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# Biological Assessment of Small Streams in the Coast Range Ecoregion and the Yakima River Basin

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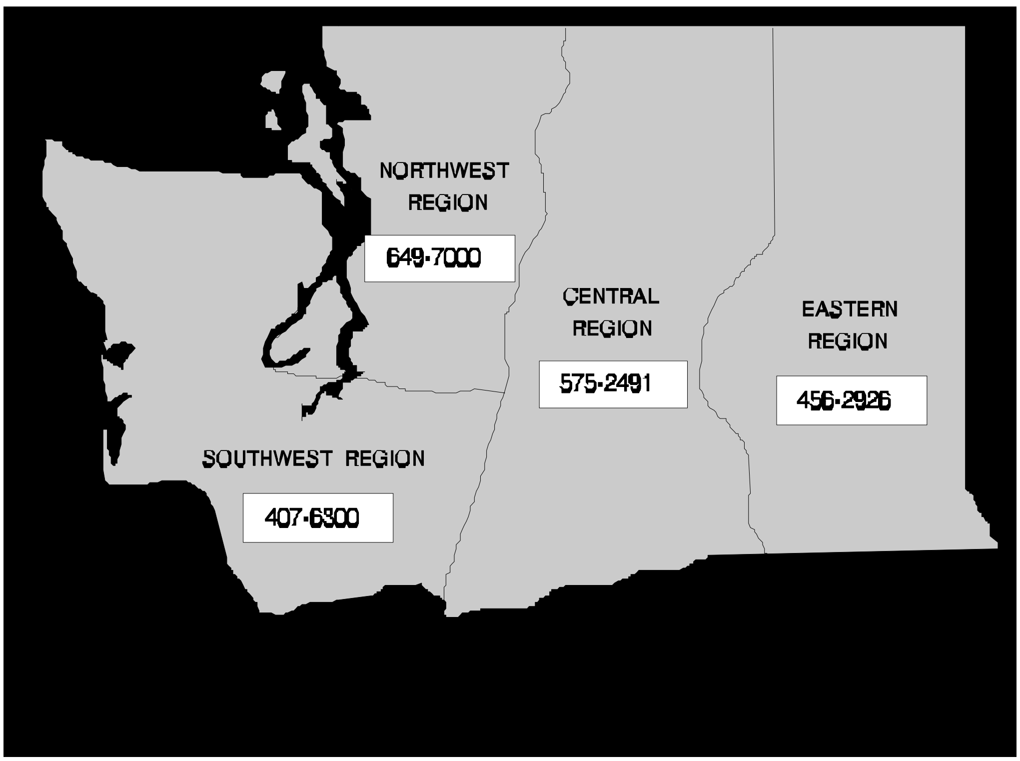


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# Biological Assessment of Small Streams in the Coast Range Ecoregion and the Yakima River Basin

by
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# Abstract

The Washington State Department of Ecology (Ecology) examined 78 first-order through third-order streams in the Yakima River Basin and the Coast Range Ecoregion, using methods developed for the national Environmental Monitoring and Assessment Program (EMAP).

To help develop water quality biological criteria Ecology examined a modified benthic index of biological integrity (B-IBI) and four fish assemblage metrics. We grouped sites into 15 classes based on ecoregion, wetted width, and geomorphology and estimated site quality using physical habitat data. We then compared the B-IBI against habitat quality and concluded that the B-IBI could provide useful descriptions of biological integrity, but that the EMAP-derived invertebrate sampling methods would need to be modified. Target streams yielded too few fish species for practical use of the fish metrics.

To assess the ecological condition of streams in each region, Ecology sampled 74 "probability" sites to measure chemical, physical, and biological status. Streams in each region were apparently unaffected by chemical pollution, and had low levels of nutrients, alkalinity, and conductivity.

Poor physical habitat conditions and impaired biological integrity were evident in both regions. Ecology ascribed regional stream conditions to forest land uses, because land use/land cover above streams in both regions was almost entirely forest. We concluded that the EMAP techniques were well adapted to fulfilling portions of Washington State duties under the Clean Water Act, especially reporting regional status under Section 305(b).

# Executive Summary

The Washington State Department of Ecology (Ecology) examined 78 first-order through third-order streams in the Yakima River Basin and the Coast Range Ecoregion using methods developed for the national Environmental Monitoring and Assessment Program (EMAP). We wanted to provide information (1) for the development of water quality biological criteria, (2) to determine the ecological condition of target streams, (3) to relate condition to predominant land uses, and (4) to determine the applicability of EMAP-derived methods in Washington State.

To help develop water quality biological criteria we evaluated previously used metrics and indices of biological integrity. We examined invertebrate samples using the benthic index of biological integrity (B-IBI). We also considered four fish assemblage metrics that have been applied locally by others, but did not construct them because there were naturally too few resident fishes present in target streams of either region.

To evaluate the B-IBI, we grouped sites into 15 classes based on ecoregion, wetted width, and geomorphology. We estimated site quality (differences between human-impacted and reference) using a habitat quality index (HQI) and a subjective best professional judgement (BPJ). We concluded that the BPJ scores were invalid because they were extremely different from the measured HQI values.

The B-IBI responded as predicted to human disturbance (as estimated by the HQI), as did most of its component metrics. A few of the metrics such as "% predators" were unreliable for some stream classes such as "large-Coast Range" and "small-Columbia Basin" streams. We concluded that the B-IBI could provide useful descriptions of biological integrity, but that the EMAP-derived invertebrate sampling methods would need to be modified to make them more comparable with existing methods and more representative of each stream reach. Our assessments were limited by the paucity of reference sites; more would be needed to make adequate decisions. We also concluded that shortening the sampling season could reduce B-IBI variability.

To assess the ecological condition of streams in each region, we used 74 "probability" sites, which were chosen using a systematic-random process, and then measured status using EMAP indicators for chemistry, physical habitat, and biology. We evaluated percentage land use/land cover for each watershed according to four classes (forest, range, agriculture, or urban) and identified the presence of permitted discharges.

Streams in each region were similar in several respects. They were apparently unaffected by chemical pollution, and had low levels of nutrients, alkalinity, and conductivity. Poor physical habitat conditions were evident for streams in both regions. Relative to federal guidance, Yakima Basin and Coast Range streams had excessive sand and fine sediment and deficient large woody debris. About one-third of Yakima Basin streams had deficient

shade relative to guidance from the Washington Forest Practices Board. About one-fourth of the streams in each region had impaired biological integrity as measured by the B-IBI.

Based on discriminant analysis, we related the condition of invertebrate assemblages in the Coast Range to several physical habitat factors: substrate size composition, amount of large woody debris, and residual pool depth. We ascribed regional stream conditions in the Coast Range and in the Yakima Basin to forest land uses such as timber management, because the land use/land cover above streams in both regions was almost entirely forest.

We concluded that EMAP techniques were well adapted to fulfilling portions of Washington State duties under the Clean Water Act. EMAP techniques would be especially applicable for reporting stream physical, chemical, and biological status under Section 305(b). We thought that other potential applications included identification of beneficial uses, design and evaluation of water quality criteria, and assistance to other research.

# Introduction

## Purpose of this Document

This report was prepared to provide an initial analysis of data gathered during 1994 and 1995 for the Regional Environmental Monitoring and Assessment Program (R-EMAP) project. It was intended to supplement information from concurrent sampling by the Oregon Department of Environmental Quality within their portion of the Coast Range Ecoregion. The U.S. Environmental Protection Agency (EPA), Region 10, also has planned a report to summarize project information from both states.

## Background

R-EMAP was derived from the EPA Environmental Monitoring and Assessment Program (EMAP). The EMAP program was designed to assess the status and trends of the nation's ecological resources. It was designed to use representative site sampling within any given region to make inferences about status and trends of the region's resources. Within each previous EMAP study, "probability" sites were chosen using a systematic-random process to make assessments by inference at state, regional, or smaller levels.

## Objectives

During 1994 and 1995, R-EMAP sampling was conducted by the Washington State Department of Ecology (Ecology) in the Yakima River Basin (Yakima Basin) and in the Coast Range Ecoregion (Coast Range) of Washington State. The study objectives were to:

- Provide information for the development of water quality biological criteria in Washington State using indices based on fish/amphibian and invertebrate taxa assemblage information;

- Determine the ecological condition (inhabitants and habitat) of small (wadeable), first-order through third-order streams (1:100,000-scale) of the Yakima Basin and the Coast Range;

- Determine the relationship between the ecological condition of these streams and the predominant land uses of the watersheds;

- Determine the applicability of EMAP-derived methods for assessments of ecological condition within Washington State streams.

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# Methods

A quality assurance project plan (Appendix A) was prepared at the start of the project.

## Sampling Sites and Times

### Site Selection and Reconnaissance

In early 1994, EPA provided a list of first-order through third-order (Strahler, 1957) probability stream sites. These were selected using a systematic-random process from 1:100,000-scale digital maps (EPA, 1991). In the Yakima Basin, only streams represented by solid lines (assumed perennial streams) were selected. The EPA provided Ecology with a list of 73 probability sites in the Coast Range (Figure 1 and Appendix B) and 42 probability sites in the Yakima Basin (Figure 2 and Appendix C). We subjectively chose four additional sites (Figures 1, 2 and Appendices A, B, C) to represent high-quality conditions for their respective regions. Three were in the Yakima Basin and one was in the Coast Range.

We then performed reconnaissance on these sites to determine which were available for sampling. Any of the following four reasons disqualified sites for sampling:

1. Too deep or swift to safely wade, or
2. Not a stream, but a wetland/pond/slough/dry channel, or
3. Inaccessible due to lack of permission from property owners, or
4. Inaccessible due to physical access barriers.

About two-thirds (74) of the probability sites selected by EPA were qualified for sampling. During 1994 and 1995 we sampled 47 probability sites in the Coast Range Ecoregion and 27 probability sites in the Yakima Basin. Adding the four subjectively chosen sites, there were 78 total sites sampled during the two years.

Seven of the probability sites were sampled twice in 1994. In 1995, five of the seven were sampled twice again; another of the seven was sampled once again.

### The Sampling Season

All sampling was performed during 1994 and 1995 (Appendix D). Yakima Basin sites were sampled during May-July. Coast Range sites were sampled during July-October. We chose the sampling season to occur as closely as possible to base flow conditions. Hayslip (1993) recommended sampling during July-October.

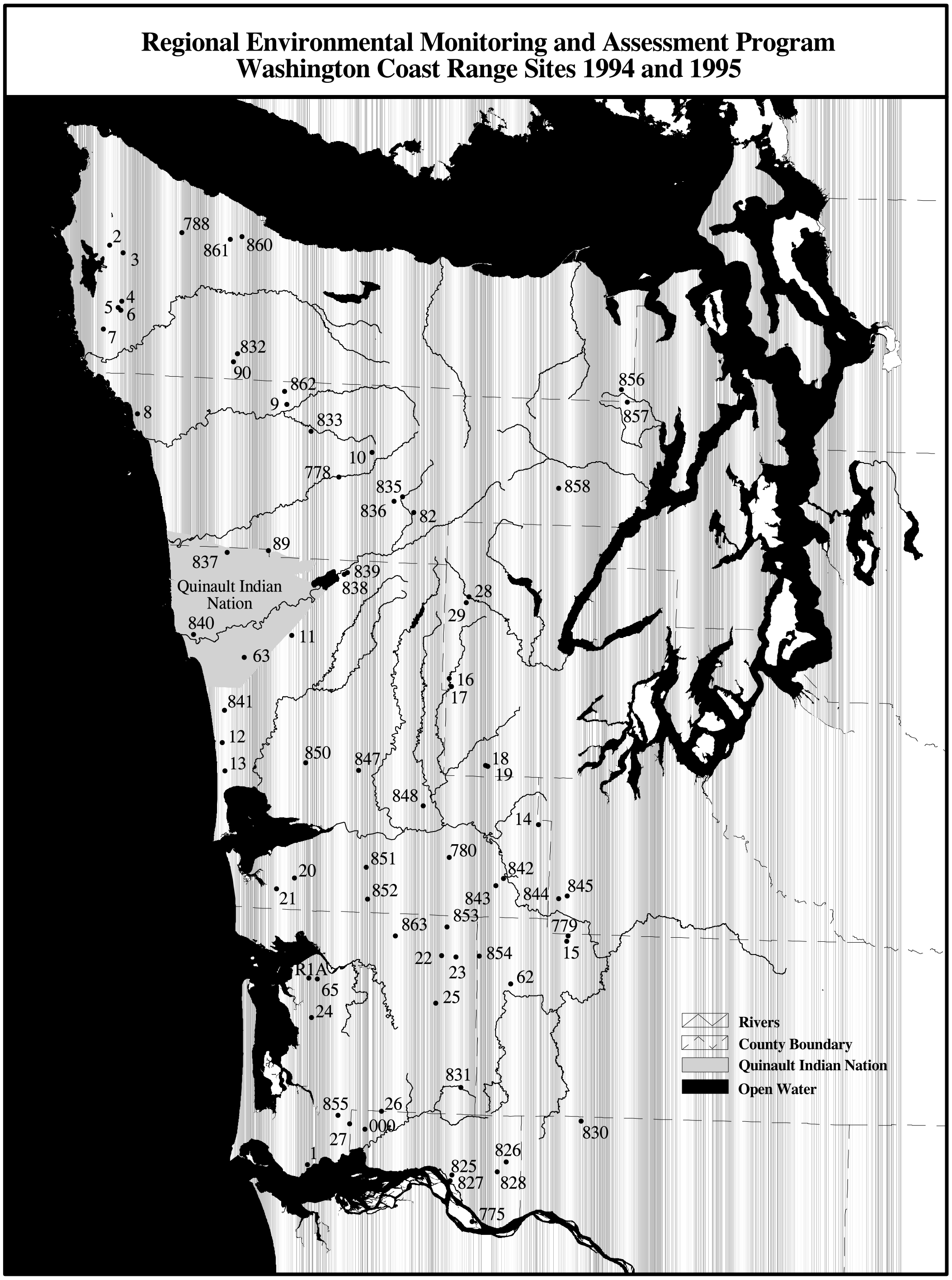


Figure 1. Regional Environmental Monitoring and Assessment Program, Coast Range sites 1994-95.

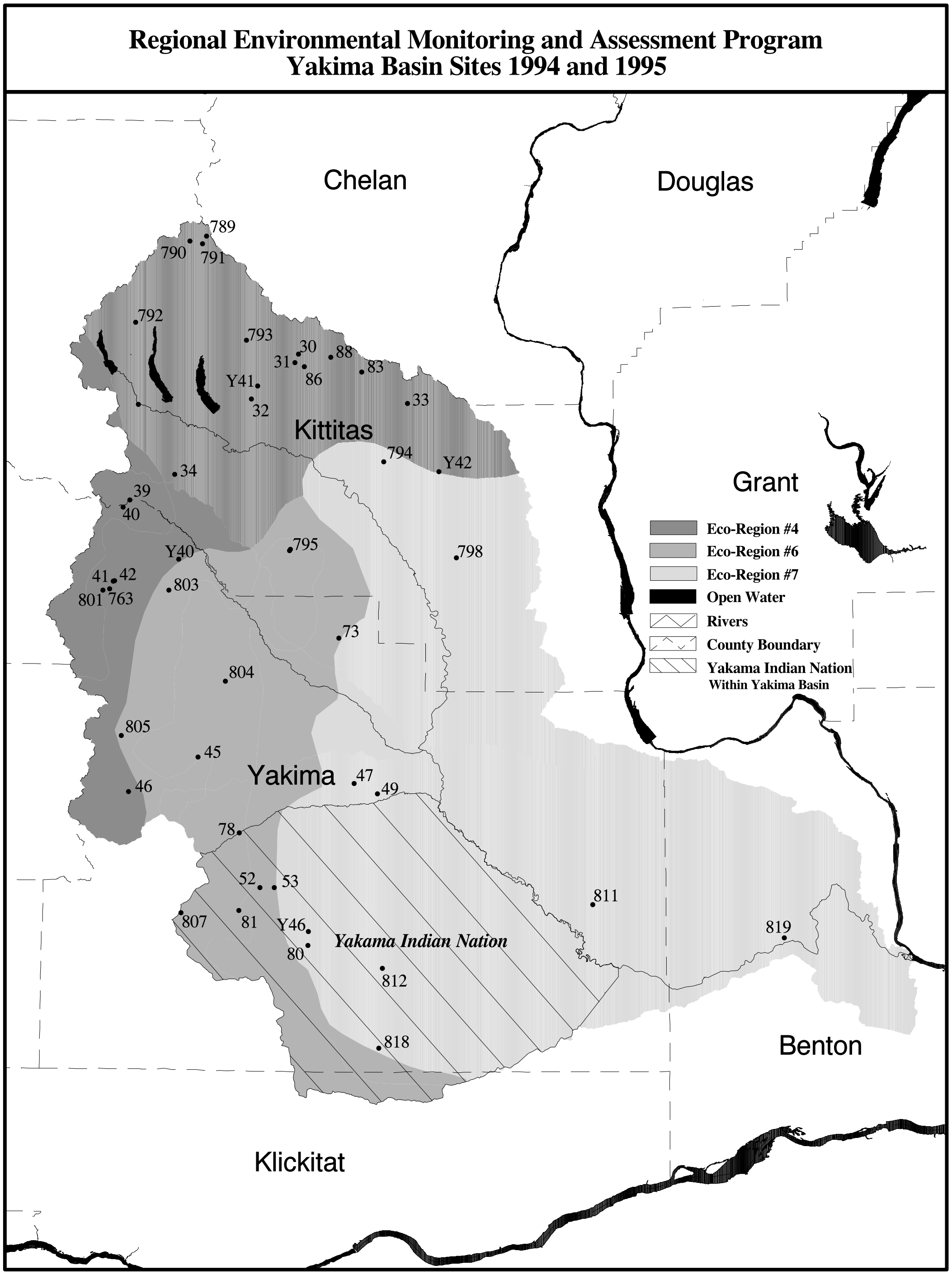


Figure 2. Regional Environmental Monitoring and Assessment Program, Yakima Basin sites 1994-95.

Yakima Basin sites were sampled during spring for two reasons:

1. Plotnikoff (1992) indicated that regional distinctions could be discerned among stream invertebrate communities whether sampling during spring, summer or fall.
2. There might be a number of intermittent streams that would become dry by July or later.

## Field and Laboratory

Field crews typically consisted of three persons but occasionally more. Crews located each site using 7.5-minute, topographic maps and hand-held Global Positioning System (GPS) receivers. Sampling activities and travel usually required a whole day (10 hours average), and occasionally two days. Each reach extended 40 wetted-widths in length, but no less than 150 meters. We marked 11 equidistant cross-sectional transects on each reach.

During mornings, the crew established the reach and transects, and then sampled for invertebrates, chemistry and physical habitat. Benthic invertebrates were collected using a 500-μ, D-frame kick net. One kick sample (0.186 $m^2$) was collected at each transect and designated by its dominant habitat as either “pool” (depositional habitat) or “riffle” (erosional habitat). Mixing all kicks from "pools" created a "pool" composite sample. Mixing all kicks from "riffles" created a "riffle" composite sample. Each composite sample consisted of 1 to 11 kicks.

Crews electrofished (single pass) during daylight, and then identified and enumerated the catch. The crew fished as much of the reach as possible, and as many habitats as possible, until 5,000 seconds were counted on the electrofishing unit. Specimens with questionable identity were retained for subsequent verification in the laboratory, either at the University of Washington or at Ecology headquarters.

We processed invertebrate samples at Ecology’s benthic laboratory by dividing each composite sample into 30 equal squares and then sorting two or more complete squares as necessary to count at least 300 organisms. Animals in the sorted sub-sample were then identified to the lowest possible taxa, as specified in Plotnikoff and White (1996). The project senior invertebrate taxonomist, Jody White, verified all samples.

Chemistry grab samples and *in situ* measurements were collected near the sixth (middle) transect of each reach. Ecology’s Manchester Laboratory analyzed the water chemistry samples.

Detailed field and laboratory methods were presented in the Quality Assurance Project Plan (Appendix A).

# Analysis

## Biological Criteria Development

Gibson (1996) listed three distinct steps to development of biological criteria: classifying natural conditions, developing indicators (assessment methods), and establishing criteria. Gerritsen and Kwon (1998) provided a brief review of some of the alternative approaches that have been used to develop biological criteria. They listed two basic approaches to classification (*a priori*, and *a posteriori*), three basic approaches to assessment (multimetric, single index, and multivariate approaches), and one basic approach to establishing criteria (comparison against a reference condition).

### Site Classification - the *a priori* approach

We chose the *a priori* approach to classification because it was simple and it had demonstrated to be reliable relative to the multivariate *a posteriori* (cluster analysis) approach when tested with a large data set from Wyoming (Gerritsen and Kwon, 1998). First we classified all sites, based on predetermined physical criteria. Then we evaluated the relative habitat quality of each site to determine its condition relative to "natural" conditions.

Biology in Northwestern streams has often been related to regional location (Hughes and others, 1987), size (Beecher and others, 1988; Mongillo and Hallock, 1995 and 1997) and geomorphology (Carter and others, 1996). Therefore we classified sites based on a combination of ecoregion (Omernik, 1987; EPA, 1986), wetted width, and geomorphology information.

*Region*

The ecoregion unit was selected as the base factor for regional classifications. All sites west of the Cascades are located in the Coast Range Ecoregion according to Omernik (1987). Appendix C lists the ecoregion (EPA, 1986) for each Yakima Basin site.

*Size*

Wetted width was selected as the base factor for stream size classifications, because this intuitively seemed to have the most meaning for biota. Other measures such as stream order and watershed area can be relatively broad and less meaningful at describing the amount of water available for habitat. We also considered the relative ease with which subsequent studies could measure stream size.

The size classes were determined based on exploratory plots (Appendix E). For example, in the Coast Range the 4-m and 13-m widths were at the inflection points (determined visually) for plots of width against cumulative number of observations. For the Yakima

Basin, 4-m and 9-m widths were at inflection points for these same types of plots. We therefore separated size classes from small (S) to large (L) as follows:

- Yakima Basin: S = 0-4 m; M = 4-9 m; L = 9+ m.
- Coast Range: S = 0-4 m; M = 4-13 m; L = 13+ m.

*Geomorphology*

Three components of the Rosgen (1994) classification were used to separate sites into each of two classes: headwaters (Rosgen types A or A+) or pool-riffle streams (any of the other Rosgen types). We used the following variables: sinuosity, bankful width/bankful depth, and slope. For the four sites where sinuosity could not be measured (missing compass) we relied on just two of the three components.

Sinuosity was calculated according to Kaufmann and others (1998) as the ratio of reach length to straight-line distance. Reach length was measured with a tape. Straight-line distance was calculated trigonometrically for the distance between each transect using compass bearings; it was then summed across the 10 distances for each reach.

$$\text{Sinuosity} = (\text{Reach length}) / (\text{straight-line distance});$$

$$= [\Sigma(D_T)]/\{(\Sigma\text{"Northing"})^2 + (\Sigma\text{"Easting"})^2\}^{1/2};$$

$$= [\Sigma(D_T)]/\{(\Sigma\, D_T \cos\theta)^2 + (\Sigma\, D_T \sin\theta)^2\}^{1/2};$$

where:

"Northing" and "Easting" are, respectively, the northern and eastern vector components of the distance from the downstream starting point;

$D_T$ = distance along channel between transects;
$\Sigma$ = summation over transects; and
$\theta$ = compass bearing in radians = $2\pi$(bearing°/360°).

Bankful width was determined as the mean (n=6) for all measured transects on each reach. Bankful depth was calculated by adding the mean thalweg depth (n=100 or 150) and the mean bankful height (n=12; 6 transects x 2 banks) for each reach.

Slope was determined as the mean % slope (n=10) for clinometer measurements sighted from upper transects to lower ones. Where clinometer measurements were unavailable (e.g., unnamed creek = WA001S; North Fork Crooked Creek = WA003S), slopes were estimated from topographic maps (1:24,000 scale).

*Habitat Quality - Judged*

During May 1996, two of the authors (Merritt and White) assigned subjective site quality scores to each of the sampled sites. The best professional judgement (BPJ) scores were assigned to help evaluate the reliability of metrics. We assigned categorical BPJ scores of 1, 2, 3, 4, or 5, with the highest site quality indicated by 5. We used absolutely no quantitative information in this evaluation, but simply our impressions based on memory.

*Habitat Quality - Measured*

Due to the limited scope of this project, we had to confine the focus of the habitat analyses to in-stream and riparian factors. We did this through development of a habitat quality index (HQI).

The HQI was constructed from four metrics; these four were selected from an initial list of 21 (Table 1): 16 physical habitat metrics and 5 chemical habitat metrics. To develop the initial list, a set of suggested EMAP physical habitat quality metrics was obtained from P. R. Kaufmann of Oregon State University (personal communication). Methods for calculating these metrics are described by Kaufmann and others (1998). These physical habitat metrics were combined with five chemical variables (of 13 measured; Appendix A) that we thought would be most appropriate.

We then examined the metric data from the repeatedly sampled sites (Appendix F) using one-factor analysis of variance across sites and t-tests across years (McCall, 1986). These analyses were used as gauges of the signal-to-noise ratios; they were not hypothesis tests, so we did not attempt to satisfy all the assumptions of parametric statistics. Metrics with detectable between-site differences were retained for the study. Of those, metrics with detectable between-year differences were discarded. Of the remainder, we discarded one metric (dissolved oxygen) due to quality control concerns (Appendix G). Percent cover from large woody debris (XFC_LWD) was discarded because its information is redundant with percent cover from large woody debris and boulders (XFC_LRG). We were left with the four metrics described below.

1. *SDWXD = standard deviation of (wetted width x thalweg depth)*

   This metric was an indicator of channel complexity. Historically, humans have reduced the complexity of stream channels (both low-gradient and high-gradient) through channelization, diking, and removal of woody debris and boulders (Sedell and Luchessa, 1982). Some activities such as logging have been associated with reduced frequency and size of pools. This has been due to the filling of pools with sediment and the loss of riparian trees (sources of pool-forming woody debris). Channel simplification has been associated with reduced aquatic animal populations (Allan, 1995).

**Table 1. Initial list of 21 habitat quality metrics.**

| Metric | Code |
|---|---|
| Habitat variability | |
| Standard deviation of thalweg depth | SDDEPTH |
| Standard deviation of (thalweg depth x wetted width) | SDWXD |
| Residual pool depth | RP100 |
| Substrate composition | |
| % Coarse | PCT_BIGR |
| % Sand | PCT_SA |
| % Fines | PCT_FN |
| Instream cover | |
| Sum: % cover - natural | XFC_NAT |
| Sum: % cover - large woody debris + boulders | XFC_LRG |
| Sum: % cover - large woody debris | XFC_LWD |
| Sum: % cover - brush/small woody debris | XFC_BRS |
| Riparian vegetation | |
| Shade - mid channel | XCDENMID |
| Sum: % riparian woody cover - 3 layers | XCMGD |
| % canopy | XC |
| % (canopy + understory) | XCM |
| Human activity | |
| Human disturbance index - total | W1_HALL |
| Human disturbance index - forestry | W1_LOG |
| Chemistry | |
| Suspended solids | TSS |
| Phosphorus | TOTP |
| Nitrogen | TPN |
| Temperature | TEMP |
| Dissolved oxygen | DO |

2. *PCT_BIGR = percent of stream bottom as coarse substrate*

   Anthropogenically produced fine sediment has been considered by some to be the most important single pollutant in U.S. streams and rivers. Although inorganic fine sediments are naturally present in all streams, during the last 50 years accelerated sediment inputs from human activities have caused enormous damage to streams in North America (Waters, 1995). We expected that the percentage of stream bottom as sand and fines would increase with increasing human influence (in the absence of natural disturbance). Conversely, we expected that the percentage of substrate as coarse particles would decrease with increasing human influence. In general, decreased diversity and abundance of stream biota have been associated with decreases in median particle size. This is possibly because the stability and heterogeneity of the substrate may decrease with decreasing median particle size (Allan, 1995). Coarse substrates such as gravel have also been related to the routing of dissolved organic matter from decaying salmon carcasses to living stream biota (Bilby and others, 1996).

3. *XFC_LRG = percent wetted area with cover from large woody debris and boulders*

   Since the settlement by Europeans in the Northwest, humans have drastically reduced the amount of cover provided by large woody debris and boulders in streams (Sedell and Luchessa, 1982). Losses of these large objects from streams have been associated with decreased habitat diversity due to fewer dams, pools, and backwater areas. Large woody debris has also been described as a nutrient source for invertebrates (Maser and Sedell, 1994).

4. *XCDENMID = shade-mid channel.*

   This was a measure of the amount of streamside vegetation. In the absence of natural disturbance, lower values of this metric can reflect greater human influence. Removal of streamside vegetation results in a number changes, including higher temperatures, simplified channel structure, and bank instability. In general, these changes result in reductions in species diversity (Allan, 1995).

We calculated the HQI for each site that had at least two other sites in its class (ecoregion, size, and geomorphology). We rated site conditions relative to the best conditions represented for the site's class. A score was first created for each of the four individual metrics by calculating the following: metric value ÷ maximum value of that metric for the stream class.

We expected values for each of the four habitat quality metrics to decrease with increasing human influence, so we used the highest sum of scores to represent the least-disturbed habitat conditions. A composite habitat quality index (HQI) was constructed for each site by calculating the following: sum of the four habitat scores for the site ÷ maximum sum of scores for the stream class.

We measured within-year and between-year variability of the HQI and its component metrics by calculating relative percent difference (RPD) (EPA 1995a).

$$RPD = [(C_1 - C_2)*100] \div [(0.5*C_1)+(0.5*C_2)],$$

where:
$C_1$ = the larger of the two values;
$C_2$ = the smaller of the two values.

Within-year RPD was calculated for a given variable at each site as the average of 1994 within-year RPD and 1995 within-year RPD. Between-year RPD was calculated for a given variable at each site as the RPD of the mean 1994 variable value and the mean 1995 variable value.

## Assessing Biological Integrity - The Multimetric Approach

We chose to use the multimetric approach to assessment for several reasons. It has been commonly used across the United States (Barbour and others, 1995) and it is simple to explain. Also, results of performance-based tests with large, western data sets suggested that the multimetric approach was robust relative to multivariate and single index approaches (Gerritsen and Kwon, 1998).

### *Invertebrates*

We calculated a modified benthic-index of biological integrity (B-IBI; Karr and Chu, 1997) using the invertebrate assemblage information. In the database, we combined habitats ("pools" and "riffles"). Metric calculations were then applied to a combined-habitat sample so that the sample for each site was based on 2 $m^2$ of stream bottom that was further sub-sampled in the lab (Appendix H). We included nine metrics of the B-IBI that have demonstrated predictable responses to human-induced disturbance among various regions; we did not include a tenth (number of "clinger" taxa) because of uncertainty in how to identify "clingers". Taxa assignments for tolerance, feeding, and life length were taken from Ecology's freshwater macroinvertebrate database (constructed by R. Plotnikoff and S. Barrett). Dr. R.W. Wisseman (Aquatic Biology Associates, Inc., Corvallis, OR) provided the original tolerance assignments for the database.

### *Fish*

We evaluated our fish assemblage information relative to metrics that have already been used. We were aware of only one study in either the Yakima Basin or the Coast Range that has used complete fish or amphibian assemblage data to evaluate biological criteria. We therefore considered the metrics that they used.

Cuffney and others (1997) calculated four fish assemblage metrics:

1. Percent individuals with *external anomalies,*
2. Percent individuals as *tolerant species,*
3. Percent individuals as *non-native species,* and
4. Percent individuals as *omnivorous/herbivorous species.*

We evaluated the percentage of individuals that had gross external anomalies. We also used species characteristics suggested by Zaroban and others (submitted 1998) to determine which species were tolerant, which species were non-native, and which ones were omnivorous or herbivorous.

Species characteristics have been described for Northwestern amphibians (e.g., Corkran and Thoms, 1996; Leonard and others 1993; McAllister, 1995; Nussbaum and others, 1983) but traits relevant to biological assessment have not been compiled and reviewed as with the fishes. Therefore we decided not to evaluate the amphibians relative to development of biological criteria.

**Scoring Criteria**

Invertebrate metrics were assigned scores of 5, 3, or 1 by examining the range and distribution of values within each stream class. We assigned a score of 5 to metric values that approximated what we expected at the least disturbed sites in the stream class. We assigned a score of 3 to metric values that deviated somewhat from our expectations for least disturbed sites. We assigned a score of 1 to metric values that strongly deviated from expectations for the least disturbed sites. The scoring criteria are listed in Table 2.

These were determined graphically for stream classes with seven or more samples (Appendix I); criteria were set at break points in the distributions. For stream classes with smaller sample sizes, we subjectively estimated the criteria. In these cases criteria were based on criteria in similar stream classes and on knowledge of the given sites.

**Seasonal and Yearly Variability**

We measured within-year and between-year variability of the B-IBI and its component metrics by calculating the relative percent difference as in the previous section. The B-IBI ranges from 9 to 45. Therefore we used the following modified version of the formula variables:

$C_1$ = the larger of the two values - 9;
$C_2$ = the smaller of the two values - 9.

We plotted the relationship of B-IBI to HQI within each of the six stream classes having seven or more samples (when including repeated visits to some sites). The B-IBI was predicted to increase in value with increasing habitat quality.

