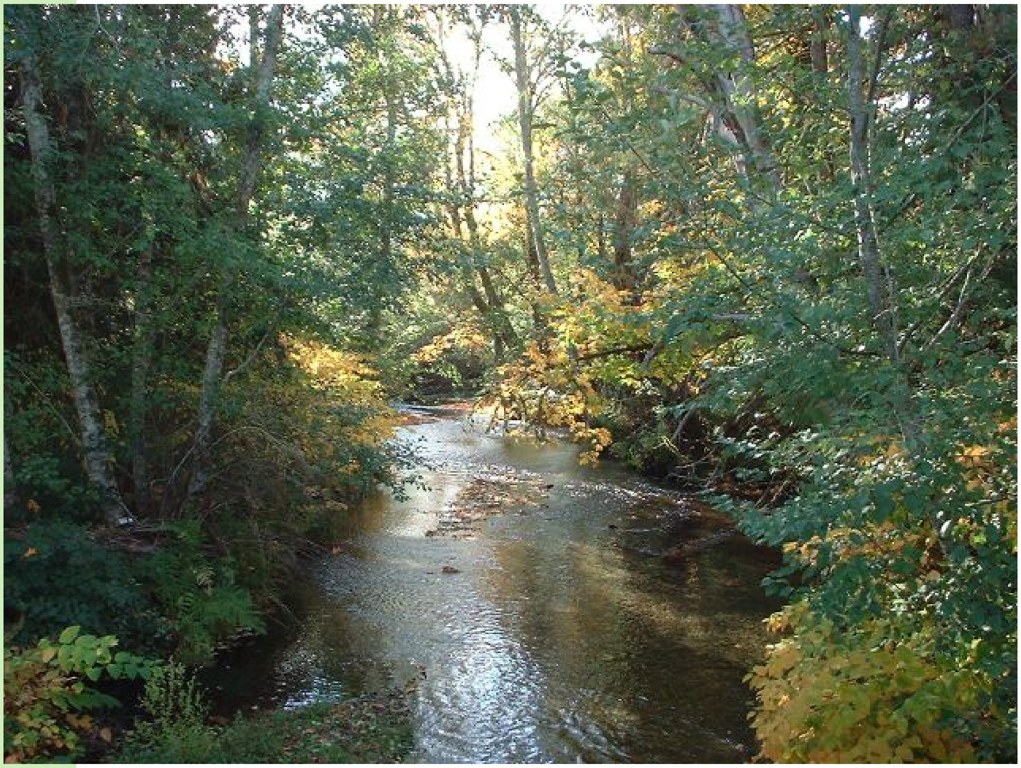

High Summer Bacteria Concentrations in Streams

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For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6677

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Olympia (360) 407-6000
- Northwest Regional Office, Bellevue (425) 649-7000
- Southwest Regional Office, Olympia (360) 407-6300
- Central Regional Office, Yakima (509) 575-2490
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High Summer Bacteria Concentrations in Streams

by
Maggie Bell-McKinnon

Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

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Abstract

Data from Thurston County Environmental Health and the Squaxin Island Tribe document an ongoing summertime pattern of high bacteria concentrations in many South Puget Sound streams. Typically during the summer, elevated bacteria levels can follow two patterns: triggered by runoff or occurring during low streamflow. Summer low streamflow bacteria patterns can suggest a direct discharge that requires further investigation to identify.

Local governments have been unable to address these bacteria problems without better information about what is causing high summer bacteria levels. In 2008, a project was undertaken by the Department of Ecology to study a set of stream bacteria data. This project was requested by Thurston County Environmental Health, the Squaxin Island Tribe, and Ecology's Water Quality Program, Southwest Regional Office.

The project goal was to identify and analyze streams with high bacteria levels during the summer.

Bacteria data were compiled from streams in five counties: Pierce, Thurston, Mason, Kitsap, and Jefferson. Data results were limited to bacteria concentrations measured from May through September, 1999 to 2007. A GIS map was produced documenting the stream location of bacteria levels above 100 colony forming units (cfu) or 100 most probable number (mpn).

In addition, an annotated bibliography was assembled which highlighted other studies looking at the correlation between bacteria and other parameters such as stream discharge, temperature, and precipitation.

Based on the literature review summarized in the annotated bibliography, it is important to consider timing and location in the collection of the bacteria samples. Also, because of the yearly variability which can occur in bacteria levels, documenting the environmental conditions (e.g., stream discharge, temperature) during the time of sampling is critical to understanding bacteria patterns.

Acknowledgements

The author would like to thank:

- Levi Keesecker of the Squaxin Island Tribe for producing the bacteria maps in Appendix A and for providing other relevant information used in this report.
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  - Sue Davis, Thurston County Environmental Health
  - Lyman Bullchild, Skokomish Tribal Nation
  - Stephanie Kenny, Mason County Health Services
  - Shannon Kirby, Mason County Conservation District
  - Glenn Gately, Jefferson County Conservation District
  - Daniel Nidzgorski, Jefferson County Environmental Health

Introduction

A number of South Puget Sound streams have been identified as having problems with high bacteria concentrations exceeding the Washington State Water Quality Standards (www.ecy.wa.gov/programs/wq/swqs/criteria-freshwater/wac173201a_200-bacteria.html).

A few of these waterbodies have been the subject of a study to establish a Total Maximum Daily Load (TMDL) of pollutants (also called a Water Quality Improvement study). The TMDL was established by Section 303(d) of the Clean Water Act. Federal law requires states to identify sources of pollution in waters that fail to meet state water quality standards, and to develop TMDLs and *Water Quality Implementation Plans* to address those pollutants. The TMDL report establishes limits on pollutants that can be discharged to the waterbody and still allow state standards to be met.

Some of the South Puget Sound streams with TMDLs completed include: South Prairie Creek, some tributaries in the Nisqually watershed, the Henderson Inlet watershed, tributaries in the Totten/Eld Inlet watershed, the Union River, and the Skokomish River. Other waterbodies in the South Sound are in the "under development" stage of a TMDL study. A complete list can be found at the following Ecology website:
www.ecy.wa.gov/programs/wq/tmdl/tmdls_by_wria/tmdl-by-wria.html

Data from Thurston County Environmental Health and the Squaxin Island Tribe document an ongoing summertime pattern of high bacteria concentrations in many South Puget Sound streams. Elevated bacteria levels can follow two patterns during the summer: triggered by runoff or occurring during low streamflow. Summer low streamflow bacteria patterns can suggest direct discharge mechanisms that require further investigation to identify.

Local governments have been unable to address bacteria problems without better information about what is causing high summer bacteria levels. In 2008, a project was undertaken by the Department of Ecology's Environmental Assessment Program to study a population of stream bacteria data. This project was requested by Thurston County Environmental Health, the Squaxin Island Tribe, and Ecology's Water Quality Program, Southwest Regional Office.

The project goal was to identify and analyze streams with high bacteria levels during the summer. Specifically, the objectives were:

- Compile existing datasets of high bacteria levels measured during the summer months and produce maps showing the location of these data.
- Correlate high bacteria levels to other environmental factors including soil type, temperature, geographic locations of existing on-site septic systems, stream discharge, and use of areas by anglers.
- Produce an annotated bibliography of the following topics as they relate to bacteria: bacteria survival and die-off; mechanisms of sediment resuspension; and sediment type and loading.

Results

Bacteria data were compiled from the following sources: Washington State Department of Ecology, the Tacoma-Pierce County Health Department, Thurston County Environmental Health, the Skokomish Indian Nation, Kitsap County Health Department, Jefferson County, and Mason County. Data collected between May and September – and results above 100 colony forming units (cfu) or most probable number (mpn) – were mapped (see Appendix A). The data covered the time period from 1999 to 2007.

Appendix B contains the bacteria sampling station location information; Appendix C shows the bacteria data results for each sampling location.

In addition, an annotated bibliography (Appendix D) was produced. This bibliography contains other studies looking at the correlation between bacteria and other parameters such as stream discharge, temperature, and precipitation.

Discussion

Bacteria Maps

Appendix A contains the maps showing the location of the high bacteria levels. It was initially planned that other environmental information would be overlaid onto these bacteria data maps (e.g., existing on-site septic systems and soil type). Unfortunately, only on-site system data from Jefferson County were available for mapping. Soil type information was not available in a format that was easily adapted to the bacteria maps.

In addition, other environmental parameter information, such as stream discharge, substrate type, and temperature, was not collected at the time the bacteria samples were collected. Because of this lack of information and the time constraints placed on this project, an in-depth analysis of the bacteria datasets was not possible.

The bacteria maps produced for this project should be viewed as a starting point for identifying areas where high bacteria levels are a concern.

Annotated Bibliography

The annotated bibliography (Appendix D) contains numerous studies where bacteria levels were correlated to other environmental parameters. The following discussion will highlight some of the points contained in the bibliography.

In the studies reviewed, the following parameters all showed some relationship to bacteria concentrations:

- Stream discharge
- Water temperature
- Conductivity
- Turbidity
- Total suspended solids
- Sediment deposition and resuspension
- Soil structure
- Chloride (a possible indicator of human influence)
- Presence of livestock
- Dissolved organic carbon
- Salinity
- Wind speed
- Solar radiation
- Precipitation

Not all of these relationships were strongly correlated; in addition, most of these studies took place in areas of the country other than the Pacific Northwest.

Studies in the Pacific Northwest

One set of bacteria data from the Pacific Northwest was from a station monitored by the Squaxin Island Tribe in Washington State (Conrad, 2008). Their data analysis found a small portion (32%) of the variation in bacteria concentrations was explained by wind speed; temperature explained 22% of the variability. Average rainfall did not appear to be an important variable at the station level.

Morace and McKenzie (2002) found sedimentation and solar radiation in the Yakima River basin reduced the number of coliform bacteria in the water column. Solar radiation can be lethal to bacteria, and sedimentation immobilizes the organisms to the bottom sediments. However, these bacteria can be resuspended during an increase in stream discharge.

A study done in a Puget Sound estuary (Struck, 1988) found 71% of the fluctuation in water column fecal coliform concentrations can be explained by corresponding fluctuations in the sediment bacteria concentrations. This suggests sediment sampling could be a more accurate indicator of general conditions in the watershed.

Studies outside of the Pacific Northwest

In North Carolina, lake and stream sediments contained densities of bacteria several times over the amount found in the overlaying water column (Giddings and Oblinger, 2004). A number of other studies showed a positive correlation of stream discharge and high bacteria concentration. Increased stream discharge can resuspend fine bottom sediments, particularly sediments with at least 25% clay.

One study in Virginia (Hyer and Moyer, 2003) specifically identified turbidity as the parameter that explained the greatest variance and was most significant in the model used. Bacteria in the water column tend to associate with suspended matter.

A study in New York (Irvine et al., 2002) showed a strong positive relationship between total suspended solids and fecal coliforms. The author and others assumed this correlation was related to the resuspension of bacteria-inoculated bed sediment as opposed to stream flushing. In contrast, increases in fecal streptococci bacteria counts during storms appeared more related to the washing of overhanging stream vegetation and stream flushing.

In Great Britain, Davies et al. (1991) found the rate of decrease in numbers of culturable bacteria was significantly faster in seawater than freshwater when exposed to natural sunlight. The survival of bacteria in freshwater may be due to the presence of ultraviolet absorbing substances, including humic acids, which would protect the bacterial cells from DNA damage by the ultraviolet radiation. Another study, Ferguson (2003) found the detrimental effects of sunlight on the survival of fecal coliforms are less than for enterococci in the presence of humic substances, whereas other fecal coliforms are more sensitive to lower pH.

McSwain (1977) suggested bacteria fluctuated seasonally and diurnally in North Carolina streams. Diurnal fluctuations in coliform counts were pronounced in the spring and fall and less pronounced in other seasons. Counts were usually highest between 1130 and 1400 hours and lowest at night between 2400 and 0330. The difference in stream temperature could account for this diurnal variation. Conrad (2008) also found fecal counts have significant year-to-year variation.

The data from McSwain (1977) also showed the seasonal cycles were influenced by multiplication of bacteria in stream sediments, and bacteria population growth was regulated by stream temperature. This study found fecal streptococci bacteria were less responsive to changes in turbidity than fecal coliform bacteria.

One theory as to why higher bacteria concentrations may occur during the summer is that dilution of bacteria is lower when the stream level is low. Livestock have also been cited as a source of bacteria to streams. They will congregate near a water source when the weather is warmer. This theory may apply to other animals (e.g., elk and deer) as well.

The influence of vegetation in filtering coliform bacteria in Georgia streams was studied by Entry et al. (2000). The ability of the soil to filter microorganisms depends largely on soil texture and pore size. However, vegetation type in riparian areas did not affect bacteria survival rates. One literature source cited in Entry's study showed 92-97% of *Escherichia coli* are filtered out in the first 4 centimeters as they move down through the soil column. However, other studies found bacteria can be transported long distances through soil. The explanation given is the preferential flow of water transporting bacteria through soil macropores, cracks, and fissures.

The Entry et al. (2000) study cited another study where bacteria survival time in the upper soils varied from 4 to 160 days, although other literature found many pathogenic organisms can live in the soil for months. Soil moisture and temperature seem to be the most important factors in bacteria survival within the soil matrix.

In a study on bacteria survival in streams in England (Flint, 1987), the author found more than 90% of *Escherichia coli* survived in river water for up to 260 days without any addition of extra carbon sources. This survival for such a long time without any replication suggests the *Escherichia coli* entered some type of dormant state; this has been termed "starvation survival". The genome will survive, enabling the bacteria which have survived starvation to recolonize a suitable habitat when favorable conditions return.

The effect of human contribution to elevated bacteria concentrations in waterbodies is widely acknowledged. Mostly this is seen in failing on-site septic systems. The possibility of anglers introducing bacteria into streams was also considered. The author spoke with staff at the Washington Department of Fish & Wildlife (WDFW) to see if any information on identifying popular fishing locations was available in GIS format. Unfortunately the answer was no. However, WDFW staff informed me that in the South Puget Sound area, anglers fish for salmon in streams primarily during September through November. There are no summer-run steelhead in South Puget Sound. Trout fishing occurs randomly up and down the streams, mostly higher up in the watershed where the water is cooler. This would seemingly preclude anglers as a significant source of bacteria in South Puget Sound area streams of concern.

However, during the salmon runs which occur during the fall, large numbers of birds can congregate in the streams to feed on the carcasses. Birds could be contributing to higher bacteria concentrations during these salmon runs. In addition, many watersheds have seen an increase of large game animals (e.g., elk) (Bell-McKinnon, 2008). These animal population increases could also be a contributing factor to higher bacteria concentrations in streams during the summer months.

Conclusions

Detailed analysis of the compiled bacteria datasets was not possible due to a lack of information needed for correlation. This current project could be viewed as Phase I of a two-phase project (see *Recommendations*).

As the annotated bibliography (Appendix D) indicates, many studies in the U.S. have shown some correlation between environmental parameters and bacteria concentrations. The most important conclusion reached in this project was the need for more data to be collected in Washington State. Many people are collecting samples for bacteria analysis but not for other parameters, such as total suspended solids, temperature, and stream discharge, for correlation.

The following are some conclusions reached as a result of the literature search:

- There appear to be diurnal fluctuations in bacteria concentrations. This result could point to the importance of the timing of sample collection.

- Still water appeared to have lower bacteria concentrations than running water within the same stream. This ties in with the belief that bacteria seem to associate with particulate matter and that sedimentation would lower bacteria concentrations. This is another factor to be considered when choosing bacteria sampling locations.

- Application of distributed watershed models to fecal bacteria is complicated by the fact that once bacteria enter the environment, their transport is affected by poorly characterized ecological processes, such as the proliferation of environmentally adapted strains of bacteria. Consequently, bacteria are unlikely to accumulate and wash off at reproducible and land-use specific rates. This is an assumption inherent in most watershed models (Surbeck, 2006).

- Pathogens present in animal fecal deposits excreted to land undergo a poorly defined process of dispersion, transport, and inactivation. The survival of pathogens in soil, water, and feces is dependent on the chemical, physical, and biological composition of these matrices (Ferguson et al., 2003).

- Because of the yearly variability which occurs in bacteria concentrations, the environmental conditions of the year (e.g., rainfall and stream temperature) when the bacteria samples are collected must be included in any analysis attempting to relate the dependent variable (bacteria) to any explanatory covariates (Conrad, 2008).

- Many of the study findings indicate nonpoint bacteria contamination is not limited to the original source of bacteria but instead to the numerous interactions that occur after the bacteria enters the stream or estuary.

- During the dry season, less dilution from lower streamflows and slower water movement probably contributes to the higher bacteria counts. Conversely, increased die-off of the bacteria by ultraviolet radiation during the sunnier low-flow season decreases the period of time viable bacteria will persist in stream or lake water. If any of the bacteria sources are chronic – such as livestock access, manure gun overshoot, poorly disinfected point sources, leaking sewer pipes, or failing septic systems – then elevated bacteria counts should be seen regularly throughout the low-flow periods.

Recommendations

As a result of this study, the following recommendations are made:

- The bacteria maps produced for this project should be viewed as a starting point for identifying areas where high bacteria levels are a concern.

- A Phase II portion of this project should be proposed and implemented. In order for any analysis of the bacteria datasets compiled for this study to occur, additional stream environmental parameters, including streamflow, total suspended solids, and substrate type, need to be measured.

- As part of the Phase II project, the annotated bibliography should be reviewed and an analysis done comparing results from bacterial studies conducted in the Pacific Northwest versus other regions of the U.S.

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Appendices

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Appendix A. Bacteria Maps

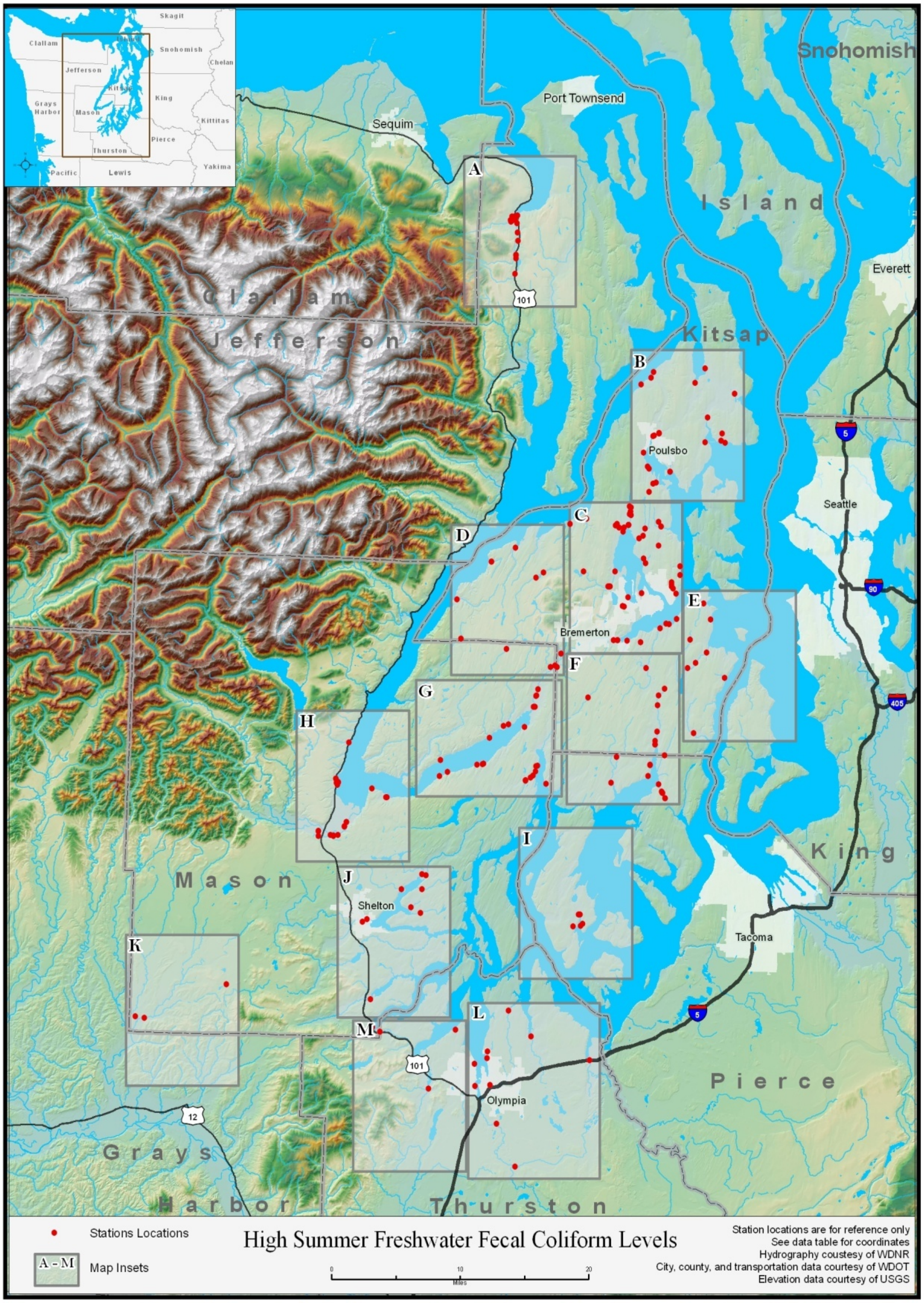

Figure 1. Maps A-M: Bacteria data stations.

