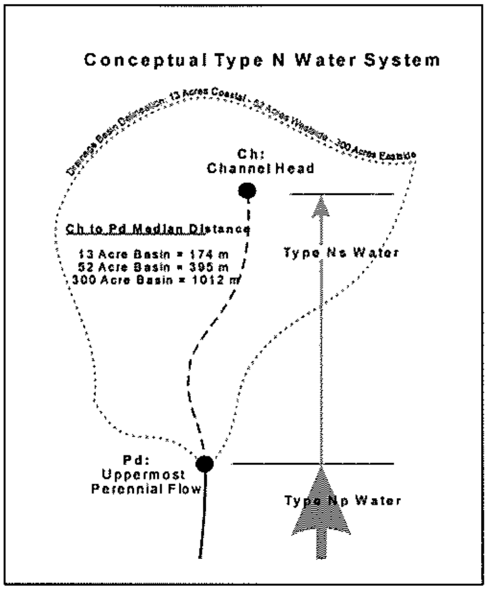
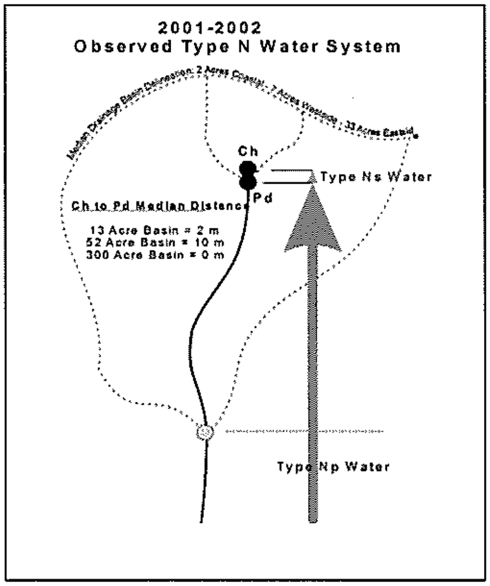
Tribal TFW/Forests & Fish Program

REPORT

Type N Stream Demarcation Study: 2002 Tribal Perennial Stream Survey Data Collection Using CMER Methods





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November 2003

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Executive Summary

Perennial Stream Survey (PSS) data was collected by the Hoh Tribe, Yakama Nation, Colville Confederated Tribes, and Kalispel Tribe during the low flow season between August 1 and October 23, 2002 and then compared to the CMER data collected in 2001[1]. This study used the same methodology as the CMER 2001 study and was conducted during 2001 data analysis and report development. The 2002 Tribal study provides inter-annual (repeat) data using a sub-set of the 2001 study sites in the Westside (52 acre default basin area or "52 dba"), effectively doubling the overall number of study sites from the 2001 Eastside data (300 acre default basin area or "300 dba"), and includes new sites in areas not sampled in 2001. This report, like the 2001 CMER project, addresses the Forests & Fish Report (FFR) Schedule L-1 priority research task to "Refine the demarcation between perennial and seasonal Type N streams" on both a remote (default) and observed (field) scale.

The 2002 site selection and data collection methods were consistent with the PSS methods version 1.21 used in the 2001 CMER study. For 2002 surveys, modifications were made to the 2001 Pilot PSS protocol based on the CMER 2001 study recommendations as described in the "Draft Perennial Stream Survey Field Sample Protocol, Version v.2002. The same field crews were used for data collection during both the 2001 and 2002 seasons. Study sites that were revisited were positively relocated using 2001 field notes and site flagging.

The intent of the 2001 CMER study (Phase I) was to collect sufficient data for estimating the sample size required for a statistically rigorous Phase II of the study. Phase I exceeded sample size expectations. Combined with 2002 sites, the result is a data set consisting of 86 study sites in the 300 dba and 152 study sites in the 52 dba, 18 of the 152 study sites within the 52 dba were used to estimate perennial stream metrics in the 13 dba (all totals based on Pd basin area counts).

Similar to the CMER 2001 study, interpretation of the 2002 data is constrained by non-random selection of the larger sample areas. However, contributors did randomly select study sites within each sample area and the sample areas were well distributed by ecoregion and precipitation values within the private forestlands of the 52 and 300 dba stratum (see Figure 3 in the Results section). Analysis of the collective data strongly indicates that the current default basin area system used to demarcate perennial and seasonal waters are significantly different. They are in fact almost an order of magnitude different based on median observed dba values. The 2001 and 2002 water year data (total precipitation over previous 12 months) indicate that the basin area and distance from channel head parameters may even be over-estimated. This is because precipitation amounts for both years were drier than normal (based on median values) in all but one sample area.

This report focuses on two parameters used in the 2001 report: a) "Pd" is the observed Type Np/Ns Water demarcation point; and b) "Ch" is the observed channel head or upper boundary of Type Ns Water.

Technical Conclusions

1. The results of the 2002 analysis are similar to the findings of the 2001 CMER report for observed Pd basin area (Table A) and Ch-Pd distance (Table B) parameters with respect to their median and frequency of distribution values.
2. For both the 2001 and 2002 studies, observed mean and median Pd basin area are highly variable and standard deviations are large relative to the mean (i.e., they have large coefficients of variation)

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[1] Palmquist et al., 2003. Type N Stream Demarcation Study Phase I: Pilot Results. CMER report review version 6.8 unless noted otherwise.

except for the 13 dba when two suspect data points are removed. (300 dba: CV = 201%; 52 dba: CV = 191%; 13 dba: CV = 90%).

3. No significant differences in Pd location between years based on inter-annual surveys.
4. Dropping the 2001 criteria for ending a survey when 200-meters of consecutive dry channel had been measured did not significantly reduce the median and frequency of distribution values for both Pd basin area and Ch-Pd distance between years as predicted.

Table A. Results of observed median Pd basin area analysis for 2001 and 2002 combined data sets. 2001 results included for comparison.

Default Basin Area	Survey Year	Sample Size	Observed Median Pd Basin Area	Percent Less Than Default
300 acres	2001	43	37 acres	89%
	2002	56	41 acres	96%
	2002 pooled	86	33 acres	91%
52 acres	2001	152	7 acres	89%
Est. 13 acres	2001	19	2 acres	89%
	2002	11	2 acres	91%

5. There is no significant linear relationship (p-value = 0.05) between perennial (Pd) basin area and measured length of seasonal channel (Ch-Pd distance), even when cooperator was added as an independent variable to account for the variability of non-randomized sites of data collection (300 dba: p-value = 0.161; 52 dba: p-value = 0.912; est. 13 dba: p-value = 0.122.

Table B. Results of observed median Ch-Pd distance (Type Ns Water channel length). 2001 results included for comparison.

Default Basin Area	Survey Year	Sample Size	Observed Median Ch-Pd Distance	Percent Less Than 100 m
300 acres	2001	25	6 meters	92%
	2002	55	0 meters	82%
	2002 pooled	67	0 meters	88%
52 acres	2001	117	10 meters	95%
Est. 13 acres	2001	18	2 meters	100%
	2002	11	8 meters	100%

6. 88 to 100 percent of all sites (2002 pooled value used for 300 dba) had Ch to Pd distances less than 100 meters and 75 percent were less than 30 meters.
7. Default basin areas are nearly an order of magnitude larger than the observed median Pd basin area for the 300 dba (33 acres), the 52 dba (7 acres), and the 13 dba (2 acres).

1.0 Introduction

Perennial Stream Survey (PSS) data was collected by the Hoh Tribe, Yakama Nation, Colville Confederated Tribes, and Kalispel Tribe during the prescribed low flow season between August 1 and October 23, 2002 and compares it to the CMER data collected in 2001[2]. This study was an independent continuation of the CMER 2001 study conducted during the period that 2001 data was being analyzed and reported. The 2002 Tribal study provides inter-annual repeat data using a sub-set of the 2001 study sites in the Westside (52 acre default basin area or "52 dba"), effectively doubles the overall number of study sited from the 2001 Eastside data (300 acre default basin area or "300 dba"), and includes new sites in areas not sampled in 2001. This report directly supports the CMER priority project in achieving the Forests & Fish Report (FFR) Schedule L-1 research task to "Refine the demarcation between perennial and seasonal Type N streams" on both a remote (default) and observed (field) scale.

This report focuses on two parameters used in the 2001 report: a) "Pd" is the observed Type Np/Ns Water demarcation point; and b) "Ch" is the observed channel head or upper boundary of Type Ns Water (Table 1). This report focuses on how the 2002 data, stratified by 13[3], 52, and 300 dba, compares to and builds upon three key metrics of the 2001 PSS data collection effort including: 1) mean annual precipitation; 2) the observed Pd basin area (basin area contributing to point Pd); and 3) the observed distance between the channel head (point "Ch") and point Pd.

Table 1. Definitions of survey points "Ch" and "Pd".

Survey Point	Definition
Ch	Channel head point - the highest observed point of a defined channel and upper boundary of Type Ns Water
Pd	Perennial discontinuous point - The highest observed point of perennial water (spatial or continuous, flowing or standing) and the Type Np/Ns Water demarcation point

The report is divided into standard scientific reporting sections including methods, results, discussion, conclusion and appendix.

1.1 Brief Review of 2001 and 2002 Study Process

Type N streams are defined as those streams that are non-fish bearing. For regulatory purposes, Type N streams are further divided into seasonal (Type Ns) and perennial (Type Np) portions. Because forest practice regulations differ substantially between Np and Ns segments, an accurate estimate of the Np/Ns break is desirable.

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[2] Palmquist et al., 2003. Type N Stream Demarcation Study Phase I: Pilot Results. CMER report review version 6.8 unless noted otherwise.

[3] Hoh data from the 52 acre default basin area region was also used independently to estimate the 13 dba in the 2001 report and that process is continued here.

The pilot phase of the Type N Demarcation Study was originally designed to gather preliminary data that would support a statewide study to "refine the demarcation of perennial and seasonal Type N streams," a task identified in Schedule L-1 of the Forest & Fish Report (FFR). It was designed to determine the:

A. Adequacy and replicability of the pilot field protocol;
B. Variability of basin areas and other parameters; and
C. Potential basin and channel attributes that are useful in defining the Np/Ns break in the field.

Ten cooperators (seven tribal, one state agency, and two timber industry) collected 2001 field data at a total of 218 independent Type N streams - a much larger sample size and distribution than originally expected. Data were collected during summer low flow conditions between August 1 and October 10. The field data were subsequently analyzed to determine the location of three hydrologic transition points:

1. Ch - the channel head
2. Pd - the highest observed perennial water (may be continuous or discontinuous, flowing or standing). Pd is the regulatory Ns/Np break
3. Pc - the upper end of continuous perennial flow.

As the data were being analyzed, the question of a 2002 season was discussed and a project proposal forwarded to CMER (see text box "Chronology of 2001-2002 Study Process"). Funding for another field season was not approved. Three of the Tribal cooperators that collected 2001 data (Hoh Tribe, Yakama Nation, and Colville Confederated Tribes) then expressed that they would fund their own data collection efforts in 2002 using a revised protocol made available for review to the Np Technical Group. Ultimately, four Tribes (add Kalispel Tribe) collected an additional 67 perennial stream survey samples and a comprehensive report has been in progress since. The primary limitation in getting this report completed and out for general review has been the difficulty in producing a stable 2001 report and corresponding data files used to conduct analysis. This has finally been accomplished with the current report version 6.85 and data files version 2.5.

Chronology of 2001-2002 Study Process

- August 1, 2001: Data collection season begins
- August 7, 2001: Perennial Stream Survey Protocol v 1.21 approved as standard for data collection.
- October 10, 2001: Data collection season ends due to start of significant precipitation
- January 23, 2002: 2001 Scope of Work approved by Np Technical Group.
- February 2002: Analysis of the 2001 data begins[1].
- March 27, 2002: Np Technical Group proposes 2002 field season projects at CMER meeting.
- May 2, 2002: Question of 2002 field season goes out – Hoh, Yakama, Colville respond they will be collecting data.
- July 8, 2002: Draft 2002 Perennial Stream Survey Protocols made available for review and comment to Np Technical Group
- August 1, 2002: Data collection season begins
- October 23, 2002: Data collection season ends due to start of significant precipitation.
- November 7, 2002: Version 1.0 draft report available for review to the Np Technical Group.
- January 14, 2003: CMER "PIP" Workshop held. Veldhuisen presentation notes that repeat "2002 data confirms" that Pd location is relatively stable.
- May 13, 2003: Report version 5.5 available for CMER review – notes that Tribes collected additional data in 2002 using revised protocol provided in Appendix R
- July 8, 2003: Veldhuisen email to UPSAG co-chairs requests process for bringing Tribal 2002 report through CMER adaptive management – suggestion to work through Np Technical Group.
- September 18, 2003:
    - "Final" report version 6.8 made available for CMER review.
    - Discussion at CMER meeting regarding process for bringing Tribal 2002 report through CMER adaptive management – revisit at October 16, 2003 CMER meeting.

2.0 Methods

The methods section will provide details of the 2002 conceptual Type N Water system, study design, data collection protocols, and data analysis.

2.1 Conceptual Type N Water System

A description of the conceptual Type N Water system was developed post-2002 to assist interpretation and analysis of the 2001 and 2002 data (Figure 1). The conceptual Type N Water system is based on the Forests and Fish Report[4] and subsequent water type system forest practices rules[5]. This system is a reconstruction of original Type N Water assumptions for data testing purposes - with the benefit of hindsight. The assumptions include:

1. Type N Waters are divided by seasonal (Type Ns) and perennial (Type Np) waters, and by implication, the common channel lengths of both Type Np and Ns Water are meaningful in both a forest practices and a hydrologic context (estimated minimum 152 meters[6]);
2. The Np/Ns break location is significantly correlated with 13 acre basins in the Western Washington Coastal zone, 52 acre basins in all other areas west of the Cascade crest, and 300 acre basins east of the Cascade crest;
3. The Np/Ns break can be "identified with simple, non-technical observations;"
4. The Np/Ns break location is significantly correlated with normal annual precipitation;
5. Type Ns Water channel length is significantly correlated with basin area.
6. The Np/Ns break location does not significantly change within or between years of normal rainfall; and
7. The Np/Ns break location does not significantly change by differences within or between geology or land management practices (e.g., sedimentary, granitic, volcanic, etc; clear-cut, second-growth, mixed-management, non-managed, etc.)

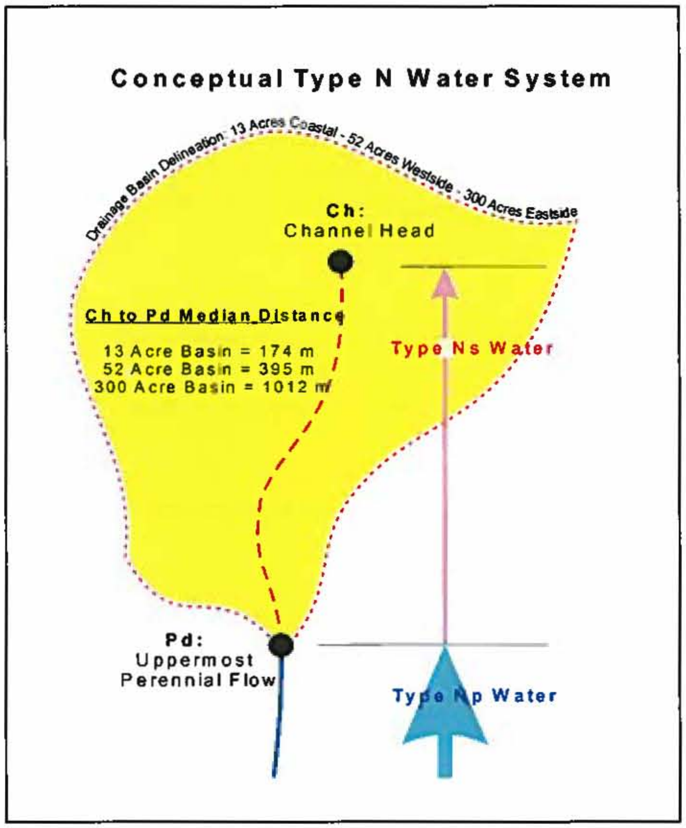

Figure 1. Conceptual Type N Water System.

The use of basin areas is based largely on the assumptions of significant differences by default basin area in "year of normal rainfall" amounts and generalized ecosystem differences with respect to which side of the Cascade crest that the private forestland resides. The assumption is that the Coastal zone precipitation

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[4] FFR Appendix B, B.1(e)(iii)

[5] Chapter 222-16-030(3) and (4) of the Washington Administrative Codes (WAC)

[6] Minimum based on "representative section of at least 500 linear feet" for determining channel geomorphic metrics of bankfull width and gradient per WAC 222-16-030(5)(f).

is highest, including moisture from fog (corresponding small basin area), and the Eastern Washington zone precipitation is lowest (corresponding large basin area).

The hydrologic model is that Type Ns Water channel lengths are expressions of seasonal precipitation and snow melt process and Type Np Water initiation is an expression of cumulative perennial groundwater input related to basin drainage size. This system is altered only where significant groundwater input at a single point (springs, wetlands, etc.) are sufficient to provide perennial flow - sometimes from the channel head resulting in no Type Ns Water above.

2.2 Study Design

The study design will describe the project objectives, sampling procedures, data collection procedures, basin delineation and area calculations, mean annual precipitation calculations, and analytical methods used in this report.

2.2.1 Project Objectives

The 2001 CMER report contains a much larger spectrum of hypothesis testing and analysis that will not be duplicated in this report. This study's objectives were to test for differences between the 2001 and 2002 data sets and differences between the 2001 data set and a combined ("pooled") 2001/2002 data set associated with:

A. Annual precipitation
   1) Estimate whether 2001 and 2002 are different in: i) water years between re-sampled data sets; and ii) water years between all 300 dba data sets;
   2) Evaluate whether 2002 independent 300 dba sites are representative of long-term annual precipitation values sampled in 2001;
   3) Evaluate whether pooling the 300 dba data is justified;
   4) Evaluate whether there is a difference in annual precipitation between the independent 300 dba data sets.

B. Observed location of point Pd
   1) Test whether there are significant differences in observed Pd basin area between all 2001 and 2002 data sets;
   2) Test whether there are significant differences in observed Pd basin area between re-sampled 2001 and 2002 data sets;
   3) Within the 300 dba, compare the 2001 Pd basin area data set with a pooled 2001/2002 data set.

C. Observed seasonal stream length (distance) from point Ch to point Pd
   1) Test whether there are significant differences in observed Ch-Pd distance between all 2001 and 2002 data sets;
   2) Test whether there are significant differences in observed Ch-Pd distance between re-sampled 2001 and 2002 data sets;
   3) Estimate whether the 2001 Ch-Pd distance data set for the 300 dba is different from the pooled 2001/2002 data set.

D. Pd Basin Area and Ch-Pd Distance (seasonal stream length) relationship
   1) Test whether Pd basin area can be used to predict Ch-Pd distance.

2.2.2 Sampling Procedures

Four Tribal cooperators collected additional Perennial Stream Survey data in 2002 including the Hoh Tribe (HOH), the Yakama Nation (YAK), the Colville Confederated Tribes (COL), and the Kalispel

Tribe (KAL). The 2002 sample size and study site distribution methods were consistent with the Perennial Stream Survey (PSS) version 1.21 used in the 2001 CMER study. Repeat survey sample sites were positively relocated using information gathered during 2001 surveys. In most cases, previous survey flagging was found to verify locations of 2001 survey points. All new 2002 survey sample sites were randomly selected within a larger cooperator-defined geographic area.

2.2.3 Data Collection Procedures

The 2001 analysis results showed that the pilot protocol met the first objective of the study by determining that the pilot field protocol was adequate and replicable for collecting observed field locations of point Pd (Type Np/Ns Water demarcation point). The 2002 site selection and data collection methods were consistent with the Perennial Stream Survey (PSS) version 1.21 used in the 2001 CMER study. For 2002 surveys, modifications were made to the 2001 Pilot PSS protocol based on the CMER 2001 study recommendations. The results of these modifications were incorporated into the "Draft Perennial Stream Survey Field Sample Protocol, Version v.2002 (Appendix A). Tribal field crews were the same as those formally trained and used for data collection during the 2001 season. Repeat study sites were positively relocated.

A significant CMER-recommended modification to the 2002 protocols was the removal of the 200-meter dry channel stop criteria and requirement to conduct the survey to the channel head. This criterion was found to be a key 2001 analysis problem as it may have overestimated Pd basin area and Ch to Pd distance measurements, especially in the 300 dba.

The findings of the 2001 report, collection of the same data points as 2001, use of trained cooperators who collected data in 2001, and improvements in the data collection protocol support the assumption that data collection quality improved between 2001 and 2002.

2.2.4 Basin Delineation and Area Calculation

The project manager[7] of the 2001 CMER report delineated and calculated all study site drainage basins within a GIS framework using ArcInfo and ArcView software. In addition, basin delineations were crosschecked with stereo pairs of aerial photographs.

The tribal cooperators also independently delineated their 2001 and 2002 point Pd basins using typical methods of on-site field interpretation, aerial photographs, and USGS 7.5 minute or GIS DEM topographic maps. Once basins were delineated within or transferred to a GIS framework, basin areas were calculated using the "ReturnArea" function as consistent with 2001 methods. A visual comparison of 2001 Pd basin areas delineated by the project manager to those calculated by Tribal cooperators on the same sites supports the assumption that the methods used are not significantly different on average. Substantial differences in calculated basin areas are noted in the results.

2.2.5 Estimating Water Year and Mean Annual Precipitation

There are two focus points to precipitation values: a) estimating whether a study site's rainfall is "normal" by calculating the total precipitation ("water year" = sum of October to September precipitation) for one year prior to the survey; and b) estimating the long-term annual precipitation for a given study site. Calculating water year using nearest NOAA weather stations to evaluate whether 2002 was "a year of

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[7] Robert Palmquist, CMER Staff Geomorphologist

normal rainfall" follows the methods defined in the 2001 report[8]. Calculating annual precipitation using GIS PRISM information also follows the methods defined in the 2001 report[9]. The PRISM annual precipitation values will be used for descriptive statistics and other testing. The assumption is that water year can be used to judge whether a given sample area or study site had relatively normal precipitation or whether it was dryer/wetter than normal as compared to being within the first and third quartiles ("normal" range) of the data set used to calculate the long-term annual precipitation values. Evaluation of wet/dry/normal patterns helps to interpret whether differences in 2001 and 2002 data can be attributed to precipitation levels as assumed in the conceptual Type N Water system.

2.3 Data Analysis

Analysis of the tribal 2002 PSS data are compared to the analysis of the 2001 Pilot PSS data as provided in the report to CMER currently being finalized. Calculations of 2001 data will use the Reach Summaries and Site Characteristics version 2.5 data files provided by the 2001 project manager. The 2001 CMER report contains a much larger spectrum of hypothesis testing and analysis that will not be duplicated in this report. The 2002 data analysis will focus on limited parts of 2001 Hypotheses B1, "Default basin areas are a consistent predictor of points Pp through Pd," and Hypothesis B4, "Other physical parameters- - either singly or in combination -- are not better predictors of points Pd through Pp than default basin areas." Data used in analysis by Site ID number and cooperator is provided in Appendix B.

The data used in analysis is divided into 12 data sets for purposes of continuity with 2001 results, statistical testing of independent and repeated sites, and pooling of related data for greater statistical power and interpretative value. The validity of pooled data will be tested for each parameter. Table 2 provides a list of these data sets with shaded rows denoting those sets directly comparable to 2001 results. A graphic illustration of the data sets and their relationships is provided in Figure 2.

Table 2. List of data sets by cooperator, default basin area, and data set code. Shaded rows denote data set concurrences with 2001 report.

Data Set	Default Basin Area	Data Set Code
Total Eastside 2001 Sites	300	TE-01
Total Eastside 2002 Sites	300	TE-02
Independent Eastside 2001 Sites	300	IE-01
Independent Eastside 2002 Sites	300	IE-02
COL 2001 Sites	300	COL-01
COL 2002 Repeated Sites	300	COL-R02
Pooled Eastside 2001 and 2002 Sites	300	PE-1
Pooled Eastside 2001 and 2002 Sites + COL 2001 Sites	300	PE-2
Total Westside 2001 Sites	52	TW-01
HOH 2001 Sites	52/13	HOH-01
HOH 2002 Repeated Sites	52/13	HOH-R02

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[8] Section 2. Methods. Year of Normal Rainfall, p.21: Water year extrapolated to sample areas from nearest NOAA long-term weather stations; Mean annual precipitation determined for each study site using GIS PRISM information.
[9] Section 2. Methods. GIS Data, Table 8, p.16.

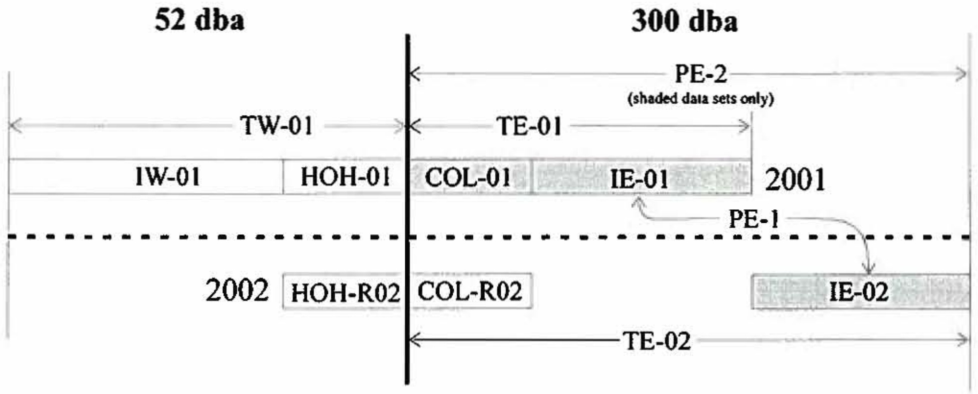

Figure 2. Data sets used in this report and their relationships by default basin area (dba) and year.

Analysis will follow a three step process including: 1) a summary of descriptive statistics (sample size, average, median, standard deviation, minimum, maximum, 1st quartile, 3rd quartile, CV of original data in percent, and CV of log scale in percent); 2) frequency of distribution; and 3) statistical tests for differences between 2001 and 2002 data.