**Table 2. B-IBI metrics, predicted responses to human disturbance, and mid-range values (values scoring 3) for each stream class.**

| Metric (predicted response) | **Coast Range** Large | **Coast Range** Medium | **Coast Range** Med.Headwater | **Coast Range** Small | **Coast Range** Sm.Headwater |
|---|---|---|---|---|---|
| Total taxa (-) | 31-40 | 41-49 | 10-20 | 23-41 | 33-48 |
| Ephemeroptera taxa (-) | 6-11 | 7-11 | 5-9 | 2-4 | 6-10 |
| Plecoptera taxa (-) | 5-6 | 6-8 | 2-4 | 4-6 | 5-8 |
| Trichoptera taxa (-) | 5-7 | 7-12 | 1-2 | 3-8 | 6-9 |
| Long-lived taxa (-) | 3-4 | 3-5 | 1 | 1-4 | 1-3 |
| Intolerant taxa (-) | 6-10 | 8-19 | 6-10 | 4-12 | 10-13 |
| % tolerant individuals (+) | 15-5 | 15-7 | 5-1 | 15-10 | 7-3 |
| % predator individuals (-) | 4-7 | 8-15 | 1 | 3-8 | 6-11 |
| % dominance - 3 taxa (+) | 70-56 | 65-48 | 90-80 | 80-58 | 60-50 |
| Metric (predicted response) | **Cascades** Large | **Cascades** Medium | | **Cascades** Small | **Cascades** Sm.Headwater |
| Total taxa (-) | 41-49 | 41-49 | | 41-47 | 33-48 |
| Ephemeroptera taxa (-) | 7-11 | 7-11 | | 9-11 | 4-10 |
| Plecoptera taxa (-) | 6-8 | 6-8 | | 4-6 | 5-8 |
| Trichoptera taxa (-) | 7-12 | 7-12 | | 7-9 | 6-9 |
| Long-lived taxa (-) | 3-5 | 3-5 | | 1-4 | 1-4 |
| Intolerant taxa (-) | 8-19 | 8-19 | | 15-20 | 10-17 |
| % tolerant individuals (+) | 15-7 | 15-7 | | 7-3 | 20-3 |
| % predator individuals (-) | 8-15 | 8-15 | | 7-12 | 5-15 |
| % dominance - 3 taxa (+) | 65-48 | 65-48 | | 60-40 | 80-48 |
| Metric (predicted response) | **East Cascades** Large | | | **East Cascades** Small | **East Cascades** Sm.Headwater |
| Total taxa (-) | 35-40 | | | 10-20 | 30-40 |
| Ephemeroptera taxa (-) | 6-10 | | | 3-6 | 4-9 |
| Plecoptera taxa (-) | 3-5 | | | 1-2 | 6-8 |
| Trichoptera taxa (-) | 6-9 | | | 1-2 | 6-9 |
| Long-lived taxa (-) | 3-5 | | | 1 | 2-4 |
| Intolerant taxa (-) | 6-17 | | | 6-10 | 10-17 |
| % tolerant individuals (+) | 15-7 | | | 5-1 | 20-6 |
| % predator individuals (-) | 3-5 | | | 1 | 5-15 |
| % dominance - 3 taxa (+) | 65-48 | | | 90-80 | 80-48 |
| Metric (predicted response) | | **Columbia Bas.** Medium | | **Columbia Bas.** Small | **Columbia Bas.** Sm.Headwater |
| Total taxa (-) | | 30-40 | | 21-26 | 5-25 |
| Ephemeroptera taxa (-) | | 5-6 | | 5-7 | 3-4 |
| Plecoptera taxa (-) | | 2-3 | | 1 | 1 |
| Trichoptera taxa (-) | | 2-4 | | 2-3 | 1-2 |
| Long-lived taxa (-) | | 2-4 | | 2 | 1-2 |
| Intolerant taxa (-) | | 2-3 | | 3-6 | 2-6 |
| % tolerant individuals (+) | | 50-25 | | 20-10 | 50-10 |
| % predator individuals (-) | | 8-15 | | 3-10 | 3-15 |
| % dominance - 3 taxa (+) | | 85-60 | | 72-66 | 85-60 |

## Regional Status

Regional status of target streams was assessed using the probability design. The sampled sites represented all streams of the target type within each region. The stream length represented by each sample site depended upon the site's probability of selection. First-order streams were more numerous than second-order or third-order streams. Therefore each first-order sample site represented a larger portion of its region.

The stream length represented by each sample site in the Yakima Basin was as follows:

- First-order streams each represented 390 km (1994 selection) or 231 km (1995 selection),
- Second-order streams represented 111 km (1994) or 58 km (1995),
- Third-order streams represented 65 km (1994) or 39 km (1995).

The stream length represented by each sample site in the Coast Range was as follows:

- First-order streams each represented 390 km (1994 selection) or 320 km (1995 selection),
- Second-order streams represented 111 km (1994) or 80 km (1995),
- Third-order streams represented 65 km (1994) or 53 km (1995).

Some of the probability sites were sampled repeatedly during the project. For assessing regional status, we only used the first sample from the first visit to these sites.

### Watershed Land Use/Land Cover

Site drainages were examined using Geographic Information Systems (GIS). Outlines of the drainages were hand-traced onto 1:24,000-scale USGS topographic maps. These tracings were then digitized and analyzed for drainage area and digital elevation (Appendices B and C). To all of the digitized watersheds we added a land use/land cover layer (USGS, 1974) for analysis of percent cover by each of four classes (agriculture, range, forest, urban). We also added another data layer to locate NPDES-permitted point source discharges (EPA, 1993). Three sites in the Yakima Basin were not analyzed (County Creek = WA040S; Tributary to Green Canyon = WA794S; Day's Creek = WA819S) because their maps were unavailable.

### Water Quality

Methods for collection of chemistry data are described in Appendix A. We computed summary statistics for the probability sample of sites in each region. We also estimated the percentage of regional stream length (km) in which chemistry variables were below detectable limits of analysis.

We examined the results of conventional water quality data relative to Washington water quality standards for surface waters (Chapter 173-201A WAC). Three of the parameters have been explicitly addressed in the standards (dissolved oxygen, pH, water temperature). We examined pH and associated data (conductivity, alkalinity). We decided not to examine dissolved oxygen data, due to quality assurance problems for that parameter (Appendix G). Stream water temperature, an important variable, normally varies diurnally. We had just one instantaneous temperature measurement at each site and therefore did not evaluate it relative to the water quality standards. The pH of streams can change diurnally too, especially in highly productive waters. Photosynthesis consumes $CO_2$, thereby raising mid-day pH; respiration produces $CO_2$, thereby lowering pH (Allan, 1995). Our sample streams did not seem to be productive, however, and our pH measurements typically were taken during late morning to mid-day. Therefore, we believed that it was reasonable to compare our pH measurements against the water quality standards, especially against the lower boundary for pH.

We assessed the percentage of regional stream length (km) in which our measurements exceeded the water quality standards for pH. Acceptable pH values, according to the standards, were between 6.5 and 8.5 for the state Class AA and Class A streams. All R-EMAP streams belonged to one of these two regulatory classes.

We assessed bias of field pH and conductivity measurements through the use of a field quality control check. A low-ionic strength solution of known pH and conductivity was measured before and after the stream measurement. The check-solution (Metcalf and Peck, 1993) had a pH of 6.98 and a conductivity of 75 µS/cm at 25°C. Therefore, bias was assessed by subtracting 6.98 pH units and 75 µS/cm at 25°C from the measured values of the quality control solution.

**Habitat**

Most of the metrics were calculated as discussed in the previous section of this document. Several others were computed for comparison to published guidance criteria (NMFS, 1996, Williams and Williams, 1997, WFPB, 1997): percent view-to-sky (PCT_SKY), logs per kilometer (LOGALL_KM), and big logs per kilometer (LOGBIG_KM).

LOGALL_KM was calculated by adding the number of logs in the bankful channel of each reach that were greater than 0.3 m in diameter and greater than 15 m long. For LOGBIG_KM, we counted logs larger than 0.6 m in diameter and larger than 15 m long. The sums were then converted from a reach length basis to a kilometer basis.

Percent view-to-sky (PCT_SKY) was based on an average of 44 densiometer measurements from the mid-channel of each stream reach. It was computed by determining the number of densiometer points (of 17) that reflected skylight rather than shade.

## Biology

Regional conditions for biological integrity (B-IBI), fish species richness, and salmonid species richness were estimated for the Yakima Basin and for the Coast Range. Salmonid richness was the number of fish species that were members of the salmonid (i.e., salmon and trout) family. We used Diaz-Ramos and others (1996) "Method 1" to generate cumulative distribution functions (CDFs). Confidence intervals on the CDFs were calculated using "Method 7" ("Variance of the Size-Weighted Cumulative Distribution Function for Proportion of a Discrete Resource; Horvitz-Thompson Variance Estimator").

## Invertebrate Habitat in the Coast Range

Concurrently with the analyses described above, we explored habitat relationships to invertebrates in the Coast Range (White and Merritt, 1998). We sorted 39 sites into clusters based on invertebrate riffle samples, then examined relationships of these clusters to habitat measures.

Sites were first classified, using invertebrate data, along an assumed gradient of impairment. The Bray-Curtis similarity coefficient (Bray and Curtis, 1957) was used as a multivariate description of each community, and site groups were identified by a hierarchical, agglomerative, group-averaged cluster routine. Relative degree of impairment was inferred from spatial patterns of benthic invertebrates as described in Green (1979). Invertebrate community types were used to classify sites into groups by assuming that communities of least-impaired (reference) conditions would be more similar to each other than to those that were more impaired. Each site cluster was evaluated to determine which community represented least-impaired (reference) conditions. We assumed that sites located in the Olympic National Park represented least-impaired conditions.

To choose other healthy stream reaches, several other assumptions were made, with each site needing more than one of the following four features to qualify:

1) located in the Olympic National Forest,

2) most of the watershed in non-commercial land,

3) intact riparian zone, and

4) diverse in-stream habitat.

Discriminant analysis was then used to test how site groups identified by the invertebrate community classification differed by their habitat characteristics. We evaluated nine variables that were subjectively chosen from the survey list (Kaufmann and others, 1998), based on their assumed relevance to forestry impacts. They are listed below, with the variable codes (Kaufmann and others 1998) printed in parentheses:

- Large woody debris tally (C1W)
- Brush and small woody debris (XFC_BRS)
- In-stream fish cover (XFC_ALL)
- Human disturbance index (W1_HALL)
- Shade in mid-channel (XCDENMID)
- Residual pool depth (RP100)
- Percent coarse substrate (PCT_BIGR)
- Percent sand (PCT_SA)
- Percent fines (PCT_FN)

# Results

## Data Summaries

The stream classifications and the data used to assign them are listed in Appendix J. Habitat quality and biological integrity data are listed in Appendix K.

## Site Information

About one-third of the sites selected by the EPA algorithm, in either region, were not sampled (Figure 3). Twenty-six of the 73 selected sites in the Coast Range were not sampled. Entry routes for eight sites were inaccessible due to lack of permission and safety issues. Eighteen of the 26 sites did not fit the target population, because they were unwadeable or they were lakes, wetlands, or tidal sloughs.

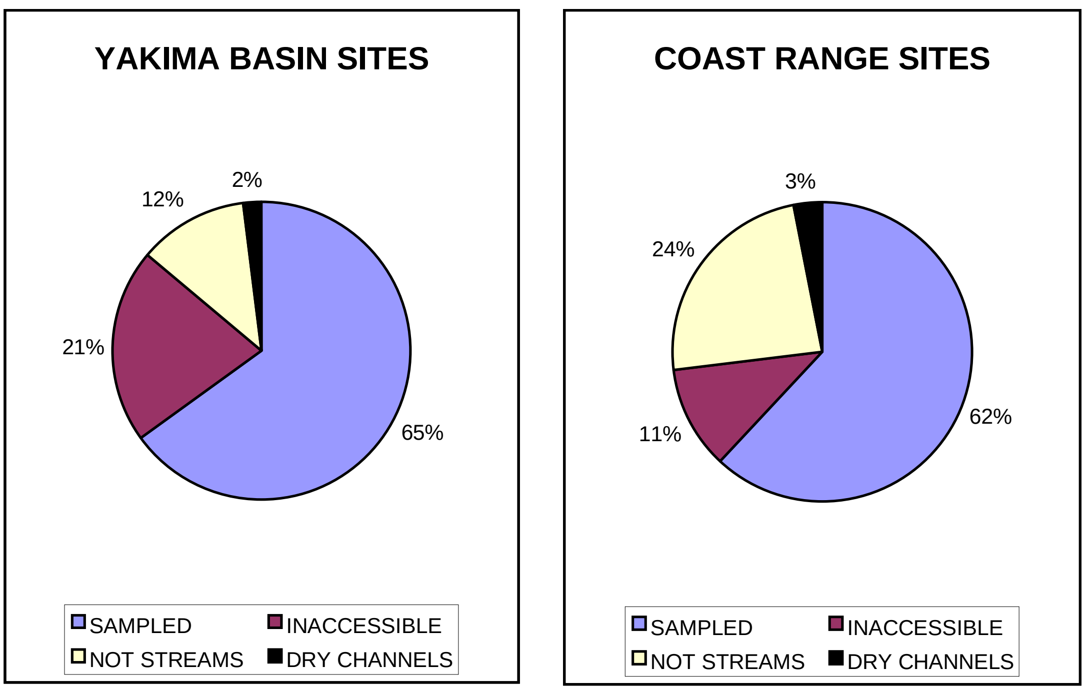


**Figure 3.** Reconnaissance results for randomly selected sites in the Yakima Basin (n = 42) and the Coast Range (n = 73). The percentages describe the proportions of selected sampling sites (not regional stream length).

Fourteen of 42 selected sites in the Yakima Basin were not sampled. Entry routes for nine sites were inaccessible due to lack of permission from property owners, barriers (e.g., culvert), or safety issues (e.g., 40% steep grade). Five of the 14 sites did not fit the target population, because they were unwadeable (too deep or too swift to wade).

We missed some of the planned repeat sampling among the seven probability sites. Seven of the probability sites were sampled repeatedly to assess seasonal and inter-annual variance. Clear Creek (WA805S) was too deep to wade throughout 1995. Sampling at Kusshi Creek (WA818S) on May 4, 1995 was aborted due to heavy rain; this was the third visit to that site.

# Biological Criteria Development

## Classification

### Grouping Sites

Fifteen stream classes were identified (Table 3 and Appendix J) based on ecoregion, wetted width, and geomorphology. Classifications were stable; they did not change with repeated sampling across seasons or years.

**Table 3. R-EMAP stream classes and their sizes.**

| Stream Class | No. sites | No. samples |
|---|---|---|
| Coast Range - Large | 7 | 10 |
| Coast Range - Medium | 20 | 23 |
| Coast Range - Medium headwaters | 3 | 3 |
| Coast Range - Small | 11 | 14 |
| Coast Range - Small headwaters | 7 | 10 |
| Cascades - Large | 2 | 2 |
| Cascades - Medium | 4 | 4 |
| Cascades - Small | 5 | 5 |
| Cascades - Small headwaters | 1 | 1 |
| East Cascades - Large | 1 | 1 |
| East Cascades - Small | 3 | 4 |
| East Cascades - Small headwaters | 7 | 7 |
| Columbia Basin - Medium | 2 | 2 |
| Columbia Basin - Small | 4 | 9 |
| Columbia Basin - Small headwater | 1 | 1 |

**Rating Sites**

The best professional judgement (BPJ) score for each site was listed in Appendix K. These subjective estimates of stream quality did not correspond as expected to quantitative measurements of habitat quality (Appendix K and Figure 4).

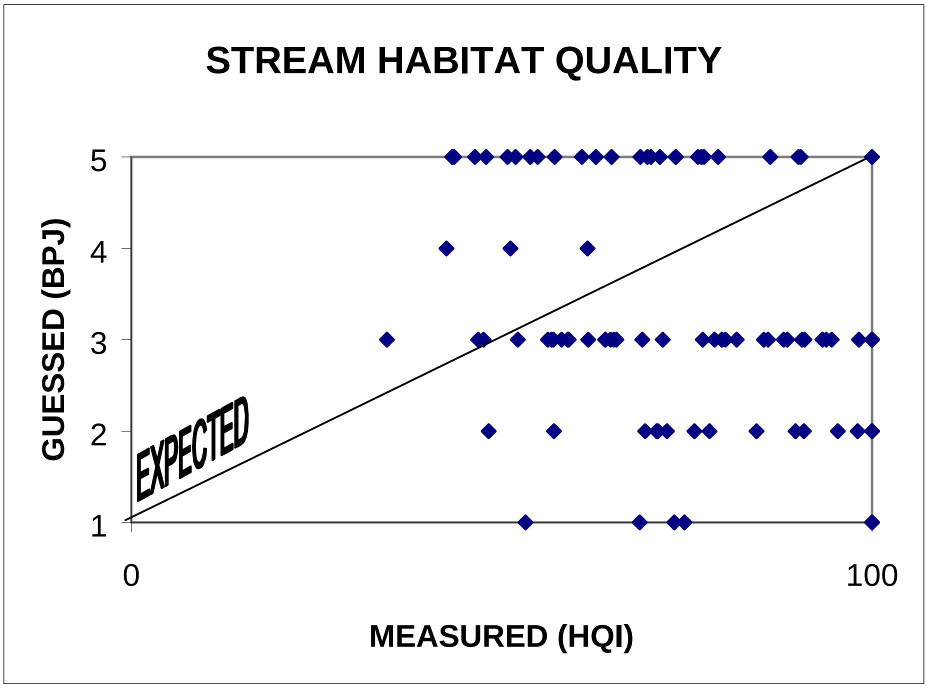


**Figure 4.** The relationship of best professional judgement to quantitative habitat quality assessment. BPJ values can range from 1 (lowest quality) to 5 (highest quality). HQI values can range from 0 (lowest quality) to 100 (highest quality).

Values of the habitat quality index (HQI) and its component metrics are listed for each sample in Appendix K. The between-year and within-year precision of these measures are illustrated in Figure 5. Within-year precision (10% RPD) of the HQI was similar to its between-year precision (18% RPD).

## Assessment

Values of the benthic index of biological integrity (B-IBI) and its component metrics are listed for each sample in Appendix K.

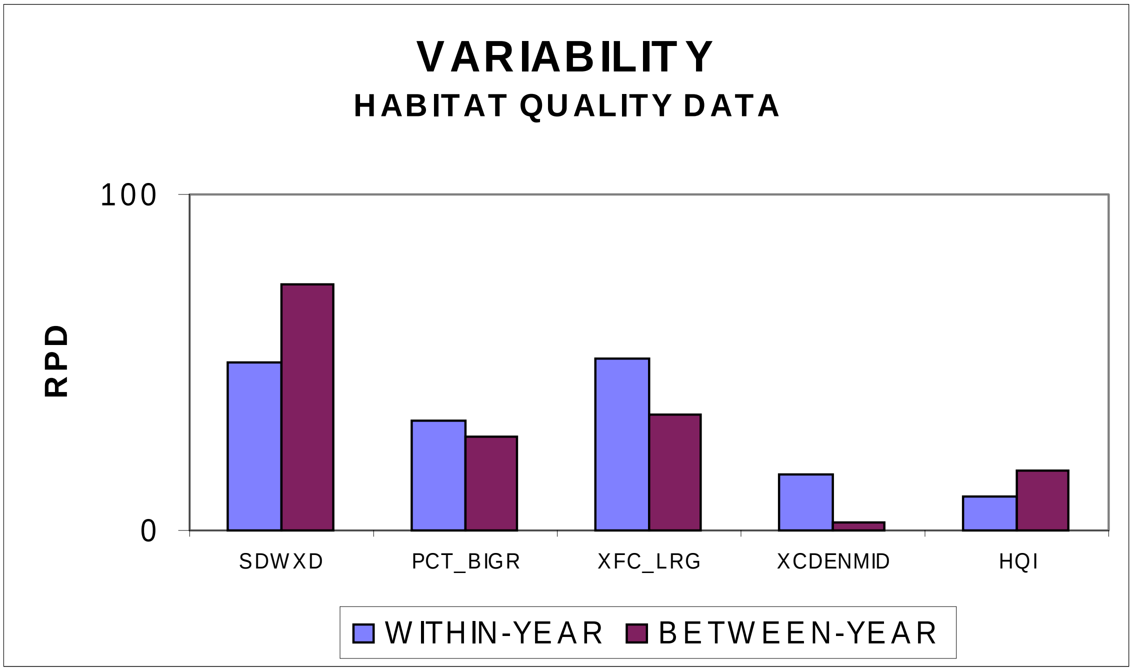


**Figure 5.** Relative percent differences for replicate measures of the habitat quality index and it's component metrics among 7 stream sites.

The between-year and within-year precision of the B-IBI and its metrics are illustrated in Figure 6. Within-year precision of the B-IBI (30% RPD) was similar to between- year precision (42% RPD). This also was true for the component metrics, except for long-lived taxa and intolerant taxa. These two metrics each had a relatively large amount of seasonal variability.

The B-IBI responded to habitat quality as predicted for all stream classes examined. Diminished habitat quality was associated with lower B-IBI scores (Figure 7). Predicted responses of component metrics are listed in Table 2. In most cases component metrics of the B-IBI also responded as predicted (Table 4). Four metrics were consistently reliable, regardless of stream class: ephemeroptera taxa, plecoptera taxa, intolerant taxa, and % dominance. Metrics in two stream classes (Coast Range - Large, and Columbia Basin - Small) responded less predictably to habitat quality than for measures in the other classes.

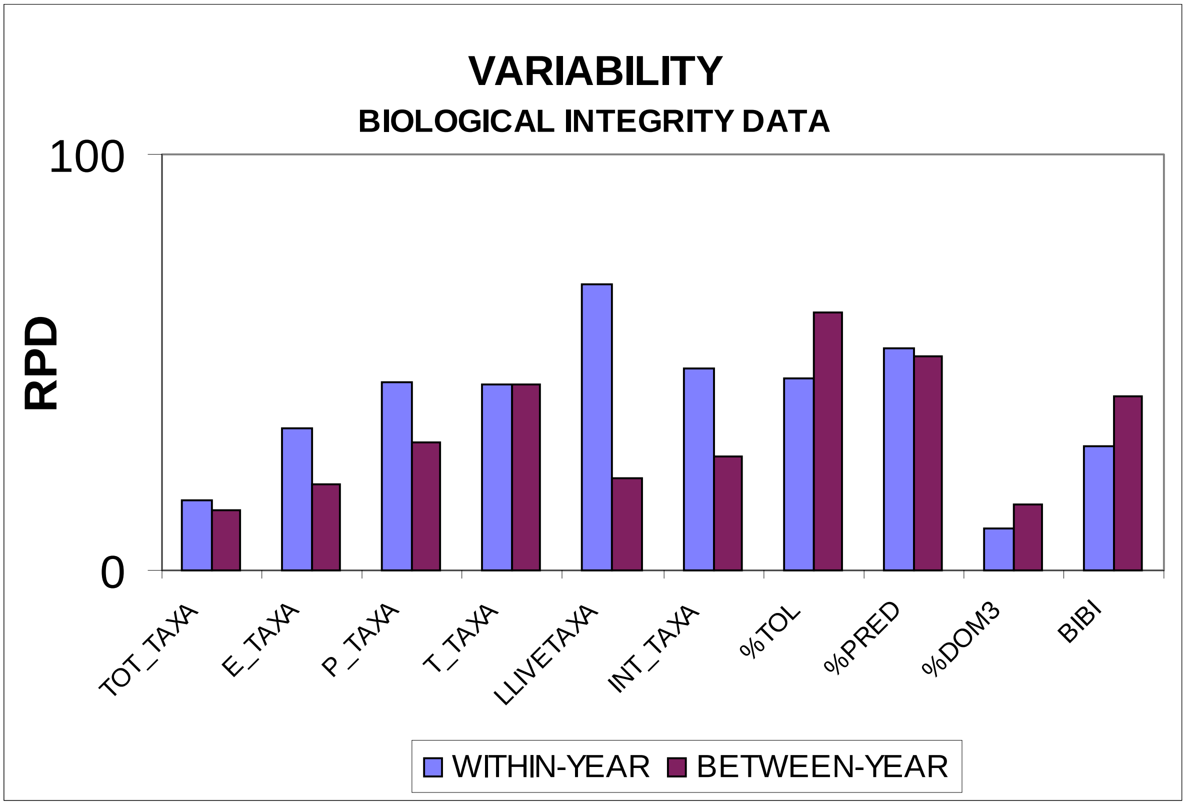


**Figure 6.** Relative percent differences for replicate measures of the benthic index of biological integrity and it's component metrics among 7 stream sites.

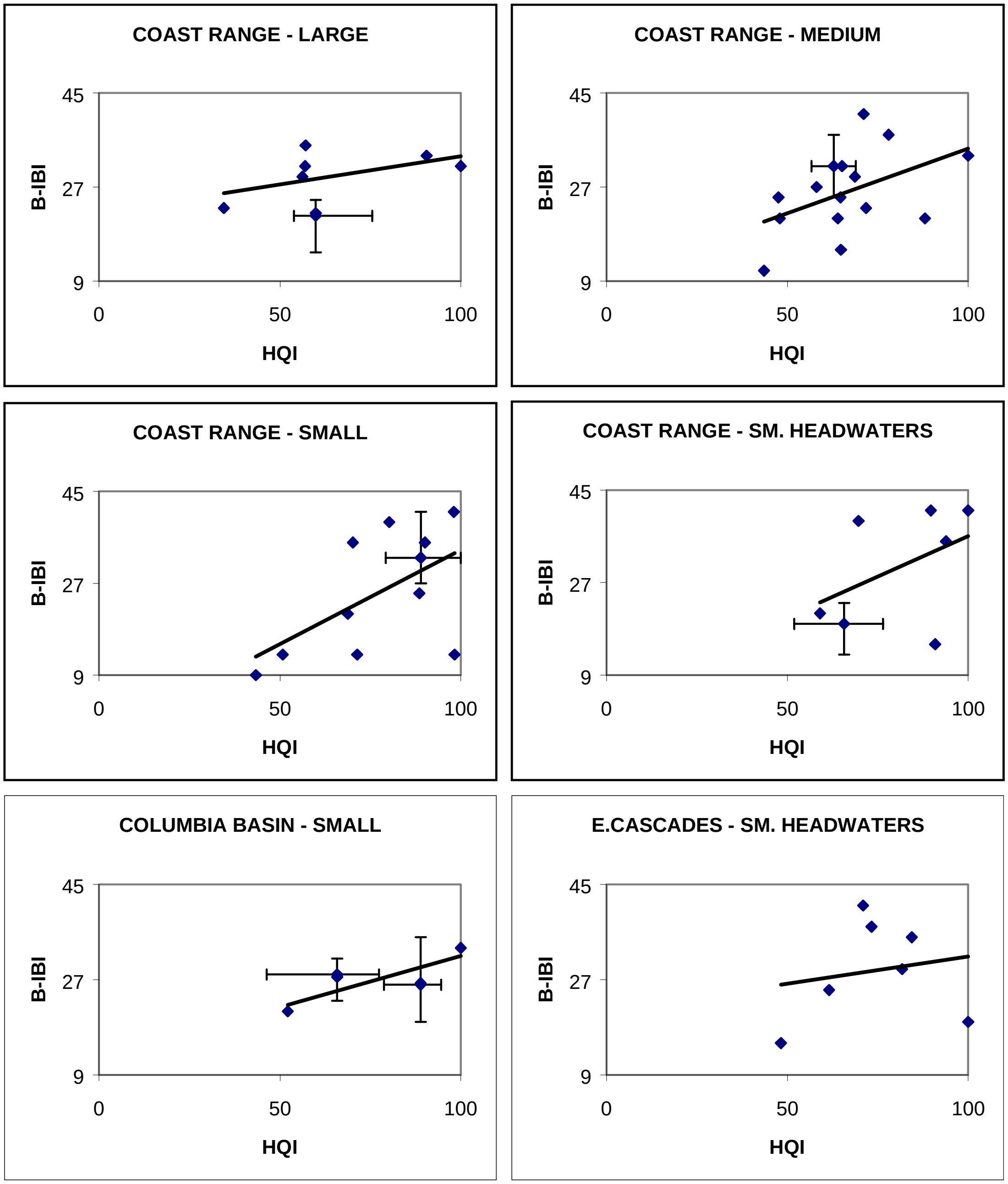


**Figure 7.** Response of the benthic index of biological integrity to differences in habitat quality in each of six stream classes. Error bars describe the range about the mean for stream sites that were sampled on multiple occasions.

**Table 4. Whether or not biological integrity metrics responded as predicted to differences in the habitat quality index (HQI).**

| Metric | **Coast Range** Large | **Coast Range** Medium | **Coast Range** Small | **Coast Range** Small Headwaters | **Columbia Basin** Small | **East Cascades** Small Headwaters |
|---|---|---|---|---|---|---|
| Total taxa | Yes | Yes | Yes | Yes | **No** | Yes |
| Ephemeroptera taxa | Yes | Yes | Yes | Yes | Yes | Yes |
| Plecoptera taxa | Yes | Yes | Yes | Yes | Yes | Yes |
| Trichoptera taxa | **No** | Yes | Yes | Yes | **No** | Yes |
| Long-lived taxa | Yes | Yes | Yes | Yes | **No** | Yes |
| Intolerant taxa | Yes | Yes | Yes | Yes | Yes | Yes |
| % tolerant individuals | **No** | Yes | Yes | Yes | **No** | Yes |
| % predator individuals | **No** | **No** | Yes | Yes | Yes | **No** |
| % dominance - 3 taxa | Yes | Yes | Yes | Yes | Yes | Yes |

# Regional Status

We estimated that in 1994-1995 there were 8,416 km of target streams (first-third order, flowing, and accessible) in the Coast Range Ecoregion and 3,027 km of target streams in the Yakima River Basin.

## Watershed Land Use/Land Cover

Watershed populations in both regions were estimated to be predominantly forest in land use/land cover (Figure 8).

**Forest**

One hundred percent (8,416 km) of target streams in the Coast Range were estimated to have over 94% forest land use/land cover. In the Yakima River Basin, 1,695 km (56%) of the target streams were estimated to have over 94% forest; 848 km (28%) were estimated to have 80-93% forest; and 484 km (16%) were estimated to have 59-79% forest.

**Range**

Rangeland was not detected in the Coast Range. Fifty-two kilometers (2%) of the streams in the Yakima Basin were estimated to have had 10-41% range as land use/land cover in their watersheds.

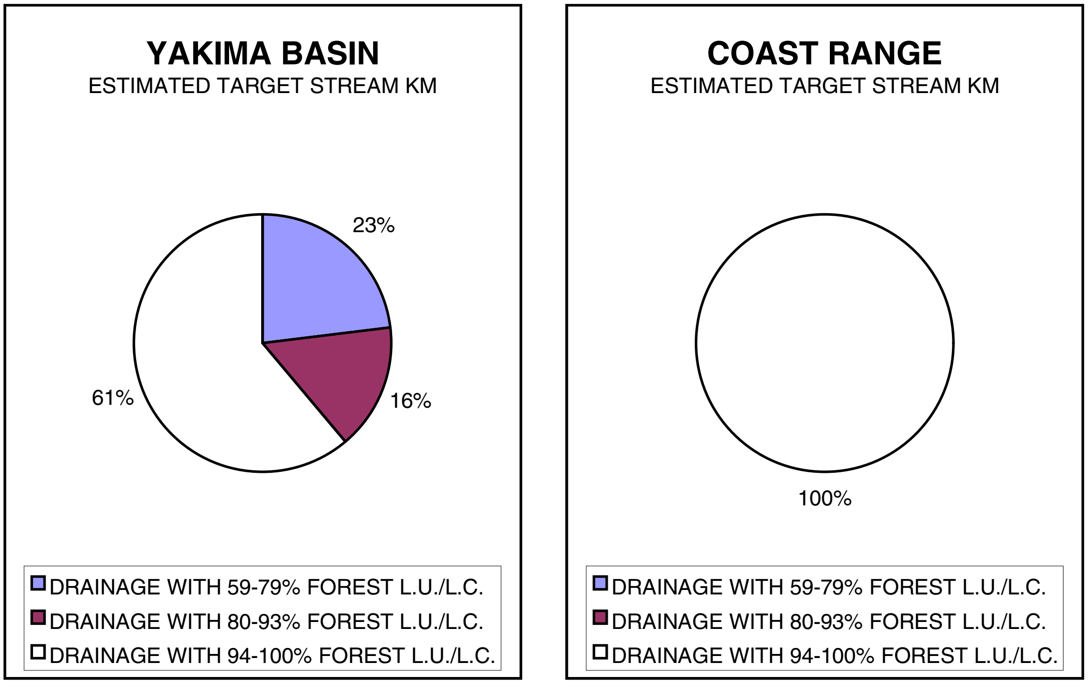


**Figure 8.** Estimated percent (length) of target stream populations, by region, with each of three levels of forest land use/land cover (L.U./L.C.) within each drainage.

**Agriculture**

There were five sites in the Coast Range that exhibited 1-2% agricultural land cover/land use in their drainages. Another site's drainage had 7% agriculture. We therefore estimated that 737 km (9%) of the Coast Range target streams had 1-7% agricultural land use/land cover.

The R-EMAP target streams analyzed did not occur in the highly agricultural portions of the Yakima Basin. Only one of the analyzed sites in the Yakima Basin had any agricultural land use/land cover (21% of the Cooke Creek watershed, WA780S). We estimated that 4 km (0.1%) of the Yakima Basin target streams had agricultural influence.

### Urban

Two sites representing 192 km (2%) of the stream population in the Coast Range had 1% urban land use/land cover in their watersheds. No urban land use/land cover was detected in the Yakima Basin.

### Point Source Discharges

Almost all target streams in either region were estimated to be without obvious point source influences. Based on the presence of only one NPDES discharge (in the Naselle River watershed, WA855S) among all watersheds analyzed in the study, we estimated 65 km (0.8%) of target streams in the Coast Range Ecoregion to have NPDES discharges.

## Water Quality

Summary statistics for the probability sample of water chemistry in each region are listed in Table 5. In either region the concentrations of constituents were relatively low. In large part, they were in concentrations lower than analytical detection limits (Table 6).

Results were compared between regions and with other ambient water quality data (Table 7). The data for each region were similar, with a few points worth noting:

- During their respective sampling seasons, the Coast Range tended to have slightly lower values for pH, conductivity, and alkalinity than the Yakima Basin.
- The Coast Range tended to have slightly higher anion (sulfate and chloride) concentrations.
- Data were comparable to ambient data from the upper main stem Yakima River (river miles 113.2-183.1), which has been described by Rinella and others (1992) as having small background concentrations of total phosphorus, total ammonia, dissolved nitrate-nitrite, and total suspended solids

The pH, conductivity, and alkalinity measures for all probability points are listed in Appendix L. We estimated that 104 km (3%) of target streams in the Yakima Basin were below 6.5, the lower limit to the water quality standard for pH. Sites that were below the pH standards occurred at moderate elevations (684 to 1061 m). There were 111 km (4%) of the Yakima Basin target streams that were estimated to be above 8.5, the upper limit to the pH standard. These were based on one sample site at 826-m elevation.

We estimated that 2,699 km (32%) of the Coast Range target streams would have failed the standards due to low pH. At Coast Range streams that exceeded the pH standards, conductivity values ranged from 18 to 97 µS/cm at 25°C and alkalinity values ranged from 4 to 59 mg/L. Sites in the Coast Range that exceeded the pH standards occurred at low elevations (29 to 114 m).

