WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Condition of Fresh Waters in Washington State for the Year 2002

Technical Appendix

June 2003

Publication No. 03-03-031
printed on recycled paper

Publication Information

Conditions of Fresh Waters in Washington State for the Year 2002: Technical Appendix

This technical appendix is available on the Department of Ecology home page on the World Wide Web at http://www.ecy.wa.gov/biblio/0303031.html

For a printed copy, contact:

Department of Ecology Publications Distributions Office
Address: PO Box 47600, Olympia WA 98504-7600
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Refer to Publication Number 03-03-031

Conditions of Fresh Waters in Washington State for the Year 2002

The parent publication is available on the Web at http://www.ecy.wa.gov/biblio/0303030.html

For a printed copy, refer to Publication No. 03-03-030.

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Condition of Fresh Waters in Washington State for the Year 2002

Technical Appendix

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Abstract

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7. A listing of all the specific locations where invasive exotic aquatic weeds have been identified by Ecology since 1994.

Acknowledgements

There are many people we like to thank for help in producing the report, *Fresh Water Conditions for Washington State,* and this technical appendix:

- Chad Brown for preparing the maps in the report
- Tom Leonard for producing the layout version of the report.
- Michelle Harper and Joan LeTourneau for formatting and publishing the technical appendix.
- Rob Plotnikoff for advocating the need to present this information to a public audience.

Introduction

This technical appendix presents details about the assessment methods and sampling locations used to develop the report, *Conditions of Fresh Waters in Washington State for the Year 2002*.

Stream Water Quality Index

Water quality indices have been developed to compile large quantities of water quality data into single values in much the same way that the Dow-Jones summarizes conditions in financial markets. Although much detail is lost in summarizing information in this way (see "Uses and Limitations"), indices make water quality information accessible to a much wider audience - including elected officials, administrators and the general public. Several water quality indices that summarize data in an easily understood format are reviewed by Couillard and Lebebvre (1985).

The Stream Water Quality Index (WQI) is a unitless number ranging from 1 to 100 that is intended to represent general water quality. A higher number indicates better water quality. For constituents with established water quality standards (based on criteria in Washington State's Water Quality Standards, WAC 173-201A), the index expresses results relative to levels required to meet these standards. For constituents without specific standards, results are expressed relative to expected conditions in the appropriate region. Multiple constituents are combined and results aggregated over time to produce a single score for each sample station.

Uses and Limitations

By design, indices contain less information than the raw data that they summarize. An index cannot provide all the information expressed by the original water quality data. An index is most useful for comparative purposes (what stations have particularly poor water quality?) and for general questions (What is the general water quality in my stream?). Indexes are less suited to answering specific questions. Site-specific decisions should be based on an analysis of the original water quality data. In short, an index is a useful tool for "communicating water quality information to the lay public and to legislative decision makers;" it is not "a complex predictive model for technical and scientific application" (McClelland, 1974).

Besides being general in nature, there are at least two reasons that an index may fail to accurately communicate water quality information. First, most indexes are based on a pre-identified set of water quality constituents. A particular station may receive a good WQI score, and yet have water quality impaired by constituents not included in the index. Second, aggregation of data may mask short-term water quality problems. A satisfactory WQI at a particular station does not necessarily mean that water quality was always satisfactory. A good score should, however, indicate that poor water quality (for evaluated constituents, at least) was not chronic.

Strategies

Different approaches to indexing water quality results are possible. One approach is to rate quality objectively, for example, using ranked data (e.g. Harkins, 1974). While this approach does not require developing subjective rating curves, it also does not permit comparisons between values generated from different data sets. For example, results between years could not be compared unless scores were re-calculated using data from all years. Anytime additional data are added and the index re-calculated (for example, to compare years), results for the same stations and dates would change because the rank order changes. Finally, this approach ranks results from pristine stations where high quality would be expected along with stations where water quality would not be expected to be pristine (regardless of human impacts). Hence, a score could only be interpreted in comparison to another known station.

A more useful index to management is one that allows water quality to be compared to that necessary to support beneficial uses. However, this approach requires subjective determinations of the beneficial uses that a particular stream segment should support, the level of water quality required to support those uses, and how critical variations from that level of quality are. For several key parameters, the first two of these determinations are already codified in Washington's Administrative Code (WAC 173-201A). Washington's Our WQI follows this approach.

Water Quality Constituents Included in the Index

For this analysis, index scores were determined for eight constituents monitored monthly by Ecology's Freshwater Monitoring Unit: temperature, dissolved oxygen (DO), pH, fecal coliform bacteria (FC), total nitrogen (TN), total phosphorus (TP), total suspended sediment (TSS), and turbidity. Rather than aggregating scores for TN and TP separately, the harmonic mean was used in the aggregation of the overall index because TN and TP are highly correlated and they measure similar impacts on water quality. Similarly, a harmonic mean of sediment-related constituents (TSS and turbidity) was also used. Future WQI analyses may include an evaluation of percent oxygen saturation and unionized ammonia. Data collection and quality control are discussed in our annual reports (e.g. Hallock and Ehinger, 2000).

Methodology

The methodology used to determine WQI scores was originally developed by the Environmental Protection Agency (EPA), Region 10. Initial development was documented only in the "gray" literature (Peterson and Bogue, 1989), but the methodology appears to be based on the well-known National Sanitation Foundation index. This index used curves to relate concentrations or measurements of various constituents to index scores and then aggregated the scores into a single number (Brown et al. 1970). The EPA curves were "a synthesis of national criteria, state standards, information in the technical literature, and professional judgment" (Peterson and Bogue, 1989).

In the 1980s, Ecology produced a WQI using the EPA methods, with further modifications of some curves to align curves with water quality standards (e.g. Hallock, 1990). The index was calculated by a Fortran program run on an EPA mainframe computer using data in the national STORET database. These procedures were somewhat cumbersome and Ecology stopped producing the index in the early 1990s. Ecology recently re-programmed the WQI procedures to assess data in Ecology's ambient stream monitoring database.

For temperature, oxygen, pH, and fecal coliform bacteria, data were converted to index scores using the same relationships used by EPA's WQI, except that the original tabulated results have been converted to quadratic equations. Because there were discontinuities in the original tables, the equations do not fit the tabulated data perfectly. For these parameters, a WQI score is related to the water quality standards criteria for that waterbody, and, therefore, to the support of beneficial uses.

The original curves for turbidity, TSS, TP, and TN do not account for natural differences caused by wide variations in geomorphology across the state. Furthermore, there are no water quality standards criteria for these constituents. Therefore, Ecology developed new curves were developed based on the distribution of data at stations within each ecoregion during high- and low-flow seasons. WQI scores were matched to various quantiles. A quadratic equation was then fit to the WQI-concentration relationships. The particular formulas used for a particular station and constituent depended on the stream class or ecoregion for that station. Calculated results <1 or >100 are converted to 1 or 100, respectively.

There were insufficient data from three ecoregions to develop independent curves. Curves developed for the Puget Lowlands, Cascades, and Northern Rockies are used for stations in the Willamette Valley, Eastern Cascades Slopes and Foothills, and Blue Mountains ecoregions, respectively. For more information on the WQI methodology, see Hallock (2002).

Because the index scores for nutrient and sediment constituents are based on the distribution of past data and not on ecological impacts or degree of degradation, poor index scores for these constituents indicate poor water quality relative to other stations in the same ecoregion, and may not necessarily indicate impairment or inability to support beneficial uses. Conversely, good index scores for these constituents may not necessarily indicate a lack of impairment or an ability to support beneficial uses. Calculated results <1 or >100 are converted to 1 or 100, respectively.

The WQI was applied to water quality data collected from October 2001 through September 2002 (Table 1). To place the WQI scores into categories used for statewide assessment, the cut-points used by EPA in the original WQI was used. According to this categorization scheme, stations with WQI scores 80 and above are considered the 'Lowest Concern", scores from 40 to 79 are of "Moderate Concern", and those below 40 are of the "Highest Concern".

Table 1. Water Quality Index (WQI) Scores for Stations Sampled in Water Year 2002.