2.3.1 Descriptive Statistics

Definitions and methods used for each descriptive statistic include:

- Sample Size: Number of sites actually sampled that had measurements of a particular parameter.
- Average: Sum of the measurements divided by the number of measurements in the sum.
- Median: Middle observation of an ordered list of observations of a particular parameter. In the case of an even number of observations, the average of the two middle numbers is computed. Or, the number that partitions the sample into two equal sizes, with 50 percent of the data below this number and 50% of the data above this number.
- Standard Deviation (Std Dev or sd): The square root of the variance where the variance is defined as the sum of the squared differences from the mean divided by (n-1) where n is the number of measurements of the parameter.
- Minimum: Lowest value in a data set.
- Maximum: Highest value in a data set.
- 1st Quartile: The number that partitions the sample to contain 25 percent data below this number.
- 3rd Quartile: The number that partitions the sample to contain 75 percent data below this number.
- CV of Original Data: Coefficient of variation. The standard deviation divided by the average.
- CV of Log Scale: Coefficient of variation. The standard deviation of the natural log transformation of the data divided by the average of the log transformation of the data.

The above estimates are computed after removing missing values. For the CV of the log scale of Ch-Pd distance, the value of 1 was added to all measurements of zero (0) Ch-Pd distance to prevent removal of those measurements in the calculation. For a discussion on measures of central tendency see CMER Report, Section 2. Methods Data Analysis, page19.

2.3.2 Frequency of Distribution

Frequency of distribution analysis was conducted by standard method including: a) sorting all the data within a data set in numerical order from lowest value to highest; b) counting the number of data points within a defined value category; c) dividing the count for each category by the data set sample size; and d) converting the result into percentage. An additional step to determine the cumulative percentage was conducted for the observed Pd basin area and Ch-Pd distance parameters by systematic summing of all lower values with the value at the category of interest (Table 3).

Table 3. Measurement categories used in frequency of distribution analysis.

Annual Precipitation Percent by Category	Pd Basin Area Cumulative Percent by Category	Ch-Pd Distance Cumulative Percent by Category
Sample Size	Sample Size	Sample Size
Average/Median Values (inches)	Average/Median Values (acres)	Average/Median Values (acres)
< 20 (inches)	< 5.2 (acres)	0 (meters)
21 - 30 (inches)	5.3 - 30 (acres)	1 - 30 (meters)
31 - 60 (inches)	31 - 52 (acres)	31 - 50 (meters)
61 - 75 (inches)	53 - 100 (acres)	51 - 100 (meters)
76 - 100 (inches)	101 - 200 (acres)	101 - 200 (meters)
101 - 125 (inches)	201 - 300 (acres)	201 - 300 (meters)
> 125 (inches)	301 - 1000 (acres)	301 - 500 (meters)
	> 1000 (acres)	501-1000 (meters)
		> 1000 (meters)

The annual precipitation size categories were selected based on both the six PRISM map categories and the three-precipitation categories used in the CMER report[10]. Pd basin area size categories were selected at order of magnitude differences from the default region criteria (5.2 and 30 acres), at the default region criteria (52 and 300 acres), at 100 acre intervals up to 300, and finally breaking at the 1000 acre and above point. Ch-Pd distance categories were selected based on an a priori observed distribution of the data.

2.3.3 Statistical Tests for Differences between 2001 and 2002 Data

Statistical testing is used to interpret whether there are differences between 2001 and 2002 data. The addition of the 2002 data provides multiple tests between different data sets to look for differences not available with the 2001 data alone. Two sample areas have repeated data and these are considered separately creating "independent" data sets to assess influence. If the results of conducting these tests shows that there are no differences, the conclusion will be that specified data sets can be combined or "pooled." All statistical tests in this report are interpreted at the $\alpha = 0.050$ level.

2.3.3.1 Rationale for Pooling Data

The objective of this section is to determine if pooling the data is reasonable. In this study the selection of sample areas within a large geographic default basin area was not random and depended on which agencies participated in this study. However, study sites within sample areas were randomly selected. Because the sample areas were not selected at random, pooling the data from study sites from different sample areas is questioned. Statistical techniques such as blocking can be used to address the issues of non-randomization. These analyses are legitimate methods and provide insights into likely differences and probable relationships between measures of interest, which is especially useful when developing a new study.

Ultimately, as with all statistical applications, the question of pooling data depends on the objective, and for this study it depends on the scale at which you intend to apply the data. In this study we have two scales, sample area and study site. If the application is to use the data for estimation and prediction, for example, sample size calculations for the entire eastside (300 dba sample area), then pooling without statistically removing sample area by blocking is desirable, if not necessary, because sample area is a

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[10] Section 3. Results: Figure 11, page 33 and Table 15, page 34.

portion of the total variability that exists within a broad geographic area. In contrast, study sites within a sample area are more similar to each other than they are to study sites in another sample area, thus, the estimate of within-sample area variability will be too small for your application, because it isn't representative of the broad geographic area. Subsequently, the computation of the coefficient of variation (CV) for sample size computations based on sites from within a sample area (i.e., not pooling sites from all sample areas) will result in a sample size that is too small, ultimately leading to a study with not enough statistical power to detect differences if differences exist, thus a waste of valuable resources. Below, three scenarios are presented for when data from different, non-randomly chosen sample areas, can be pooled.

1. The first scenario is when all sample areas are used in the study. It's a census of the sample areas, and no longer a sample, thus randomization is not possible.
2. The second scenario is a subjective but informed rationale for pooling. If scientists can agree that the sample areas under study are representative of the data one might encounter in the population of interest, then pooling can be rationalized. Here, representative sample is defined as a sample with a distribution of measures that would be highly unlikely to change greatly with additional sampling of the remaining population. In the situation of a representative sample, it is intended that you have captured the variability that exists in the population through this sample. Further, if other variables, such as geology are confounded with sample area, then it might be impossible to completely randomize a study based on sample area.
3. The third scenario is when scientists can't agree that the sample areas under study are representative of the data one might encounter in the population of interest. The addition of "sample area" as a blocking variable to an analysis of variance or analysis of covariance will account for any effects of sample areas. After accounting for the effects of the sample areas, the remaining effects will be statistically free of biases introduced by actions due to sample areas, including non-randomized selection of sample areas. However, because there are usually other confounding effects, the estimated effects of blocking variables cannot be interpreted, thus, are ignored in hypothesis testing. Then, if hypothesis tests provide a consistent failure to detect differences that would otherwise argue against pooling, then, pooling is acceptable.

2.3.3.2 Tests for Pooling Data

For the above reasons, the following analyses will be conducted because they best represent the concept of capturing the variability of the entire 300 dba, and this can be done best by pooling rather than taking a sample area by sample area approach. Further, estimates of variability from this analysis will be more appropriate for future exercises, such as sample size computations for the entire 300 dba. The analyses below focus on other factors, specifically between year variation that if exists, would question our ability to pool the data.

Five of the 12 data sets are used for statistical testing of differences between 2001 and 2002 sites in the 13 and 300 dba. A subset of these sites (HOH-R02, n=11; and COL-R02, n=13), are 2002 re-samples of 2001 sites. The 52 dba sites have been statistically analyzed previously and will not be included in this report. The purpose of the statistical analysis is to determine if the observed point Pd basin area in 2001 differs from the observed point Pd basin area in 2002, in the 13 and 300 dba sites measured in both of these years. Four tests of hypotheses for each of the three parameters are provided: 1) paired t-tests for repeated sites in the 13 dba HOH-01 and HOH-R02 data sets[11]; 2) paired t-tests for repeated sites in the 300 dba COL-01 and COL-R02 data sets; 3) a standard two-sample t-test for independent sites in the 300 dba IE-01 and IE-02 data sets; and 4) a standard two-sample t-test for 2001 "repeated sites" combined with the independent sites in the 300 dba TW-01 and IE-02 data sets. In the situations where the validity

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[11] The HOH 13 dba sites are actually from 52 dba survey sites in the coastal area of the Hoh watershed. They were used as surrogates in the 2001 report as no other 13 dba sites were surveyed.

of the t-tests is in question, a Mann-Whitney test is used to test the hypothesis that the two samples are not different.

A paired t-test is used to avoid any potential effects from the selection of the study site, therefore the differences are only attributable to differences between years. For the paired t-tests on HOH-01/HOH-R02 and COL-01/COL-R02 data sets, boxplots are used to assess normality of the differences (2001 data minus 2002 repeat data, by site). For the standard two-sample t-tests on IE-01 and IE-02 data sets, boxplots are used to assess homogeneity of variance (i.e., similar variance) between the 2001 and 2002 data sets. Two sample t-tests are robust to most assumptions, especially departures in normality, thus normality was not assessed. However, two sample t-tests are less robust to the presence of non-homogeneous variance especially when skewness and/or unequal sample size are present. If the logarithm transformation was not sufficient for stabilizing variances, then removal of extreme points was used to transform data to distributions with homogeneous variance. Also, inspections of the ratios of the standard deviations and sample sizes (Ramsey and Schafer, 1997[12]) were performed to assist in determining the validity of the t-tests for the data set of interest.

In general, the validity of the t-tests diminishes when the ratio of the variances equals the ratio of the sample sizes and these ratios approach 4 or more. When a ratio exceeded 2.5 in our analyses, a Mann-Whitney test was performed. For a more detailed description of the validity of t-tests under non-homogeneous variance, skewness, and unequal sample size, see Ramsey and Schafer (1997).

A standard two sample t-tests was used for the TE-01, IE-01, and IE-02 data sets. The TE-01 data set (i.e., all 300 dba sites plus COL repeat sites for 2001 only) allows us to mimic adding additional randomly sampled sites without additional field sampling. Note that the additional data is only for 2001, thus, this mimicry is limited in scope.

2.3.4 Statistical Tests for Relationships between Pd Basin Area and Ch-Pd Distance

The objective of this analysis is to test the hypothesis that there is no linear relationship between Pd basin area and Ch-Pd distance; i.e., we will test the hypothesis that the slope of Pd basin area is equal to zero. Two linear regression models are used to test this hypothesis for the 52 and 300 dba stratum separately. In the first model, Pd basin area is the sole independent variable. In the second model, cooperator and year are added as independent variables, to account for the variability of non-randomized sites and for years of data collection. As only one cooperator sampled study sites that could be used as a surrogate in the 13 dba stratum, only the first model with Pd basin area as the sole independent variable can be used.

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[12] Ramsey, F. and D. Schafer. 1997. The Statistical Sleuth. Wadsworth Publishing Company, Belmont, CA.

3.0 Results

The Results section provides comparisons of 2001 and 2002 data analysis pertaining to sample size and area, annual precipitation, Pd basin area, channel head (Ch) to Pd distance. Where 2001 data is reported, it complies with the most current version of the 2001 report and related data files unless noted otherwise. Within each parameter section, analysis is divided into descriptive statistics, frequency of distribution, and statistical tests for differences between 2001 and 2002 data.

3.1 Sample Areas and Study Site Populations

The 2001 study surveyed a total of 218 study sites with 172 located in the 52 dba and 46 in the 300 dba of the state[13]. As no samples were collected in the 13 dba, the report uses data from the most adjacent 22 HOH-01 study sites to estimate how 13 dba data might differ from the 52 dba[14] data. In 2002, HOH, YAK, COL, and KAL cooperators conducted 67 Perennial Stream Surveys during the 2002 field season. The total number represents 2002 repeat surveys on 24 sites and 43 new sites in geographically different locations than where 2001 data was collected (Figure 3).

General Location of 2001 & 2002 Perennial Stream Surveys in Washington State

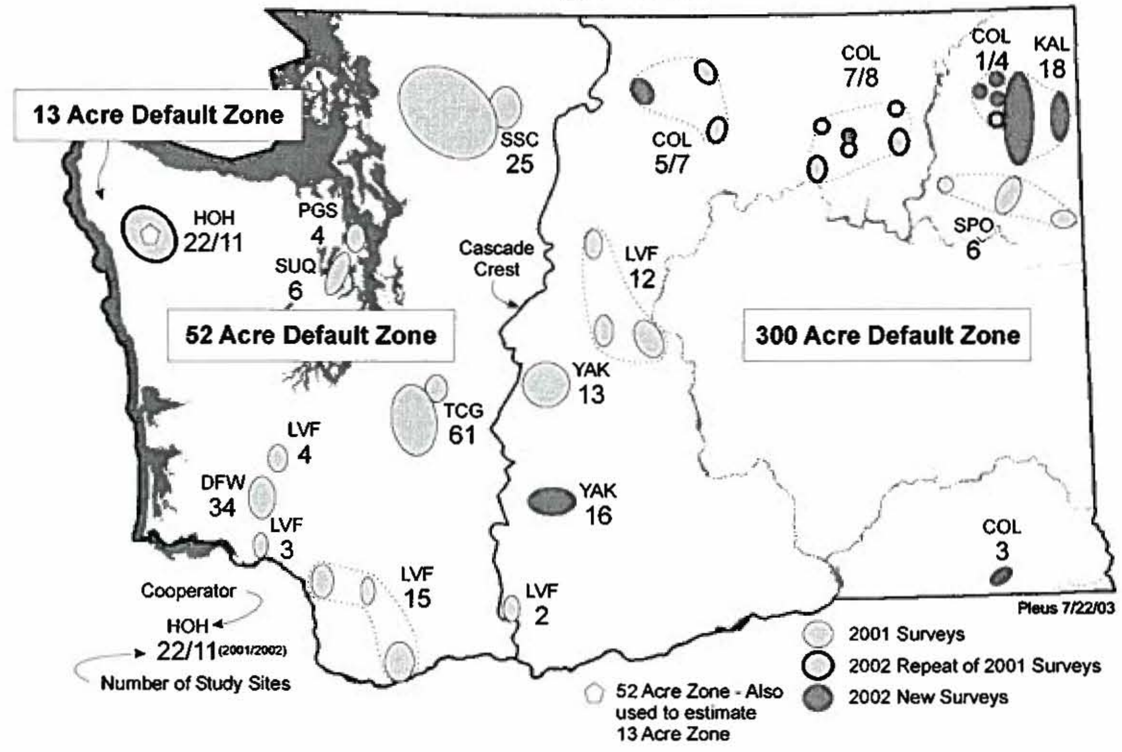

Figure 3. State of Washington map showing the general locations of 2001 and 2002 Perennial Stream Surveys.

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[13] Breakdown of sample size by default region from previous report versions. Version 2.5 data files identify only 171 study sites with one of the three parameters used in this report.

[14] Section 2. Methods: Data Analysis, FFR default regions, p. 19

The HOH Tribe randomly selected 11 of their original 22 study sites surveyed in 2001 for resample and did not collect data on any new study sites. The COL cooperator repeated all 13 of their 2001 study sites and collected data on 9 new sites in different geographic areas, including the Blue Mountains in southeast Washington. The YAK cooperator did not repeat any of the 13 study sites surveyed in 2001. They focused their 2002 surveys in the Ahtanum River watershed (NW section of WRIA 37) and collected data on 16 new sites. The KAL cooperator did not collect Perennial Stream Survey data in 2001, but did collect data on 18 new study sites in the Pend Oreille River watershed (Southern section of WRIA 62 near Idaho boarder). The study site identification number for each data set used in descriptive statistics and statistical tests is provided in Table 4.

Table 4. List of sample populations used in statistical testing by cooperator, population code, and associated site identification number.

Data Set Code	Study Site ID #
TE-01	IE-01 + COL-01
TE-02	COL-R02 + 300-342
IE-01	92-110, 191-200.5, 202-205, 212,
IE-02	300-342
COL-01	80-91
COL-R02	80-91
PE-1	IE-01 + IE-02
PE-2	PE-1 + COL-01
TW-01	1-79, 111-190, 201, 206-209, 213-215.5, 217-238
HOH-01	217-238
HOH-R02	217, 218, 220, 223, 225, 229, 231, 232, 236-238

The combined results of the 2001 and 2002 data collection provides a large sample size of non-statistically random sample areas within which statistically random study sites were identified. Sample sizes by data set and parameter used in this report's analysis are provided in Table 5.

Table 5. Sample area and size counts by parameter and divided by Eastside (300 dba), Westside (52 dba), and Coastal (13 dba) default basin areas for respective years. Shaded columns denote data set concurrences with 2001 report.

Sample Area & Size Counts by Parameter	**Eastside (300 dba)**								**Westside (52 dba)**	**Coastal (13 dba)**	
	TE-01	TE-02	IE-01	IE-02	COL-01	COL-R02	PE-1	PE-2	TW-01	HOH-01	HOH-R02
Total Sample Size	**46**	**56**	**34**	**43**	**13**	**13**	77	**89**	**171**	**22**	**11**
Annual Precipitation Sample Size	46	56	34	43	12	13	77	89	171	21	10
Pd Basin Area Sample Size	43	56	32	43	11	13	75	86	152	19	11
Ch-Pd Distance Sample Size	25	55	22	42	3	13	64	67	117	18	11

Results

- 261 independent surveys + 24 repeated surveys = 285 total surveys between 2001 and 2002
- The HOH-R02 data collection provided a 50 percent repeat (11/22) sub-sample of the HOH-01 data set.
- The COL-R02 data collection provided a 100 percent repeat of the COL-01 data set.
- The TE-02 data collection provided a 22 percent larger sample size (56/46) than the TE-01 data set.

- Reductions in sample sizes for Pd basin area from total survey sample size in 2001 are primarily due to the protocols not requiring sufficient topographic map detail to accurately transfer the data points to a GIS format.
- Reductions in sample size for Ch-Pd distance reflects the problem of the 200-meter dry channel protocol stopping many surveys before they reached the channel head.
- The nearly perfect capture of point Ch (55 out of 56 sites) in the TE-02 data set for the Ch-Pd distance parameter reflects the results of 2002 improvements to the 2001 protocol.

3.2 Water Year and Mean Annual Precipitation

This section will analyze variability associated with annual precipitation in inches through use of descriptive statistics, frequency of distribution, and statistical testing.

3.2.1 Estimated Water Year and "Normal" Rainfall Analysis

Water Year (WY) for this study is defined as the 12 months beginning on October 1 of previous calendar. Quartile ratings are divided into Wet (W), Dry (D), and Normal (N) categories based on whether the precipitation totals fall below the 1st quartile, above the 3rd quartile, or between the 1st and 3rd quartiles respectively. Quartile ratings are provided for both the water year and for the survey season months (August and September) only. Three 2001 weather stations were recalculated for 2002 and three new stations (Colville, Dayton & Yakima) were added to better represent new 2002 Eastside sampling areas (Table 6).

Table 6. Precipitation data for water years 2001 and 2002 summarized by the NOAA weather station closest to cooperator sample areas.

NOAA Weather Station	Default Basin Area	Water Year (WY)	WY Precip. Total (inches)	Median (inches)	Quartile Rating	Aug & Sept Water Months Precip. Total (inches)	Quartile Rating
Forks (HOH)	13	2001	86.12	119.61	D	12.30	W
		2002	126.21		N	3.01	D
Republic (COL)	300	2001	10.74	16.39	D	1.09	D
		2002	14.26		N	0.91	D
Winthrop (COL)	300	2001	8.32	13.92	D	0.85	N
		2002	9.84		D	0.21	D
Colville (COL, KAL)	300	2002	16.35	16.44	N	0.79	N
Dayton (COL – Blue Mt)	300	2002	15.77	19.27	D	0.32	D
Yakima (YAK)	300	2002	7.24	7.79	N	0.1	D

Results

- Water years for 2002 were higher (wetter) in total precipitation than 2001 weather stations for Forks, Republic, and Winthrop.
- All 2001 and 2002 water years were lower (drier) in total precipitation than their respective median values except for 2002 Forks.
- All 2001 and 2002 survey season water months were lower (drier) in total precipitation than their respective median values except for 2001 Forks.

- In the 13 acre default basin area, the Forks weather station indicates that 2001 had an unusually dry water year and an unusually wet survey season and 2002 had a normal water year and unusually dry survey season.
- In the northwestern portion of the 300 acre default basin area, the Republic and Winthrop weather stations indicate that 2001 had an unusually dry water year and mixed dry/normal survey seasons and 2002 had a mixed dry/normal water year and unusually dry survey season.
- In the northeastern portion of the 300 acre default basin area, the Colville weather station indicates that 2002 had a normal water and survey season.
- In the southeastern portion of the 300 acre default basin area, the Dayton weather station indicates that 2002 had an unusually dry water year and survey season.
- In the western central portion of the 300 acre default basin area, the Yakima weather station indicates that 2002 had a normal water year and an unusually dry survey season.

3.2.2 Annual Precipitation Descriptive Statistics Analysis

The 2001 report[15] interpreted the Westside basin areas and distances downstream as "probably representative of a year of normal rainfall," and the Eastside basin areas and distances downstream as being "larger than those occurring during a year of normal rainfall." Table 7 provides descriptive statistics for 2001 and 2002 annual precipitation information by default basin stratification and associated data set.

Results

- All data sets show similar values of average and median precipitation (similarities are within, not between, data sets).
- The 2002 results reflect the general 2001 progression in annual precipitation medians (previously not quantified) from the 300 dba (35/39 inches), to the 52 dba (76/79 inches), to the 13 dba (125/125 inches).
- There is an 18-inch increase in median values between TE-01 (35 inches) and IE-01 (53 inches) values when the effect of the COL-01 data set (22 inches) is removed. 2002 result supports the observation that COL sites were drier than the other 300 dba sites.
- Pooling the data sets in PE-1 and PE-2 show similar average and median values as those in the TE-01 and TE-02 data sets.
- The range of minimum and maximum values for the 52 and 300 dba show a potential significant overlap of values.
- The addition of the HOH-01 data used to estimate the 13 dba back within the IW-01 data only changed its median value from 76 to 79 inches even though all 21 HOH-01 data sites had significantly higher precipitation values.
- A large difference between the 3rd quartile and the maximum combined with the proximity of the 3rd quartile to similar mean and median values indicates skewness in the data set

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[15] Section 4. Discussion – Year of Normal Rainfall, p. 37

Table 7. Annual precipitation summary of descriptive statistics for 2001 and 2002 perennial stream surveys sorted by 13, 52, and 300 default basin area and twelve associated data sets.

Annual Precipitation Descriptive Statistics	**Eastside** (300 dba)								**Westside** (52 dba)	**Est. Coastal** (13 dba)	
	TE-01 (Total)	TE-02 (Total)	IE-01	IE-02	COL-01	COL-R02	PE-1 (Pooled)	PE-2 (Pooled)	TW-01 (Total)	HOH-01	HOH-R02
Sample Size	**46**	**56**	**34**	**43**	**12**	**13**	**77**	**89**	**171**	**21**	**10**
Average (inches)	42	36	48	40	23	23	44	41	82	127	130
Median (inches)	**35**	**39**	**53**	**39**	**22**	**23**	**39**	**39**	**79**	**125**	**125**
Stand Dev (acres)	22	11	22	9	7	7	16	17	23	12	12
Minimum (inches)	13	15	15	17	13	15	15	13	19	117	117
Maximum (inches)	111	63	111	63	37	37	111	111	155	155	155
1st Quartile (inches)	22	31	33	37	19	19	35	27	69	125	125
3rd Quartile (inches)	61	39	63	41	28	27	53	49	95	125	133
CV Original Data (%)	53	30	45	21	30	29	37	44	29	6	9
CV of Log Scale (%)	16	10	14	6	10	9	10	13	7	1	2

3.2.3 Annual Precipitation Frequency of Distribution Analysis

The frequency of distribution for study sites by annual precipitation was determined for all data by a simple count of study sites with precipitation levels within a selected size category in inches (Table 8). The highest percentage of study sites falling within a precipitation category is highlighted.

Table 8. Annual precipitation frequency of distribution statistics for 2001 and 2002 perennial stream surveys sorted by 13, 52, and 300 default basin area and twelve associated data sets.

Annual Precipitation Percent by Category	**Eastside (300 dba)**								**Westside (52 dba)**	**Est. Coastal (13 dba)**	
	TE-01	TE-02	IE-01	IE-02	COL-01	COL-R02	PE-1	PE-2	TW-01	HOH-01	HOH-R02
Sample Size	46	56	34	43	12	13	77	89	171	21	21
Average/Median Values (inches)	**42 / 35**	**36 / 39**	**48 / 53**	**40 / 39**	**23 / 22**	**23 / 23**	**44 / 39**	**41 / 39**	**82 / 79**	**127/ 125**	**130 / 125**
< 20 (inches)	22%	11%	18%	2%	33%	38%	9%	12%	< 1%	0	0
21 - 30 (inches)	15%	14%	0	2%	58%	54%	1%	9%	1%	0	0
31 - 60 (inches)	35%	71%	44%	91%	8%	8%	70%	62%	7%	0	0
61 - 75 (inches)	26%	4%	35%	5%	0	0	18%	16%	35%	0	0
76 - 100 (inches)	0	0	0	0	0	0	0	0	38%	0	0
101 - 125 (inches)	2%	0	3%	0	0	0	1%	1%	16%	81%	81%
> 125 (inches)	0	0	0	0	0	0	0	0	2%	19%	19%

Results

- Within the Eastside (300 dba) stratum, the 31-60 inch annual precipitation category had the highest number of study sites for TE-01 (35%), TE-02 (71%), PE-1 (70%) and PE-2 (62%).
- The 300 dba study sites used in TE-01 reflect a broader distribution across the annual precipitation range than TE-02.
- Within the 52 dba, the 76 – 100 inch category had the highest number of study sites in the IW-01 (43%) and TW-01 (38%) data sets.
- The greatest overlap (sites with similar precipitation values) between the 52 and 300 dba appears to be in the 61-75 inch category with secondary overlap in the 31-60 inch category.
- Within the 13 dba, 101-125 inch category had the highest number of study sites for both HOH-01 (81%) and HOH-R02 (81%).
- As the observed results were similar between years and 2002 cooperators do not report significant in-field precipitation differences. This supports the assumption that the methods used to calculate annual precipitation are suitable for comparisons and that 2002 also was "a year of normal rainfall."

3.2.4 Statistical Tests for Differences Between 2001 and 2002 Annual Precipitation Data

The purpose of this analysis is to determine if the precipitation in 2001 differs statistically from the precipitation in 2002, in the 13 and 300 dba sites measured in both of these years. Three tests of hypotheses are shown: a standard two-sample t-test for independent sites in the 300 dba (IE-01 and IE-02), a standard two-sample t-test for 2001 "repeated sites" combined with the independent sites in the 300 dba (TE-01 and IE-02), and a Mann-Whitney Test.