## Table 5.  Summary statistics for chemistry and habitat data among probability sites.

| | | | YAKIMA BASIN | | | | COAST RANGE | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | CODE | UNITS | MEAN | STD.DEV | MIN. | MAX. | MEAN | STD.DEV | MIN. | MAX. |
| Alkalinity | ALK | mg/L | 58 | 47 | 8 | 241 | 27 | 12 | 4 | 59 |
| Total suspended solids | TSS | mg/L | 3 | 4 | 1 | 16 | 4 | 12 | 1 | 81 |
| Dissolved organic carbon | DOC | mg/L | 2.1 | 1.1 | 1.0 | 4.7 | 2.6 | 2.2 | 1.0 | 10.0 |
| Ammonia | NH3 | mg/L | 0.01 | 0.00 | 0.01 | 0.02 | 0.02 | 0.03 | 0.01 | 0.20 |
| Nitrate-nitrite | NO23 | mg/L | 0.11 | 0.45 | 0.01 | 2.34 | 0.11 | 0.17 | 0.01 | 1.08 |
| Total phosphorus | TOTP | mg/L | 0.03 | 0.02 | 0.01 | 0.09 | 0.02 | 0.03 | 0.01 | 0.11 |
| Total persulfate nitrogen | TPN | mg/L | 0.19 | 0.62 | 0.01 | 3.27 | 0.23 | 0.20 | 0.04 | 1.19 |
| Chloride | Cl | mg/L | 1.4 | 2.5 | 0.2 | 13.4 | 4.2 | 2.0 | 0.7 | 9.7 |
| Sulfate | SO4 | mg/L | 3.8 | 7.2 | 0.7 | 37.6 | 4.6 | 4.5 | 0.8 | 22.7 |
| Water temperature | T | deg.C | 8.4 | 2.4 | 4.8 | 13.5 | 12.5 | 2.3 | 7.3 | 17.4 |
| pH | pH | pH units | 7.24 | 0.55 | 6.33 | 8.58 | 6.78 | 0.45 | 5.52 | 7.56 |
| Dissolved oxygen | DO | mg/L | 9.9 | 1.5 | 3.6 | 11.7 | 9.2 | 1.9 | 3.3 | 12.2 |
| Conductivity | COND | uS/cm at 25 deg.C | 124.8 | 110.9 | 18.0 | 600.0 | 76.9 | 25.6 | 29.6 | 138.8 |
| Std. Dev. Thalweg depth | SDDEPTH | cm | 10.5 | 5.6 | 1.4 | 26.5 | 18.5 | 12.2 | 1.4 | 45.9 |
| Std. Dev. (wetted width x thalweg depth) | SDWXD | cm x cm | 9869 | 19274 | 28 | 88224 | 18465 | 24530 | 28 | 107175 |
| Residual pool depth | RP100 | % | 6.6 | 4.0 | 0.2 | 17.8 | 13.7 | 11.4 | 0.2 | 47.7 |
| Percent coarse substrate | PCT_BIGR | % | 55.1 | 20.4 | 14.5 | 91.1 | 51.8 | 27.2 | 0.0 | 94.2 |
| Percent sand substrate | PCT_SA | % | 19.3 | 13.3 | 0.0 | 49.1 | 17.9 | 15.5 | 0.0 | 92.0 |
| Percent fine substrate | PCT_FN | % | 10.4 | 14.7 | 0.0 | 49.1 | 13.0 | 20.0 | 0.0 | 100.0 |
| Sum: % natural cover | XFC_NAT | % | 56.0 | 32.0 | 20.0 | 166.9 | 52.6 | 31.2 | 14.1 | 166.9 |
| Sum: % large cover | XFC_LRG | % | 17.0 | 14.8 | 0.7 | 63.9 | 20.8 | 18.9 | 0.0 | 75.5 |
| Sum: % large woody debris cover | XFC_LWD | % | 5.4 | 5.7 | 0.0 | 20.3 | 9.6 | 12.4 | 0.0 | 57.5 |
| Sum: % brush/small wood cover | XFC_BRS | % | 10.5 | 9.9 | 0.0 | 46.4 | 9.9 | 9.8 | 0.0 | 54.8 |
| Shade - mid channel | XCDEN MID | points | 11.8 | 4.5 | 1.2 | 16.8 | 12.2 | 4.3 | 1.2 | 17.0 |
| Sum: % riparian woody cover - 3 layers | XCMGW | % | 62.3 | 28.2 | 7.5 | 141.3 | 73.3 | 32.6 | 7.5 | 147.6 |
| Sum: % canopy | XC | % | 80.7 | 24.4 | 0.0 | 100.0 | 84.9 | 21.2 | 0.0 | 100.0 |
| Sum: % canopy+ understory | XCM | % | 77.9 | 24.1 | 0.0 | 100.0 | 83.2 | 21.2 | 0.0 | 100.0 |
| Human disturbance index - total | W1_HALL | score | 0.95 | 0.93 | 0.00 | 4.13 | 0.97 | 0.97 | 0.00 | 4.13 |
| Human disturbance index - forestry | W1_LOG | score | 0.37 | 0.38 | 0.00 | 1.30 | 0.58 | 0.59 | 0.00 | 1.97 |
| Percent view-to-sky | PCT_SKY | % | 31 | 26 | 1 | 93 | 27 | 25 | 0 | 81 |
| Big logs per kilometer | LOG BIG_KM | logs/km | 6.7 | 17.5 | 0.0 | 86.0 | 10.7 | 15.6 | 0.0 | 80.0 |
| Logs per kilometer | LOG ALL_KM | logs/km | 11.9 | 25.7 | 0.0 | 128.0 | 15.6 | 18.9 | 0.0 | 86.7 |

**Table 6. Estimated amount (length) of streams (by region) that had selected chemistry variables at concentrations below analytical detection limits.**

| Parameter | Yakima Basin | | Coast Range | |
|---|---|---|---|---|
| | Estimated Streams under the Detection Limit | | | |
| Carbon (DOC) | 214 km | 7% | 2,748 km | 33% |
| Phosphorus (TOT.P) | 796 km | 26% | 3,436 km | 41% |
| Nitrogen (TPN) | 296 km | 10% | 0 km | 0% |
| Ammonia (NH3) | 2,661 km | 88% | 5,943 km | 71% |
| Nitrate-Nitrite (NO2-NO3) | 2,570 km | 85% | 752 km | 9% |
| Sulfate (SO4) | 353 km | 12% | 613 km | 7 % |
| Suspended Solids (TSS) | 854 km | 28% | 3,723 km | 44% |

**Table 7. Comparative values for water quality data for ambient monitoring studies.**

| CODE | UNITS | R-EMAP Streams Yakima Basin | R-EMAP Streams Coast Range | Yakima River Main Stem | Precipitation Coastal | Precipitation Cascades | Rivers World Average |
|---|---|---|---|---|---|---|---|
| ALK | mg/L | 58 | 27 | 24-43 | | | |
| TSS | mg/L | 3 | 4 | 4-8 | | | |
| DOC | mg/L | 2.1 | 2.6 | | | | |
| NH3 | mg/L | 0.01 | 0.02 | 0.01 | 0.05 | 0.10 | |
| NO23 | mg/L | 0.11 | 0.11 | 0.03-0.13 | | | |
| TOTP | mg/L | 0.03 | 0.02 | 0.02-0.04 | | | |
| TPN | mg/L | 0.19 | 0.23 | | | | |
| Cl | mg/L | 1.4 | 4.2 | 2.2-4.6 | 0.3 | 0.3 | 5.8-7.8 |
| SO4 | mg/L | 3.8 | 4.6 | 3.1-3.4 | 0.5 | 1.0 | 8.3-11.0 |
| T | deg.C | 8.4 | 12.5 | 8.2-8.8 | | | |
| pH | pH units | 7.24 | 6.78 | 7.5-7.6 | 4.95 | 4.67 | |
| DO | mg/L | 9.9 | 9.2 | 10.9-11.1 | | | |
| COND | uS/cm at 25 deg.C | 124.8 | 76.9 | 62-114 | 8.8 | 12.3 | |

Yakima River, main stem (Rinella, McKenzie, and Furher, 1992).
Median of monthly data within river miles 113-183.1, during water years 1974-1981 (T, TSS, COND, and DO) and 1975 (Cl, SO4, ALK).
Precipitation, Coastal (NADP, 1998).
Hoh Ranger Station, Olympic National Park:
Mean of 6 months: July-September 1994-1995.
Precipitation, Cascades (NADP, 1998).
University of Washington Pack Forest, LaGrande:
Mean of 6 months: July-September 1994-1995.
Rivers, world average (Hem, 1985).

## Habitat

Summary statistics (Table 5) for the probability samples provided baseline information for each region. Several of the factors were rated relative to guidance in various documents (NMFS, 1996; Williams and Williams, 1997; WFPB, 1997): sediment concentration, large woody debris, and shade.

**Sediment**

The NMFS (1996) suggested that properly functioning streams of the Northwest should normally have streambed sediment concentrations of less than 12% fine particles (< 0.85 mm). In R-EMAP, particles were classified slightly differently; sediments were classified as< 0.06 mm and sand was classified as 0.06 mm to 2 mm. On average, R-EMAP streams (Table 5) showed percent fines (< 0.06 mm) alone to nearly exceed the NMFS recommendations for particles less than 0.85 mm. On average, R-EMAP stream bottoms were composed of roughly one-third fines/sand (particles < 2mm). Assuming that the NMFS guidelines are reasonable, the general quantity of fine/sand sediment in Coast Range or Yakima Basin target streams could therefore be described as unacceptably excessive.

**Large woody debris**

Most of the Yakima Basin wadeable stream population was estimated to be deficient of large woody debris, relative to federal guidance criteria. The National Marine Fisheries Service (NMFS, 1996) indicated that coastal Northwest streams east of the Cascade ridge (e.g., those in Yakima Basin), if properly functioning, should normally contain more than 20 logs (> 0.3 m diameter, > 11 m long) per kilometer of channel. The federal government (Williams and Williams, 1997) recommended that these streams should have over 32 logs this size per kilometer of channel. We estimated that Yakima Basin target streams had an average of about 12 logs (> 0.3 m diameter, > 15 m long) per kilometer of bankful stream channel. During May-July 1994-1995, approximately 2,126 km (74 %) of target streams in the Yakima Basin had fewer than 20 logs per kilometer; approximately 2,739 km (90 %) of target streams had less than 32 logs/km.

Most of the Coast Range wadeable stream population was estimated to be deficient of large woody debris, relative to federal guidance criteria. NMFS (1996) suggested that properly functioning streams in this region should have more than 50 logs (> 0.6 m diameter, > 15 m long) per kilometer of stream. The USFS/BLM (Williams and Williams, 1997) recommended that streams in this region should have more than 129 logs of this size per kilometer. We measured approximately 11 logs this size per kilometer of bankful stream channel. During July-October 1994-1995 approximately 8,096 km (96%) of Coast Range target streams had less than 50 logs/km. Approximately 8,416 km (100%) of the streams had less than 120 logs/km.

**Shade**

The Washington Forest Practice Board (WFPB, 1997) listed a set of "maximum allowable view-to-sky" values for non-glacial streams in Washington. The guidance numbers were adjusted based on:

- location east or west of the Cascade ridge,
- elevation, and
- water quality class (e.g., A or AA).

They intended to provide a way to evaluate the vulnerability of streams to exceeding the temperature criteria.

We estimated that 909 km (30%) of target streams in the Yakima Basin had percent view-to-sky in excess of the WFPB thresholds during 1994-1995. We estimated that 1,029 km (12%) of Coast Range target streams had excessive view-to-sky.

## Biology

One hundred eighty-seven benthic macroinvertebrate taxa were sampled during the project (Appendix M). This included 158 taxa in the Coast Range, 116 taxa in the Cascades, 112 taxa in the Eastern Cascades Slopes and Foothills, and 102 taxa in the Columbia Basin.

Thirty-six vertebrate species were captured during the project: 18 in the Yakima Basin and 26 in the Coast Range (Table 8). In the Yakima Basin, 4 of these species were amphibians while 14 were fishes. In the Coast Range, 8 of the vertebrate species were amphibians while 18 were fishes.

Gross external anomalies were not present among fish in R-EMAP samples. Among the 14 fish species captured in the Yakima Basin, Ecology captured one tolerant species, one non-native species, and two omnivorous/herbivorous species. Among the 18 fish species captured in the Coast Range, we captured only two tolerant species, one non-native species, and no omnivores/herbivores. Two of the species captured in the Yakima Basin and seven species in the Coast Range were those that include anadromous forms. Due to the paucity of relevant species, we decided not to calculate a multimetric index for fish assemblages.

**Table 8. Vertebrates identified in the Coast Range and Yakima Basin. The ecoregions were Coast Range (1), Cascades (4), Eastern Cascades Slopes and Foothills (6), and Columbia Basin (7).**

| | | | ECOREGIONS | | | | | |
|---|---|---|---|---|---|---|---|---|
| **SPECIES** | **COMMON NAME** | **FAMILY** | **1** | **1** | **4** | **6** | **7** | **4/6/7** |
| *Acrocheilus alutaceus* | chiselmouth | cyprinidae | | | | | | ** |
| *Ambyostoma gracile* | northwestern salamander | ambystomatidae | X | | | | | |
| *Ascaphus truei* | tailed frog | ambystomatidae | X | | X | X | | |
| *Bufo boreas* | western toad | bufonidae | X | | | | | |
| *Catostomus catostomus* | longnose sucker | catostomidae | | * | | | X | |
| *Catostomus columbianus* | bridgelip sucker | catostomidae | | | | | X | ** |
| *Catostomus macrocheilus* | largescale sucker | catostomidae | | * | | | | ** |
| *Catostomus platyrhynchus* | mountain sucker | catostomidae | | | | | X | ** |
| *Cottus aleuticus* | coastrange sculpin | cottidae | X | * | | | | |
| *Cottus asper* | prickly sculpin | cottidae | X | * | | | | |
| *Cottus beldingi* | Paiute sculpin | cottidae | | | X | X | X | ** |
| *Cottus cognatus* | slimy sculpin | cottidae | | | | | | ** |
| *Cottus confusus* | shorthead sculpin | cottidae | X | * | | | | ** |
| *Cottus gulosus* | riffle sculpin | cottidae | X | * | | | | |
| *Cottus perplexus* | reticulate sculpin | cottidae | X | * | | | | |
| *Cottus rhotheus* | torrent sculpin | cottidae | X | * | X | X | | ** |
| *Cyprinus carpio* | common carp | cyprinidae | | | | | | ** |
| *Dicamptodon copei* | Cope's giant salamander | dicamptodontidae | X | | | | | |
| *Dicamptodon tenebrosus* | Pacific giant salamander | dicamptodontidae | | | X | | | |
| *Gasterosteus aculeatus* | threespine stickleback | gasterosteidae | X | * | | | | ** |
| *Lampetra ayresi* | river lamprey | petromyzontidae | | * | | | | ** |
| *Lampetra richardsoni* | western brook lamprey | petromyzontidae | X | * | | | | ** |
| *Lampetra tridendata* | Pacific lamprey | petromyzontidae | X | * | | | | |
| *Lepomis gibbosus* | pumpkinseed | centrarchidae | | | | | | ** |
| *Lepomis macrochirus* | bluegill | centrarchidae | | | | | | ** |
| *Micropterus dolomieui* | smallmouth bass | centrarchidae | | | | | | ** |
| *Micropterus salmoides* | largemouth bass | centrarchidae | | | | | | ** |
| *Mylocheilus caurinus* | peamouth | cyprinidae | | * | | | | |
| *Novumbra hubbsi* | Olympic mudminnow | umbridae | X | * | | | | |
| *Oncorhynchus clarkii* | cutthroat trout | salmonidae | X | | X | X | | ** |
| *Oncorhynchus kisutch* | coho salmon | salmonidae | X | | | | | ** |
| *Oncorhynchus mykiss* | rainbow trout/steelhead | salmonidae | X | | X | X | X | ** |
| *Oncorhynchus tshawytscha* | chinook salmon | salmonidae | X | | | | | ** |
| *Prosopium coulteri* | pygmy whitefish | salmonidae | | * | | | | |
| *Prosopium williamsoni* | mountain whitefish | salmonidae | | | | | | ** |
| *Pseudacris regilla* | Pacific treefrog | hylidae | | | | | X | |
| *Ptychocheilus oregonensis* | northern squawfish | cyprinidae | | * | | | | ** |
| *Rana aurora* | red-legged frog | ranidae | X | | X | | | |
| *Rana cascadae* | cascades frog | ranidae | | | X | | | |
| *Rana pretiosa* | spotted frog | ranidae | | | | | X | |
| *Rhinichthys cataractae* | longnose dace | cyprinidae | X | * | X | | X | ** |
| *Rhinichthys falcatus* | leopard dace | cyprinidae | | | | | X | ** |
| *Rhinichthys osculus* | speckled dace | cyprinidae | X | * | X | X | X | ** |
| *Rhyacotriton kezeri* | Columbia torrent salamander | rhyacotritonidae | X | | | | | |
| *Rhyacotriton olympicus* | Olympic torrent salamander | rhyacotritonidae | X | | | | | |
| *Richardsonius balteatus* | redside shiner | cyprinidae | | * | | | X | ** |
| *Salvelinus confluentus/malma* | bull trout/Dolly Varden | salmonidae | X | | | | | ** |
| *Salvelinus fontinalis* | brook trout | salmonidae | X | | X | X | | ** |
| *Taricha granulosa* | roughskin newt | salamandridae | X | | | | | |

X - Vertebrates identified by the R-EMAP project.

* - Native, non-game fish identified from the Olympic Peninsula by Mongillo and Hallock (1997). This table does not reflect Mongillo and Hallock's recognition of the Salish sucker as a separate species from the longnose sucker (*Catostomus catostomus*).

** - Fish species identified from the Yakima Basin by Cuffney and others (1997).

We described baseline biological conditions for the regions using descriptive statistics (Table 5) and graphs of cumulative distribution functions (Figure 9 and Appendix N). Biological integrity (B-IBI) scores were similar between regions. Graphs for both regions were relatively linear. Therefore, we had no obvious inflection points (natural breaks in the curves) to serve as criteria. Instead, we visually chose the lower 25th percentile from Figure 9 to describe the impaired condition for each region. Based on these criteria 671 km of target streams in the Yakima Basin were impaired (B-IBI < 22); approximately 1,094 km of target streams in the Coast Range were impaired (B-IBI < 20).

For the Yakima Basin, we estimated that 1,574 km (52%) of target streams would yield no fish by our sampling methods and that 1,635 km (54%) of target streams would yield no salmonids. In the Coast Range, we estimated 1,515 km (18%) of the target streams would yield no fish and that 4,208 km (50%) would yield two species or less. We estimated that 2,693 km (32%) of the Coast Range target streams would yield no salmonids.

## Invertebrate Habitat in the Coast Range

Classification of sites by cluster analysis of macroinvertebrate riffle samples showed five clusters along a gradient of inferred impact. One cluster was identified as "unimpaired", another as "severely-impaired", and three others as "moderately-impaired". Discriminant analysis separated all five identified groups by their habitat characteristics (Wilkes Lambda < 0.001). All nine variables tested were significant in separation of groups except for "shade in mid-channel" (XCDENMID). A biplot of the site scores from the first two discriminant functions shows a separation between the "unimpaired" and "severely-impaired" sites (Figure 10). The habitat variables that best separated the groups on the first canonical axis were substrate size and amount of woody debris. Residual pool depth (RP100), a measure of habitat complexity, was best at separating groups along the second axis.

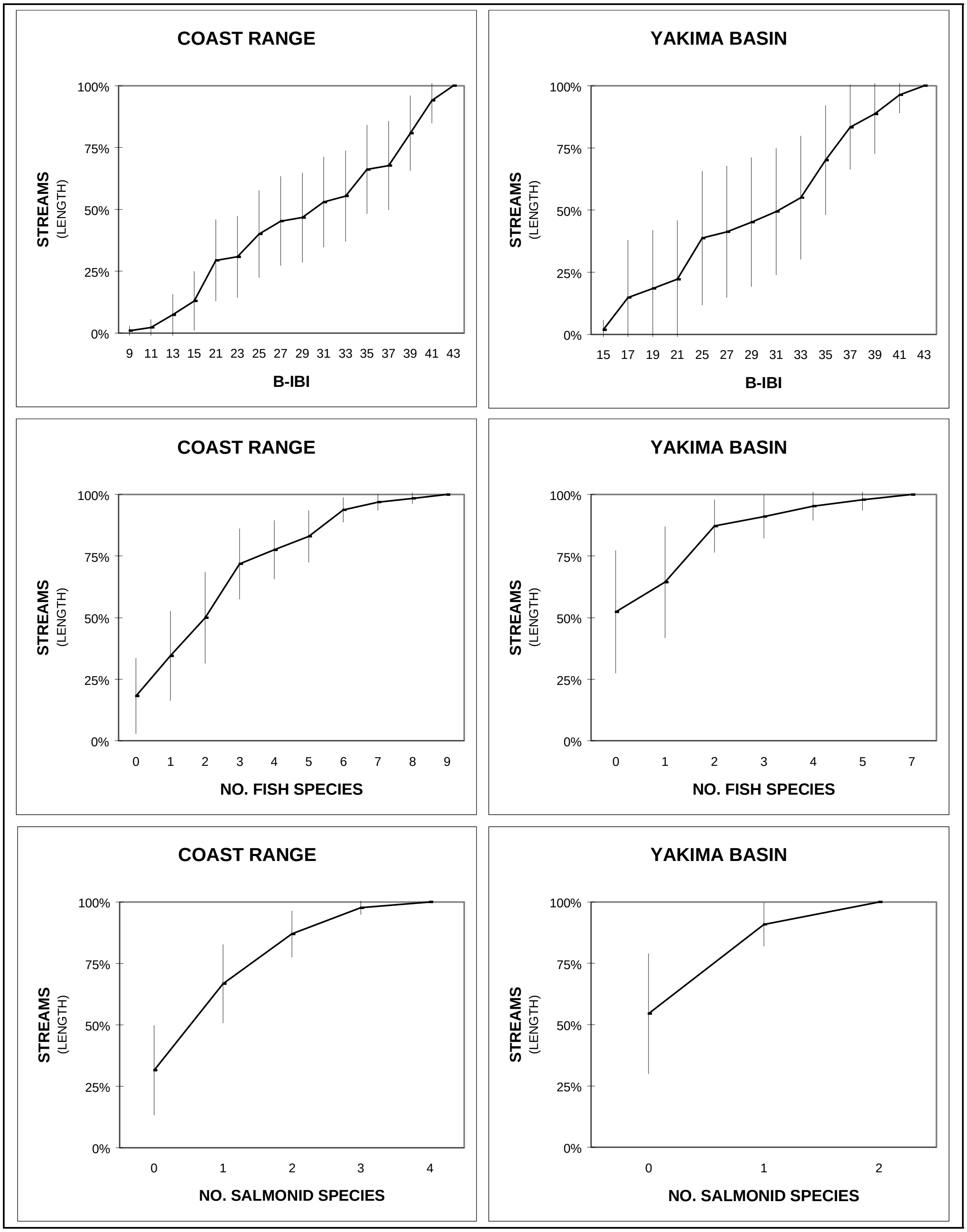


**Figure 9.** Cumulative distribution functions of regional stream biological condition scores. Vertical bars indicate 95% confidence intervals (not calculated where percentage of streams = 100%).

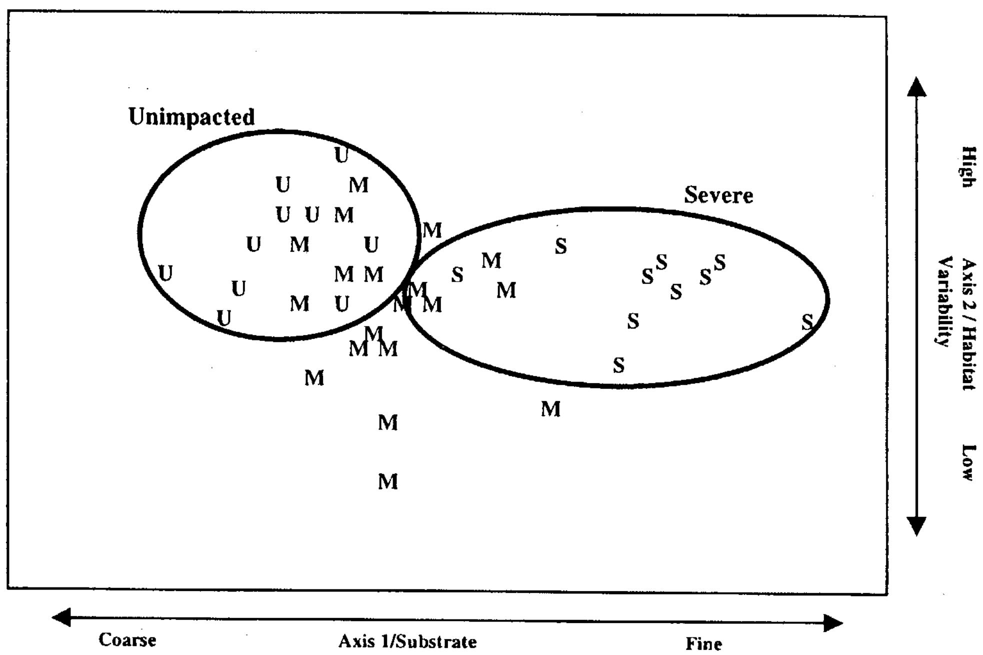


**Figure 10.** Plot of Coast Range habitat data from the first two discriminant functions. Axis 1 measures substrate composition and axis 2 measures habitat variability. Circles illustrate the major disturbance clusters from the macroinvertebrate classification. Sites are designated by letters (U = unimpaired; M = moderately impaired; S = severely impaired).

# Discussion

## Stream Conditions and Land Uses

### Status

We described stream ecological condition at the regional scale using water quality, habitat, and biology data within the context of probability sampling. This provided a "snapshot" overview of small stream conditions in the Yakima Basin and Coast Range for 1994-1995. The status can be monitored to detect regional trends.

Target streams (first- through third-order, flowing, wadeable) in the two regions were similar to each other in a number of respects. The percentage of biologically impaired streams (based on the Benthic Index of Biological Integrity) was estimated to be approximately 25% in both regions. Streams in both regions also were estimated to have few fish species present, too few to make assessments primarily based on the fish assemblages.

Watershed land use/land cover (based on 1974 data) above sites in either region was nearly all forest (Figure 8), with almost no urbanization, agriculture, or grazing. This was reflected in the descriptions of the regional stream conditions. There was a lack of chemical habitat effects (e.g., pollutants, nutrients, or fish body abnormalities) that have often been seen in agricultural or urban settings (Allan, 1995; Boward, 1996; May and others, 1997; Baumann and others, 1987). If we assumed that federal guidance criteria (NMFS, 1996; Williams and Williams, 1997) were reasonable for these target streams, then there was excess sediment and deficient large woody debris in both the Yakima Basin and the Coast Range. If we assumed that guidance criteria (WFPB, 1997) were reasonable, then there was deficient shade in about one-third of the streams in the Yakima Basin. These types of physical habitat effects have been associated with human land use settings such as timber management (WFPB, 1997; Meehan, 1991; MacDonald, 1991).

Physical habitat components such as sediment size composition, amount of large woody debris, and stream channel complexity have often been associated with the status of fishes (WFPB, 1997; Meehan, 1991; Stouder and others, 1997). We demonstrated that these factors also were related to the biological integrity of invertebrate communities in the Coast Range (Figure 10).

## Missing Information

### Land Use

Detailed, contemporary land use analysis using Geographic Information Systems (GIS) might have helped to discern natural disturbances from human causes of habitat degradation; this was missing due to limitations on the scope of the project.

### Agricultural Effects

Agriculture has a profound impact on water quality, notably within the lower Yakima Basin (Joy and others, 1996; Joy and Patterson, 1997; Ecology, 1997). We had hoped to provide some evaluation of agricultural impacts on surface waters, especially in the Yakima Basin. This was not possible when limiting site selection to perennial first- through third-order streams in the entire basin. The lower Yakima Basin was mostly located within the Columbia Basin ecoregion, whereas the R-EMAP streams were mostly located in the other two ecoregions. We concluded from this that the ecoregion provides a useful classification for evaluating specific land use practices. For example, if we had selected streams only from the Columbia Basin ecoregion portion of the Yakima Basin, we would have been better able to address agricultural influences. Yakima Basin watersheds that might have included agricultural land uses would likely have been found above ephemeral or intermittent streams, regulated canals or ditches, or larger-order rivers at lower elevations. New methods would need to be developed for evaluating these types of resources.

### Zero-order Streams

We were unable to evaluate the headwater streams (perennial, intermittent, or ephemeral) that do not appear on 1:100,000-scale maps. This was significant, because these headwaters are perhaps the largest (in terms of stream length or drainage area) lotic resource in the state. For example, the Washington Department of Natural Resources Habitat Conservation Plan (WADNR, 1997) reported that Forest Practice Rules-Type 5 streams (headwaters) comprise 90% of the stream network among five western Washington planning units.

# Biological Criteria Development

Biological criteria (biocriteria) are expressions that describe the biological integrity of aquatic communities inhabiting reference waters of a given stream class (EPA, 1990). We tested just one of various ways to develop biological criteria. There have been other successful strategies. We hoped that our approach would not only provide predictable results for invertebrate or fish community assessments, but would also be simple enough to discuss clearly. We believed that an *a priori* approach to classification, coupled with a multimetric assessment technique, would satisfy our simplicity requirement. The results were mostly predictable and repeatable in spite of problems with our sampling methods.

## Classification

### Grouping Sites

All approaches depend upon proper classification. We chose an *a priori* approach because this has been successful in other studies (Gerritsen and Kwon, 1998). The specific factors and variables that we deemed important were debatable. For example, although we chose ecoregion, size (wetted width), and geomorphology (sinuosity, channel confinement, and slope) as factors on which to classify sites, other factors or variables might be worth testing. The Oregon Department of Environmental Quality (ODEQ) explored R-EMAP Coast Range data and concluded that macroinvertebrate communities could be classified according to latitude/longitude and elevation (Canale, personal communication). Researchers in the Coast Range (Mongillo and Hallock, 1997) and in the Yakima Basin (Pearsons and others, 1996) have related the number of fish species to site elevation (an inverse relationship). We chose wetted width as a way to classify size because we thought it would reflect the actual conditions experienced by the biota. Others have used watershed area (e.g., ODEQ) or stream order (e.g., Fausch and others, 1990).

### Rating Sites

*Physical Habitat*

Based on the lack of chemical effects, it was apparent that physical habitat was the key issue affecting site quality of first- through third-order streams in these regions. It was therefore appropriate to develop a habitat quality index (HQI) based on physical data.

We concluded that it would be inappropriate to classify habitat quality subjectively whenever quantifiable alternatives are available. Our subjective habitat quality assessment results were extremely different from our measured results (Figure 4). Other authors (Ralph and others, 1991; Ralph and others, 1994; Roper and Scarnecchia, 1995; Pool and others, 1997) have discussed problems with calculating subjective habitat descriptions such as pool frequency.

The four HQI metrics were good ones. They were all on a list of nine metrics selected by Drake (1998) from over 90 developed by Kaufmann and others (1998). He used principal components analysis (PCA) to reduce the list to 20, and correlation analysis with biological data to reduce the list to nine. Data were from 17 Oregon Coast Range reference sites.

Drake's metrics are listed below with **bold** type for members of our HQI:

- Percent sand + Percent fines,
- **Percent coarse substrate**,
- Percent canopy,
- **Shade - mid channel**,
- **Fish cover from big objects**
  (Drake's metric included cover from undercut banks; ours did not),
- Human disturbance index - agriculture,
- Residual pool depth,
- **Standard deviation of (thalweg depth x wetted width)**, and
- Percent fast water (riffle/run/rapid/cascade/falls)

*Missing Information from HQI*

The habitat quality index (HQI) was incomplete in several respects. It did not include a few of the metrics that were listed by Drake (1998). It did not address barriers or impediments to fish migration. It did not directly measure human influences on habitat quality.

The Pacific Northwest Salmon Habitat Indicators Workgroup of seven government agencies (Green Mountain Institute, 1998) described a set of four primary components to physical habitat for Northwest streams: sediment, stream morphology, land/water interaction, and impediments/barriers. The HQI addressed the first three of these elements, but not the last. Examples of impediments/barriers that we did not evaluate were in the Yakima Basin. These included Bonneville Dam, The Dalles Dam, John Day Dam, McNary Dam, Prosser Dam, Roza Dam, Ellensburg Dam, Cle Elum Dam, and numerous diversions on most streams in the Kittitas Valley, e.g., Cooke, Naneum, and Manashtash Creeks (Quinn, 1991, Hindman and others, 1991).

We evaluated land use/land cover information, but with old and coarse data. This was useful for making statements about regional condition, but not so for site-specific evaluations. The HQI metrics typically decrease with increasing human influence, but we would need to gather recent, detailed land use data to discern human influence from natural disturbance.

*The Need for Reference Sites*

Selection of reference sites is key to the success to biocriteria development (Gibson, 1996). None of our stream classes had enough members or had been sampled through a sufficient time-scale to make definitive statements about reference conditions. We concluded, as others have (Rahr and others, 1998; Bisson and others 1997) that society should find, maintain and monitor reference basins (e.g., fifth-order or sixth-order drainages) on a long-term basis. We tried rating R-EMAP sites subjectively, with poor results (Figure 4). We have therefore advocated the use of quantitative methods for selecting reference sites.

Hawkins (1998) described a reference site project in forests of the Coast Range and Cascades ecoregions. Researchers from Utah State University and the National Aquatic Monitoring Center (U.S. Bureau of Land Management) have sampled invertebrates from over 100 reference sites so far, in an attempt to describe natural expectations. They have been using methods that are comparable to the Washington protocols (Plotnikoff, 1994) and others. This will likely provide important information.

In some regions natural conditions have already been decimated. Hughes (1995) advocated using the historical record for these situations. Hughes and others (1998) used historical fish assemblage information to describe reference conditions in the Willamette Valley, Oregon. Invertebrates and most other assemblages have not been historically documented to the extent that fishes have been. Therefore this technique would be difficult to apply where there were naturally few fish species. In these situations we should protect and monitor the least disturbed of the sites available and adjust expectations upward as conditions improve.

## Assessment

We found the invertebrate assemblages to provide useful information for assessing biological integrity. Fish assemblage sampling provided supporting information, but in itself was not very useful at describing biological integrity among the small, often mountainous streams in the Yakima Basin and Coast Range. Fish assemblage information could be more effective at describing biological integrity when applied to systems with more native resident species. These would include larger, lower elevation streams or drainages that were free from recent glaciation.

### Macroinvertebrates

The benthic index of biological integrity (B-IBI) was effective. However, R-EMAP invertebrate sampling should be modified to become more representative of stream reaches, less variable, and more comparable to other studies.

The B-IBI decreased (as predicted) with decreased habitat quality (Figure 7). Component metrics also decreased (Table 4), with exceptions in large streams and in a stream class with only four sites. One metric (% predators) was unpredictable in three of the stream classes. These problems were likely related to (1) difficulty assessing habitat quality (discussed above) and (2) inappropriate sampling and processing techniques.

Sampling was performed at established transects, and over half of the component kicks were required to be taken from the margins of the stream. Therefore, the type of habitat sampled was variable and not necessarily representative of the reach. Marginal habitat was often neither "riffle" nor "pool" habitat, but consisted of eddies or slow and shallow water. The margin sampling might have been related to the poor response of the "% predator" metric. About 40% of the predators in the Washington database express semi-voltine (long-lived) life history traits. Long-lived taxa would be less likely to occur in changing environments (e.g., the margins) than in stable habitats deeper in the channel. Therefore, we would be likely to miss predators with margin sampling.

We created another problem by maintaining separate composite samples for "riffle" and "pool" samples. Although we used a standard sub-sampling technique in the laboratory, the number of kicks included in each composite was variable (between 1 and 11). A different effective area of stream bottom was therefore examined from each reach.

Four metrics displayed relatively high seasonal variability, compared to between-year variability (Figure 6). A shorter sampling season might have improved their responses to habitat quality.