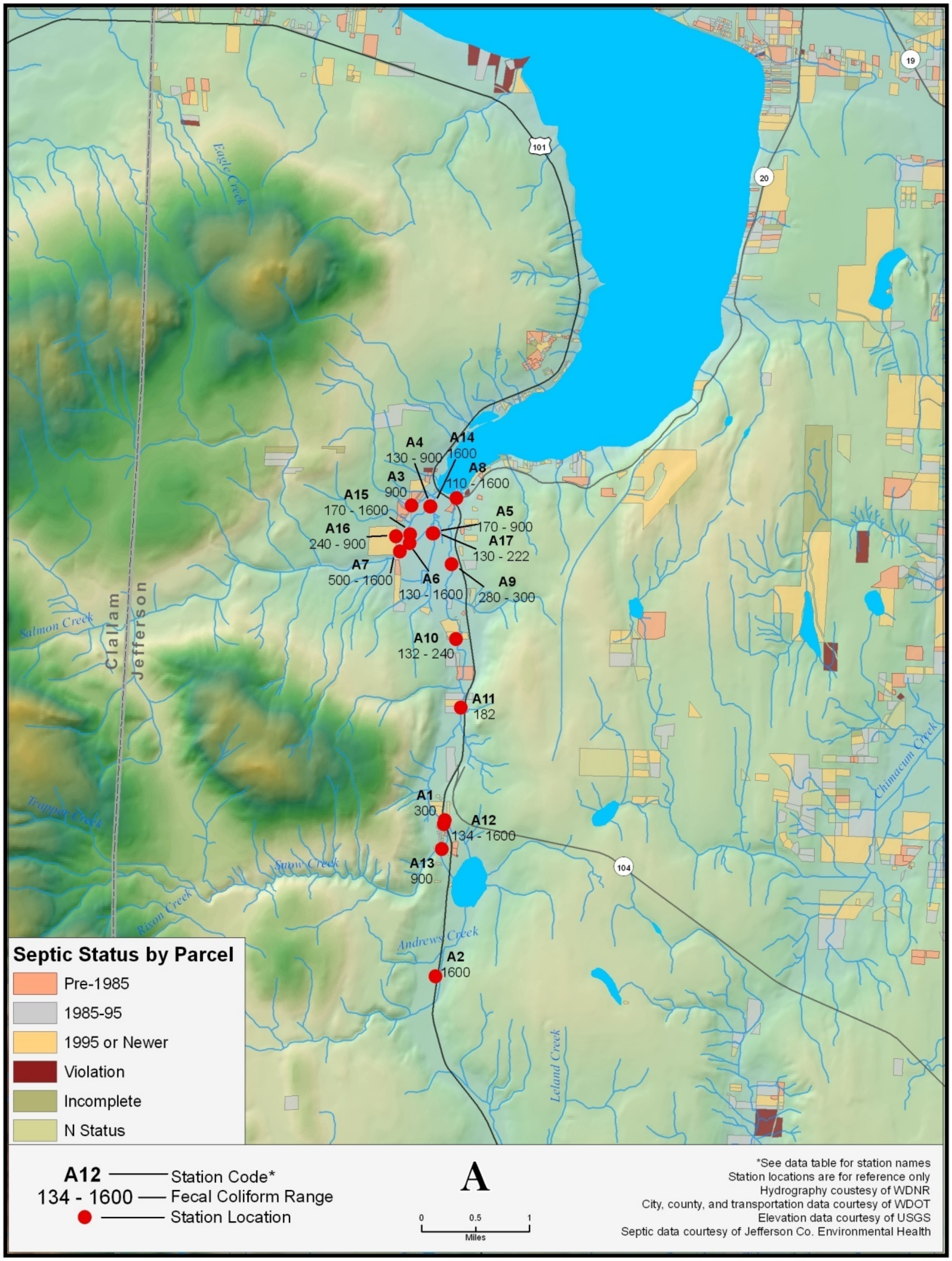

Figure 2. Map A: Jefferson County stations where bacteria data were collected by Jefferson County Health Department.

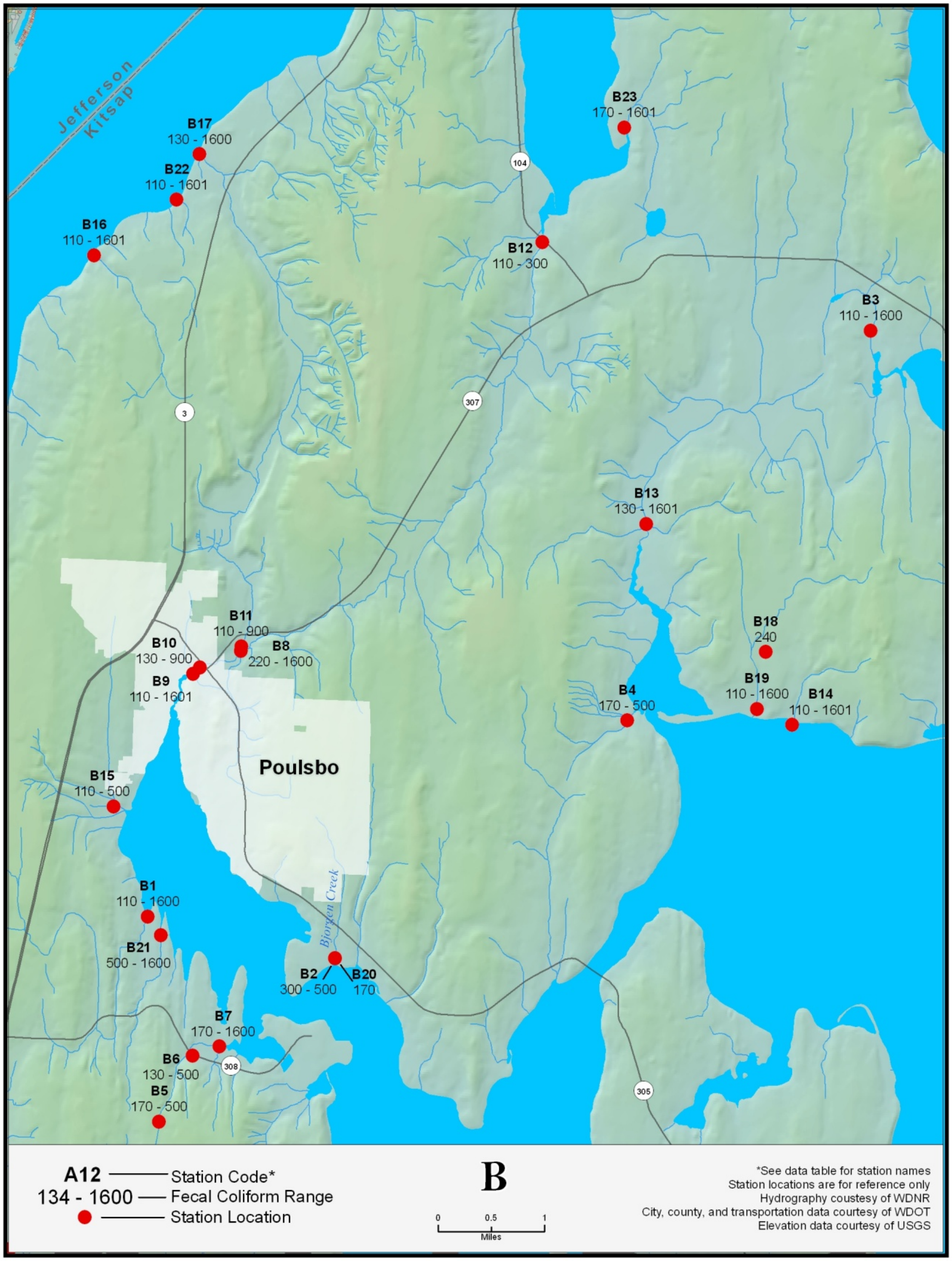

Figure 3. Map B: Kitsap County stations where bacteria data were collected by Kitsap County Health Department.

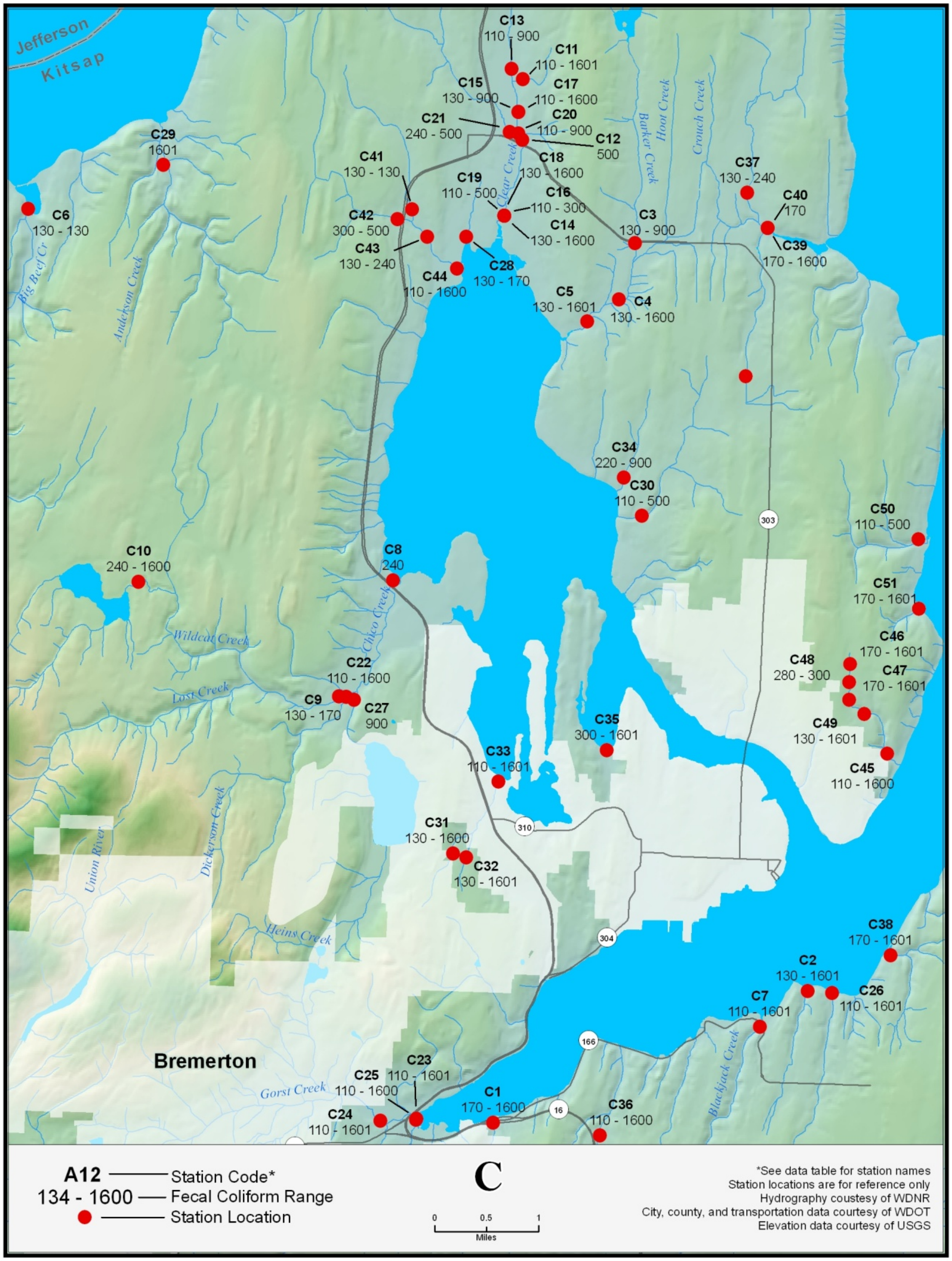

Figure 4. Map C: Kitsap County stations where bacteria data were collected by Kitsap County Health Department.

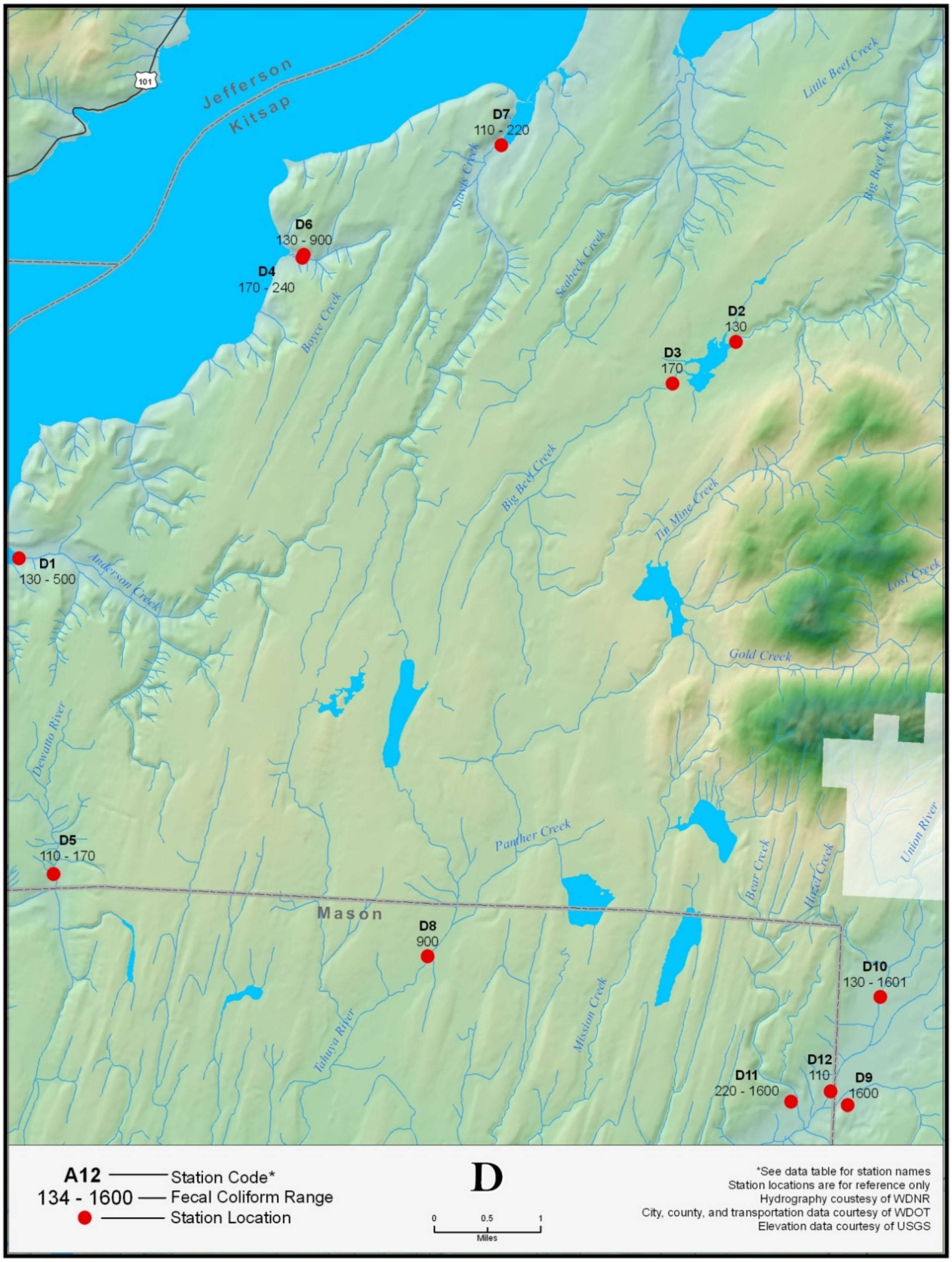

Figure 5. Map D: Mason and Kitsap County stations where bacteria data were collected by Kitsap County Health Department and the Washington State Department of Ecology.

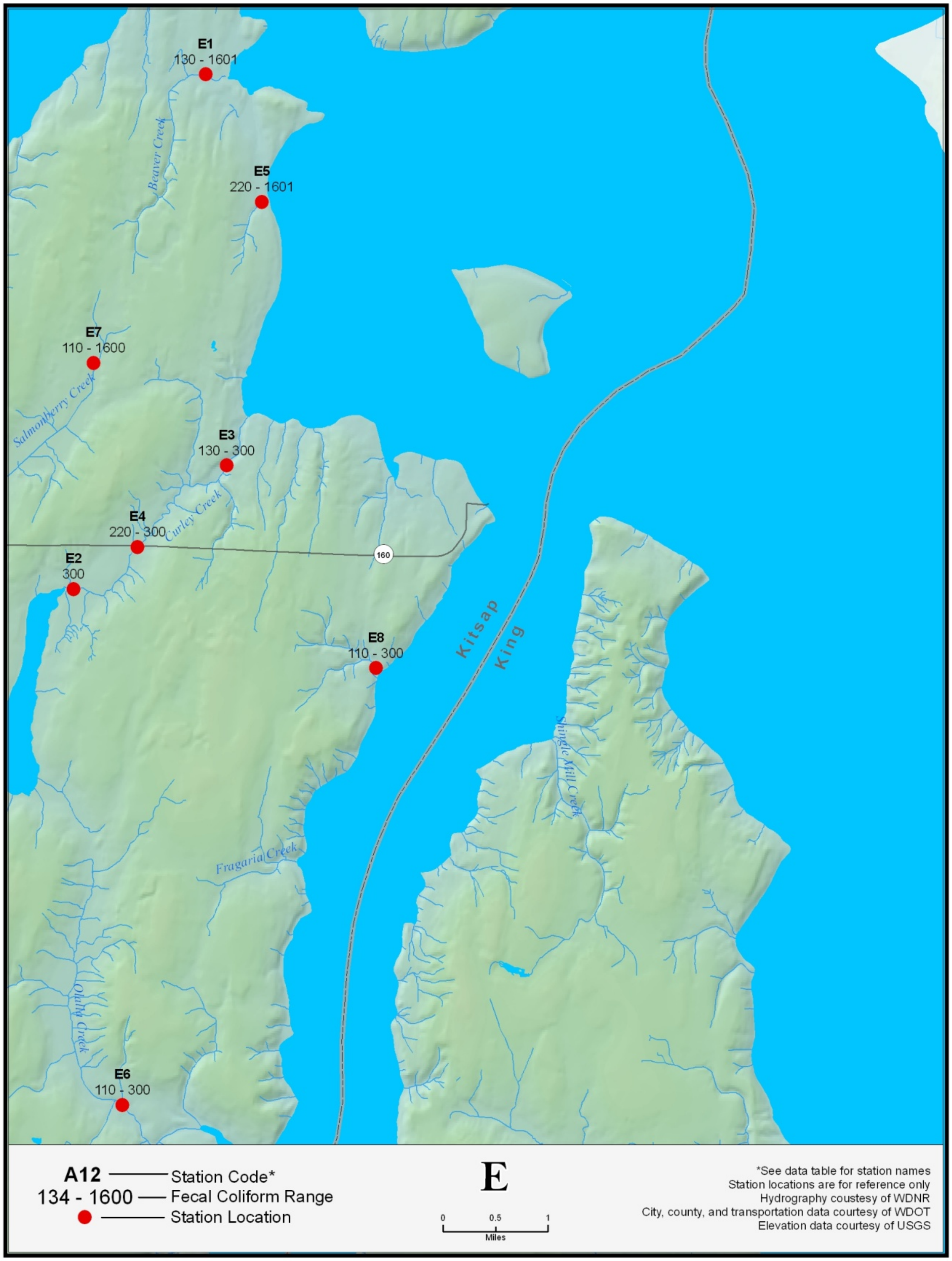

Figure 6. Map E: Kitsap County stations where bacteria data were collected by Kitsap County Health Department.

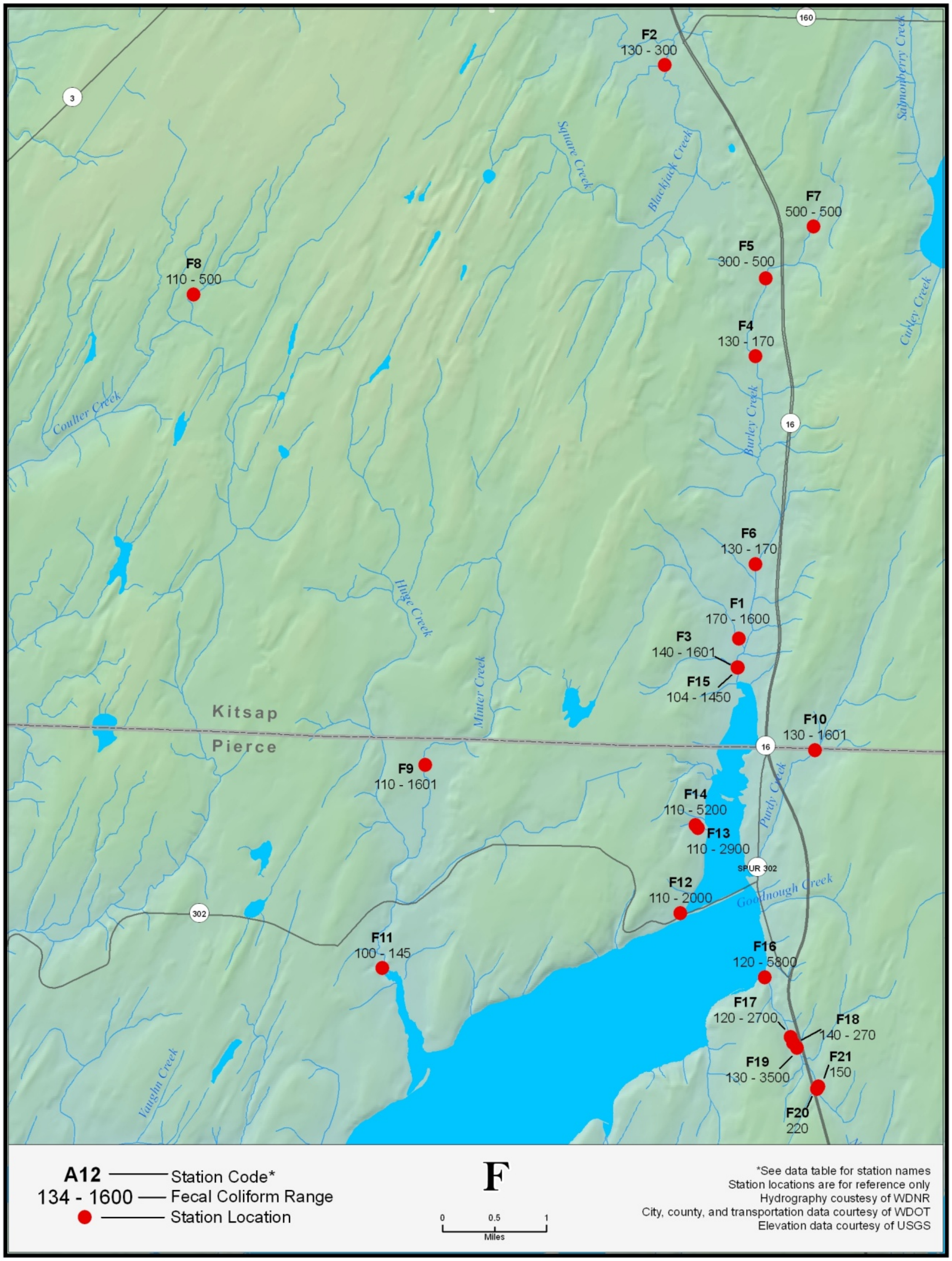

Figure 7. Map F: Kitsap and Pierce County stations where bacteria data were collected by Kitsap County Health Department and the Tacoma-Pierce County Health Department.