Station ID	Station Name	Ecoregion	WQI
01A050	Nooksack R @ Brennan	Puget Lowlands	58
01A120	Nooksack R @ No Cedarville	Puget Lowlands	60
01A140	Nooksack R above the MF	Cascades	40
01D080	Sumas R @ Jones Road	Puget Lowlands	48
01F070	SF Nooksack @ Potter Rd	Puget Lowlands	59
01G070	MF Nooksack R	Cascades	38
01H070	Terrell Cr nr Jackson Rd.	Puget Lowlands	60[a]
03A060	Skagit R nr Mount Vernon	Puget Lowlands	72
03B050	Samish R nr Burlington	Puget Lowlands	33
04A100	Skagit R @ Marblemount	Cascades	59
05A070	Stillaguamish R nr Silvana	Puget Lowlands	43
05A090	SF Stillaguamish @ Arlington	Puget Lowlands	49
05A110	SF Stillaguamish nr Granite Falls	Puget Lowlands	67
05B070	NF Stillaguamish @ Cicero	Puget Lowlands	57
05B110	NF Stillaguamish nr Darrington	Cascades	44
07A090	Snohomish R @ Snohomish	Puget Lowlands	90
07C070	Skykomish R @ Monroe	Puget Lowlands	94
07D050	Snoqualmie R nr Monroe	Puget Lowlands	83
07D130	Snoqualmie R @ Snoqualmie	Puget Lowlands	92
08C070	Cedar R @ Logan St/Renton	Puget Lowlands	68
08C110	Cedar R nr Landsburg	Puget Lowlands	96
09A080	Green R @ Tukwila	Puget Lowlands	68
09A190	Green R @ Kanaskat	Puget Lowlands	92
10A050	Puyallup R @ Puyallup	Puget Lowlands	59
10A070	Puyallup R @ Meridian St	Puget Lowlands	59
10C095	White River @ R Street	Puget Lowlands	35
11A070	Nisqually R @ Nisqually	Puget Lowlands	84
13A060	Deschutes R @ E St Bridge	Puget Lowlands	70
16A070	Skokomish R nr Potlatch	Puget Lowlands	95
16C090	Duckabush R nr Brinnon	Coast Range	94
18A050	Dungeness R nr Mouth	Puget Lowlands	92
18B070	Elwha R nr Port Angeles	Coast Range	83
20B070	Hoh R @ DNR Campground	Coast Range	80
22A070	Humptulips R nr Humptulips	Coast Range	78
23A070	Chehalis R @ Porter	Puget Lowlands	62
23A100	Chehalis R @ Prather Rd	Puget Lowlands	64
23A160	Chehalis R @ Dryad	Puget Lowlands	56
24B090	Willapa R nr Willapa	Coast Range	33
24F070	Naselle R nr Naselle	Coast Range	61
26B070	Cowlitz R @ Kelso	Puget Lowlands	68
27B070	Kalama R nr Kalama	Puget Lowlands	92
27D090	EF Lewis R nr Dollar Corner	Willamette Valley	82

Station ID	Station Name	Ecoregion	WQI
28G070	Gibbons Cr nr Washougal	Willamette Valley	44
28H070	Campen Cr nr Washougal	Willamette Valley	42
31A070	Columbia R @ Umatilla	Columbia Basin	91
32A070	Walla Walla R nr Touchet	Columbia Basin	68
33A050	Snake R nr Pasco	Columbia Basin	86
34A070	Palouse R @ Hooper	Columbia Basin	58
34A120	Palouse R at Colfax	Columbia Basin	48
34A170	Palouse R @ Palouse	Columbia Basin	65
34B110	SF Palouse R @ Pullman	Columbia Basin	50
34H070	Pleasant Valley Cr blw St John	Columbia Basin	41
35A150	Snake R @ Interstate Br	Columbia Basin	79
35B060	Tucannon R @ Powers	Columbia Basin	75
35D070	Asotin Cr @ Asotin	Columbia Basin	60
35F110	Pataha Cr @ Rosy Grade	Columbia Basin	68
36A070	Columbia R nr Vernita	Columbia Basin	95
37A090	Yakima R @ Kiona	Columbia Basin	62
37A205	Yakima R @ Nob Hill	Columbia Basin	88
37E120	Wide Hollow Creek @ Randall Park	Columbia Basin	51
37G120	Ahtanum Cr @ 62nd Ave	Columbia Basin	75
38A050	Naches R @ Yakima on US HWY 97	Columbia Basin	93
38G120	Cowiche Cr @ Zimmerman rd	Columbia Basin	47
39A050	Yakima R @ Harrison Bridge	Columbia Basin	88[a]
39A090	Yakima R nr Cle Elum	Cascades	83
41A070	Crab Cr nr Beverly	Columbia Basin	53
45A070	Wenatchee R @ Wenatchee	Columbia Basin	93
45A110	Wenatchee R nr Leavenworth	Cascades	75
45C070	Chumstick Cr nr Leavenworth	Cascades	53[a]
45E070	Mission Cr nr Cashmere	Cascades	42[a]
46A070	Entiat R nr Entiat	Columbia Basin	95
48A070	Methow R nr Pateros	Columbia Basin	94
48A140	Methow R @ Twisp	Columbia Basin	96
49A070	Okanogan R @ Malott	Columbia Basin	77
49A190	Okanogan R @ Oroville	Columbia Basin	80
49B070	Similkameen R @ Oroville	Columbia Basin	75
53A070	Columbia R @ Grand Coulee	Columbia Basin	89
54A120	Spokane R @ Riverside State Pk	Northern Rockies	71
55B070	Little Spokane R nr Mouth	Northern Rockies	59
56A070	Hangman Cr @ Mouth	Columbia Basin	65
57A150	Spokane R @ Stateline Br	Columbia Basin	86
60A070	Kettle R nr Barstow	Northern Rockies	65
61A070	Columbia R @ Northport	Northern Rockies	78
62A090	Pend Oreille @ Metaline Falls	Northern Rockies	77
62A150	Pend Oreille R @ Newport	Northern Rockies	83

[a] Score not based on a full year's data. Use with caution.

Trend Analysis

The presence or absence of trends over time is a good indication of the degree to which water quality is responding to changes in the watershed. Formal statistical trend analysis provides a rational, scientific basis for addressing issues with natural variations in water quality. This natural variability can be assessed such that a trend in human-caused changes in water quality can be determined. If a distinct relationship exists between stream flow and the concentration of a water quality indicator, then a trend in flows may create a trend in the indicator data or obscure a human-caused trend.

The Seasonal Kendall's Tau test is a good choice for evaluating trends when water quality varies by season (Gilbert, 1987). This test can be used even if there are missing values or if values are below the analytical detection limit. The validity of the test does not depend on data being normally distributed. The statistical software called WQHYDRO (Aroner, 2001) was used to evaluate for trends at each station using the residual or raw indicator data at a 95% confidence level for statistical significance.

Water quality constituents are frequently correlated with flow. During high-flow years, some constituents are typically higher (e.g., sediment) and others lower (e.g., temperature) than during low-flow years. As a result, year-to-year changes in an index could actually be attributable to variability in flow (natural or otherwise), rather than to changes in watershed conditions. Therefore, a second set of annual flow-adjusted WQI scores was calculated for long-term stations after removing variability in water quality constituents due to flow. This was done for each station by 1) determining the residuals from a hyperbolic regression of each constituent (raw data) with flow, 2) adding the mean of each constituent back to the residuals, and 3) calculating WQIs on the adjusted data. Flow-adjustments were done with WQHYDRO (Aroner, 2002) and Access. Note that while mean pre- and post-flow adjusted raw values were the same, the WQI scores calculated from those data will not necessarily have the same central tendencies.

An analysis of trends in monthly WQI scores calculated from data collected between 1992-2001 at the long-term stations was performed using WQHydro (Aroner, 2002). Trends were also performed on monthly scores adjusted for variability in flow, as described above. Reported probabilities include corrections for auto-correlation. Prior to adjusting for flow, statistically significant ($p < 0.05$) improving trends were indicated at four stations and declining trends at one station. Adjusting for flow increased the trend slope at nearly three quarters of the stations and resulted in improving trends at 9 stations and no declining trends. That is, trends in flow were apparently masking improving trends in water quality at most stations. Whether that is because flows were increasing or decreasing has not been evaluated and is station-specific, depending on which constituent(s) drive the WQI at a particular station. Some constituents are positively correlated with flow (e.g., sediment and nutrients) and some negatively (e.g., temperature and pH).

Trends of multiple stations can be evaluated together using a statistical method called meta-analysis (Reckhow et al. 1993). Stations can be grouped from various geographic regions or watershed land uses to draw a collective assessment of trend for each group. Stations were grouped according to their location in each ecological region as defined by the U.S. EPA (Omernick and Gallant, 1986). Results of the station trend test were used in meta-analysis to evaluate trends in indicators for each ecoregion and also on a statewide basis. A statistically significant improvement in water quality was observed statewide, with the greatest improvement in the Columbia Basin Ecoregion. Although, the trend is statistically significant, the magnitude of the trend is small amounting to only a 1.5 units change in the WQI scores over a 10 year period.

Table 2. Trend Analysis Data for WQI from 1992-2001.