3.2.4.1 Annual Precipitation Standard Two Sample T-Tests and Mann-Whitney Test

Precipitation: IE-01 and IE-02 data sets

Precipitation for independent sites was skewed and there is non-homogeneous variance for the two years (Figure 4). A natural logarithm transformation of the independent sites (Figure 5) transforms the distribution of the data for the two years to be more symmetric and eliminates potential "extreme points" but does not rectify the non-homogeneous variance. The ratio of the two standard deviations is approximately 2.5 on both the original scale and natural logarithm scale, and the sample sizes are moderately large and similar for both groups (sd_{2001}= 21.517, sd_{2002} = 8.473, ratio is 2.539; sd_{2001} log scale = 0.531, sd_{2002} log scale= 0.217, ratio is 2.447; n_{2001} = 34, n_{2002} = 43, ratio of the sample sizes is 1.26). Based on this information, we concluded that the t-tests are marginally valid for this data set (Ramsey and Schafer, 1997).

- A standard two sample t-test **failed to reject** the hypothesis that there are no differences in the natural logarithm of precipitation between IE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = 0.904, df = 75, p-value = 0.369). The means on the natural logarithm scale are 3.75 and 3.67, respectively, for 2001 and 2002 data.
- The Mann-Whitney Test **failed to reject** the hypothesis that the true mu equals zero (Mann-Whitney Test: rank-sum normal statistic with correction Z = 1.53, p-value = 0.126)

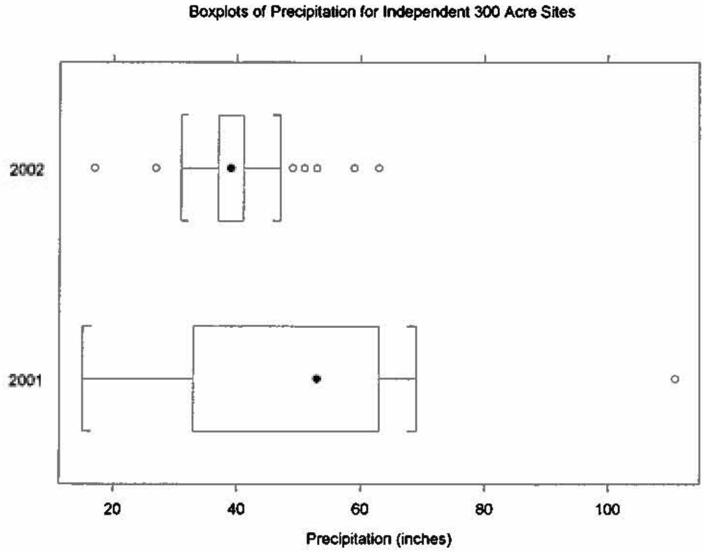

Figure 4. Boxplots of precipitation for independent 300 dba sites, original scale.

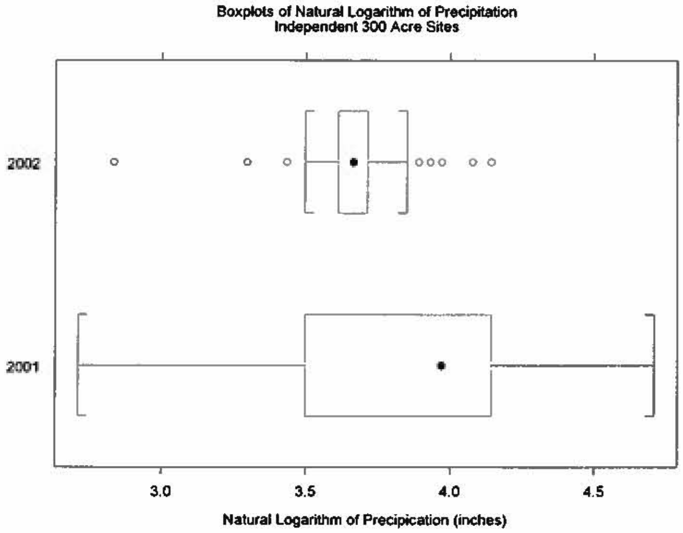

Figure 5. Boxplots of precipitation for IE-01 and IE-02 data sets, natural logarithm scale.

Precipitation: TE-01 and IE-02 data sets

As with the previous analysis, the natural logarithm of precipitation remedies the skewness but not the non-homogeneous variance (Figure 6 and 7). Standard deviation for 2001 increased slightly, resulting in an increase in the ratio of the standard deviations ($sd_{2001} = 21.843$, $sd_{2002} = 8.473$, ratio = 2.6). Sample sizes are almost identical ($n_1 = 46$, $n_2 = 43$), thus the t-test was judged to be valid for these data (Ramsey and Schafer, 1997). However, because the ratio of the variance is relatively large for the data in this study, a Mann-Whitney Test was employed as a conservative hypothesis test.

- Adding 13 more sites resulted in a slight move in the 2001 mean (natural logarithm scales) towards the mean of the 2002 data, and, resulted in an increase in the standard deviation and consequently, resulted in an increase in the ratio of the standard deviations. The sample sizes are nearly identical.
- A two sample t-test **failed to reject** the hypothesis that there is no difference between the TE-01 and IE-02 data (Two sample t-test: t = -1.021, df = 87, p-value = 0.310). The means on the natural logarithm scale are 3.58 and 3.67, respectively, for 2001 and 2002.
- A Mann-Whitney Test **failed to reject** the hypothesis that the true mu equals zero (Mann-Whitney Test: rank-sum normal statistic with correction Z = -0.722, p-value = 0.470).

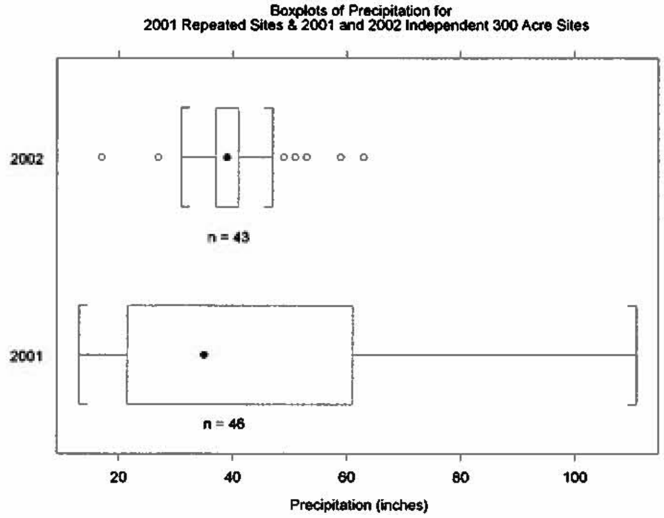

Figure 6. Boxplot of precipitation for the TE-01 and IE-02 data sets.

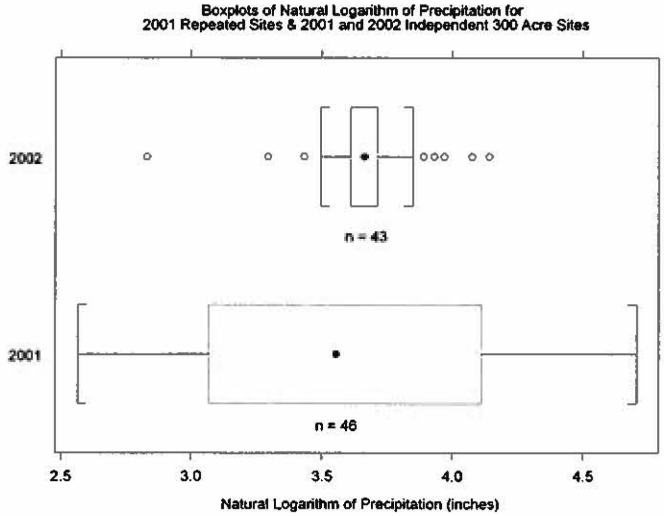

Figure 7. Boxplot of the natural logarithm of precipitation for the TE-01 and IE-02 data sets.

3.2.4.2 Statistical Conclusion for Annual Precipitation

All hypothesis tests and observations consistently **fail to reject** the hypothesis that there is no difference in annual precipitation between 2001 and 2002. Therefore, both pooling IE-01 and IE-02 for creating PE-1 and pooling TE-01 and IE-02 for creating the data set PE-2 is justified.

3.3 Observed Point Pd Basin Area

This section will analyze variability associated with observed Pd basin area in acres through use of descriptive statistics, frequency of distribution, and statistical testing.

3.3.1 Observed Point Pd Basin Area Descriptive Statistics Analysis

The 2001 report found that the observed Pd basin areas differ from their respective FFR default regions. This is reflected in median values nearly an order of magnitude different including 37 acres for TE-01, 7 acres for IW-01, and 2 acres for HOH-01 data sets (Table 9).

Results

- There are large differences between average and median values for all data sets. This indicates skewness in the data.
- In the 300 dba, the TE-01 median value results (37 acres) are similar to the TE-02 data set (41 acres) and PE-2 data sets (33 acres).
- The addition of the HOH-01 data set back with the IW-01 data set does not change the median value from 7 acres (TW-01) and changes the average by only two acres.
- An inverse relationship between Pd basin area and annual precipitation is observed where there is a 17-acre decrease in median values between TE-01 (37 acres) and IE-01 (20 acres) when the effect of the COL-01 data set (58 acres) is removed. 2002 results are similar. This could indicate geographic variability within the 300 dba.
- The HOH-R02 repeated surveys do not appear different from HOH-01 results in the measures of central tendency. The observed 2001 variability (standard deviation) may reflect an error in delineating the two largest basin areas in that data set. Delineation of basin areas for Sites # 226 and 227 differed substantially from those the cooperator calculated using on-site information. Site #226 - 85 acres by project manager and 3 acres by cooperator; Site #227 – 17 acres by project manager and 6 acres by cooperator. If cooperator calculations were used instead, the standard deviation would be _2.3_and the CV would be 90%. This indicates that the variability in the HOH is less variable than the greater 52 dba data set and the least variable default basin area of the three default stratum.
- A large difference between the 3rd quartile and the maximum combined with the proximity of the 3rd quartile to similar mean and median values indicates skewness in the data sets. Assuming cooperator basin area values best represent Sites #226 and 227, the HOH data sets has less skew than the others.

Table 9. Observed Pd basin area summary of descriptive statistics for 2001 and 2002 perennial stream surveys sorted by 13, 52, and 300 default basin area and twelve associated data sets.

Pd Basin Area Descriptive Statistics[16]	**Eastside** (300 dba)								**Westside** (52 dba)	**Est. Coastal** (13 dba)	
	TE-01 (Total)	TE-02 (Total)	IE-01	IE-02	COL-01	COL-R02	PE-1 (Pooled)	PE-2 (Pooled)	TW-01 (Total)	HOH-01	HOH-R02
Sample Size	**43**	**56**	**32**	**43**	**11**	**13**	**75**	**86**	**152**	**18**	**11**
Average (acres)	118	77	73	70	252	99	71	94	22	8	4
Median (acres)	**37**	**41**	**20**	**29**	**58**	**66**	**27**	**33**	**7**	**2**	**2**
Stand Dev (acres)	242	107	146	112	392	92	127	189	42	20	4
Minimum (acres)	0.4	0.4	0.4	0.4	12	9	0.4	0.4	0.1	0.1	1
Maximum (acres)	1,224	604	620	604	1224	289	620	1224	260	85	13
1st Quartile (acres)	9	13	8	11	39	41	9	10	3	1	1
3rd Quartile (acres)	68	85	54	80	203	143	68	73	22	5	5
CV Original Data (%)	206	140	201	160	156	92	178	201	191	249	100
CV of Log Scale (%)	55	40	61	44	31	27	51	49	70	215	95

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[16] 2001 data from version 6.85 - Section 3. Results: Basin Area Variability, Table 12, p.28

3.3.2 Observed Point Pd Basin Area Frequency of Distribution Analysis

The frequency of distribution for study sites by point Pd basin area was determined for all data by a simple count of study sites with basin area levels within a selected size category in acres (Table 10). Highlighted values denote order of magnitude and approximate 90% cumulative percent levels.

Table 10. Observed Pd basin area frequency of distribution statistics for 2001 and 2002 perennial stream surveys sorted by 13, 52, and 300 default basin area and twelve associated data sets.

Pd Basin Area <u>Cumulative</u> Percent by Category	**Eastside (300 dba)**								**Westside (52 dba)**	**Est. Coastal (13 dba)**	
	TE-01	TE-02	IE-01	IE-02	COL-01	COL-R02	PE-1	PE-2	TW-01	HOH-01	HOH-R02
Sample Size	43	56	32	43	11	13	75	86	152	19	11
Average/Median Values (acres)	**118 / 36**	**77 / 41**	**73 / 20**	**70 / 29**	**252 / 58**	**99 / 66**	**71 / 27**	**94 / 33**	**22 / 7**	**8 / 2**	**4 / 2**
< 5.2 (acres)	19%	5%	35%	9%	0%	0%	16%	14%	45%	79%	73%
5.3 - 30 (acres)	47%	43%	56%	51%	18%	23%	53%	49%	84%	95%	100%
31 - 52 (acres)	68%	59%	75%	65%	45%	38%	69%	66%	89%	95%	
53 - 100 (acres)	80%	79%	88%	81%	55%	69%	84%	80%	96%	100%	
101 - 200 (acres)	87%	91%	91%	95%	73%	77%	93%	90%	99%		
201 - 300 (acres)	89%	96%	91%	95%	82%	100%	93%	91%	100%		
301 - 1000 (acres)	98%	100%	100%	100%	91%		100%	98%			
> 1000 (acres)	100%				100%			100%			

Results

- All data sets except for COL-01 and COL-R02 for the 300 dba shows that approximately 50 percent of the sites were an order of magnitude less than the default value, 80 percent were less than 100 acres.
- Data set PE-2 shows that 90 percent of the sites were less than or equal to 200 acres.
- The TW-01 data set for the 52 dba shows that 45% of the sites were an order of magnitude less than, and 89% were less than the default value.
- Adding the HOH-01 data set to IW-01 does not appear to significantly change distribution values (TW-01).
- The HOH-01 and HOH-R02 data in the 13 dba shows that 73-79% of the sites were less than 5.2 acres.
- Except for COL-01, only 2 percent of a given data set is larger than 300 acres.

3.3.3 Statistical Tests for Differences between 2001 and 2002 Observed Point Pd Basin Area Data

The purpose of this analysis is to determine if the observed point Pd basin area in 2001 differs statistically from the observed point Pd basin area in 2002, in the 13 and 300 dba sites measured in both of these years. Four tests of hypotheses are shown: paired t-tests for repeated sites in the 13 (HOH-01 and HOH-R02) and 300 dba (COL-01 and COL-R02), and a standard two-sample t-test for independent sites in the 300 dba (IE-01 and IE-02), and a standard two-sample t-test for 2001 "repeated sites" combined with the independent sites in the 300 dba (TW-01 and IE-02).

3.3.3.1 Pd Basin Area Paired T-Tests

<u>Pd Basin Area: HOH-01 and HOH-R02 data sets</u>

In order for site to be included in a paired t-test, each site must be sampled both in 2001 and 2002. For the HOH 13 dba sites, only 9 sites meet this criterion as Sites #236 and 237 were surveyed in both years, but not used in the 2001 analysis. Inspection of the boxplot of the differences for the HOH 13 dba sites, the data are skewed left because of the existence of two left extreme points (Figure 8). Removing these two points and replotting the remaining data, the resulting boxplot illustrates a distribution that is slightly skewed to the right (Figure 9). Note that removal of two data points from a small data set is not optimal and caution should be used in any interpretation of such tests.

- The paired t-test **failed to reject** the hypothesis that the differences between HOH-01 and HOH-R02 data sets were not different from zero (Paired t-test: t-statistic = -1.2, df = 8, p-value = 0.2645.
- Also, the paired t-test **failed to reject** the hypothesis that the differences between HOH-01 and HOH-R02 data sets minus sites 16 and 22 were not different from zero (Paired t-test: t-statistic = 0.3368, df = 6, p-value = 0.7477.

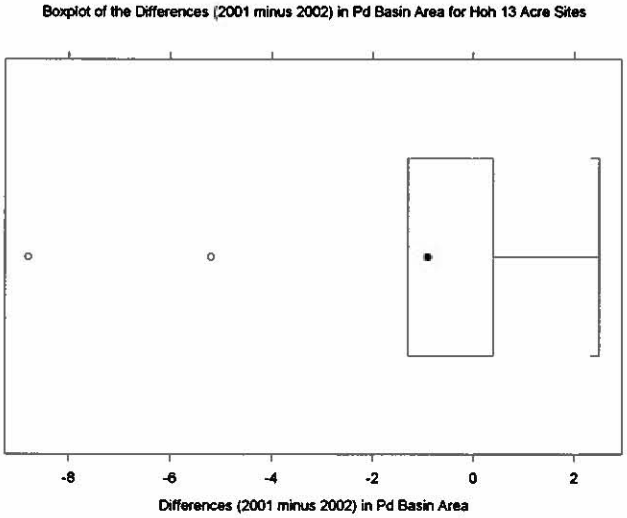

Figure 8. Boxplot of the differences in Pd basin area for the HOH-01 and HOH-R02 data sets, all sites.

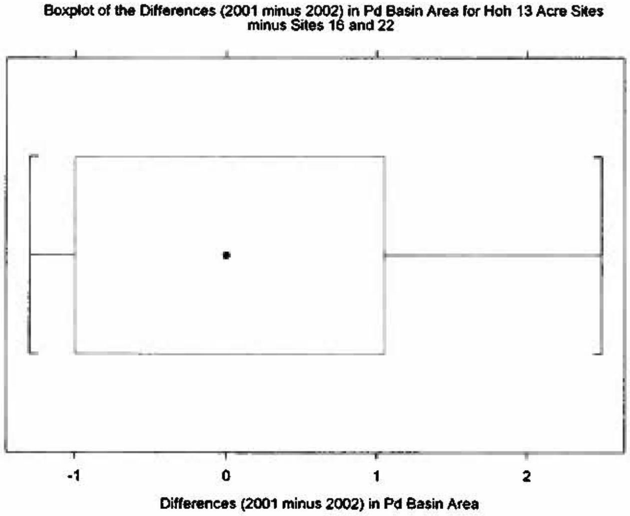

Figure 9. Boxplot of the differences in Pd basin area for the HOH-01 and HOH-R02 data sets, less sites 16 and 22.

Pd Basin Area: COL-01 and COL-R02 data sets

The distribution of the differences of Pd basin area is slightly skewed (Figure 10). These two extreme points were identified as Site # 80 and 82. Removal of these extreme points results in a distribution of the differences that is nearly symmetric (Figure 11).

- A paired t-test **failed to reject** the hypothesis that the differences in Pd basin area between COL-01 and COL-R02 data sets for all sites are zero (including the extreme points) (Paired t-test , t-statistic = 1.217, df = 10, p-value = 0.251).
- A paired t-test of the differences between COL-01 and COL-R02 data set Pd basin area measurements, without sites 80 and 81, **failed to reject** the hypothesis that the differences are zero (paired t-test, t-statistic = -1.158, df = 8, p-value = 0.280).

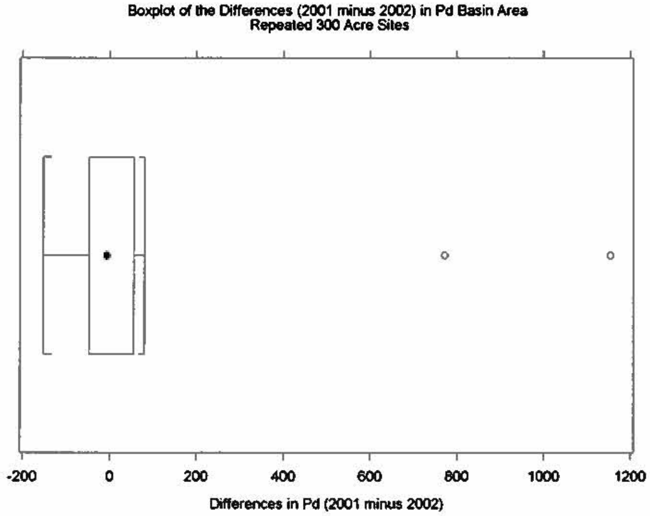

Figure 10. Boxplots of the differences in Pd for COL-01 and COL-R02 data sets (2001 minus 2002). The two values greater than 600 belong to sites # 80 and 82.

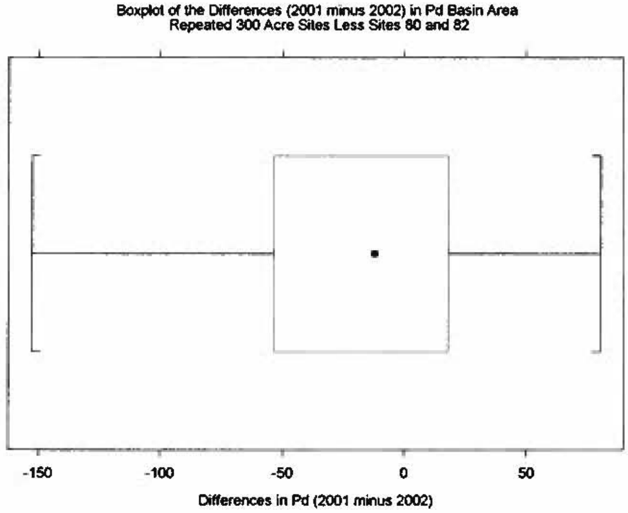

Figure 11. Boxplot of differences in Pd for COL-01 and COL-R02 data sets, minus sites 80 and 82.

3.3.3.2 Observed Pd Basin Area Standard Two Sample T-Tests

Pd Basin Area: IE-01 and IE-02 data sets

As with Pd basin area for all sites, precipitation for independent sites was skewed right for both 2001 and 2002 two years (Figure 12). Natural log transformation of independent sites (Figure 13) removes much of the skewness in the data.

- A two sample t-test **failed to reject** the hypothesis of the natural logarithm of Pd basin area for independent sites differed between IE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = -1.167, df = 73, p-value = 0.247).

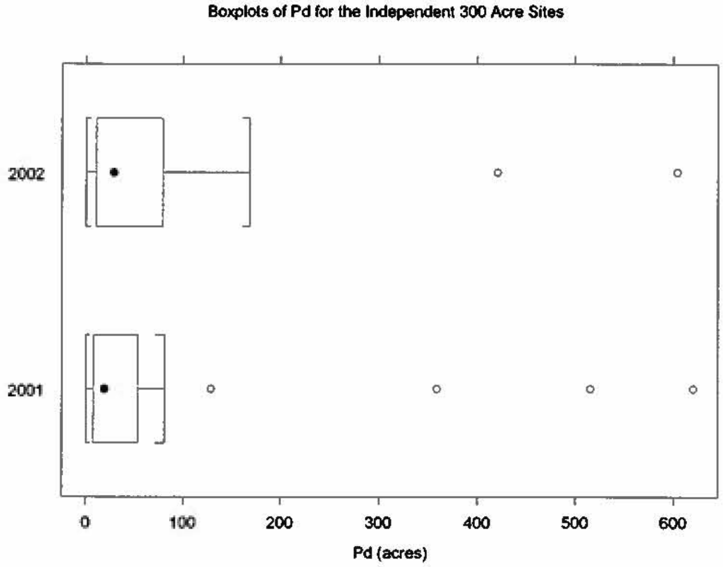

Figure 12. Boxplots of Pd measured in independent sites, original scale.

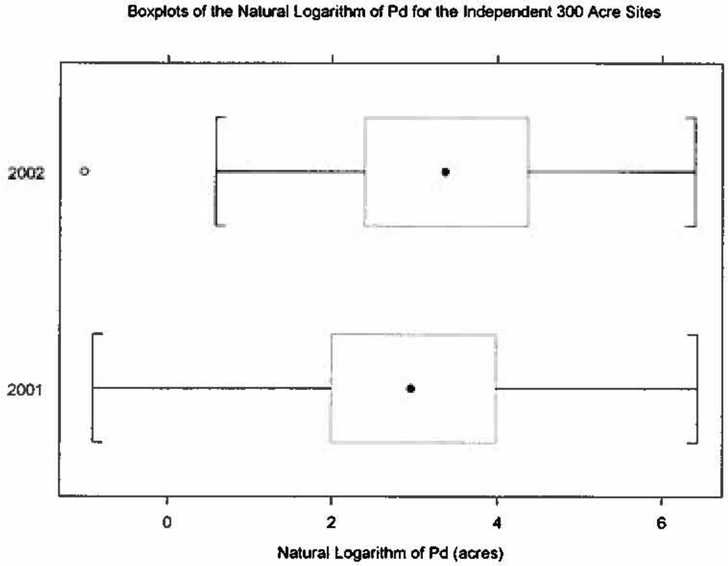

Figure 13. Boxplots of Pd measured in independent 300 acre sites, natural logarithm scale.

Pd Basin Area: TE-01 and IE-02 data sets

The distribution of the original data is skewed to the right (Figure 14) and by visual inspection it is apparent that the natural logarithm transformation removes the skewness and variances are similar (Figure 15).

- The two sample t-test **failed to reject** the hypothesis that the natural logarithm of Pd basin area was not different between TE-01 and IE-02 data sets. (Two sample t-test: t-statistic = -0.048, df = 84, p-value = 0.962).

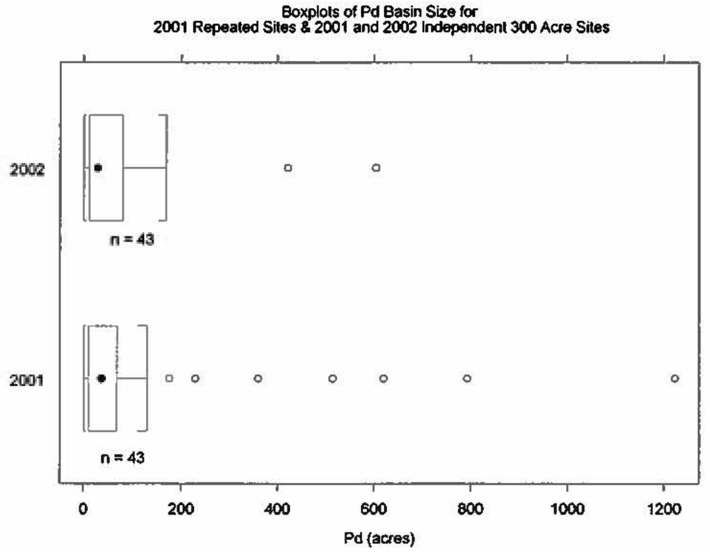

Figure 14. Boxplots of Pd basin area for TE-01 and IE-02 data sets.