It was also unfortunate that the R-EMAP samples were collected differently from those of existing studies. Although regional stream macroinvertebrate surveys were lacking in the Coast Range, there have been a number of surveys in the Yakima Basin (Cuffney and others, 1997; Carter and others, 1996; Plotnikoff, 1995; and Plotnikoff, 1992). Our sampling methods were different, so direct comparisons were impractical. It is unfortunate that R-EMAP sampling was divergent from state protocols (Plotnikoff, 1994). The R-EMAP procedures and state methods were very close, except for two key elements: compositing methods and sampling locations. If we had collected an equal number of kicks for each composite and collected from "classic riffles" and "classic pools" (rather than from margins and transects) we would have had data that was more representative of each reach and more comparable to existing information.

**Fish**

The fish assemblage information, based on R-EMAP techniques, did not provide much information for evaluating biological integrity of streams. This was mainly because there were few resident fish species captured. Anadromous fishes added confounding information to the biological assessment because they could be affected by conditions outside the drainage basins (i.e., the ocean or migratory corridor).

First- through third-order wadeable streams in our study regions naturally consisted of few resident fish species. McPhail and Lindsey (1986) listed only 61 native freshwater fish species within the entire Northwest (an area west of the Continental divide, extending from the Columbia drainage north to the Stikine River drainage in Canada); they attributed this principally to glaciation. During the Pleistocene epoch over three-fourths of the region was covered in ice, and during the last (Fraser) glaciation, mountain glaciers occurred throughout the area. Mongillo and Hallock (1997) surveyed 253 sites on the Olympic Peninsula and identified only 19 species of resident native non-game fish (Table 8); their samples averaged just two species per site. The vast majority of the species collected were found at elevations below 200 m.

R-EMAP fish community results for the Yakima Basin were different than those reported by Cuffney and others (1997). They collected 17 species in the Yakima Basin that we did not detect (Table 8). Many of the species that they collected (e.g., mountain whitefish, chislemouth, common carp, threespine stickleback, northern squawfish, and members of the centrarchidae family) were those known to be more prevalent among larger streams or at lower elevations. They sampled among larger, deeper, lower segments than we did. Cuffney and others also sampled during October to November rather than our May to July sampling season. This could account for some of the difference in catches of migratory species.

# Applicability of EMAP Methods

## State Implementation of the Clean Water Act

EMAP and probability sampling seem well adapted to fulfilling portions of the Clean Water Act (U.S. Government Printing Office, 1988), which has an explicit objective to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters".

### 305(b) Report

Section 305(b) of the Clean Water Act requires Washington State to monitor water quality and report its status every two years. The report is expected to include statements about the proportion of Washington's stream length that supports or fails to support the beneficial uses as specified in the water quality criteria (173-201A WAC).

Sampling for 305(b) has mostly been conducted at sites that were thought to be impaired. This created two major problems: (1) The picture of status was likely skewed toward greater impairment than was real, and (2) there was no way to track trends, except at specific sites.

Using the R-EMAP probability design we were able to report the proportion of regional stream length that was of a given status. We defined status levels in terms of chemical, physical, and biological integrity of the regions' target streams. We used graphs of cumulative distribution functions to depict baseline data for the regions. For illustrative purposes, we used graphs for invertebrate biological integrity and for richness of fish and salmonids, but we could have used other (e.g., physical and chemical) metrics. Trend detection might later be derived from subsequent sampling among probability sites in either region. Leftward shifts in the B-IBI curves would indicate deteriorating regional stream health. Leftward shifts in the richness curves would indicate loss of species.

Reluctance toward use of probability sampling has centered on the difficulty and cost of access. Chemical monitoring for 305(b) has been done on a monthly basis and thus would be costly to accomplish among random sites. A benefit of monitoring habitat and biology, however, would be that sampling on a once yearly cycle might be adequate. Biological status, for example, is a reflection of conditions occurring across the life span of organisms, not just at the time of sampling. Furthermore, we have determined that there were few impediments to access among random sites in either the Yakima Basin or the Coast Range (Figure 3) during the R-EMAP sampling season.

**Beneficial Uses**

As defined in Washington's water quality criteria (173-201A WAC) beneficial uses have referred to activities such as swimming, fishing, aquatic life habitat, and agricultural or domestic water supplies. Each of Washington's four stream classes (AA, A, B, C) has a specific list of beneficial uses that are required to be protected. Washington has proposed restructuring the water quality standards toward a use-based approach (Ecology, 1998). Under this scheme, beneficial uses would be assigned to each stream, rather than to classes of streams. By directly measuring the aquatic life and habitat within streams, R-EMAP could provide valuable data to help identify the most appropriate beneficial uses of streams.

**Criteria Design/Evaluation**

R-EMAP was useful for the development of biological criteria. We gained evidence that macroinvertebrate assemblages can provide predictable measures of human disturbance and that the Benthic Index of Biological Integrity (B-IBI) might be useful for assessing biological integrity. We learned the need for identifying and monitoring more references sites. The project also helped us to discover ways to improve invertebrate sampling techniques.

The probability design provided an objective way to evaluate water quality criteria. For example, it would be unreasonable to expect pH to measure within the criteria (6.5 to 8.5 pH units) among many of the small streams of the Coast Range. We found approximately one-third of the target streams there to measure below pH 6.5 during summer midday conditions, even though there was no evidence of point sources or airborne sources of acidity.

## Other Public Benefits

The R-EMAP project provided various other public applications.

### University Research

Christina Bradley (Idaho State University) has been researching effects of sedimentation on invertebrates using data from R-EMAP and other projects. The National Council of the Paper Industry for Air and Stream Improvement (NCASI) sponsored her work. Tracy Farrell (The Evergreen State College) evaluated the habitat of harlequin ducks (*Histrionicus histrionicus*) using R-EMAP data (Farrell, 1997). Jenna Scholtz (University of Washington) has used R-EMAP data in the project titled Stream Temperature Organizational Database for the Eastern Cascades (STODEC). She has been evaluating biological and physical attributes of streams in the Wenatchee National Forest relative to recorded temperature information from various sources.

### Enhancing the Species Distribution Records

The broad-scale focus of R-EMAP has helped us to enhance the distribution records for biological taxa within the state. We added invertebrate records and specimens to Ecology's collection. We added fish information to the records maintained by the Washington Department of Fish and Wildlife and helped to expand the list of catalogued fish specimens that now reside at the University of Washington Fish Collection.

### Building the Biological Assessment Knowledge Base

R-EMAP has helped to build the knowledge base of Ecology employees and other citizens. The authors and many others who participated learned much about biological assessment.

# Conclusions and Recommendations

## Site Access and Logistics

### Conclusions

- One-third of sites selected in either region could not be sampled for several reasons:
  - ◊ Some sites were inaccessible due to spring conditions (snow, mud, high flows),
  - ◊ Permission to access adjacent property was denied by some landowners, and
  - ◊ Some sites were not target streams but were wetlands, ponds, sloughs, dry channels, or too deep to wade.
- Target streams were almost all in forest (land use/land cover) and predominantly in mountains.
- Sampling was difficult with three persons, but efficient with four or more.

### Recommendations

- For probability sampling in mountainous regions, select and perform reconnaissance on 50% more sites than are needed for sampling.
- For R-EMAP field sampling, use a crew of four or more persons.
- Avoid R-EMAP sampling during spring in mountainous regions.

## Biological Criteria Development

### Conclusions for Classification

- Classification of sites using an *a priori* approach (ecoregion, wetted width, and geomorphology) was simple and did not change across seasons or years.
- We had few sites within each class; therefore we had few reference sites.
- The habitat quality index (HQI) was repeatable; it had little variability across years or within years.
- Selection of the four HQI metrics was in agreement with more exhaustive analyses by Drake (1998).
- The HQI was incomplete, missing information about:
  - ◊ Impediments/barriers to migration,
  - ◊ Direct measures of human influence, and

  - ◊ Other promising metrics suggested by Drake (1998).

- Subjective estimates of habitat quality were extremely poor.

## Recommendations for Classification

- Classify sites using an *a priori* approach:
  - ◊ After closely examining the data, and
  - ◊ After identifying a sufficient number of reference sites.
- Include the four metrics of the HQI in a final R-EMAP habitat index.
- Supplement the four metrics of the HQI with additional metrics such as:
  - ◊ Barriers/impediments to fish migration,
  - ◊ Detailed, contemporary measures of land use characteristics, and
  - ◊ Some of the metrics suggested by Drake (1998).
- Using quantitative information, find more reference sites.

## Conclusions for Assessment

**Invertebrates**

- The benthic index of biologic integrity (B-IBI) was simple and responded predictably to changes in habitat quality, except that:
  - ◊ Several metrics were unpredictable within the two stream classes with few sites.
  - ◊ The metric "percent predators" was unpredictable among three of six stream classes.
- Several metrics displayed relatively large within-year variability.
- The R-EMAP invertebrate sampling methods were incomparable to those of other studies and could not be standardized for effort.

**Fish**

- There were few resident fish species in R-EMAP streams because:
  - ◊ R-EMAP streams were often located higher than where most species reside.
  - ◊ The number of resident species for these regions is naturally small.
- Metrics used by Cuffney and others (1997) in lower portions of the Yakima Basin could not be applied to R-EMAP target streams, which were mostly mountainous.

## Recommendations for Assessment

**Invertebrates**

- Measure biological integrity using the B-IBI.
- Modify the invertebrate sampling method to:
  - ◊ Keep sampling away from margins,
  - ◊ Collect and analyze an equal sample area from each stream, and
  - ◊ Make sampling techniques comparable to Ecology's methods and others.
- Minimize the length of the sampling season.
- Measure more reference sites.

**Fish**

- For first- through third-order streams in the Coast Range or Yakima Basin, do not use fish as a primary method of assessing biological integrity.
- Consider fish for measuring biological integrity in relatively species-rich systems.
- Use fish data as evidence to support biological integrity data supplied by invertebrate sampling.

# Regional Status

## Conclusions

**Both regions**

- Stream drainages were almost entirely forest (land use/land cover).
- Streams were apparently not affected by chemical or point source insults.
- Average stream conditions reflected low levels of chemical constituents (e.g., nutrients, organics, or ions).
- Average stream conditions reflected excessive sand or fine sediment, relative to guidance criteria.
- Average stream conditions were deficient in large woody debris relative to guidance criteria.
- Streams had few fish or salmonid species.
- About 25% of the stream kilometers were deemed biologically impaired. (The lower $25^{th}$ percentile of B-IBI scores was chosen to describe the impaired biological condition for linear cumulative distributions.)

**Yakima Basin**

About one-third of the stream length in the Yakima Basin was deficient of shade, relative to guidance criteria.

**Coast Range**

- About one-third of the stream length in the Coast Range has pH below the range allowed by Washington water quality standards.
- Invertebrate communities clustered according to physical habitat measurements, with strong influences from:
  - ◊ Substrate size
  - ◊ Amount of large woody debris
  - ◊ Residual pool depth

## Recommendations

- Monitor biological integrity of streams in these regions using invertebrates.
- Monitor habitat condition of streams in these regions using physical habitat information, including:
  - ◊ Sediment concentration by size class,
  - ◊ Amount of large woody debris,
  - ◊ Residual pool area,
  - ◊ Shade, and
  - ◊ Temperature.
- Monitor regional stream chemistry by focusing on:
  - ◊ Nutrients,
  - ◊ Organics, and
  - ◊ pH (with related variables such as alkalinity and conductivity).

# Applicability of R-EMAP

## Conclusions

- EMAP-derived methods allowed us to gauge the status of chemical, physical and biological conditions and report them in terms of stream length.
- The R-EMAP project helped to describe some of the aquatic taxa using streams and their chemical and physical habitat.
- R-EMAP provided useful information for the development of biological criteria.

- The R-EMAP project demonstrated how the pH water quality standard might be unreasonably high, relative to natural conditions in the Coast Range.
- Various researchers and institutions have used R-EMAP data.
- The R-EMAP project has provided a vehicle for participants to gain knowledge about biological assessment techniques.

## Recommendations

- EMAP-derived methods should be used for reporting status and trends under the Clean Water Act, Section 305(b).
- Data generated from EMAP-derived methods should be used to help define the beneficial uses of streams.
- EMAP-derived methods should be used to help objectively design and evaluate water quality standards, including biological criteria.
- R-EMAP data should be made easily available to the public.
- The state should continue its involvement with R-EMAP or other funding sources that allow expansion of public knowledge of biological assessment.

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# Appendices

**APPENDIX A.**

# Biological Assessment of Wadable Streams in the Coast Range Ecoregion and the Yakima River Basin

## Final
## Quality Assurance Project Plan

by
Glenn D. Merritt
September 13, 1994

Washington State Department of Ecology
Environmental Investigations and Laboratory Services
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**Approvals:**

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# 1.0 Purpose of this Document

This document is intended to focus planning and promote communication among the Staff responsible for implementing this project. It describes the objectives of the project and the procedures to be followed to ensure that the data generated will serve those objectives.

# 2.0 Project Description

## 2.1 Historical Information

This project is part of the Regional Environmental Monitoring and Assessment Program (R-EMAP), which is a component of the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP).

### 2.1.1 EMAP

The EMAP program was initiated by the EPA's Office of Research and Development, In conjunction with other Federal agencies, to assess the status and trends of the Nation's ecological resources. EMAP was designed in 1988, in response to EPA's Science Advisory Board recommendation for increased research, monitoring, and assessment of our Nation's natural resources. The program was initiated in 1990 and is presently conducting pilot and demonstration projects in seven resource categories (Agroecosystems, Arid Ecosystems, Estuaries, Forests, Great Lakes, Surface Waters, and Wetlands). EMAP examines a sample of sites within each resource to make inferences about status and trends of the resource population; the "probability" sites comprising the sample are chosen using a stratified-random process. EMAP was designed to make assessments at the regional, state, or smaller levels. Therefore the EMAP approach is increasingly being used by the EPA Regional Offices and some states to assess ecological resources in high interest areas.

### 2.1.2 R-EMAP

R-EMAP is coordinated through EPA Regional Offices, other Federal agencies, and States. Its objectives are to:

• Evaluate and improve EMAP concepts for state and local use;
• Assess the applicability of EMAP indicators at differing scales; and
• Demonstrate the utility of EMAP for resolving issues of importance to EPA Regions and States.

REMAP proposals are submitted to EMAP by the EPA Regional Offices for studies on small geographic scales and time frames. All proposals undergo a competitive peer-review process before being approved for funding; this project has already undergone that process (EPA, 1993).

### 2.1.3 R-EMAP in Washington State

Two priority areas in the Northwest have been designated by EPA for application of the EMAP approach. EPA has awarded R-EMAP funding to the Washington State Department of Ecology (Ecology) and to the Oregon Department of Environmental Quality for the following project:

> " Biological Assessment of Wadable Streams in
> the Coast Range Ecoregion and the Yakima River Basin."

## 2.2 Project Objectives

The objectives of Ecology's portion of R-EMAP are to:

- Determine the ecological condition (inhabitants and habitat) of the first-order through third-order streams (Strahler definition of stream-order; Small and Witherick, 1986) of the Yakima River Basin and Washington's portion of the Coast Range Ecoregion;

- Determine the relationship between the ecological condition of these streams and the predominant land uses of the watersheds (e.g., agriculture, grazing, and forestry);

- Provide information for the development of water quality biological criteria in Washington State using indices based on fish/amphibian and invertebrate taxa assemblage information; and

- Determine the applicability of EMAP-derived methods for assessments of ecological condition within Washington State streams.

The ecological condition of a stream is the status of its biota and habitat. For R-EMAP its is based on the relative abundances of fish/amphibian species, the relative abundances of macroinvertebrate taxa, and their physical and chemical habitat.

## 2.3 Site Information and design

During May through October 1994, Ecology will examine 44 stream reaches in the Coast Range Ecoregion and 23 stream reaches in the Yakima River Basin (Figure 1). Most of these reaches are probability sites, chosen to represent the population of reaches within each of the three stream-order classes for each of the two regions. Additional subjectively selected sites will also be sampled.

The probability sites were selected by EPA using the EMAP stratified-random method (EPA, 1991) and a computer algorithm. The 1994 sites for R-EMAP in Washington are listed in Table 1. The EPA has set a target of 30 probability sites to be sampled in the Coast Range Ecoregion and 15 probability sites to be sampled in the Yakima River Basin. They have selected nine extra sites in the Coast Range and four extra sites in the Yakima River Basin. This provides for sites which, upon reconnaissance, may be discovered to be either inaccessible or which cannot be safely sampled.

Nine reference sites (Table 2) have been "hand-selected" by Ecology, based on subjective opinions of various other scientists. These sites are intended to represent the most natural biological conditions for similar stream types within a zone of consideration (e.g., ecoregion or watershed management area). None have likely avoided human influence, but they may be the least influenced of those streams accessible to us.

The five reference sites in the Washington Coast Range Ecoregion were selected from a list of candidates suggested by Theile, Kiilsgaard, and Omernik (1992). These include representation of four sub-ecoregions, three watershed management areas, and the Olympic Rainshadow.

Four reference sites in the Yakima River Basin were chosen to provide representation of three ecoregions and three watershed management areas. Selections for three of these sites (Y40, Y41, and Y42) were based on information from Ecology's Ecoregion Bioassessment Pilot Project for Timber/Fish/Wildlife (Plotnikoff, 1992). Selection of the fourth site (Y46) was based on consultation with Yakima Nation scientists (Jennings, 1994).

During 1995, another set of stream reaches will be selected for sampling using the EMAP probability design (at least 30 in the Coast Range and at least 15 in the Yakima Basin). To assess inter-annual variability, a subset of these will be sites already sampled in 1994. Length of a stream reach will be approximately 40 wetted channel widths; it will be no less than 150 meters. No more than one stream reach is expected to be sampled within a day.

Ten percent of the sites scheduled for 1994 will be resampled during the same year to assess seasonal sampling variability. A systematic timing of resample dates was used to develop the schedule. Three sites will be replicated in the Yakima basin; replication will occur at 1-, 3-, and 5-week intervals. Four sites will be replicated in the Coast Range Ecoregion; replication will occur at 7-, 9-, 11-, and 13-week intervals.

We will examine stream conditions using the following indicators developed by the EMAP-Surface Waters Program:

- Macroinvertebrate assemblage (kick sampling)
- Fish assemblage (electrofishing and seining)
- Physical habitat
- Water chemistry

The fish assemblage indicator will also use amphibian species information for specimens which are incidentally captured during fishing operations.

Additionally, land uses within the study areas will be examined using existing aerial photography or Geographic Information System (GIS) information.

## 2.4 Schedule

The project schedule for state fiscal years 1994-1996 is shown in Table 3. There are Three products scheduled for delivery. An annual biological data report will be delivered to EPA during May 1995; another will be delivered in May 1996. These will be in electronic format (e.g. Lotus files). Also, a completion project report will be prepared to examine issues associated with variability and to associate land use impacts with stream condition. It will examine the relative variability of metrics within and among streams and attempt to make associations between land use patterns and stream health. It will also make recommendations related to long-term issues of Ecology's Environmental Investigations and Laboratory Services (EILS) Program, such as the development of biocriteria and future monitoring needs.

The 1994 sampling schedule is depicted in Table 4. The schedule is somewhat flexible and may be altered due to inclement weather, equipment breakdown, access permission denial, or other unanticipated events. Not all sites were scheduled due to results of reconnaissance.

# 3.0 Project Organization and Responsibility

## 3.1 Washington State Department of Ecology

**R-EMAP Project Leader for Washington State**

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Glenn is the R-EMAP lead for Ecology. He is responsible for Ecology's Quality Assurance Project Plan and Ecology's Project Report. He, along with Betsy Dickes and Scott Girdner, will collect, reduce, and analyze the data. This includes sorting and identification of invertebrates.

**R-EMAP Team in Washington State**

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Telephone: (206) 407-6697 Facsimile (206) 407-6884

Betsy is working with Glenn Merritt and Scott Girdner to collect samples and to collect and reduce data.

Scott Girdner
Washington State Department of Ecology
Watershed Assessments Section
300 Desmond Drive, P.O. Box 47710
Olympia, WA 98504-7710
Telephone: (206) 407-6000 Facsimile (206) 407-6884

Scott is working with Glenn Merritt and Betsy Dickes to collect samples and to collect and reduce data.

**Biological Assessment Monitoring in Washington**

Rob Plotnikoff
Washington State Department of Ecology
Ambient Monitoring Section
300 Desmond Drive, P.O. Box 47710
Olympia, WA 98504-7710
Telephone: (206) 407-6687 Facsimile (206) 407-6884

Rob is working on the Biological Assessment Monitoring Pilot Project, which is separate from R-EMAP, but which involves many of the same techniques. It began in 1993, therefore R-EMAP can benefit greatly from much of Rob's groundwork. We anticipate consulting with him frequently. He will also provide training to R-EMAP personnel for collection and processing of benthic macroinvertebrates.

**Manchester Environmental Laboratory**
Washington State Department of Ecology
7411 Beach Drive East
Port Orchard, WA 98366-8204
Telephone: (206) 871-8860  Facsimile (206) 871-8850

The Manchester Environmental Laboratory is providing many services to this project. They are analyzing water chemistry samples, preparing a field quality assurance standard (Peck and Metcalf, 1993), supplying sampling gear (containers, coolers, sample ID numbers, labels) and are providing a sample courier service from Olympia to Manchester. Specific persons to contact for various services are listed on page 9 of the Manchester Environmental Laboratory User's Manual (Ecology, 1994).

## 3.2 U.S. Environmental Protection Agency

**R-EMAP Project Leader for EPA-Region 10**
Gretchen Hayslip
U.S. Environmental Protection Agency - Region 10
Environmental Services Division
1200 Sixth Ave. ES-097, Seattle, WA 98101
Telephone: (206) 553-1685  Facsimile (206) 553-0119

Gretchen has the overall responsibility for R-EMAP in EPA-Region 10.

**EPA-Region 10 Contact for Logistics and Field Support**
Dave Terpening
U.S. Environmental Protection Agency - Region 10
Environmental Services Division
1200 Sixth Ave. ES-097, Seattle, WA 98101
Telephone: (206) 553-6905  Facsimile (206) 553-0119

Dave Terpening is assisting, on an intermittent basis, with the collection of field samples, collection of data, and consultation regarding equipment and supplies. He is coordinating the field training session and will be participating in it.

**EPA-Region 10 Contact for Data Management**
Daniel Palmiter
ICF Kaiser, Environment and Energy Group
1200 Sixth Ave. Suite 1510, Seattle, WA 98101
Telephone: (206) 224-4172  Facsimile (206) 224-4188

Dan will be coordinating the entry and review of the data collected by Ecology. He will be receiving field data from Ecology in the form of hand-written records on data forms which he has designed. He will receive the reduced biology data in Lotus worksheets; he will receive chemistry data in STORET.

## 3.3 Others

**Yakima Indian Nation Field Sampler**
Jannine Jennings
Hydrologist - Water Quality
Yakima Indian Nation, Environmental Protection Program
P.O. Box 151, Toppenish WA 98948
Telephone: (509) 865-5121  Facsimile (509) 865-5522

Jannine, along with EPA personnel, will sample at sites within the Yakima Nation after participating in the R-EMAP training session

**R-EMAP Project Leader for Oregon**
Rick Hafele
Oregon Department of Environmental Quality
Telephone (503) 229-5983

Rick is responsible for Oregon's portion of the R-EMAP project in EPA-Region 10. He and Glenn Merritt (Ecology) will coordinate methods and training with EPA to assure comparability between Oregon and Washington

**R-EMAP Field Team Leader for Oregon**
Mike Mulvey
Oregon Department of Environmental Quality
Telephone (503) 229-5983

Mike is directing the field operations relating to Oregon's component of the Coast Range investigation. His team consists of himself and two other persons.

**University of Washington Fish Collection**
Brian Urbain
Fish Collection
School of Fisheries, HF-15
University of Washington
Seattle, WA 98195
Telephone: (206) 543-3816 Facsimile (206) 685-3275
Email: urbain@fish.washington.edu

Brian is the University of Washington Fish Collection Manager. He has agreed to have personnel at the University's Fish Collection identify R-EMAP fish voucher samples in exchange for the right to maintain the specimens within the museum.

# 4.0 Data Quality Objectives

The focus of data collection for this project relates to biology. Can differences in the biological metrics among streams be discerned relative to variance associated with metrics within a stream? This question is one that must be answered by Ecology's Environmental Investigations and Laboratory Services Program if it is to assess the utility of bioassessment as a monitoring tool. Typically, bioassessment has been unused by many regulatory agencies because of the perception that the variability associated with biological metrics is too large within sites to make definitive, legally defensible conclusions about the condition of a site.

Biological analyses in R-EMAP will use indices which are based upon suites of biological metrics described below. Biologists have claimed that community health indicators using fish (or invertebrates) which are based on the use of 10-12 metrics are much less variable than any single metric (Karr, 1994). Suites of metrics will therefore be developed for this project following identification (and verification) of biological specimens to the lowest taxa level possible (to species for fish, to family or lower for invertebrates). They will be based on modifications of existing indices (e.g., Karr, 1981l Karr et al., 1986; Hilsenhoff, 1977; and Hilsenhoff, 1982) for use in Washington streams. EPA (1993) provides a compilation some regional variations of Karr's Index of Biotic Integrity including some suggested for western Oregon. Many of these and others may be appropriate for use in Washington. EPA (1990, section 7) provides some suggestions for macroinvertebrate metrics. The indices will be related to differences in habitat (physical and chemical) and to differences in land use as determined by any available information (GIS, aerial photography, site reconnaissance). The data quality objectives for R-EMAP are summarized in Table 5.

## 4.1 Precision

For each of seven stream sites sampled, there will be a duplicate set of field samples/measures collected within a visit. This is called a field quality assurance sample (FQA). The FQA samples will be collected for water chemistry samples and water chemistry field measures. The FQAs will provide information relating to sampling/analysis variability. The FQAs will help evaluate if the water sampling methods are repeatable.

Seasonal bias in sampling will be assessed through the use of systematic, repeat sampling (see section 2.3)

To estimate the maximum variance of sampling invertebrates, a site will be randomly selected. From this site, kick samples will be analyzed individually before compositing.

We also will evaluate the variability related to subsampling (in the laboratory) invertebrates from composites. During 1994, for each of 7 riffle composites and 7 pool composites, we will duplicate the sorting and analysis procedures. Duplicate sorting and analysis will be performed independently by scientists at ODEQ.

Precision data cannot be generated for fish assemblage data. Electrofishing will be performed on a single pass through the stream reach; additional passes would not be comparable due to behavioral reactions of fish.

Variance of physical habitat measures can be estimated through use of existing EMAP habitat data which has been generated in Oregon and other states.

## 4.2 Bias

Bias regarding macroinvertebrate identifications will be minimized through the use of a reference collection and through cross checks with ODEQ personnel (see section 4.1). Ecology's Ambient Monitoring Section maintains a macroinvertebrate type collection for each major basin studied. This collection has a representative of each taxon and serves as a basin record and as a reference for checking identifications.
Tally sheets will be developed using the Ambient Monitoring Section's reference collection and data.

Bias regarding taxonomic identifications will be verified through the collection of voucher samples at each site. Examples saved will include species which are difficult to identify in the field, or those which are in an unusual location for their listed range. Fish will be saved according to predefined protocols. All fish saved will be sent to the University of Washington Fish Collection for identification. The specimens will then remain in their collection.

Bias of field measures (temperature, dissolved oxygen, pH, and conductivity) will be minimized or assessed using quality control procedures (see section 8).

## 4.3 Representativeness

The EMAP sites have been selected using a stratified-random design (EPA 1991) which gives the best chance of obtaining a representative sample. The pool of reference sites was developed through field reconnaissance and interviews (see section 2.3) to find sites which represent areas with minimal anthropogenic impairment.

Sampling will occur in the summer when precipitation and stream flows are typically minimal and with the least daily variance. Daily bias will be minimized by specifying that sampling will not occur during or immediately following heavy rain/high flow.

## 4.4 Completeness

We will attempt to attain 100% completeness. However, the EMAP sites were selected using a computer algorithm; its selections must be verified using reconnaissance. The EPA has selected 13 more EMAP sites (28% more) than the 44 which are deemed necessary for sampling. This provides enough sites for analyses in case reconnaissance reveals that up to 13 sites are inaccessible, or not able to be safely sampled.

## 4.5 Comparability

The R-EMAP project for Washington is part of the EMAP program which is national in scope. Its Coast Range Ecoregion assessment is designed to augment a project being conducted concurrently by ODEQ in the Oregon Coast Range. Therefore, our methods must be directly comparable with those used by other EMAP projects, especially those in ERA-Region 10. This comparability is assured through various means. Methods have been chosen from the list of those developed by the EMAP program. Modifications have been adopted, but these have been incorporated in consultation with EPA and the ODEQ. Training will be conducted with EPA, ODEQ, and Ecology together. ODEQ will visit Ecology sampling activities in the Yakima River basin prior to July, so that they can calibrate their techniques to ours and so that they can provide an independent sampling audit of our crew. Also, electronic data entry, data management, and reporting will be performed by EPA-Region 10. Water chemistry data will be entered into the national STORET database by Ecology.

We also seek to assess the comparability of R-EMAP with existing bioassessment studies within Ecology. Selection of the reference sites used by Plotnikoff (l992; see section 2.3) will help us evaluate our conclusions relative to those provided by the Ambient Biological Monitoring Pilot Project. Plotnikoff has evaluated the invertebrate communities among three of our reference sites; he sampled them during 1991 and 1993, and plans to resample in 1995. His data will therefore provide us with estimates of inter-annual variance among these sites.

# 5.0 Sampling Procedures

Samples to be collected are listed in Table 6. A proposed sampling schedule is listed in Table 4. One set of samples will be collected from each stream. These will be delivered to their destinations on a daily to weekly basis. Samples will be maintained in coolers and locked in the van while in the field. Whenever possible, water samples will be delivered to the Tumwater boat shed for pickup by the Ecology courier. Occasionally, at remote locations, water samples will be shipped by commercial courier such as UPS, Greyhound, or Horizon Air. The field crew will work on a Sunday through Thursday schedule to allow samples with the shortest holding time (TSS) to be delivered to the laboratory by Friday. Biological samples will be delivered, on a daily to weekly basis, to the sample storage area, in the basement of Ecology's Headquarters Building. Each week the invertebrate samples will be examined and recharged with ethanol, as needed. Fish samples will be transported by vehicle to the University of Washington Fish Collection as time permits.

Collection of nutrients is discussed in Ecology (1993). Collection of biological samples is discussed in EPA (1994a). Other water samples, except DOC, will be collected by dipping the opened jar into the stream and then capping when full. DOC will be collected according to the following protocol:

1. Fill the syringe with 60 mL of stream water and rinse (three times).
2. Fill the syringe with 60 mL of stream water and attach the filter disk to the syringe.
3. Rinse the filter by expelling the water.
4. Remove the filter from the syringe.
5. Fill the syringe again with 60 mL of sample.
6. Attach the filter to the syringe again.
7. Expel 60 mL of the sample through the filter into the sample container.

# 6.0 Analytical Procedures

See Table 5 for the analytical procedures selected. Water chemistry analyses are from Ecology (1994) and APHA (1992). Fish and physical habitat analyses are from EPA (1994a). Macroinvertebrate analyses are from EPA (1994b).

# 7.0 Quality Control Procedures

The YSI dissolved oxygen (DO) meter will receive quality control checks for temperature and DO three times each year: May, July and October. DO will be measured with both the meter and a Winkler titration, concurrently. We will expect measures to agree within 1 mg/L. Temperature will be measured with both the meter and a NIST-traceable mercury thermometer. We will expect measures to agree within 1°C.

Field pH and conductivity measures will be controlled with a quality control check solution (QCCS) developed by Metcalf and Peck (1993). This is a 1:100 dilution of a National Institute of Standards and Technology (NIST) biphosphate buffer. The dilute solution (100 L) will be prepared by the Manchester Laboratory; 4-L portions of the final dilution will be sent to the field crew weekly, as needed. At each site, after calibration is performed, measurement of pH will be required to be within 0.5 pH units of the theoretical value for the QCCS; measurement of conductivity will be required to be within 10 uS/cm at 25 °C of the theoretical value for the QCCS.

R-EMAP will use duplicates to estimate precision of collecting/processing water chemistry and macroinvertebrate invertebrate samples (see Section 4. 1). For quality control of the laboratory chemistry analyses, the routine quality control procedures of the Manchester Environmental Laboratory will be acceptable for R-EMAP.

# 8.0 Data Assessment Procedures

For all applicable data, replicate variance will be examined relative to the data quality objectives (DQOs). The sample mean and variance about that mean will be calculated at each of seven sites (see section 4. 1) for seasonal differences (n=2 at each site) and also for sampling variance within a visit (n=2 for each site). The variance can then be expressed as a percentage of the mean. Due to the small sample size, ranges may be used as alternate estimates of variance. If variance exceeds that prescribed by the DQOs, the data will be examined more closely for veracity and validity. If warranted, the data quality objectives might be reassessed to more closely match reality. The review of data relative to DQOs will be described in the Completion Project Report to be delivered in June 1996.

## 8.1 Physical habitat and other field data

Field measures will be recorded in pencil on field data forms. The crew will inspect all of these forms prior to leaving the site. They will look for completeness and errors in logic, units, and significant figures. They will also look to ensure that the calibrations and quality control checks were within range.

## 8.2 Water chemistry

The water chemistry data generated by the Ecology's Manchester Laboratory (or through a contract) will be reviewed by the Manchester Laboratory before it is reported.  The parameters are standard procedures.  We will rely on the laboratory's conventional methods for verifying and validating data.

## 8.3 Fish

To minimize bias of fish data, tally data will be examined and compared with reports received from the University of Washington Fish Collection. Corrections will be made to the tally data so that they agree with the identifications made by the museum.

## 8.4 Macroinvertebrates

Taxonomic identifications which are different than those provided by ODEQ cross-checks will by re-examined. If discrepancies still occur, samples may be sent to a third party for verification.

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Small, J.S. and M, Witherick. 1986. A modern dictionary of geography. Edward Arnold Publishers, Baltimore, MD.