Station	Location	Not Flow-adjusted		Adjusted for Flow	
		Slope	Probability (p)	Slope	Probability (p)
01A050	Nooksack R. @ Brennan	0.6255	0.4243	1.1787	0.1155
01A120	Nooksack R @ No Cedarville	0.3289	0.3172	0.6397	0.3353
03A060	Skagit R nr Mount Vernon	0.1595	0.1076	0.4365	0.0873
03B050	Samish R nr Burlington	0.7984	0.1647	0.3761	0.4271
04A100	Skagit R @ Marblemount	0.1216	0.6883	0.2191	0.2009
05A070	**Stillaguamish R nr Silvana**	0.1048	0.8098	**1.0394**	**0.0289**
05A090	SF Stillaguamish @ Arlington	-0.1231	0.6252	4.4290	0.2131
05A110	SF Stilly nr Granite Falls	0.2290	0.3421		
05B070	NF Stillaguamish @ Cicero	0.4066	0.1886	0.8345	0.1640
05B110	NF Stillaguamish nr Darrington	-0.4803	0.6579	-0.1144	0.8770
07A090	**Snohomish R @ Snohomish**	**0.2591**	**0.0363**	**0.4428**	**0.0071**
07C070	**Skykomish R @ Monroe**	0.1590	0.0679	**0.2560**	**0.0116**
07D050	Snoqualmie R nr Monroe	0.3633	0.2805	0.7795	0.0652
07D130	Snoqualmie R @ Snoqualmie	0.1173	0.0916	0.0962	0.4392
08C070	Cedar R @ Logan St/Renton	-0.0421	0.7558	-0.0197	0.8297
08C110	Cedar R nr Landsburg	0.0673	0.2725	0.0156	0.6137
09A080	Green R @ Tukwila	0.9447	0.0836	0.8805	0.1096
09A190	Green R @ Kanaskat	0.1030	0.1550	0.0872	0.1220
10A070	**Puyallup R @ Meridian St**	**1.4928**	**0.0102**	**1.7195**	**0.0112**
11A070	**Nisqually R @ Nisqually**	0.0425	0.7276	**0.6388**	**0.0267**
13A060	Deschutes R @ E St Bridge	-0.8074	0.2589	-0.7721	0.0870
16A070	**Skokomish R nr Potlatch**	**0.2208**	**0.0478**	**0.2873**	**0.0095**
16C090	Duckabush R nr Brinnon	0.0216	0.7585	0.0628	0.4817
18B070	Elwha R nr Port Angeles	0.1260	0.2181	0.1537	0.1077
20B070	Hoh R @ DNR Campground	0.0067	0.9705	0.3461	0.1092
22A070	**Humptulips R nr Humptulips**	0.0720	0.4929	**0.5351**	**0.0168**
23A070	Chehalis R @ Porter	-0.3493	0.4203	-0.6246	0.0879
23A160	Chehalis R @ Dryad	-0.0582	0.5866	0.2385	0.3648
24B090	Willapa R nr Willapa	0.7374	0.3083	0.3380	0.4836
24F070	Naselle R nr Naselle	0.0464	0.8695	0.3000	0.3168
26B070	Cowlitz R @ Kelso	-0.1572	0.7592	0.6765	0.1732
27B070	Kalama R nr Kalama	0.0213	0.9759	-0.8470	0.2202
27D090	EF Lewis R nr Dollar Corner	-0.0866	0.2379	-0.0263	0.6109
31A070	Columbia R @ Umatilla	0.0920	0.5548	0.1019	0.4820

Station	Location	Not Flow-adjusted		Adjusted for Flow	
		Slope	Probability (p)	Slope	Probability (p)
32A070	**Walla Walla R nr Touchet**	1.5411	0.0516	**1.6406**	**0.0163**
33A050	Snake R nr Pasco	0.2976	0.1792	0.3373	0.3034
34A070	Palouse R @ Hooper	0.0389	0.9552	0.1454	0.7486
34A170	**Palouse R @ Palouse**	0.1369	0.6192	**0.7530**	**0.0331**
34B110	**SF Palouse R @ Pullman**	**1.6408**	**0.0178**	1.4500	0.0681
35A150	Snake R @ Interstate Br	-0.1401	0.4771	-0.0038	0.9361
35B060	Tucannon R @ Powers	1.4140	0.1098	1.1226	0.1329
36A070	Columbia R nr Vernita	0.1690	0.3276	0.1771	0.3353
37A090	Yakima R @ Kiona	0.0324	0.9408	0.9192	0.1822
37A205	Yakima R @ Nob Hill	0.2708	0.3649	-0.6141	0.1469
39A090	Yakima R nr Cle Elum	0.0504	0.7652	-0.0920	0.7457
41A070	Crab Cr nr Beverly	-0.2443	0.6160	-0.3141	0.3822
45A070	Wenatchee R @ Wenatchee	-0.2428	0.1185	-0.2744	0.1437
45A110	Wenatchee R nr Leavenworth	-0.0367	0.7987	0.0859	0.5040
46A070	Entiat R nr Entiat	-0.0060	0.9110	0.0617	0.1696
48A070	**Methow R nr Pateros**	**-0.1824**	**0.0151**	-0.0736	0.2728
48A140	Methow R @ Twisp	-0.0413	0.1915	-0.0241	0.7618
49A070	Okanogan R @ Malott	0.0438	0.7836	0.2049	0.1175
49A190	Okanogan R @ Oroville	0.0765	0.7713	0.1537	0.4425
49B070	Similkameen R @ Oroville	0.0371	0.8192	0.0491	0.7333
53A070	Columbia R @ Grand Coulee	0.0781	0.1916	0.0645	0.2367
54A120	Spokane R @ Riverside SP	-0.3766	0.4001	0.5544	0.0728
55B070	Little Spokane R nr Mouth	-1.9217	0.0633	-0.8903	0.0635
56A070	Hangman Cr @ Mouth	0.2946	0.7460	0.0060	1.0000
57A150	Spokane R @ Stateline Br	0.0290	0.6291	-0.0744	0.3734
60A070	Kettle R nr Barstow	0.0948	0.7690	0.1198	0.5956
61A070	Columbia R @ Northport	0.1230	0.3502	0.3258	0.0777
62A150	Pend Oreille R @ Newport	-0.0236	0.8549	0.0854	0.7763

Positive slopes indicate improving conditions. Negative slopes indicate declining conditions
Bold indicates a significant trend at 95% confidence.

Table 3. Regional Trends in WQI.

Ecoregion	Number of Stations	Temperature		
		Regional Z score	Probability	Mean Change Last 10 years (WQI units)
Coast Range	7	0.9961	0.96	Not significant
Puget Lowlands	24	-2.3728	**<0.01**	1.9
Willamette Valley	1	-0.7131	1.00	Not significant
Cascades	3	1.1842	1.00	Not significant
Columbia Basin	22	-0.6497	**0.02**	2.4
Northern Rockies	5	-0.1665	0.42	Not significant
Statewide	62	-1.4060	**<0.01**	1.5

Bold indicates a statistically significant trend was found

Water Quality of Basin Stations

Basin stations are generally monitored for one year only (although they may be re-visited every five years) to collect current water quality information. The basin monitoring stations are selected to support Ecology's basin approach to water quality management and to address site-specific water quality issues. These stations are selected to support the waste discharge permitting process, TMDL assessments, site-specific needs, and to allow expanded coverage over a long-term network. Some basin stations are selected to target known problems and may not necessarily reflect general ambient conditions. Basin monitoring stations are typically monitored for one year to collect current water quality information. The current basin station monitoring program conducts monthly monitoring of twelve water quality constituents at approximately 20 stations across the state. During water year 2002, basin station sampling was focused in the following basins: Snake, Wenatchee, Nooksack/San Juan, and Western Olympics. Water quality data collected at the basin monitoring stations sampled in 2002 were assessed against the numeric criteria for the protection of aquatic life in Washington's Water Quality Standards.

Table 4. Ecology's Basin Monitoring Stations for Water Year 2002.

Station	Location	Indicators Not Meeting Water Quality Standards Established to Protect Aquatic Life
01A140	Nooksack R above the MF	None – all indicators met tested standards
01D080	Sumas R @ Jones Road	Dissolved oxygen
01F070	SF Nooksack @ Potter Rd	Temperature
01G070	MF Nooksack R	Mercury
01H070	Terrell Cr near Jackson Rd.	None – all indicators met tested standards
10A050	Puyallup R @ Puyallup	None – all indicators met tested standards
10C095	White River @ R Street	Temperature, pH
18A050	Dungeness R near Mouth	None – all indicators met tested standards
23A100	Chehalis R @ Prather Rd	Temperature
28G070	Gibbons Cr near Washougal	None – all indicators met tested standards
28H070	Campen Cr near Washougal	None – all indicators met tested standards
34A120	Palouse R at Colfax	Dissolved oxygen, Temperature, pH
34H070	Pleasant Valley Cr blw St John	Temperature, pH
35D070	Asotin Cr @ Asotin	Temperature, pH
35F110	Pataha Cr @ Rosy Grade	None – all indicators met tested standards
37E120	Wide Hollow Creek @ Randall Park	None – all indicators met tested standards
37G120	Ahtanum Cr @ 62nd Ave	None – all indicators met tested standards
38A050	Naches R @ Yakima on US HWY 97	None – all indicators met tested standards
38G120	Cowiche Cr @ Zimmerman rd	pH
39A050	Yakima R @ Harrison Bridge	pH
45C070	Chumstick Cr near Leavenworth	None – all indicators met tested standards
45E070	Mission Cr near Cashmere	None – all indicators met tested standards
62A090	Pend Oreille @ Metaline Falls	Temperature, pH

Continuous Temperature Measurements

In the summer of 2002, the Environmental Monitoring and Trends Section (EMTS) continued for a second year collecting temperature data at 30-minute intervals at most of our long-term ambient monitoring stations as well as some basin stations. Fifty-two sites were monitored in 2002. The purpose of this monitoring is to collect season-long diurnal temperature data that may be used for trend analyses and to determine compliance with current and proposed water quality standards.

Seasonal maximums and the maximum seven-day average of daily maximums were derived for the 52 (main document says 53, I think) stations monitored in 2002. The seasonal maximum at most stations (39) exceeded criteria established as the water quality standard. A new temperature criterion of 16˚C based on the maximum seven-day average of maximum daily measurements is being proposed as a water quality standard for most streams in Washington. Forty-five stations would have exceeded this criterion.

Table 5. Continuous Temperature Monitoring Summary for Water Year 2002.