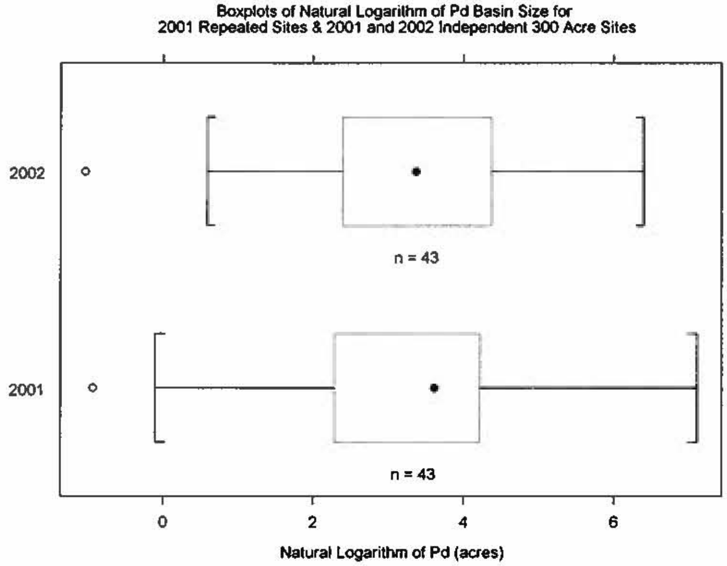

Figure 15. Boxplots of natural logarithm of Pd basin area for TE-01 and IE-02 data sets.

3.3.3.3 Statistical Conclusion for Observed Pd Basin Area

All hypothesis tests consistently fail to reject the hypothesis that there is no difference in Pd basin area between 2001 and 2002. Therefore, both pooling IE-01 and IE-02 for creating PE-1 and pooling TE-01 and IE-02 for creating the data set PE-2 is justified.

3.4 Observed Point Channel Head (Ch) to Pd Distance

This section will analyze variability associated with observed channel head (Ch) to Pd distance in meters through use of descriptive statistics, frequency of distribution, and statistical testing.

3.4.1 Observed Point Ch to Pd Distance Descriptive Statistics

The 2001 report did not find a statistical difference between those with "0" distances included ("Channel Head Springs and Seeps Included") and those with "0" distances removed ("No Channel Head Springs and Seeps"). Therefore, only the data including "0" distances are compared to 2002 results in Table 11.

Results

- Median values across all data sets and default regions do not appear to vary substantially.
- Differences between average and median values appear to be large and indicate skewness. However, these distances may not be functionally different for TE-01, IE-01, IW-01, TW-01, HOH-01 and HOH-R02.
- Average/standard deviation values increased from TE-01 (23/44) to TE-02 (137/463). This increase could be explained by an expansion of geographic sample area from which sites were surveyed.
- A large difference between the 3rd quartile and the maximum combined with the proximity of the 3rd quartile to similar mean and median values indicates skewness in the data sets.

Table 11. Observed Ch-Pd distance summary of descriptive statistics for 2001 and 2002 perennial stream surveys sorted by 13, 52, and 300 default basin area and twelve associated data sets.

Ch-Pd Distance Descriptive Statistics[17]	**Eastside** (300 dba)								**Westside** (52 dba)	**Est. Coastal** (13 dba)	
	TE-01 (Total)	TE-02 (Total)	IE-01	IE-02	COL-01	COL-R02	PE-1 (Pooled)	PE-2 (Pooled)	TW-01 (Total)	HOH-01	HOH-R02
Sample Size	**25**	**55**	**22**	**42**	**3**	**13**	**64**	**67**	**117**	**18**	**11**
Average (meters)	23	137	18	151	60	93	105	103	24	4	19
Median (meters)	**6**	**0**	**6**	**0**	**0**	**11**	**0**	**0**	**10**	**2**	**8**
Stand Dev (meters)	44	463	30	523	104	166	427	418	37	6	26
Minimum (meters)	0	0	0	0	0	0	0	0	0	0	0
Maximum (meters)	180	3145	122	3145	180	587	3145	3145	225	22	70
1st Quartile (meters)	0	0	0.3	0	0	0	0	0	1	1	1
3rd Quartile (meters)	22	59	12	37	90	102	31	32	29	6	5
CV Original Data (%)	187	338	173	347	173	179	408	406	154	136	133
CV of LogScale (%)[18]	61	31	84	153	173	104	130	54	69	79	67

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[17] 2001 data from version 6.85 - Section 4. Discussion: Alternative Indicators, Table 16, p.46

[18] For Ch-Pd distance the value of 1 was added to each of the sites before the natural log transformation. This ensures that all sites with the measurement of Ch-Pd are included in the calculation of CV of log scale.

3.4.2 Observed Point Ch-Pd Distance Frequency of Distribution Analysis

The frequency of distribution for study sites by point Ch to Pd distance was determined for 2001 data by a simple count of study sites with basin areas within a selected basin size category (Table 12).

Table 12. Observed Ch-Pd distance frequency of distribution statistics for 2001 and 2002 perennial stream surveys sorted by 13, 52, and 300 default basin area and twelve associated data sets.

Ch-Pd Distance <u>Cumulative</u> Percent by Category	**Eastside (300 dba)**								**Westside (52 dba)**	**Est. Coastal (13 dba)**	
	TE-01	TE-02	IE-01	IE-02	COL-01	COL-R02	PE-1	PE-2	TW-01	HOH-01	HOH-R02
Sample Size	25	55	22	42	3	13	64	67	117	18	11
Average/Median Values (acres)	**24 / 6**	**137 / 0**	**18 / 6**	**151 / 0**	**60 / 0**	**93 / 11**	**105 / 0**	**103 / 0**	**24 / 10**	**4 / 2**	**19 / 8**
0 (meters)	32%	62%	27%	67%	67%	46%	53%	54%	21%	17%	9%
1 - 30 (meters)	76%	69%	77%	71%	67%	62%	73%	73%	76%	100%	82%
31 - 50 (meters)	88%	75%	91%	79%	67%	62%	83%	82%	85%		82%
51 - 100 (meters)	92%	82%	95%	86%	67%	69%	89%	88%	95%		100%
101 - 200 (meters)	100%	89%	100%	90%	100%	85%	94%	94%	99%		
201 - 300 (meters)		91%		90%		92%	94%	94%	100%		
301 - 500 (meters)		93%		93%		92%	95%	96%			
501-1000 (meters)		96%		95%		100%	97%	97%			
> 1000 (meters)		100%		100%			100%	100%			

<u>Results</u>

- Within the 300 dba, 62 to 77 percent of the sites for all data sets have Ch-Pd distances less than 30 meters, and 82 to 95 percent of the sites for all data sets (except COL-01 and COL-R02) have less than 100 meters. PE-2 shows that only 4 percent of the data accounts for distances greater than 300 meters
- Within the 53 dba, TW-01 shows that 76 percent of the sites have Ch-Pd distances less than 30 meters and 95 percent less than 100 meters. TW-01 shows that only 1 percent of the data accounts for distances greater than 200 meters
- Within the 13 dba, 82 to 100 percent of the sites have Ch-Pd distances less than 30 meters. For HOH-R02, only 2 sites out of 11 had Ch-Pd distances between 51 and 100 meters.
- PE-2 shows that the median value (0 meters) accounts for 54 percent of the sites, and the average value (103 meters) accounts for nearly 88 percent of the sites.
- Adding the HOH-01 data to the IW-01 data set does not appear to substantially change distribution values for TW-01.

3.4.3 Statistical Tests for Differences between 2001 and 2002 Observed Point Ch to Pd Distance Data

The purpose of this analysis is to determine if Ch-Pd in 2001 differs statistically from the Ch-Pd in 2002, in the 13 and 300 dba sites measured in these years. Because of skewness and the presence of many zeros, several tests are shown including paired t-tests for repeated sites in the 13 (HOH-01 and HOH-R02) and 300 dba (COL-01 and COL-R02), and a standard two-sample t-test for independent sites in the 300 dba (IE-01 and IE-02), and a standard two-sample t-test for 2001 "repeated sites" combined with the independent sites in the 300 dba (TW-01 and IE-02), and a Mann-Whitney test.

3.4.3.1 Ch-Pd Distance Paired T-Tests

<u>Ch-Pd Distance: HOH-01 and HOH-R02 data sets</u>

The distribution of the data (Figure 16) appears symmetric with one extreme point to the right. Removal of one point, Site ID# 9, results in a distribution that is symmetric (Figure 17).

- The paired t-test **failed to reject** the hypothesis that the differences in Ch-Pd between HOH-01 and HOH-R02 repeated sites were not different from zero (t = -1.254, df = 7, p-value = 0.250).
- Also, the paired t-test **failed to reject** the hypothesis that the differences in Ch-Pd between HOH-01 and HOH-R02 repeated sites less site # 9 were not different from zero (Paired t-test: t-statistic = -1.446, df = 6, p-value = 0.198)

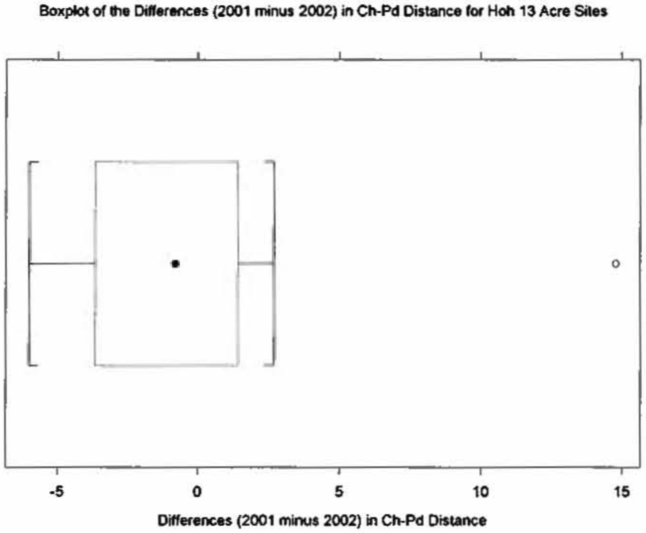

Figure 16. Boxplot of the differences between HOH-01 and HOH-R02 data sets in Ch-Pd distance, all sites.

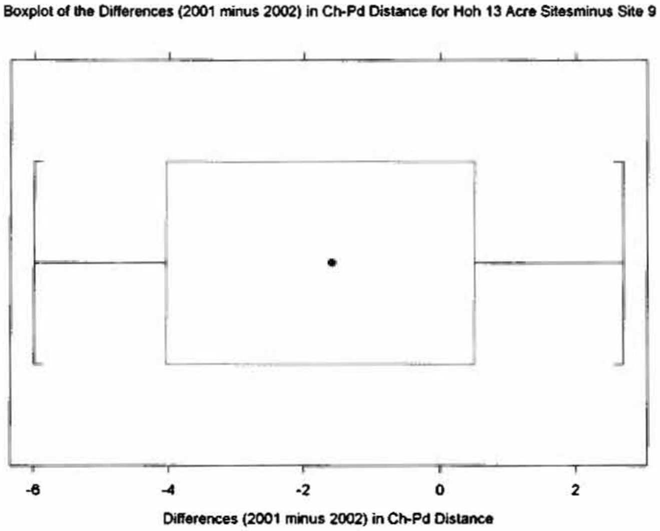

Figure 17. Boxplot of the differences between HOH-01 and HOH-R02 data sets in Ch-Pd distance, sites less site 9.

Ch-Pd Distance: COL-01 and COL-R02 data sets

Ch-Pd was measured in only 3 sites of the 13 repeated sites, which is not enough data to conduct a paired t-test on Ch-Pd.

3.4.3.2 Ch-Pd Distance Standard Two Sample T-Tests and Mann-Whitney Test

Statistical analysis of the Ch-Pd data is more complicated due to the existence of many zeros, yet in this study zero values have important meaning. In addition to the many zeros, the Ch-Pd data are highly skewed and as with the other parameters in this study, a natural logarithm transformation is a possible solution. However, any logarithmic transformation of zero, independent of scale (natural logarithm, base-10 logarithm, etc.) is mathematically undefined. Taking the log of zero is practically identical to dividing by zero, and thus any values in the data set that are zero are removed from any analysis involving a logarithmic transformation.

Since values of zero Ch-Pd in this study are meaningful and there are many sites with zero Ch-Pd, a (natural) logarithm transformation results in a non-random removal of sites from the analyses, resulting in a bias of the results. One solution to this problem is to add a small value (for example, 0.1) to each data point prior to taking a log transformation to avoid elimination of meaningful data. Another solution is to avoid the natural logarithm transformation by instead removing a small number of extreme points that contribute the long tail of the skewed distribution. Finally, one could also conduct the Mann-Whitney (non-parametric) test, which allows us to avoid distributional assumptions and avoid removing data from the data set.

For this analysis, the natural logarithm transformation, Mann-Whitney non-parametric test, and removal of extreme points were utilized for conducting two-sample t-tests. Two tests on the log scale were performed: standard two sample t-test using the natural logarithm scale of original data (eliminating sites with zeros) and a standard two sample t-test using the natural logarithm of the data + 0.1. In the analysis of the log transformation of the original sites (i.e., not adding 0.1 before the transformation), we are changing the question, which can be stated, "Are there differences between the years 2001 and 2002 in Ch-Pd *for those sites with non-zero Ch-Pd measures*?" Also, we conducted two-sample t-tests for Ch-Pd less than 200 and Ch-Pd less than 100 to remove potential influential points (outliers), and a Mann-Whitney Test for all data points. The latter is robust to extreme points, thus allows us to utilize hypothesis testing using all data points without the concern about the distributional assumptions.

Ch-Pd Distance: IE-01 and IE-02 data sets

Two analyses using the natural logarithm transformation where conducted in this section. The first analysis removes the zero Ch-Pd distance measurement sites from the analysis. The second analysis adds 0.1 to all Ch-Pd distance measurements including the non-zero values. The second method allows us to include all sites that had Ch-Pd measurements in the analysis.

Natural Logarithm Transformation: Removal of Zeros

Inspection of the boxplots (Figures 18) illustrates the skewness of the Ch-Pd data for the independent sites, with many values near zero. A natural logarithm transformation, which results in the removal of the zeros, almost completely remedies the skewness and the non-homogeneous variance (Figure 19).

- A standard two sample t-test of the natural logarithm transformation of Ch-Pd for independent sites **rejects** the hypothesis that the natural logarithm of Ch-Pd differs between IE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = -4.7262, df = 28, p-value = 0.0001). The mean of the natural logarithm of Ch-Pd for 2001 is 2.343 meters, and the mean of the natural logarithm of Ch-Pd for 2002 is 4.903 meters, with the Ch-Pd for 2001 larger on average by 2.559 meters.

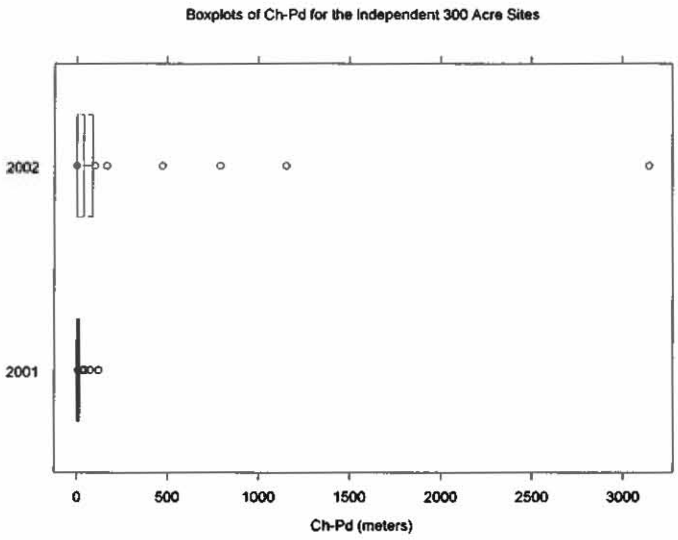

Figure 18. Boxplots of Ch-Pd distance for IE-01 and IE-02 data sets.

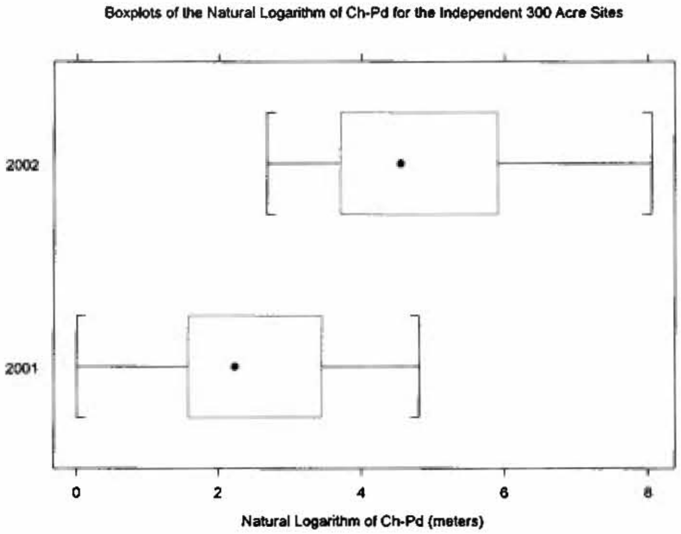

Figure 19. Boxplots of Ch-PD distance for IE-01 and IE-02 data sets, natural logarithm scale. Note that the sites with a Ch-Pd measure are eliminated from the data set with the natural logarithm transformation.

Natural Logarithm Transformation: Ch-PD Distance + 0.1

After a natural logarithm transformation of Ch-PD+0.1, the data for independent 300 acre sites are skewed (Figure 20). The standard deviations on the natural logarithm scale are similar for the two years ($sd_{2001} = 2.426$, $sd_{2002} = 3.549$, ratio of 2002 to 2001 is 1.464) with moderate but unequal sample sizes ($n_{2001} = 22$, $n_{2002} = 42$, ratio is 1.9). We concluded that the t-test is marginally valid for these data.

- A two sample t-test **failed to reject** the hypothesis that there is no difference in the natural log scale of Ch-Pd =0.1 between IE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = 1.173, df = 62, p-value = 0.245).

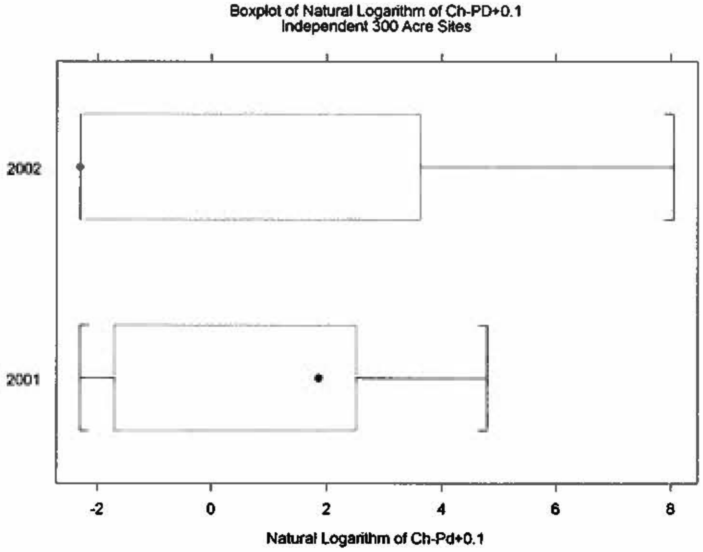

Figure 20. Natural logarithm of Ch-Pd+0.1for IE-01 and IE-02 data sets.

Mann-Whitney Non-Parametric Test of TE-01 and IE-02 Data Sets

The natural logarithm transformation fails to stabilize the variances and distributions of the 2001 and 2002 data sets, thus the non-parametric Mann-Whitney test was also performed for this analysis. Because this test is robust to outliers, there is no need to remove outliers to conduct a Mann-Whitney test and should not be used in analyses such as those in subsequent sections, where we are removing extreme points to stabilize the variance and distributions.

- A Mann-Whitney test failed to reject the hypothesis that the true mu is not equal to 0. Rank-sum normal statistic with correction Z = 1.418, p-value = 0.156.

Ch-Pd and removal of "extreme points"

Using cumulative percent tables (see Table 12 above), 90% of the data falls below 200 meters. For this reason, 200 and 100 meters were chosen as cut-points, with values larger than these identified as "extreme points." Two cut-points were chosen to give researchers more information concerning the data and any differences that might exist based on more choices of the cut-point.

Ch-Pd Distance < 200 meters: IE-01 and IE-02 data sets

Boxplots of the Ch-Pd data less than 200 meters (Figure 21) illustrates that the interquartile range (between the 1st and 3rd quartiles) of the 2001 and 2002 data are located approximately the same location, and the medians and means are similar for the two years ($\text{median}_{2001}= 6.41$, $\text{mean}_{2001} = 17.47$; $\text{median}_{2002}= 0$, $\text{mean}_{2002} = 19.88$). The standard deviations are also similar for the two years ($sd_{2001} = 30.266$, $sd_{2002} = 43.066$, ratio of 2002 to 2001 is 1.423) with moderate but unequal sample sizes ($n_{2001} = 22$, $n_{2002} = 38$, ratio is 1.7).

- A two sample t-test **fails to reject** the hypothesis that there is no difference in Ch-Pd less than 200 meters between IE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = -0.231, df = 58, p-value = 0.819).

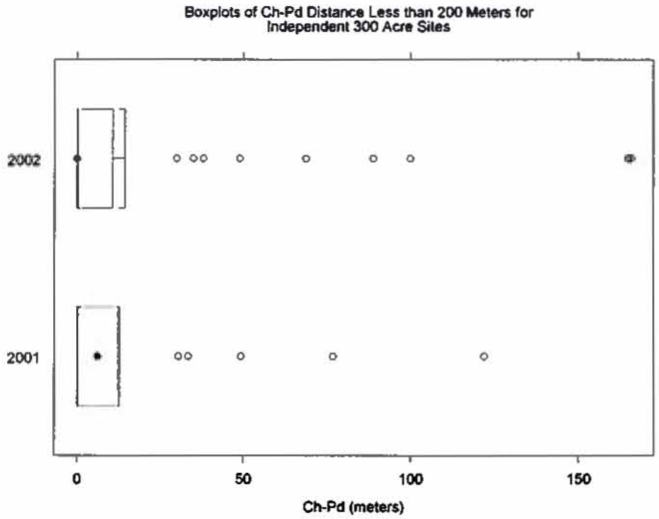

Figure 21. Boxplots of Ch-Pd less than 200 meters for the IE-01 and IE-02 data sets

Ch-Pd Distance < 100 meters: IE-01 and IE-02 data sets

Figure 22 illustrates that Ch-Pd data below 100 meters for the two years have almost identical interquartile ranges and similar means and medians. ($median_{2001}$= 5.5, $mean_{2001}$ = 12.5; $median_{2002}$= 0, $mean_{2002}$ = 9.269). The standard deviations are also similar for the two years (sd_{2001} = 19.736, sd_{2002} = 21.593, ratio of 2002 to 2001 is 1.094) with moderate but unequal sample sizes (n_{2001} = 21, n_{2002} = 35, ratio is 1.7).

- A two sample t-test **fails to reject** the hypothesis that there is no difference in Ch-Pd less than 100 meters between IE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = 0.559, df = 54, p-value = 0.578).

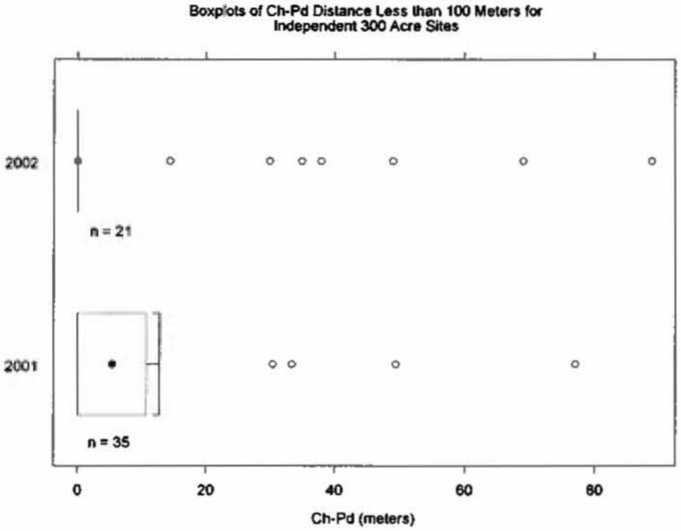

Figure 22. Boxplots of Ch-Pd less than 100 meters for the IE-01 and IE-02 data sets.

Ch-Pd Distance: TE-01 and IE-02 data sets

Adding the 2001 repeated 300 acre sites added only 3 sites to the data set.

Natural Logarithm Transformation: Effective Removal of Zeros

Inspection of the boxplots (Figures 23) illustrates the skewness of the Ch-Pd data for the 2001 "repeated sites" combined with the independent 300 acre sites, with many values near zero. A natural logarithm transformation, which results in the removal of the zeros, also almost completely remedies the skewness and the non-homogeneous variance (Figure 24).

- A standard two sample t-test of the natural logarithm transformation of Ch-Pd for independent sites **rejects** the hypothesis that the natural logarithm of Ch-Pd differs between TE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = t = -4.2979, df = 29, p-value = 0.0002). The mean of the natural logarithm of Ch-Pd for 2001 is 2.511 meters, and the mean of the natural logarithm of Ch-Pd for 2002 is 4.903 meters, with the Ch-Pd for 2002 larger on average by 2.392 meters.
- These results are consistent with the results for the independent 300 acre sites alone, however, the means are closer with the addition of more data.