Theile, S.A., Kiilsgaard, C.W., and J.M. Omernik. 1992. The subdivision of the Coast Range Ecoregion of Oregon and Washington (Draft). U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

Table 1. The 1994 R-EMAP sites in Washington State. The GAZ. PAGE refers to the Washington Atlas and Gazetteer, Delorme Mapping Company, 1992. The last 23 sites are those within the Yakima River Basin; all other sites are in the Coast Range Ecoregion.

| REMAP ID | STREAM | COUNTY | LEGAL DESCRIPTION | USGS QUADARNGLE (1:24000) | GAZ. PAGE | LAT. DEG | LAT. MIN | LAT. SEC | LON. DEG | LON. MIN | LON. SEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WA775S | STURGEON PEN SLOUGH | Wahkiakum | T8NR5W19 | Nassa Point | 31 | 46 | 09 | 46 | 123 | 21 | 17 |
| WA778S | TRB QUEETS R. | Jefferson | T25NR9W | Bob Creek | 31 | 47 | 41 | 20 | 123 | 50 | 39 |
| WA779S | LINCOLN CR. | Lewis | T15NR3WS30 | Rochester | 45 | 46 | 45 | 36 | 123 | 05 | 50 |
| WA780S | DELEZENE CR. | Grays Harbor | T17NR6WS32 | South Elma | 45 | 46 | 54 | 46 | 123 | 27 | 49 |
| WA788S | E.BR.HERMAN CR. | Clallam | T31NR13WS22 | Ellis Mountain | 91 | 48 | 10 | 42 | 124 | 21 | 35 |
| WA825S | BROOKS SLOUGH | Wahkiakum | T9NR6WS15 | Skamokawa | 31 | 46 | 15 | 30 | 123 | 25 | 09 |
| WA826S | ELOCHAMAN R | Wahkiakum | T9NR5WS1 | Skamokowa Pass | 31 | 46 | 17 | 21 | 123 | 15 | 35 |
| WA827S | STEAMBOAT SLOUGH | Wahkiakum | T9NR6WS21 | Cathlamet | 31 | 46 | 14 | 46 | 123 | 25 | 26 |
| WA828S | ELOCHAMAN R | Wahkiakum | T9NR5WS15 | Skamokowa Pass | 31 | 46 | 16 | 04 | 123 | 17 | 06 |
| WA830S | CAMPBELL CR. | Cowlitz | T10NR3WS3 | Wildwood | 31 | 46 | 22 | 41 | 123 | 02 | 27 |
| WA831S | EF GRAYS R. | Pacific | T11NR6WS14 | Blaney Creek | 31 | 46 | 26 | 21 | 123 | 24 | 10 |
| WA832S | TRB SF CALAWAH | Clallam | T28NR11WS18? | Indian Pass | 75 | 46 | 56 | 00 | 124 | 10 | 17 |
| WA833S | TRIB.SF HOH R. | Jefferson | T26NR10WS1 | Owl Mountain | 76 | 47 | 46 | 51 | 123 | 56 | 07 |
| WA835S | KIMTA CR. | Jefferson | T25NR8W | Kimta Peak | 76 | 47 | 39 | 13 | 123 | 38 | 47 |
| WA836S | THREE PRUNE CR. | Jefferson | T25NR8W | Kimta Peak | 76 | 47 | 38 | 36 | 123 | 40 | 18 |
| WA837S | SALMON R. | Grays Harbor | T23NR12WS2 | Salmon River West | 75 | 47 | 31 | 24 | 124 | 10 | 27 |
| WA838S | ZIEGLER CR. | Grays Harbor | T23NR9W | Lake Quinault East | 60 | 47 | 29 | 19 | 123 | 48 | 55 |
| WA839S | ZIEGLER CR. | Grays Harbor | T23NR9W | Lake Quinault East | 60 | 47 | 29 | 33 | 123 | 48 | 22 |
| WA840S | TRB QUINALT R. | Grays Harbor | T22NR12WS31 | Taholah | 59 | 47 | 21 | 01 | 124 | 15 | 52 |
| WA841S | BEAVER CR. | Grays Harbor | T20NR12WS27 | Moclips | 59 | 47 | 11 | 49 | 124 | 09 | 37 |
| WA842S | ROCK CR. | Grays Harbor | T16NR5WS15 | Cedarville | 45 | 46 | 52 | 24 | 123 | 17 | 50 |
| WA843S | WILLIAMS CR. | Grays Harbor | T16NR5WS21 | Cedarville | 45 | 46 | 51 | 30 | 123 | 19 | 12 |
| WA844S | BLACK R. | Thurston | T16NR4WS35 | Oakville | 45 | 46 | 50 | 10 | 123 | 07 | 47 |
| WA845S | BLACK R. | Thurston | T16NR3WS30 | Rochester | 45 | 46 | 50 | 32 | 123 | 06 | 13 |
| WA847S | EF WISHKAH R. | Grays Harbor | T19NR9WS36 | Wynoochee Vly SW | 60 | 47 | 05 | 06 | 123 | 44 | 46 |
| WA848S | CAMP CR. | Grays Harbor | T18NR7WS27 | Prices Peak | 60 | 47 | 01 | 03 | 123 | 32 | 52 |
| WA850S | WF HOQUIAM R. | Grays Harbor | T19NR10WS34 | New London | 60 | 47 | 05 | 46 | 123 | 54 | 25 |
| WA851S | LITTLE NORTH R. | Grays Harbor | T16NR8WS8 | Central Park | 44 | 46 | 53 | 10 | 123 | 42 | 40 |
| WA852S | LOWER SALMON CR | Grays Harbor | T15NR8WS5 | Elkhorn Creek | 44 | 46 | 49 | 14 | 123 | 42 | 12 |
| WA853S | TRB NORTH R. | Pacific | T15NR6WS20 | Blue Mountain | 45 | 46 | 46 | 11 | 123 | 27 | 41 |
| WA854S | FALL R. | Lewis | T14NR5WS7 | Doty | 45 | 46 | 42 | 42 | 123 | 21 | 44 |
| WA855S | NASELLE R. | Pacific | T10NR9WS2,11,10 | Knappton | 30 | 46 | 22 | 17 | 123 | 45 | 58 |
| WA856S | DEADFALL CR. | Clallam | T28NR2W | Uncas | 78 | 47 | 53 | 28 | 122 | 59 | 21 |
| WA857S | TRB LTL QUILCENE | Jefferson | T27NR2W | Mt Walker | 78 | 47 | 51 | 54 | 122 | 58 | 12 |
| WA858S | DUCKABUSH R. | Jefferson | T25NR4W | The Brothers | 77 | 47 | 41 | 00 | 123 | 10 | 17 |
| WA860S | SF PYSHT R. | Clallam | T31NR11WS19 | West of Pysht | 91 | 48 | 10 | 32 | 124 | 10 | 25 |
| WA861S | PYSHT R. | Clallam | T31NR12WS23 | West of Pysht | 91 | 48 | 10 | 09 | 124 | 12 | 36 |
| WA862S | ALL-IN-CR. | Jefferson | T27NR10WS8 | Spruce Mountain | 75 | 47 | 51 | 39 | 124 | 01 | 15 |
| WA863S | TRB SMITH CR. | Pacific | T15NR8WS36 | East of Raymond | 44 | 46 | 44 | 48 | 123 | 36 | 55 |
| R1A | BONE R. | Pacific | T14NR10WS36 | Bay Center | 44 | * | * | * | * | * | * |
| R1B | PHELAN CREEK | Jefferson | T24NR11WS11* | Salmon River E. | 75 | * | * | * | * | * | * |
| R1K | FINLEY CREEK | Jefferson | T24NR9WS26* | Finley Creek | 76 | * | * | * | * | * | * |
| R1G | BARNES CREEK | Clallam | T29NR8WS6* | Lake Crescent | 92 | * | * | * | * | * | * |
| R1GRS | S. BR. LITTLE RIVER | Clallam | T29NR6WS8* | Elwah/Port Angeles | 93 | * | * | * | * | * | * |

Table 1. Continued.

| REMAP ID | STREAM | COUNTY | LEGAL DESCRIPTION | USGS QUADARNGLE (1:24000) | GAZ. PAGE | LAT. DEG | LAT. MIN | LAT. SEC | LON. DEG | LON. MIN | LON. SEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| WA763S | TRIB. AMERICAN R. | Yakima | T17NR11E | Goose Prairie | 49 | 46 | 55 | 20 | 121 | 21 | 08 |
| WA789S | TRB HYAS L.(N) | Kittitas | T24NR14ES16 | The Cradle | 81 | 47 | 34 | 09 | 121 | 06 | 03 |
| WA790S | TRB HYAS L.(S) | Kittitas | T24NR14ES19 | Mount Daniel | 81 | 47 | 33 | 33 | 121 | 08 | 41 |
| WA791S | CLE ELUM R. | Kittitas | T24NR14ES20 | The Cradle | 81 | 47 | 33 | 18 | 121 | 06 | 39 |
| WA792S | BOX CANYON | Kittitas | T22NR12ES13 | Chikimin | 65 | 47 | 24 | 37 | 121 | 17 | 24 |
| WA793S | JOLLY CR. | Kittitas | T22NR15ES20 | Mount Stewart | 66 | 47 | 22 | 45 | 120 | 59 | 25 |
| WA794S | TRB GREEN CNYN | Kittitas | T19NR18ES8 | Reecer Canyon | 66 | 47 | 09 | 26 | 120 | 37 | 15 |
| WA795S | TRB SF MANASHTASH | Kittitas | T17NR16ES5 | Hudson Creek | 50 | 46 | 59 | 48 | 120 | 52 | 10 |
| WA796S | SF MANASHTASH | Kittitas | T17NR16ES5 | Hudson Creek | 50 | 46 | 59 | 41 | 120 | 52 | 18 |
| WA798S | COOKE CR. | Kittitas | T17NR19ES11 | Kittitas | 51 | 46 | 58 | 54 | 120 | 25 | 31 |
| WA801S | AMERICAN RIVER | Yakima | T17NR11E | Goose Prairie | 49 | 46 | 55 | 12 | 121 | 22 | 11 |
| WA803S | TRB BUMPING R. | Yakima | T17NR13ES34 | Old Scab Mountain | 49 | 46 | 55 | 16 | 121 | 11 | 38 |
| WA804S | TRIB.LTL RATTLESNAKE CR. | Yakima | T15NR14ES26 | Meeks Table | 49 | 46 | 45 | 18 | 121 | 02 | 29 |
| WA805S | CLEAR CR. | Yakima | T14NR11E | Spiral Butte | 49 | 46 | 39 | 14 | 121 | 18 | 59 |
| WA807S | PANTHER CR. | Yakima | T10NR13ES26 | Castile Falls | 35 | 46 | 19 | 50 | 121 | 09 | 15 |
| WA811S | DERUYTER CULVERT | Yakima | T10NR22ES16 | Sunnyside | 37 | 46 | 20 | 48 | 120 | 03 | 60 |
| WA812S | DRY CREEK | Yakima | T9NR18ES30 | Logy Creek NE | 36 | 46 | 13 | 52 | 120 | 37 | 21 |
| WA818S | KUSSHI CR. | Yakima | T7NR17ES24 | Logy Creek SW | 36 | 46 | 05 | 04 | 120 | 37 | 51 |
| WA819S | DAY'S CR. | Benton | T9NR26ES9 | Corral Canyon | 38 | 46 | 16 | 59 | 119 | 33 | 43 |
| Y40 | AMERICAN R. | Yakima | T17NR13ES12 | Old Scab Mtn. | 49 | 46 | 58 | 38 | 121 | 10 | 04 |
| Y41 | MF TEANAWAY R. | Kittitas | T21NR15ES21 | Teanaway Butte | 66 | 47 | 17 | 43 | 120 | 57 | 34 |
| Y42 | NANEUM CNYN. | Kittitas | T19NR19ES16 | Naneum Canyon | 67 | 47 | 08 | 21 | 120 | 28 | 19 |
| Y46 | TOPPENISH CR. | Yakima | T9NR16ES4 | Fort Simcoe | 36 | 46 | 17 | 53 | 120 | 49 | 01 |

* Exact legal description and coordinates will depend upon judgements made upon visitation.

Table 2. The nine "hand-selected" reference sites for R-EMAP in Washington State And the areas they represent.

| REMAP ID | ECOREGION (ECOREGION NUMBER) | SUBECOREGION (SUBECOREGION NUMBER) | WATERSHED |
|---|---|---|---|
| Y40 | E.CASCADES SLOPES/FOOTHILLS (9) | NONE DEFINED | NACHES |
| Y41 | CASCADES (4) | NONE DEFINED | UPPER YAKIMA |
| Y42 | COLUMBIA PLATEAU (10) | YAKIMA FOLDS (10g) | UPPER YAKIMA |
| Y46 | COLUMBIA PLATEAU (10) | YAKIMA FOLDS (10g) | LOWER YAKIMA |
| R1A | COAST RANGE (1) | COASTAL LOWLANDS (1a) | LOWER COLUMBIA |
| R1B | COAST RANGE (1) | COASTAL UPLANDS (1b) | WESTERN OLYMPIC |
| R1G | COAST RANGE (1) | VOLCANICS (1g) | EASTERN OLYMPIC |
| R1K | COAST RANGE (1) | LOW OLYMPICS (1k) | WESTERN OLYMPIC |
| R1GRS | COAST RANGE (1) | 1g (RAINSHADOW) | EASTERN OLYMPIC |

Table 3. The schedule for implementation of R-EMAP in Washington State during fiscal years 1994, 1995, and 1996.

| | FY 94 | | | | | FY 95 | | | | | | | | | | | | FY 96 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACTIVITY BY MONTH | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J |
| PROJ. LEAD HIRED | X | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 94 EMAP SITES SELECTED | | X | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 94 REF. SITES SELECTED | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PROJECT TEAM HIRED | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| PROCUREMENT | | X | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| QAPP | | | X | X | X | X | | | | | | | | | | | | | | | | | | | | | | | |
| TRAINING | | | X | | | | | | | | | | | | | | | | | | | | | | | | | | |
| YAKIMA RECONN. | | | X | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| YAKIMA SAMPLING | | | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| COAST RANGE RECONN. | | | | | X | X | X | X | X | | | | | | | | | | | | | | | | | | | | |
| COAST RANGE SAMPLING | | | | | | X | X | X | X | | | | | | | | | | | | | | | | | | | | |
| CHEM. ANALYSES | | | | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | | | |
| FISH ID | | | | X | X | X | X | X | X | X | X | | | | | | | | | | | | | | | | | | |
| INVERT ID | | | | | | | | | | X | X | X | X | | | | | | | | | | | | | | | | |
| METRICS COMPUTED | | | | | | | | | | | | X | X | X | X | | | | | | | | | | | | | | |
| 94 BIO DATA TO EPA | | | | | | | | | | | | | | | | X | | | | | | | | | | | | | |
| 95 EMAP SITES SELECTED | | | | | | | | | | | | | | X | | | | | | | | | | | | | | | |
| 95 REF. SITES SELECTED | | | | | | | | | | | | | | | X | | | | | | | | | | | | | | |
| PROCUREMENT | | | | | | | | | | | X | | | | | | | | | | | | | | | | | | |
| YAKIMA RECONN. | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | | |
| YAKIMA SAMPLING | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | |
| COAST RANGE RECONN. | | | | | | | | | | | | | | | | | X | | | | | | | | | | | | |
| COAST RANGE SAMPLING | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CHEM. ANALYSES | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | |
| FISH ID | | | | | | | | | | | | | | | | X | X | | | | | | | | | | | | |
| COAST RANGE RECONN. | | | | | | | | | | | | | | | | | | X | | | | | | | | | | | |
| COAST RANGE SAMPLING | | | | | | | | | | | | | | | | | | X | X | X | X | | | | | | | | |
| CHEM. ANALYSES | | | | | | | | | | | | | | | | | | X | X | X | X | | | | | | | | |
| FISH ID | | | | | | | | | | | | | | | | | | X | X | X | X | X | X | | | | | | |
| INVERT ID | | | | | | | | | | | | | | | | | | | | | | X | X | X | X | | | | |
| METRICS COMPUTED | | | | | | | | | | | | | | | | | | | | | | | | X | X | X | X | | |
| 95 BIO DATA TO EPA | | | | | | | | | | | | | | | | | | | | | | | | | | | | X | |
| PROJECT & QA REPORT | | | | | | | | | | | | | | | | | | | | | | | | | | | X | X | X |

Table 4. The 1994 sampling schedule. Bold faced sites are repeats. The first eight weeks are scheduled for the Yakima River Basin; the remainder are scheduled for the Coast Range Ecoregion.

| WEEK | SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|---|---|---|---|---|
| 5/15 | | WA819S | **WA818S** | WA812S | | | |
| 5/22 | | | **WA818S** | WA807S | | | |
| 5/29 | | WA794S | **WA798S** | **WA805S** | Y46 | | |
| 6/05 | | Y42 | WA804S | | | | |
| 6/12 | | WA795S | WA796S | WA763S | | | |
| 6/19 | | WA801S | **WA805S** | WA803S | | | |
| 6/26 | | WA791S | WA792S | Y41 | | | |
| 7/03 | | | | | **WA798S** | | |
| 7/17 | | | WA788S | **WA861S** | WA860S | | |
| 7/24 | | | WA832S | WA833S | WA840S | | |
| 7/31 | | | WA837S | **WA850S** | | | |
| 8/7 | | | WA778S | WA839S | WA838S | | |
| 8/14 | | | R1A | **WA855S** | | | |
| 8/21 | | | WA828S | WA826S | WA830S | | |
| 8/28 | | | **WA780S** | WA856S | WA779S | | |
| 9/11 | | | WA831S | WA863S | WA853S | | |
| 9/18 | | | WA842S | WA830S | WA845S | | |
| 9/25 | | WA852S | WA851S | WA847S | | | |
| 10/2 | | | R1K | R1B | | | |
| 10/9 | | | R1G | R1GRS | WA844S | | |
| 10/16 | | **WA780S** | **WA855S** | **WA850S** | **WA861S** | | |

Table 5. Data quality objectives for R-EMAP in Washington State.

| PARAMETER (METHOD) | UNITS | PRECISION | BIAS | EXPECTED R RANGE | DETECTION LIMIT |
|---|---|---|---|---|---|
| LATITUDE (MAGELLAN GPS) | ° ' " | 00° 00' 10 " | 00° 00' 10 " | 46° 00' 00" - 49° 00' 00" | N/A |
| LONGITUDE (MAGELLAN GPS) | ° ' " | 000° 00' 10" | 000° 00' 10" | 119° 00' 00" - 125° 00' 00" | N/A |
| WATER TEMP. (YSI 57) | °C | 0.3 ° | 1.0 ° | 0.0 - 30.0 | N/A |
| pH (ROSS/ORION) | pH UNITS | 0.1 | 0.1 | 4.0 - 10.0 | N/A |
| CONDUCTIVITY (BECKMAN BRIDGE) | us/cm at 25 °C | 10% | 2% | 0 - 1500 | 1.0 |
| DISSOLVED OXYGEN (YSI 57) | mg/L | 1% | 1% | 0.0 - 20.0 | 0.1 |
| TOTAL PERSULFATE N (APHA 4500-NO3-F; MODIFIED) | mg/L | * | * | 0.10 - 10.00 | 0.10 |
| TOTAL P (APHA 4500-P F) | mg/L | * | * | 0.01 - 0.50 | 0.01 |
| NITRATE-NITRITE (APHA 4500-NO3 F) (APHA 4500-NO3 F) | mg/L | * | * | 0.01 - 10.00 | 0.01 |
| SULFATE (APHA 4110 B) | mg/L | * | * | 0.5 - 100.0 | 0.5 |
| CHLORIDE (APHA 4110 B) | mg/L | * | * | 0.1 - 30.0 | 0.1 |
| TOT. SUSPENDED SOLIDS (APHA 2540) | mg/L | * | * | 1 - 500 | 1 |
| AMMONIA (APHA 4500-NH3 D) | mg/L | * | * | 0.01 - 0.50 | 0.01 |
| ALKALINITY (APHA 2320) | mg/L | * | * | 1 - 300 | 1 |
| DOC (APHA 5310 B) | mg/L | * | * | 1 - 100 | 1 |
| STREAM DEPTH | m | 10% | 10% | 0.01 - 2.0 | 0.01 |
| LARGE WOODT DEBRIS | NUMBER | 10% | 10% | 0-200 | 0 |
| STREAM CHANNEL WIDTH | m | 10% | 10% | 0-10 | 0 |
| CURRENT VELOCITY | ft/sec | 10% | 10% | 0-100 | 0.1 |
| SLOPE | DEGREES | 10% | 10% | 0-360 | 4 |
| BEARING | DEGREES | 10% | 10% | 0-360 | 4 |
| SURFACE FINES | POINTS | 20 | 20 | 0-400 | 1 |
| CANOPY COVER | POINTS | 2 | 2 | 1-17 | 1 |
| INVERTEBRATE COUNT BY TAXA | INIVIDUALS | 80% | 10% | 0-300 | 1 |
| FISH TALLY BY TAXA | INIVIDUALS | 80% | 10% | 0-200 | 1 |
| FISH TOTAL LENGTH | mm | 10% | 5% | 5-6100 | 1 |
| FISH ANOMALIES | % OCCURRENCE by SPP. | 20% | 10% | 0-100 | 1 |
| DERIVED INDEX FOR FISH | SCORE | 10% | 5% | 0-60 | N/A |
| DERIVED INDEX FOR INVERTEBRATES | SCORE | 10% | 5% | 0-60 | N/A |

* Methods for these parameters have been established by R-EMAP programmatic requirements. Therefore, the analytical precision and bias provided by routine application of these methods will be considered acceptable for use of these data.

Table 6. Samples to be collected for R-EMAP in Washington State during 1994-1995.

| SAMPLE | CONTAINERS | NUMBER/ SITE | PRESERVATIVES | HOLDING TIME | DESTINATION |
|---|---|---|---|---|---|
| TOTAL P (a) | 125-mL POLYETHYLENE | 1* | ICE, H2SO4, DARKNESS | 28 DAYS | ECOLOGY-MANCHESTER |
| TOTAL N (a) | 125-mL POLYETHYLENE | 1 | ICE, H2SO4, DARKNESS | 28 DAYS | ECOLOGY-MANCHESTER |
| NITRATE-NITRITE (a) | 125-mL POLYETHYLENE | 1* | ICE, H2SO4, DARKNESS | 28 DAYS | ECOLOGY-MANCHESTER |
| AMMONIA (a) | 125-mL POLYETHYLENE | 1* | ICE, H2SO4, DARKNESS | 28 DAYS | ECOLOGY-MANCHESTER |
| SULFATE | 1-L POLYETHYLENE** | 1** | ICE | 28 DAYS | ECOLOGY-MANCHESTER |
| CHLORIDE | 1-L POLYETHYLENE** | 1** | ICE | 28 DAYS | ECOLOGY-MANCHESTER |
| ALKALINITY | 1-L POLYETHYLENE** | 1** | ICE | 14 DAYS | ECOLOGY-MANCHESTER |
| TOTAL SUSPENDED SOLIDS | 1-L POLYETHYLENE | 1 | ICE | 7 DAYS | ECOLOGY-MANCHESTER |
| DISSOLVED ORGANIC CARBON | 60-mL POLYETHYLENE | 1 | ICE, H2S04 | 28 DAYS | ECOLOGY-MANCHESTER |
| MACROINVERTEBRATES (b) (RIFFLE) | 1-GAL ZIP BAG IN 5-GAL BUCKET | 1-11 | 70% ET-OH | INDEFI-NITE | ECOLOGY-HQ |
| MACROINVERTEBRATES (b) (POOL) | 1-GAL ZIP BAG IN 5-GAL BUCKET | 1-11 | 70% ET-OH | INDEFI-NITE | ECOLOGY-HQ |
| FISH VOUCHERS (b) | 2-L POLYETHYLENE | 1-2 | 10% FORMALIN SATURATED WITH BORAX | INDEFI-NITE | UNIV. WASHINGTON FISH COLLECTION, SEATTLE |

(a) Sample collection SOP is in Ecology (1993).
(b) Sample collection SOP is in EPA (1994a).
* Total P, nitrate-nitrite, and ammonia will all be included in the same sample bottle.
** Sulfate, chloride, and alkalinity will all be included in the same sample bottle.

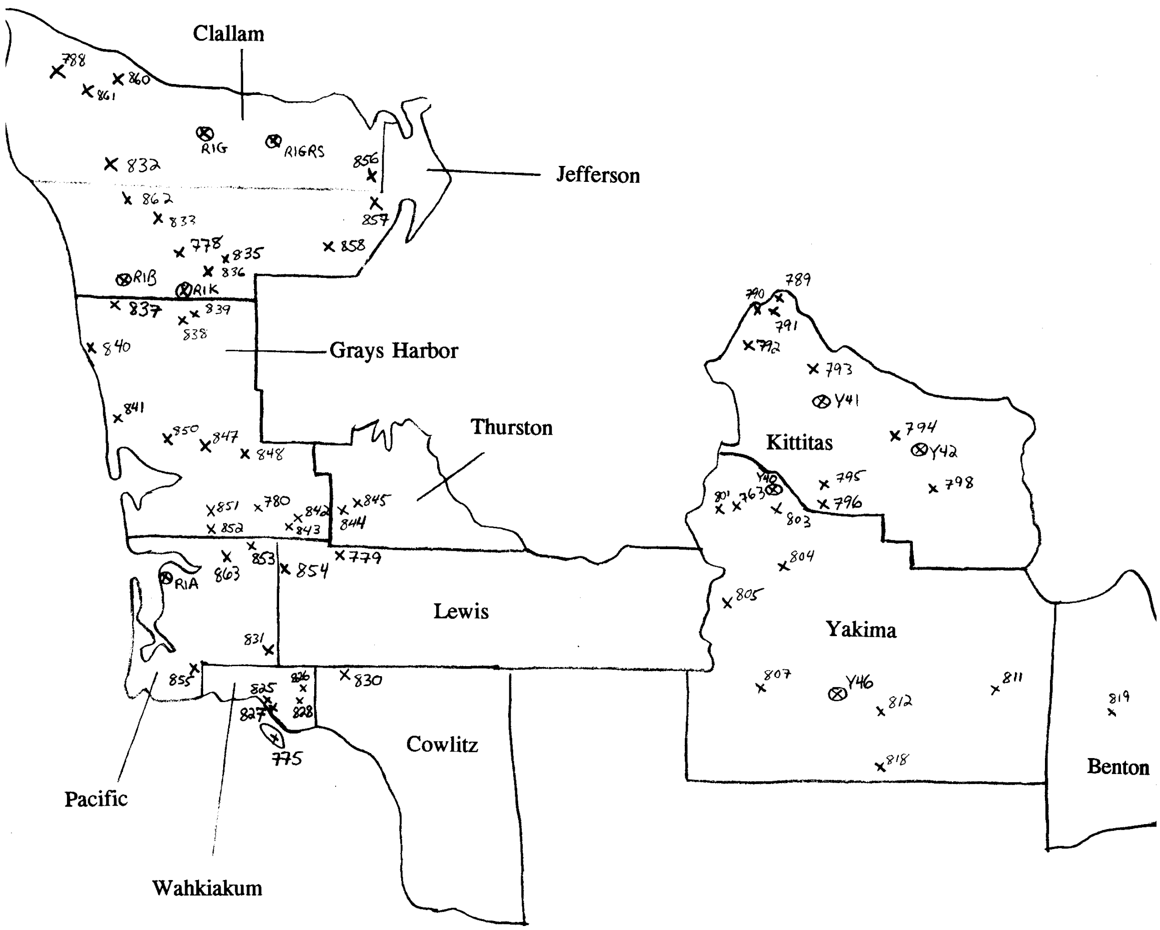


Figure 1. The 1994 R-EMAP sites in Washington State, by county. Circled sites are "hand-selected" reference sites; all others are probability sites.

# APPENDIX B. SAMPLED SITES IN THE COAST RANGE ECOREGION.

| STREAM ID | STREAM NAME | LATITUDE (decimal degrees) | LONGITUDE (decimal degrees) | SEGMENT NUMBER | STREAM CLASS | WATERSHED AREA (ha) | ELEV. (ft) | STREAM ORDR |
|---|---|---|---|---|---|---|---|---|
| WA001S | (NO NAME) | 46.2671 | 123.8501 | WA-24-6100 | RA | 155.61 | 109 | 1 |
| WA002S | BIG R. | 48.1446 | 124.5798 | WA-20-6100 | RAA | 3829.50 | 108 | 2 |
| WA003S | NF CROOKED CR. | 48.1302 | 124.5373 | WA-20-6210 | RAA | 44.82 | 408 | 1 |
| WA004S | TRB WF DICKEY | 48.0299 | 124.5338 | WA-20-5170 | RAA | 987.27 | 122 | 2 |
| WA007S | COAL CR. | 47.9711 | 124.5862 | WA-20-5010 | RAA | 1550.74 | 129 | 2 |
| WA009S | WEST TWIN CR. | 47.8343 | 124.0129 | WA-20-2770 | RAA | 42.52 | 979 | 1 |
| WA011S | COOK CR. | 47.3584 | 123.9669 | WA-21-2500 | RAA | 3547.41 | 253 | 2 |
| WA014S | NF PORTER CR | 46.9871 | 123.1981 | WA-23-4100 | RA | 2103.66 | 605 | 2 |
| WA016S | MF SATSOP R. | 47.2823 | 123.4836 | WA-22-4080 | RAA | 6831.57 | 449 | 3 |
| WA017S | MF SATSOP R. | 47.2661 | 123.4761 | WA-22-4080 | RAA | 7318.59 | 383 | 3 |
| WA018S | TRB CLOQUALLUM | 47.1052 | 123.3631 | WA22-4048 | RA | 188.89 | 252 | 1 |
| WA019S | CLOQUALLUM CR. | 47.1042 | 123.3571 | WA22-4042 | RA | 5801.60 | 272 | 2 |
| WA022S | FALL R. | 47.7104 | 123.4754 | WA-24-1019 | RA | 4616.81 | 455 | 3 |
| WA023S | FALL R. | 46.7083 | 123.4322 | WA-24-1019 | RA | 3671.87 | 694 | 3 |
| WA024S | CANON R. | 46.5718 | 123.8576 | WA-24-5210 | RA | 3894.10 | 130 | 3 |
| WA025S | MILL CR. | 46.6113 | 123.4866 | WA-24-2031 | RA | 558.04 | 496 | 2 |
| WA026S | TRB SALMON CR. | 46.3839 | 123.6363 | WA-24-3019 | RA | 9.24 | 468 | 1 |
| WA027S | SALMON CR. | 46.3549 | 123.7304 | WA-24-3018 | RA | 4019.03 | 59 | 2 |
| WA028S | SF SKOKOMISH R. | 47.4520 | 123.4321 | WA-16-1030 | RAA | 5454.59 | 828 | 3 |
| WA029S | PINE CR. | 47.4401 | 123.4397 | WA-16-1070 | RA | 858.17 | 1152 | 1 |
| WA062S | DUNN CR. | 46.6565 | 123.2641 | WA23-1107 | RA | 1079.80 | 416 | 2 |
| WA065S | NF PALIX R. | 46.6514 | 123.8450 | WA-24-5000 | RA | 39.04 | 218 | 1 |
| WA089S | NF SALMON R. | 47.5304 | 124.0492 | WA-21-1060 | RAA | 1158.92 | 550 | 1 |
| WA780S | DELEZENE CR. | 46.9129 | 123.4636 | WA-22-4500 | RA | 197.03 | 306 | 1 |
| WA788S | E.BR.HERMAN CR. | 48.1784 | 124.3598 | WA-19-2150 | RAA | 80.37 | 742 | 1 |
| WA826S | ELOCHAMAN R | 46.2892 | 123.2598 | WA-25-3010 | RA | 10554.14 | 299 | 3 |
| WA828S | ELOCHAMAN R | 46.2678 | 123.2849 | WA-25-3010 | RA | 11939.88 | 150 | 3 |
| WA831S | EF GRAYS R. | 46.4391 | 123.4028 | WA-25-1018 | RA | 1669.94 | 826 | 2 |
| WA832S | TRB SF CALAWAH | 47.9334 | 124.1714 | WA-20-1090 | RAA | 41.48 | 867 | 1 |
| WA833S | TRIB.SF HOH R. | 47.7807 | 123.9353 | WA-20-2122 | RAA | 384.90 | 796 | 1 |
| WA835S | KIMTA CR. | 47.6537 | 123.6464 | WA-21-2037 | RAA | 1405.43 | 993 | 2 |
| WA836S | THREE PRUNE CR. | 47.6434 | 123.6716 | WA-21-2035 | RAA | 738.11 | 1474 | 1 |
| WA837S | SALMON R. | 47.5234 | 124.1741 | WA-21-1050 |  | 7088.57 | 236 | 3 |
| WA838S | ZIEGLER CR. | 47.4886 | 123.8153 | WA-21-2028 | RAA | 864.58 | 196 | 2 |
| WA840S | TRB QUINALT R. | 47.3502 | 124.2645 | WA-21-2011 |  | 24.78 | 130 | 1 |
| WA842S | ROCK CR. | 46.8734 | 123.2972 | WA-23-1013 | RA | 6665.05 | 52 | 3 |
| WA843S | WILLIAMS CR. | 46.8584 | 123.3199 | WA-23-1011 | RA | 2038.75 | 94 | 2 |
| WA848S | CAMP CR. | 47.0176 | 123.5478 | WA-22-4041 | RA | 71.79 | 231 | 1 |
| WA850S | WF HOQUIAM R. | 47.0962 | 123.9069 | WA-22-2020 | RA | 1286.83 | 125 | 2 |
| WA851S | LITTLE NORTH R. | 46.8861 | 123.7112 | WA-24-1015 | RA | 5237.16 | 108 | 2 |
| WA853S | TRB NORTH R. | 46.7697 | 123.4614 | WA-24-1018 | RA |  | 374 | 1 |
| WA855S | NASELLE R. | 46.3713 | 123.7661 | WA-24-3010 | RA | 14855.25 | 18 | 3 |
| WA856S | DEADFALL CR. | 47.8912 | 122.9891 | WA-17-2080 | RAA | 303.11 | 2199 | 3 |
| WA858S | DUCKABUSH R. | 47.6832 | 123.1713 | WA-16-3010 | RAA | 9501.29 | 1286 | 3 |
| WA860S | SF PYSHT R. | 48.1755 | 124.1737 | WA-19-1020 | RAA | 3892.70 | 136 | 3 |
| WA861S | PYSHT R. | 48.1693 | 124.2099 | WA-19-1010 | RAA | 2610.74 | 109 | 2 |
| WA863S | TRB SMITH CR. | 46.7467 | 123.6152 | WA-24-1013 | RA | 37.61 | 373 | 1 |
| WAR1AS | BONE R. | 46.6527 | 123.8700 | WA-24-5500 | RA | 139.55 | 48 | 1 |

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# APPENDIX C.  SAMPLED SITES IN THE YAKIMA RIVER BASIN.