Station	Location	Water Class	Maximum Temperature Measured		Maximum 7-day Mean of Maximum Daily Measurements	
			°C	Date[a]	°C	Date [a,b]
01A050	Nooksack R @ Brennan	A	17.1	2002-08-23	16.7	2002-08-26
01A120	Nooksack R @ No Cedarville	A	17.7	2002-08-14	17.3	2002-08-13
01A140	Nooksack R above the MF	A	15.9	2002-08-22	15.5	2002-08-12
01D080	**Sumas R @ Jones Road**	A	**19.7**	2002-07-24	18.2	2002-07-26
01F070	**SF Nooksack @ Potter Rd**	A	**21.1**	2002-08-14	20.0	2002-08-13
01G070	MF Nooksack R	AA	13.1	2002-07-25	12.4	2002-08-11
03B050	**Samish R nr Burlington**	A	**18.4**	2002-07-23	16.8	2002-08-13
04A100	Skagit R @ Marblemount	AA	13.2	2002-08-27	13.0	2002-08-26
05A070	**Stillaguamish R nr Silvana**	A	**21.7**	2002-08-14	20.9	2002-08-14
05A090	**SF Stillaguamish @ Arlington**	A	**21.7**	2002-08-14	20.9	2002-08-14
05A110	**SF Stillaguamish nr Granite Falls**	AA	**18.9**	2002-08-29	18.0	2002-08-27
05B070	**NF Stillaguamish @ Cicero**	A	**20.7**	2002-08-13	19.9	2002-08-13
05B110	NF Stillaguamish nr Darrington	A	17.3	2002-08-28	16.8	2002-08-13
07C070	**Skykomish R @ Monroe**	A	**18.8**	2002-08-14	18.3	2002-08-14
07D050	**Snoqualmie R nr Monroe**	A	**20.2**	2002-08-15	19.7	2002-08-15
07D130	**Snoqualmie R @ Snoqualmie**	A	**19.0**	2002-08-13	18.4	2002-08-14
08C070	**Cedar R @ Logan St/Renton**	A	**19.8**	2002-07-24	18.3	2002-08-14
08C110	Cedar R nr Landsburg	AA	14.4	2002-07-24	13.1	2002-07-25
09A080	**Green R @ Tukwila**	A	**21.4**	2002-08-14	20.7	2002-08-14
10A050	Puyallup R @ Puyallup	A	18.0	2002-08-09	17.5	2002-08-11
10C085	**White R nr Sumner**	A	**22.7**	2002-07-23	21.3	2002-07-21
10C095	**White River @ R Street**	A	**22.2**	2002-07-23	20.9	2002-07-21
10C115	**White R nr 274th Ave**	AA	**17.6**	2002-07-22	16.8	2002-07-23
10C135	**White R abv Rainier School WWTP**	AA	**17.4**	2002-07-25	16.8	2002-07-24
11A070	Nisqually R @ Nisqually	A	15.7	2002-07-23	15.3	2002-07-21

Station	Location	Water Class	Maximum Temperature Measured		Maximum 7-day Mean of Maximum Daily Measurements	
			ºC	Date[a]	ºC	Date [a,b]
13A060	**Deschutes R @ E St Bridge**	A	**20.0**	2002-07-23	19.1	2002-07-21
16A070	Skokomish R nr Potlatch	AA	15.4	2002-07-24	15.0	2002-07-21
16C090	Duckabush R nr Brinnon	AA	13.7	2002-08-14	13.2	2002-08-14
18A050	Dungeness R nr Mouth	A	17.8	2002-08-13	17.2	2002-08-13
18B070	Elwha R nr Port Angeles	AA	16.6	2002-09-13	16.3	2002-09-12
20B070	**Hoh R @ DNR Campground**	AA	**17.5**	2002-08-13	17.0	2002-08-12
22A070	**Humptulips R nr Humptulips**	A	**22.0**	2002-07-22	20.6	2002-08-14
23A070	**Chehalis R @ Porter**	A	**24.5**	2002-07-23	23.1	2002-07-22
24B090	**Willapa R nr Willapa**	A	**24.8**	2002-07-22	22.7	2002-07-23
24F070	**Naselle R nr Naselle**	A	**20.9**	2002-08-13	19.4	2002-08-15
26B070	**Cowlitz R @ Kelso**	A	**19.4**	2002-07-22	17.8	2002-08-11
27B070	**Kalama R nr Kalama**	A	**19.2**	2002-07-24	18.5	2002-07-22
27D090	**EF Lewis R nr Dollar Corner**	A	**25.0**	2002-08-13	23.9	2002-08-15
32A070	**Walla Walla R nr Touchet**	B	**30.7**	2002-07-13	28.3	2002-07-14
34A170	**Palouse R @ Palouse**	A	**30.5**	2002-07-13	29.1	2002-07-14
34B110	**SF Palouse R @ Pullman**	A	**25.1**	2002-07-13	23.8	2002-07-14
35B060	**Tucannon R @ Powers**	A	**27.5**	2002-07-12	26.1	2002-07-14
37A205	**Yakima R @ Nob Hill**	A	**21.3**	2002-07-13	20.0	2002-08-28
39A090	**Yakima R nr Cle Elum**	AA	**20.7**	2002-08-14	20.2	2002-08-15
41A070	**Crab Cr nr Beverly**	B	**30.5**	2002-07-13	28.6	2002-07-14
46A070	**Entiat R nr Entiat**	A	**22.3**	2002-08-14	20.9	2002-08-13
48A140	**Methow R @ Twisp**	A	**20.0**	2002-08-23	18.7	2002-08-25
49A190	**Okanogan R @ Oroville**	A	**27.7**	2002-07-13	26.7	2002-07-14
55B070	**Little Spokane R nr Mouth**	A	**19.1**	2002-07-12	18.4	2002-07-14
56A070	**Hangman Cr @ Mouth**	A	**33.2**	2002-07-10	27.8	2002-07-13
57A150	**Spokane R @ Stateline Br**	A	**23.6**	2002-08-28	23.0	2002-08-02
60A070	**Kettle R nr Barstow**	AA	**24.4**	2002-07-24	23.9	2002-07-24

[a] There may be other dates or other seven day periods with the same maximum.
[b] Date shown is middle of seven day period.
Bold indicates station exceeded the water quality standard criteria

Sanitary Conditions

Acceptable water quality for the support of swimming and shellfish harvesting is commonly determined by use of the indicator bacteria, fecal coliform. Since it is impossible to test for all pathogenic organisms, fecal coliform bacteria is used as an indicator of pollution. Fecal coliform originate from the intestinal tract of warm-blooded animals and their levels in water are relatively easy to measure. Because of this, water quality standards for fecal coliform have been promulgated to protect the beneficial water uses of swimming and shellfish harvesting.

Water quality data collected by Ecology show that standards over the past 5 years have not been met for fecal coliform at 8 of the core stream monitoring stations. The water quality standards for fecal coliform are based on statistical criteria of the data distribution. The standard has two criteria based on the geometric mean and the 10th percentile. Data collected from each station must be assessed for compliance using the distribution of the data. Also, any evaluation of the reduction in fecal coliform needed to comply with standards must take into account this site-specific distribution so that both criteria are met.

One approach to determine the amount of reduction need in fecal coliform levels is use of the Statistical Rollback Method (Ott, 1995). This approach can be used to evaluate the distribution of the existing data against the two fecal coliform criteria of the water quality standards. Sixty-three of Ecology's stream stations had data on fecal coliform that cover the last 5 years (1996 – 2000). Only eight of the stations evaluated violated the water quality standards over this period. Of these stations, most exceeded the 10^{th} percentile criterion, but not the geometric mean criterion. The Statistical Rollback Method was applied to these data and the percent reduction in fecal coliform levels needed to meet the standards was derived. These reductions are based on the assumption that the distribution will not change when fecal coliform levels are reduced. This information on the amount of fecal coliform loading that needs to be reduced may help decide where pollution control efforts should be targeted.

Table 6. Fecal Coliform Levels Sampled in Water Year 2002 and the Percent Reductions Required to Meet Water Quality Standards.