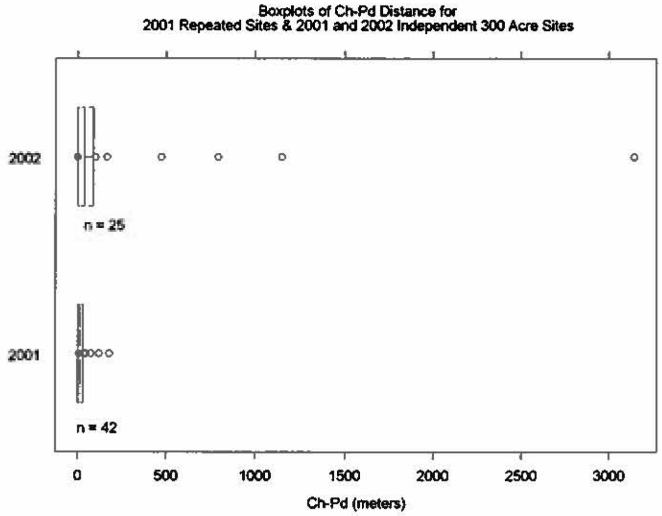

Figure 23. Boxplots of Ch-Pd distance for TE-01 and IE-02 data sets.

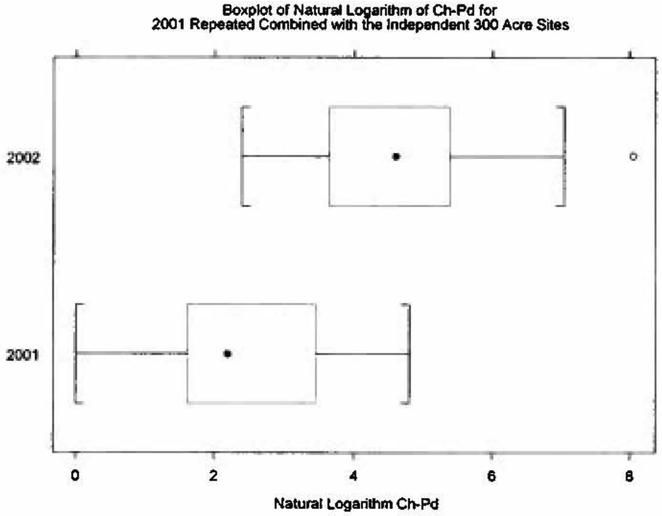

Figure 24. Boxplots of the natural logarithm of Ch-PD for TE-01 and IE-02 data sets.

Natural Logarithm Transformation: Ch-Pd Distance + 0.1

After a natural logarithm transformation of Ch-Pd+0.1, the data for 2001 "repeated sites" and the independent 300 acre sites are skewed (Figure 25). The standard deviations on the natural logarithm scale are similar for the two years (sd_{2001} = 2.607, sd_{2002} = 3.549), ratio of 2002 to 2001 is 1.36, lower than for the independent 300 acre sites. Also, the data sets have moderate but unequal sample sizes (n_{2001} = 25, n_{2002} = 42) and the ratio is 1.7, also lower for this data set than for the independent 300 acre sites. We concluded that the t-test is marginally valid for these data.

- A two sample t-test **failed to reject** the hypothesis that there is no difference in the natural log scale of Ch-Pd =0.1 between TE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = 1.0831, df = 65, p-value = 0.283).

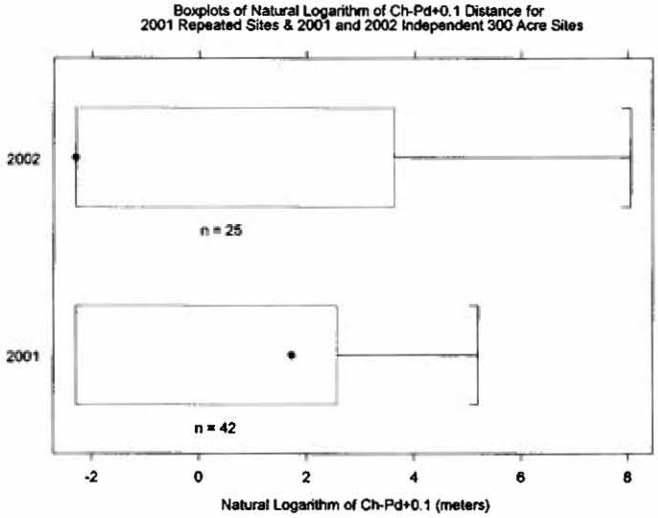

Figure 25._Boxplots of the natural logarithm of Ch-PD+0.1 for TE-01 and IE-02 data sets.

Ch-Pd Distance < 200 meters: TE-01 and IE-02 data sets

Boxplots of the Ch-Pd data less than 200 meters (Figure 26) illustrates that the interquartile range (between the 1st and 3rd quartiles) of the 2001 and 2002 data are located approximately the same location, and the medians and means are similar for the two years ($median_{2001}$= 6.0, $mean_{2001}$ =22.56; $median_{2002}$=0, $mean_{2002}$ =19.88). The standard deviations are also similar for the two years (sd_{2001} =43.578, sd_{2002} = 43.066, ratio of 2002 to 2001 is 0.988) with moderate but unequal sample sizes (n_{2001} = 25, n_{2002} = 38, ratio is 1.5).

- A two sample t-test **fails to reject** the hypothesis that there is no difference in Ch-Pd less than 200 meters between TE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = t = 0.241, df = 61, p-value = 0.811)

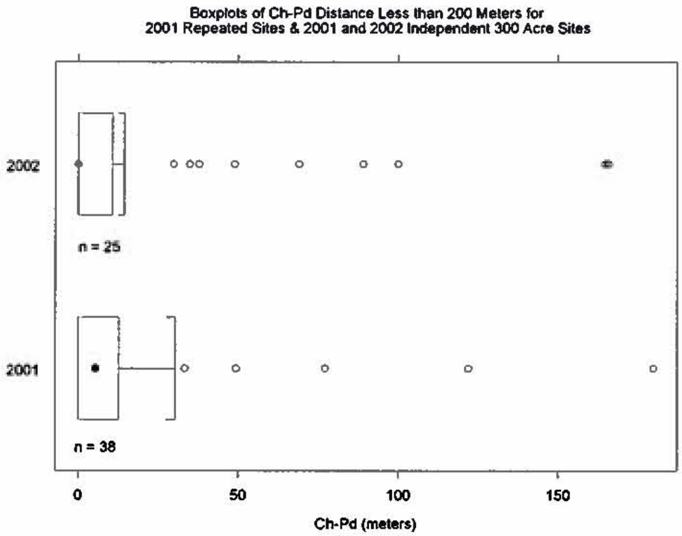

Figure 26. Boxplots of Ch-Pd less than 200 meters for TE-01 and IE-02 data sets.

Ch-Pd Distance < 100 meters: TE-01 and IE-02 data sets

Figure 27 illustrates that Ch-Pd data below 100 meters for the two years have similar standard deviations (sd_{2001} = 19.159, sd_{2002} = 21.593, ratio of 2002 to 2001 is 1.127) with moderate but unequal sample sizes (n_{2001} = 23, n_{2002} = 35, ratio is 1.523).

- A two sample t-test **fails to reject** the hypothesis that there is no difference in Ch-Pd less than 100 between TE-01 and IE-02 data sets (Standard two sample t-test: t-statistic = 0.383, df = 56, p-value = 0.703).

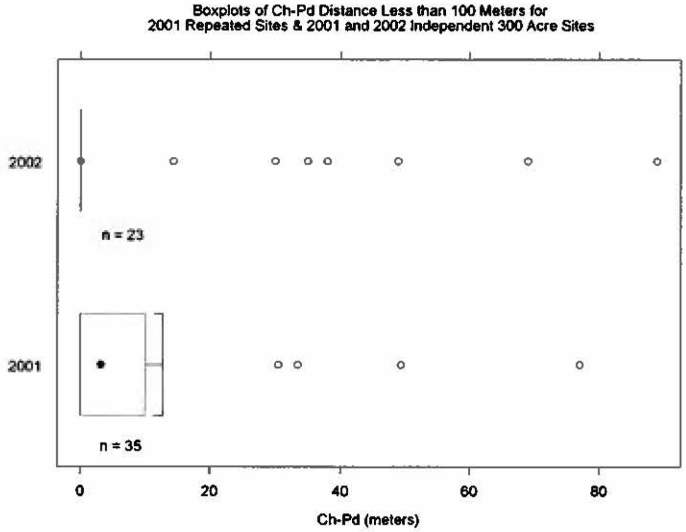

Figure 27. Boxplots of Ch-Pd less than 100 meters for TE-01 and IE-02 data sets.

Mann-Whitney Non-Parametric Test—all data

A Mann-Whitney test failed to reject the hypothesis that the true mu is not equal to 0. Rank-sum normal statistic with correction Z = 1.347, p-value = 0.178.

3.4.3.3 Statistical Conclusion for Observed Ch-Pd Distance

All hypothesis tests consistently fail to reject the hypothesis that there is no difference in Ch-Pd distance between 2001 and 2002, except in situations when we use the log transformation of the original Ch-Pd data. The non-parametric Mann-Whitney test is recommended for interpretation for this parameter because the log transformation failed to stabilize the variance for 2001 and 2002 data sets for Ch-Pd + 0.01 (i.e., without removing the zero-value data points). Based on the Mann-Whitney test, both pooling IE-01 and IE-02 for creating PE-1 and pooling TE-01 and IE-02 for creating the data set PE-2 is justified.

3.5 Pd Basin Area and Ch-Pd Distance Relationship

The objective of this section is to test whether there is a statistically significant linear relationship between Pd basin area and Ch-Pd distance for the PE-2, TW-01, and HOH-01 data sets.

3.5.1 Pd Basin Area and Ch-Pd Distance Relationship for the PE-2 Data Set

Two linear regression models were estimated to answer the above question for the PE-2 data set (300 dba study sites measured in 2001 and the independent (non-repeated) sites for 2002). In the first model, Pd basin area was the sole independent variable. In the second model, cooperator and year was added as independent variables, to account for the variability of non-randomized sites and years of data collection.

```
S-PLUS Output:
Model 1: Response = Ch-Pd
Estimated coefficients and other statistics:
                 Value  Std. Error  t value Pr(>|t|)
  (Intercept)  12.5503     7.4175    1.6920  0.0959
  Pd            0.2294     0.1285    1.7848  0.0794

Residual standard error: 42.76 on 59 degrees of
freedom
Multiple R-Squared: 0.05123
F-statistic: 3.186 on 1 and 59 degrees of freedom,
the p-value is 0.07943
25 observations deleted due to missing values

Model 2: Response = Ch-Pd
Estimated coefficients and other statistics:
                  Value Std. Error  t value Pr(>|t|)
    (Intercept)32.7922  17.5185   1.8719   0.0665
     whoKAL    16.1530  18.0349   0.8957   0.3743
     whoLVF   -29.5329  22.1626  -1.3326   0.1882
     whoYAK    -4.9719  15.9598  -0.3115   0.7566
     Year     -26.5778  14.6686  -1.8119   0.0755
      Pd        0.1923   0.1354   1.4201   0.1612

Residual standard error: 42.61 on 55 degrees of
freedom
Multiple R-Squared: 0.1219
F-statistic: 1.527 on 5 and 55 degrees of freedom,
the p-value is 0.1967
```

There are 4 extreme points in the PE-2 data set (defined as Ch-Pd distances greater than 200 meters). These points were removed from the analysis to stabilize the variance required for interpretation of the linear regression model. Note that characteristics due to many zero values is not rectified with a natural logarithm transformation of Ch-Pd + 0.1, thus, those results are not reported. A visual inspection of the relationship between the Ch-Pd and Pd, on the original scale is provided (Figure 28). The linear relationship is neither visually or statistically significant (p=0.079).

- Model 1: The linear regression model with Ch-Pd < 200 meters as the response variable and Pd basin area as the explanatory variable **fails to reject** the hypothesis that the slope for Pd basin area is zero (p-value = 0.079).
- Model 2: The linear regression model with Ch-Pd < 200 meters as the response variable and cooperator, year, and Pd basin area as explanatory variables **fails to reject** the hypothesis that the slope for Pd basin area is zero (p= 0.161).

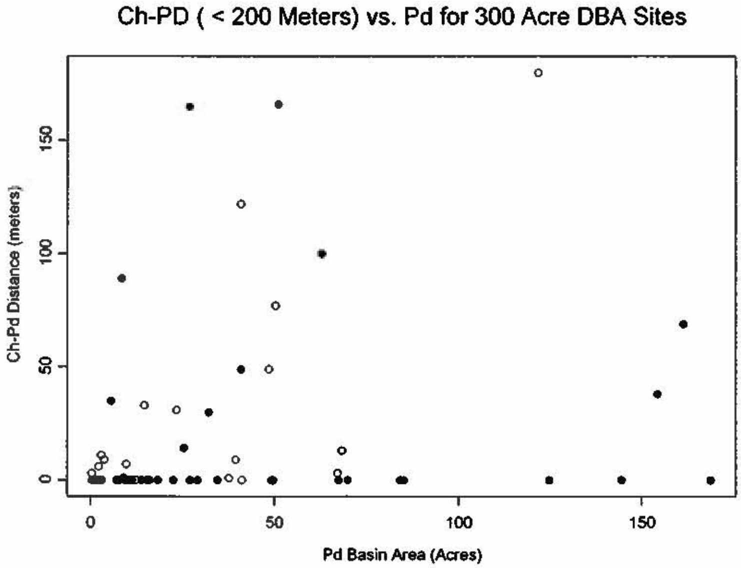

Figure 28: Ch-Pd distance vs. Pd basin area for values of Ch-Pd less than 200 meters. Four points of the PE-2 data were removed as a result of restricting Ch-Pd to be less than 200 meters. Open circles are 2001 and closed circles are 2002 study sites.

3.5.2 Pd Basin Area and Ch-Pd Distance Relationship for the TW-01 Data Set

Two linear regression models were estimated to answer the above question for the TW-01 data set (52 dba study sites measured in 2001). In the first model, Pd basin area was the sole independent variable. In the second model, cooperator was added as an independent variable, to account for the variability of non-randomized sites of data collection.

These points with Ch-Pd greater than 200 were removed from the analysis for consistency with the analysis of the 300 dba study sites. As a result, only one site (site number 76) was removed from the analysis. Also, a natural logarithm transformation of Ch-Pd + 0.1 rectifies non-homogeneous variance for the full model (i.e., the model with cooperator and Pd basin area as independent variables), thus the results of the natural logarithm transformation for both models are presented here. The results of the analyses of Ch-Pd on the original scale are consistent with the results on the natural logarithm scale; thus, the analyses on the original scale are not presented here.

A visual inspection of the relationship between the Ch-Pd and Pd, on the original scale (Figure 29) and the natural logarithm scale (Figure 30) are provided. Note the scatter in the points with clumping near zero and the lack of an obvious linear relationship in both plots.

```
S-PLUS Output:
Model 1: Response = ln (Ch-Pd + 0.1)
Estimated coefficients and other statistics:
             Value Std. Error t value Pr(>|t|)
(Intercept) 1.5902 0.2612     6.0887  0.0000
         pd 0.0085 0.0065     1.2993  0.1970

Residual standard error: 2.31 on 94 degrees of
freedom
Multiple R-Squared: 0.01764
F-statistic: 1.688 on 1 and 94 degrees of freedom,
the p-value is 0.197

Model 2: Response = ln(Ch-Pd +0.1)
Coefficients:
              Value Std. Error t value Pr(>|t|)
(Intercept)  2.8422  0.3955     7.1860  0.0000
     whoHOH -2.3005  0.6128    -3.7539  0.0003
     whoLVF -0.5658  0.6590    -0.8585  0.3929
     whoSSC -3.2031  0.5756    -5.5653  0.0000
     whoSUQ -2.9526  1.3878    -2.1276  0.0361
     whoTCG  0.3149  0.5831     0.5400  0.5906
         pd  0.0006  0.0056     0.1106  0.9122

Residual standard error: 1.882 on 89 degrees of
freedom
Multiple R-Squared: 0.3823
F-statistic: 9.181 on 6 and 89 degrees of freedom,
the p-value is 8.11e-008
```

- Model 1: The linear regression model with Ch-Pd < 200 meters as the response variable and Pd basin area as the explanatory variable **fails to reject** the hypothesis that the slope for Pd basin area is zero (p-value = 0.197).
- Model 2: The linear regression model with Ch-Pd < 200 meters as the response variable and cooperator, year, and Pd basin area as explanatory variables **fails to reject** the hypothesis that the slope for Pd basin area is zero (p= 0.912).

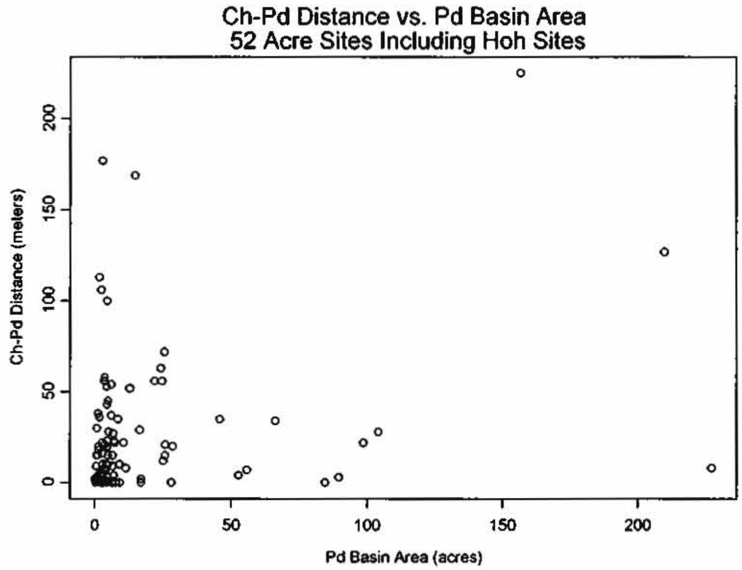

Figure 29: Ch-Pd distance vs. Pd basin area for values of Ch-Pd less than 200 meters, original scale. One point of the TW-01 data was removed as a result of restricting Ch-Pd to be less than 200 meters.

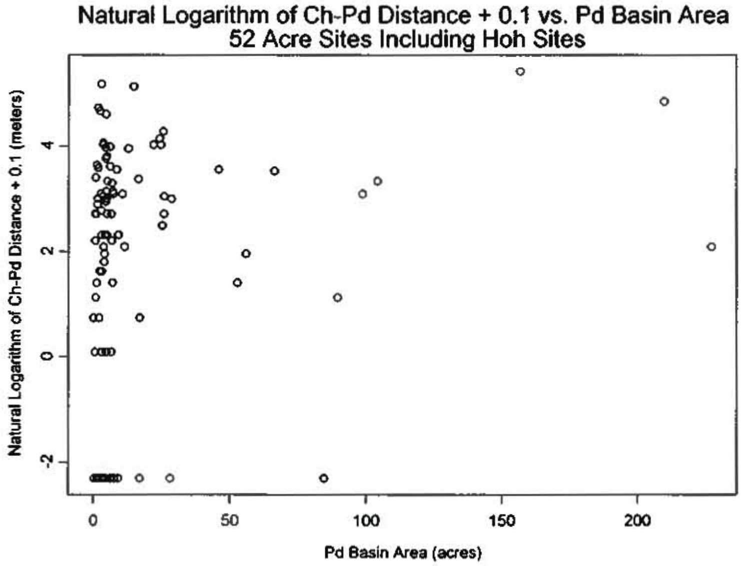

Figure 30: Natural logarithm of Ch-Pd distance + 0.1 vs. Pd basin area for values of Ch-Pd less than 200 meters. One point of the TW-01 data was removed as a result of restricting Ch-Pd to be less than 200 meters.

3.5.3 Pd Basin Area and Ch-Pd Distance Relationship for the HOH-01 Data Set

A linear regression models were estimated to answer the above question for the HOH-01 data set (52 dba study sites measured in 2001). In this model, Pd basin area was the sole independent variable. In contrast to the other study sites, there was only cooperator in this region.

There were no points with Ch-Pd greater than 200 in the HOH-01 data set. Also, a natural logarithm transformation of Ch-Pd + 0.1 was used unsuccessfully to attempt to rectify non-homogeneous variance. The results of the analyses on both scales are presented here.

A visual inspection of the relationship between the Ch-Pd and Pd, on the original scale (Figure 31) and the natural logarithm scale (Figure 32) are provided. These illustrate the lack of a linear relationship between Ch-Pd and Pd.

- Model 1: The linear regression model with Ch-Pd < 200 meters as the response variable and Pd basin area as the explanatory variable **fails to reject** the hypothesis that the slope for Pd basin area is zero (p-value = 0.496).
- Model 2: The linear regression model with natural logarithm of Ch-Pd < 200 meters + 0.1 as the response variable and Pd basin area as explanatory variables **fails to reject** the hypothesis that the slope for Pd basin area is zero (p= 0.122).

```
S-PLUS Output:
Model 1: Response = Ch-Pd
Estimated coefficients and other statistics
              Value Std. Error t value Pr(>|t|)
(Intercept)  5.2422  1.7649     2.9702  0.0101
         pd -0.0564  0.0808    -0.6985  0.4963

Residual standard error: 6.473 on 14 degrees of
freedom
Multiple R-Squared: 0.03368
F-statistic: 0.4879 on 1 and 14 degrees of freedom,
the p-value is 0.4963

Model 2: Response = ln(Ch-Pd +0.1)
Estimated coefficients and other statistics:
              Value Std. Error t value Pr(>|t|)
(Intercept)  0.8424  0.4487     1.8774  0.0815
         pd -0.0338  0.0205    -1.6483  0.1215

Residual standard error: 1.646 on 14 degrees of
freedom
Multiple R-Squared: 0.1625
F-statistic: 2.717 on 1 and 14 degrees of freedom,
the p-value is 0.1215
```

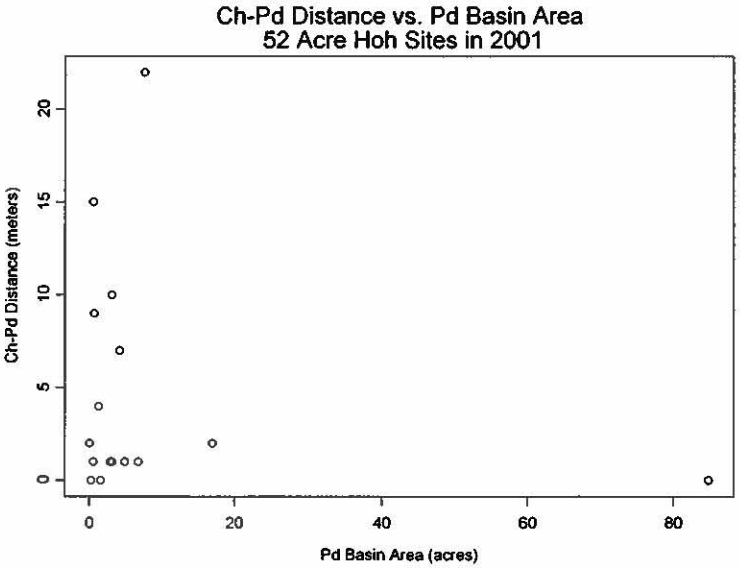

Figure 31: Ch-Pd distance vs. Pd basin area for values of Ch-Pd less than 200 meters, original scale. No points of the HOH-01 data were removed as a result of restricting Ch-Pd to be less than 200 meters.

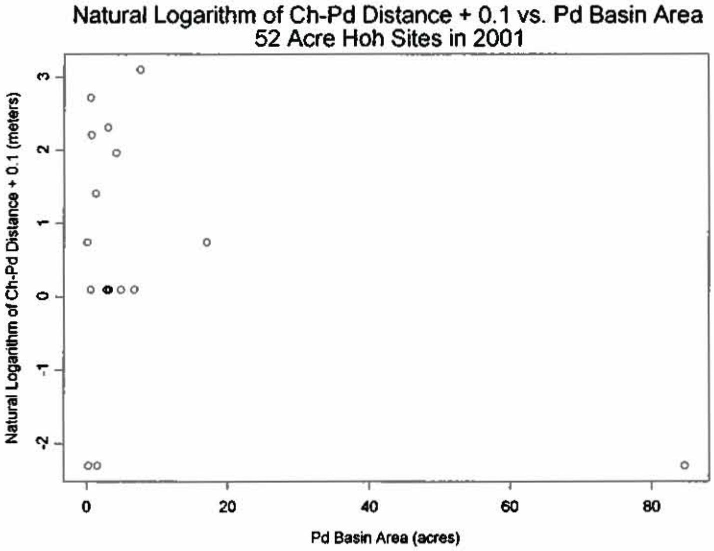

Figure 32: Natural logarithm of Ch-Pd distance + 0.1 vs. Pd basin area for values of Ch-Pd less than 200 meters. No points of the HOH-01 data were removed as a result of restricting Ch-Pd to be less than 200 meters.

3.5.4 Statistical Conclusion for Pd Basin Area and Ch-Pd Distance Relationship

All hypothesis tests consistently **fail to reject** the hypothesis that the slope for Pd basin area is zero in data sets PE-2, TW-01, and HOH-01.

4.0 Discussion

The discussion section will focus on the value of the Phase I data, evaluation of the year of normal rainfall data, key results of the three parameters tested in this report, and a revisit to the conceptual Type N Water system assumptions.

4.1 Value of the 2001 and 2002 Data

The primary objective of the Type N Stream Demarcation study is to "refine the demarcation between perennial and seasonal Type N streams" on both a remote (default) and observed (field) scales. The 2001 CMER study (Phase I) was intended to collect enough data to estimate the sample size required for a statistically rigorous Phase II of the study. Phase I far exceeded sample size expectations. Combined with 2002 sites, the result are data sets that consisting of 86 study sites in the 300 dba and 152 study sites in the 52 dba, 18 of which were located in the estimated 13 dba (totals based on Pd basin area counts).

Similar to the CMER 2001 study, interpretation of the 2002 data is limited by non-random selection of the larger sample areas. However, contributors randomly selected study sites within each sample area and the sample areas were well distributed by ecoregion and precipitation values within the private forestlands of the 52 and 300 dba stratum (see Figure 3 in the Results section). Analysis of the collective data strongly indicates that current predictions of Type N stream demarcation are incorrect by close to an order of magnitude based on median observed dba values. Additional analyses and observations support this finding. The water year data (total precipitation over previous year) indicates that results may actually overestimate the basin area and distance from channel head parameters. Precipitation amounts were either unusually dry or drier than median levels in all but one sample area.