| STREAM ID | STREAM NAME | LATITUDE (decimal degrees) | LONGITUDE (decimal degrees) | SEGMENT NUMBER | STREAM CLASS | WATERSHED AREA (ha) | ELEV. (ft) | STREAM ORDER | ECOREGEGION |
|---|---|---|---|---|---|---|---|---|---|
| WA031S | JUNGLE CR. | 47.3380 | 120.8596 | WA-39-2154 | RAA | 1410.98 | 2677 | 2 | CASCADES |
| WA032S | WF TEANAWAY R. | 47.2712 | 120.9769 | WA-39-2300 | RA | 6047.60 | 2491 | 3 | CASCADES |
| WA039S | MF LTL.NACHES R. | 47.0850 | 121.3005 | WA-38-1095 | RAA | 1361.38 | 3367 | 2 | CASCADES |
| WA040S | COUNTY CR. | 47.0716 | 121.3176 | WA-38-1097 | RAA | 409.27 | 3572 | 1 | CASCADES |
| WA083S | SWAUK CR. | 47.3221 | 120.6798 | WA-39-1420 | RAA | 3486.73 | 3033 | 3 | CASCADES |
| WA085S | TRB YAKIMA R. | 47.2604 | 121.2803 | WA-39-4100 | RAA | 207.78 | 2334 | 2 | CASCADES |
| WA086S | JACK CR. | 47.3314 | 120.8334 | WA-39-2153 | RAA | 1938.75 | 2688 | 2 | CASCADES |
| WA088S | JACK CR. | 47.3489 | 120.7638 | WA-39-2153 | RAA | 347.48 | 3372 | 1 | CASCADES |
| WA791S | CLE ELUM R. | 47.5550 | 121.1108 | WA-39-1050 | RA | 2527.05 | 3482 | 3 | CASCADES |
| WA792S | BOX CANYON | 47.4102 | 121.2899 | WA-39-1320 | RAA | 953.10 | 3127 | 2 | CASCADES |
| WAY41S | MF TEANAWAY R. | 47.2953 | 120.9594 | WA-39-2200 | RA | 6733.65 | 2622 | 3 | CASCADES |
| WAY42S | NANEUM CNYN. | 47.1392 | 120.4719 | WA-39-1025 | RA | 17516.97 | 2583 | 3 | CASCADES |
| WA045S | FISH CR. | 46.6159 | 121.1129 | WA-38-3050 | RAA | 751.15 | 3550 | 2 | E.CASCADES |
| WA052S | YESMOWIT CNYN | 46.3774 | 120.9458 | WA-37-1057 | | 672.90 | 2147 | 2 | E.CASCADES |
| WA053S | YESMOWIT CNYN | 46.3782 | 120.9087 | WA-37-1057 | | 2104.72 | 1721 | 2 | E.CASCADES |
| WA073S | WOODCAMP CNYN | 46.8350 | 120.7399 | WA-39-1016 | RA | 1014.49 | 2317 | 2 | E.CASCADES |
| WA081S | NF TOPPENISH | 46.3356 | 121.0019 | WA-37-1100 | | 651.65 | 3483 | 1 | E.CASCADES |
| WA795S | TRB SF MANASHTASH | 46.9966 | 120.8693 | WA-39-3027 | RAA | 690.69 | 3539 | 2 | E.CASCADES |
| WA796S | SF MANASHTASH | 46.9946 | 120.8718 | WA-39-3020 | RA | 6987.69 | 3390 | 3 | E.CASCADES |
| WA803S | TRB BUMPING R. | 46.9212 | 121.1940 | WA-38-1072 | RAA | 706.19 | 3421 | 2 | E.CASCADES |
| WA804S | TRIB.LTL RATTLESNAKE | 46.7549 | 121.0414 | WA-38-1039 | RAA | 269.21 | 3746 | 1 | E.CASCADES |
| WA805S | CLEAR CR. | 46.6540 | 121.3165 | WA-38-4100 | RAA | 4579.12 | 3172 | 3 | E.CASCADES |
| WA807S | PANTHER CR. | 46.3305 | 121.1542 | WA-37-1590 | | 981.61 | 4320 | 2 | E.CASCADES |
| WA080S | MILL CR. | 46.2726 | 120.8189 | WA-37-1054 | | 1587.58 | 2245 | 3 | COLUMBIA BAS. |
| WA794S | TRB GREEN CNYN | 47.1572 | 120.6207 | WA-39-1036 | RA | 366.73 | 2687 | 1 | COLUMBIA BAS. |
| WA798S | COOKE CR. | 46.9818 | 120.4254 | WA-39-1034 | RA | 9234.66 | 1620 | 3 | COLUMBIA BAS. |
| WA812S | DRY CREEK | 46.2311 | 120.6225 | WA-37-1037 | | 25405.13 | 1625 | 3 | COLUMBIA BAS. |
| WA818S | KUSSHI CR. | 46.0844 | 120.6308 | WA-37-1039 | | 2470.08 | 2710 | 2 | COLUMBIA BAS. |
| WA819S | DAY'S CR. | 46.2831 | 119.5619 | WA-37-1013 | RA | 1436.80 | 622 | 2 | COLUMBIA BAS. |
| WAY46S | TOPPENISH CR. | 46.2981 | 120.8169 | WA-37-1050 | | 30875.94 | 1438 | 3 | COLUMBIA BAS. |

# APPENDIX D. SAMPLING DATES.

| STREAM ID | SAMPLE DATE | SAMPLE VISIT TYPE | STREAM ID | SAMPLE DATE | SAMPLE VISIT TYPE |
|---|---|---|---|---|---|
| WA001S | 26-Jul-95 | Only | WA803S | 23-Jun-94 | Only |
| WA002S | 11-Jul-95 | Only | WA804S | 08-Jun-94 | Only |
| WA003S | 08-Aug-95 | Only | WA805S | 02-Jun-94 | First |
| WA004S | 09-Aug-95 | Only | WA805S | 22-Jun-94 | Second |
| WA007S | 01-Aug-95 | Only | WA807S | 25-May-94 | Only |
| WA009S | 02-Aug-95 | Only | WA812S | 18-May-94 | Only |
| WA011S | 12-Jul-95 | Only | WA818S | 17-May-94 | First |
| WA014S | 14-Aug-95 | Only | WA818S | 24-May-94 | Second |
| WA016S | 31-Aug-95 | Only | WA818S | 28-Jun-95 | Fourth* |
| WA017S | 29-Aug-95 | Only | WA819S | 16-May-94 | Only |
| WA018S | 10-Aug-95 | Only | WA826S | 24-Aug-94 | Only |
| WA019S | 05-Sep-95 | Only | WA828S | 23-Aug-94 | Only |
| WA022S | 13-Sep-95 | Only | WA831S | 15-Sep-94 | Only |
| WA023S | 19-Sep-95 | Only | WA832S | 26-Jul-94 | Only |
| WA024S | 27-Jul-95 | Only | WA833S | 27-Jul-94 | Only |
| WA025S | 07-Sep-95 | Only | WA835S | 26-Sep-94 | Only |
| WA026S | 25-Jul-95 | Only | WA836S | 27-Sep-94 | Only |
| WA027S | 06-Sep-95 | Only | WA837S | 02-Aug-94 | Only |
| WA028S | 22-Aug-95 | Only | WA838S | 11-Aug-94 | Only |
| WA029S | 24-Aug-95 | Only | WA840S | 28-Jul-94 | First |
| WA031S | 07-Jun-95 | Only | WA840S | 19-Oct-94 | Second |
| WA032S | 14-Jun-95 | Only | WA840S | 03-Aug-95 | Third |
| WA039S | 21-Jun-95 | Only | WA840S | 27-Sep-95 | Fourth |
| WA040S | 20-Jun-95 | Only | WA842S | 20-Sep-94 | Only |
| WA045S | 31-May-95 | Only | WA843S | 25-Aug-94 | Only |
| WA052S | 22-Jun-95 | Only | WA848S | 21-Sep-94 | Only |
| WA053S | 06-Jun-95 | Only | WA850S | 03-Aug-94 | Only |
| WA062S | 29-Sep-95 | Only | WA851S | 11-Oct-94 | Only |
| WA065S | 20-Sep-95 | Only | WA853S | 14-Sep-94 | Only |
| WA073S | 23-May-95 | Only | WA855S | 17-Aug-94 | First |
| WA080S | 03-May-95 | Only | WA855S | 18-Oct-94 | Second |
| WA081S | 27-Jun-95 | Only | WA855S | 18-Jul-95 | Third |
| WA083S | 24-May-95 | Only | WA855S | 21-Sep-95 | Fourth |
| WA085S | 15-Jun-95 | Only | WA856S | 31-Aug-94 | Only |
| WA086S | 13-Jun-95 | Only | WA858S | 04-Oct-94 | Only |
| WA088S | 08-Jun-95 | Only | WA860S | 20-Jul-94 | Only |
| WA089S | 26-Sep-95 | Only | WA861S | 21-Jul-94 | First |
| WA780S | 30-Aug-94 | First | WA861S | 20-Oct-94 | Second |
| WA780S | 12-Oct-94 | Second | WA861S | 17-Aug-95 | Third |
| WA780S | 13-Jul-95 | Third | WA861S | 28-Sep-95 | Fourth |
| WA780S | 25-Sep-95 | Fourth | WA863S | 13-Sep-94 | Only |
| WA788S | 19-Jul-94 | Only | WAR1AS | 16-Aug-94 | Only |
| WA791S | 28-Jun-94 | Only | WAY41S | 30-Jun-94 | Only |
| WA792S | 29-Jun-94 | Only | WAY42S | 07-Jun-94 | Only |
| WA794S | 31-May-94 | Only | WAY46S | 26-May-94 | Only |
| WA795S | 14-Jun-94 | Only | * WA818S visit 3 aborted in storm on 04-May-95. | | |
| WA796S | 15-Jun-94 | Only | | | |
| WA798S | 01-Jun-94 | First | | | |
| WA798S | 08-Jul-94 | Second | | | |
| WA798S | 01-Jun-95 | Third | | | |
| WA798S | 29-Jun-95 | Fourth | | | |

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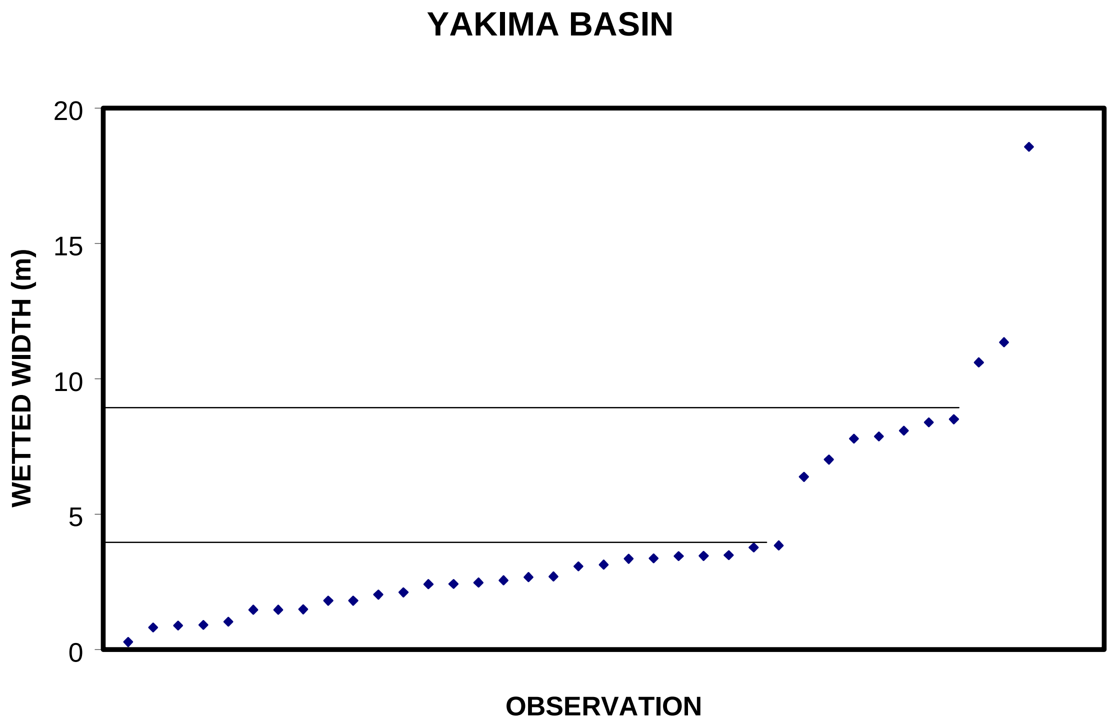
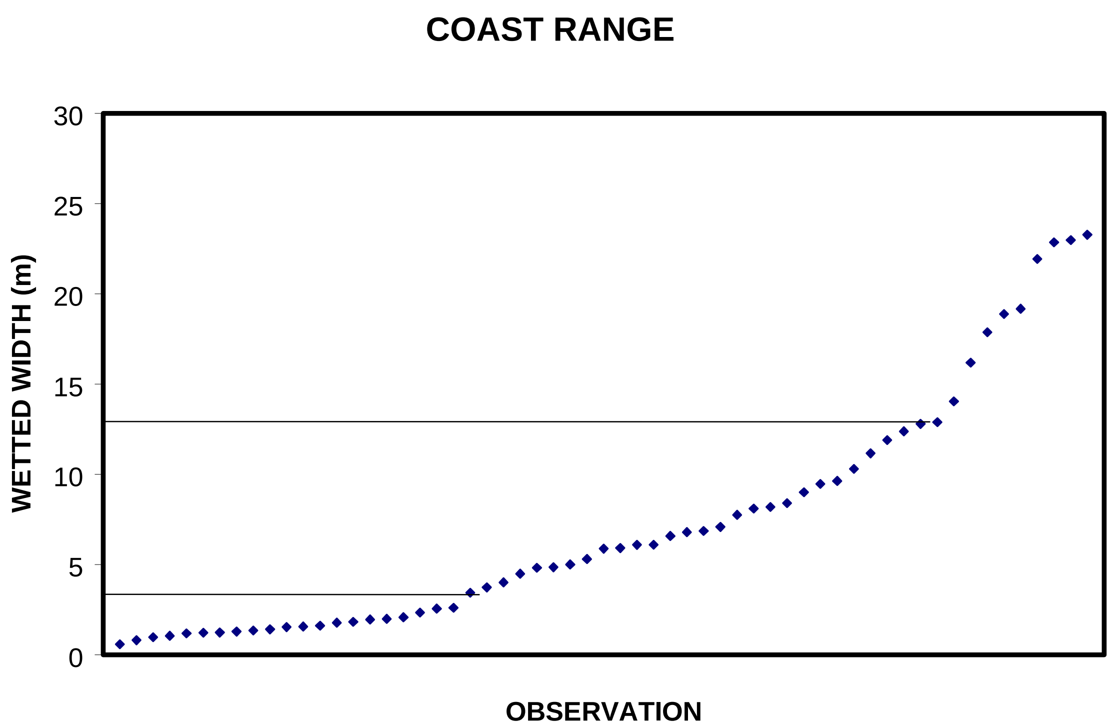
**APPENDIX E.  STREAM SIZE PLOTS FOR CLASSIFICATION.**



## APPENDIX F. HABITAT QUALITY METRICS AT REPEATEDLY SAMPLED SITES: DETECTING SITE DIFFERENCES AND ANNUAL DIFFERENCES.

| METRIC CODE | METRIC NAME | AOV FOR SITES P | T-TEST FOR YEARS P (TWO-TAIL) |
|---|---|---|---|
| SDDEPTH | Standard deviation of thalweg depth | 0.000 | 0.002 |
| SDWXD | Standard deviation of (thalweg depth x wetted width) | 0.002 | 0.962 |
| RP100 | Residual pool depth | 0.000 | 0.002 |
| PCT_BIGR | Percent coarse substrate | 0.000 | 0.828 |
| PCT_SA | Percent sand | 0.323 | |
| PCT_FN | Percent fines | 0.299 | |
| XFC_NAT | Sum of percent fish cover from natural objects | 0.197 | |
| XFC_LRG | Sum of percent fish cover from large woody debris and boulders | 0.012 | 0.307 |
| XFC_LWD | Sum of percent fish cover from large woody debris | 0.007 | 0.235 |
| XFC_BRS | Sum of percent fish cover from brush and small woody debris | 0.131 | |
| XCDENMID | Shade - mid channel (by densiometer) | 0.000 | 0.525 |
| XCMGW | Percent riparian woody cover - 3 layers | 0.665 | |
| XC | Percent canopy | 0.050 | |
| XCMGW | Percent (canopy + understory) | 0.143 | |
| W1_HALL | Human disturbance index - total | 0.000 | 0.010 |
| W1_LOG | Human disturbance index - forestry | 0.008 | 0.064 |
| TSS | Total suspended solids | 0.304 | |
| TOTP | Total phosphorus | 0.040 | |
| TPN | Total persulfate nitrogen | 0.009 | 0.044 |
| TEMP | Temperature | 0.698 | |
| DO | Dissolved oxygen | 0.001 | 0.505 |

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## APPENDIX G. DISSOLVED OXYGEN QUALITY CONTROL DATA.

Bias was evaluated by comparing dissolved oxygen meter readings with Winkler titrations. The Quality Assurance Project Plan's targeted "accuracy" was 1%.

| STREAM ID | SAMPLE DATE | D.O. (mg/L) METER | D.O. (mg/L) WINKLER | PERCENT BIAS |
|---|---|---|---|---|
| WA798S | 6/1/94 | 10.3 | 9.5 | 8.4 |
| WA818S | 6/28/95 | 4.0 | 9.5 | -57.9 |
| WA855S | 7/18/95 | 8.6 | 8.4 | 2.4 |
| WA065S | 9/20/95 | 6.6 | 8.2 | -19.5 |
| WA855S | 9/21/95 | 7.9 | 8.2 | -3.7 |

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# APPENDIX H. INVERTEBRATE SAMPLING EFFORT.

| | POOLS | | RIFFLES | | | POOLS | | RIFFLES | |
|---|---|---|---|---|---|---|---|---|---|
| STREAM ID | NO.KICKS | AREA SORTED (m2) | NO.KICKS | AREA SORTED (m2) | STREAM ID | NO.KICKS | AREA SORTED (m2) | NO.KICKS | AREA SORTED (m2) |
| WA001S | 1 | 0.19 | 10 | 0.43 | WA798S-2 | 1 | 0.19 | 10 | 0.12 |
| WA002S | 9 | 0.11 | 2 | 0.19 | WA798S-3 | 3 | 0.33 | 8 | 0.10 |
| WA003S | 3 | 0.56 | 4 | 0.22 | WA798S-4 | 1 | 0.11 | 10 | 0.12 |
| WA004S | 10 | 0.37 | 0 | 0.00 | WA803S | 1 | 0.19 | 10 | 0.37 |
| WA007S | 10 | 0.25 | 1 | 0.07 | WA804S | 7 | 0.09 | 4 | 0.05 |
| WA009S | 3 | 0.17 | 8 | 0.25 | WA805S-1 | 0 | 0.00 | 11 | 0.55 |
| WA011S | 8 | 0.10 | 3 | 0.07 | WA805S-2 | 1 | 0.19 | 10 | 0.62 |
| WA014S | 3 | 0.19 | 8 | 0.10 | WA807S | 2 | 0.37 | 9 | 0.45 |
| WA016S | 7 | 0.04 | 4 | 0.05 | WA812S | 6 | 0.07 | 5 | 0.06 |
| WA017S | 5 | 0.19 | 6 | 0.22 | WA818S-1 | 2 | 0.19 | 1 | 0.19 |
| WA018S | 9 | 0.11 | 1 | 0.07 | WA818S-2 | 2 | 0.14 | 2 | 0.14 |
| WA019S | 8 | 0.25 | 3 | 0.22 | WA818S-4 | 5 | 0.28 | 2 | 0.37 |
| WA022S | 5 | 0.50 | 6 | 0.33 | WA819S | 3 | 0.09 | 5 | 0.15 |
| WA023S | 8 | 0.20 | 3 | 0.17 | WA826S | 3 | 0.04 | 8 | 0.10 |
| WA024S | 7 | 0.65 | 3 | 0.26 | WA828S | 3 | 0.22 | 8 | 0.10 |
| WA025S | 6 | 0.37 | 5 | 0.15 | WA831S | 2 | 0.07 | 9 | 0.67 |
| WA026S | 4 | 0.10 | 7 | 0.52 | WA832S | 3 | 0.22 | 8 | 0.10 |
| WA027S | 10 | | 1 | 0.19 | WA833S | 1 | 0.19 | 10 | 0.12 |
| WA028S | 6 | 0.11 | 5 | 0.09 | WA835S | 0 | 0.00 | 11 | 2.04 |
| WA029S | 6 | 0.74 | 5 | 0.31 | WA836S | 0 | 0.00 | 11 | 0.41 |
| WA031S | 6 | 0.15 | 5 | 0.25 | WA837S | 2 | 0.07 | 8 | 0.10 |
| WA032S | 0 | 0.00 | 11 | 0.41 | WA838S | 9 | 0.11 | 0 | 0.00 |
| WA039S | 2 | 0.15 | 9 | 0.22 | WA840S-1 | 6 | 0.07 | 5 | 0.09 |
| WA040S | 7 | 0.26 | 4 | 0.17 | WA840S-2 | 3 | 0.09 | 8 | 0.25 |
| WA045S | 0 | 0.00 | 11 | 0.27 | WA840S-3 | 8 | 0.02 | 1 | 0.09 |
| WA052S | 3 | 0.56 | 8 | 0.50 | WA840S-4 | 10 | 0.74 | 1 | 0.19 |
| WA053S | 3 | 0.45 | 8 | 0.59 | WA842S | 8 | 0.15 | 3 | 0.07 |
| WA062S | 2 | 0.02 | 9 | 0.50 | WA843S | 11 | 0.20 | 0 | 0.00 |
| WA065S | 10 | 0.50 | 0 | 0.00 | WA848S | 1 | 0.19 | 10 | 0.31 |
| WA073S | 0 | 0.00 | 11 | 0.17 | WA850S | 3 | 0.06 | 8 | 0.20 |
| WA080S | 4 | 0.57 | 7 | 1.17 | WA851S | 5 | 0.06 | 6 | 0.11 |
| WA081S | 4 | 0.25 | 7 | 0.30 | WA853S | 5 | 0.19 | 6 | 0.07 |
| WA083S | 1 | 0.19 | 10 | 0.12 | WA855S-1 | 4 | 0.05 | 7 | 0.09 |
| WA085S | 3 | 0.22 | 8 | 0.20 | WA855S-2 | 6 | 0.07 | 5 | 0.06 |
| WA086S | 2 | 0.22 | 9 | 0.22 | WA855S-3 | 6 | 0.15 | 4 | 0.20 |
| WA088S | 2 | 0.15 | 9 | 0.11 | WA855S-4 | 5 | 0.19 | 6 | 0.15 |
| WA089S | 5 | 0.37 | 6 | 0.11 | WA856S | 4 | 0.05 | 7 | 0.13 |
| WA780S-1 | 3 | 0.07 | 8 | 0.10 | WA858S | 8 | 0.10 | 3 | 0.11 |
| WA780S-2 | 6 | 0.11 | 5 | 0.06 | WA860S | 4 | 0.74 | 7 | 0.26 |
| WA780S-3 | 9 | 0.06 | 2 | 0.06 | WA861S-1 | 9 | 0.17 | 2 | 0.12 |
| WA780S-4 | 9 | 0.56 | 2 | 0.07 | WA861S-2 | 4 | 0.05 | 7 | 0.52 |
| WA788S | 3 | 0.11 | 3 | 0.04 | WA861S-3 | 1 | 0.19 | 8 | 0.35 |
| WA791S | 3 | 0.13 | 8 | 0.30 | WA861S-4 | 7 | 0.37 | 4 | 0.17 |
| WA792S | 2 | 0.37 | 9 | 1.67 | WA863S | 0 | 0.00 | 11 | 0.27 |
| WA794S | 2 | 0.11 | 9 | 1.67 | WAR1AS | 10 | 0.12 | 0 | 0.00 |
| WA795S | 4 | 0.74 | 6 | 0.11 | WAY41S | 9 | 0.33 | 2 | 0.07 |
| WA796S | 3 | 0.56 | 8 | 0.15 | WAY42S | 0 | 0.00 | 11 | 0.20 |
| WA798S-1 | 5 | 0.06 | 6 | 0.04 | WAY46S | 1 | 0.04 | 10 | 0.19 |

Area sorted is equal to the fraction sorted in the laboratory multiplied by the stream area sampled in the field.
Stream area sampled in the field is equal to the number of kicks collected multiplied by 0.186 $m^2$ per kick.

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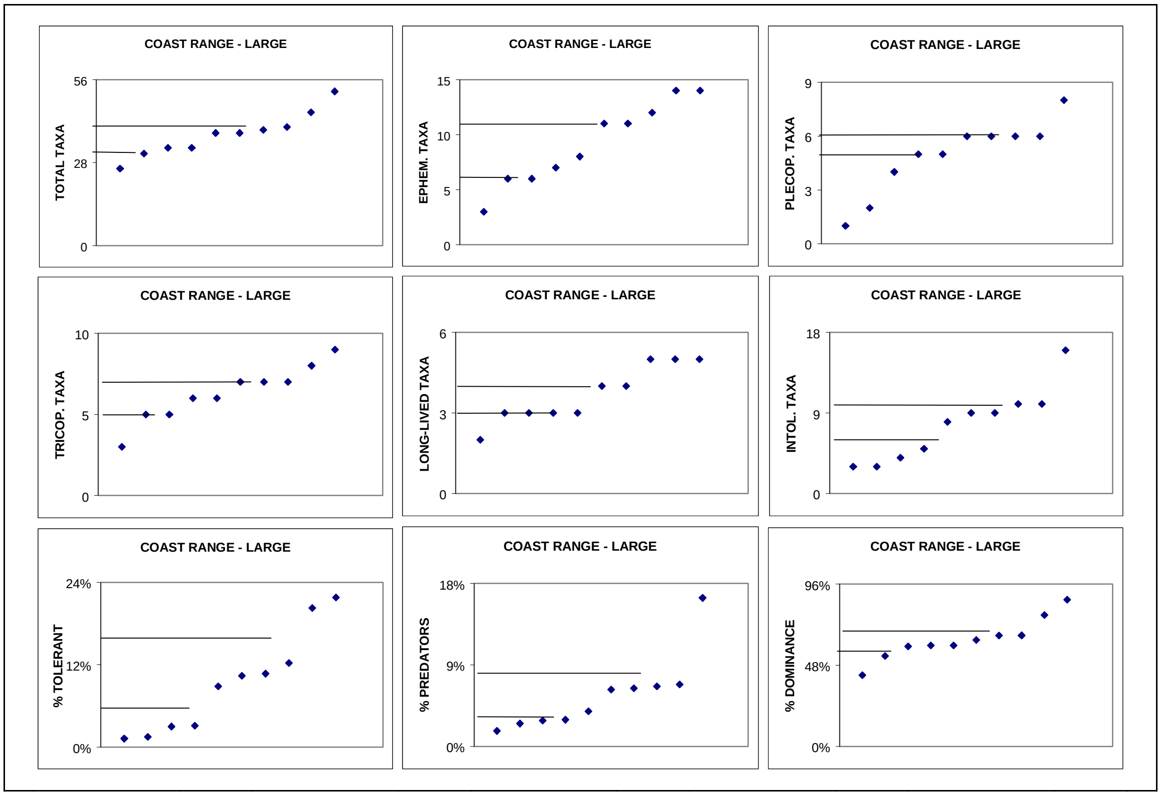
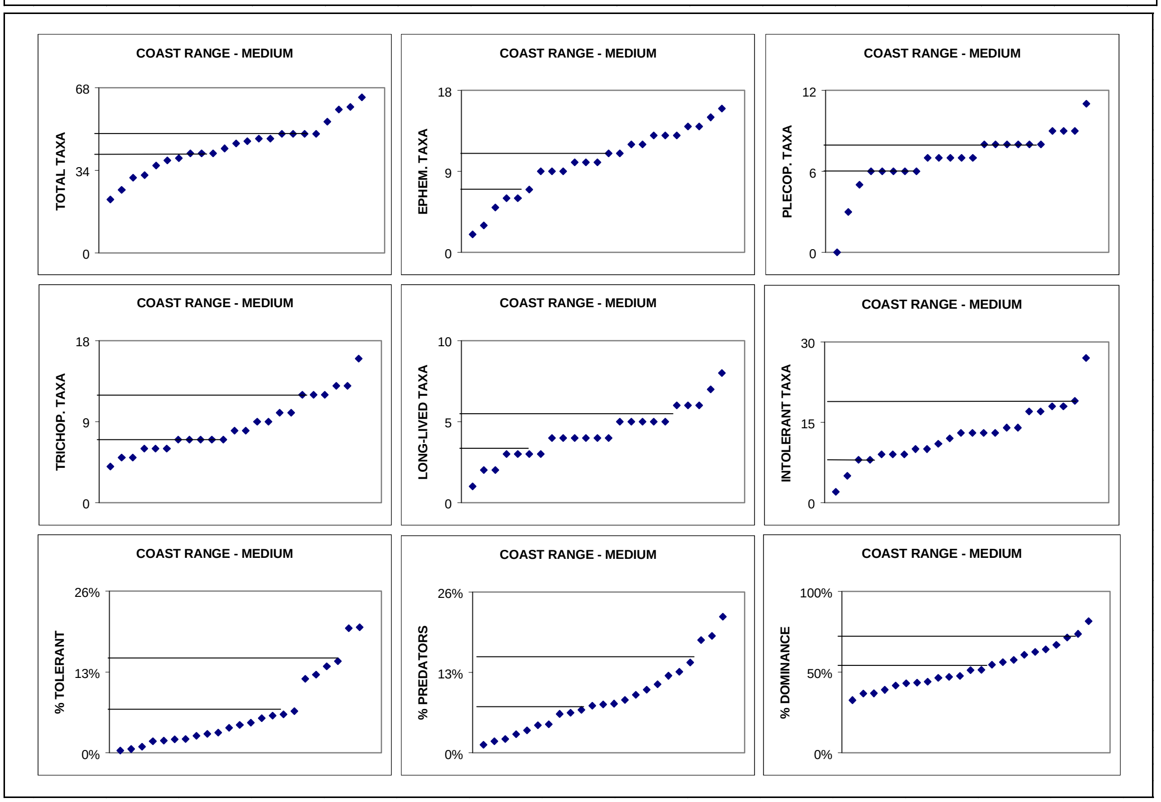
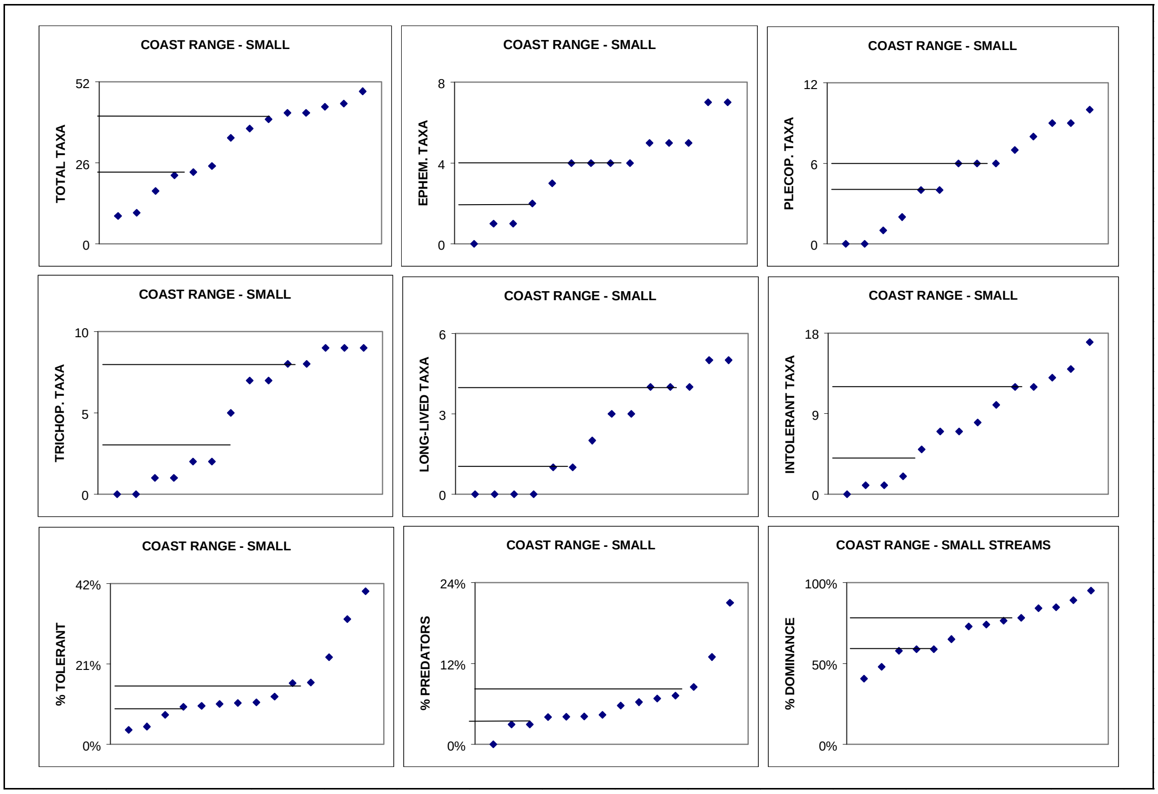
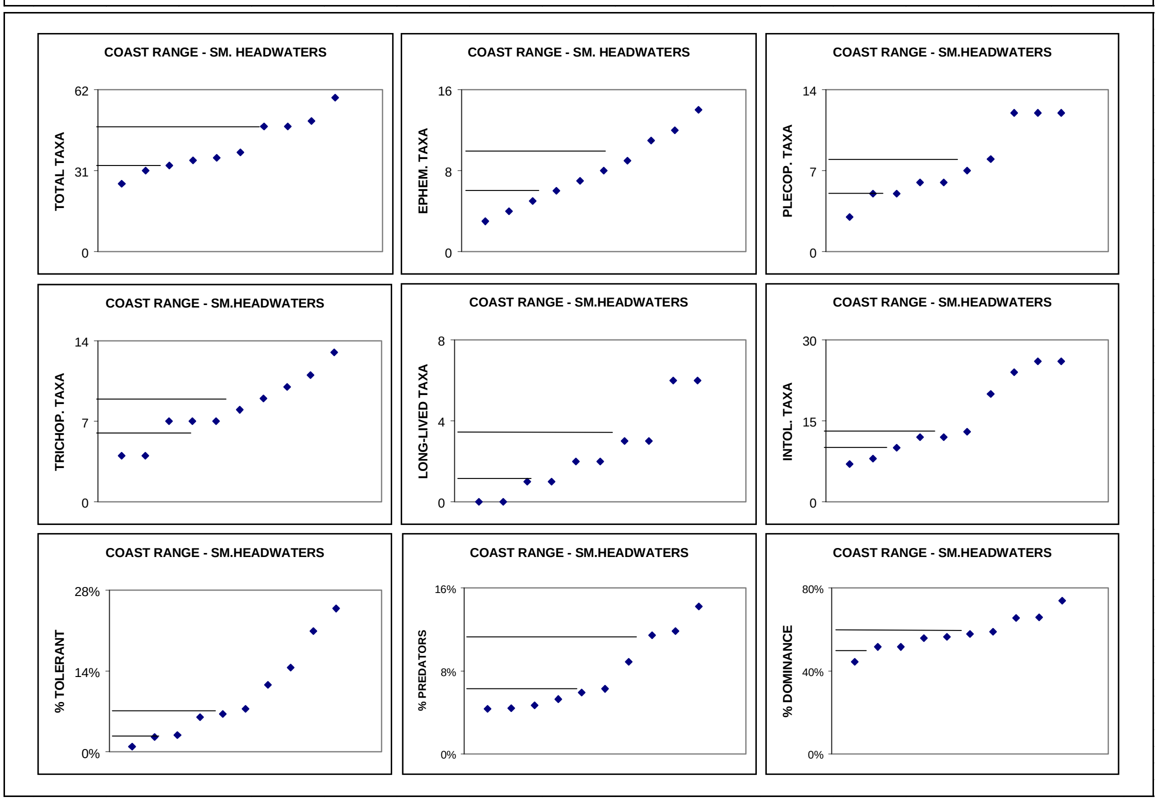
# APPENDIX I. BIOMETRIC VALUE DISTRIBUTIONS BY STREAM CLASS AND SCORING LEVELS FOR B-IBI CALCULATIONS.