Station	Location	Water Class	Geometric Mean (cfu/100mL)	90th Percentile (cfu/100mL)	Percent Reduction Required
01A050	Nooksack R @ Brennan	A	27	58	0
01A120	Nooksack R @ No Cedarville	A	8	97	0
01A140	Nooksack R above the MF	A	4	39	0
01D080	Sumas R @ Jones Road	A	135	486	14%
01F070	SF Nooksack @ Potter Rd	A	6	88	0
01G070	MF Nooksack R	AA	4	36	0
01H070	Terrell Cr nr Jackson Rd.	AA	14	82	0
03A060	Skagit R nr Mount Vernon	A	13	170	0
03B050	Samish R nr Burlington	A	84	974	23%
04A100	Skagit R @ Marblemount	AA	3	14	0
05A070	Stillaguamish R nr Silvana	A	31	219	2%
05A090	SF Stillaguamish @ Arlington	A	32	199	0
05A110	SF Stillaguamish nr Granite Falls	AA	4	14	0
05B070	NF Stillaguamish @ Cicero	A	18	120	0
05B110	NF Stillaguamish nr Darrington	A	13	69	0
07A090	Snohomish R @ Snohomish	A	14	33	0
07C070	Skykomish R @ Monroe	A	3	13	0
07D050	Snoqualmie R nr Monroe	A	20	67	0
07D130	Snoqualmie R @ Snoqualmie	A	7	38	0
08C070	Cedar R @ Logan St/Renton	A	30	343	9%
08C110	Cedar R nr Landsburg	AA	2	7	0
09A080	Green R @ Tukwila	A	56	250	4%
09A190	Green R @ Kanaskat	AA	5	19	0
10A050	Puyallup R @ Puyallup	A	68	238	3%
10A070	Puyallup R @ Meridian St	A	57	212	1%
10C095	White River @ R Street	A	62	749	20%
11A070	Nisqually R @ Nisqually	A	9	28	0
13A060	Deschutes R @ E St Bridge	A	23	101	0
16A070	Skokomish R nr Potlatch	AA	5	24	0
16C090	Duckabush R nr Brinnon	AA	3	14	0
18A050	Dungeness R nr Mouth	A	16	50	0
18B070	Elwha R nr Port Angeles	AA	1	1	0
20B070	Hoh R @ DNR Campground	AA	3	8	0
22A070	Humptulips R nr Humptulips	A	6	16	0
23A070	Chehalis R @ Porter	A	23	95	0
23A100	Chehalis R @ Prather Rd	A	17	86	0
23A160	Chehalis R @ Dryad	A	28	321	8%
24B090	Willapa R nr Willapa	A	63	500	15%
24F070	Naselle R nr Naselle	A	33	154	0
26B070	Cowlitz R @ Kelso	A	19	67	0
27B070	Kalama R nr Kalama	A	22	69	0

Station	Location	Water Class	Geometric Mean (cfu/100mL)	90th Percentile (cfu/100mL)	Percent Reduction Required
27D090	EF Lewis R nr Dollar Corner	A	37	314	8%
28G070	Gibbons Cr nr Washougal	A	119	874	21%
28H070	Campen Cr nr Washougal	A	158	931	22%
31A070	Columbia R @ Umatilla	A	2	5	0
32A070	Walla Walla R nr Touchet	B	48	166	0
33A050	Snake R nr Pasco	A	2	10	0
34A070	Palouse R @ Hooper	B	34	117	0
34A120	Palouse R at Colfax	A	37	313	8%
34A170	Palouse R @ Palouse	A	46	138	0
34B110	SF Palouse R @ Pullman	A	133	656	18%
34H070	Pleasant Valley Cr blw St John	A	43	342	9%
35A150	Snake R @ Interstate Br	A	3	14	0
35B060	Tucannon R @ Powers	A	81	257	5%
35D070	Asotin Cr @ Asotin	A	45	193	0
35F110	Pataha Cr @ Rosy Grade	A	104	493	15%
36A070	Columbia R nr Vernita	A	1	1	0
37A090	Yakima R @ Kiona	A	11	45	0
37A205	Yakima R @ Nob Hill	A	11	47	0
37E120	Wide Hollow Creek @ Randall Park	A	321	1720	29%
37G120	Ahtanum Cr @ 62nd Ave	A	139	413	12%
38A050	Naches R @ Yakima on US HWY 97 [a]	A	3	9	0
38G120	Cowiche Cr @ Zimmerman rd	A	173	1837	29%
39A050	Yakima R @ Harrison Bridge [a]	A	2	6	0
39A090	Yakima R nr Cle Elum	AA	2	7	0
41A070	Crab Cr nr Beverly	B	55	195	0
45A070	Wenatchee R @ Wenatchee	A	8	24	0
45A110	Wenatchee R nr Leavenworth	AA	3	8	0
45C070	Chumstick Cr nr Leavenworth [b]	A	17	215	1%
45E070	Mission Cr nr Cashmere [b]	A	167	1135	25%
46A070	Entiat R nr Entiat	A	3	13	0
48A070	Methow R nr Pateros	A	2	7	0
48A140	Methow R @ Twisp	A	2	6	0
49A070	Okanogan R @ Malott	A	6	33	0
49A190	Okanogan R @ Oroville	A	2	9	0
49B070	Similkameen R @ Oroville	A	3	28	0
53A070	Columbia R @ Grand Coulee	A	1	1	0
54A120	Spokane R @ Riverside State Pk	A	11	52	0
55B070	Little Spokane R nr Mouth	A	37	97	0
56A070	Hangman Cr @ Mouth	A	30	116	0
57A150	Spokane R @ Stateline Br	A	5	20	0
60A070	Kettle R nr Barstow	AA	2	7	0
61A070	Columbia R @ Northport	AA	5	53	0
62A090	Pend Oreille @ Metaline Falls	A	1	2	0
62A150	Pend Oreille R @ Newport	A	1	3	0

Biological Health

A biological model was developed that predicts expected aquatic macroinvertebrate community composition for streams in Western Washington (Hawkins *et al*., 2000). The model (River Invertebrate Prediction and Classification System; RIVPACS) is constructed from biological, physical, and chemical information collected at over one-hundred reference sites throughout Western Washington.

Physicochemical variables that describe stream setting and that are highly correlated with the assortment of species located in that setting are the basis for evaluating sites suspected to have suffered some level of degradation (Armitage *et al*., 1983; Clarke *et al*., 1996). The direct comparison of a site score with that expected from model predictions describes the probability that the "candidate" site belongs to the reference condition. The expression "O/E", observed over expected site scores, are some fraction of identical community expectations which would be "1.00" for mean reference conditions.

The model built for Western Washington streams considers "O/E" scores of 0.86 (or 86% similarity) and greater to be identical to "reference" conditions and have no apparent signs of degradation. "O/E" scores smaller than 0.86 are considered to have impaired biological health. The RIVPACS model performance parameters show a standard deviation of reference site scores of 0.14 (i.e., scores of 86% or higher are considered reference), the taxa must be present in at least 50 percent of reference sites to be included in calculating the expected score for a site (i.e., the probability of capture for individual taxa is greater than 0.50), and the taxa included in the model are based on a 300-count Sub-sample routine. The site scores presented are derived from data collected from Western Washington streams that have been evaluated based on the RIVPACS model (Wright *et al*., 1993).

Table 7. Observed vs. Expected Aquatic Macroinvertebrate Community Compositions Measured Since 1992.

wria	county	site_name	date	latitude	longitude	O/E
01	Whatcom	Austin Cr	09/14/2000	48.700	122.333	0.94
01	Whatcom	Bertrand Cr @ Bertheusen Park	09/10/1998	48.963	122.507	0.78
01	Whatcom	Breckenridge Cr blw South Pass Rd	09/12/1996	48.928	122.266	0.92
01	Whatcom	California Cr at Bruce Rd	09/17/1996	48.908	122.643	0.23
01	Whatcom	Chuckanut Cr @ Aroyo Park	09/09/1998	48.703	122.484	0.94
01	Whatcom	Chuckanut Cr @ Aroyo Park	09/15/1999	48.703	122.484	1.02
01	Whatcom	Deer Cr @ Deer Creek Drive	09/10/1998	48.845	122.545	0.86
01	Whatcom	Deer Cr @ Deer Creek Drive	09/15/1999	48.845	122.545	1.02
01	Whatcom	Hutchinson Cr at DNR campground	09/10/1996	48.720	122.157	0.83
01	Whatcom	North Fork Dakota Cr at Stein Rd	09/17/1996	48.963	122.629	0.47
01	Whatcom	Padden Cr at Fairhaven Park	09/12/1996	48.712	122.493	1.02
01	Whatcom	Padden Cr at Lake Padden Park	09/09/1996	48.705	122.465	0.47
01	Whatcom	Racehorse Cr	09/10/1996	48.886	122.133	0.52
01	Whatcom	Smith Cr at Cedarville Br	09/10/1996	48.844	122.278	0.57
01	Whatcom	Squalicum Cr at Cornwall Park	09/11/1996	48.776	122.486	0.70
01	Whatcom	Sumas River blw Swift Cr	09/12/1996	48.919	122.313	0.32
01	Whatcom	Thompson Cr nr mouth	09/16/1996	48.880	121.909	1.00
01	Whatcom	Upper Padden Cr	09/10/1998	48.707	122.467	0.94
01	Whatcom	Whatcom Cr blw Whatcom Falls	09/11/1998	48.755	122.428	0.55
03	Skagit	OToole Cr @ Skagit Valley Highway	09/09/1998	48.511	121.919	1.05
03	Skagit	OToole Cr @ Skagit Valley Highway	09/15/1999	48.511	121.919	0.85
03	Skagit	Samish R	09/15/1995	48.553	122.288	0.51
04	Skagit	Diobsud Cr	09/14/1995	48.561	121.415	0.81
04	Skagit	Diobsud Cr	09/14/2000	48.561	121.415	0.93
04	Skagit	Finney Cr	09/12/1995	48.512	121.822	0.56
04	Skagit	Illabot Cr	09/12/1995	48.482	121.501	0.56
04	Skagit	Jackman Cr	09/13/1995	48.524	121.713	0.56
04	Skagit	Pressentin Cr nr mouth	09/09/1998	48.518	121.850	0.81
04	Whatcom	Bacon Creek	09/13/2000	48.650	121.410	0.98
05	Skagit	Little Deer Cr nr Mouth	08/02/2001	48.388	121.869	0.93
05	Skagit	N. Fork Stillaguamish R @ RM39	07/30/2001	48.353	121.618	0.93
05	Snohomish	Armstrong Cr	09/04/2001	48.217	122.136	0.72
05	Snohomish	Boulder Cr @ Highway 530	07/31/2001	48.281	121.781	0.86
05	Snohomish	Canyon Cr	09/04/2001	48.115	121.961	1.04
05	Snohomish	Deer Cr @ RM 0.5	09/20/1995	48.272	121.930	0.48
05	Snohomish	Deer Cr @ RM 1.0	07/31/2001	48.277	121.929	0.86
05	Snohomish	Grant Cr	09/20/1995	48.272	122.014	0.59
05	Snohomish	Jim Cr	09/19/1995	48.223	121.958	0.69
05	Snohomish	Jim Cr	09/14/1999	48.223	121.958	0.88
05	Snohomish	Jim Cr @ Naval Station	08/20/2001	48.218	121.942	0.95
05	Snohomish	Jim Cr nr Mouth	08/03/2001	48.184	122.075	1.04
05	Snohomish	Jim Cr nr Mouth	08/20/2001	48.184	122.075	0.93
05	Snohomish	Long Cr	09/19/1995	48.078	121.688	0.81