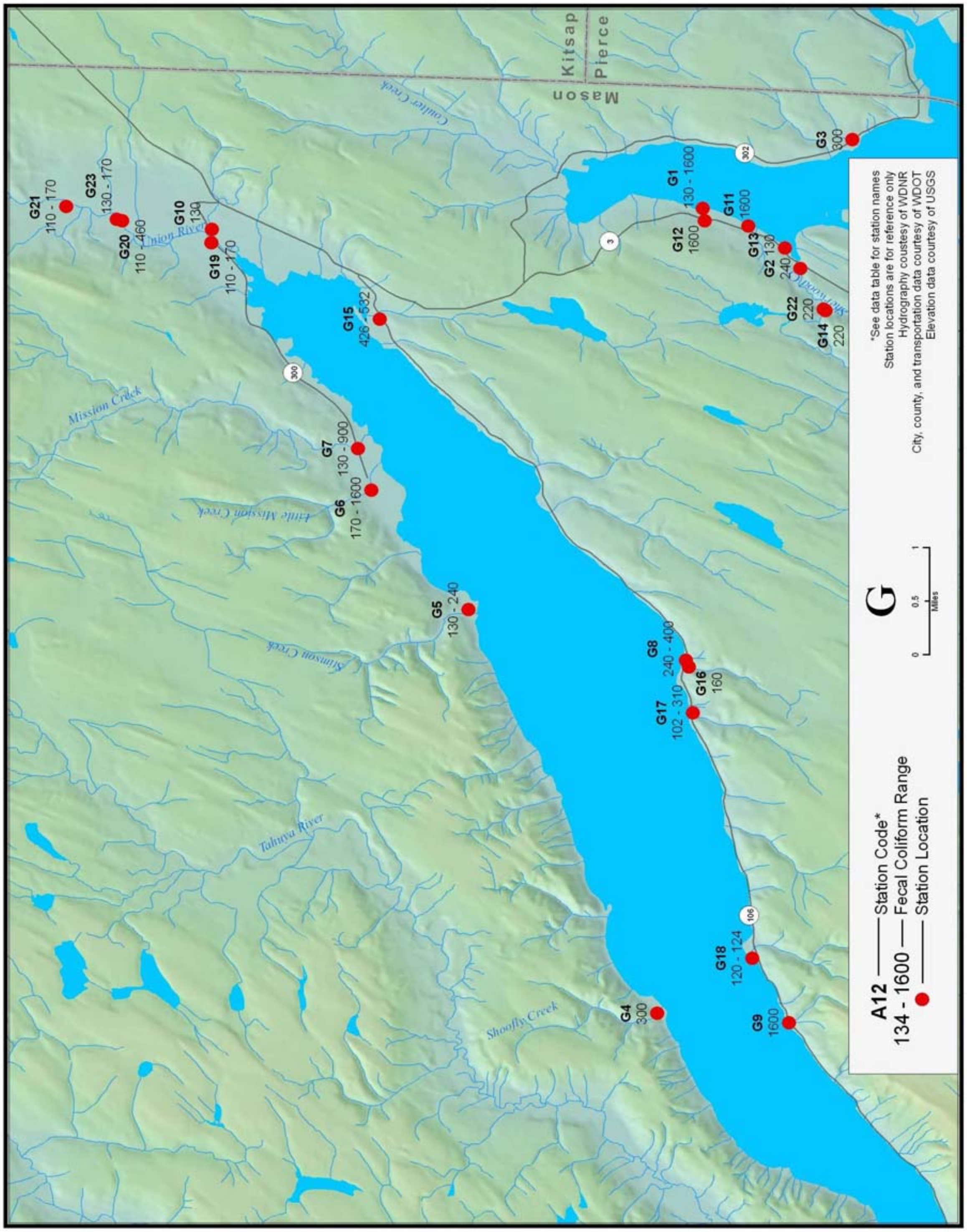

Figure 8. Map G: Mason County stations where bacteria data were collected by Mason County Public Health.

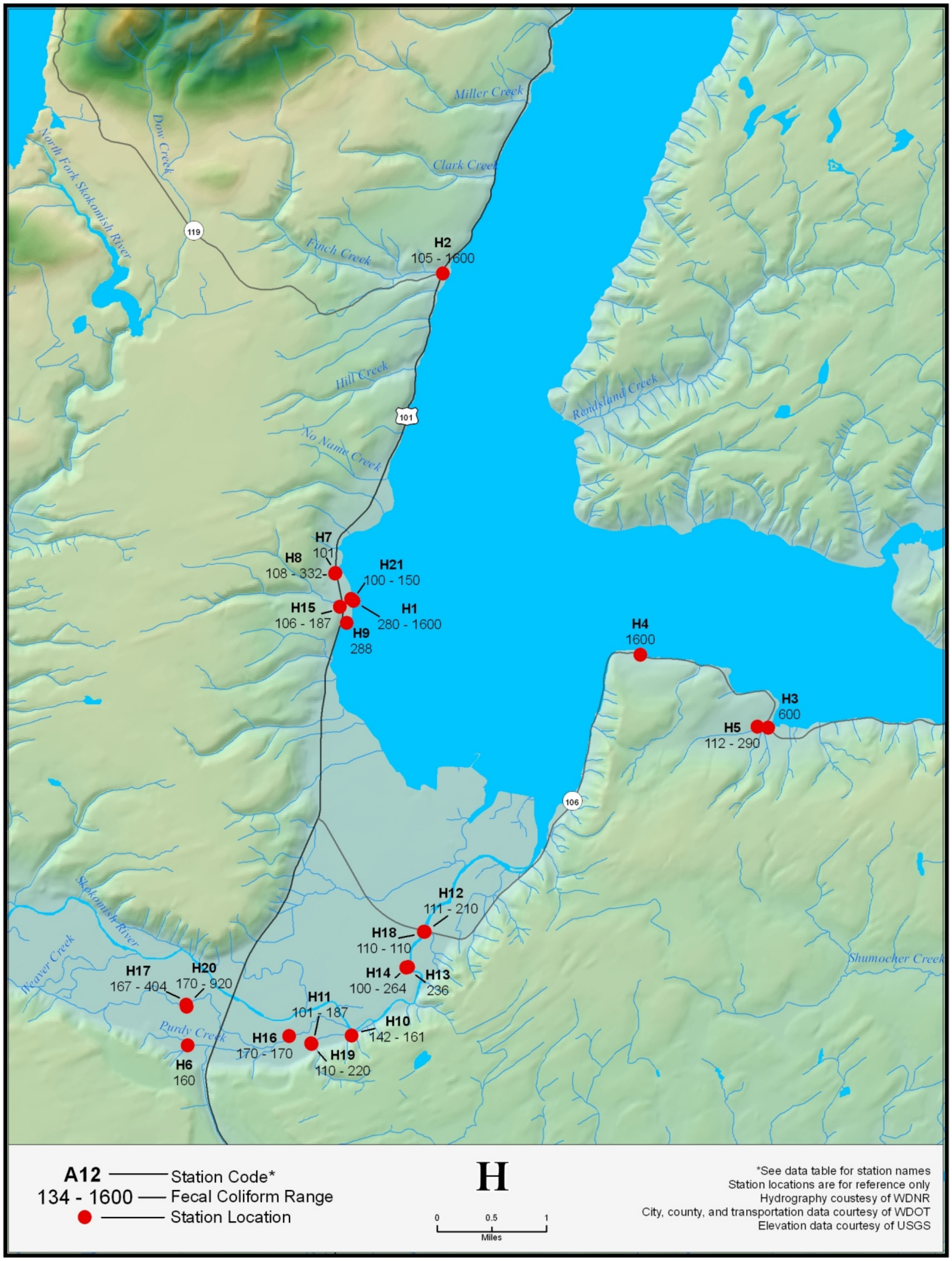

Figure 9. Map H: Mason County stations where bacteria data were collected by the Washington State Department of Ecology, Skokomish Tribe, and Mason County Public Health.

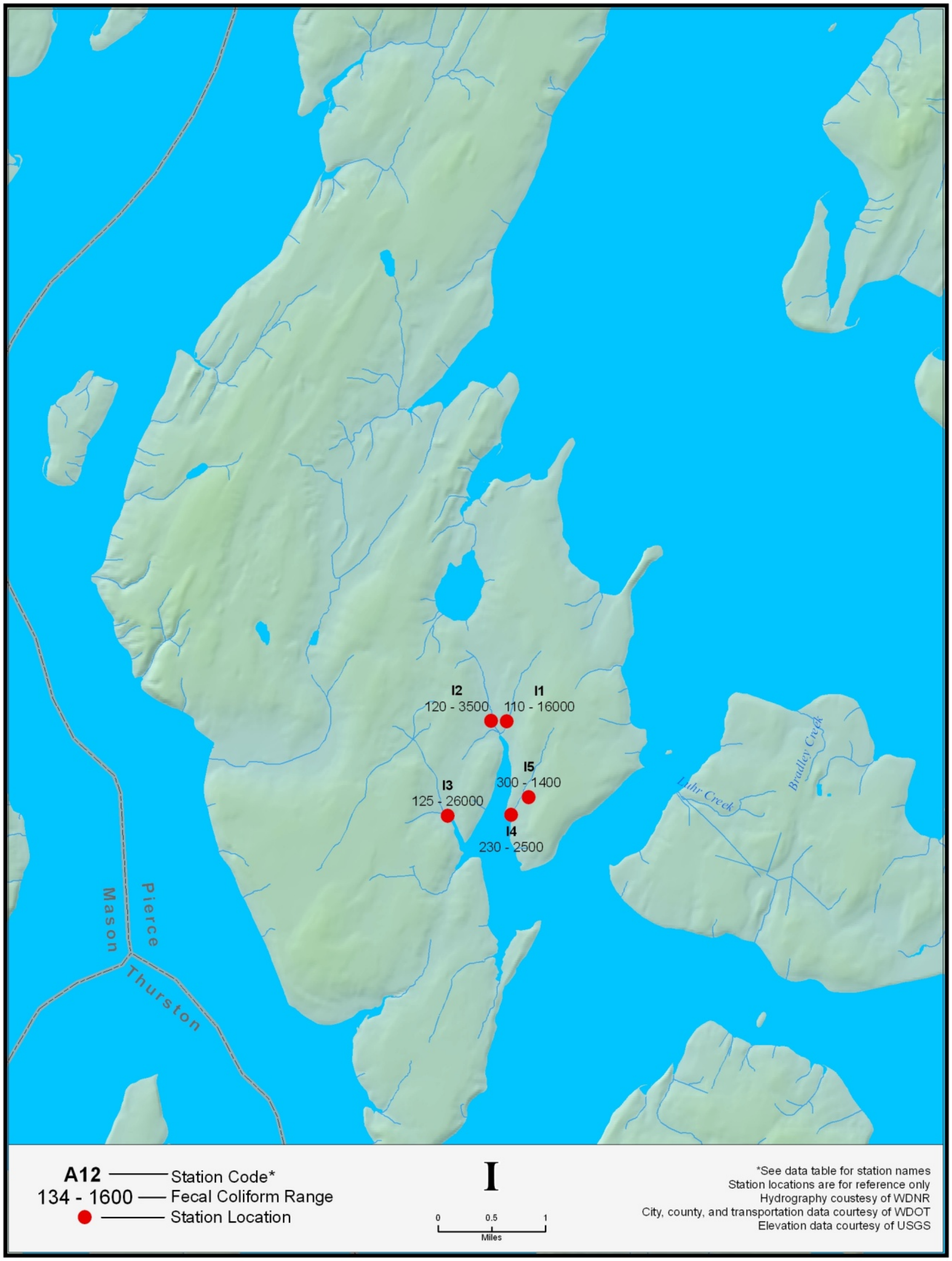

Figure 10. Map I: Pierce County stations where bacteria data were collected by Tacoma-Pierce County Health Department.

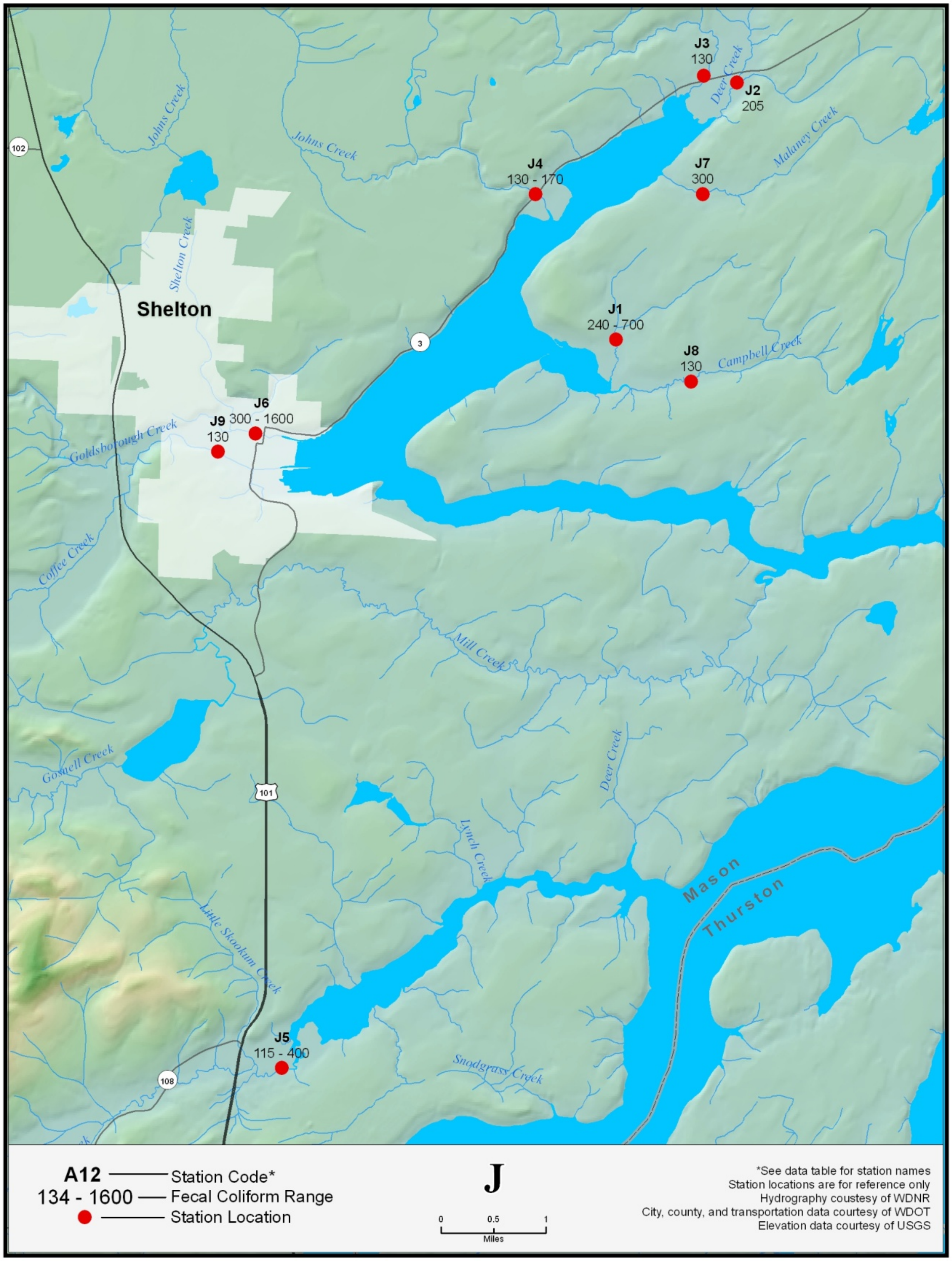

Figure 11. Map J: Mason County stations where bacteria data were collected by Mason County Public Health.

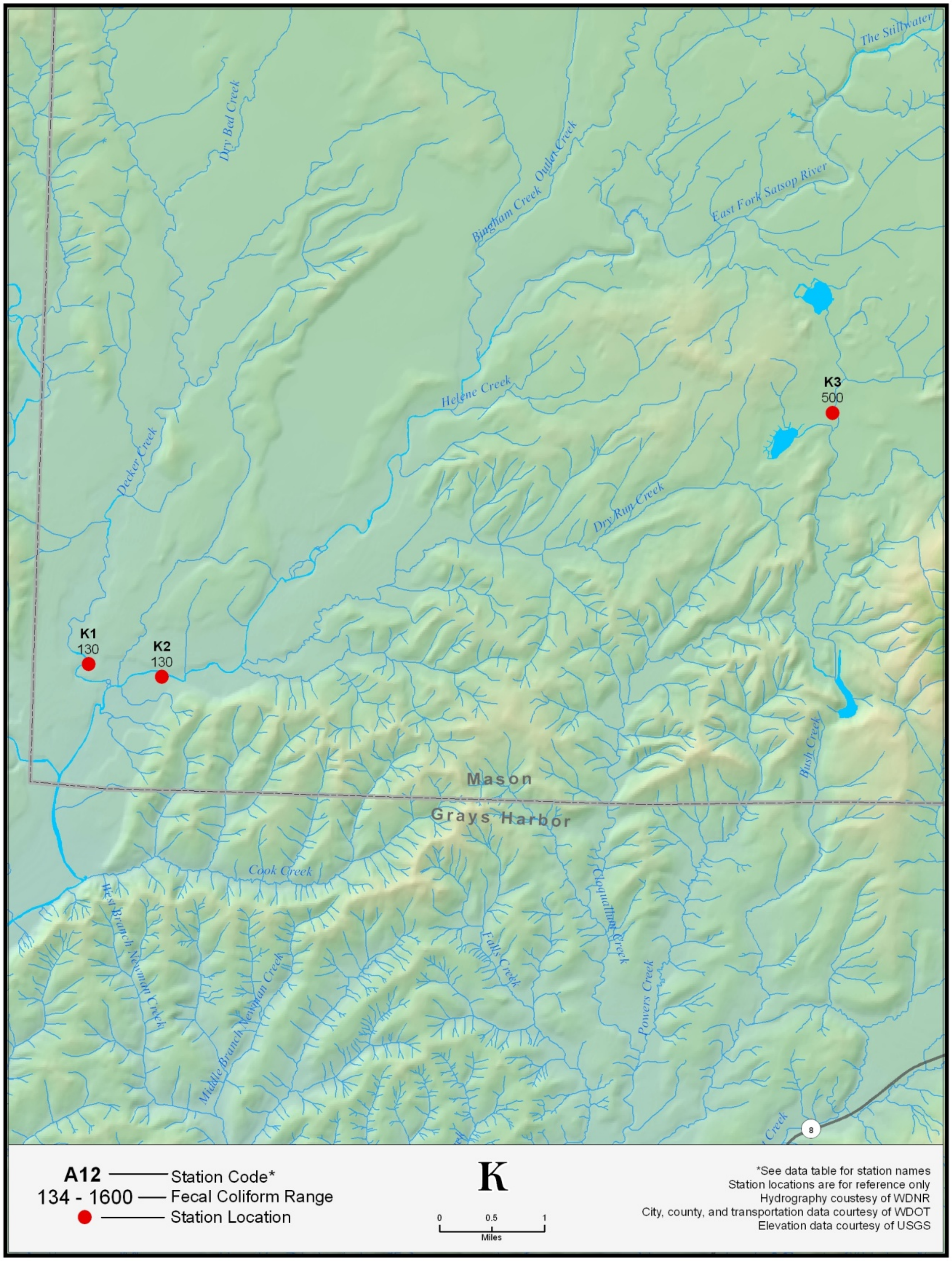

Figure 12. Map K: Mason County stations where bacteria data were collected by Mason County Public Health.

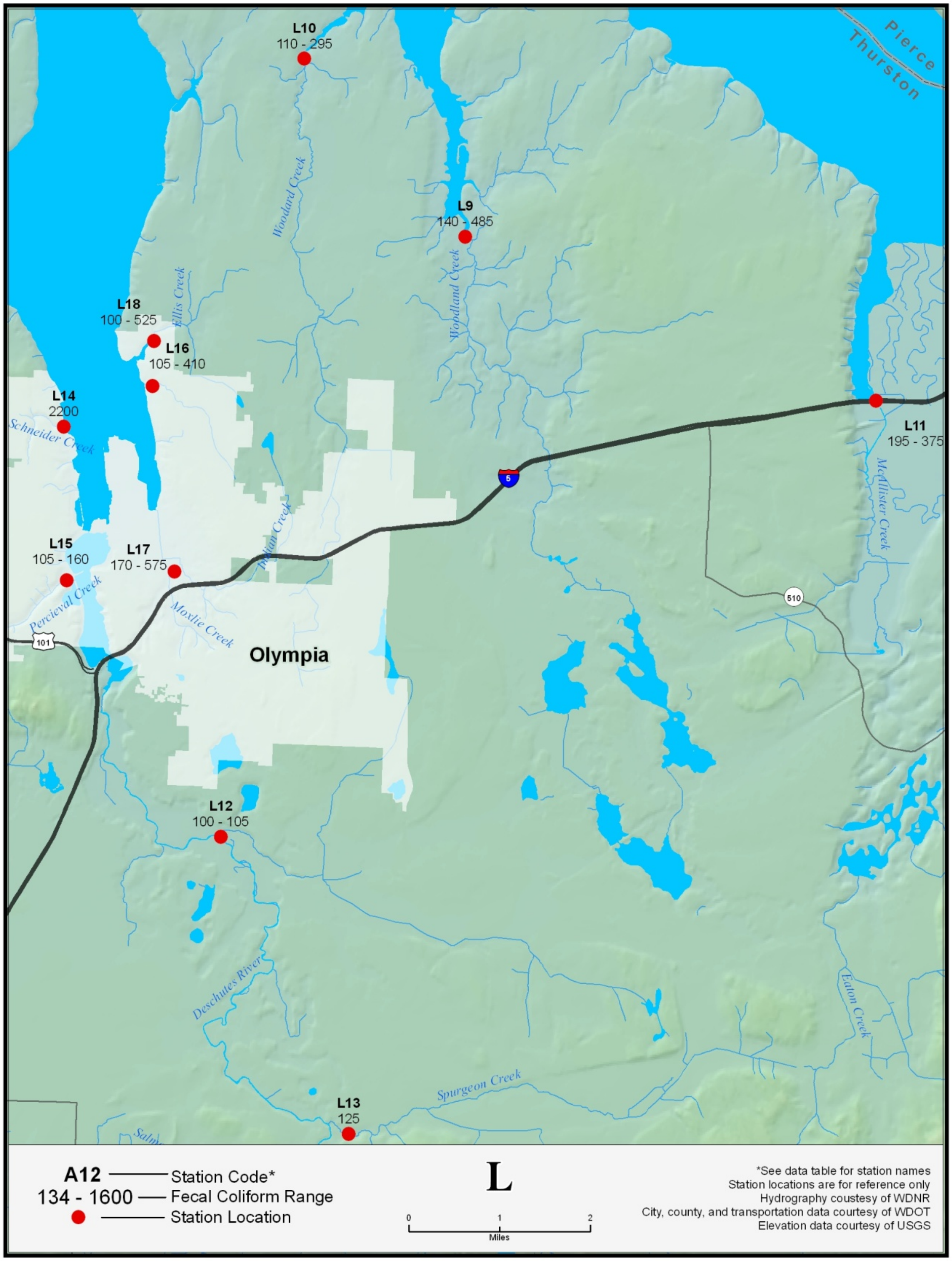

Figure 13. Map L: Thurston County Stations where bacteria data were collected by Thurston County Environmental Health.