It is also important to point out that without the extra data collected during Phase I, it is unlikely that there would be sufficient information to have discovered the problem with the current Coastal / Westside / Eastside stratification system, or to evaluate the use of ecosystems for a stratification system, or to recognize that the variability around a basin area default is not likely to be reduced. This could have been a costly finding of a Phase II study.

Based on these findings, it is concluded that the specific results analyzed in this report cannot be quantified with statistical accuracy, but can be qualified by professional judgment as "highly likely" or "highly unlikely" in representing the distribution of actual field conditions across the state, and in regards to informing scientific discussions in the development of any Phase II Type N stream demarcation study.

4.2 Year of Normal Rainfall

All 2001 and 2002 survey season water months were lower (drier) in total precipitation than their respective median values except for 2001 Forks. This would indicate that Pd basin area and Ch-Pd values may be underestimating actual values for 2001 and 2002 data in the 52 and 300 dba. However, the translation of water year precipitation on the location of Pd during the survey window is not well understood. For example, repeat surveys in the HOH and COL data sets did not find a statistical difference in Pd basin area even though there was a substantial survey season precipitation change between 2001 and 2002 in the HOH data set. The 2001 water year was "unusually dry" and the survey season was "unusually wet" whereas the 2002 water year was "normal" on the wet side with an "unusually dry" survey season. Although not statistically different, the average and median values for Ch-

Pd distance were greater in 2002, which indicates that the survey season rainfall was the primary driver in Pd location.

4.3 Key Results

All tests on the variability of annual precipitation, observed Pd basin area, and observed Ch-Pd distance failed to reject the hypothesis that there are no differences between 2001 and 2002 data sets. Therefore, the use of the PE-2 (300 dba) and HOH-R02 (13 dba) data sets are justified for drawing conclusions about Type N stream demarcation results within their respective stratum. Table 13 provides an overview of the key results for parameter averages, medians, and sample size for comparable 2001 report (shaded columns) and 2002 report data sets.

Table 13. Key results for parameter averages, medians, and sample size for comparative 2001 report and 2002 report data sets.

Average / Median and Sample Size Values by Parameter	**Eastside** (300 dba)			**Westside** (52 dba)	**Est. Coastal** (13 dba)	
	TE-01 (Total)	TE-02 (Total)	PE-2 (Pooled)	TW-01 (Total)	HOH-01	HOH-R02
Annual Precipitation (inches)	42 / **35** (*n* = 46)	36 / **39** (*n* = 56)	41 / **39** (*n* = 89)	82 / **79** (*n* = 171)	127 / **125** (*n* = 21)	130 / **125** (*n* = 10)
Pd Basin Area (acres)	118 / **37** (*n* = 43)	77 / **41** (*n* = 56)	94 / **33** (*n* = 86)	22 / **7** (*n* = 152)	8 / **2** (*n* = 18)	4 / **2** (*n* = 11)
Ch-Pd Distance (meters)	23 / **6** (*n* = 25)	137 / **0** (*n* = 55)	103 / **0** (*n* = 67)	24 / **10** (*n* = 117)	4 / **2** (*n* = 18)	19 / **8** (*n* = 11)

4.3.1 Annual Precipitation Differences

The results found no significant difference in annual precipitation between data sets when extreme points were removed. Averages and median values were within zero and seven inches of each other with the key data sets of PE-2, TW-01, and HOH-01 being within three inches of each other. This indicates a normal distribution of the data within each stratum for this parameter. Observations of differences between maximum and third quartile values indicate that maximum values were extreme points and not useful in describing the PE-2 (111/49 inches) and TW-01 (155/95 inches) data sets.

The frequency of distribution analysis shows that the majority (70%) of 300 dba sites (PE-2 data set) were located in the 31-60 inch category with the next largest number of sites (18%) in the 61-75 inch category. The lowest annual precipitation average/medians were from the COL-01 (22/23) and COL-R02 (23/23) data sets. This indicates that the 300 dba stratum assumption of similar annual precipitation across its range may be incorrect.

For the 52 dba (TW-01 data set), the majority of the sites (38%) were found in the 76-100 inch category with the next largest number of sites in the 61-75 inch category. This shows what appears to be a substantial overlap in annual precipitation values between these stratums. Again, this indicates that the 52 dba stratum assumption of similar annual precipitation across its range may be incorrect.

For the 13 dba (HOH-01 data set), the majority of sites (81%) were found in the 100-125 inch category with the only other category of greater than 125 inches having the remaining sites (19%). However, unlike the 52 and 300 dba stratum, only one data set was used to estimate the value across an un-delineated 13 dba stratum so caution must be applied for interpretation.

4.3.2 Observed Pd Basin Area Differences

The results found no significant difference in observed Pd basin area between data sets when extreme points were removed. Averages and median values differed by 61 acres in the 300 dba (PE-2 data set), 15 acres in the 52 dba (TW-01 data set), and 6 acres in the 13 dba (HOH-01 data set). This indicates a skewed distribution of the data within each stratum for this parameter. Observations of differences between maximum and third quartile values indicate that maximum values were extreme points and not useful in describing the PE-2 (1224/73 acres), TW-01 (260/22 acres), and HOH-01 (85/5 acres) data sets.

The frequency of distribution analysis shows that the 49 percent of the 300 dba sites (PE-2 data set) were less than or equal to 30 acres and 90 percent were less than or equal to 200 acres. Seven percent of the data were in the 301 to 1000 acre category and only 2 percent were in the greater than 1000 acre category. The highest Pd basin area average/medians were from the COL-01 (252/58 acres) and COL-R02 (99/66 acres) data sets. This and the progression of values across acre size categories within the quartiles indicate that the 300 dba stratum assumption of similar Pd basin area across its range may be incorrect.

For the 52 dba (TW-01 data set), frequency of distribution analysis shows that 45 percent of the data set sites were less than or equal to 5.2 acres and 89% were less than or equal to 52 acres. Similar to the 300 dba, the progression of values across acre size categories within the quartiles indicates that the 52 dba stratum assumption of similar Pd basin area across its range may be incorrect.

For the 13 dba (HOH-01 data set), frequency of distribution analysis shows that 79 percent of the data set sites were less than or equal to 5.2 acres with only one site greater than 30 acres. The HOH cooperator views their 2001 Site # 226 at 85 acres as an incorrect delineation by the project manager[19]. Greater variability analysis for this stratum was not conducted due to difficulties in delineating accurate areas on very small basins.

4.3.3 Observed Ch-Pd Distance Differences

The results found no significant difference in observed Ch-Pd distance between data sets when extreme points were removed. Median values for all twelve data sets were similar (range from 0 to 15 meters). Averages and median values differed by 103 meters in the 300 dba (PE-2 data set), 14 meters in the 52 dba (TW-01 data set), and 2 meters in the 13 dba (HOH-01 data set). This indicates a skewed distribution of the data within each stratum for this parameter. Observations of differences between maximum and third quartile values indicate that maximum values were extreme points and not useful in describing the PE-2 (3145/31 meters), TW-01 (225/29 meters), and HOH-01 (22/1 meters) data sets.

The frequency of distribution analysis shows that the 54 percent of the 300 dba sites (PE-2 data set) were 0 (zero) meters in length, 73 percent were less than or equal to 30 meters, and 89 percent were less than or equal to 100 meters. Six percent of the data accounted for sites with lengths greater than 300 meters. The significance of differences less than 100 meters is questionable in a forest practices context.

For the 52 dba (TW-01 data set), frequency of distribution analysis shows that 21 percent of the sites were 0 (zero) meters in length, 76 percent were less than or equal to 30 meters, and 95 percent were less than or

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[19] The HOH cooperator had independently calculated only a 3 acre basin for that site.

equal to 100 meters. Only one site had a length greater than 200 meters. Again, the significance of differences less than 100 meters is questionable in a forest practices context.

For the 13 dba (HOH-01 data set), frequency of distribution analysis shows that 17 percent of the sites were 0 (zero) meters in length and 100 percent were less than or equal to 30 meters. HOH-R02 indicated that greater length variability exists, as two sites were found with lengths greater than 30 meters (Site 218 = 67 meters and Site 229 = 70 meters). Again, the significance of differences less than 100 meters is questionable in a forest practices context.

4.3.4 Pd Basin Area and Ch-Pd Distance Relationship

There is no evidence suggesting that Pd basin area is a predictor of Ch-Pd distance for the PE-2, TW-01, and HOH-01 data sets. This means that the distance between channel head and downstream to where perennial flow initiates does not increase as Pd basin area increases. This is a very unexpected finding of this study with the strongest consistency across all data sets.

4.4 Conceptual Type N Water System Assumptions Revisited

A revisit to the conceptual Type N Water system and its assumptions is a useful forum for discussing the results of this study. Each assumption will be repeated and discussions will be noted below by bullet.

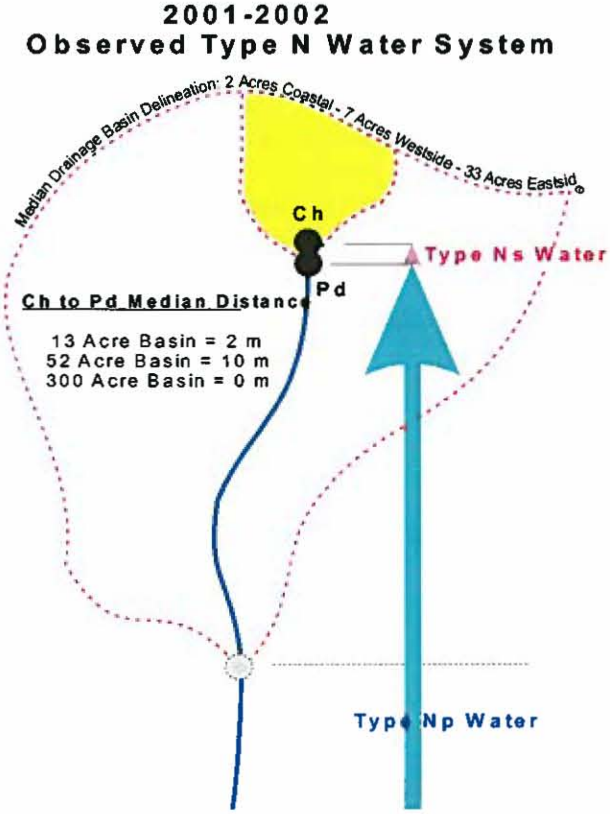

Figure 33. Illustrated changes from the conceptual to the observed Type N Water system median values.

1. Type N Waters are divided by seasonal (Type Ns) and perennial (Type Np) waters, and by implication, the common channel lengths of both Type Np and Ns Water are significant in both a forest practices and a hydrologic context (minimum estimated 152 meters[20]).
   - **False**: The data shows that the assumption of a significant Type Ns Water channel length within a forest practices context not correct (Figure 33). All data sets used in this study found that approximately 90 percent of all sites had Ch-Pd distances less than 100 meters and approximately 75 percent had distances less than 30 meters. This rejection of the assumption is supported by significant differences in Type Ns Water median channel lengths between the estimated lengths using the default basin area ("e-dba") intersect[21] and the observed lengths using Ch-Pd distance ("Ch-Pd") (300 dba: 1012 meter e-dba/0 meter

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[20] Minimum based on "representative section of at least 500 linear feet" for determining channel geomorphic metrics of bankfull width and gradient per WAC 222-16-030(5)(f).

[21] Palmquist, 2003. Estimated length of affected stream channel. September 10

Ch-Pd; 52 dba: 395 meter e-dba/10 meter Ch-Pd; 13 dba: 174 meter e-dba/2 meter Ch-Pd). These represent observed Ch-Pd distance differences from estimated values as equal to or greater than 97 percent.

2. The Np/Ns break location is significantly correlated with 13 acre basins in the Western Washington Coastal zone, 52 acre basins in all other areas west of the Cascade crest, and 300 acre basins east of the Cascade crest;
   - **False**: Median values identify that 50 percent of the sites have observed Pd basin areas less than 33 acres (300 dba), 7 acres (52 dba), and 2 acres (13 dba). The variability of the observed values indicates that it is not well explained by the current default basin area stratification system.
3. The Np/Ns break can be "identified with simple, non-technical observations."
   - **True**: This was validated in the 2001 report and 2002 results concur. The best field indicator was locating the channel head and working downstream to the first indicator of flowing water. If conditions did not permit observation within the designated seasonal window, a field default distance downstream from the channel head could be applied.
4. The Np/Ns break location is significantly correlated with normal annual precipitation.
   - **True**: The 2001 report supports this correlation as a better stratification (less variability) for predicting observed Pd locations[22]. However, a statewide stratification based on annual precipitation is questionable from a mapping/delineation standpoint.
5. Type Ns Water channel length is significantly correlated with normal annual precipitation.
   - **False**: Observed Ch-Pd distance values appear consistent across all data sets and dba stratum. This does not support that Type Ns Water lengths are correlated to annual precipitation.
6. The Np/Ns break location does not significantly change within or between years of normal rainfall.
   - **True**: Limited inter-annual variability data (HOH-01/HOH-R02 and COL-01/COL-R02 data set testing) supports no significant differences. Other studies conducted post-2001 also supports this conclusion (Hunter[23]; Veldhuisen[24] *pers. comm.*)
7. The Np/Ns break location does not significantly change by differences within or between geology or land management practices (e.g., sedimentary, granitic, volcanic, etc; clear-cut, second-growth, mixed-management, non-managed, etc.).
   - **Unknown**: Not tested.

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[22] Section 3. Results. Alternative Stratification Schemes for FFR Defaults

[23] 2002 repeated surveys on 17 - 2001 WDFW study sites: 88% < 10 meters

[24] 2003 repeated surveys on 17 - 2001 SSC study sites: 80% < 100 meters

5.0 Conclusions

This report focuses on two parameters used in the 2001 report: a) "Pd" is the observed Type Np/Ns Water demarcation point; and b) "Ch" is the observed channel head or upper boundary of Type Ns Water. Similar to the CMER 2001 study, interpretation of the 2002 data is constrained by non-random selection of the larger sample areas. However, contributors did randomly select study sites within each sample area and the sample areas were well distributed by ecoregion and precipitation values within the private forestlands of the 52 and 300 dba stratum (see Figure 3 in the Results section). Analysis of the collective data strongly indicates that the current default basin area system used to demarcate perennial and seasonal waters are significantly different. They are in fact almost an order of magnitude different based on median observed dba values. The 2001 and 2002 water year data (total precipitation over previous 12 months) indicate that the basin area and distance from channel head parameters may even be over-estimated. This is because precipitation amounts for both years were drier than normal (based on median values) in all but one sample area. The following technical conclusions are made based on the findings of this report:

1. The results of the 2002 analysis are similar to the findings of the 2001 CMER report for observed Pd basin area (Table A) and Ch-Pd distance (Table B) parameters with respect to their median and frequency of distribution values.
2. For both the 2001 and 2002 studies, observed mean and median Pd basin area are highly variable and standard deviations are large relative to the mean (i.e., they have large coefficients of variation) except for the 13 dba when two suspect data points are removed. (300 dba: CV = 201%; 52 dba: CV = 191%; 13 dba: CV = 90%).
3. No significant differences in Pd location between years based on inter-annual surveys.
4. Dropping the 2001 criteria for ending a survey when 200-meters of consecutive dry channel had been measured did not significantly reduce the median and frequency of distribution values for both Pd basin area and Ch-Pd distance between years as predicted.
5. There is no significant linear relationship (p-value = 0.05) between perennial (Pd) basin area and measured length of seasonal channel (Ch-Pd distance), even when cooperator was added as an independent variable to account for the variability of non-randomized sites of data collection (300 dba: p-value = 0.161; 52 dba: p-value = 0.912; est. 13 dba: p-value = 0.122.
6. 88 to 100 percent of all sites (2002 pooled value used for 300 dba) had Ch to Pd distances less than 100 meters and 75 percent were less than 30 meters.
7. Default basin areas are nearly an order of magnitude larger than the observed median Pd basin area for the 300 dba (33 acres), the 52 dba (7 acres), and the 13 dba (2 acres).

Table A. Results of observed median Pd basin area analysis for 2001 and 2002 combined data sets. 2001 results included for comparison.

Default Basin Area	Survey Year	Sample Size	Observed Median Pd Basin Area	Percent Less Than Default
300 acres	2001	43	37 acres	89%
	2002	56	41 acres	96%
	2002 pooled	86	33 acres	91%
52 acres	2001	152	7 acres	89%
Est. 13 acres	2001	19	2 acres	89%
	2002	11	2 acres	91%

Table B. Results of observed median Ch-Pd distance (Type Ns Water channel length). 2001 results included for comparison.

Default Basin Area	Survey Year	Sample Size	Observed Median Ch-Pd Distance	Percent Less Than 100 m
300 acres	2001	25	6 meters	92%
	2002	55	0 meters	82%
	2002 pooled	67	0 meters	88%
52 acres	2001	117	10 meters	95%
Est. 13 acres	2001	18	2 meters	100%
	2002	11	8 meters	100%

6.0 Acknowledgements

This report is the compilation of a group effort and is provided as a service to the Tribal TFW/Forests & Fish Program. Co-author Pam Goodman, NWIFC Biometrician, came in at a late stage and helped immensely with the analysis of the data and reviews of the document. Data collection and reviews were accomplished by the other co-authors and staff at their tribes. In addition, I would like to thank Curt Veldhuisen of the Skagit System Cooperative for his guidance and help in developing and reviewing the report; Kris Ray of the Colville Confederated Tribes for reviews of the document; Marianna Alexandersdottir (another NWIFC Biometrician) Mary Raines, and Steve McConnell (part of NWIFC TFW/FFR Program Core Team) for help in reviewing and guidance on analysis.

7.0 Appendix

Appendix A: Perennial Stream Survey Field Sample Protocol (Version 2002)

Appendix B: 2001 and 2002 Perennial Stream Survey Data: Combined 2001 Reach Summaries and Site Characteristics version 2.5 files and 2002 Tribal cooperator data sets

Perennial Stream Survey
Field Sample Protocol
(Version 2002)

Contents

1 Introduction

This protocol was developed to provide a consistent and repeatable method to evaluate the upper extent of perennial and seasonal stream conditions in the forested landscapes of Washington State. It is also designed to help understand the geomorphic and hydrologic factors affecting perennial surface flow and to determine the temporal and spatial variability of these features. Another focus of the study design is to test the hypothesis that other easily measured factors such as distance from divide, bankfull width, etc. have stronger relationships to the initiation of perennial flow than basin area. To accomplish these objectives, it is necessary to collect stream data along an entire stream spectrum of flow conditions on the selected stream channel including upper portions of spatially contiguous flow, spatially intermittent flow, seasonal flow, and upstream sensitive sites.

This protocol is intended to ensure that data collected in the summer of 2002 by various cooperators is comparable to 2001 pilot data and between cooperator crews. Therefore the v. 1.21 document was not modified to change the information collected but rather to improve guidance for the collection of the same information recorded in 2001. Data collected from this information may also be used to help develop proposed Forest Practices Board Manual Section 23 guidelines for field identification of the uppermost extent of Type Np Water. Please note that this protocol has not been adopted by the Forest Practices Board as an operational protocol for harvest unit application or water typing.

Data collected in 2002 is expected to provide continued useful insights into a) strengths and weaknesses of the protocol, b) appropriate sample sizes for the statewide study, and c) variables affecting selected relationships that might be useful in data stratification planning. Individual cooperators may choose to collect additional information not described here, so long as it does not affect the results or the analyst's ability to extract the core information collected using this protocol. Efforts conducted in 2002 are a continuation of the pilot 2001 effort for the larger statewide program projected for 2003.

2 Pre-Survey Preparation

This section of the protocols provides the information and tasks required prior to conducting the field portion of the Perennial Stream Survey in section 3 below. Section 2 includes: 2.1 study site selection; 2.2 site verification and access; 2.3 timing of surveys; 2.4 quality assurance/quality control plan; 2.5 survey equipment; and 2.6 survey materials.

2.1 Study Site Selection

Revisited 2001 sites must be surveyed using this protocol. For new sites, the area within which sites can be selected will be restricted to lands managed under Forest Practices Rules or other lands with similar site conditions. The intention of this restriction is to avoid spending time sampling site conditions that are rare or absent on FFR lands (e.g. agricultural or high alpine areas). The area from which the random selection was, or will be made must be defined and documented in the post-survey report. For example, if you pick streams at random from an area comprised of three Watershed Analysis Units (WAUs), you must specify the names and locations of those WAUs.

Three options are identified below (others may be used with permission) for conducting random site selection:

Option 1: GIS or hand mapped random selection of intersections between Type 1, 2, or 3 Water (fish bearing) and Type 4 Water (non-fish bearing) streams. Using a GIS system or a water type map, identify and number all Type 3/ 4 breaks within the area of interest. Using a computerized random number generator, a random number generator on a hand held calculator, or random number tables available in statistical texts, select sites to be sampled.

Option 2: Using the same procedures in Option 1, randomly select points at where streams intersect section boundaries. From the intersections selected, identify the closest water type break. This will represent the stream to be sampled.

Option 3: If a DNR stream type map is not available, randomly select locations where two, second order streams come together. Stream order is based on USGS 7.5 minute topographic maps where headwater streams having no identified tributaries is considered a "1," where two "1's" intersect a "2" is formed, and where two "2's" intersect a "3" is formed, etc. (Strahler, 1964). Follow the procedures described in Option 1 for the random selection.

Downstream Survey Additional Requirement: Starting from the point of site selection, the headwater tributary where the downstream survey begins is chosen using a map of the stream network. On the map, follow the stream upstream to each mapped tributary (assume all are flowing), then choose which tributary to follow using a coin toss. As you move up the selected branch, repeat this process at each subsequent tributary junction until you reach a first-order channel. This channel will be the site where the survey will begin.

2.2 Site Verification and Access

Permission is required to access private lands that the survey is expected to cover. If you are having difficulty obtaining access, contact George McFadden[1] (CMER Staff – Project Implementation Coordinator) for help. Stream sites that look easy to find on a USGS topographic map in the office are often difficult to locate in the field. It is highly advisable to use additional information that can be gained through aerial photographs, ortho photographs, and landowner knowledge and/or road maps before heading out to the field. Work done in the office will be often rewarded many fold in the field.

2.3 Timing of Surveys

Surveys are to be conducted during the driest season in summer. For this survey, this period is defined as extending from August 1 through September 30, or to the beginning of the fall rains.

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[1] George McFadden (Northwest Indian Fisheries Commission) Phone: (360)438-1180; or email: gmcfadden@nwifc.org

For instance, field sampling can continue into October until fall rains begin, provided that documentation of weather conditions are included with the data set.

2.4 Quality Assurance/Quality Control Plan

These protocols assume that crews collecting 2002 perennial stream survey data are the same as those that collected 2001 data and do not require additional training. No additional budget has been made for quality assurance or quality control measures at this time and therefore is not required. Continued high quality documentation of the surveys showing that the protocols were applied appropriately and consistently will be used to judge data acceptance. Complete documentation of your field observations and procedures is thus essential.

2.5 Survey Equipment [not completed]

USGS 7.5 Min Topographic Field Map
Aerial photo
Field forms on waterproof paper
Field copy of protocols

Hip chain, hypsometer, laser rangefinder, or other length-measuring device
Clinometer, Abney Level, or other slope-measuring device
Field tape measure and/or Measuring rod
Coin
Altimeter (Optional)
GPS with good resolution (±3meters) (Optional)

Pencils
Watch
Compass
Flagging
Permanent marker
Appropriate field clothing for wet, rough, and spiny encounters
Appropriate field safety/emergency equipment

2.6 Survey Materials [not completed]

Two data forms are provided at the end of this document. Form A provides overall summary information and is discussed under Section 5.0. Form B is used to record field data.

Prior to starting data collection, fill out the header information on Form B. This information includes:

- Organization (e.g. name of tribe, company, agency collecting the data)
- Site number

- Township, section, and range of starting point
- Topo quad name
- Surveyors name(s)
- Stream name or name of nearest named tributary downstream
- Date
- Landowner(s)
- WAU
- Description of starting point (e.g. bridge at Mile Post X.X on road Y).
- Vegetation category that applies to the majority of the watershed above each tributary selected (None, sparse, moderate, dense, clear cut, partial cut, mature, ... – use the watershed analysis, hydrology module definitions)
- Precipitation for the 2 days previous to the survey (qualitative or from nearby weather station)
- Survey type (Original or Repeat)
- Tributary number (use only when doing Total Tributary Survey)
- Name of study area from which random samples were drawn.

Some of this information can be completed in the office after conducting the survey.

3 Standard Method for Conducting the Perennial Stream Survey

This section of the protocols provides the information and instructions for applying the field portion of the Perennial Stream Survey. This section assumes adequate completion of the tasks required in section 2 above. The protocols are organized to allow quick review of basic survey procedures and required parameters first, followed by detailed information regarding parameter descriptions and criteria for support and review purposes.

A field map based on a USGS 7.5 minute topographic map is highly advised to take along to document specified survey locations. If you cannot locate the channel system on the map, the data analyst will not be able to do so, and the field observations may be unusable. The back of the map can be used to make sketches of survey starting and ending points. Section 3 should be copied onto waterproof paper and used in the field during surveys for reference. Section 3 includes: 3.1 survey caveats; 3.2 site verification and survey reach investigation; 3.3 survey starting point: identification and marking; 3.4 primary segment data collection; 3.5 secondary segment data collection; and 3.6 survey ending point: identification and marking.

3.1 Survey Caveats

<u>Precipitation</u>: Do not start a survey for at least 2 days after a 24-hour + storm event ends (may be longer for bigger events). Crews will need to use their judgment and record weather and precipitation conditions to determine if the stream is still responding to the event. If crews have begun the survey and significant precipitation falls, the survey must be stopped when a flow response is noted. The suspension of surveys due to rainfall from sudden, short summer thunderstorms will depend on its direct affect on flow conditions. Flow observations such as noting measured increases in water elevation (mark a stick), presence of overland flow, or new flow in a previously dry channel means that the survey must stop. Unless the flow category of

the survey can be finished before a stream response is noted, the survey will have to be completely redone at a later time to ensure data integrity between flow conditions.