wria	county	site_name	date	latitude	longitude	O/E
05	Snohomish	N. Fork Stillaguamish R @ Hazel	08/01/2001	48.278	121.806	0.95
05	Snohomish	Pilchuck Cr @ Hi-Way 9	09/06/2001	48.263	122.167	1.01
05	Snohomish	Pilchuck Cr @ I-5	09/06/2001	48.216	122.215	0.84
05	Snohomish	Portage Cr 1	09/18/1995	48.184	122.138	0.42
05	Snohomish	Portage Cr 2	09/05/2001	48.182	122.148	0.84
05	Snohomish	Portage Cr 3	09/05/2001	48.179	122.122	0.92
05	Snohomish	Squire Cr nr Mouth	07/31/2001	48.273	121.677	0.61
07	King	Griffin Cr @ Trestle (Waterway 2000)	09/08/1998	47.616	121.903	1.12
07	King	Griffin Cr @ Trestle (Waterway 2000)	09/13/1999	47.616	121.903	1.20
07	King	Harris Creek	09/13/1999	47.691	121.901	1.12
07	Snohomish	Catherine Cr nr mouth	09/16/1997	48.008	122.046	0.96
07	Snohomish	Little Pilchuck Cr	09/16/1997	48.009	122.045	0.88
07	Snohomish	Woods Cr abv Woods Cr Rd.	09/16/1997	47.953	121.887	0.96
07	Snohomish	Woods Cr abv Woods Cr Rd.	09/08/1998	47.953	121.887	1.20
07	Snohomish	Woods Cr abv Woods Cr Rd.	09/13/1999	47.953	121.887	1.04
07	Snohomish	Woods Cr at Calhoun Rd	09/17/1997	47.860	121.959	0.96
08	King	Bear Creek-Little	08/12/1999	47.756	122.167	0.73
08	King	Big Bear Creek	09/14/1999	47.756	122.055	0.80
08	King	Carey Creek	08/20/1998	47.426	121.974	1.04
08	King	Carey Creek	08/17/1999	47.426	121.974	0.88
08	King	Holder Cr nr Hobart	08/20/1998	47.435	121.972	1.04
08	King	Rock Cr abv Summit-Landsberg Rd	09/09/1999	47.365	122.012	0.88
08	King	Swamp Creek @ Bothel Way	08/12/1999	47.754	122.233	0.76
08	King	Taylor Cr	10/13/1994	47.384	121.847	0.66
09	King	Big Soos Cr at 208th St	09/04/1997	47.417	122.157	0.48
09	King	Covington Cr	10/11/1994	47.317	122.117	1.20
09	King	Covington Cr	08/20/1998	47.317	122.117	1.21
09	King	Covington Cr	08/18/1999	47.317	122.117	1.21
09	King	Green R at Kanasket	09/29/1994	47.319	121.892	0.90
09	King	McSorley Creek @ Saltwater St. Park	08/17/1999	47.374	122.321	0.76
09	King	Newaukum Cr at 212th St	09/03/1997	47.274	122.054	0.96
09	King	Newaukum Creek	08/18/1999	47.283	122.065	0.96
10	Pierce	Clearwater R	09/05/1997	47.129	121.802	0.76
10	Pierce	Huckleberry Cr (WRIA 10)	09/05/1997	47.077	121.587	0.90
10	Pierce	Hylebos Creek	08/16/1999	47.248	122.344	0.25
10	Pierce	Wapato Cr at Freeman Rd	09/04/1997	47.226	122.319	0.42
10	Pierce	Wapato Creek @ Freeman Rd	08/16/1999	47.226	122.319	0.34
11	Pierce	Elbe Site (unnamed)	09/01/1994	46.771	122.065	0.94
11	Pierce	Twentyfivemile Cr	09/18/1997	46.927	122.256	0.74
12	Pierce	Chambers Cr at Steilacoom Lake	09/18/1997	47.177	122.535	0.32
15	Kitsap	Chico Creek	08/19/1999	47.587	122.714	0.70
15	Kitsap	Dewatto River	08/19/1998	47.524	122.957	1.05
15	Kitsap	Little Anderson Cr	08/19/1999	47.567	122.962	0.68
15	Kitsap	Seabeck Cr nr mouth	09/15/1994	47.623	122.838	0.78
15	Kitsap	Seabeck Cr nr mouth	08/19/1998	47.623	122.838	1.05

wria	county	site_name	date	latitude	longitude	O/E
15	Kitsap	Seabeck Cr nr mouth	09/10/1999	47.623	122.838	0.70
15	Mason	Tahuya R	09/15/1994	47.515	122.881	0.60
15	Mason	Tahuya R	08/19/1998	47.515	122.881	0.97
15	Mason	Upper Tahuya R	09/10/1999	47.516	122.880	0.83
16	Mason	Duckabush River	09/19/1994	47.682	123.019	0.84
16	Mason	Duckabush River	10/12/2000	47.682	123.019	0.89
16	Mason	Duckabush River	08/15/2001	47.682	123.019	1.18
18	Clallam	Dungeness R	09/19/1994	48.021	123.134	0.82
18	Clallam	Siebert Cr blw SR101	09/21/1994	48.109	123.278	1.04
18	Clallam	South Branch Little R	09/20/1994	48.053	123.502	0.62
18	Clallam	South Branch Little R	09/12/2000	48.053	123.502	0.42
18	Clallam	South Branch Little R	08/16/2001	48.053	123.502	0.97
19	Clallam	Lyre R at DNR Campground	09/20/1994	48.153	123.832	0.77
22	Grays Harbor	Cook Cr nr mouth	08/18/1998	47.070	123.474	1.05
22	Grays Harbor	Cook Cr nr mouth	09/09/1999	47.070	123.474	1.04
23	Grays Harbor	Appletree Creek	09/11/2000	46.881	123.224	1.14
23	Grays Harbor	Cedar River @ Cedar Falls	09/08/1999	46.881	123.224	0.91
23	Grays Harbor	Porter Creek	08/18/1998	46.976	123.274	1.10
23	Grays Harbor	Porter Creek	09/08/1999	46.976	123.274	0.77
23	Grays Harbor	Porter Creek	08/14/2001	46.976	123.274	1.12
23	Lewis	N. Fork Newaukum R @ Watershed Bndry	08/17/1998	46.683	122.738	0.86
23	Lewis	Stillman Cr nr Boistfort	08/17/1998	46.528	123.147	0.96
23	Lewis	Stillman Cr nr Boistfort	09/27/2000	46.528	123.147	0.96
23	Lewis	Stillman Cr nr Boistfort	09/14/2001	46.528	123.147	1.00
23	Thurston	Monroe Creek	08/18/1998	46.933	123.136	1.20
23	Thurston	Monroe Creek	09/08/1999	46.933	123.136	0.69
24	Wahkiakum	Ellsworth Cr	09/12/2001	46.393	123.884	1.09
26	Lewis	Butter Creek at FR5290	08/27/1993	46.628	121.664	0.74
26	Lewis	Ohanapecosh R	08/27/1993	46.757	121.556	0.73
26	Lewis	Simmons Cr	09/13/1993	46.531	122.331	0.84
26	Lewis	Simmons Cr	08/31/1994	46.531	122.331	0.84
29	Skamania	Bear Cr nr Carson	10/04/2000	45.787	121.802	1.01
29	Skamania	Bear Cr nr Carson	09/11/2001	45.787	121.802	1.18
29	Skamania	Trapper Cr at Trapper Cr Wilderness	08/16/1993	45.895	122.013	0.76
29	Skamania	Trapper Cr at Trapper Cr Wilderness	10/05/2000	45.895	122.013	1.14
29	Skamania	Trapper Cr at Trapper Cr Wilderness	09/11/2001	45.895	122.013	1.18

Aquatic Weeds

The Washington Department of Ecology has been collecting information on aquatic plants from lakes and rivers throughout the state since 1994. The main objective of this program is to inventory and monitor the spread of invasive exotic (non-native) aquatic plant species through the state. Other goals of the program are to provide technical assistance on aquatic plant identification and control of invasive species, and to conduct special projects evaluating the impacts of invasive non-native species and their control.