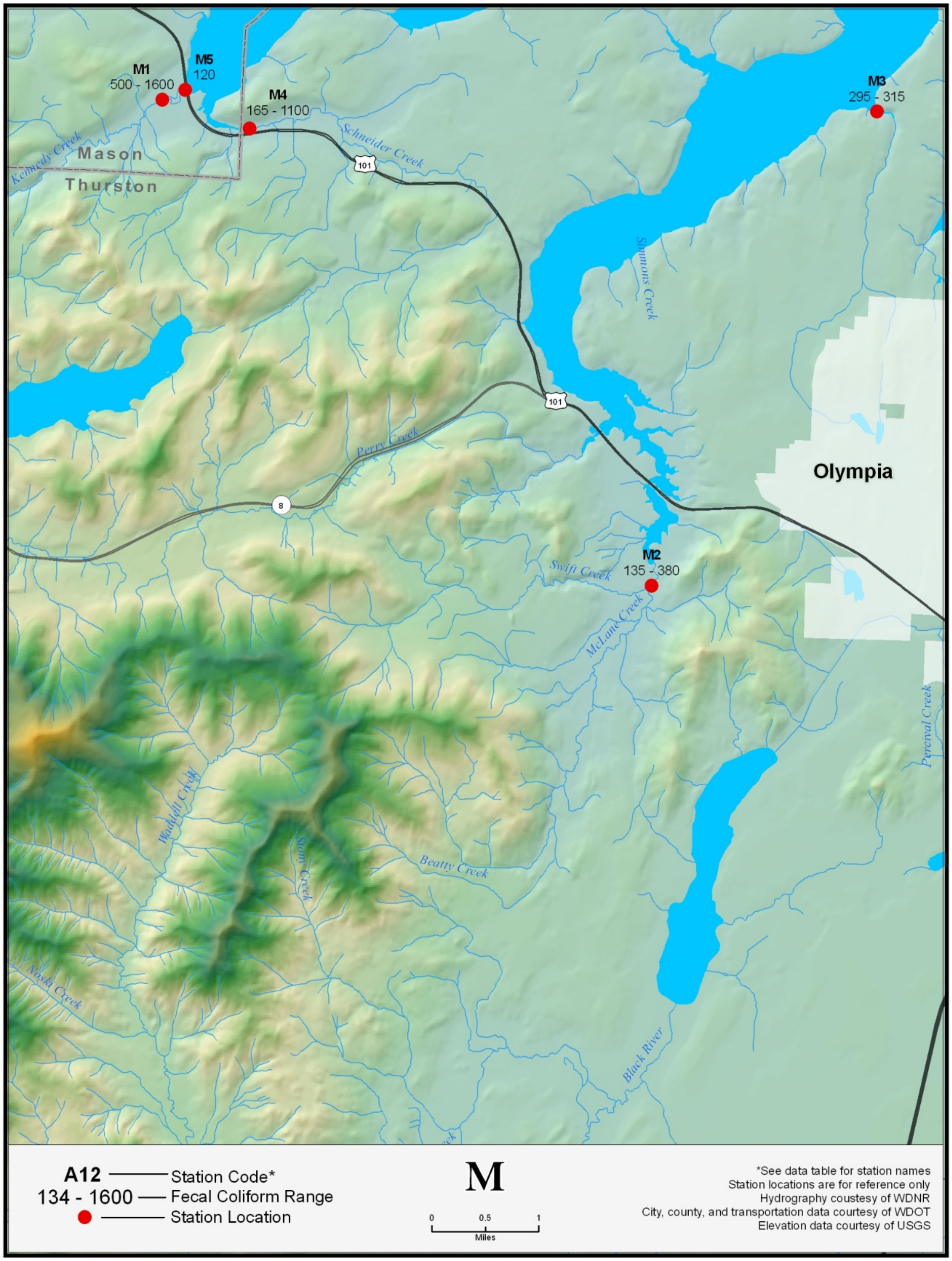

Figure 14. Map M: Mason and Thurston County stations where bacteria data were collected by Mason County Public Health and Thurston County Environmental Health.

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Appendix B. Station Locations

Table B-1. Bacteria Data Station Locations by Data Source

Data Source	Map Station Code	Station Name	Latitude	Longitude
Thurston County Environmental Health				
	L9	HENWL0000	47.09238	-122.8220
	L10	HENWO0000	47.11986	-122.8608
	L11	NISMC0000	47.06819	-122.7251
	L12	DESCH0300	46.99591	-122.8749
	L13	DESSP0500	46.94935	-122.8430
	L14	BUDSC0000	47.06027	-122.9143
	L15	BUDPE0000	47.03585	-122.9125
	L16	BUDMI0000	47.06712	-122.8938
	L17	BUDIN0010	47.03776	-122.8875
	L18	BUDEL0000	47.07431	-122.8939
	M2	ELDMC0000	47.03186	-122.9893
	M3	ELDGC0000	47.09684	-122.9476
	M4	TOTSC0000	47.09184	-123.0719
	M5	TOTKE0000	47.09677	-123.0849
Department of Ecology, Skokomish River TMDL				
	H6	Ten Acre Creek on Campbell Lane	47.303506	-123.1839
	H19	Purdy Creek at Bourgault Rd	47.304238	-123.1597
	H18	Skokomish River at Hwy 106 Bridge	47.319608	-123.1385
	H20	Weaver Creek at Bourgault Rd	47.308621	-123.1844
Kitsap County Health Department				
	B1	Big Scandia Creek at 17139 Scandia Ct	47.71813	-122.6561
	B2	Bjorgen Creek, near Tukwila Rd at 16647	47.71319	-122.6182
	B3	Carpenter Creek, Barber cut-off Rd	47.80004	-122.5136
	B4	Cowling Creek, downstream of weir	47.74642	-122.5606
	B5	Daniels Creek, Central Valley Rd	47.690423	-122.6527
	B6	Daniels Creek, Hwy 308	47.699461	-122.6463
	B7	Daniels Creek, near Norbut Lane	47.70083	-122.6409
	B8	Dogfish Creek - East Fork	47.75445	-122.6387

Data Source	Map Station Code	Station Name	Latitude	Longitude
	B9	Dogfish Creek, near Bond Rd	47.75207	-122.6470
	B10	Dogfish Creek, South Fork	47.75116	-122.6483
	B11	Dogfish Creek, West Fork	47.75506	-122.6387
	B12	Gamble Creek, Hwy 104	47.81087	-122.5803
	B13	Grovers Creek, near hatchery	47.77309	-122.5577
	B14	Indianola Creek, on beach west of dock	47.74642	-122.5274
	B15	Johnson Creek, south of Norfin Way	47.73291	-122.6636
	B16	Jump-off Joe Creek, footbridge	47.80748	-122.6705
	B17	Kinman Creek, near mouth	47.82153	-122.6498
	B18	Kitsap Creek, downstream of Indianola Rd	47.75618	-122.5331
	B19	Kitsap Creek, near Seaview Lane	47.74845	-122.5345
	B20	Klebeal Creek, near Hwy 305	47.7132	-122.6182
	B21	Little Scandia Creek, Scandia Rd	47.715665	-122.6534
	B22	Lofall Creek, near mouth at beach	47.81528	-122.6542
	B23	Martha-John Creek, near Gamble Place	47.82671	-122.5643
	C1	Anderson Creek, between Hwys 16 & 166	47.52743	-122.6822
	C2	Annapolis Creek, downstream of Arnold Ave	47.54695	-122.6181
	C3	Barker Creek, near 601 Bucklin Hill Rd	47.65026	-122.6579
	C4	Barker Creek, near 8600 Nels Nelson Rd	47.64234	-122.6608
	C5	Barker Creek, upstream of Barker Creek Rd	47.63917	-122.6673
	C6	Big Beef Creek, off Manley Rd	47.65264	-122.7834
	C7	Blackjack Creek, upstream Bay St	47.54179	-122.6278
	C8	Chico Creek, Kittyhawk Drive	47.60243	-122.7059
	C9	Chico Creek, Taylor Rd	47.58608	-122.7163
	C10	Chico Creek, Wildcat Lake Rd	47.60122	-122.7583
	C11	Clear Creek - Ridgetop Blvd.	47.67264	-122.6820
	C12	Clear Creek, 11200 Silverdale Way	47.6642	-122.6817
	C13	Clear Creek, Clear Creek Trail	47.67398	-122.6843
	C14	Clear Creek, Levin Rd	47.65357	-122.6851

Data Source	Map Station Code	Station Name	Latitude	Longitude
	C15	Clear Creek, Myhre Rd	47.66804	-122.6827
	C16	Clear Creek, off Levin Rd	47.65357	-122.6851
	C17	Clear Creek, off Mickleberry Rd	47.66804	-122.6827
	C18	Clear Creek, Ridgetop Blvd.	47.65357	-122.6851
	C19	Clear Creek, Schold Rd	47.65357	-122.6851
	C20	Clear Creek, Silverdale Way	47.66508	-122.6826
	C21	Clear Creek, W Fork upstream of Schold Rd	47.66524	-122.6843
	C22	Dickerson Creek, Taylor Rd	47.58608	-122.7149
	C23	Gorst Creek, Hwy 3	47.52754	-122.6980
	C24	Gorst Creek, Sam Christopherson Rd	47.52725	-122.7054
	C25	Huge Creek, 3785 County Line Rd	47.52769	-122.6980
	C26	Karcher Creek, KCSD5 WWTP	47.54672	-122.6131
	C27	Kitsap Creek, Northlake Way	47.58568	-122.7133
	C28	Kitsap Mall Creek, western outfall	47.650464	-122.6927
	C29	Little Anderson Creek, Anderson Hill Rd	47.65927	-122.7557
	C30	Mosher Creek, Tracyton Blvd.	47.61235	-122.6549
	C31	Ostrich Bay Creek, north of Broad St.	47.56471	-122.6919
	C32	Ostrich Bay Creek, south of Broad St.	47.56421	-122.6892
	C33	Ostrich Bay Creek, Shorewood Drive	47.57485	-122.6830
	C34	Parman Creek, Tracyton Blvd.	47.61759	-122.6589
	C35	Phinney Creek, Phinney Bay Drive	47.57966	-122.6609
	C36	Ross Creek, off Clear Ridge Ct	47.52607	-122.6601
	C37	Royal Valley Creek, Paulsen Rd	47.65766	-122.6350
	C38	Sacco Creek, end of Sacco Lane	47.55221	-122.6012
	C39	Steele Creek, Brownsville Hwy	47.65285	-122.6306
	C40	Steele Creek, west trib, confluence w/ ST01	47.65285	-122.6306
	C41	Strawberry Creek, Anderson Hill Rd	47.65411	-122.7041
	C42	Strawberry Creek, Provost Rd	47.65266	-122.7071
	C43	Strawberry Creek, Silverdale Loop Rd	47.650337	-122.7008

Data Source	Map Station Code	Station Name	Latitude	Longitude
	C44	Strawberry Creek, Washington Ave	47.64605	-122.6945
	C45	Enetai Creek, Trenton Ave	47.58562	-122.6080
	C46	Enetai Creek, Franklin St	47.59255	-122.6111
	C47	Enetai Creek, Helm St	47.58755	-122.6111
	C48	Enetai Creek, NE 30th St	47.59003	-122.6113
	C50	Illahee Creek, near 5171 Illahee Rd	47.61013	-122.5977
	C51	State Park Creek, Illahee State Park	47.60047	-122.5972
	C52	Steele Creek, Fairgrounds Rd	47.63213	-122.6343
	D1	Big Anderson Creek, upstream of Sea-Hol bridge	47.56678	-122.9676
	D2	Big Beef Creek, below Lake Symington Spillway	47.59909	-122.8245
	D3	Big Beef Creek, downstream of Holly Rd	47.59319	-122.8371
	D4	Boyce Creek, Guillemot Cove County Park	47.60875	-122.9124
	D5	Dewatto River, Bear Creek Rd	47.52405	-122.9587
	D6	Seabeck Creek, near Miami Beach	47.60912	-122.9122
	D7	Stavis Creek, Stavis Rd bridge	47.62485	-122.8730
	D8	Tahuya River, Elfendal Pass	47.51441	-122.8829
	D9	Union River - East Fork	47.49592	-122.7976
	D10	Union River, Belfair Hwy bridge	47.51074	-122.7917
	D11	Union River, near old Belfair Hwy	47.49771	-122.8011
	E1	Beaver Creek, Ecology Lab Drive	47.57029	-122.5563
	E2	Curley Creek, Long Lake Rd bridge	47.49915	-122.5805
	E3	Curley Creek, near SE Martin Lane	47.51667	-122.5501
	E4	Curley Creek, Sedgwick Rd bridge	47.50516	-122.5678
	E5	Duncan Creek, Colchester Drive	47.55298	-122.5443
	E6	Olalla Creek, Forsman Rd	47.42852	-122.5679

Data Source	Map Station Code	Station Name	Latitude	Longitude
	E7	Salmonberry Creek, Howe Farm Park	47.53025	-122.5776
	E8	Wilson Creek, end of Pristine Beach Lane	47.48938	-122.5187
	F1	Bear Creek, North of Pine Rd	47.41842	-122.6312
	F2	Blackjack Creek, Sedgwick Rd crossing	47.49785	-122.6496
	F3	Burley Creek, bridge off Spruce	47.41445	-122.6313
	F4	Burley Creek, Holman Rd	47.45774	-122.6294
	F5	Burley Creek, Mullinex Rd	47.46862	-122.6277
	F6	Burley Creek, Oak Rd bridge	47.42888	-122.6282
	F7	Burley Creek, Spring Creek Rd	47.47598	-122.6181
	F8	Coulter Creek, Lake Flora Rd	47.46416	-122.7452
	F9	Minter Creek, Glenwood Rd	47.39974	-122.6949
	F10	Purdy Creek, near 160th	47.40323	-122.6149
Skokomish Tribal Data				
	H7	Harvey Terrace Lower	47.36466	-123.15820
	H8	Hurley Hill Ditch	47.36472	-123.15819
	H9	Potlatch State Park (beach)	47.35814	-123.15562
	H10	Purdy Creek - mouth	47.30357	-123.15201
	H11	Purdy Creek at Bourgault Rd bridge	47.30234	-123.15984
	H12	Skokomish River at 106 Bridge	47.31763	-123.13840
	H13	Skokomish River at Chico's Eddy	47.31289	-123.14136
	H14	ss1ALEX'S	47.31282	-123.14173
	H15	Upper Potlatch Creek	47.36022	-123.15703
	H16	Weaver Creek at the lower bridge	47.30320	-123.16421
	H17	Weaver Creek Valley Rd bridge	47.30690	-123.18442
	H21	Potlatch Creek - mouth	47.36136	-123.15497

Data Source	Map Station Code	Station Name	Latitude	Longitude
Department of Ecology, Union River TMDL				
	D12	UR5BEAR	47°29'47"	122°48'28"
	G10	UR4ARCH	47°29'47"	122°48'07"
	G19	UR1HY300	47°27'08"	122°50'02"
	G20	UR2TMBR	47°27'53"	122°49'47"
	G21	UR3RIVER	47°28'17"	122°49'39"
Mason County Data from Ecology's EIM Database				
	G15	Devereaux Creek	47.4296504	-122.8495
	G16	Happy Hollow Creek	47.3877405	-122.9172
	G17	Mulberg Creek	47.3870174	-122.9263
	G18	Twanoh Creek	47.3781683	-122.9751
	H5	Big Bend Creek	47.3479735	-123.0760
Tacoma-Pierce County Health Department				
	F11	Mouth of Minter Creek	47.3713	-122.7025
	F12	BL02	47.3801	-122.6417
	F13	Martin North	47.392	-122.6385
	F14	Martin Upper	47.3924	-122.6391
	F15	Burley Creek - mouth	47.4144	-122.6312
	F16	McCormick Creek - mouth (Station 2)	47.3715	-122.624
	F17	McCormick Creek below lift station (Station 1)	47.3633	-122.6184
	F18	McCormick Creek above lift station (Station 4)	47.3625	-122.6178
	F19	McCormick Creek at bridge (Station 5)	47.3618	-122.617
	F20	McCormick Creek above Hwy 16 (Station 7)	47.3565	-122.6124
	F21	McCormick Creek above Hwy 16 (Station 8)	47.3562	-122.6127
	I1	FB1	47.2267	-122.7481
	I2	FB2	47.2267	-122.7511
	I3	FB3	47.2138	-122.7592
	I4	Dalton Creek - mouth	47.2142	-122.7467
	I5	FB6	47.2166	-122.7433

Data Source	Map Station Code	Station Name	Latitude	Longitude
Jefferson County Health Department				
	A1	AND/0.0	47.94481	-122.88605
	A2	AND/1.71	47.92394	-122.88695
	A3	CAS/0.3	47.9867	-122.89452
	A4	SA/0.15	47.98666	-122.89073
	A5	SA/0.4	47.98311	-122.89017
	A6	SA/0.6	47.98168	-122.89474
	A7	SA/0.7	47.98052	-122.8966
	A8	SN/0.2	47.98787	-122.88558
	A9	SN/0.8	47.97907	-122.88618
	A10	SN/1.6	47.96907	-122.88483
	A11	SN/2.3	47.95993	-122.88346
	A12	SN/3.5	47.94429	-122.88616
	A13	SN/3.9	47.94094	-122.88647
	A14	TUD/0.0	47.9867	-122.89079
	A15	TUD/0.4	47.98288	-122.89466
	A16	TUD/0.5	47.98255	-122.89748
	A17	UVD/0.0	47.98309	-122.89003
Mason County Public Health				
	G1	Site 21, Unnamed creek at Allyn pump station, intersection Hwy 106 & Hwy 3	47.38782	-122.82553
	G2	Site 27, Sherwood Creek at Hwy 3 bridge	47.37473	-122.83698
	G3	Site 30, Unnamed creek in Victor just after 4590 Hwy 302	47.36843	-122.81092
	G4	Site 36, Shoofly Creek at North Shore Rd	47.39045	-122.98677
	G5	Site 37, Stimson Creek at North Shore Rd culvert	47.41685	-122.90718
	G6	Site 38, Little Mission Cr at North Shore Rd culvert	47.43005	-122.88378
	G7	Site 39, Big Mission Cr at North Shore Rd bridge	47.43197	-122.87558
	G8	Site 44	47.38813	-122.91592
	G9	Site 47	47.3731	-122.98783
	G10	Site 40B, Belfair Creek at North Shore Rd (Hwy 300 at this point) bridge	47.45203	-122.83253
	G11	Site 61, Culvert at Lennard K's, Hwy 3 in Allyn	47.38177	-122.82873
	G12	Site 60, Unnamed creek at Michael Dr across intersection from Allyn pump station.	47.38748	-122.82795

Data Source	Map Station Code	Station Name	Latitude	Longitude
	G13	Site 62, Culvert at Kayak Park, Hwy 3 in Allyn	47.37685	-122.83298
	G22	Site 63, Tributary into Sherwood Creek, intersection of Sherwood Rd & Sherwood Cr Rd; tributary is approx 20 ft west of intersection coming off N bank	47.37152	-122.84496
	G23	Site 82, Union River at Timberline Rd Bridge RR, next to gauge	47.46379	-122.83123
	H1	Site 13, Potlatch Creek at Potlatch State Park	47.36288	-123.15575
	H2	Site 15, Finch Creek at 101 bridge	47.40663	-123.14045
	H3	Site 50	47.34795	-123.0739
	H4	Site 51	47.35703	-123.09933
	J1	Site 22, Uncle John Creek at Agate Loop Rd culvert	47.22863	-123.0282
	J2	Site 23, Deer Creek at Hwy 3 bridge	47.26443	-123.0053
	J3	Site 24, Cranberry Creek at Hwy 3 bridge	47.26523	-123.01207
	J4	Site 25, Johns Creek at Hwy 3 bridge	47.24822	-123.04542
	J5	Site 31, Skookum Creek	47.12715	-123.0909
	J6	Site 26, Shelton Creek at DQ rear parking lot, upstream of footbridge	47.21418	-123.10092
	J7	Site 53, Malaney Cr at Agate Rd culvert. Park SW of bridge, beware unstable logs. DS, RL. WAND	47.24898	-123.01153
	J8	Site 54, Campbell Creek at Agate Rd culvert	47.22318	-123.01266
	J9	Site 57, Goldsborough Creek at 7th St. bridge	47.21145	-123.10790
	K1	Site 2, Decker Creek	47.0992	-123.47817
	K2	Site 3, Satsop River middle fork at east end of Schaffer Park road access	47.09785	-123.46327
	K3	Site 7, Cloquallum Creek	47.1375	-123.32988
	M1	Site 19, Kennedy Creek bridge at Old Olympic Hwy	47.09518	-123.09068

Appendix C. Results Data

Table C-1. Bacteria Data Results by Data Source.