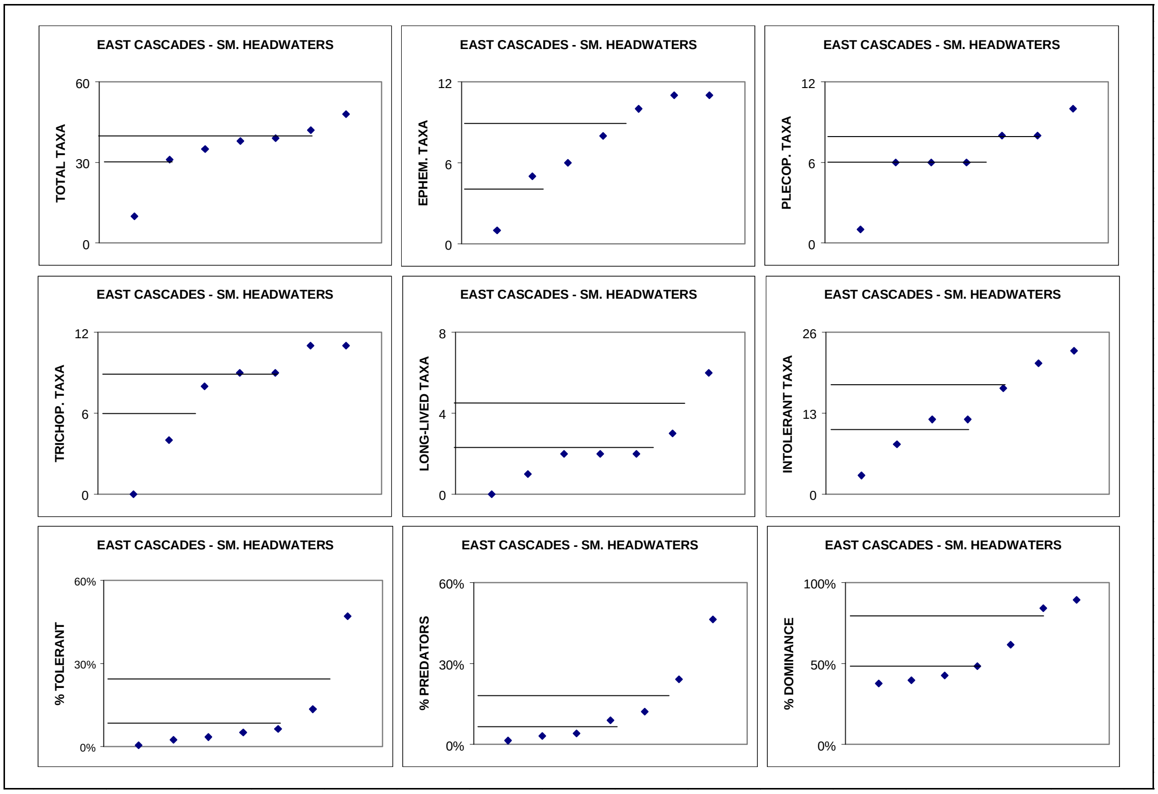



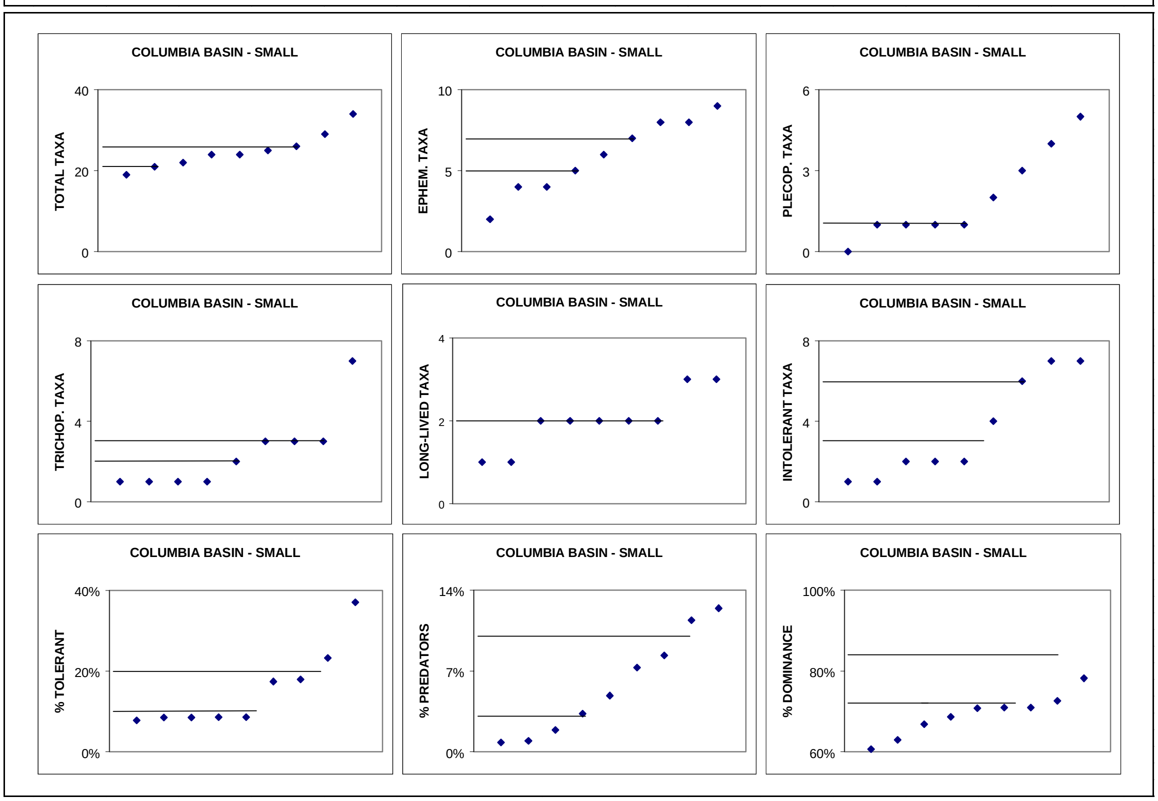


COAST RANGE - SMALL
TOTAL TAXA
52
26
0
COAST RANGE - SMALL
EPHEM. TAXA
8
4
0
COAST RANGE - SMALL
PLECOP. TAXA
12
6
0
COAST RANGE - SMALL
TRICHOP. TAXA
10
5
0
COAST RANGE - SMALL
LONG-LIVED TAXA
6
3
0
COAST RANGE - SMALL
INTOLERANT TAXA
18
9
0
COAST RANGE - SMALL
% TOLERANT
42%
21%
0%
COAST RANGE - SMALL
% PREDATORS
24%
12%
0%
COAST RANGE - SMALL STREAMS
% DOMINANCE
100%
50%
0%

COAST RANGE - SM. HEADWATERS
TOTAL TAXA
62
31
0
COAST RANGE - SM. HEADWATERS
EPHEM. TAXA
16
8
0
COAST RANGE - SM.HEADWATERS
PLECOP. TAXA
14
7
0
COAST RANGE - SM.HEADWATERS
TRICHOP. TAXA
14
7
0
COAST RANGE - SM.HEADWATERS
LONG-LIVED TAXA
8
4
0
COAST RANGE - SM.HEADWATERS
INTOL. TAXA
30
15
0
COAST RANGE - SM.HEADWATERS
% TOLERANT
28%
14%
0%
COAST RANGE - SM.HEADWATERS
% PREDATORS
16%
8%
0%
COAST RANGE - SM.HEADWATERS
% DOMINANCE
80%
40%
0%


EAST CASCADES - SM. HEADWATERS
TOTAL TAXA
60
30
0
EAST CASCADES - SM. HEADWATERS
EPHEM. TAXA
12
6
0
EAST CASCADES - SM. HEADWATERS
PLECOP. TAXA
12
6
0
EAST CASCADES - SM. HEADWATERS
TRICHOP. TAXA
12
6
0
EAST CASCADES - SM. HEADWATERS
LONG-LIVED TAXA
8
4
0
EAST CASCADES - SM. HEADWATERS
INTOLERANT TAXA
26
13
0
EAST CASCADES - SM. HEADWATERS
% TOLERANT
60%
30%
0%
EAST CASCADES - SM. HEADWATERS
% PREDATORS
60%
30%
0%
EAST CASCADES - SM. HEADWATERS
% DOMINANCE
100%
50%
0%


COLUMBIA BASIN - SMALL
TOTAL TAXA
40
20
0
COLUMBIA BASIN - SMALL
EPHEM. TAXA
10
5
0
COLUMBIA BASIN - SMALL
PLECOP. TAXA
6
3
0
COLUMBIA BASIN - SMALL
TRICHOP. TAXA
8
4
0
COLUMBIA BASIN - SMALL
LONG-LIVED TAXA
4
2
0
COLUMBIA BASIN - SMALL
INTOLERANT TAXA
8
4
0
COLUMBIA BASIN - SMALL
% TOLERANT
40%
20%
0%
COLUMBIA BASIN - SMALL
% PREDATORS
14%
7%
0%
COLUMBIA BASIN - SMALL
% DOMINANCE
100%
80%
60%

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# APPENDIX J. STREAM CLASSIFICATIONS.

## COAST RANGE ECOREGION

| STREAM ID | WET-W (m) | SIN. | W/D | SLOPE | SIZE | TYPE | STREAM ID | WET-W (m) | SIN. | W/D | SLOPE | SIZE | TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WA016S | 22.9 | 1.55 | 22.8 | 0.008 | **L** | **POOL-RIFFLE** | WA858S | 12.9 | 1.36 | 20.7 | 0.004 | **M** | **POOL-RIFFLE** |
| WA017S | 17.9 | 2.25 | 19.2 | 0.006 | **L** | **POOL-RIFFLE** | WA860S | 11.2 | 1.03 | 13.6 | 0.013 | **M** | **POOL-RIFFLE** |
| WA028S | 18.9 | 1.15 | 32.7 | 0.008 | **L** | **POOL-RIFFLE** | WA861S-1 | 7.8 | 1.43 | 12.5 | 0.011 | **M** | **POOL-RIFFLE** |
| WA826S | 14.0 | 1.55 | 17.6 | 0.008 | **L** | **POOL-RIFFLE** | WA861S-2 | 10.3 | 1.72 | 15.3 | 0.002 | **M** | **POOL-RIFFLE** |
| WA828S | 16.2 | 1.31 | 21.0 | 0.014 | **L** | **POOL-RIFFLE** | WA861S-3 | 9.0 | 1.69 | 13.6 | 0.006 | **M** | **POOL-RIFFLE** |
| WA837S | 19.2 | 1.04 | 41.2 | 0.012 | **L** | **POOL-RIFFLE** | WA861S-4 | 9.6 | 1.40 | 10.3 | 0.008 | **M** | **POOL-RIFFLE** |
| WA855S-1 | 23.3 | 1.14 | 20.6 | 0.003 | **L** | **POOL-RIFFLE** | WA001S | 0.6 | 1.02 | 3.2 | 0.040 | **S** | **HEADWATERS** |
| WA855S-2 | 30.4 | 1.15 | 24.6 | 0.000 | **L** | **POOL-RIFFLE** | WA003S | 2.0 | 1.12 | 7.1 | 0.060 | **S** | **HEADWATERS** |
| WA855S-3 | 23.0 | 1.08 | 21.9 | 0.008 | **L** | **POOL-RIFFLE** | WA009S | 1.8 | 1.06 | 5.5 | 0.082 | **S** | **HEADWATERS** |
| WA855S-4 | 21.9 | 1.10 | 22.7 | 0.003 | **L** | **POOL-RIFFLE** | WA788S | 2.1 | 1.03 | 13.4 | 0.098 | **S** | **HEADWATERS** |
| WA833S | 4.5 | 1.17 | 11.8 | 0.053 | **M** | **HEADWATERS** | WA832S | 2.0 | 1.08 | 7.8 | 0.068 | **S** | **HEADWATERS** |
| WA835S | 6.1 | 1.27 | 4.1 | 0.066 | **M** | **HEADWATERS** | WA840S-1 | 1.2 | 1.11 | 2.5 | 0.048 | **S** | **HEADWATERS** |
| WA836S | 4.8 | 1.30 | 0.8 | 0.057 | **M** | **HEADWATERS** | WA840S-2 | 1.0 | 1.09 | 4.6 | 0.053 | **S** | **HEADWATERS** |
| WA002S | 8.4 | 1.14 | 8.5 | 0.004 | **M** | **POOL-RIFFLE** | WA840S-3 | 1.1 | 1.03 | 4.2 | 0.051 | **S** | **HEADWATERS** |
| WA007S | 8.2 | 1.11 | 13.9 | 0.010 | **M** | **POOL-RIFFLE** | WA840S-4 | 1.6 | 1.11 | 3.1 | 0.051 | **S** | **HEADWATERS** |
| WA011S | 12.4 | 1.77 | 13.0 | 0.012 | **M** | **POOL-RIFFLE** | WA856S | 2.6 | 1.11 | 8.3 | 0.224 | **S** | **HEADWATERS** |
| WA014S | 5.9 | 1.08 | 12.7 | 0.020 | **M** | **POOL-RIFFLE** | WA004S | 1.2 | 1.29 | 4.0 | 0.005 | **S** | **POOL-RIFFLE** |
| WA019S | 11.9 |  | 14.0 | 0.002 | **M** | **POOL-RIFFLE** | WA018S | 1.4 | 1.05 | 2.2 | 0.013 | **S** | **POOL-RIFFLE** |
| WA022S | 6.9 |  | 8.4 | 0.022 | **M** | **POOL-RIFFLE** | WA025S | 3.4 |  | 8.6 | 0.024 | **S** | **POOL-RIFFLE** |
| WA023S | 7.1 | 1.08 | 16.6 | 0.012 | **M** | **POOL-RIFFLE** | WA026S | 1.3 | 1.06 | 4.7 | 0.032 | **S** | **POOL-RIFFLE** |
| WA024S | 8.1 | 1.19 | 8.2 | 0.013 | **M** | **POOL-RIFFLE** | WA065S | 1.2 | 1.13 | 2.8 | 0.014 | **S** | **POOL-RIFFLE** |
| WA027S | 12.8 |  | 13.9 | 0.001 | **M** | **POOL-RIFFLE** | WA780S-1 | 1.6 | 1.06 | 4.3 | 0.017 | **S** | **POOL-RIFFLE** |
| WA029S | 6.6 | 1.08 | 11.1 | 0.020 | **M** | **POOL-RIFFLE** | WA780S-2 | 1.5 | 1.07 | 5.8 | 0.018 | **S** | **POOL-RIFFLE** |
| WA062S | 4.9 | 1.11 | 10.4 | 0.022 | **M** | **POOL-RIFFLE** | WA780S-3 | 2.3 | 1.13 | 7.6 | 0.016 | **S** | **POOL-RIFFLE** |
| WA089S | 6.1 | 1.09 | 10.5 | 0.021 | **M** | **POOL-RIFFLE** | WA780S-4 | 2.6 | 1.07 | 4.7 | 0.009 | **S** | **POOL-RIFFLE** |
| WA831S | 6.8 | 1.02 | 11.5 | 0.018 | **M** | **POOL-RIFFLE** | WA838S | 3.7 | 1.05 | 7.4 | 0.005 | **S** | **POOL-RIFFLE** |
| WA842S | 9.5 | 1.88 | 12.5 | 0.007 | **M** | **POOL-RIFFLE** | WA848S | 1.3 | 1.29 | 5.0 | 0.033 | **S** | **POOL-RIFFLE** |
| WA843S | 5.0 | 1.10 | 4.0 | 0.001 | **M** | **POOL-RIFFLE** | WA853S | 1.8 | 1.03 | 8.3 | 0.026 | **S** | **POOL-RIFFLE** |
| WA850S | 5.3 | 1.31 | 8.9 | 0.009 | **M** | **POOL-RIFFLE** | WA863S | 0.8 | 1.02 | 4.3 | 0.039 | **S** | **POOL-RIFFLE** |
| WA851S | 5.9 | 1.23 | 7.2 | 0.006 | **M** | **POOL-RIFFLE** | WAR1AS | 4.0 | 1.21 | 7.2 | 0.012 | **S** | **POOL-RIFFLE** |

## COLUMBIA BASIN ECOREGION

| STREAM ID | WET-W (m) | SIN. | W/D | SLOPE | SIZE | TYPE |
|---|---|---|---|---|---|---|
| WA812S | 7.9 | 1.06 | 13.5 | 0.009 | **M** | **POOL-RIFFLE** |
| WAY46S | 8.1 | 1.15 | 10.7 | 0.010 | **M** | **POOL-RIFFLE** |
| WA794S | 0.3 | 1.10 | 10.5 | 0.046 | **S** | **HEADWATERS** |
| WA080S | 3.5 | 1.38 | 5.3 | 0.023 | **S** | **POOL-RIFFLE** |
| WA798S-1 | 1.5 | 1.05 | 5.9 | 0.014 | **S** | **POOL-RIFFLE** |
| WA798S-2 | 2.1 | 1.05 | 6.2 | 0.007 | **S** | **POOL-RIFFLE** |
| WA798S-3 | 2.7 | 1.06 | 5.9 | 0.008 | **S** | **POOL-RIFFLE** |
| WA798S-4 | 2.5 | 1.04 | 5.4 | 0.017 | **S** | **POOL-RIFFLE** |
| WA818S-1 | 0.9 | 1.09 | 7.3 | 0.025 | **S** | **POOL-RIFFLE** |
| WA818S-2 | 0.9 | 1.08 | 10.3 | 0.025 | **S** | **POOL-RIFFLE** |
| WA818S-4 | 1.5 | 1.12 | 11.2 | 0.031 | **S** | **POOL-RIFFLE** |
| WA819S | 2.4 | 1.05 | 6.6 | 0.027 | **S** | **POOL-RIFFLE** |

## CASCADES ECOREGION

| STREAM ID | WET-W (m) | SIN. | W/D | SLOPE | SIZE | TYPE |
|---|---|---|---|---|---|---|
| WA791S | 18.6 | 1.12 | 20.8 | 0.004 | **L** | **POOL-RIFFLE** |
| WAY41S | 11.4 | 1.21 | 27.8 | 0.007 | **L** | **POOL-RIFFLE** |
| WA032S | 8.4 | 1.07 | 10.6 | 0.016 | **M** | **POOL-RIFFLE** |
| WA039S | 6.4 | 1.67 | 10.5 | 0.024 | **M** | **POOL-RIFFLE** |
| WA792S | 8.5 | 1.10 | 10.9 | 0.040 | **M** | **POOL-RIFFLE** |
| WAY42S | 7.8 | 1.18 | 13.5 | 0.016 | **M** | **POOL-RIFFLE** |
| WA085S | 2.0 | 2.09 | 9.0 | 0.092 | **S** | **HEADWATERS** |
| WA031S | 2.6 | 1.15 | 7.5 | 0.015 | **S** | **POOL-RIFFLE** |
| WA040S | 2.7 | 1.68 | 6.4 | 0.029 | **S** | **POOL-RIFFLE** |
| WA083S | 3.8 | 1.01 | 9.8 | 0.020 | **S** | **POOL-RIFFLE** |
| WA086S | 3.5 | 1.24 | 11.8 | 0.016 | **S** | **POOL-RIFFLE** |
| WA088S | 1.8 | 1.15 | 7.7 | 0.039 | **S** | **POOL-RIFFLE** |

## EAST CASCADES ECOREGION

| STREAM ID | WET-W (m) | SIN. | W/D | SLOPE | SIZE | TYPE |
|---|---|---|---|---|---|---|
| WA796S | 10.6 | 1.08 | 13.9 | 0.020 | **L** | **POOL-RIFFLE** |
| WA045S | 3.5 | 1.23 | 11.1 | 0.087 | **S** | **HEADWATERS** |
| WA052S | 1.8 | 1.11 | 8.2 | 0.072 | **S** | **HEADWATERS** |
| WA073S | 1.5 | 1.05 | 7.7 | 0.068 | **S** | **HEADWATERS** |
| WA081S | 2.4 | 1.20 | 11.3 | 0.057 | **S** | **HEADWATERS** |
| WA795S | 1.0 | 1.15 | 6.7 | 0.123 | **S** | **HEADWATERS** |
| WA803S | 3.1 | 1.12 | 7.5 | 0.043 | **S** | **HEADWATERS** |
| WA804S | 0.8 | 1.26 | 4.5 | 0.134 | **S** | **HEADWATERS** |
| WA053S | 3.4 | 1.32 | 13.9 | 0.028 | **S** | **POOL-RIFFLE** |
| WA805S-1 | 3.9 | 1.11 | 4.8 | 0.019 | **S** | **POOL-RIFFLE** |
| WA805S-2 | 3.4 | 1.19 | 5.4 | 0.009 | **S** | **POOL-RIFFLE** |
| WA807S | 3.1 | 1.14 | 6.9 | 0.034 | **S** | **POOL-RIFFLE** |

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# APPENDIX K. HABITAT QUALITY AND BIOLOGICAL INTEGRITY DATA.

| STREAM_ID | STREAM_CLASS | SDWXD | PCT_BIGR | XFC_LRG | XCDENMID | HQI | BPJ | TOT_TAXA | E_TAXA | P_TAXA | T_TAXA | LLIVETAXA | INT_TAXA | %TOL | %PRED | %DOM3 | BIBI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WA016S | COAST_RANGE_L | 37808.7 | 38.2 | 5.5 | 3.3 | 34.52 | 3 | 33 | 8 | 5 | 6 | 2 | 8 | 1% | 4% | 87% | 23 |
| WA017S | COAST_RANGE_L | 51511.7 | 50.0 | 9.5 | 7.0 | 56.25 | 3 | 38 | 11 | 6 | 7 | 5 | 10 | 3% | 7% | 78% | 29 |
| WA028S | COAST_RANGE_L | 25858.1 | 90.9 | 5.9 | 4.3 | 57.07 | 2 | 38 | 14 | 1 | 9 | 3 | 16 | 1% | 16% | 66% | 35 |
| WA826S | COAST_RANGE_L | 33414.1 | 81.1 | 45.0 | 10.2 | 100.00 | 3 | 45 | 11 | 8 | 5 | 5 | 9 | 12% | 3% | 63% | 31 |
| WA828S | COAST_RANGE_L | 86172.2 | 79.2 | 53.2 | 4.0 | 90.52 | 3 | 52 | 14 | 6 | 8 | 4 | 9 | 9% | 3% | 42% | 33 |
| WA837S | COAST_RANGE_L | 29392.0 | 65.5 | 13.0 | 5.7 | 56.99 | 3 | 39 | 12 | 5 | 7 | 3 | 10 | 3% | 7% | 60% | 31 |
| WA855S-1 | COAST_RANGE_L | 94674.5 | 61.8 | 2.3 | 4.9 | 54.88 | 5 | 33 | 6 | 2 | 7 | 4 | 3 | 22% | 2% | 53% | 21 |
| WA855S-2 | COAST_RANGE_L | 257044.4 | 74.5 | 5.5 | 1.9 | 73.54 | 5 | 26 | 3 | 4 | 3 | 3 | 4 | 11% | 3% | 66% | 15 |
| WA855S-3 | COAST_RANGE_L | 159107.7 | 46.2 | 0.9 | 4.1 | 53.88 | 5 | 40 | 6 | 6 | 6 | 5 | 3 | 20% | 6% | 60% | 25 |
| WA855S-4 | COAST_RANGE_L | 106498.1 | 77.4 | 5.5 | 2.8 | 57.16 | 5 | 31 | 7 | 6 | 5 | 3 | 5 | 10% | 6% | 59% | 25 |
| WA002S | COAST_RANGE_M | 47371.7 | 18.2 | 8.2 | 9.3 | 42.55 | 4 | 36 | 7 | 7 | 5 | 6 | 8 | 3% | 11% | 74% | 25 |
| WA007S | COAST_RANGE_M | 16096.0 | 36.4 | 14.1 | 11.5 | 46.82 | 3 | 49 | 9 | 8 | 13 | 5 | 12 | 15% | 22% | 48% | 33 |
| WA011S | COAST_RANGE_M | 80040.1 | 63.6 | 6.4 | 14.3 | 76.02 | 2 | 54 | 16 | 8 | 12 | 7 | 17 | 2% | 9% | 55% | 35 |
| WA014S | COAST_RANGE_M | 4781.0 | 80.0 | 27.3 | 11.7 | 65.49 | 3 | 41 | 9 | 6 | 7 | 5 | 9 | 6% | 12% | 42% | 31 |
| WA019S | COAST_RANGE_M | 25150.0 | 41.8 | 3.6 | 14.2 | 51.17 | 4 | 59 | 14 | 9 | 10 | 4 | 13 | 4% | 13% | 46% | 37 |
| WA022S | COAST_RANGE_M | 20221.4 | 94.2 | 59.3 | 16.0 | 100.00 | 3 | 64 | 15 | 7 | 16 | 8 | 17 | 20% | 7% | 44% | 33 |
| WA023S | COAST_RANGE_M | 26580.1 | 61.8 | 7.7 | 13.1 | 58.12 | 3 | 46 | 10 | 8 | 12 | 4 | 9 | 13% | 8% | 37% | 27 |
| WA024S | COAST_RANGE_M | 52996.3 | 90.9 | 4.1 | 15.3 | 78.04 | 2 | 60 | 12 | 11 | 12 | 6 | 18 | 2% | 6% | 39% | 37 |
| WA027S | COAST_RANGE_M | 107175.0 | 14.5 | 1.8 | 14.1 | 64.82 | 5 | 26 | 5 | 3 | 4 | 3 | 5 | 3% | 2% | 81% | 15 |
| WA029S | COAST_RANGE_M | 22269.1 | 85.5 | 19.3 | 13.2 | 71.08 | 2 | 49 | 13 | 9 | 13 | 5 | 27 | 2% | 19% | 47% | 41 |
| WA062S | COAST_RANGE_M | 4311.1 | 48.1 | 9.5 | 12.8 | 47.57 | 3 | 45 | 9 | 6 | 8 | 5 | 10 | 14% | 8% | 51% | 25 |
| WA089S | COAST_RANGE_M | 16194.7 | 83.6 | 5.9 | 15.0 | 65.14 | 3 | 49 | 14 | 7 | 10 | 4 | 18 | 4% | 6% | 44% | 31 |
| WA831S | COAST_RANGE_M | 29134.1 | 80.0 | 45.5 | 14.7 | 88.09 | 3 | 38 | 11 | 6 | 7 | 2 | 13 | 2% | 5% | 67% | 21 |
| WA842S | COAST_RANGE_M | 45762.1 | 65.5 | 5.9 | 13.1 | 63.99 | 3 | 43 | 6 | 6 | 9 | 2 | 8 | 12% | 4% | 56% | 21 |
| WA843S | COAST_RANGE_M | 25556.1 | 3.6 | 11.1 | 14.8 | 43.57 | 5 | 22 | 2 | 0 | 5 | 3 | 2 | 20% | 1% | 71% | 11 |
| WA850S | COAST_RANGE_M | 27001.8 | 58.2 | 11.8 | 15.9 | 64.70 | 3 | 39 | 6 | 6 | 8 | 6 | 13 | 7% | 4% | 58% | 25 |
| WA851S | COAST_RANGE_M | 17876.8 | 21.8 | 10.9 | 15.1 | 47.92 | 5 | 32 | 3 | 7 | 6 | 3 | 9 | 6% | 3% | 64% | 21 |
| WA858S | COAST_RANGE_M | 39778.1 | 81.8 | 43.0 | 3.6 | 68.66 | 1 | 41 | 13 | 8 | 6 | 1 | 19 | 1% | 10% | 43% | 29 |
| WA860S | COAST_RANGE_M | 20002.6 | 63.6 | 27.7 | 15.3 | 71.76 | 3 | 31 | 10 | 5 | 7 | 4 | 10 | 1% | 2% | 63% | 23 |
| WA861S-1 | COAST_RANGE_M | 24214.5 | 60.0 | 9.1 | 12.6 | 56.70 | 3 | 41 | 11 | 8 | 6 | 4 | 14 | 0% | 8% | 51% | 25 |
| WA861S-2 | COAST_RANGE_M | 36766.1 | 52.7 | 9.5 | 14.4 | 61.68 | 3 | 47 | 10 | 8 | 7 | 3 | 14 | 3% | 9% | 61% | 29 |
| WA861S-3 | COAST_RANGE_M | 70710.5 | 47.3 | 10.5 | 11.2 | 64.02 | 3 | 47 | 13 | 7 | 7 | 5 | 11 | 5% | 15% | 37% | 33 |
| WA861S-4 | COAST_RANGE_M | 40461.9 | 67.3 | 11.8 | 14.5 | 68.98 | 3 | 49 | 12 | 9 | 9 | 4 | 13 | 6% | 18% | 33% | 37 |
| WA833S | COAST_RANGE_MH | 2362.5 | 93.8 | 19.5 | 7.6 | 53.21 | 1 | 46 | 14 | 9 | 10 | 2 | 23 | 3% | 8% | 54% | 43 |
| WA835S | COAST_RANGE_MH | 18788.4 | 87.3 | 75.5 | 10.7 | 100.00 | 1 | 36 | 10 | 7 | 8 | 1 | 16 | 0% | 1% | 79% | 43 |
| WA836S | COAST_RANGE_MH | 7869.3 | 89.1 | 74.8 | 6.2 | 74.68 | 1 | 18 | 6 | 5 | 3 | 1 | 12 | 0% | 5% | 67% | 39 |
| WA004S | COAST_RANGE_S | 1199.8 | 0.0 | 8.6 | 13.8 | 43.34 | 5 | 9 | 1 | 0 |  | 0 | 0 | 16% | 3% | 95% | 9 |
| WA018S | COAST_RANGE_S | 7686.0 | 2.0 | 0.0 | 14.6 | 50.78 | 5 | 22 | 0 | 2 |  | 1 | 2 | 33% | 4% | 84% | 13 |
| WA025S | COAST_RANGE_S | 6381.5 | 47.3 | 2.7 | 17.0 | 98.04 | 2 | 49 | 7 | 10 | 8 | 5 | 17 | 12% | 21% | 41% | 41 |
| WA026S | COAST_RANGE_S | 3200.6 | 9.4 | 22.7 | 15.6 | 70.17 | 5 | 42 | 4 | 9 | 9 | 2 | 12 | 8% | 6% | 74% | 35 |
| WA065S | COAST_RANGE_S | 3246.4 | 0.0 | 37.7 | 14.0 | 68.73 | 5 | 25 | 3 | 4 | 2 | 0 | 5 | 11% | 3% | 76% | 21 |
| WA780S-1 | COAST_RANGE_S | 1154.5 | 43.6 | 10.9 | 16.0 | 90.35 | 5 | 40 | 4 | 7 | 8 | 3 | 8 | 16% | 7% | 59% | 27 |
| WA780S-2 | COAST_RANGE_S | 2880.9 | 40.0 | 8.2 | 15.5 | 86.26 | 5 | 42 | 7 | 6 | 7 | 3 | 10 | 11% | 7% | 59% | 31 |
| WA780S-3 | COAST_RANGE_S | 6241.0 | 43.6 | 10.9 | 16.7 | 100.00 | 5 | 34 | 4 | 6 | 5 | 4 | 7 | 5% | 6% | 78% | 29 |
| WA780S-4 | COAST_RANGE_S | 6003.3 | 25.5 | 6.4 | 16.5 | 79.21 | 5 | 45 | 5 | 9 | 9 | 4 | 14 | 11% | 13% | 48% | 41 |
| WA838S | COAST_RANGE_S | 11512.8 | 34.5 | 9.1 | 5.9 | 71.36 | 5 | 17 | 2 | 1 | 2 | 0 | 1 | 23% | 4% | 85% | 13 |
| WA848S | COAST_RANGE_S | 1376.7 | 2.0 | 57.5 | 17.0 | 90.08 | 5 | 37 | 5 | 4 | 9 | 5 | 13 | 40% | 4% | 58% | 35 |
| WA853S | COAST_RANGE_S | 2654.6 | 23.6 | 18.9 | 16.0 | 80.21 | 3 | 44 | 5 | 8 | 7 | 4 | 12 | 4% | 9% | 73% | 39 |