For most lakes the method used is to circumnavigate the littoral zone in a small boat. When a different plant or type of habitat is observed, samples are collected for identification. Notes on species distribution, abundance, and maximum depth of growth are made. In addition secchi depth and alkalinity data are collected.

This report identifies lakes where invasive exotic aquatic plants were discovered throughout the state since 1994. In addition, the type of aquatic plant found is identified by its common name.

Table 8. Location of Invasive Exotic Aquatic Weeds Identified.

County	Waterbody Name	Scientific name	Common name	Location
Adams	Hutchinson Lake	Myriophyllum spicatum	Eurasian water-milfoil	16N-28E-15
Chelan	Chelan Lake	Myriophyllum spicatum	Eurasian water-milfoil	27N-22E-13
Chelan	Cortez (Three) Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-21E-29
Chelan	Domke Lake	Myriophyllum spicatum	Eurasian water-milfoil	31N-18E-22
Chelan	Roses (Alkali) Lake	Myriophyllum spicatum	Eurasian water-milfoil	28N-21E-26
Chelan	Wapato Lake	Myriophyllum spicatum	Eurasian water-milfoil	28N-21E-23
Clallam	Sutherland Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-08W-22
Clallam	Unnamed Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-04W-17
Clark	Battleground Lake	Egeria densa	Brazilian elodea	04N-03E-30
Clark	Caterpillar Slough	Myriophyllum spicatum	Eurasian water-milfoil	03N-01W-36
Clark	Columbia River at Ridgefield	Myriophyllum spicatum	Eurasian water-milfoil	04N-01W-24
Clark	Klineline Pond	Egeria densa	Brazilian elodea	03N-01E-26
Clark	Lacamas Lake	Egeria densa	Brazilian elodea	01N-03E-02
Clatsop	Columbia River at Astoria	Myriophyllum spicatum	Eurasian water-milfoil	08N-08W-18
Columbia	Snake River at Little Goose Dam	Myriophyllum spicatum	Eurasian water-milfoil	13N-38E-26
Columbia	Snake River near Lyons Ferry	Myriophyllum spicatum	Eurasian water-milfoil	13N-37E-30
Cowlitz	Kress Lake	Myriophyllum spicatum	Eurasian water-milfoil	07N-01W-31
Cowlitz	Silver Lake	Egeria densa	Brazilian elodea	10N-01W-36
Cowlitz	Solo Slough	Cabomba caroliniana	fanwort	08N-03W-14
Cowlitz	Solo Slough	Egeria densa	Brazilian elodea	08N-03W-14
Cowlitz	Solo Slough	Ludwigia hexapetala	water primrose	08N-03W-14
Cowlitz	Solo Slough	Myriophyllum aquaticum	parrotfeather	08N-03W-14

County	Waterbody Name	Scientific name	Common name	Location
Cowlitz	Willow Grove Slough	Cabomba caroliniana	fanwort	08N-03W-14
Cowlitz	Willow Grove Slough	Egeria densa	Brazilian elodea	08N-03W-14
Cowlitz	Willow Grove Slough	Myriophyllum spicatum	Eurasian water-milfoil	08N-03W-14
Franklin	Scooteney Reservoir	Myriophyllum spicatum	Eurasian water-milfoil	14N-30E-27
Franklin	Snake River at Ice Harbor Dam	Myriophyllum spicatum	Eurasian water-milfoil	09N-31E-24
Franklin	Snake River at Lower Monumental Dam	Myriophyllum spicatum	Eurasian water-milfoil	13N-34E-34
Franklin	Snake River at Lyons Ferry	Myriophyllum spicatum	Eurasian water-milfoil	13N-37E-19
Grant	Babcock Ridge Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-23E-10
Grant	Banks Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-28E-33
Grant	Billy Clapp Lake	Myriophyllum spicatum	Eurasian water-milfoil	23N-28E-36
Grant	Burke Lake	Myriophyllum spicatum	Eurasian water-milfoil	19N-23E-23
Grant	Caliche Lake	Myriophyllum spicatum	Eurasian water-milfoil	18N-23E-22
Grant	Evergreen Lake	Myriophyllum spicatum	Eurasian water-milfoil	19N-23E-22
Grant	Moses Lake	Myriophyllum spicatum	Eurasian water-milfoil	18N-28E-09
Grant	Potholes Reservoir	Myriophyllum spicatum	Eurasian water-milfoil	17N-28E-11
Grant	Priest Rapids Lake	Myriophyllum spicatum	Eurasian water-milfoil	14N-23E-16
Grant	Red Rock Lake	Myriophyllum spicatum	Eurasian water-milfoil	16N-26E-17
Grant	Stan Coffin Lake	Myriophyllum spicatum	Eurasian water-milfoil	19N-23E-10
Grant	Winchester Wasteway	Myriophyllum spicatum	Eurasian water-milfoil	19N-25E-25
Grant	Winchester Wasteway Ext.	Myriophyllum spicatum	Eurasian water-milfoil	18N-26E-25
Grays Harbor	Chehalis River	Myriophyllum aquaticum	parrotfeather	17N-06W-02
Grays Harbor	Connor Creek	Myriophyllum spicatum	Eurasian water-milfoil	18N-12W-03
Grays Harbor	Duck Lake	Egeria densa	Brazilian elodea	17N-12W-14
Grays Harbor	Duck Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-12W-14
Island	Goss Lake	Myriophyllum spicatum	Eurasian water-milfoil	29N-03E-06
Island	Unnamed Pond	Egeria densa	Brazilian elodea	30N-03E-32
Island	Unnamed Pond	Myriophyllum aquaticum	parrotfeather	32N-02E-35
Jefferson	Leland Lake	Egeria densa	Brazilian elodea	28N-02W-26
King	Bass Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-06E-02
King	Desire Lake	Myriophyllum spicatum	Eurasian water-milfoil	23N-05E-36
King	Dolloff Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-04E-10
King	Fenwick Lake	Egeria densa	Brazilian elodea	22N-04E-26
King	Green Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-04E-05
King	Lucerne Lake	Hydrilla verticillata	hydrilla	22N-06E-28
King	Lucerne Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-06E-28
King	Meridian Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-05E-27
King	Neilson (Holm) Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-05E-14
King	Number Twelve Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-06E-12
King	Otter (Spring) Lake	Myriophyllum spicatum	Eurasian water-milfoil	23N-06E-31
King	Phantom Lake	Myriophyllum spicatum	Eurasian water-milfoil	24N-05E-02
King	Pipe Lake	Hydrilla verticillata	hydrilla	22N-06E-28
King	Pipe Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-06E-28

County	Waterbody Name	Scientific name	Common name	Location
King	Sammamish Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-04E-13
King	Sawyer Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-06E-04
King	Shadow Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-06E-07
King	Shady Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-05E-01
King	Ship Canal	Myriophyllum spicatum	Eurasian water-milfoil	25N-3E-13
King	Star Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-04E-34
King	Steel Lake	Myriophyllum spicatum	Eurasian water-milfoil	21N-04E-09
King	Union Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-04E-19
King	Unnamed Pond	Myriophyllum aquaticum	parrotfeather	24N-05E-11
King	Washington Lake	Egeria densa	Brazilian elodea	25N-04E-16
King	Washington Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-04E-16
King	Wilderness Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-06E-27
Kitsap	Long Lake	Egeria densa	Brazilian elodea	23N-02E-17
Kitsap	Long Lake	Myriophyllum spicatum	Eurasian water-milfoil	23N-02E-17
Kittitas	Fiorito Ponds	Myriophyllum spicatum	Eurasian water-milfoil	17N-19E-30
Kittitas	Lavender Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-14E-20
Kittitas	Mattoon Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-18E-11
Kittitas	Private Pond (20N-16E-10)	Myriophyllum spicatum	Eurasian water-milfoil	20N-16E-10
Klickitat	Columbia River at Bingen	Myriophyllum spicatum	Eurasian water-milfoil	03N-11E-32
Klickitat	Columbia River at Maryhill	Myriophyllum spicatum	Eurasian water-milfoil	02N-15E-14
Klickitat	Horsethief Lake	Myriophyllum spicatum	Eurasian water-milfoil	02N-14E-19
Lewis	Carlisle Lake	Myriophyllum spicatum	Eurasian water-milfoil	13N-01E-30
Lewis	Chehalis River	Egeria densa	Brazilian elodea	14N-03W-02
Lewis	Chehalis River	Myriophyllum aquaticum	parrotfeather	14N-03W-02
Lewis	Cowlitz River near Blue Cr	Myriophyllum spicatum	Eurasian water-milfoil	11N-01E-01
Lewis	Interstate Ave Slough	Myriophyllum aquaticum	parrotfeather	14N-02W-32
Lewis	Mayfield Reservoir	Myriophyllum spicatum	Eurasian water-milfoil	12N-02E-29
Lewis	Plummer Lake	Egeria densa	Brazilian elodea	14N-02W-07
Lewis	Riffe Lake	Myriophyllum spicatum	Eurasian water-milfoil	12N-03E-10
Lewis	South County Park Pond	Myriophyllum spicatum	Eurasian water-milfoil	11N-01W-17
Lewis	Swofford Pond	Myriophyllum spicatum	Eurasian water-milfoil	12N-03E-26
Mason	Island Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-03W-06
Mason	Limerick Lake	Egeria densa	Brazilian elodea	21N-03W-27
Mason	Mason Lake	Myriophyllum spicatum	Eurasian water-milfoil	22N-02W-34
Okanogan	Conconully (Salmon) Lake	Myriophyllum spicatum	Eurasian water-milfoil	35N-25E-06
Okanogan	Conconully Reservoir	Myriophyllum spicatum	Eurasian water-milfoil	35N-25E-18
Okanogan	Osoyoos Lake	Myriophyllum spicatum	Eurasian water-milfoil	40N-27E-22
Okanogan	Palmer Lake	Myriophyllum spicatum	Eurasian water-milfoil	39N-25E-11
Okanogan	Whitestone Lake	Myriophyllum spicatum	Eurasian water-milfoil	38N-27E-17
Pacific	Black Lake	Egeria densa	Brazilian elodea	10N-11W-28
Pacific	Black Lake	Myriophyllum spicatum	Eurasian water-milfoil	10N-11W-28