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
Thurston County Environmental Health				
L9	HENWL0000	6/12/06	485	cfu
L9	HENWL0000	7/11/06	190	cfu
L9	HENWL0000	9/13/06	140	cfu
L10	HENWO0000	7/11/06	110	cfu
L10	HENWO0000	8/7/06	128	cfu
L10	HENWO0000	9/13/06	295	cfu
L11	NISMC0000	6/12/06	210	cfu
L11	NISMC0000	7/11/06	355	cfu
L11	NISMC0000	8/8/06	375	cfu
L11	NISMC0000	9/13/06	195	cfu
L12	DESCH0300	5/16/06	105	cfu
L12	DESCH0300	6/12/06	100	cfu
L12	DESCH0300	7/10/06	100	cfu
L12	DESCH0300	9/12/06	105	cfu
L13	DESSP0500	7/11/06	125	cfu
L14	BUDSC0000	7/11/05	2200	cfu
L15	BUDPE0000	7/10/06	105	cfu
L15	BUDPE0000	9/12/06	160	cfu
L16	BUDMI0000	5/9/05	410	cfu
L16	BUDMI0000	6/6/05	240	cfu
L16	BUDMI0000	7/12/05	325	cfu
L16	BUDMI0000	8/10/05	285	cfu
L16	BUDMI0000	9/26/05	105	cfu
L17	BUDIN0010	5/9/05	248	cfu
L17	BUDIN0010	6/6/05	415	cfu
L17	BUDIN0010	7/11/05	575	cfu
L17	BUDIN0010	8/10/05	433	cfu
L17	BUDIN0010	9/26/05	170	cfu
L18	BUDEL0000	5/9/05	525	cfu
L18	BUDEL0000	6/6/05	220	cfu
L18	BUDEL0000	7/12/05	100	cfu
M2	ELDMC0000	6/13/06	135	cfu
M2	ELDMC0000	7/10/06	260	cfu
M2	ELDMC0000	8/8/06	380	cfu
M2	ELDMC0000	9/12/06	190	cfu
M3	ELDGC0000	5/15/06	315	cfu
M3	ELDGC0000	6/13/06	295	cfu
M4	TOTSC0000	6/13/06	1100	cfu
M4	TOTSC0000	8/8/06	165	cfu
M5	TOTKE0000	7/10/06	120	cfu
Department of Ecology, Skokomish River TMDL				
H6	Ten Acre Creek on Campbell Lane	05/22/06	160	cfu
H18	Skokomish River at Hwy 106 Bridge	05/22/06	110	cfu

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
H18	Skokomish River at Hwy 106 Bridge	06/05/06	110	cfu
H19	Purdy Creek at Bourgault Rd	05/22/06	220	cfu
H19	Purdy Creek at Bourgault Rd	06/05/06	110	cfu
H20	Weaver Creek at Bourgault Rd	05/22/06	920	cfu
H20	Weaver Creek at Bourgault Rd	06/05/06	170	cfu
Kitsap County Health Department				
B1	Big Scandia Creek at 17139 Scandia Ct	7/21/04	240	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	8/23/04	500	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	9/29/04	300	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	5/3/05	300	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	6/2/05	1600	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	7/12/05	500	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	8/25/05	110	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	9/20/05	130	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	5/24/06	1600	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	7/13/06	240	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	8/17/06	300	mpn
B1	Big Scandia Creek at 17139 Scandia Ct	9/7/06	130	mpn
B2	Bjorgen Creek, near Tukwila Rd at 16647	5/24/06	500	mpn
B2	Bjorgen Creek, near Tukwila Rd at 16647	9/7/06	300	mpn
B3	Carpenter Creek, Barber Cut-Off Rd	7/21/04	170	mpn
B3	Carpenter Creek, Barber Cut-Off Rd	8/23/04	1600	mpn
B3	Carpenter Creek, Barber Cut-Off Rd	6/2/05	170	mpn
B3	Carpenter Creek, Barber Cut-Off Rd	8/25/05	110	mpn
B3	Carpenter Creek, Barber Cut-Off Rd	7/13/06	240	mpn
B4	Cowling Creek, downstream of weir	7/21/04	170	mpn
B4	Cowling Creek, downstream of weir	8/23/04	300	mpn
B4	Cowling Creek, downstream of weir	6/2/05	500	mpn
B4	Cowling Creek, downstream of weir	5/24/06	500	mpn
B5	Daniels Creek, Central Valley Rd	6/20/06	240	mpn
B5	Daniels Creek, Central Valley Rd	7/13/06	500	mpn
B5	Daniels Creek, Central Valley Rd	8/17/06	300	mpn
B5	Daniels Creek, Central Valley Rd	9/7/06	170	mpn
B6	Daniels Creek, Hwy 308	5/24/06	170	mpn
B6	Daniels Creek, Hwy 308	6/20/06	130	mpn
B6	Daniels Creek, Hwy 308	7/13/06	170	mpn
B6	Daniels Creek, Hwy 308	9/7/06	500	mpn
B7	Daniels Creek, near Norbut Lane	6/23/04	900	mpn
B7	Daniels Creek, near Norbut Lane	7/21/04	1600	mpn
B7	Daniels Creek, near Norbut Lane	8/23/04	300	mpn
B7	Daniels Creek, near Norbut Lane	9/29/04	300	mpn
B7	Daniels Creek, near Norbut Lane	6/2/05	280	mpn
B7	Daniels Creek, near Norbut Lane	7/12/05	1600	mpn
B7	Daniels Creek, near Norbut Lane	8/25/05	900	mpn
B7	Daniels Creek, near Norbut Lane	9/20/05	300	mpn
B7	Daniels Creek, near Norbut Lane	6/20/06	170	mpn
B7	Daniels Creek, near Norbut Lane	7/13/06	240	mpn
B7	Daniels Creek, near Norbut Lane	9/7/06	300	mpn
B8	Dogfish Creek - East Fork	6/23/04	240	mpn
B8	Dogfish Creek - East Fork	7/21/04	240	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
B8	Dogfish Creek - East Fork	8/23/04	300	mpn
B8	Dogfish Creek - East Fork	6/2/05	1600	mpn
B8	Dogfish Creek - East Fork	7/12/05	220	mpn
B8	Dogfish Creek - East Fork	8/25/05	220	mpn
B8	Dogfish Creek - East Fork	5/24/06	500	mpn
B8	Dogfish Creek - East Fork	7/13/06	500	mpn
B8	Dogfish Creek - East Fork	8/17/06	500	mpn
B8	Dogfish Creek - East Fork	9/7/06	900	mpn
B9	Dogfish Creek, near Bond Rd	6/23/04	110	mpn
B9	Dogfish Creek, near Bond Rd	7/21/04	170	mpn
B9	Dogfish Creek, near Bond Rd	8/23/04	1601	mpn
B9	Dogfish Creek, near Bond Rd	5/3/05	140	mpn
B9	Dogfish Creek, near Bond Rd	6/2/05	900	mpn
B9	Dogfish Creek, near Bond Rd	8/25/05	110	mpn
B9	Dogfish Creek, near Bond Rd	5/24/06	300	mpn
B9	Dogfish Creek, near Bond Rd	6/20/06	130	mpn
B9	Dogfish Creek, near Bond Rd	7/13/06	240	mpn
B9	Dogfish Creek, near Bond Rd	8/17/06	300	mpn
B9	Dogfish Creek, near Bond Rd	9/7/06	280	mpn
B10	Dogfish Creek, South Fork	8/23/04	900	mpn
B10	Dogfish Creek, South Fork	6/2/05	220	mpn
B10	Dogfish Creek, South Fork	7/12/05	130	mpn
B10	Dogfish Creek, South Fork	8/25/05	220	mpn
B10	Dogfish Creek, South Fork	5/24/06	900	mpn
B10	Dogfish Creek, South Fork	6/20/06	130	mpn
B11	Dogfish Creek, West Fork	8/23/04	900	mpn
B11	Dogfish Creek, West Fork	7/12/05	110	mpn
B11	Dogfish Creek, West Fork	8/25/05	110	mpn
B11	Dogfish Creek, West Fork	5/24/06	220	mpn
B11	Dogfish Creek, West Fork	9/7/06	110	mpn
B12	Gamble Creek, Hwy 104	7/20/04	110	mpn
B12	Gamble Creek, Hwy 104	5/10/05	300	mpn
B13	Grovers Creek, near hatchery	7/21/04	1601	mpn
B13	Grovers Creek, near hatchery	8/23/04	1600	mpn
B13	Grovers Creek, near hatchery	9/29/04	130	mpn
B13	Grovers Creek, near hatchery	5/24/06	1600	mpn
B14	Indianola Creek, on beach west of dock	6/23/04	1601	mpn
B14	Indianola Creek, on beach west of dock	7/21/04	110	mpn
B14	Indianola Creek, on beach west of dock	8/23/04	900	mpn
B14	Indianola Creek, on beach west of dock	7/12/05	300	mpn
B14	Indianola Creek, on beach west of dock	8/25/05	1601	mpn
B14	Indianola Creek, on beach west of dock	9/20/05	500	mpn
B14	Indianola Creek, on beach west of dock	5/24/06	130	mpn
B14	Indianola Creek, on beach west of dock	8/17/06	240	mpn
B14	Indianola Creek, on beach west of dock	9/7/06	240	mpn
B15	Johnson Creek, south of Norfin Way	7/21/04	140	mpn
B15	Johnson Creek, south of Norfin Way	8/23/04	110	mpn
B15	Johnson Creek, south of Norfin Way	5/3/05	500	mpn
B15	Johnson Creek, south of Norfin Way	6/2/05	280	mpn
B15	Johnson Creek, south of Norfin Way	8/25/05	140	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
B15	Johnson Creek, south of Norfin Way	5/24/06	170	mpn
B16	Jump-off Joe Creek, footbridge	6/2/04	140	mpn
B16	Jump-off Joe Creek, footbridge	7/20/04	900	mpn
B16	Jump-off Joe Creek, footbridge	8/10/04	170	mpn
B16	Jump-off Joe Creek, footbridge	9/15/04	110	mpn
B16	Jump-off Joe Creek, footbridge	6/16/05	130	mpn
B16	Jump-off Joe Creek, footbridge	7/19/05	170	mpn
B16	Jump-off Joe Creek, footbridge	8/17/05	900	mpn
B16	Jump-off Joe Creek, footbridge	9/15/05	110	mpn
B16	Jump-off Joe Creek, footbridge	5/24/06	1601	mpn
B16	Jump-off Joe Creek, footbridge	9/7/06	110	mpn
B17	Kinman Creek, near mouth	5/4/04	1600	mpn
B17	Kinman Creek, near mouth	7/20/04	130	mpn
B17	Kinman Creek, near mouth	9/15/04	170	mpn
B17	Kinman Creek, near mouth	5/10/05	500	mpn
B17	Kinman Creek, near mouth	8/17/05	1600	mpn
B17	Kinman Creek, near mouth	6/20/06	130	mpn
B17	Kinman Creek, near mouth	9/7/06	300	mpn
B18	Kitsap Creek, downstream of Indianola Rd	9/7/06	240	mpn
B19	Kitsap Creek, near Seaview Lane	6/23/04	900	mpn
B19	Kitsap Creek, near Seaview Lane	8/23/04	300	mpn
B19	Kitsap Creek, near Seaview Lane	9/29/04	220	mpn
B19	Kitsap Creek, near Seaview Lane	7/12/05	110	mpn
B19	Kitsap Creek, near Seaview Lane	8/25/05	1600	mpn
B19	Kitsap Creek, near Seaview Lane	5/24/06	220	mpn
B19	Kitsap Creek, near Seaview Lane	7/13/06	1600	mpn
B19	Kitsap Creek, near Seaview Lane	8/17/06	300	mpn
B19	Kitsap Creek, near Seaview Lane	9/7/06	140	mpn
B20	Klebeal Creek, near Hwy 305	9/7/06	170	mpn
B21	Little Scandia Creek, Scandia Rd	5/24/06	1600	mpn
B21	Little Scandia Creek, Scandia Rd	6/20/06	500	mpn
B21	Little Scandia Creek, Scandia Rd	7/13/06	1600	mpn
B21	Little Scandia Creek, Scandia Rd	8/17/06	900	mpn
B21	Little Scandia Creek, Scandia Rd	9/7/06	1600	mpn
B22	Lofall Creek, near mouth at beach	5/4/04	1600	mpn
B22	Lofall Creek, near mouth at beach	6/2/04	280	mpn
B22	Lofall Creek, near mouth at beach	7/20/04	500	mpn
B22	Lofall Creek, near mouth at beach	8/10/04	240	mpn
B22	Lofall Creek, near mouth at beach	9/15/04	500	mpn
B22	Lofall Creek, near mouth at beach	5/10/05	300	mpn
B22	Lofall Creek, near mouth at beach	7/19/05	110	mpn
B22	Lofall Creek, near mouth at beach	8/17/05	240	mpn
B22	Lofall Creek, near mouth at beach	9/15/05	500	mpn
B22	Lofall Creek, near mouth at beach	5/24/06	300	mpn
B22	Lofall Creek, near mouth at beach	6/20/06	500	mpn
B22	Lofall Creek, near mouth at beach	7/13/06	500	mpn
B22	Lofall Creek, near mouth at beach	8/17/06	1601	mpn
B23	Martha-John Creek, near Gamble Place	7/20/04	300	mpn
B23	Martha-John Creek, near Gamble Place	8/10/04	1600	mpn
B23	Martha-John Creek, near Gamble Place	5/10/05	1601	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
B23	Martha-John Creek, near Gamble Place	7/19/05	500	mpn
B23	Martha-John Creek, near Gamble Place	8/17/05	500	mpn
B23	Martha-John Creek, near Gamble Place	5/24/06	170	mpn
B23	Martha-John Creek, near Gamble Place	8/17/06	170	mpn
C1	Anderson Creek, between Hwys 16 & 166	7/14/04	170	mpn
C1	Anderson Creek, between Hwys 16 & 166	9/19/06	1600	mpn
C2	Annapolis Creek, downstream Arnold Ave	6/8/04	1601	mpn
C2	Annapolis Creek, downstream Arnold Ave	7/14/04	170	mpn
C2	Annapolis Creek, downstream Arnold Ave	5/23/05	130	mpn
C2	Annapolis Creek, downstream Arnold Ave	7/5/05	500	mpn
C2	Annapolis Creek, downstream Arnold Ave	9/7/05	1600	mpn
C2	Annapolis Creek, downstream Arnold Ave	5/16/06	500	mpn
C2	Annapolis Creek, downstream Arnold Ave	6/14/06	280	mpn
C2	Annapolis Creek, downstream Arnold Ave	7/19/06	170	mpn
C2	Annapolis Creek, downstream Arnold Ave	8/24/06	140	mpn
C2	Annapolis Creek, downstream Arnold Ave	9/19/06	1601	mpn
C3	Barker Creek, near 601 Bucklin Hill Rd	5/11/04	220	mpn
C3	Barker Creek, near 601 Bucklin Hill Rd	6/10/04	130	mpn
C3	Barker Creek, near 601 Bucklin Hill Rd	9/22/04	130	mpn
C3	Barker Creek, near 601 Bucklin Hill Rd	5/19/05	500	mpn
C3	Barker Creek, near 601 Bucklin Hill Rd	7/14/05	240	mpn
C3	Barker Creek, near 601 Bucklin Hill Rd	9/8/05	900	mpn
C3	Barker Creek, near 601 Bucklin Hill Rd	8/23/06	170	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	6/10/04	300	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	7/13/04	300	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	8/3/04	240	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	9/22/04	240	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	5/19/05	900	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	6/21/05	1600	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	9/8/05	900	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	6/13/06	130	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	7/18/06	300	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	8/23/06	300	mpn
C4	Barker Creek, near 8600 Nels Nelson Rd	9/21/06	500	mpn
C5	Barker Creek, upstream Barker Creek Rd	5/11/04	240	mpn
C5	Barker Creek, upstream Barker Creek Rd	7/13/04	300	mpn
C5	Barker Creek, upstream Barker Creek Rd	8/3/04	130	mpn
C5	Barker Creek, upstream Barker Creek Rd	9/22/04	130	mpn
C5	Barker Creek, upstream Barker Creek Rd	5/19/05	500	mpn
C5	Barker Creek, upstream Barker Creek Rd	6/21/05	220	mpn
C5	Barker Creek, upstream Barker Creek Rd	8/11/05	220	mpn
C5	Barker Creek, upstream Barker Creek Rd	9/8/05	500	mpn
C5	Barker Creek, upstream Barker Creek Rd	6/13/06	130	mpn
C5	Barker Creek, upstream Barker Creek Rd	7/18/06	1601	mpn
C5	Barker Creek, upstream Barker Creek Rd	9/21/06	170	mpn
C6	Big Beef Creek, off Manley Rd	6/16/05	130	mpn
C6	Big Beef Creek, off Manley Rd	7/11/06	130	mpn
C6	Big Beef Creek, off Manley Rd	9/6/06	130	mpn
C7	Blackjack Creek, upstream Bay St	8/4/04	500	mpn
C7	Blackjack Creek, upstream Bay St	9/7/05	280	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
C7	Blackjack Creek, upstream Bay St	6/14/06	130	mpn
C7	Blackjack Creek, upstream Bay St	8/24/06	110	mpn
C7	Blackjack Creek, upstream Bay St	9/19/06	1601	mpn
C8	Chico Creek, Kittyhawk Drive	5/10/06	240	mpn
C9	Chico Creek, Taylor Rd	6/10/04	130	mpn
C9	Chico Creek, Taylor Rd	8/3/04	170	mpn
C9	Chico Creek, Taylor Rd	5/19/05	140	mpn
C9	Chico Creek, Taylor Rd	8/11/05	130	mpn
C10	Chico Creek, Wildcat Lake Rd	6/10/04	1600	mpn
C10	Chico Creek, Wildcat Lake Rd	8/3/04	240	mpn
C11	Clear Creek - Ridgetop Creek	6/10/04	500	mpn
C11	Clear Creek - Ridgetop Creek	9/8/05	1601	mpn
C11	Clear Creek - Ridgetop Creek	5/10/06	110	mpn
C11	Clear Creek - Ridgetop Creek	6/13/06	130	mpn
C11	Clear Creek - Ridgetop Creek	7/18/06	1601	mpn
C12	Clear Creek, 11200 Silverdale Way	9/21/06	500	mpn
C13	Clear Creek, Clear Creek Trail	7/18/06	130	mpn
C13	Clear Creek, Clear Creek Trail	8/23/06	110	mpn
C13	Clear Creek, Clear Creek Trail	9/21/06	900	mpn
C14	Clear Creek, Levin Rd	6/10/04	130	mpn
C14	Clear Creek, Levin Rd	7/13/04	240	mpn
C14	Clear Creek, Levin Rd	8/3/04	170	mpn
C14	Clear Creek, Levin Rd	9/22/04	1600	mpn
C14	Clear Creek, Levin Rd	5/19/05	1600	mpn
C14	Clear Creek, Levin Rd	7/14/05	900	mpn
C14	Clear Creek, Levin Rd	8/11/05	220	mpn
C14	Clear Creek, Levin Rd	8/23/06	300	mpn
C14	Clear Creek, Levin Rd	9/21/06	140	mpn
C15	Clear Creek, Myhre Rd	6/10/04	220	mpn
C15	Clear Creek, Myhre Rd	7/13/04	130	mpn
C15	Clear Creek, Myhre Rd	8/3/04	240	mpn
C15	Clear Creek, Myhre Rd	9/22/04	500	mpn
C15	Clear Creek, Myhre Rd	5/19/05	280	mpn
C15	Clear Creek, Myhre Rd	6/21/05	140	mpn
C15	Clear Creek, Myhre Rd	7/14/05	300	mpn
C15	Clear Creek, Myhre Rd	8/11/05	900	mpn
C15	Clear Creek, Myhre Rd	9/21/06	130	mpn
C16	Clear Creek, off Levin Rd	6/10/04	110	mpn
C16	Clear Creek, off Levin Rd	7/13/04	240	mpn
C16	Clear Creek, off Levin Rd	9/22/04	130	mpn
C16	Clear Creek, off Levin Rd	5/19/05	300	mpn
C16	Clear Creek, off Levin Rd	6/21/05	280	mpn
C16	Clear Creek, off Levin Rd	8/11/05	300	mpn
C16	Clear Creek, off Levin Rd	7/18/06	130	mpn
C16	Clear Creek, off Levin Rd	9/21/06	170	mpn
C17	Clear Creek, off Mickleberry Rd	6/10/04	240	mpn
C17	Clear Creek, off Mickleberry Rd	7/13/04	110	mpn
C17	Clear Creek, off Mickleberry Rd	9/22/04	1600	mpn
C17	Clear Creek, off Mickleberry Rd	5/19/05	900	mpn
C17	Clear Creek, off Mickleberry Rd	6/21/05	220	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
C17	Clear Creek, off Mickleberry Rd	7/14/05	300	mpn
C17	Clear Creek, off Mickleberry Rd	8/11/05	240	mpn
C17	Clear Creek, off Mickleberry Rd	5/10/06	240	mpn
C17	Clear Creek, off Mickleberry Rd	8/23/06	170	mpn
C17	Clear Creek, off Mickleberry Rd	9/21/06	130	mpn
C18	Clear Creek, Ridgetop Blvd.	7/13/04	500	mpn
C18	Clear Creek, Ridgetop Blvd.	8/3/04	130	mpn
C18	Clear Creek, Ridgetop Blvd.	5/19/05	500	mpn
C18	Clear Creek, Ridgetop Blvd.	6/21/05	500	mpn
C18	Clear Creek, Ridgetop Blvd.	7/14/05	900	mpn
C18	Clear Creek, Ridgetop Blvd.	8/11/05	1600	mpn
C18	Clear Creek, Ridgetop Blvd.	9/8/05	1600	mpn
C18	Clear Creek, Ridgetop Blvd.	6/13/06	130	mpn
C18	Clear Creek, Ridgetop Blvd.	7/18/06	300	mpn
C18	Clear Creek, Ridgetop Blvd.	8/23/06	240	mpn
C18	Clear Creek, Ridgetop Blvd.	9/21/06	130	mpn
C19	Clear Creek, Schold Rd	6/10/04	220	mpn
C19	Clear Creek, Schold Rd	8/3/04	140	mpn
C19	Clear Creek, Schold Rd	5/19/05	240	mpn
C19	Clear Creek, Schold Rd	7/14/05	500	mpn
C19	Clear Creek, Schold Rd	8/11/05	300	mpn
C19	Clear Creek, Schold Rd	7/18/06	110	mpn
C19	Clear Creek, Schold Rd	8/23/06	130	mpn
C19	Clear Creek, Schold Rd	9/21/06	220	mpn
C20	Clear Creek, Silverdale Way	5/11/04	130	mpn
C20	Clear Creek, Silverdale Way	6/10/04	900	mpn
C20	Clear Creek, Silverdale Way	9/22/04	130	mpn
C20	Clear Creek, Silverdale Way	7/14/05	140	mpn
C20	Clear Creek, Silverdale Way	8/11/05	240	mpn
C20	Clear Creek, Silverdale Way	8/23/06	110	mpn
C21	Clear Creek, W Fork upstream Schold Rd	6/10/04	300	mpn
C21	Clear Creek, W Fork upstream Schold Rd	8/3/04	240	mpn
C21	Clear Creek, W Fork upstream Schold Rd	9/22/04	240	mpn
C21	Clear Creek, W Fork upstream Schold Rd	5/19/05	500	mpn
C21	Clear Creek, W Fork upstream Schold Rd	7/14/05	300	mpn
C21	Clear Creek, W Fork upstream Schold Rd	8/11/05	300	mpn
C22	Dickerson Creek, Taylor Rd	7/13/04	1600	mpn
C22	Dickerson Creek, Taylor Rd	8/3/04	300	mpn
C22	Dickerson Creek, Taylor Rd	6/21/05	170	mpn
C22	Dickerson Creek, Taylor Rd	7/14/05	110	mpn
C23	Gorst Creek, Hwy 3	5/13/04	130	mpn
C23	Gorst Creek, Hwy 3	6/8/04	130	mpn
C23	Gorst Creek, Hwy 3	7/15/04	220	mpn
C23	Gorst Creek, Hwy 3	8/4/04	170	mpn
C23	Gorst Creek, Hwy 3	7/5/05	110	mpn
C23	Gorst Creek, Hwy 3	9/7/05	300	mpn
C23	Gorst Creek, Hwy 3	9/19/06	1601	mpn
C24	Gorst Creek, Sam Christopherson Rd	7/14/04	240	mpn
C24	Gorst Creek, Sam Christopherson Rd	8/4/04	900	mpn
C24	Gorst Creek, Sam Christopherson Rd	8/10/05	110	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
C24	Gorst Creek, Sam Christopherson Rd	9/19/06	1601	mpn
C25	Huge Creek, 3785 County Line Rd	8/11/04	130	mpn
C25	Huge Creek, 3785 County Line Rd	5/18/05	110	mpn
C25	Huge Creek, 3785 County Line Rd	8/30/05	1600	mpn
C26	Karcher Creek, KCSD5 WWTP	8/4/04	1600	mpn
C26	Karcher Creek, KCSD5 WWTP	5/23/05	170	mpn
C26	Karcher Creek, KCSD5 WWTP	7/5/05	900	mpn
C26	Karcher Creek, KCSD5 WWTP	8/10/05	1601	mpn
C26	Karcher Creek, KCSD5 WWTP	9/7/05	220	mpn
C26	Karcher Creek, KCSD5 WWTP	6/14/06	110	mpn
C26	Karcher Creek, KCSD5 WWTP	9/19/06	1601	mpn
C27	Kitsap Creek, Northlake Way	7/18/06	900	mpn
C28	Kitsap Mall Creek, western outfall	6/13/06	130	mpn
C28	Kitsap Mall Creek, western outfall	8/23/06	130	mpn
C28	Kitsap Mall Creek, western outfall	9/21/06	170	mpn
C29	Little Anderson Creek, Anderson Hill Rd	8/10/06	1601	mpn
C30	Mosher Creek, Tracyton Blvd.	5/11/04	300	mpn
C30	Mosher Creek, Tracyton Blvd.	5/19/05	500	mpn
C30	Mosher Creek, Tracyton Blvd.	7/14/05	110	mpn
C30	Mosher Creek, Tracyton Blvd.	9/21/06	240	mpn
C31	Ostrich Bay Creek, North of Broad St	5/11/04	300	mpn
C31	Ostrich Bay Creek, North of Broad St	6/10/04	170	mpn
C31	Ostrich Bay Creek, North of Broad St	7/13/04	900	mpn
C31	Ostrich Bay Creek, North of Broad St	8/3/04	500	mpn
C31	Ostrich Bay Creek, North of Broad St	9/22/04	240	mpn
C31	Ostrich Bay Creek, North of Broad St	5/19/05	220	mpn
C31	Ostrich Bay Creek, North of Broad St	6/21/05	900	mpn
C31	Ostrich Bay Creek, North of Broad St	7/14/05	130	mpn
C31	Ostrich Bay Creek, North of Broad St	8/11/05	500	mpn
C31	Ostrich Bay Creek, North of Broad St	9/8/05	170	mpn
C31	Ostrich Bay Creek, North of Broad St	7/18/06	500	mpn
C31	Ostrich Bay Creek, North of Broad St	8/23/06	900	mpn
C31	Ostrich Bay Creek, North of Broad St	9/21/06	1600	mpn
C32	Ostrich Bay Creek, South of Broad St	5/11/04	1601	mpn
C32	Ostrich Bay Creek, South of Broad St	6/10/04	900	mpn
C32	Ostrich Bay Creek, South of Broad St	8/3/04	170	mpn
C32	Ostrich Bay Creek, South of Broad St	9/22/04	1600	mpn
C32	Ostrich Bay Creek, South of Broad St	5/19/05	1601	mpn
C32	Ostrich Bay Creek, South of Broad St	6/21/05	130	mpn
C32	Ostrich Bay Creek, South of Broad St	8/11/05	1601	mpn
C32	Ostrich Bay Creek, South of Broad St	5/10/06	1601	mpn
C32	Ostrich Bay Creek, South of Broad St	8/23/06	900	mpn
C32	Ostrich Bay Creek, South of Broad St	9/21/06	900	mpn
C33	Ostrich Bay Creek, Shorewood Drive	5/11/04	300	mpn
C33	Ostrich Bay Creek, Shorewood Drive	6/10/04	220	mpn
C33	Ostrich Bay Creek, Shorewood Drive	7/13/04	240	mpn
C33	Ostrich Bay Creek, Shorewood Drive	8/3/04	500	mpn
C33	Ostrich Bay Creek, Shorewood Drive	9/22/04	1600	mpn
C33	Ostrich Bay Creek, Shorewood Drive	5/19/05	130	mpn
C33	Ostrich Bay Creek, Shorewood Drive	7/14/05	500	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
C33	Ostrich Bay Creek, Shorewood Drive	8/11/05	1601	mpn
C33	Ostrich Bay Creek, Shorewood Drive	9/8/05	1601	mpn
C33	Ostrich Bay Creek, Shorewood Drive	5/10/06	110	mpn
C33	Ostrich Bay Creek, Shorewood Drive	6/13/06	130	mpn
C33	Ostrich Bay Creek, Shorewood Drive	8/23/06	900	mpn
C33	Ostrich Bay Creek, Shorewood Drive	9/21/06	1600	mpn
C34	Parman Creek, Tracyton Blvd.	5/19/05	900	mpn
C34	Parman Creek, Tracyton Blvd.	6/21/05	220	mpn
C34	Parman Creek, Tracyton Blvd.	5/10/06	500	mpn
C34	Parman Creek, Tracyton Blvd.	9/21/06	300	mpn
C35	Phinney Creek, Phinney Bay Drive	6/10/04	1601	mpn
C35	Phinney Creek, Phinney Bay Drive	7/13/04	1601	mpn
C35	Phinney Creek, Phinney Bay Drive	8/3/04	1600	mpn
C35	Phinney Creek, Phinney Bay Drive	9/22/04	1600	mpn
C35	Phinney Creek, Phinney Bay Drive	5/19/05	1601	mpn
C35	Phinney Creek, Phinney Bay Drive	6/21/05	1601	mpn
C35	Phinney Creek, Phinney Bay Drive	7/14/05	1601	mpn
C35	Phinney Creek, Phinney Bay Drive	8/11/05	1601	mpn
C35	Phinney Creek, Phinney Bay Drive	9/8/05	1601	mpn
C35	Phinney Creek, Phinney Bay Drive	5/10/06	500	mpn
C35	Phinney Creek, Phinney Bay Drive	6/13/06	500	mpn
C35	Phinney Creek, Phinney Bay Drive	7/18/06	1600	mpn
C35	Phinney Creek, Phinney Bay Drive	8/23/06	300	mpn
C35	Phinney Creek, Phinney Bay Drive	9/21/06	1600	mpn
C36	Ross Creek, off Clear Ridge Ct	7/14/04	110	mpn
C36	Ross Creek, off Clear Ridge Ct	8/4/04	170	mpn
C36	Ross Creek, off Clear Ridge Ct	8/10/05	1600	mpn
C36	Ross Creek, off Clear Ridge Ct	6/14/06	130	mpn
C36	Ross Creek, off Clear Ridge Ct	7/19/06	130	mpn
C36	Ross Creek, off Clear Ridge Ct	9/19/06	1600	mpn
C37	Royal Valley Creek, Paulsen Rd	5/10/06	240	mpn
C37	Royal Valley Creek, Paulsen Rd	6/13/06	130	mpn
C38	Sacco Creek, end of Sacco Lane	6/8/04	170	mpn
C38	Sacco Creek, end of Sacco Lane	8/4/04	240	mpn
C38	Sacco Creek, end of Sacco Lane	5/23/05	1601	mpn
C38	Sacco Creek, end of Sacco Lane	6/15/05	900	mpn
C38	Sacco Creek, end of Sacco Lane	7/5/05	900	mpn
C38	Sacco Creek, end of Sacco Lane	8/10/05	280	mpn
C38	Sacco Creek, end of Sacco Lane	9/7/05	500	mpn
C38	Sacco Creek, end of Sacco Lane	6/14/06	1600	mpn
C38	Sacco Creek, end of Sacco Lane	7/19/06	280	mpn
C38	Sacco Creek, end of Sacco Lane	8/24/06	900	mpn
C38	Sacco Creek, end of Sacco Lane	9/19/06	500	mpn
C39	Steele Creek, Brownsville Hwy	7/21/04	900	mpn
C39	Steele Creek, Brownsville Hwy	8/23/04	430	mpn
C39	Steele Creek, Brownsville Hwy	9/29/04	900	mpn
C39	Steele Creek, Brownsville Hwy	6/2/05	1600	mpn
C39	Steele Creek, Brownsville Hwy	7/12/05	500	mpn
C39	Steele Creek, Brownsville Hwy	9/20/05	240	mpn
C39	Steele Creek, Brownsville Hwy	5/10/06	300	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
C39	Steele Creek, Brownsville Hwy	7/18/06	170	mpn
C39	Steele Creek, Brownsville Hwy	8/23/06	500	mpn
C39	Steele Creek, Brownsville Hwy	9/21/06	220	mpn
C40	Steele Creek, west trib, confluence w/ ST01	5/10/06	170	mpn
C41	Strawberry Creek, Anderson Hill Rd	7/18/06	130	mpn
C41	Strawberry Creek, Anderson Hill Rd	8/23/06	130	mpn
C42	Strawberry Creek, Provost Rd	6/13/06	500	mpn
C42	Strawberry Creek, Provost Rd	8/23/06	300	mpn
C43	Strawberry Creek, Silverdale Loop Rd	6/13/06	130	mpn
C43	Strawberry Creek, Silverdale Loop Rd	7/18/06	140	mpn
C43	Strawberry Creek, Silverdale Loop Rd	8/23/06	170	mpn
C43	Strawberry Creek, Silverdale Loop Rd	9/21/06	240	mpn
C44	Strawberry Creek, Washington Ave	5/11/04	130	mpn
C44	Strawberry Creek, Washington Ave	6/10/04	1600	mpn
C44	Strawberry Creek, Washington Ave	7/13/04	500	mpn
C44	Strawberry Creek, Washington Ave	8/3/04	130	mpn
C44	Strawberry Creek, Washington Ave	9/22/04	500	mpn
C44	Strawberry Creek, Washington Ave	5/19/05	1600	mpn
C44	Strawberry Creek, Washington Ave	7/14/05	110	mpn
C44	Strawberry Creek, Washington Ave	8/11/05	110	mpn
C44	Strawberry Creek, Washington Ave	9/8/05	170	mpn
C44	Strawberry Creek, Washington Ave	6/13/06	300	mpn
C44	Strawberry Creek, Washington Ave	7/18/06	240	mpn
C44	Strawberry Creek, Washington Ave	8/23/06	240	mpn
C45	Enetai Creek, Enetai Beach Rd	6/23/04	900	mpn
C45	Enetai Creek, Enetai Beach Rd	7/21/04	1600	mpn
C45	Enetai Creek, Enetai Beach Rd	8/23/04	900	mpn
C45	Enetai Creek, Enetai Beach Rd	9/29/04	300	mpn
C45	Enetai Creek, Enetai Beach Rd	5/3/05	130	mpn
C45	Enetai Creek, Enetai Beach Rd	6/2/05	350	mpn
C45	Enetai Creek, Enetai Beach Rd	7/12/05	500	mpn
C45	Enetai Creek, Enetai Beach Rd	8/25/05	170	mpn
C45	Enetai Creek, Enetai Beach Rd	9/20/05	300	mpn
C45	Enetai Creek, Enetai Beach Rd	7/18/06	110	mpn
C45	Enetai Creek, Enetai Beach Rd	8/23/06	900	mpn
C45	Enetai Creek, Enetai Beach Rd	9/21/06	500	mpn
C45	Enetai Creek, Trenton Ave	6/23/04	1600	mpn
C45	Enetai Creek, Trenton Ave	7/21/04	900	mpn
C45	Enetai Creek, Trenton Ave	8/23/04	1600	mpn
C45	Enetai Creek, Trenton Ave	5/3/05	170	mpn
C45	Enetai Creek, Trenton Ave	6/2/05	900	mpn
C45	Enetai Creek, Trenton Ave	7/12/05	1601	mpn
C45	Enetai Creek, Trenton Ave	8/25/05	130	mpn
C45	Enetai Creek, Trenton Ave	9/20/05	1601	mpn
C45	Enetai Creek, Trenton Ave	6/13/06	300	mpn
C45	Enetai Creek, Trenton Ave	7/18/06	300	mpn
C45	Enetai Creek, Trenton Ave	8/23/06	1601	mpn
C45	Enetai Creek, Trenton Ave	9/21/06	1600	mpn
C46	Enetai Creek, Franklin St	9/29/04	170	mpn
C46	Enetai Creek, Franklin St	6/2/05	1601	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
C46	Enetai Creek, Franklin St	7/12/05	1601	mpn
C46	Enetai Creek, Franklin St	5/10/06	1601	mpn
C46	Enetai Creek, Franklin St	6/13/06	1601	mpn
C47	Enetai Creek, Helm St	6/23/04	1600	mpn
C47	Enetai Creek, Helm St	7/21/04	500	mpn
C47	Enetai Creek, Helm St	8/23/04	900	mpn
C47	Enetai Creek, Helm St	9/29/04	170	mpn
C47	Enetai Creek, Helm St	6/2/05	1601	mpn
C47	Enetai Creek, Helm St	7/12/05	900	mpn
C47	Enetai Creek, Helm St	9/20/05	170	mpn
C47	Enetai Creek, Helm St	5/10/06	500	mpn
C47	Enetai Creek, Helm St	6/13/06	1600	mpn
C47	Enetai Creek, Helm St	8/23/06	300	mpn
C47	Enetai Creek, Helm St	9/21/06	1600	mpn
C48	Enetai Creek, NE 30th St	7/12/05	280	mpn
C48	Enetai Creek, NE 30th St	6/13/06	300	mpn
C50	Illahee Creek, near 5171 Illahee Rd	8/23/04	130	mpn
C50	Illahee Creek, near 5171 Illahee Rd	5/3/05	500	mpn
C50	Illahee Creek, near 5171 Illahee Rd	6/2/05	300	mpn
C50	Illahee Creek, near 5171 Illahee Rd	9/21/06	110	mpn
C51	State Park Creek, Illahee State Park	6/23/04	300	mpn
C51	State Park Creek, Illahee State Park	7/21/04	220	mpn
C51	State Park Creek, Illahee State Park	8/23/04	1601	mpn
C51	State Park Creek, Illahee State Park	5/3/05	110	mpn
C51	State Park Creek, Illahee State Park	6/2/05	220	mpn
C51	State Park Creek, Illahee State Park	8/25/05	1600	mpn
C51	State Park Creek, Illahee State Park	9/20/05	170	mpn
C51	State Park Creek, Illahee State Park	7/18/06	500	mpn
C51	State Park Creek, Illahee State Park	8/23/06	1600	mpn
C52	Steele Creek, Fairgrounds Rd	5/10/06	300	mpn
C52	Steele Creek, Fairgrounds Rd	6/13/06	130	mpn
C52	Steele Creek, Fairgrounds Rd	7/18/06	300	mpn
C52	Steele Creek, Fairgrounds Rd	8/23/06	240	mpn
C52	Steele Creek, Fairgrounds Rd	9/21/06	300	mpn
D1	Big Anderson Creek, upstream Sea-Hol bridge	6/2/04	500	mpn
D1	Big Anderson Creek, upstream Sea-Hol bridge	8/17/05	500	mpn
D1	Big Anderson Creek, upstream Sea-Hol bridge	7/11/06	130	mpn
D1	Big Anderson Creek, upstream Sea-Hol bridge	8/10/06	130	mpn
D2	Big Beef Creek, below Lake Symington Spillway	9/15/04	130	mpn
D3	Big Beef Creek, downstream Holly Rd	8/17/05	170	mpn
D4	Boyce Creek, Guillemot Cove County Park	8/10/04	240	mpn
D4	Boyce Creek, Guillemot Cove County Park	8/10/06	170	mpn
D5	Dewatto River, Bear Creek Rd	5/5/04	110	mpn
D5	Dewatto River, Bear Creek Rd	7/26/05	170	mpn
D6	Seabeck Creek, near Miami Beach	7/20/04	130	mpn
D6	Seabeck Creek, near Miami Beach	8/17/05	350	mpn
D6	Seabeck Creek, near Miami Beach	9/15/05	130	mpn
D6	Seabeck Creek, near Miami Beach	8/10/06	900	mpn
D7	Stavis Creek, Stavis Rd bridge	5/10/05	140	mpn
D7	Stavis Creek, Stavis Rd bridge	8/17/05	110	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
D7	Stavis Creek, Stavis Rd bridge	5/17/06	220	mpn
D7	Stavis Creek, Stavis Rd bridge	8/10/06	130	mpn
D8	Tahuya River, Elfendal Pass	5/18/05	900	mpn
D9	Union River - East Fork	5/18/05	1600	mpn
D10	Union River, Belfair Hwy bridge	5/18/05	1601	mpn
D10	Union River, Belfair Hwy bridge	8/30/05	170	mpn
D10	Union River, Belfair Hwy bridge	7/11/06	220	mpn
D10	Union River, Belfair Hwy bridge	8/10/06	130	mpn
D11	Union River, near old Belfair Hwy	8/11/04	240	mpn
D11	Union River, near old Belfair Hwy	5/18/05	1600	mpn
D11	Union River, near old Belfair Hwy	8/30/05	220	mpn
D11	Union River, near old Belfair Hwy	7/11/06	1600	mpn
E1	Beaver Creek, Ecology Lab Drive	5/13/04	130	mpn
E1	Beaver Creek, Ecology Lab Drive	7/14/04	300	mpn
E1	Beaver Creek, Ecology Lab Drive	8/4/04	1601	mpn
E1	Beaver Creek, Ecology Lab Drive	5/23/05	300	mpn
E1	Beaver Creek, Ecology Lab Drive	6/15/05	900	mpn
E1	Beaver Creek, Ecology Lab Drive	7/5/05	900	mpn
E1	Beaver Creek, Ecology Lab Drive	6/14/06	300	mpn
E1	Beaver Creek, Ecology Lab Drive	7/19/06	170	mpn
E1	Beaver Creek, Ecology Lab Drive	9/19/06	1601	mpn
E2	Curley Creek, Long Lake Rd bridge	9/19/06	300	mpn
E3	Curley Creek, near SE Martin Lane	7/5/05	130	mpn
E3	Curley Creek, near SE Martin Lane	9/19/06	300	mpn
E4	Curley Creek, Sedgwick Rd bridge	7/5/05	220	mpn
E4	Curley Creek, Sedgwick Rd bridge	8/10/05	300	mpn
E5	Duncan Creek, Colchester Drive	8/4/04	220	mpn
E5	Duncan Creek, Colchester Drive	6/15/05	300	mpn
E5	Duncan Creek, Colchester Drive	9/19/06	1601	mpn
E6	Olalla Creek, Forsman Rd	7/14/04	170	mpn
E6	Olalla Creek, Forsman Rd	8/10/05	110	mpn
E6	Olalla Creek, Forsman Rd	6/14/06	300	mpn
E7	Salmonberry Creek, Howe Farm Park	7/14/04	220	mpn
E7	Salmonberry Creek, Howe Farm Park	8/4/04	110	mpn
E7	Salmonberry Creek, Howe Farm Park	5/23/05	280	mpn
E7	Salmonberry Creek, Howe Farm Park	9/19/06	1600	mpn
E8	Wilson Creek, end of Pristine Beach Lane	5/13/04	300	mpn
E8	Wilson Creek, end of Pristine Beach Lane	5/23/05	240	mpn
E8	Wilson Creek, end of Pristine Beach Lane	6/15/05	110	mpn
E8	Wilson Creek, end of Pristine Beach Lane	8/10/05	130	mpn
E8	Wilson Creek, end of Pristine Beach Lane	9/7/05	130	mpn
E8	Wilson Creek, end of Pristine Beach Lane	5/16/06	300	mpn
E8	Wilson Creek, end of Pristine Beach Lane	6/14/06	300	mpn
F1	Bear Creek, North of Pine Rd	5/5/04	500	mpn
F1	Bear Creek, North of Pine Rd	6/1/04	170	mpn
F1	Bear Creek, North of Pine Rd	7/8/04	300	mpn
F1	Bear Creek, North of Pine Rd	8/11/04	300	mpn
F1	Bear Creek, North of Pine Rd	9/21/04	500	mpn
F1	Bear Creek, North of Pine Rd	5/18/05	1600	mpn
F1	Bear Creek, North of Pine Rd	8/30/05	220	mpn