Water Regulation/Diversion: Stop the survey and move on to a new site where crews encounter a human-made water diversion, or a spring development, or other human-made structure that is intentionally regulating or diverting water from the stream. Drainage modifications from forest practices features such as roads, skid trails, and landings are not considered unusual for this survey and should be included according to the protocol.

Lakes and Ponds: In general, mapped lakes and ponds will not be included within a survey reach due to the likelihood of fish use. Streams entering a lake or pond are candidates for this survey if they have at least 5 meters of continuous flowing water at the point where they enter the feature. If an unmapped lake or pond is found during the survey, treat it as a segment and record data accordingly. If the pond meets the definition of a wetland, and the outlet of the wetland is a Type 4 Water, then conduct the regular survey and record data accordingly.

Upstream Random Tributary Selection: During an upstream survey, crews will often find tributaries entering the stream with similar flow categories. The crews will then need to randomly choose the stream on which to continue the upstream survey and instructions are provided below to accomplish this. The purpose of using random selection is to prevent the hydrologic bias to follow tributaries with the most flow. Random selection tests the hypothesis that basin area relationships are consistent regardless of the tributary chosen. The exception is a small tributary entering a larger stream's floodplain where flow conditions could be related to the larger stream's hyporheic ground flow.

Repeat Between Year (Inter-Annual) Surveys: Inter-annual surveys record the variation in channel flow characteristics between different summer dry seasons. Comparing multiple year data from the same stream tests the hypothesis that differences in precipitation does not affect the location of the perennial initiation point. The repeat survey must cover the entire survey reach of the previous year, or a larger reach if needed, using the following protocols:

- Determine new starting/ending points where necessary
- Repeat 2001 tributary pathway (no coin flips…unless no other choice due to trib/flow conditions upstream/downstream of 2001 highest flow)
- Identify in field form notes the positions of previous PSS Map code locations if known (Ss, Pp, Ps, Pn, Ph, Se) points and distance from start
- Disregard and remove all other previous flagging
- Conduct regular survey otherwise

Repeat Within Season (Intra-Annual) Surveys: Intra-annual surveys record the variation in channel flow characteristics within the same summer dry season. Comparing multiple season data from the same stream tests the hypothesis that differences in precipitation and groundwater inflow does not affect the location of the perennial initiation point. The repeat survey must cover the entire first survey reach of that season, or a larger reach if needed, using the following protocols:

- Determine new starting/ending points where necessary
- Repeat first 2002 tributary pathway regardless of trib/flow conditions

- Identify in field form notes the positions of previous PSS Map codes locations (Ss, Pp, Ps, Pn, Ph, Se) points and distance from start
- Disregard and remove all other previous flagging
- Collect limited data: segment number, distance from start, flow category, channel category, PSS Map code, and associated feature information.

3.2 Site Verification and Survey Reach Investigation

Site verification is the process by which the randomly selected stream is accurately found in the field. The better the office preparation and investigation, the more likely that this can be accomplished quickly in the field. Particular attention should be placed on investigating whether the site selected has only spatially intermittent flow to its mouth. This may be more common in Eastern Washington. Assuming the procedures outlined in section 2 were used correctly, begin the survey at the mapped or known point of uppermost fish use.

Once the stream is verified, the next step is to investigate the survey reach for the best access points and likely start and end points. Usually, this can be done by driving around the area and viewing the stream conditions at various road crossings and with some footwork. In some situations, it may be more efficient to simply start the survey at a road crossing the continuously flowing reach of the stream.

Limitations to access points may also require using different survey approaches. An "In/Out" survey approach is recommended in most situations. In this approach, the survey crew starts a partial survey by segment identification, flagging, and measuring the break distances to the survey end point. On the return trip back to the starting point, the survey crew collects the remainder of the information. A "One-Way" survey approach is useful where the survey crew will not be retracing their stream route back to their vehicle or exit point. This is most commonly used in very difficult situations where the majority of the stream reach is very steep or heavily vegetated (e.g. devil's club, blackberry, etc.) or covered in organic debris (slash).

At times, sites may be encountered that cannot be sampled (e.g. completely dry-no flow, access denied, unsafe conditions). In these situations move East to the next stream site that can be sampled. If the second site cannot be sampled, then move to the next site south. Document situations where the pre-selected site could not be sampled, the reason it could not be sampled, and the process used to determine the next accessible site.

3.3 Survey Starting Point: Identification and Marking

Mark the starting point with survey flagging. If in an area with abundant cattle or elk, make sure to tie flagging as high as possible. Mark the flagging with the site number, segment "**#0**," date (mm/dd/yy) and "**START**" using permanent marker. Identify, mark, and label ("Ss") starting point location on the USGS 7.5 minute field copy. On the field form, the only columns that are completed are the "Segment Number" ("**0**") and "Distance from Start (m)" ("**0**"). GPS readings, if possible, can be recorded in the Notes column and can be useful for field relocation in repeat surveys.

The starting point for an **upstream** survey is a point at least 200 meters downstream of the spatially continuous flow initiation point and where investigation shows there is spatially continuous flow from that point downstream to the stream's mouth; OR at the junction where it flows into another with spatially continuous flow, a lake or pond, or with a stream mapped as a Type 3 Water (fish bearing), even if it started with a dry flow category.

- Example A: Situation: Investigation shows that a road crossing or tributary junction is 253 meters downstream of Pp. – Solution: Start the survey at the road crossing or tributary junction to provide an easily located starting point.
- Example B: Situation: Investigation shows that a road crossing (trib junc., etc.) is 175 meters downstream of Pp. – Solution: Start the survey at the 200 meter point, so that at least 200 m of continuous flow would be documented.
- Example C: Investigation shows that a road crossing is 500 meters downstream of Pp – start survey at road crossing or start survey at 200 meter point and record distance from the start to the road crossing to simplify future relocation.

The starting point for a **downstream** survey is at the channel head, or the highest elevation of seeps, springs, wetlands, or wet sites that drain into the channel head and where investigation shows there are no channels upslope of that point which contribute flow at the time of the survey or during the wet season. Where a "Piped Channel" (PC) (see section 3.3.3 for definition) is the uppermost channel category, the channel head is located at the uppermost window or to the extent where flowing water can be heard upstream of that point.

Perennial streams may begin at lake, pond, or wetland features. These water bodies fix the location of perennial flow. When this situation is encountered the shoreline should be inspected to determine whether another stream enters it. If so, the survey should be continued along this stream segment to its uppermost extent. Treat multiple channels with the same flow categories as multiple tributaries that require random selection.

Permanent flagging is not required as part of this survey if landowners or survey crew do not wish to apply. However, flagging is helpful during the survey for quality control and measurement purposes and can be removed after needed. Biodegradable flagging is preferred in other situations. If more permanent marking such as aluminum tagging and triangulation documentation is needed for start, end, and specific intermediate points along the survey reach, refer to the TFW Reference Point Survey (Pleus and Schuett-Hames, 1998) Section 3.1 for detailed procedures.

Survey instructions are applicable to either an upstream or downstream survey approach unless otherwise noted.

3.4 Primary Segment Data Collection

Walk towards the survey reach endpoint. Identify the next segment break location (Table 1) and mark it with a sequentially numbered flag (e.g., **#1**, **#2**, **#3**, etc.). The length of each segment is determined by changes in physical conditions. The longest segment is 100 meters (330 feet) and the shortest segment is 5 meters (16 feet) except for Modified Channels (MC) which have a minimum length of 1 meter (3.3 feet). At each change in physical conditions, or at 100 meter intervals where no change is noted, record the following on the field form:

- Segment Number: Record the next sequential whole number from the start of the survey.
- Distance from Start: Record distance to the nearest whole meter. Distances are to be cumulative. In other words, all distances recorded are to be the distance from the starting point.
- Flow Category: Choose one of the following codes - "**FW**", "**SW**", "**FP**", "**SP**"," "**O**", "**D**", or "**U**" (Table 2). Record as capitals.
- Channel Category: Choose one of the following codes - "**DC**", "**PD**", "**MC**", "**PC**", "**OC**", "**UC**", or "**NC**" (Table 3). Record as capitals.
- PSS Map Code: Choose up to three of the following codes - "**Ss**", "**Pp**", "**Ps**", "**Pn**", "**Ph**", or "**Se**" if appropriate for that segment break location (Table 4). Record as noted in uppercase and lowercase. Identify point location on field map.

NOTE: The flow and channel category data recorded on the field form reflects segment reach characteristics found between the last segment break and the one just identified. On the field form, the row recorded for segment number "1" will reflect the stream reach characteristics between segment breaks "0" and "1"; segment number "2" will reflect the reach between segment breaks "1" and "2"; and so forth.

If conducting a "One-Way" survey, go to section 3.5 of the procedure and complete the "Additional Segment Parameter Data Collection" for that segment. Upon completion, this cycle will be repeated for each segment to the end of the survey.

If conducting an "In/Out" survey, continue application of section 3.4 procedures to the survey reach end, marking and collecting segment information as noted above. When the end has been verified and marked, go to section 3.5 of the procedure to collect the "Additional Segment Parameter Data Collection" information on the return portion of the survey.

It is highly recommended that hip-chain string be removed from the survey reach after use. Hip-chain line has been documented to ensnare and kill small wildlife such as birds, and its removal promotes good relations with landowners and leaves streams in the same condition as found. Always use biodegradable line regardless of intent to retrieve.

Detailed segment break criteria and additional information regarding the segment parameters is provided in the rest of this section and can be referred to as needed.

3.4.1 Segment Break and Upstream Tributary Survey Selection Information

PSS segment breaks are identified at locations using one of five criteria found in Table 1.

Table 1. Segment breaks are established and numbered sequentially at each of the following points where conditions are met along the survey reach.

Segment Break Criteria
100 meters (330 feet) of same flow category
Point of next flow category change
Point of next channel category change
Tributary junction of same or next higher flow category
Modified channel start and end points

100 meters (330 feet) of same flow category: Make segment breaks every 100 meters IF the flow category does not change. In general, the "100 meters of same flow category" criteria will most often apply to the downstream flowing water (FW) portion of the survey reach and upstream dry (D) portions of the survey reach. Eastern Washington systems may often have long stretches of dry within the survey reach.

Point of next flow category change: Make segment breaks at every change in flow category based on the criteria in Table 2. This will often require some field investigation around the break to determine if the next segment flow category meets the minimum criteria.

Point of next channel category change: Make segment breaks at every change in channel category based on their physical criteria in Table 3. This will often require some investigation around the break to determine if the next segment channel category meets the minimum 5 meter length criteria.

Tributary junction of same or next higher flow category: Make segment breaks at every tributary junction that has the same or next "higher" flow category (FW > SW > FP > SP > D). There is no minimum tributary segment length criteria in situations where two tributaries enter in similar places along a survey reach. Use the upstream flow category to determine if a segment break is need for obscured (O) or unknown (U) situations.

Mark the location of the stream that was not followed on the field map. If you encounter a dry tributary junction, also record the distance and flow type of this tributary on the data form. It may be necessary to confirm the flow category of the tributary junction by walking at least 5 meters upstream. It is important to clearly mark the course of the survey as it changes at tributary segments so that the analyst can trace the route on a GIS layer.

UPSTREAM SURVEY ONLY: At segment breaks where two tributaries with the same flow categories are encountered for the first time, you must flip a coin to decide which tributary to continue the survey on. If "heads", the survey proceeds up the right tributary as seen facing upstream. If "tails", the survey proceeds up the left tributary. Record results of the coin toss in the "Notes" column of the field form. The relative size or flow of the two tributaries has no bearing on the decision as long as the flow categories for the two are the same. For subsequent tributaries where both streams have the same flow category, alternate the previous direction (e.g. if the coin flip said go *left* at the first tributary, go *right* at the second). Continue to alternate directions as needed until the survey is complete. For situations where more than two tributaries with the same flow category intersect, cut up and number pieces of paper, then draw one from a hat.

Distributaries and pirated channels: If a distributary is identified during an upstream survey, make a segment break and describe the feature in the Notes. Continue upstream and complete the survey. If a distributary is identified during a downstream survey, make a segment break at the junction and describe the feature in the Notes. Investigate to determine which channel was the one randomly selected and continue the survey down that channel – regardless of flow conditions. Flip a coin to decide which channel to take otherwise.

Modified channel start and end points: Make segment breaks at both the start and ending points of modified channels using the description in Table 3 below. There is no minimum modified channel segment length criteria.

3.4.2 Flow Category Information

Surveyors must use their best judgment to assign each segment with one of seven flow categories. This information is also helpful in identifying the location of the breaks between flow categories. Table 2 provides the flow categories by their field codes and corresponding flow types and descriptions.

Table 2. Flow category field codes, types and descriptions.

Field Code	Flow Type	Description
FW	**Flowing Water**	Survey sections with continuous surface water flow that is equal to or greater than 5 meters (16 feet) in length - no minimum width and depth. If a portion of dry channel less than 5 meters long separates two FW category sections of channel – disregard the dry channel section and combine. FW includes non-isolated pools of standing water were the only noticeable flow is that entering and/or exiting.
SW	**Standing Water**	Survey sections of isolated still surface water equal to or greater than 5 meters (16 feet) in length - no minimum width and depth. TEST: If dry dust or small pine needles placed anywhere on the surface of the pool move without the aid of wind, it is flowing water, not standing water.
FP	**Flowing Pocket Water**	Survey sections of dry and isolated flowing surface water equal to or greater than 5 meters (16 feet) in length including downstream and upstream dry sections of the channel. Individual pockets of water must have a minimum surface area of 0.1 square meters (0.1 length x 0.1 meter width) – otherwise record as dry.
SP	**Standing Pocket**	Survey sections of dry and isolated standing surface water equal

	Water	to or greater than 5 meters (16 feet) in length including downstream and upstream dry sections of the channel. Individual pockets of water must have a minimum surface area of 0.1 square meters (0.1 length x 0.1 meter width) – otherwise record as dry.
O	**Obscured**	Survey sections equal to or greater than 5 meters (16 feet) whose flow category cannot be identified because visibility is obscured by slash, debris, dense vegetation, etc. However, an "obscured" segment break is not required in situations where the flow category is the same downstream and upstream of the obscured portion (<u>not just FW</u>), and is consistent with evidence seen or heard through breaks in cover.
D	**Dry**	Survey sections where no surface or piped channel water is present equal to or greater than 5 meters (16 feet). This includes dry, moist and saturated substrates without surface water. Dry survey sections less than 5 meters (16 feet) are disregarded unless combined with FP or SP categories.
U	**Unknown**	Survey sections that cannot be physically accessed or observed. For example, this may be a result of landowner restrictions, current operations such as timber harvest or blasting, steep inaccessible terrain, etc. In some situations, especially where no channel enters from above, it may be best to discontinue the survey and select an alternative stream site. If the survey is continued, the surveyor must identify the beginning and ending points on the field map, and describe the situation in the field notes including why it should not affect survey results.

<u>Difficult Flow Category Situations:</u> Where side channels (i.e. sections where channel diverges into two or more sub-channels, then recombines below) are encountered, follow the channel with the greater flow quantity or higher flow category. Flow going under organic cover, such as logs, trees, stumps, and soil- or vegetation-covered root mats does not represent a segment break based on flow, except where it meets the "Obscured" and meets the 5 meter length criteria. As a rule of thumb, imagine the stream without its organic cover, when describing its flow definition. If a survey section does not fit any of the above categories, record the section as an "obscured" segment break and describe the situation in your notes. Back in the office, consult with your team leader and make corrections if necessary.

3.4.3 Channel Category Information

Segment breaks using channel category criteria <u>alone</u> must equal to or greater than 5 meters long – <u>except</u> for modified channels that can be equal to or greater than 1 meters (3.3 feet) long. Otherwise, combine short channel categories with an adjacent segment that has the most closely associated category. Surveyors must use their best judgment to identify and assign one of seven channel categories. This information is also helpful in identifying the location of the breaks between channel categories. Table 3 provides the channel categories by their field codes and corresponding flow types and descriptions.

Table 3. Channel category field codes, types, and descriptions.

Field Code	Channel Type	Description
DC	**Defined Channel**	A stream channel defined by sharp incision into the substrate where water and mineral sediment are (or have been) transported in concentrated flows and vegetation and organic detritus is generally absent. Channels form as a result of downslope hydraulic (water-powered) scour into mineral substrate. For purposes of this survey, the low flow sections of the streambed must be mostly mineral substrate, comprised of sand, gravel, cobble, boulders, or bedrock. The boundary between the defined channel and surrounding riparian area is clear and usually abrupt. Woody debris or root mats suspended over the stream are not part of the streambed.
PD	**Poorly Defined Channel**	This is a stream channel with evidence of scour or deposition via past or present flowing water, but is not incised or poorly defined. Substrate material may include organic detritus, fine sediment deposits, or live vegetation, often in a patchy distribution. The boundary between the stream and riparian area is difficult to identify or patchy. Most common where channels flow through wetland, seep, and wet-site areas.
MC	**Modified channel**	All channels in culverts and following road ditches are in this category. Other circumstances, such as recent forest practices, recreational dirt bike activity, or agricultural practices (e.g., livestock) that make it difficult to classify natural channel type should be classified as modified channel. The details must be recorded in the notes.
PC	**Piped Channel**	Channels conveying flowing water through single or multiple "pipes" in the soil. These, sometimes called "tunnels" or "tubes," usually occur in areas with dense root mats with organic growth cover (as opposed to downed wood). Often, no expressed channel is defined at the surface. Pipes can often be observed through holes or windows that partially expose the subsurface channel. Piping DOES NOT include places where water simply disappears into the substrate or places where the channel has been modified by direct human activity. Generally, these channel situations are associated with established vegetation (i.e. tree or other roots), small channels covered by canopy litter, macro-pores in the soil, or lava tubes.
OC	**Obscured or Covered Channel**	Survey sections equal to or greater than 5 meters whose channel category cannot be identified because visibility is obscured by slash, debris, dense vegetation, etc. Primarily used when an "obscured" flow category is applied.
UC	**Unknown Channel**	Survey sections that cannot be physically accessed or observed. Primarily used when an "unknown" flow category is applied.
NC	**No Channel**	An area or swale with no observable evidence of scour or erosion that defines it's boundary with riparian or upslope areas.

3.4.4 Perennial Stream Survey (PSS) Map Code Information

PSS map codes are applied at corresponding survey segment breaks as they are identified during or defined after the survey is completed. If not sure of a call, describe the situation in the notes with best professional estimation of the possibilities and contact the CMER project manager (Robert Palmquist, CMER Staff) for help.

Table 4. Perennial Stream Survey (PSS) map codes, names, and descriptions.

Map Code	PSS Map Code Name	Description
Ss	**Survey Start**	Point location defining the start of survey reach segment data collection.
Pp	**Continuous Flow**	Point location defining the uppermost extent of a segment with continuous flowing water category (FW). From this point downstream at least 200 meters of continuous flowing water category is documented. Flow below Pp is considered spatially contiguous. Flow above Pp is considered spatially intermittent.
Pn	**Intermittent Flowing Water**	Point location defining the uppermost extent of a segment with intermittent flowing water category (FW or FP). Must be upstream of, or may coincide with Pp. Flow below Pn is considered spatially intermittent. From Pn upstream must be either SW or SP or D flow category, unless initiation point coincides with the channel head (Ph).
Ps	**Intermittent Standing Water**	Point location, if present, defining the uppermost extent of a segment with intermittent standing water or standing pocket water flow category (SW or SP).
Ph	**Channel Head**	Point location on stream of uppermost extent of a segment with evidence of scour and erosion into soils. From Ph upslope, if flow continues, must be labeled as "No Channel" (NC).
Se	**Survey End**	Point location on stream that defines the uppermost extent of survey reach where segment data collection ends.

As each PSS map code point is identified, attempt to locate its position and local basin area constraints on the field map. This may be done using GPS and/or orienteering methods. Keep in mind that these headwater streams may not be present on topographic maps. Hence, crews may have to interpret and map the stream as they travel along it. Use of multiple orienteering tools (compass, orientation to mapped features) to locate sites on the maps is encouraged. Protected aerial photographs are a good tool for locating features and locations that can then be transferred to the field map. Care should be taken to account for scale differences.

3.5 Secondary Segment Data Collection

Secondary data is collected for each segment that helps characterize stream conditions related to hydrology and geology factors affecting the survey. Secondary data to record for each segment includes:

- Average Segment Bankfull Width (BFW): Record width to the nearest tenth (0.1) of a meter (0.4 feet).
- Average Segment Bankfull Depth (BFD): Record depth to the nearest tenth (0.1) of a meter (0.4 feet).
- Average Segment Channel Gradient (Grad): Record gradient to the nearest percent in whole numbers (e.g., "3", "4", "5",..., "20", etc.).
- Average Segment Dominant Substrate (Dom Sub): Choose one of the following codes – "**F**", "**S**", "**G**", "**C**", "**B**", or "**R**" (Table 6). Record as capitals.
- Segment Break-Associated Features (BAF): Choose up to five of the following codes with the primary factor listed first or circled - "**HSP**", "**SP**", "**SCP**", "**HSE**", "**SSE**", "**SE**", "**NP**", "**AF**", "**CH**", "**WE**", "**WS**", "**TJ**", "**BP**", "**LP**", "**GB**", "**DS**", "**RC**", "**RD**", "**SC**", "**WD**", "**OT**", or "**NO**" (Table 7). Record as capitals.
- Segment Associated Features (AF): Choose up to five of the following codes with the primary factor listed first or circled - "**HSP**", "**SP**", "**SCP**", "**HSE**", "**SSE**", "**SE**", "**NP**", "**AF**", "**CH**", "**WE**", "**WS**", "**TJ**", "**BP**", "**LP**", "**GB**", "**DS**", "**RC**", "**RD**", "**SC**", "**WD**", "**OT**", or "**NO**" (Table 7). Record as capitals.
- Average Segment Valley Confinement (Conf): Choose one of the following codes – "**C**", "**M**", or "**U**" (Table 5). Record as capitals.

Segment data must be associated with the reach between the last and the next segment break. This means that Segment Number "0" always has only limited data associated with it (Distance from Start, PSS Map Code, and Associated Feature at Break); Segment Number "1" reflects characteristics between segments "0" and "1" or at "1"; Segment Number "2" reflects characteristics between segments "1" and "2" or at "2"; and so forth – REGARDLESS of upstream or downstream survey, or One-Way or In/Out approaches.

All additional segment data is collected for dry channel segments. Obscured/covered flow and channel conditions, modified channels, and piped channels may require reasonable estimation of additional data or leave blank. Unknown segments are not expected to have additional data included.

This portion of the survey can be completed after each segment break is established and recorded in a "One-Way" approach (return to section 3.4), or in a continuous reverse procession by sequential segment in an "In/Out" survey approach.

Detailed segment data collection criteria and additional information regarding the segment parameters is provided in the rest of this section and can be referred to as needed.

3.5.1 Average Segment Bankfull Width and Depth

Average segment bankfull width and depth measurements are based on standard TFW Reference Point Survey methods as defined in Pleus and Schuett-Hames (1998). Representative hydrologic bankfull values provide information about the basin hydrology.

Where a floodplain is present, the edge of the bank is characterized by 1) a berm or other break in slope from the floodplain down to the streambed; 2) a change in vegetation from trees, and perennial vegetation (brush – not moss) to bare surfaces and annual or water tolerant vegetation, and; 3) a change in substrate from fines or organic cover to sand, gravel, boulders or bedrock. The average bankfull width should be representative of the segment's length. For uniform channels or short segments, a single representative measurement is adequate. For irregular and longer channel segments, take three representative measurements and average together.

Bankfull depth is measured at each bankfull width measurement location and is defined as the average distance from the bankfull width at its estimated water surface elevation (represented by a tape stretched from bankfull edge to bankfull edge) to the substrate of the channel bed. For uniform channels, a single depth measurement is sufficient. For complex channels, take three bankfull depth readings at ¼, ½ and ¾ intervals across the bankfull width channel and average them together.

Difficult situations

Multiple channels: Bankfull width is the combined width of all channels identified along the measurement cross section. The width of dry gravel bars within the channel are included in the total bankfull width measurement. The width of islands that rise higher than the bankfull elevation (estimated water level where water would start flowing onto floodplain) is not included.

Piped Channels and Culverts: Natural piped channel and human-made culverts or other feature "bankfull widths" are taken at the widest lateral portion of the "window" access or exit hole. Bankfull depths are estimated as ½ the height of the pipe.

Seeps, Wetlands, & Wet-sites: Hydrologic "bankfull" widths and depths are extrapolated to include portions of the wetland- or saturated soil-associated situations regardless of whether a channel exists. If the segment has no channel (NC), swale depression, or even if raised, record a "0" for bankfull depth. Measurements represent the extent of periodic inundation "...where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland" (WAC 222-16-010). The "mark upon the soil" can be identified using erosion/scour patterns, soil changes, wetland obligate vegetation such as water parsley and skunk cabbage.

3.5.2 Average Segment Channel Gradient

Channel gradients provide information on stream energy dynamics and fluvial processes. Significant changes in gradient often translate to flow changes. Average segment channel gradient is measured using a clinometer or similar devise that measures slope in percent. Gradient readings must reflect the general segment channel bed slope along its entire length and can be taken in an upstream or downstream direction. Gradient is measured between two points along the segment length. One method is to tie a piece of flagging at eye level from the channel bed for point 1, move to the point 2 along the segment channel bed and take a reading back to point 1. Another way to measure gradient is to calibrate where your eye level ("0" percent gradient) intersects a second crew member's measuring rod or body. Each crew moves to representative points along the segment at channel bed elevation and gradient is measured between those points.

This method can be used to record upstream and downstream gradients where needed to confirm segment breaks caused by gradient increases or decrease of 10 percent or greater.

3.5.3 Average Segment Dominant Substrate

Average segment dominant substrate is estimated visually along the segment length. The dominant substrate size is determined by estimating which size category covers the most surface area within its bankfull width. In complex situations, make 3 or more observations along the segment length and record in the notes. At the segment end, review the notes to determine which category was the dominant. If desired, record a sub-dominant substrate category in the Notes.

Table 6. Average segment dominant substrate codes, types, and descriptions.