County	Waterbody Name	Scientific name	Common name	Location
Pacific	Loomis Lake	Egeria densa	Brazilian elodea	11N-11W-21
Pacific	Loomis Lake	Myriophyllum spicatum	Eurasian water-milfoil	11N-11W-21
Pacific	Sloughs near Long Beach	Myriophyllum aquaticum	parrotfeather	10N-11W
Pend Oreille	Davis Lake	Myriophyllum spicatum	Eurasian water-milfoil	32N-44E-31
Pend Oreille	Diamond Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-44E-03
Pend Oreille	Fan Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-43E-32
Pend Oreille	Horseshoe Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-43E-08
Pend Oreille	Little Spokane River	Myriophyllum spicatum	Eurasian water-milfoil	56N-43E-34
Pend Oreille	Marshall Lake	Myriophyllum spicatum	Eurasian water-milfoil	32N-45E-23
Pend Oreille	Nile Lake	Myriophyllum spicatum	Eurasian water-milfoil	37N-42E-35
Pend Oreille	Pend Oreille River	Myriophyllum spicatum	Eurasian water-milfoil	38N-43E-32
Pend Oreille	Sacheen Lake	Myriophyllum spicatum	Eurasian water-milfoil	31N-43E-35
Pierce	Clear Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-04E-27
Pierce	Harts Lake	Myriophyllum spicatum	Eurasian water-milfoil	16N-03E-07
Pierce	Hidden Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-05E-20
Pierce	Ohop Lake	Egeria densa	Brazilian elodea	16N-04E-10
Pierce	Slough, Port of Tacoma	Myriophyllum aquaticum	parrotfeather	20N-03E-02
Pierce	Tapps Lake	Myriophyllum spicatum	Eurasian water-milfoil	20N-05E-08
Skagit	Beaver Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-05E-07
Skagit	Big Lake	Egeria densa	Brazilian elodea	34N-04E-36
Skagit	Big Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-04E-36
Skagit	Campbell Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-01E-13
Skagit	Clear Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-05E-07
Skagit	Erie Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-01E-11
Skagit	Heart Lake	Myriophyllum spicatum	Eurasian water-milfoil	35N-01E-36
Skagit	McMurray Lake	Myriophyllum spicatum	Eurasian water-milfoil	33N-05E-30
Skagit	Sixteen Lake	Myriophyllum spicatum	Eurasian water-milfoil	33N-04E-15
Skamania	Drano Lake	Myriophyllum spicatum	Eurasian water-milfoil	03N-09E-26
Skamania	Coldwater Lake	Myriophyllum spicatum	Eurasian water-milfoil	10N-05E-31
Snohomish	Goodwin Lake	Myriophyllum spicatum	Eurasian water-milfoil	31N-04E-33
Snohomish	Meadow Lake	Hydrocharis morsus-ranae	European frog-bit	28N-07E-18
Snohomish	Nina Lake	Myriophyllum aquaticum	parrotfeather	31N-05E-32
Snohomish	Roesiger Lake	Myriophyllum spicatum	Eurasian water-milfoil	29N-07E-28
Snohomish	Shoecraft Lake	Myriophyllum spicatum	Eurasian water-milfoil	31N-04E-33
Snohomish	Silver Lake	Myriophyllum spicatum	Eurasian water-milfoil	28N-05E-30
Snohomish	Stevens Lake	Myriophyllum spicatum	Eurasian water-milfoil	29N-06E-08
Snohomish	Swartz Lake	Egeria densa	Brazilian elodea	30N-07E-20
Spokane	Eloika Lake	Myriophyllum spicatum	Eurasian water-milfoil	29N-43E-15
Spokane	Liberty Lake	Myriophyllum spicatum	Eurasian water-milfoil	25N-42E-22
Spokane	Long Lake (Reservoir)	Myriophyllum spicatum	Eurasian water-milfoil	27N-39E-13
Spokane	Long Lake (Reservoir)	Nymphoides peltata	water fringe	27N-39E-13
Spokane	Newman Lake	Myriophyllum spicatum	Eurasian water-milfoil	26N-42E-10
Spokane	North Silver Lake	Myriophyllum spicatum	Eurasian water-milfoil	24N-41E-17
Spokane	Silver Lake	Myriophyllum spicatum	Eurasian water-milfoil	24N-41E-32

County	Waterbody Name	Scientific name	Common name	Location
Stevens	Black Lake	Myriophyllum spicatum	Eurasian water-milfoil	35N-41E-03
Stevens	Gillette Lake	Myriophyllum spicatum	Eurasian water-milfoil	36N-42E-20
Stevens	Heritage Lake	Myriophyllum spicatum	Eurasian water-milfoil	36N-42E-08
Stevens	Loon Lake	Myriophyllum spicatum	Eurasian water-milfoil	30N-41E-33
Stevens	McDowell Lake	Myriophyllum spicatum	Eurasian water-milfoil	34N-41E-06
Stevens	Sherry Lake	Myriophyllum spicatum	Eurasian water-milfoil	36N-42E-20
Stevens	Thomas Lake	Myriophyllum spicatum	Eurasian water-milfoil	36N-42E-18
Thurston	Capitol Lake	Myriophyllum spicatum	Eurasian water-milfoil	18N-02W-15
Thurston	Lois Lake	Myriophyllum spicatum	Eurasian water-milfoil	18N-01W-15
Thurston	Long Lake	Myriophyllum spicatum	Eurasian water-milfoil	18N-01W-22
Thurston	Nisqually River	Egeria densa	Brazilian elodea	18N-01E-05
Thurston	Scott Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-02W-33
Thurston	Skiview Lake	Myriophyllum spicatum	Eurasian water-milfoil	17N-02W-08
Wahkiakum	Brooks Slough	Myriophyllum aquaticum	parrotfeather	09N-06W-26
Wahkiakum	Columbia River at Cathlamet	Myriophyllum spicatum	Eurasian water-milfoil	08N-06W-02
Wahkiakum	Columbia River at Skamokawa	Myriophyllum aquaticum	parrotfeather	09N-06W-18
Wahkiakum	Puget Island Sloughs	Egeria densa	Brazilian elodea	08N-06W-14
Wahkiakum	Puget Island Sloughs	Myriophyllum aquaticum	parrotfeather	08N-06W-14
Walla Walla	Snake River at Ice Harbor Dam	Myriophyllum spicatum	Eurasian water-milfoil	09N-31E-24
Walla Walla	Snake River at Lower Monumental Dam - Walla Walla	Myriophyllum spicatum	Eurasian water-milfoil	13N-34E-34
Whatcom	Whatcom Lake	Myriophyllum spicatum	Eurasian water-milfoil	38N-03E-28
Whitman	Snake River at Central Ferry	Myriophyllum spicatum	Eurasian water-milfoil	13N-40E-08
Whitman	Snake River at Little Goose Dam	Myriophyllum spicatum	Eurasian water-milfoil	13N-38E-23
Whitman	Snake River at Lower Granite Dam	Myriophyllum spicatum	Eurasian water-milfoil	13N-43E-12
Yakima	Buena Lake	Myriophyllum spicatum	Eurasian water-milfoil	11N-20E-21
Yakima	Byron Lake	Myriophyllum spicatum	Eurasian water-milfoil	08N-23E-12
Yakima	Dog Lake	Myriophyllum spicatum	Eurasian water-milfoil	14N-12E-31
Yakima	Freeway (Rotary) Lake	Myriophyllum spicatum	Eurasian water-milfoil	13N-19E-07
Yakima	I-82 Pond, Exit 50	Myriophyllum aquaticum	parrotfeather	11N-20E-28
Yakima	I-82 Ponds, Exit 52	Myriophyllum aquaticum	parrotfeather	11N-20E-35
Yakima	Pond 2	Myriophyllum spicatum	Eurasian water-milfoil	12N-19E-35
Yakima	Pond 3	Myriophyllum spicatum	Eurasian water-milfoil	11N-19E-01
Yakima	Pond 4	Myriophyllum spicatum	Eurasian water-milfoil	11N-20E-17
Yakima	Pond 5	Myriophyllum spicatum	Eurasian water-milfoil	11N-20E-20
Yakima	Unnamed Ponds	Myriophyllum spicatum	Eurasian water-milfoil	12N-19E-20

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