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
F1	Bear Creek, North of Pine Rd	5/16/06	300	mpn
F1	Bear Creek, North of Pine Rd	6/14/06	500	mpn
F1	Bear Creek, North of Pine Rd	7/19/06	300	mpn
F1	Bear Creek, North of Pine Rd	8/24/06	240	mpn
F1	Bear Creek, North of Pine Rd	9/19/06	300	mpn
F2	Blackjack Creek, Sedgwick Rd crossing	8/4/04	240	mpn
F2	Blackjack Creek, Sedgwick Rd crossing	9/7/05	130	mpn
F2	Blackjack Creek, Sedgwick Rd crossing	8/24/06	300	mpn
F3	Burley Creek, bridge off Spruce	7/8/04	300	mpn
F3	Burley Creek, bridge off Spruce	5/18/05	1601	mpn
F3	Burley Creek, bridge off Spruce	6/22/05	1600	mpn
F3	Burley Creek, bridge off Spruce	7/26/05	300	mpn
F3	Burley Creek, bridge off Spruce	8/30/05	300	mpn
F3	Burley Creek, bridge off Spruce	9/27/05	140	mpn
F3	Burley Creek, bridge off Spruce	6/14/06	300	mpn
F3	Burley Creek, bridge off Spruce	8/24/06	300	mpn
F3	Burley Creek, bridge off Spruce	9/19/06	220	mpn
F4	Burley Creek, Holman Rd	8/24/06	130	mpn
F4	Burley Creek, Holman Rd	9/19/06	170	mpn
F5	Burley Creek, Mullinex Rd	8/24/06	300	mpn
F5	Burley Creek, Mullinex Rd	9/19/06	500	mpn
F6	Burley Creek, Oak Rd bridge	6/14/06	130	mpn
F6	Burley Creek, Oak Rd bridge	8/24/06	170	mpn
F7	Burley Creek, Spring Creek Rd	7/8/04	500	mpn
F7	Burley Creek, Spring Creek Rd	5/18/05	500	mpn
F8	Coulter Creek, Lake Flora Rd	8/11/04	500	mpn
F8	Coulter Creek, Lake Flora Rd	5/18/05	110	mpn
F9	Minter Creek, Glenwood Rd	5/18/05	500	mpn
F9	Minter Creek, Glenwood Rd	7/26/05	110	mpn
F9	Minter Creek, Glenwood Rd	8/30/05	1601	mpn
F9	Minter Creek, Glenwood Rd	8/10/06	1601	mpn
F9	Minter Creek, Glenwood Rd	9/6/06	140	mpn
F10	Purdy Creek, near 160th	8/11/04	170	mpn
F10	Purdy Creek, near 160th	5/18/05	1601	mpn
F10	Purdy Creek, near 160th	7/26/05	130	mpn
F10	Purdy Creek, near 160th	8/30/05	170	mpn
F10	Purdy Creek, near 160th	9/27/05	170	mpn
Skokomish Tribal Data				
H7	Harvey Terrace Lower	Jun-06	101	cfu
H8	Hurley Hill Ditch	Jul-05	332	cfu
H8	Hurley Hill Ditch	Sep-05	188	cfu
H8	Hurley Hill Ditch	Jun-06	108	cfu
H8	Hurley Hill Ditch	Jul-06	197	cfu
H9	Potlatch State Park (beach)	Jul-06	288	cfu
H10	Purdy Creek - mouth	Sep-06	161	cfu
H10	Purdy Creek - mouth	Sep-07	142	cfu
H11	Purdy Creek at Bourgault Rd bridge	Sep-05	101	cfu
H11	Purdy Creek at Bourgault Rd bridge	Jun-06	187	cfu
H11	Purdy Creek at Bourgault Rd bridge	Sep-06	136	cfu
H11	Purdy Creek at Bourgault Rd bridge	Sep-07	121	cfu