| STREAM_ID | STREAM_CLASS | SDWXD | PCT_BIGR | XFC_LRG | XCDENMID | HQI | BPJ | TOT_TAXA | E_TAXA | P_TAXA | T_TAXA | LLIVETAXA | INT_TAXA | %TOL | %PRED | %DOM3 | BIBI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WA863S | COAST_RANGE_S | 599.7 | 2.5 | 56.8 | 16.9 | 88.57 | 3 | 23 | 4 | 6 | 1 | 1 | 7 | 10% | 4% | 65% | 25 |
| WAR1AS | COAST_RANGE_S | 27418.8 | 0.0 | 26.1 | 14.1 | 98.24 | 3 | 10 | 1 | 0 | 1 | 0 | 1 | 10% | 0% | 89% | 13 |
| WA001S | COAST_RANGE_SH | 256.5 | 25.5 | 21.4 | 17.0 | 59.05 | 3 | 36 | 7 | 5 | 7 | 2 | 13 | 15% | 5% | 74% | 21 |
| WA003S | COAST_RANGE_SH | 1300.2 | 25.7 | 31.3 | 16.8 | 69.68 | 5 | 50 | 8 | 12 | 10 | 3 | 20 | 7% | 14% | 44% | 39 |
| WA009S | COAST_RANGE_SH | 1907.8 | 65.5 | 48.6 | 16.3 | 100.00 | 1 | 48 | 11 | 12 | 11 | 6 | 26 | 1% | 12% | 56% | 41 |
| WA788S | COAST_RANGE_SH | 6968.8 | 34.3 | 33.2 | 11.2 | 90.89 | 3 | 33 | 9 | 3 | 4 | 0 | 7 | 21% | 6% | 56% | 15 |
| WA832S | COAST_RANGE_SH | 3816.5 | 74.5 | 15.0 | 14.7 | 89.68 | 2 | 59 | 14 | 12 | 13 | 6 | 24 | 3% | 9% | 59% | 41 |
| WA840S-1 | COAST_RANGE_SH | 1251.4 | 8.3 | 54.8 | 17.0 | 76.49 | 5 | 35 | 4 | 7 | 7 | 1 | 12 | 7% | 4% | 52% | 21 |
| WA840S-2 | COAST_RANGE_SH | 543.3 | 20.5 | 46.8 | 16.9 | 73.48 | 5 | 38 | 5 | 6 | 8 | 1 | 12 | 6% | 5% | 52% | 23 |
| WA840S-3 | COAST_RANGE_SH | 1914.7 | 9.3 | 23.4 | 16.9 | 60.83 | 5 | 31 | 6 | 6 | 7 | 2 | 10 | 12% | 4% | 66% | 19 |
| WA840S-4 | COAST_RANGE_SH | 2232.5 | 4.4 | 10.0 | 16.9 | 51.89 | 5 | 26 | 3 | 5 | 4 | 0 | 8 | 25% | 6% | 66% | 13 |
| WA856S | COAST_RANGE_SH | 5076.9 | 58.2 | 17.3 | 16.8 | 93.84 | 3 | 48 | 12 | 8 | 9 | 3 | 26 | 3% | 11% | 58% | 35 |
| WA791S | CASCADES_L | 88223.5 | 38.2 | 32.3 | 3.7 | | 1 | 43 | 6 | 8 | 10 | 7 | 9 | 19% | 4% | 64% | 33 |
| WAY41S | CASCADES_L | 26983.3 | 63.0 | 38.2 | 3.7 | | 2 | 37 | 12 | 3 | 11 | 3 | 13 | 3% | 5% | 59% | 33 |
| WA792S | CASCADES_M | 18836.1 | 63.6 | 43.4 | 8.0 | 100.00 | 2 | 50 | 12 | 10 | 13 | 2 | 24 | 2% | 8% | 55% | 35 |
| WAY42S | CASCADES_M | 6022.6 | 65.5 | 14.6 | 11.0 | 69.39 | 2 | 39 | 11 | 5 | 11 | 5 | 13 | 11% | 4% | 41% | 19 |
| WA032S | CASCADES_M | 6906.5 | 89.1 | 17.3 | 2.9 | 58.90 | 3 | 34 | 10 | 3 | 7 | 4 | 12 | 3% | 22% | 50% | 27 |
| WA039S | CASCADES_M | 16740.3 | 50.9 | 16.8 | 9.9 | 79.73 | 3 | 51 | 12 | 9 | 10 | 5 | 23 | 3% | 12% | 51% | 37 |
| WA086S | CASCADES_S | 2711.3 | 58.2 | 1.4 | 12.5 | 77.16 | 3 | 49 | 14 | 4 | 11 | 3 | 20 | 3% | 8% | 54% | 35 |
| WA083S | CASCADES_S | 3417.8 | 61.8 | 4.1 | 9.3 | 85.96 | 3 | 42 | 11 | 5 | 7 | 3 | 17 | 8% | 8% | 34% | 27 |
| WA031S | CASCADES_S | 3737.9 | 63.6 | 2.7 | 9.3 | 85.40 | 3 | 44 | 14 | 4 | 9 | 4 | 15 | 5% | 12% | 43% | 29 |
| WA040S | CASCADES_S | 4006.8 | 14.5 | 10.9 | 16.2 | 100.00 | 3 | 50 | 10 | 10 | 10 | 4 | 26 | 5% | 11% | 46% | 35 |
| WA088S | CASCADES_S | 1780.0 | 38.2 | 5.9 | 16.0 | 79.75 | 3 | 49 | 10 | 13 | 9 | 4 | 24 | 1% | 18% | 42% | 37 |
| WA085S | CASCADES_SH | 1220.3 | 64.0 | 34.1 | 16.0 | | 4 | 47 | 12 | 9 | 11 | 3 | 20 | 2% | 16% | 49% | 39 |
| WA812S | COLUMBIA_BAS_M | 21342.2 | 80.0 | 8.2 | 11.8 | | 2 | 28 | 7 | 4 | 2 | 2 | 4 | 7% | 3% | 83% | 33 |
| WAY46S | COLUMBIA_BAS_M | 17699.1 | 76.4 | 7.7 | 4.6 | | 2 | 41 | 9 | 3 | 7 | 5 | 6 | 26% | 14% | 62% | 37 |
| WA080S | COLUMBIA_BAS_S | 5716.4 | 49.1 | 13.6 | 14.0 | 100.00 | 3 | 29 | 4 | 5 | 1 | 2 | 7 | 17% | 11% | 61% | 33 |
| WA798S-1 | COLUMBIA_BAS_S | 3076.5 | 21.8 | 5.5 | 16.0 | 62.72 | 5 | 34 | 7 | 4 | 7 | 1 | 2 | 9% | 3% | 71% | 31 |
| WA798S-2 | COLUMBIA_BAS_S | 1132.6 | 25.5 | 1.4 | 16.4 | 46.38 | 5 | 24 | 4 | 1 | 3 | 3 | 1 | 8% | 1% | 78% | 23 |
| WA798S-3 | COLUMBIA_BAS_S | 5580.0 | 38.2 | 3.2 | 16.4 | 77.32 | 5 | 26 | 9 | 1 | 1 | 2 | 7 | 8% | 2% | 71% | 29 |
| WA798S-4 | COLUMBIA_BAS_S | 5344.6 | 49.1 | 1.4 | 16.7 | 76.98 | 5 | 21 | 8 | 1 | 1 | 2 | 1 | 9% | 1% | 63% | 27 |
| WA818S-1 | COLUMBIA_BAS_S | 5705.6 | 54.0 | 12.3 | 10.7 | 93.30 | 3 | 25 | 8 | 3 | 1 | 2 | 6 | 23% | 5% | 73% | 25 |
| WA818S-2 | COLUMBIA_BAS_S | 3478.8 | 76.0 | 12.5 | 12.8 | 94.54 | 3 | 19 | 5 | 1 | 2 | 1 | 2 | 37% | 8% | 71% | 19 |
| WA818S-4 | COLUMBIA_BAS_S | 2262.9 | 71.4 | 9.3 | 12.1 | 78.73 | 3 | 24 | 6 | 2 | 3 | 3 | 4 | 9% | 12% | 67% | 35 |
| WA819S | COLUMBIA_BAS_S | 4301.6 | 30.3 | 0.7 | 10.3 | 52.18 | 3 | 22 | 2 | 0 | 3 | 2 | 2 | 18% | 7% | 69% | 21 |
| WA794S | COLUMBIA_BAS_SH | 27.9 | 36.4 | 2.3 | 1.2 | | 3 | 12 | 0 | 1 | 1 | 2 | 1 | 84% | 3% | 95% | 17 |
| WA796S | E.CASCADES_L | 56015.6 | 49.1 | 15.5 | 5.7 | | 3 | 50 | 11 | 9 | 13 | 7 | 23 | 8% | 10% | 38% | 39 |
| WA805S-1 | E.CASCADES_S | 4369.4 | 60.0 | 16.4 | 15.2 | 100.00 | 2 | 20 | 6 | 1 | 2 | 1 | 6 | 2% | 4% | 69% | 31 |
| WA805S-2 | E.CASCADES_S | 6991.7 | 54.5 | 10.2 | 13.8 | 95.39 | 2 | 20 | 8 | 2 | 4 | 0 | 8 | 2% | 1% | 76% | 31 |
| WA053S | E.CASCADES_S | 3039.2 | 85.5 | 15.5 | 9.8 | 90.78 | 2 | 28 | 8 | 4 | 3 | 1 | 11 | 2% | 5% | 80% | 39 |
| WA807S | E.CASCADES_S | 2421.8 | 47.3 | 9.5 | 14.0 | 72.29 | 2 | 42 | 10 | 6 | 8 | 1 | 19 | 8% | 8% | 48% | 43 |
| WA073S | E.CASCADES_SH | 620.6 | 34.5 | 8.2 | 15.3 | 48.25 | 2 | 10 | 1 | 1 | | 0 | 3 | 47% | 46% | 89% | 15 |
| WA795S | E.CASCADES_SH | 935.0 | 91.1 | 63.9 | 16.8 | 100.00 | 2 | 31 | 5 | 8 | 4 | 1 | 8 | 2% | 3% | 84% | 19 |
| WA804S | E.CASCADES_SH | 367.7 | 40.0 | 30.5 | 16.2 | 61.58 | 4 | 38 | 6 | 6 | 9 | 2 | 12 | 13% | 4% | 62% | 25 |
| WA045S | E.CASCADES_SH | 6311.2 | 40.0 | 17.7 | 14.4 | 81.73 | 3 | 35 | 8 | 6 | 8 | 2 | 12 | 5% | 1% | 43% | 29 |
| WA803S | E.CASCADES_SH | 2319.2 | 63.6 | 26.1 | 14.0 | 73.29 | 1 | 42 | 10 | 6 | 11 | 3 | 23 | 0% | 9% | 48% | 37 |
| WA052S | E.CASCADES_SH | 1468.0 | 89.1 | 32.7 | 15.7 | 84.42 | 2 | 39 | 11 | 8 | 11 | 2 | 17 | 6% | 24% | 40% | 35 |
| WA081S | E.CASCADES_SH | 2790.9 | 69.1 | 16.6 | 13.0 | 70.93 | 2 | 48 | 11 | 10 | 9 | 6 | 21 | 3% | 12% | 38% | 41 |

# APPENDIX L.
# PROBABILITY DATA FOR pH, CONDUCTIVITY, AND ALKALINITY.

| STREAM ID | SAMPLE DATE | pH (units) | BIAS (before) | BIAS (after) | CONDUCTIVITY (uS/cm @ 25oC) | BIAS (before) | BIAS (after) | ALKALINITY (mg/L) |
|---|---|---|---|---|---|---|---|---|
| WA001S | 7/26/95 | 6.58 | -0.22 | -0.02 | 55 | 2 | 2 | 14 |
| WA002S | 7/11/95 | 7.01 | 0.20 | 0.23 | 66 | 2 | | 23 |
| WA003S | 8/8/95 | 6.96 | 0.02 | 0.11 | 61 | 3 | 3 | 15 |
| WA004S | 8/9/95 | 5.52 | 0.03 | 0.05 | 30 | 3 | 3 | 4 |
| WA007S | 8/1/95 | 6.65 | 0.05 | 0.05 | 63 | 2 | 2 | 18 |
| WA009S | 8/2/95 | 7.16 | 0.02 | 0.02 | 139 | 3 | 3 | 40 |
| WA011S | 7/12/95 | 6.86 | 0.09 | 0.06 | 68 | 3 | 3 | 29 |
| WA014S | 8/14/95 | 7.32 | 0.07 | 0.07 | 54 | 3 | 2 | 21 |
| WA016S | 8/31/95 | 7.32 | -0.06 | 0.01 | 60 | -6 | -6 | 26 |
| WA017S | 8/29/95 | 7.56 | 0.01 | 0.02 | 63 | -6 | -5 | 26 |
| WA018S | 8/10/95 | 6.02 | -0.03 | -0.03 | 58 | 3 | 4 | 19 |
| WA019S | 9/5/95 | 7.38 | 0.11 | 0.19 | 76 | 3 | 3 | 34 |
| WA022S | 9/13/95 | 7.49 | 0.03 | 0.12 | 77 | 3 | 3 | 27 |
| WA023S | 9/19/95 | 7.38 | 0.14 | 0.14 | 80 | 3 | 3 | 29 |
| WA024S | 7/27/95 | 7.44 | -0.05 | 0.05 | 84 | 1 | 1 | 31 |
| WA025S | 9/7/95 | 7.40 | 0.05 | 0.11 | 82 | 3 | 3 | 25 |
| WA026S | 7/25/95 | 6.56 | -0.04 | 0.05 | 44 | 3 | 3 | 15 |
| WA027S | 9/6/95 | 6.79 | 0.03 | 0.16 | 52 | 4 | 4 | 13 |
| WA028S | 8/22/95 | 7.50 | -0.04 | 0.08 | 64 | 0 | 2 | 34 |
| WA029S | 8/24/95 | | | | 45 | 4 | 5 | 23 |
| WA031S | 6/7/95 | 7.72 | -0.05 | 0.00 | 152 | 4 | 4 | 76 |
| WA032S | 6/14/95 | 7.30 | -0.02 | -0.02 | 71 | 3 | 3 | 36 |
| WA039S | 6/21/95 | 7.25 | -0.02 | -0.01 | 38 | 3 | 3 | 18 |
| WA040S | 6/20/95 | 7.13 | -0.06 | 0.03 | 41 | 3 | 4 | 21 |
| WA045S | 5/31/95 | 7.57 | 0.09 | 0.14 | 110 | 3 | 3 | 47 |
| WA052S | 6/22/95 | 7.18 | -0.03 | 0.00 | 131 | 2 | 2 | 65 |
| WA053S | 6/6/95 | 7.58 | 0.00 | 0.13 | 136 | 7 | 7 | 67 |
| WA062S | 9/29/95 | 7.22 | 0.09 | 0.23 | 97 | -7 | -7 | 30 |
| WA065S | 9/20/95 | 6.14 | 0.07 | 0.08 | 45 | 3 | 3 | 7 |
| WA073S | 5/23/95 | 7.76 | 0.03 | 0.08 | 127 | 3 | 3 | 48 |
| WA080S | 5/3/95 | 6.33 | -0.57 | -0.18 | 97 | 3 | 3 | 48 |
| WA081S | 6/27/95 | 7.21 | -0.06 | 0.08 | 92 | 3 | 4 | 45 |
| WA083S | 5/24/95 | 7.65 | 0.02 | 0.06 | 112 | 6 | 2 | 56 |
| WA085S | 6/15/95 | 7.18 | 0.01 | 0.08 | 68 | 3 | 3 | 34 |
| WA086S | 6/13/95 | 7.81 | 0.03 | 0.09 | 233 | 3 | 4 | 122 |
| WA088S | 6/8/95 | 7.92 | -0.05 | 0.08 | 192 | 3 | 3 | 99 |
| WA089S | 9/26/95 | 6.76 | 0.10 | 0.22 | 56 | 1 | 1 | 18 |
| WA780S | 8/30/94 | 6.47 | 0.08 | 0.05 | 66 | 9 | 9 | 20 |
| WA788S | 7/19/94 | 6.53 | 0.98 | 0.10 | 60 | 1 | 1 | 28 |
| WA791S | 6/28/94 | 6.48 | 0.01 | 0.16 | 18 | 1 | 10 | 8 |
| WA792S | 6/29/94 | 6.53 | 0.13 | 0.13 | 27 | 9 | 10 | 11 |
| WA794S | 5/31/94 | 6.82 | 0.01 | 0.10 | 186 | | 10 | 93 |
| WA795S | 6/14/94 | 6.68 | -0.01 | 0.32 | 115 | 5 | 10 | 57 |
| WA796S | 6/15/94 | 6.87 | 0.05 | 0.30 | 65 | 7 | 7 | 32 |
| WA798S | 6/1/94 | 7.35 | -0.05 | 0.18 | 235 | 9 | 9 | 109 |
| WA803S | 6/23/94 | 6.91 | -0.06 | 0.22 | 80 | 6 | 7 | 34 |
| WA804S | 6/8/94 | 6.76 | 0.03 | 0.17 | 80 | 15 | 10 | 35 |
| WA805S | 6/2/94 | 6.69 | -0.03 | 0.11 | 45 | 10 | 10 | 17 |
| WA807S | 5/25/94 | 6.88 | 0.00 | 0.03 | 74 | 20 | 19 | 29 |
| WA812S | 5/18/94 | 7.22 | | 0.17 | 130 | | 10 | 62 |
| WA818S | 5/17/94 | 8.58 | 0.19 | 0.16 | 115 | | 2 | 50 |
| WA819S | 5/16/94 | 8.22 | 0.49 | 0.50 | 600 | | 10 | 241 |
| WA826S | 8/24/94 | 6.41 | -0.08 | 0.14 | 92 | 9 | 5 | 27 |
| WA828S | 8/23/94 | 6.47 | -0.16 | 0.07 | 87 | 6 | 8 | 59 |
| WA831S | 9/15/94 | 6.50 | -0.13 | -0.08 | 66 | 10 | | 22 |
| WA832S | 7/26/94 | 7.03 | -0.04 | 0.04 | 71 | 7 | 8 | 21 |
| WA833S | 7/27/94 | 7.14 | -0.10 | 0.01 | 110 | 5 | 5 | 31 |
| WA835S | 9/26/94 | 6.64 | -0.01 | 0.16 | 134 | 4 | 6 | 56 |
| WA836S | 9/27/94 | 6.79 | -0.16 | 0.01 | 85 | 2 | 2 | 50 |
| WA837S | 8/2/94 | 6.48 | -0.03 | 0.09 | 50 | 8 | 9 | 15 |
| WA838S | 8/11/94 | 6.54 | 0.05 | 0.12 | 55 | 13 | 9 | 20 |
| WA840S | 7/28/94 | 6.27 | -0.06 | -0.06 | 59 | 7 | 9 | 7 |
| WA842S | 9/20/94 | 6.53 | 0.06 | 0.07 | 85 | 8 | 8 | 30 |
| WA843S | 8/25/94 | 6.40 | -0.02 | 0.03 | 90 | 8 | 5 | 33 |
| WA848S | 9/21/94 | 6.40 | -0.04 | 0.00 | 79 | 10 | 8 | 31 |
| WA850S | 8/3/94 | 6.92 | 0.04 | 0.14 | 80 | 8 | 5 | 30 |
| WA851S | 10/11/94 | 6.34 | 0.07 | 0.01 | 92 | 3 | 3 | 32 |
| WA853S | 9/14/94 | 6.73 | 0.09 | 0.22 | 118 | 10 | 11 | 28 |
| WA855S | 8/17/94 | 6.50 | -0.19 | -0.01 | 70 | 10 | 10 | 22 |
| WA856S | 8/31/94 | 6.67 | -0.11 | 0.01 | 130 | 9 | 9 | 59 |
| WA858S | 10/4/94 | 6.74 | 0.02 | 0.07 | 108 | 4 | 4 | 44 |
| WA860S | 7/20/94 | 6.98 | -0.13 | 0.04 | 134 | 8 | 11 | 39 |
| WA861S | 7/21/94 | 6.94 | -0.15 | -0.11 | 105 | 8 | 5 | 36 |
| WA863S | 9/13/94 | 6.25 | -0.10 | 0.11 | 70 | 13 | 9 | 17 |

**APPENDIX M. MACROINVERTEBRATE TAXA IDENTIFIED IN R-EMAP SAMPLES 1994-1995.**

| TAXON | FAMILY | ECOREGION 1 | 4 | 6 | 7 |
|---|---|---|---|---|---|
| **ACARINA** | | | | | |
| Trombidiformes (Order) | | X | X | X | X |
| **AMPHIPODA** | | | | | |
| *Gammarus sp.* | Gammaridae | X | X | | X |
| *Hyalella azteca* | Hyalellidae | X | | | X |
| **BRANCHIOBDELLIDA** | | | | | |
| Branchiobdellida (Order) | | X | X | | |
| **COLEOPTERA** | | | | | |
| Dytiscidae | Dytiscidae | X | X | X | X |
| *Ampumixis dispar* | Elmidae | X | | X | |
| *Cleptelmis ornata* | Elmidae | X | X | | X |
| *Heterlimnius corpulentus* | Elmidae | X | X | X | X |
| *Lara avara* | Elmidae | X | X | X | |
| *Narpus concolor* | Elmidae | X | X | X | X |
| *Optioservus sp.* | Elmidae | X | X | X | X |
| *Zaitzevia sp.* | Elmidae | X | X | X | X |
| Elmidae | Elmidae | X | | | |
| Hydrophilidae | Hydrophilidae | X | X | X | X |
| *Dicranopselaphus sp.* | Psephenidae | X | | | |
| **COPEPODA** | | | | | |
| Copepoda (Subclass) | | X | | X | X |
| **DECAPODA** | | | | | |
| *Pacifastacus sp.* | Astacidae | X | X | X | X |
| **DIPTERA** | | | | | |
| *Atherix sp.* | Athericidae | X | | X | |
| Athericidae | Athericidae | | | X | |
| Blephariceridae | Blephariceridae | X | X | X | X |
| Ceratopogonidae | Ceratopogonidae | X | X | X | X |
| *Eucorethra sp.* | Chaoboridae | X | | | |
| Chironomidae | Chironomidae | X | X | X | X |
| *Deuterophlebia sp.* | Deuterophlebiidae | | X | | |
| *Dixa sp.* | Dixidae | X | X | X | X |
| *Dixella sp.* | Dixidae | X | | | |
| *Meringodixa sp.* | Dixidae | X | | X | X |
| Dolichopodidae | Dolichopodidae | | | | X |
| *Chelifera sp.* | Empididae | X | X | X | X |
| *Clinocera sp.* | Empididae | X | X | X | X |
| *Hemerodromia sp.* | Empididae | X | | | X |
| *Oreogeton sp.* | Empididae | X | | | |
| Empididae | Empididae | X | | X | X |
| Muscidae | Muscidae | X | | X | |
| *Glutops sp.* | Pelecorhynchidae | X | X | X | X |
| *Maruina sp.* | Psychodidae | X | X | X | |
| *Pericoma sp.* | Psychodidae | X | X | X | X |
| *Psychoda sp.* | Psychodidae | | X | | |
| Psychodidae | Psychodidae | | | X | |
| Ptychopteridae | Ptychopteridae | X | X | X | X |
| Simuliidae | Simuliidae | X | X | X | X |
| Stratiomyidae | Stratiomyidae | X | | X | X |
| Tabanidae | Tabanidae | X | X | X | X |
| *Antocha sp.* | Tipulidae | X | X | X | X |
| *Dicranota sp.* | Tipulidae | X | X | X | X |

| TAXON | FAMILY | ECOREGION 1 | 4 | 6 | 7 |
|---|---|---|---|---|---|
| *Hexatoma sp.* | Tipulidae | X | X | X | |
| *Limnophila sp.* | Tipulidae | X | X | X | X |
| *Limonia sp.* | Tipulidae | X | | X | X |
| *Ormosia sp.* | Tipulidae | X | | | X |
| *Pedicia sp.* | Tipulidae | X | X | | |
| *Rhabdomastix sp.* | Tipulidae | X | X | X | X |
| *Tipula sp.* | Tipulidae | X | | | X |
| Tipulidae | Tipulidae | X | X | X | X |
| Diptera (Order) | | X | X | X | X |
| **EPHEMEROPTERA** | | | | | |
| *Acentrella insignificans* | Baetidae | X | X | X | X |
| *Baetis bicaudatus* | Baetidae | X | X | X | X |
| *Baetis bicaudatus/tricaudatus* | Baetidae | X | X | X | X |
| *Baetis tricaudatus* | Baetidae | X | X | X | X |
| *Centroptilum sp.* | Baetidae | X | | | |
| *Diphetor hageni* | Baetidae | X | X | X | X |
| Baetidae | Baetidae | X | X | | X |
| *Attenella sp.* | Ephemerellidae | X | X | X | |
| *Caudatella hystrix* | Ephemerellidae | X | | | |
| *Caudatella orestes* | Ephemerellidae | X | X | | |
| *Drunella coloradensis/flavilinea* | Ephemerellidae | X | X | X | X |
| *Drunella doddsi* | Ephemerellidae | X | X | X | |
| *Drunella grandis* | Ephemerellidae | X | X | | |
| *Drunella sp.* | Ephemerellidae | X | | | |
| *Drunella spinifera* | Ephemerellidae | X | X | | |
| *Ephemerella inermis/infrequens* | Ephemerellidae | X | X | X | X |
| *Serratella teresa* | Ephemerellidae | X | | X | X |
| *Serratella tibialis* | Ephemerellidae | X | X | X | X |
| *Timpanoga hecuba* | Ephemerellidae | X | X | | |
| Ephemerellidae | Ephemerellidae | | | | X |
| *Cinygma sp.* | Heptageniidae | X | | X | |
| *Cinygmula sp.* | Heptageniidae | X | X | X | X |
| *Epeorus albertae* | Heptageniidae | X | | X | X |
| *Epeorus deceptivus* | Heptageniidae | X | X | X | X |
| *Epeorus grandis* | Heptageniidae | X | X | X | |
| *Epeorus longimanus* | Heptageniidae | X | X | X | X |
| *Heptagenia sp.* | Heptageniidae | X | | | X |
| *Heptagenia/Nixe sp.* | Heptageniidae | | | X | |
| *Nixe sp.* | Heptageniidae | X | | X | X |
| *Rhithrogena sp.* | Heptageniidae | X | X | X | |
| *Rhithrogena hageni* | Heptageniidae | X | | | |
| *Rhithrogena robusta* | Heptageniidae | X | | | |
| Heptageniidae | Heptageniidae | X | | X | X |
| *Paraleptophlebia bicornuta* | Leptophlebiidae | X | | | |
| *Paraleptophlebia sp.* | Leptophlebiidae | X | X | X | X |
| *Rickera sorpta* | Perlodidae | X | X | X | |
| *Siphlonurus sp.* | Siphlonuridae | X | | | X |
| *Tricorythodes minutus* | Tricorythidae | X | | | X |
| Ephemeroptera (Order) | | X | X | X | X |
| **GASTROPODA** | | | | | |
| *Juga sp.* | Pleuroceridae | X | | | |
| Gastropoda | | X | X | X | X |

| TAXON | FAMILY | ECOREGION 1 | 4 | 6 | 7 |
|---|---|---|---|---|---|
| **HIRUDINEA** | | | | | |
| Hirudinea (Subclass) | | X | X | | X |
| **LEPIDOPTERA** | | | | | |
| *Petrophila sp.* | Pyralidae | | | | X |
| Lepidoptera (Order) | | X | | | X |
| **MEGALOPTERA** | | | | | |
| *Neohermes sp.* | Corydalidae | | | | X |
| *Sialis sp.* | Sialidae | X | X | X | X |
| **NEMATODA** | | | | | |
| Nematoda (Phylum) | | X | X | X | X |
| **ODONATA** | | | | | |
| Coenagrionidae | Coenagrionidae | | | | X |
| Gomphidae | Gomphidae | X | | | |
| Libellulidae | Libellulidae | | | | X |
| **OLIGOCHAETA** | | | | | |
| Oligochaeta (Class) | | X | X | X | X |
| **OSTRACODA** | | | | | |
| Ostracoda (Subclass) | | X | X | X | X |
| **PELECYPODA** | | | | | |
| Pisidiidae | Pisidiidae | X | X | X | X |
| Pelecypoda (Class) | | | X | | X |
| **PLECOPTERA** | | | | | |
| Capniidae | Capniidae | X | X | X | X |
| *Kathroperla perdita* | Chloroperlidae | X | | | |
| *Paraperla frontalis* | Chloroperlidae | X | X | X | X |
| *Sweltsa sp.* | Chloroperlidae | X | X | X | X |
| Chloroperlidae | Chloroperlidae | X | X | X | X |
| *Moselia infuscata* | Leuctridae | X | X | X | |
| Leuctridae | Leuctridae | X | X | X | X |
| *Amphinemura sp.* | Nemouridae | | X | X | X |
| *Malenka sp.* | Nemouridae | X | X | | |
| *Soyedina sp.* | Nemouridae | X | | | |
| *Visoka cataractae* | Nemouridae | X | X | X | |
| *Zapada cinctipes* | Nemouridae | X | X | X | X |
| *Zapada columbiana* | Nemouridae | X | X | X | |
| *Zapada frigida* | Nemouridae | X | | | |
| Nemouridae | Nemouridae | X | | X | X |
| *Yoraperla mariana* | Peltoperlidae | X | X | X | |
| *Calineuria californica* | Perlidae | X | X | X | |
| *Claassenia sabulosa* | Perlidae | | X | | |
| *Doroneuria sp.* | Perlidae | | X | X | |
| Perlidae | Perlidae | | X | | |
| *Cultus sp.* | Perlodidae | X | | X | |
| *Hesperoperla pacifica* | Perlodidae | X | X | | |
| *Isoperla sp.* | Perlodidae | X | X | X | X |
| *Kogotus nonus* | Perlodidae | | | X | X |
| *Megarcys sp.* | Perlodidae | X | X | X | |
| *Setvena bradleyi* | Perlodidae | | X | | |
| *Skwala sp.* | Perlodidae | X | X | X | |
| Perlodidae | Perlodidae | X | X | X | |
| Pteronarcidae | Pteronarcidae | | X | | |
| *Pteronarcella sp.* | Pteronarcyidae | X | | | X |

| TAXON | FAMILY | ECOREGION 1 | 4 | 6 | 7 |
|---|---|---|---|---|---|
| *Pteronarcys sp.* | Pteronarcyidae | X | X | X | |
| *Doddsia occidentalis* | Taeniopterygidae | X | | | X |
| *Taeniopteryx sp.* | Taeniopterygidae | X | | | X |
| Plecoptera (Order) | | | X | | X |
| **TRICOPTERA** | | | | | |
| *Brachycentrus americanus* | Brachycentridae | | | X | |
| *Micrasema sp.* | Brachycentridae | X | X | X | |
| *Agapetus sp.* | Glossosomatidae | | X | | |
| *Anagapetus sp.* | Glossosomatidae | X | | X | |
| *Glossosoma sp.* | Glossosomatidae | X | X | X | X |
| Glossosomatidae | Glossosomatidae | | | X | |
| *Arctopsyche grandis* | Hydropsychidae | X | X | | |
| *Cheumatopsyche sp.* | Hydropsychidae | X | | | X |
| *Hydropsyche sp.* | Hydropsychidae | X | X | X | X |
| *Parapsyche elsis* | Hydropsychidae | X | X | X | X |
| Hydropsychidae | Hydropsychidae | X | | | |
| *Hydroptila sp.* | Hydroptilidae | X | X | | X |
| *Oxyethira sp.* | Hydroptilidae | X | | | |
| Hydroptilidae | Hydroptilidae | | X | | X |
| *Lepidostoma sp.* | Lepidostomatidae | X | X | X | X |
| Lepidostomatidae | Lepidostomatidae | | | | X |
| *Mystacides sp.* | Leptoceridae | X | | | |
| Leptoceridae | Leptoceridae | X | | | |
| *Apatania sp.* | Limnephilidae | X | X | X | |
| *Chyranda centralis* | Limnephilidae | | X | X | |
| *Cryptochia sp.* | Limnephilidae | X | X | X | |
| *Desmona sp.* | Limnephilidae | X | | | |
| *Dicosmoecus atripes* | Limnephilidae | | X | | X |
| *Dicosmoecus gilvipes* | Limnephilidae | X | X | | X |
| *Ecclisocosmoecus scylla* | Limnephilidae | X | X | X | |
| *Ecclisomyia sp.* | Limnephilidae | X | X | X | |
| *Goera archaon* | Limnephilidae | X | | | |
| *Hydatophylax hesperus* | Limnephilidae | X | X | | |
| *Onocosmoecus sp.* | Limnephilidae | X | X | X | X |
| *Pedomoecus sierra* | Limnephilidae | | | X | |
| *Psychoglypha sp.* | Limnephilidae | X | X | X | X |
| Limnephilidae | Limnephilidae | X | X | X | X |
| Dolophilodes sp. | Philopotamidae | X | | | X |
| Wormaldia sp. | Philopotamidae | X | | X | |
| Nyctiophylax sp. | Polycentropodidae | X | X | | |
| Polycentropus sp. | Polycentropodidae | X | | X | |
| *Psychomyia sp* | Psychomyiidae | X | | | |
| *Rhyacophila malkini* | Rhyacophylidae | X | | | |
| *Rhyacophila sibirica grp.* | Rhyacophylidae | X | X | X | |
| *Rhyacophila verrula grp.* | Rhyacophilidae | | X | | |
| Rhyacophilidae | Rhyacophilidae | X | | | |
| *Neophylax sp.* | Uenoidae | X | X | X | |
| *Neothremma sp.* | Uenoidae | X | | | |
| Trichoptera (Order) | | X | X | X | X |
| **TURBELLARIA** | | | | | |
| Turbellaria (Class) | | X | X | X | X |

# APPENDIX N. REGIONAL BIOLOGICAL STATUS: CUMULATIVE DISTRIBUTIONS.

| COAST RANGE MEASUREMENT | % STREAMS (length) | 95% CONFIDENCE UPPER LIMIT | 95% CONFIDENCE LOWER LIMIT |
|---|---|---|---|
| B-IBI = 9 | 1% | 3% | -1% |
| B-IBI = 11 or less | 2% | 6% | -1% |
| B-IBI = 13 or less | 7% | 16% | -1% |
| B-IBI = 15 or less | 13% | 25% | 1% |
| B-IBI = 21 or less | 29% | 46% | 13% |
| B-IBI = 23 or less | 31% | 47% | 14% |
| B-IBI = 25 or less | 40% | 58% | 22% |
| B-IBI = 27 or less | 45% | 63% | 27% |
| B-IBI = 29 or less | 47% | 65% | 29% |
| B-IBI = 31 or less | 53% | 71% | 35% |
| B-IBI = 33 or less | 55% | 74% | 37% |
| B-IBI = 35 or less | 66% | 84% | 48% |
| B-IBI = 37 or less | 68% | 86% | 50% |
| B-IBI = 39 or less | 81% | 96% | 66% |
| B-IBI = 41 or less | 94% | 103% | 85% |
| B-IBI = 43 or less | 100% | | |
| FISHES = 0 species | 18% | 33% | 3% |
| FISHES = 1 species or less | 34% | 53% | 16% |
| FISHES = 2 species or less | 50% | 68% | 31% |
| FISHES = 3 species or less | 72% | 86% | 57% |
| FISHES = 4 species or less | 78% | 89% | 66% |
| FISHES = 5 species or less | 83% | 94% | 73% |
| FISHES = 6 species or less | 94% | 99% | 89% |
| FISHES = 7 species or less | 97% | 100% | 94% |
| FISHES = 8 species or less | 98% | 101% | 96% |
| FISHES = 9 species or less | 100% | | |
| SALMONIDS = 0 species | 32% | 50% | 13% |
| SALMONIDS = 1 species or less | 67% | 83% | 51% |
| SALMONIDS = 2 species or less | 87% | 96% | 77% |
| SALMONIDS = 3 species or less | 98% | 100% | 95% |
| SALMONIDS = 4 species or less | 100% | | |

| YAKIMA BASIN MEASUREMENT | % STREAMS (length) | 95% CONFIDENCE UPPER LIMIT | LOWER LIMIT |
|---|---|---|---|
| B-IBI = 15 | 2% | 6% | -2% |
| B-IBI = 17 or less | 15% | 38% | -8% |
| B-IBI = 19 or less | 18% | 42% | -5% |
| B-IBI = 21 or less | 22% | 46% | -2% |
| B-IBI = 25 or less | 39% | 66% | 12% |
| B-IBI = 27 or less | 41% | 68% | 15% |
| B-IBI = 29 or less | 45% | 71% | 19% |
| B-IBI = 31 or less | 49% | 75% | 24% |
| B-IBI = 33 or less | 55% | 80% | 30% |
| B-IBI = 35 or less | 70% | 92% | 48% |
| B-IBI = 37 or less | 83% | 100% | 66% |
| B-IBI = 39 or less | 89% | 105% | 73% |
| B-IBI = 41 or less | 96% | 104% | 89% |
| B-IBI = 43 or less | 100% | | |
| FISHES = 0 species | 52% | 77% | 27% |
| FISHES = 1 species or less | 64% | 87% | 42% |
| FISHES = 2 species or less | 87% | 98% | 76% |
| FISHES = 3 species or less | 91% | 100% | 82% |
| FISHES = 4 species or less | 95% | 101% | 89% |
| FISHES = 5 species or less | 98% | 102% | 94% |
| FISHES = 7 species or less | 100% | | |
| SALMONIDS = 0 species | 54% | 79% | 30% |
| SALMONIDS = 1 species or less | 91% | 100% | 82% |
| SALMONIDS = 2 species or less | 100% | | |