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
H12	Skokomish River at 106 bridge	Sep-06	210	cfu
H12	Skokomish River at 106 bridge	Sep-07	111	cfu
H13	Skokomish River at Chico's Eddy	Sep-06	236	cfu
H14	ss1ALEX'S	Jul-05	100	cfu
H14	ss1ALEX'S	Sep-06	264	cfu
H14	ss1ALEX'S	Aug-07	174	cfu
H14	ss1ALEX'S	Sep-07	143	cfu
H15	Upper Potlatch Creek	May-06	106	cfu
H15	Upper Potlatch Creek	Jul-06	187	cfu
H15	Upper Potlatch Creek	Aug-06	124	cfu
H15	Upper Potlatch Creek	Sep-06	130	cfu
H16	Weaver Creek at the lower bridge	May-07	170	cfu
H16	Weaver Creek at the lower bridge	Sep-07	170	cfu
H17	Weaver Creek Valley Rd bridge	May-06	404	cfu
H17	Weaver Creek Valley Rd bridge	Jul-07	167	cfu
H21	Potlatch Creek - mouth	May-06	108	cfu
H21	Potlatch Creek - mouth	Aug-06	125	cfu
H21	Potlatch Creek - mouth	Sep-06	150	cfu
H21	Potlatch Creek - mouth	May-07	100	cfu
Department of Ecology, Union River TMDL				
D12	UR5BEAR	5/18/99	110	cfu
G10	UR4ARCH	12/14/99	130	cfu
G19	UR1HY300	5/18/99	110	cfu
G19	UR1HY300	8/24/99	170	cfu
G19	UR1HY300	11/30/99	160	cfu
G19	UR1HY300	12/14/99	170	cfu
G20	UR2TMBR	5/18/99	110	cfu
G20	UR2TMBR	7/27/99	460	cfu
G20	UR2TMBR	8/24/99	240	cfu
G21	UR3RIVER	6/29/99	110	cfu
G21	UR3RIVER	7/27/99	170	cfu
G21	UR3RIVER	8/24/99	170	cfu
G21	UR3RIVER	11/30/99	110	cfu
Mason County Data from Ecology's EIM Database				
G15	Devereaux Creek	7/8/04	532	cfu
G15	Devereaux Creek	9/7/04	426	cfu
G16	Happy Hollow Creek	9/7/04	160	cfu
G17	Mulberg Creek	7/8/04	310	cfu
G17	Mulberg Creek	7/28/04	102	cfu
G17	Mulberg Creek	9/7/04	266	cfu
G18	Twanoh Creek	7/28/04	120	cfu
G18	Twanoh Creek	9/7/04	124	cfu
H5	Big Bend Creek	7/8/04	166	cfu
H5	Big Bend Creek	8/19/04	290	cfu
H5	Big Bend Creek	9/7/04	112	cfu
Tacoma-Pierce County Health Department				
F11	Mouth of Minter Creek	5/1/06	120	cfu
F11	Mouth of Minter Creek	7/25/06	135	cfu
F11	Mouth of Minter Creek	8/22/06	100	cfu

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
F11	Mouth of Minter Creek	9/27/06	115	cfu
F11	Mouth of Minter Creek	5/8/07	145	cfu
F11	Mouth of Minter Creek	8/16/07	100	cfu
F11	Mouth of Minter Creek	9/17/07	140	cfu
F12	BL02	6/23/04	800	cfu
F12	BL02	7/7/04	300	cfu
F12	BL02	8/5/04	1600	cfu
F12	BL02	9/1/04	2000	cfu
F12	BL02	8/11/05	140	cfu
F12	BL02	9/8/05	110	cfu
F12	BL02	6/15/06	210	cfu
F12	BL02	7/25/06	240	cfu
F12	BL02	9/27/06	190	cfu
F12	BL02	6/19/07	370	cfu
F12	BL02	7/23/07	120	cfu
F12	BL02	8/16/07	160	cfu
F12	BL02	9/17/07	130	cfu
F13	Martin North	6/23/04	260	cfu
F13	Martin North	8/5/04	600	cfu
F13	Martin North	9/1/04	2000	cfu
F13	Martin North	6/16/05	300	cfu
F13	Martin North	7/13/05	120	cfu
F13	Martin North	6/15/06	150	cfu
F13	Martin North	7/25/06	110	cfu
F13	Martin North	5/8/07	2,900	cfu
F13	Martin North	6/19/07	420	cfu
F13	Martin North	7/23/07	320	cfu
F13	Martin North	8/16/07	110	cfu
F14	Martin Upper	8/5/04	200	cfu
F14	Martin Upper	9/1/04	1300	cfu
F14	Martin Upper	6/16/05	1700	cfu
F14	Martin Upper	5/1/06	110	cfu
F14	Martin Upper	7/25/06	230	cfu
F14	Martin Upper	5/8/07	5,200	cfu
F14	Martin Upper	6/19/07	960	cfu
F14	Martin Upper	7/23/07	820	cfu
F15	Burley Creek - mouth	6/23/04	250	cfu
F15	Burley Creek - mouth	7/7/04	275	cfu
F15	Burley Creek - mouth	8/5/04	435	cfu
F15	Burley Creek - mouth	9/1/04	1450	cfu
F15	Burley Creek - mouth	7/13/05	160	cfu
F15	Burley Creek - mouth	8/11/05	190	cfu
F15	Burley Creek - mouth	9/8/05	170	cfu
F15	Burley Creek - mouth	6/15/06	315	cfu
F15	Burley Creek - mouth	7/25/06	155	cfu
F15	Burley Creek - mouth	6/19/07	135	cfu
F15	Burley Creek - mouth	7/23/07	170	cfu
F15	Burley Creek - mouth	8/16/07	104	cfu
F15	Burley Creek - mouth	9/17/07	170	cfu
F16	McCormick Creek - mouth (Station 2)	5/3/05	1600	cfu

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
F16	McCormick Creek - mouth (Station 2)	5/24/05	4000	cfu
F16	McCormick Creek - mouth (Station 2)	6/2/05	5800	cfu
F16	McCormick Creek - mouth (Station 2)	6/9/05	3700	cfu
F16	McCormick Creek - mouth (Station 2)	6/23/05	380	cfu
F16	McCormick Creek - mouth (Station 2)	7/5/05	1800	cfu
F16	McCormick Creek - mouth (Station 2)	7/6/05	285	cfu
F16	McCormick Creek - mouth (Station 2)	7/11/05	1700	cfu
F16	McCormick Creek - mouth (Station 2)	7/14/05	150	cfu
F16	McCormick Creek - mouth (Station 2)	7/25/05	410	cfu
F16	McCormick Creek - mouth (Station 2)	8/29/05	510	cfu
F16	McCormick Creek - mouth (Station 2)	9/7/05	220	cfu
F16	McCormick Creek - mouth (Station 2)	9/22/05	250	cfu
F16	McCormick Creek - mouth (Station 2)	9/29/05	320	cfu
F16	McCormick Creek - mouth (Station 2)	8/22/06	120	cfu
F17	McCormick Creek below lift station (Station 1)	5/3/05	1600	cfu
F17	McCormick Creek below lift station (Station 1)	5/16/05	1100	cfu
F17	McCormick Creek below lift station (Station 1)	5/24/05	270	cfu
F17	McCormick Creek below lift station (Station 1)	6/2/05	2000	cfu
F17	McCormick Creek below lift station (Station 1)	6/9/05	1200	cfu
F17	McCormick Creek below lift station (Station 1)	6/16/05	230	cfu
F17	McCormick Creek below lift station (Station 1)	6/23/05	900	cfu
F17	McCormick Creek below lift station (Station 1)	6/28/05	450	cfu
F17	McCormick Creek below lift station (Station 1)	7/5/05	2700	cfu
F17	McCormick Creek below lift station (Station 1)	7/6/05	340	cfu
F17	McCormick Creek below lift station (Station 1)	7/11/05	600	cfu
F17	McCormick Creek below lift station (Station 1)	7/14/05	250	cfu
F17	McCormick Creek below lift station (Station 1)	7/19/05	120	cfu
F17	McCormick Creek below lift station (Station 1)	7/25/05	140	cfu
F17	McCormick Creek below lift station (Station 1)	8/1/05	200	cfu
F17	McCormick Creek below lift station (Station 1)	8/9/05	250	cfu
F17	McCormick Creek below lift station (Station 1)	8/11/05	140	cfu
F17	McCormick Creek below lift station (Station 1)	8/16/05	270	cfu
F17	McCormick Creek below lift station (Station 1)	8/22/05	360	cfu
F17	McCormick Creek below lift station (Station 1)	8/29/05	285	cfu
F17	McCormick Creek below lift station (Station 1)	9/7/05	730	cfu
F17	McCormick Creek below lift station (Station 1)	9/12/05	300	cfu
F17	McCormick Creek below lift station (Station 1)	9/15/05	310	cfu
F17	McCormick Creek below lift station (Station 1)	9/19/05	190	cfu
F17	McCormick Creek below lift station (Station 1)	9/20/05	260	cfu
F17	McCormick Creek below lift station (Station 1)	9/22/05	160	cfu
F17	McCormick Creek below lift station (Station 1)	9/26/05	350	cfu
F17	McCormick Creek below lift station (Station 1)	9/29/05	910	cfu
F17	McCormick Creek below lift station (Station 1)	5/3/06	300	cfu
F17	McCormick Creek below lift station (Station 1)	7/5/06	120	cfu
F17	McCormick Creek below lift station (Station 1)	8/22/06	370	cfu
F17	McCormick Creek below lift station (Station 1)	9/13/06	1,100	cfu
F18	McCormick Creek above lift station (Station 4)	5/11/05	140	cfu
F18	McCormick Creek above lift station (Station 4)	7/14/05	230	cfu
F18	McCormick Creek above lift station (Station 4)	8/1/05	190	cfu
F18	McCormick Creek above lift station (Station 4)	8/9/05	240	cfu

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
F18	McCormick Creek above lift station (Station 4)	8/11/05	270	cfu
F19	McCormick Creek at bridge (Station 5)	5/11/05	130	cfu
F19	McCormick Creek at bridge (Station 5)	6/16/05	135	cfu
F19	McCormick Creek at bridge (Station 5)	6/23/05	225	cfu
F19	McCormick Creek at bridge (Station 5)	6/28/05	420	cfu
F19	McCormick Creek at bridge (Station 5)	7/19/05	130	cfu
F19	McCormick Creek at bridge (Station 5)	7/25/05	140	cfu
F19	McCormick Creek at bridge (Station 5)	8/1/05	170	cfu
F19	McCormick Creek at bridge (Station 5)	8/9/05	270	cfu
F19	McCormick Creek at bridge (Station 5)	8/11/05	310	cfu
F19	McCormick Creek at bridge (Station 5)	9/12/05	330	cfu
F19	McCormick Creek at bridge (Station 5)	9/15/05	315	cfu
F19	McCormick Creek at bridge (Station 5)	9/19/05	230	cfu
F19	McCormick Creek at bridge (Station 5)	9/20/05	200	cfu
F19	McCormick Creek at bridge (Station 5)	9/22/05	140	cfu
F19	McCormick Creek at bridge (Station 5)	9/26/05	310	cfu
F19	McCormick Creek at bridge (Station 5)	9/29/05	3500	cfu
F19	McCormick Creek at bridge (Station 5)	8/22/06	220	cfu
F19	McCormick Creek at bridge (Station 5)	9/13/06	365	cfu
F20	McCormick Creek above Hwy 16 (Station 7)	9/29/05	220	cfu
F21	McCormick Creek above Hwy 16 (Station 8)	9/29/05	150	cfu
I1	FB1	6/23/04	1600	cfu
I1	FB1	7/7/04	1500	cfu
I1	FB1	8/5/04	900	cfu
I1	FB1	9/1/04	3550	cfu
I1	FB1	5/10/05	>1,600	cfu
I1	FB1	5/17/05	170	cfu
I1	FB1	6/13/05	430	cfu
I1	FB1	7/13/05	1,500	cfu
I1	FB1	7/26/05	300	cfu
I1	FB1	8/9/05	1,300	cfu
I1	FB1	9/7/05	1,600	cfu
I1	FB1	9/28/05	190	cfu
I1	FB1	5/1/06	140	cfu
I1	FB1	6/14/06	900	cfu
I1	FB1	7/25/06	2,500	cfu
I1	FB1	8/3/06	700	cfu
I1	FB1	8/14/06	2,100	cfu
I1	FB1	9/25/06	1,400	cfu
I1	FB1	6/19/07	110	cfu
I1	FB1	7/17/07	>16,000	cfu
I1	FB1	8/20/07	360	cfu
I1	FB1	9/17/07	340	cfu
I2	FB2	7/7/04	1800	cfu
I2	FB2	8/5/04	2000	cfu
I2	FB2	9/1/04	3500	cfu
I2	FB2	5/17/05	200	cfu
I2	FB2	6/13/05	330	cfu
I2	FB2	7/13/05	130	cfu
I2	FB2	9/7/05	130	cfu

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
I2	FB2	6/14/06	120	cfu
I2	FB2	7/25/06	200	cfu
I2	FB2	7/17/07	2,400	cfu
I2	FB2	8/2/07	130	cfu
I2	FB2	8/16/07	160	cfu
I2	FB2	9/17/07	120	cfu
I3	FB3	6/23/04	1000	cfu
I3	FB3	7/7/04	245	cfu
I3	FB3	8/5/04	800	cfu
I3	FB3	9/1/04	2500	cfu
I3	FB3	5/17/05	180	cfu
I3	FB3	6/13/05	125	cfu
I3	FB3	9/7/05	220	cfu
I3	FB3	7/25/06	230	cfu
I3	FB3	8/14/06	130	cfu
I3	FB3	6/19/07	270	cfu
I3	FB3	7/17/07	5,000	cfu
I3	FB3	8/2/07	26,000	cfu
I3	FB3	8/8/07	460	cfu
I3	FB3	8/16/07	130	cfu
I3	FB3	9/17/07	135	cfu
I4	Dalton Creek - mouth	7/28/2003	500	cfu
I4	Dalton Creek - mouth	5/10/05	1600	cfu
I4	Dalton Creek - mouth	5/17/05	410	cfu
I4	Dalton Creek - mouth	6/13/05	230	cfu
I4	Dalton Creek - mouth	7/13/05	2500	cfu
I4	Dalton Creek - mouth	5/1/06	450	cfu
I4	Dalton Creek - mouth	6/6/06	280	cfu
I4	Dalton Creek - mouth	5/10/07	1000	cfu
I5	FB6	5/10/05	300	cfu
I5	FB6	7/13/05	1400	cfu
Mason County Health Department				
G1	Site 21, Unnamed creek at Allyn pump station, intersection Hwy 106 & Hwy 3	08/10/04	130	cfu
G1	Site 21, Unnamed creek at Allyn pump station, intersection Hwy 106 & Hwy 3	09/19/05	300	cfu
G1	Site 21, Unnamed creek at Allyn pump station, intersection Hwy 106 & Hwy 3	09/12/06	1601	cfu
G1	Site 21, Unnamed creek at Allyn pump station, intersection Hwy 106 & Hwy 3	09/19/06	1601	cfu
G2	Site 27, Sherwood Creek at Hwy 3 bridge	09/15/04	240	cfu
G2	Site 27, Sherwood Creek at Hwy 3 bridge	11/02/04	400	cfu
G3	Site 30, Unnamed creek in Victor just after 4590 Hwy 302	09/28/04	300	cfu
G4	Site 36, Shoofly Creek at North Shore Rd	08/10/04	300	cfu
G4	Site 36, Shoofly Creek at North Shore Rd	12/20/05	130	cfu
G5	Site 37, Stimson Creek at North Shore Rd culvert	08/10/04	130	cfu
G5	Site 37, Stimson Creek at North Shore Rd culvert	09/06/05	170	cfu
G5	Site 37, Stimson Creek at North Shore Rd culvert	09/20/05	240	cfu
G6	Site 38, Little Mission Cr at North Shore Rd culvert	09/06/05	170	cfu

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
G6	Site 38, Little Mission Cr at North Shore Rd culvert	12/20/05	515	cfu
G6	Site 38, Little Mission Cr at North Shore Rd culvert	08/23/06	240	cfu
G6	Site 38, Little Mission Cr at North Shore Rd culvert	06/26/07	1600	cfu
G7	Site 39, Big Mission Cr at North Shore Rd bridge	09/06/05	240	cfu
G7	Site 39, Big Mission Cr at North Shore Rd bridge	09/20/05	130	cfu
G7	Site 39, Big Mission Cr at North Shore Rd bridge	11/28/05	110	cfu
G7	Site 39, Big Mission Cr at North Shore Rd bridge	08/07/06	130	cfu
G7	Site 39, Big Mission Cr at North Shore Rd bridge	08/23/06	900	cfu
G8	Site 44	08/10/04	400	cfu
G8	Site 44	08/31/04	240	cfu
G8	Site 44	08/07/06	130	cfu
G9	Site 47	09/28/04	1600	cfu
G10	Site 40B, Belfair Cr at North Shore Rd (Hwy 300 at this point) bridge	08/07/06	130	cfu
G11	Site 61, Culvert at Lennard K's, Hwy 3 in Allyn	09/19/05	1601	cfu
G11	Site 61, Culvert at Lennard K's, Hwy 3 in Allyn	10/18/05	240	cfu
G12	Site 60, Unnamed creek at Michael Dr across intersection from Allyn pump station.	09/19/06	1601	cfu
G13	Site 62, Culvert at Kayak Park, Hwy 3 in Allyn	09/12/06	130	cfu
G22	Site 63	06/27/05	220	cfu
G23	Site 82	05/22/07	170	cfu
G23	Site 82	06/26/07	130	cfu
H1	Site 13, Potlatch Creek at Potlatch State Park	9/27/04	1600	cfu
H1	Site 13, Potlatch Creek at Potlatch State Park	8/10/05	500	cfu
H1	Site 13, Potlatch Creek at Potlatch State Park	9/28/05	1601	cfu
H1	Site 13, Potlatch Creek at Potlatch State Park	12/19/05	1601	cfu
H1	Site 13, Potlatch Creek at Potlatch State Park	1/23/06	145	cfu
H1	Site 13, Potlatch Creek at Potlatch State Park	5/31/06	300	cfu
H1	Site 13, Potlatch Creek at Potlatch State Park	8/8/06	300	cfu
H1	Site 13, Potlatch Creek at Potlatch State Park	8/22/06	280	cfu
H1	Site 13, Potlatch Creek at Potlatch State Park	02/25/04	1601	cfu
H2	Site 15, Finch Creek at 101 bridge	09/07/04	105	cfu
H2	Site 15, Finch Creek at 101 bridge	09/27/04	900	cfu
H2	Site 15, Finch Creek at 101 bridge	11/22/04	170	cfu
H2	Site 15, Finch Creek at 101 bridge	08/10/05	1601	cfu
H3	Site 50	08/10/04	600	cfu
H4	Site 51	09/28/04	1601	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	04/26/04	220	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	08/25/04	700	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	09/15/04	300	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	10/26/04	220	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	11/02/04	900	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	12/08/04	560	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	09/21/05	240	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	10/10/05	110	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	10/31/05	1601	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	01/30/06	170	cfu
J1	Site 22, Uncle John Cr at Agate Loop Rd culvert	08/09/06	240	cfu
J2	Site 23, Deer Creek at Hwy 3 bridge	09/13/04	205	cfu
J2	Site 23, Deer Creek at Hwy 3 bridge	10/18/04	110	cfu

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
J2	Site 23, Deer Creek at Hwy 3 bridge	10/31/05	500	cfu
J3	Site 24, Cranberry Creek at Hwy 3 bridge	08/25/04	130	cfu
J3	Site 24, Cranberry Creek at Hwy 3 bridge	09/21/05	130	cfu
J3	Site 24, Cranberry Creek at Hwy 3 bridge	10/10/05	100	cfu
J4	Site 25, Johns Creek at Hwy 3 bridge	08/25/04	130	cfu
J4	Site 25, Johns Creek at Hwy 3 bridge	10/31/05	130	cfu
J4	Site 25, Johns Creek at Hwy 3 bridge	08/09/06	170	cfu
J5	Site 31, Skookum Creek	08/18/04	220	cfu
J5	Site 31, Skookum Creek	08/25/04	400	cfu
J5	Site 31, Skookum Creek	09/15/04	140	cfu
J5	Site 31, Skookum Creek	09/30/04	220	cfu
J5	Site 31, Skookum Creek	11/02/04	500	cfu
J5	Site 31, Skookum Creek	12/08/04	130	cfu
J5	Site 31, Skookum Creek	09/08/05	115	cfu
J5	Site 31, Skookum Creek	10/04/05	240	cfu
J5	Site 31, Skookum Creek	10/31/05	1601	cfu
J5	Site 31, Skookum Creek	02/28/06	205	cfu
J5	Site 31, Skookum Creek	08/21/06	130	cfu
J5	Site 31, Skookum Creek	09/11/06	130	cfu
J6	Site 26	09/07/05	1600	cfu
J6	Site 26	08/21/06	300	cfu
J7	Site 53	09/15/04	*300*	cfu
J8	Site 54	09/29/04	130	cfu
J9	Site 57	08/18/04	130	cfu
K1	Site 2, Decker Creek	9/15/04	130	cfu
K1	Site 2, Decker Creek	10/4/05	500	cfu
K1	Site 2, Decker Creek	10/31/05	900	cfu
K2	Site 3, Satsop River middle fork at east end of Schaffer Park road access	9/8/05	130	cfu
K2	Site 3, Satsop River middle fork at east end of Schaffer Park road access	10/31/05	315	cfu
K3	Site 7, Cloquallum Creek	7/19/05	500	cfu
K3	Site 7, Cloquallum Creek	10/31/05	1600	cfu
M1	Site 19, Kennedy Cr Bridge at Old Olympic Hwy	08/18/04	1601	cfu
M1	Site 19, Kennedy Cr Bridge at Old Olympic Hwy	08/25/04	500	cfu
M1	Site 19, Kennedy Cr Bridge at Old Olympic Hwy	09/08/05	500	cfu
M1	Site 19, Kennedy Cr Bridge at Old Olympic Hwy	10/31/05	1601	cfu
Jefferson County Health Department Data				
A1	AND/0.0	6/5/07	300	cfu
A2	AND/1.71	6/5/07	1600	cfu
A3	CAS/0.3	6/5/07	900	cfu
A3	CAS/0.3	6/5/07	900	cfu
A4	SA/0.15	5/9/07	300	cfu
A4	SA/0.15	6/5/07	300	cfu
A4	SA/0.15	6/19/07	130	cfu
A4	SA/0.15	7/31/07	220	cfu
A4	SA/0.15	8/28/07	240	cfu
A4	SA/0.15	9/11/07	170	cfu
A4	SA/0.15	9/24/07	900	cfu
A5	SA/0.4	5/9/07	240	cfu

Map Station Code	Location	Date	Bacteria Result	Unit of Measure
A5	SA/0.4	6/5/07	900	cfu
A5	SA/0.4	6/19/07	500	cfu
A5	SA/0.4	7/31/07	200	cfu
A5	SA/0.4	7/31/07	170	cfu
A5	SA/0.4	8/14/07	300	cfu
A5	SA/0.4	9/11/07	500	cfu
A5	SA/0.4	9/11/07	500	cfu
A5	SA/0.4	9/24/07	900	cfu
A6	SA/0.6	8/14/07	130	cfu
A6	SA/0.6	8/28/07	240	cfu
A6	SA/0.6	9/11/07	1600	cfu
A6	SA/0.6	9/11/07	1600	cfu
A6	SA/0.6	9/24/07	280	cfu
A7	SA/0.7	6/5/07	500	cfu
A7	SA/0.7	7/5/07	1600	cfu
A8	SN/0.2	5/9/07	110	cfu
A8	SN/0.2	6/6/07	220	cfu
A8	SN/0.2	7/5/07	170	cfu
A8	SN/0.2	8/14/07	1600	cfu
A8	SN/0.2	9/11/07	500	cfu
A9	SN/0.8	6/5/07	300	cfu
A9	SN/0.8	7/31/07	280	cfu
A10	SN/1.6	6/5/07	240	cfu
A10	SN/1.6	6/6/07	132	cfu
A11	SN/2.3	6/6/07	182	cfu
A12	SN/3.5	6/5/07	1600	cfu
A12	SN/3.5	6/6/07	134	cfu
A13	SN/3.9	6/5/07	900	cfu
A14	TUD/0.0	6/5/07	1600	cfu
A15	TUD/0.4	5/23/07	240	cfu
A15	TUD/0.4	6/5/07	1600	cfu
A15	TUD/0.4	6/5/07	1600	cfu
A15	TUD/0.4	6/19/07	1600	cfu
A15	TUD/0.4	7/5/07	170	cfu
A16	TUD/0.5	6/5/07	900	cfu
A16	TUD/0.5	7/5/07	240	cfu
A17	UVD/0.0	5/9/07	222	cfu
A17	UVD/0.0	5/9/07	130	cfu

cfu=colony forming unit
mpn=most probable number

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Appendix D. Annotated Bibliography

Buckwalter, T.F. et al., 2006. Fecal Indicator Bacteria in the Allegheny, Monongahela and Ohio Rivers and Selected Tributaries, Allegheny County, Pennsylvania, 2001-2005. USGS Scientific Investigations Report 2006-5216.

Water samples were collected during the summer and early fall during dry and wet weather conditions.

Spearman's correlation tests were done to determine if field characteristics were related to fecal coliform bacteria concentrations. The strongest correlations were between the bacteria levels and streamflow, specific conductance, and turbidity.

Christensen, V.G. et al., 1998. Continuous Turbidity Monitoring and Regression Analysis to Estimate Total Suspended Solids and Fecal Coliform Bacteria Loads in Real Time. In Proceedings of the Seventh Federal Interagency Sedimentation Conference, March 25-29, 2001, Reno, Nevada: Subcommittee on Sedimentation, v. 1, p. III-94 to III-101.
http://ks.water.usgs.gov/Kansas/pubs/reports/vgc.fisc.html

The study area was several streams in Kansas. Continuously recorded data and data from periodic collection of water quality samples were used to develop surrogate relations between turbidity and constituents of concern.

This study found continuous and periodic monitoring have allowed the identification of trends in turbidity, total suspended solids, and fecal coliform bacteria and the estimation of chemical load transported in the Little Arkansas River. One point of interest was the discovery of high fecal coliform densities in the dry months when cattle (a case could be made for any animals seeking water) congregate near streams.

Christensen, V.G., 2001. Characterization of surface-water quality based on real-time monitoring and regression analysis, Quivira National Wildlife Refuge, south-central Kansas, December 1998 through June 2001. USGS Water-Resources Investigations Report 2001-4248.

To assess the quality of water flowing from Rattlesnake Creek into the refuge, the U.S. Geological Survey (USGS) collected periodic water samples from December 1998 through June 2001. The USGS analyzed the samples for physical properties, dissolved solids, total suspended solids, suspended sediment, major ions, nutrients, metals, pesticides, and indicator bacteria.

Because many parameters (e.g., bacteria and dissolved solids) which are a concern for the health and habitat of fish and wildlife cannot be measured continuously, regression equations were developed from a comparison of the results of periodic samples and in-stream measurements.

Load estimates were used to evaluate seasonal variation in water quality. Load estimates also were used to calculate yields, which are useful for site comparisons.

The regression equation for bacteria used water temperature and turbidity as explanatory variables. The relatively low R^2 (0.661) and relatively high relative percentage difference (50.0%) for the fecal coliform equation indicates the equation has a higher degree of uncertainty compared with the equations for the other parameters measured in this study. This uncertainty is due to the regression but also includes analytical uncertainty which can be as high as 50% for bacteria analysis.

Clark, M.L. and J.R. Norris, 2000. Occurrence of Fecal Coliform Bacteria in Selected Streams in Wyoming, 1990-99. USGS Water-Resources Investigation Report 00-4198.

The USGS, in cooperation with the Wyoming Department of Environmental Quality, collected water samples for bacteria analysis at 18 stream sites.

Fecal coliform concentrations showed positive correlations with stream discharge. Previous literature has shown surface runoff from pastures, feedlots, and urban areas contribute sediment and associated bacteria to streams. Increased discharge can also resuspend fine bottom sediments, particularly those with at least 25% clay.

In addition to transport processes and variable bacteria survival rates, land use activity (such as cattle grazing and outdoor recreational activities) generally increase during the spring and summer months.

Spearman's rank correlation procedure was used to determine the relation between various water quality field measurements. Discharge and water temperature were positively correlated with fecal coliform concentrations, while specific conductance, pH and dissolved oxygen generally were negatively correlated with fecal coliform.

Conrad, R., 2008. Fecal Coliform Count Analysis for Station 614. Unpublished (done for the Squaxin Island Tribe), 11 pages.

Conclusions:

- Mean fecal counts at Station 614 have significant year-to-year variation.
- Because of this yearly variability, the effect of the year must be included in any analysis attempting to relate the dependent variable (bacteria) to any explanatory covariates.
- For the following covariates (temperature, salinity, wind speed, and rainfall), wind speed explained the greatest amount of the variation in mean bacteria levels; temperature was second. However, only a small portion of the variability was explained; 32% by wind speed and 22% by temperature.
- The model which explains the most variation in mean bacteria levels includes both temperature and salinity. This model still explains less than half of the variation in mean bacteria levels.
- Future analysis should focus on temperature, wind speed, and salinity. Average rainfall does not appear to be important at the station level.

Davies, C.M. et al., 1991. Sunlight and the Survival of Enteric Bacteria in Natural Waters. Journal of Applied Bacteriology, 70:265-274.

This study showed the rate of decrease in numbers of culturable bacteria was significantly faster in seawater than in freshwater when exposed to natural sunlight. The lethal effect of light is aggravated by salinity levels.

The survival of bacteria in freshwater may be due to the presence of ultraviolet absorbing substances, including humic substances, which would protect the bacterial cells from DNA damage by the ultraviolet radiation.

A study was cited where the correlation between numbers of *Escherichia coli* and pathogens in freshwater is much higher and their capacity for survival greater than in marine waters.

There is a portion of the viable bacteria community which cannot be recovered by culturing techniques; these are termed viable but not culturable bacteria.

Entry, J.A. et al., 2000. The Influence of Vegetation in Riparian Filterstrips on coliform Bacteria: II. Survival in Soils. Journal of Environmental Quality, Vol. 29:1215-1224.

This paper found the potential for movement of bacteria in surface runoff and groundwater will in part depend on soil type and the amount and type of vegetation growing at the site. The ability of the soil to filter microorganisms depends largely on soil texture and pore size. However, vegetation type in riparian areas did not affect bacteria survival rates.

The authors cited a study where bacteria survival time in the upper soils varied from 4 to 160 days, although other literature found many pathogenic organisms can live in the soil for months.

Soil moisture seemed to be the most important factor in the survival of bacteria; the higher the soil moisture, the higher the bacteria survival rate. Soil temperature also exerts a major influence on bacteria survival.

One literature source cited in this study showed 92-97% of *Escherichia coli* are filtered out in the first 4 cm as they move down through the soil column. However other field and lab studies found enteric microorganisms can be transported long distances through soil. The explanation given is the preferential flow of water transporting bacteria through soil macro pores, cracks, and fissures.

Ferguson, C. et al., 2003. Fate And Transport of Surface Water Pathogens in Watersheds. Critical Reviews in Environmental Science and Technology, 33(3):299-361.

Pathogens present in animal fecal deposits excreted to land undergo a poorly defined process of dispersion, transport, and inactivation. The survival of pathogens and indicators in soil, water, and feces is dependent on the chemical, physical, and biological composition of these matrices.

In response to environmental stress, bacteria can either die or adapt using a number of mechanisms including the formation of spores, or viable but nonculturable cells.

The detrimental effects of sunlight on the survival of fecal coliforms are less than for enterococci in the presence of humic substances whereas fecal coliforms are more sensitive to lower pH.

Soil passage is considered an important barrier against viruses. The contamination of groundwater is often related to surface water intrusion via poorly constructed wellheads. The current assumption is that a groundwater travel time of 60 days is adequate to inactivate pathogenic microorganisms.

Traditionally, bacterial indicators of fecal contamination have been used to assess the microbial quality of water. It is now apparent these bacterial indicators are not suitable for assessing the risk posed by protozoan pathogens and some enteric viruses.

Key factors for inactivating enteric bacteria and viral and protozoan pathogens:

- Water/osmotic potential
- Temperature, sunlight, and pH
- Inorganic (ammonia) and organic nutrients
- Adsorption/desorption effects
- Hydrological movement
- Mechanical and biological movement

Temperature, particularly when combined with reduced moisture, is often cited as the most important environmental factor affecting bacteria survival.

Flint, K.P., 1987. The Long Term Survival of *Escherichia coli* in River Water. Journal of Applied Bacteriology, 1987, 63:261-270.

The results suggested it is a biological component of water which is primarily responsible for the disappearance of *Escherichia coli* from water samples. Temperature was shown to be a secondary, although very important, factor.

The author found more than 90% of introduced *Escherichia coli* species survived in river water for up to 260 days without the addition of any extra carbon sources. This survival for such a long time without any replication suggests the *Escherichia coli* species entered some type of dormant state. This state has been termed “starvation survival”.

Starvation survival becomes an important concept in ecology because it concerns the long-term survival of individuals in unfavorable conditions. Hence the genome will survive enabling the small numbers of bacteria which have survived starvation to recolonize a suitable habitat when favorable conditions return.

Giddings, E.M. and C.J. Oblinger, 2004. Fecal Indicator Bacteria in the Newfound Creek Watershed, Western North Carolina, During a High and Low Streamflow Condition, 2003. USGS Scientific Investigations Report 2004-5257.

Numerous authors have documented that fecal bacteria can survive for relatively long periods in stream and lake sediments. Bacteria attach to sediment particles and survive in the nutrient-rich environment of the sediment bed. Lake and stream sediments can contain densities of bacteria several times over the amount found in the overlying water column.

Results indicated that during low-flow stream conditions, non-human sources of bacteria were present at one of the sampling locations. During high stream-flow, human sources were present.

Halstad, Melissa, 2002. Effects of stream flow on the stream temperature, E. coli concentrations and dissolved oxygen levels in the West Branch of the Sheepscot River. Alna, ME. Sheepscot Valley Conservation Association (SVCA) Water Quality Monitoring Program.

Eight years of data was collected on the Sheepscot River in Maine. A scatter plot revealed a negative relationship of streamflow to *E. coli* concentrations, indicating a point source of bacteria. A regression analysis of this data showed the relationship to be not significant ($R^2 = 0.04$).

Hill, D.D. et al., 2006. The Impact of Rainfall on Fecal Coliform Bacteria in Bayou Dorcheat (North Louisiana). International Journal of Environmental Research and Public Health, 3(1), 114-117.

Based on two years of data, this study found the fecal coliform levels were not significantly linked to rainfall amounts.

Hyer, K.E. and D.L. Moyer, 2003. Patterns and Sources of Fecal Coliform Bacteria in Three Streams in Virginia, 1999-2000. USGS Water-Resources Investigations Report 03-4115.

Correlations were examined between the observed fecal coliform concentrations and other stream parameters to develop multiple linear regression models for predicting fecal coliform concentrations at each sampling station in the study.

In all the models, turbidity was identified as the parameter that explained the greatest variance and was most significant in the model. Other authors have observed correlations between turbidity and fecal coliform concentrations. Conceptually, the strong relationship may exist because both constituents are flushed into the stream during storm events. It can be concluded that conditions that favor elevated fecal coliform concentrations also favor elevated turbidity levels.

Irvine, K.N. et al., 2002. Turbidity, Suspended Solids and Bacterial Relationships in the Buffalo River Watershed. Middle States Geographer, 2002, 35:42-51.

This paper summarizes the results of sampling that was done in the Buffalo River, New York watershed over the past decade.

The results show total suspended solids (TSS) is significantly correlated with fecal coliform levels and turbidity. The authors assume part of the correlation between TSS and fecal coliform is related to resuspension of bacteria inoculated bed sediment.

The results of this study show a strong positive relationship between TSS and turbidity as well as TSS and fecal coliform.

Koening, S.E., 2000. Fecal Coliform and *Escherichia coli* Bacteria in the St. Croix National Scenic Riverway, Summer 1999. USGS Water-Resources Investigations Report 00-4214.

Bacteria samples were collected in the St. Croix National Scenic Riverway (Minnesota and Wisconsin) from May through September 1999 at 22 locations. Stream discharges were normal to above average during the study period.

There were no consistent short-term variations in fecal coliform or *E. coli* concentrations during the summer period. In addition, there was no significant relation between bacteria concentration and discharge based on these results.

McSwain, M.R., 1977. Baseline Levels and Seasonal Variations of Enteric Bacteria in Oligotrophic Streams. Watershed Research in Eastern North America, A Workshop to Compare Results, Volume II February 28-March 3, 1977. Report No. NSF/RA-770255. Smithsonian Institute, Edgewater, Maryland, Chesapeake Bay Center for Environmental Studies, p 555-574, 1977.

Data suggested bacteria fluctuated seasonally and diurnally. Measurements of bacteria were correlated with stream turbidity and temperature. Data suggested seasonal cycles were caused by multiplication of bacteria in stream sediments and population growth was regulated by stream temperature. Fecal streptococci were less responsive to changes in turbidity than were coliforms.

Elevated levels of fecal coliforms during storms appeared more related to bottom sediment disturbance than to stream flushing. In contrast, increases in fecal streptococci counts during storms appeared more related to the washing of overhanging stream vegetation and stream flushing.

Of the stream parameters measured, only streamflow and stream temperature exhibited any correlation with seasonal counts of bacteria. The correlation with streamflow was inverse; i.e., the highest counts were obtained during the fall when flow was lowest, and the lowest counts were obtained during the winter when flow was highest. A stronger correlation existed between total coliform counts and stream temperature ($R^2 = 0.79$).

Diurnal fluctuations in total coliform counts were pronounced in the spring and fall, and less pronounced in other seasons. Counts were usually highest between 1130 and 1400 hours, and lowest at night between 2400 and 0330. Diurnal fluctuations were least pronounced during winter when almost no bacteria were counted in the morning. Diurnal cycles for fecal coliforms and fecal streptococci were similar to those for total coliforms.

The results of this study suggest that the most immediate source of total and fecal coliforms is stream sediments. Data further suggest that coliforms are able to multiply in sediments, and that multiplication is regulated by stream temperatures.

Morace, J.L. and S.W. McKenzie, 2002. Fecal-Indicator Bacteria in the Yakima River Basin, Washington—An Examination of 1999 and 2000 Synoptic-Sampling Data and their Relation to Historical Data. USGS Water-Resources Investigations Report 02–4054.

This paper showed relationships between fecal coliform bacteria and various environmental parameters. Sedimentation and solar radiation reduce the number of coliform bacteria in the water column. Solar radiation is lethal, and sedimentation immobilizes the organisms to the bottom sediments. Bottom sediments can contain substantially larger concentrations of bacteria than the overlying water. A literature review found that temperature, proximity of pollution sources, livestock-management practices, wildlife activities, fecal-deposit age, and the containment of organisms within the channel and the banks are the major factors affecting the concentrations of bacteria in runoff from agricultural lands.

When all of the data from the three synoptic samplings are tested, the correlations between bacteria concentrations and several parameters are significant. Yet only chloride and dissolved organic carbon, both measured only during the August 1999 synoptic sampling, were strongly correlated. Conversely, when only the data from the August 1999 synoptic sampling are used, every correlation is significant, and all but nitrite concentrations and water temperature have strong correlations. The July and October–November 2000 synoptic sampling data had strong significant correlations with only some of the nutrient concentrations.

Groundwater contributions were indicated at sites where a negative correlation existed between nitrite-nitrate and fecal coliform. In general, lower fecal coliform concentrations corresponded with lower temperatures, and higher counts with higher temperatures.

Three conclusions were reached:

1. Overland runoff transports bacteria from land surfaces to streams.
2. Bacteria in the water column tend to associate with suspended matter.
3. With increasing densities of warm-blooded animals, the likelihood of fecal coliform contamination in streams also increases.

Struck, P.H., 1988. The Relationship Between Sediment and Fecal Coliform Levels in a Puget Sound Estuary. Journal of Environmental Health, July/August 1988:403-407.

This study was undertaken to explore the following relationships:

- Correlation between stream water and stream sediment fecal coliform levels and how the two fluctuate with respect to rainfall.
- The type and extent of growth that occurs in sediment under laboratory conditions.

This study found that even after the repair of 22 failing on-site septic systems in the Burley Creek watershed, only a 15% reduction in fecal coliform loading occurred.

Study results often showed a several hundred-fold elevation of fecal coliform concentrations in the water column following a rainfall. In addition, freshwater and marine sediments collected were found to have concentrations of fecal coliform often several orders of magnitude higher than those found in the water column at the same sampling station.

Fecal coliform bacteria experienced a rapid decline in water with increasing salinity; this decline usually corresponded to an increase in sediment concentrations. This study found 71% of the fluctuation in water fecal coliform levels can be explained by corresponding fluctuations in sediment concentrations.

The results of bacteria growth monitoring indicate fecal coliform in the Burley Creek water column are capable of settling into sediments and reproducing exponentially.

This study also found that in some cases fecal coliform are only weakly associated with sediment substrate. A rain event, or other activity which disturbs sediments, could cause substantial errors in test interpretation.

In this study, it does not appear that fecal coliform populations in sediments are self-sustaining. Without the constant settling out of the water column from nonpoint sources such as failing drainfields and/or livestock wastes, as well as the constant deposition of nutrient-rich particulates, fecal coliform levels in sediments would not exceed those seen in undisturbed systems.

This study found the magnitude of the difference between bacteria levels in the water column and the precision of correlation between sediment and water column concentrations suggest sediment sampling could be a more accurate indicator of general conditions in the watershed.

The results of this study and others indicate nonpoint bacteria contamination is not limited to the original source of bacteria but to the numerous interactions that occur after the bacteria enter the stream or estuary.

Surbeck, C.Q. et al., 2006. Flow Fingerprinting Fecal Pollution and Suspended Solids in Stormwater Runoff from an Urban Coastal Watershed. Environmental Science and Technology, 2006, 40:4435-4441.

This paper found the concentrations of fecal indicator bacteria and F^{+-+} coliphages exhibited little to no dependence on streamflow rates. The study showed the concentration of fecal pollution increases abruptly at the onset of stormwater runoff and remains elevated (or increases steadily) over the storm hydrograph. This suggests fecal bacteria are mobilized into surface water runoff by a process largely flow independent.

This study found the concentrations of total suspended solids (TSS) exhibited a very strong dependence on streamflow.

Application of distributed watershed models to fecal bacteria is complicated by the fact that once bacteria enter the environment, their transport is affected by poorly characterized ecological processes such as the proliferation of environmentally adapted strains of fecal bacteria. Consequently, bacteria are unlikely to accumulate and wash off at reproducible and land-use specific rates. This is an assumption inherent in most watershed models.

Van Donsel, D.J. et al., 1967. Seasonal Variations in Survival of Indicator Bacteria in Soil and Their Contribution to Stormwater Pollution. Applied Microbiology, Nov. 1967, 1362-1370.

This study found the 90% reduction times in soil for fecal coliform ranged from 3.3 days in the summer to 13.4 days in autumn. During the summer, the fecal coliform survived slightly longer than the fecal streptococcus.

There was evidence of aftergrowth of nonfecal coliforms in the soil as a result of temperature and rainfall variations. Such aftergrowth may contribute to variations in bacterial count of stormwater runoff which has no relation to the sanitary history of the drainage area.

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Appendix E. Glossary and Acronyms

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

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

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Diurnal: Of, or pertaining to, a day or each day; daily. (1) Occurring during the daytime only, as different from nocturnal or crepuscular, or (2) Daily; related to actions which are completed in the course of a calendar day, and which typically recur every calendar day (e.g., diurnal temperature rises during the day, and falls during the night).

Enterococci: A subgroup of the fecal streptococci that includes *S. faecalis*, *S. faecium*, *S. gallinarum*, and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5% sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C.

Fecal coliform: That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Humic substances: The degraded material of plant and animal tissues.

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

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

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

Riparian: Relating to the banks along a natural course of water.

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

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

cfu	Colony forming unit
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
GIS	Geographic Information System
mpn	Most probable number
USGS	U.S. Geographical Survey
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WWTP	Wastewater treatment plant