Field code	Substrate Type	Description
F	Fines: silt/muck/mud	Less than 0.625 mm grain size - including larger organic components
S	Sand	Sediment 0.625 to 2 mm grain size - not including organic components
G	Gravel	2.0 to 64.0 mm (i.e., rocks smaller than a baseball)
C	Cobble	64.0 to 256.0 mm (i.e., rocks larger than a baseball and smaller than a basketball)
B	Boulders	Greater than 256.0 mm (i.e., rocks larger than a basketball)
R	Bedrock	Solid or fractured rock with no discernible size limitation of individual pieces.

3.5.4 Segment Break-Associated Features

Segment break-associated features in Table 7 are recorded where they correspond to a segment break point (new segment number). This does not include those associated features that are found along the length of the segment and/or do not trigger a segment break in and of themselves (refer to section 3.4.6 below). If no features affect the segment break call, record "**NO**" for "none". Up to five features per segment break can be recorded. When recording associated features, estimate which one has the most significant effect on the segment break call at the time of the survey. Circle this code or list it first if multiple factors are noted.

Table 7. Average segment associate feature codes, types, and descriptions.

Field Code	Feature Type	Description
HSP	Headwater Spring	WAC 222-16-010 Forest practices sensitive site: "A permanent spring at the head of a perennial channel. Where a headwater spring can be found, it will coincide with the uppermost extent of Type Np Water."
SP	Spring	Other than regulatory "Headwater Springs" features. Springs include areas within or adjacent to the channel wherein a single stream of water issues from the ground and enters the channel in a discernable flow. The size of the spring area may be smaller or slightly larger than the channel width and is generally not associated with significant areas of saturated soils. This may include closely associated multiple exit points due to organic matter or sediment that combine to form a single stream into the channel. Within a channel, it could be a pool from which water continuously flows. Adjacent to the channel, the continuous flow may enter directly, or enter by a short (< 5 m) tributary channel.
SCP	Spring Complex	Other than regulatory "Headwater Springs" or "Spring" features. Complex springs include areas within or adjacent to the channel wherein multiple streams of water issue from the ground in discernable flow. The size of the spring complex area is generally much larger than the channel width and associated with significant areas of saturated soils. Multiple exit points due to organic matter or sediment. Within a channel, it could be a pool from which water continuously flows. Adjacent to the channel, the continuous flow may enter directly, or enter by a short (< 5 m) tributary channel, or be connected by saturated soils.
HSE	Headwall Seep	WAC 222-16-010 Forest practices sensitive site: "A seep located at the toe of a cliff or other steep topographical feature and at the head of a Type Np Water which connects to the stream channel network via overland flow, and is characterized by loose substrate and/or fractured bedrock with perennial water at or near the surface throughout the year."
SSE	Side-Slope Seep	WAC 222-16-010 Forest practices sensitive site: "A seep within 100 feet of a Type Np Water located on side-slopes which are greater than 20 percent, connected to the stream channel network via overland flow, and characterized by loose substrate and fractured bedrock, excluding muck with perennial water at or near the surface throughout the year. Water delivery to the Type Np channel is visible by someone standing in or near the stream."
SE	Seep	Other than regulatory "Headwall Seep" and "Side-Slope Seeps" Seeps are areas within or adjacent to the channel. Within the channel, they usually occur with intermittent flow conditions.

		Channel adjacent seeps are areas where water, which slowly oozes from the ground, does not form a DC or PD channel (see section 3.3.3). Seeps often emerge from flat or raised (convex) terrain areas. Seeps may have wetland vegetation and fine to coarse substrates.
NP	Type Np Intersection	WAC 222-16-010 Forest practices sensitive site: "The intersection of two or more Type Np Waters."
AF	Alluvial Fan	WAC 222-16-010 Forest practices sensitive site: "An erosional land form consisting of cone-shaped deposit of water-borne, often coarse-sized sediments. (a) The upstream end of the fan (cone apex) is typically characterized by a distinct increase in channel width where a stream emerges from a narrow valley; (b) The downstream edge of the fan is defined as the sediment confluence with a higher order channel; and (c) The lateral margins of a fan are characterized by distinct local changes in sediment elevation and often show disturbed vegetation. Alluvial fan does not include features that were formed under climatic or geologic conditions which are not currently present or that are no longer dynamic.
CH	Convergent Headwalls	WAC 222-16-010: "Teardrop-shaped landforms, broad at the ridgetop and terminating where headwaters converge into a single channel; they are broadly concave both longitudinally and across the slope, but may contain sharp ridges separating the headwater channels."
WE	Wetland	WAC 222-16-010 and 222-16-035: Type A, B, or Forested wetland equal to or greater than 0.25 acres as defined in forest practices rules. "Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal conditions, do support, a prevalence of vegetation typically adapted for like in saturated soil conditions, such as swamps, bogs, fens, and similar areas. This includes wetlands created, restored, or enhanced as part of a mitigation procedure. This does not include constructed wetlands or the following surface waters of the state intentionally constructed from wetland sites: Irrigation and drainage ditches, grass lined swales, canals, agricultural detention facilities, farm ponds, and landscape amenities." They may or may not have surface water visible or a discernable channel.
WS	Wet Site	Other than regulatory wetlands. Wet sites include smaller wetlands (< 0.25 acres), bogs, and other saturated soils vegetation patches (e.g. devil's club, willow, water parsley, skunk cabbage, etc.) including those with or without surface water.
TJ	Tributary Junction	Additional defined or poorly defined channels equal to or greater than 5 meters in length entering the survey segment, whether flowing or dry.

BP	Beaver Pond	Actively maintained, inactive, or breached are acceptable.
LP	Lake or Pond	Natural or human-made. Does not include beaver ponds. These are typically larger perennial surface water features that are not formed by fluvial processes (scour and erosion) or generally associated with woody debris. Refer to the wetlands feature if the pond is associated with wetland features. If unsure which, record both codes.
GB	Gradient Break	Change of at least 10 percent between measured downstream and upstream gradients. Does not include gradient breaks due to debris slides or sediment storage by woody debris. Classic situations correspond to headwall or bedrock outcrops. Record measurements in Notes.
DS	Debris Slide	Evidence of debris slide, torrent, or other mass wasting (deposition, scour, etc.). Describe feature in Notes.
RC	Road Crossing	Channel going through culver to under bridge with roadbed fill. Flow visibly affected by constriction or pirating of upslope flow into crossing head, or by the effects of the crossing itself.
RD	Road Drainage	Visible road drainage inputs from ditches, water bars, or other drainage structures except those noted as RC above.
SC	Substrate Change	Significant change in substrate characteristics
WD	Woody Debris	In-channel accumulations of small or large woody debris that significantly affect channel complexity and/or result in sediment deposition (storage) within a segment or that cause a segment break.
OT	Other	Other features potentially affecting changes in flow or segment break. Describe in Notes column.
NO	None	No features present.

3.5.5 Segment Associated Features

Segment associated features use the same codes as listed in Table 7 and are recorded if found along the segment length during the survey. This does not include those associated features that trigger a segment break (refer to section 3.4.5 above). If no features are present, record "**NO**" for "none". Up to five features per segment can be recorded. When recording associated features, estimate which one has the most significant effect on flow conditions at the time of the survey. Circle this code or list it first if multiple factors are noted. If the same feature is found multiple times (independent of each other), the same code can be recorded multiple times or the number recorded in the notes column.

3.5.6 Average Segment Valley Confinement (Optional)

Average segment valley confinement is based on standard TFW Stream Segment Identification methods as defined in Pleus and Schuett-Hames (1998). Confinement values provide information about the ability of the channel to migrate within its floodplain and possible relationships to surface flow and groundwater inputs. This parameter is estimated from the stream and should reflect the majority of the segment's length.

Table 5. Average segment valley confinement codes, types, and descriptions.

Field code	Confinement Type	TFW Confinement Description
C	Confined	Floodplain < 2 channel (bankfull) widths
M	Moderately Confined	Floodplain width ≥ 2 and < 4 channel (bankfull) widths
U	Unconfined	Floodplain ≥ 4 channel (bankfull) widths

A confined channel has very little or no room for lateral movement. This includes incised channels and those constrained by topographic features. Inner gorges are often confined. Moderately confined channels have more room for lateral movement across its floodplain and may often describe lower gradient bench sections of the survey where soils have deposited over time. Unconfined segments are expected to be uncommon in headwater surveys, but should be easily identified where they occur. A good rule of thumb is: "If it is definitely not confined or unconfined – it is moderately confined."

3.5.7 Notes

Use this column to record additional information as required in protocols or other significant survey observations for that segment. If more space is needed, mark a footnote number in the column to track notes on a separate sheet of paper. Also note anecdotally whether fish, tadpoles or other amphibians are observed during the survey. If unusual situations are encountered, make a sketch map on the back of the field map or a separate sheet of paper.

3.5.8 Additional Information

Additional information or specific features can be recorded along the survey reach between segment breaks using subsequent rows on the data form. Do not assign additional segment numbers, but you can record distances and other data as needed. See Appendix B for an example of a completed field form. However, when completed and ready for data entry, all parameters using this protocol for a single segment must be extracted from independent individual data and entered on one row. Analysis of individual additional data is the responsibility of the cooperator collecting it.

3.6 Survey Ending Point: Identification and Marking

Mark the ending point with survey flagging. Mark the flagging with the site number, segment number, date (mm/dd/yy), and "**END**" using permanent marker. Identify, mark, and label ("**Se**") the ending point location on the USGS 7.5 minute field map copy. On the field form, complete all necessary columns. In the next empty row, write "**END OF SURVEY**" for quality control purposes. GPS readings, if possible, can be recorded in the Notes column and can be useful for field relocation in repeat surveys.

The starting point for a **downstream** survey is at the channel head, or the highest elevation of seeps, springs, wetlands, or wet sites that drain into the channel head and where investigation shows there are no channels upslope of that point which contribute flow at the time of the survey or during the wet season. Where a "Piped Channel" (PC) (see section 3.3.3 for definition) is the uppermost channel category, the channel head is located at the uppermost window or to the extent where flowing water can be heard upstream of that point.

The ending point for a **downstream** survey is a point at least 200 meters downstream of the spatially continuous flow initiation point and where investigation shows there is spatially continuous flow from that point downstream to the stream's mouth; OR at the junction where it flows into another with spatially continuous flow, a lake or pond, or with a stream mapped as a Type 3 Water (fish bearing), even if it started with a dry flow category.

- Example A: Situation: Investigation shows that a road crossing or tributary junction is 253 meters downstream of Pp – Solution: End survey at the road crossing or tributary junction.
- Example B: Situation: Investigation shows that a road crossing (trib junc., etc.) is 175 meters downstream of Pp – Solution: End the survey at the 200 meter point.
- Example C: Situation: Investigation shows that a road crossing is 500 meters downstream of Pp – Solution: End survey at road crossing or start survey at 200 meter point and record distance from the start to the road crossing.

Form A: 2002 Perennial Stream Survey Summary Information

PSS/Site #:

Survey Type: ☐ Random ☐ Repeat

Reference Site: ☐ Yes ☐ No

Survey Date:

Survey Repeat Type: (if conducted)
- ☐ Between 2002 and 2001
- ☐ Within 2002 Season

Basin Acre Default:
☐ 13 ☐ 52 ☐ 300

Lead Crew:

Data Contact Information

Name ______

Affiliation ______

Address ______

______

Phone Number ______

E-mail ______

Survey Location Information

WAU Name ______

USGS 7.5 Minute Topo Name

______

Township ______

Range ______

Section ______

Elevation at Survey Start ______ ☐ Meters ☐ Feet

Elevation at Survey End ______ ☐ Meters ☐ Feet

Aerial Photo Number ______

Landowner ______

Landowner Contact ______

Other Maps/Photo Information ______

______

______

Basin Dominant Upslope Vegetative Information

Stand Composition
- ☐ Conifer
- ☐ Deciduous
- ☐ Mix

Stand Density
- ☐ Sparse
- ☐ Moderate
- ☐ Dense

Stand Age
- ☐ Young
- ☐ Mature
- ☐ Second Growth
- ☐ Old Growth

Harvest Management
- ☐ Clear Cut
- ☐ Partial Cut
- ☐ No Cut (recent observable)

Checklist

Form A
- ☐ Completed & Error Checked
- ☐ Spreadsheet Entry & Error Checked

Form B
- ☐ Completed & Error Checked
- ☐ Spreadsheet Entry & Error Checked

USGS 7.5 Minute Topo Map
- ☐ PSS map points identified
- ☐ Pp and Pn Basin Areas delineated
- ☐ Error Checked

GIS Layer (Optional)
- ☐ PSS map points identified
- ☐ Pn Basin Area delineated
- ☐ Error Checked

☐ Error Checked

Page ______ of ______

Form A: 2002 Perennial Stream Survey Summary Information (cont.)

PSS/Site # **Survey Date:**

Driving Directions to Access Location	Access Directions to Stream Survey Start Location	Basin Area Comments	General Summary Notes

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Page ________ of __________

Form B: Perennial Stream Survey Data Collection

PSS/Site #:

Date:

Affiliation:

Survey Type: ☐ Random ☐ Repeat (check one)

Stream Name:

Survey Direction: ☐ Upstream ☐ Downstream (check one)

Survey Crew:

Survey Measurement Units: ☐ Metric ☐ English ft/in ☐ English ft/tenths (check one)

Segment Number	Distance from Start	Flow Category	Channel Category	PSS Map Code	Avg Seg Bankfull Width	Avg Seg Bankfull Depth	Avg Seg Channel Gradient (%)	Avg Seg Dominant Substrate	Seg Break - Assoc Feature(s) (circle primary)	Seg Assoc Feature(s) (circle primary)	Avg Seg. Valley Confinement	Notes

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Page ________ of ___________

Form B: Perennial Stream Survey Data Collection (cont.)

PSS/Site #	**Date:**
	NOTES

Sketch Pad

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Page ________ of ___________

Perennial Stream Survey Criteria & Code Field Sheet

Primary Segment Data Collection

Segment Break Criteria
(Section 3.4.1)

- 100 meters (330 feet) of same flow category
- Point of next flow category change
- Point of next channel category change
- Tributary junction of same or next higher flow category
- Modified channel start and end points

Flow Category Codes
(Section 3.4.2)

FW = Flowing Water
SW = Standing Water
FP = Flowing Pocket Water
SP = Standing Pocket Water
O = Obscured
D = Dry
U = Unknown

[5 meter min length]

Channel Category Codes
(Section 3.4.3)

DC = Defined Channel
PD = Poorly Defined Channel
MC = Modified Channel
PC = Piped Channel
OC = Obscured or Covered Channel
UC = Unknown Channel
NC = No Channel

[5 m min length except MC is 1 m]

PSS Map Point Codes
(Section 3.4.4)

Ss = Survey Reach Start
Pp = Uppermost extent of spatially continuous flow
Pn = Uppermost extent of spatially intermittent flow
Ps = Uppermost extent of standing water flow
Ph = Channel head
Se = Survey Reach End

Secondary Segment Data Collection

Dominant Substrate Codes
(Section 3.5.3)

F = Fines: silt/muck/mud
S = Sand (0.625 – 2.0 mm)
G = Gravel (2 – 64 mm)
C = Cobble (64 – 256 mm)
B = Boulders (> 256 mm)
R = Bedrock

Associated Feature Codes
(Section 3.5.4 and 3.5.5)

HSP = Headwater Spring
SP = Spring
SCP = Spring Complex
HSE = Headwall Seep
SSE = Side-Slope Seep
SE = Seep
NP = Type Np Tributary Intersection
AF = Alluvial Fan
CH = Convergent Headwalls
WE = Wetland
WS = Wet Site
TJ = Tributary Junction
BP = Beaver Pond
LP = Lake or Pond

GB = Gradient Break
DS = Debris Slide
RC = Road Crossing
RD = Road Drainage
SC = Substrate Change
WD = Woody Debris
OT = Other
NO = None

Valley Confinement
(Section 3.5.6)

C = Confined (floodplain width < 2 bankfull widths)

M = Moderately Confined (floodplain width 2 - 4 bankfull widths)

U = Unconfined (floodplain width > 4 bankfull widths)

☐ Error Checked

Page ________ of ___________

Site ID	Region	Coop Code ID	Year	Annual Precip (inches)	Pd Area (acres)	Ch-Pd (meters)
1	52	SUQ	2001	53	3.2	NA
2	52	SUQ	2001	43	4.5	0.0
3	52	SUQ	2001	47	11.6	7.6
4	52	SUQ	2001	NA	NA	0.0
5	52	SUQ	2001	55	42.3	NA
6	52	SUQ	2001	63	29.0	NA
7	52	SUQ	2001	63	2.3	NA
8	52	DFW	2001	65	2.9	21.7
9	52	DFW	2001	79	5.1	44.6
10	52	DFW	2001	91	7.2	22.8
11	52	DFW	2001	93	10.8	22.1
12	52	DFW	2001	93	NA	NA
13	52	DFW	2001	NA	NA	14.1
14	52	DFW	2001	67	2.5	106.4
18	52	DFW	2001	91	4.8	99.9
19	52	DFW	2001	75	6.8	15.1
20	52	DFW	2001	99	9.3	10.0
21	52	DFW	2001	81	26.0	21.3
22	52	DFW	2001	81	4.8	0.0
24	52	DFW	2001	81	NA	10.8
26	52	DFW	2001	81	NA	NA
27	52	DFW	2001	99	4.7	18.6
28	52	DFW	2001	81	NA	NA
28.5	52	DFW	2001	81	3.0	176.6
29	52	DFW	2001	81	3.0	16.3
30	52	DFW	2001	99	4.9	20.2
31	52	DFW	2001	91	3.8	57.7
32	52	DFW	2001	93	52.8	3.9
33	52	DFW	2001	99	5.1	14.7
34	52	DFW	2001	99	NA	10.1
35	52	DFW	2001	99	NA	NA
36	52	DFW	2001	81	6.9	8.8
40	52	DFW	2001	89	4.4	10.1
41	52	DFW	2001	89	NA	0.0
42	52	DFW	2001	89	NA	67.3
43	52	DFW	2001	91	8.0	0.0
48	52	DFW	2001	110	NA	NA
49	52	DFW	2001	110	14.8	168.9
50	52	DFW	2001	110	4.8	22.7
51	52	DFW	2001	97	1.9	113.1
52	52	DFW	2001	97	NA	5.5
53	52	SSC	2001	19	1.8	0.0
54	52	SSC	2001	77	3.7	55.8
55	52	SSC	2001	77	1.9	0.0
56	52	SSC	2001	83	3.5	0.0
57	52	SSC	2001	83	NA	27.4
58	52	SSC	2001	83	2.9	0.0
59	52	SSC	2001	71	4.6	0.0
60	52	SSC	2001	71	4.7	43.0
61	52	SSC	2001	71	28.7	20.0
62	52	SSC	2001	77	1.4	0.0
63	52	SSC	2001	77	9.4	0.0

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Site ID	Region	Coop Code ID	Year	Annual Precip (inches)	Pd Area (acres)	Ch-Pd (meters)
64	52	SSC	2001	75	NA	41.0
65	52	SSC	2001		NA	0.0
67	52	SSC	2001	75	8.8	35.0
68	52	SSC	2001	73	28.3	0.0
69	52	SSC	2001	85	4.1	6.1
70	52	SSC	2001	99	6.8	0.0
71	52	SSC	2001	105	2.6	NA
72	52	SSC	2001	95	13.0	52.1
73	52	SSC	2001	95	25.9	15.0
74	52	SSC	2001	103	1.8	0.0
75	52	SSC	2001	103	2.2	0.0
76	52	SSC	2001	90	156.7	225.0
77	52	SSC	2001	71	17.0	0.0
78	52	SSC	2001	71	6.5	NA
79	52	SSC	2001	71	6.4	0.0
80	300	COL	2001	13	1223.7	NA
81	300	COL	2001	NA	NA	NA
82	300	COL	2001	15	793.1	NA
83	300	COL	2001	17	176.3	NA
84	300	COL	2001	23	228.8	NA
84	300	COL	2001	23	50.0	NA
85	300	COL	2001	29	NA	NA
86	300	COL	2001	21	12.4	0.0
87	300	COL	2001	19	41.1	0.0
88	300	COL	2001	21	58.3	NA
89	300	COL	2001	29	27.1	NA
90	300	COL	2001	27	37.0	NA
91	300	COL	2001	37	121.8	180.0
92	300	SPO	2001	16	515.6	NA
93	300	SPO	2001	17	81.2	NA
94	300	SPO	2001	15	359.2	NA
95	300	SPO	2001	15	129.2	NA
96	300	SPO	2001	18	1.4	NA
97	300	SPO	2001	18	36.2	NA
98	300	YAK	2001	63	68.4	12.8
99	300	YAK	2001	59	50.3	77.1
100	300	YAK	2001	61	NA	0.0
101	300	YAK	2001	63	23.3	30.5
102	300	YAK	2001	63	48.5	49.4
103	300	YAK	2001	51	15.3	0.0
104	300	YAK	2001	51	2.2	5.5
105	300	YAK	2001	57	2.9	10.7
106	300	YAK	2001	61	2.1	0.0
107	300	YAK	2001	61	0.9	0.0
108	300	YAK	2001	65	11.5	NA
109	300	YAK	2001	65	40.8	122.0
110	300	YAK	2001	67	10.0	0.0
111	52	TCG	2001	65	89.7	2.7
112	52	TCG	2001	65	3.9	NA
113	52	TCG	2001	65	5.0	NA
114	52	TCG	2001	63	0.9	30.2
115	52	TCG	2001	63	1.9	36.4

Site ID	Region	Coop Code ID	Year	Annual Precip (inches)	Pd Area (acres)	Ch-Pd (meters)
116	52	TCG	2001	63	0.9	3.4
117	52	TCG	2001	63	1.2	15.0
118	52	TCG	2001	71	5.6	NA
119	52	TCG	2001	71	50.9	NA
120	52	TCG	2001	70	NA	0.0
121	52	TCG	2001	69	1.5	NA
122	52	TCG	2001	67	25.7	72.5
123	52	TCG	2001	67	25.3	11.6
124	52	TCG	2001	69	55.9	7.4
125	52	TCG	2001	75	19.3	NA
126	52	TCG	2001	75	22.2	NA
127	52	TCG	2001	75	10.7	NA
128	52	TCG	2001	75	1.4	37.6
129	52	TCG	2001	67	6.3	37.2
130	52	TCG	2001	69	24.4	63.5
131	52	TCG	2001	67	10.5	NA
132	52	TCG	2001	71	25.6	NA
133	52	TCG	2001	71	22.5	NA
134	52	TCG	2001	71	1.6	19.5
135	52	TCG	2001	85	210.0	127.1
136	52	TCG	2001	87	18.9	NA
137	52	TCG	2001	79	0.7	NA
138	52	TCG	2001	77	190.7	NA
139	52	TCG	2001	77	24.8	56.5
140	52	TCG	2001	69	22.4	NA
141	52	TCG	2001	69	98.7	22.2
142	52	TCG	2001	69	9.8	NA
143	52	TCG	2001	NA	NA	5.9
144	52	TCG	2001	55	260.4	NA
145	52	TCG	2001	55	28.3	NA
146	52	TCG	2001	55	3.7	20.8
147	52	TCG	2001	71	2.4	NA
148	52	TCG	2001	71	83.2	NA
149	52	TCG	2001	69	46.0	34.8
150	52	TCG	2001	69	66.3	34.1
151	52	TCG	2001	85	18.9	NA
152	52	TCG	2001	87	6.3	54.3
153	52	TCG	2001	85	72.6	NA
154	52	TCG	2001	77	6.5	NA
155	52	TCG	2001	67	44.4	NA
156	52	TCG	2001	67	146.1	NA
157	52	TCG	2001	65	12.0	NA
158	52	TCG	2001	61	69.6	NA
159	52	TCG	2001	79	9.0	NA
160	52	TCG	2001	83	1.9	NA
161	52	TCG	2001	77	35.0	NA
162	52	TCG	2001	77	31.6	NA
163	52	TCG	2001	83	2.2	NA
164	52	TCG	2001	83	3.6	NA
165	52	TCG	2001	83	8.6	NA
166	52	TCG	2001	73	104.3	28.4
167	52	TCG	2001	73	5.3	28.0

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Site ID	Region	Coop Code ID	Year	Annual Precip (inches)	Pd Area (acres)	Ch-Pd (meters)
168	52	TCG	2001	71	NA	38.6
169	52	TCG	2001	69	3.9	8.2
170	52	TCG	2001	NA	NA	11.3
171	52	TCG	2001	83	11.4	NA
172	52	PGS	2001	37	16.2	NA
173	52	PGS	2001	37	NA	0.0
174	52	PGS	2001	37	NA	7.3
175	52	PGS	2001	37	NA	0.0
176	52	LVF	2001	65	1.5	18.2
177	52	LVF	2001	65	2.2	2.5
178	52	LVF	2001	67	1.4	NA
179	52	LVF	2001	69	7.5	NA
180	52	LVF	2001	69	9.4	NA
181	52	LVF	2001	77	3.5	NA
182	52	LVF	2001	79	7.0	27.4
183	52	LVF	2001	85	3.2	4.7
184	52	LVF	2001	87	22.0	55.9
185	52	LVF	2001	85	4.6	52.5
186	52	LVF	2001	85	5.6	NA
187	52	LVF	2001	25	7.2	4.1
188	52	LVF	2001	25	17.6	NA
189	52	LVF	2001	41	227.1	7.8
190	52	LVF	2001	35	4.9	1.0
191	300	LVF	2001	35	37.5	1.0
192	300	LVF	2001	33	9.7	7.3
193	300	LVF	2001	33	0.4	3.0
194	300	LVF	2001	33	9.0	1.0
195	300	LVF	2001	33	15.7	NA
195	300	LVF	2001	37	9.2	0.0
196	300	LVF	2001	35	67.2	3.2
197	300	LVF	2001	69	3.7	9.3
200	300	LVF	2001	69	3.9	NA
200.5	300	LVF	2001	69	39.4	8.8
201	52	LVF	2001	NA	NA	61.1
202	300	LVF	2001	55	64.6	NA
203	300	LVF	2001	53	27.8	NA
204	300	LVF	2001	53	14.6	33.5
205	300	LVF	2001	33	620.2	NA
206	52	LVF	2001	89	16.0	NA
207	52	LVF	2001	103	58.5	NA
208	52	LVF	2001	103	36.1	NA
209	52	LVF	2001	111	16.5	29.1
212	300	LVF	2001	111	NA	9.3
213	52	LVF	2001	101	2.4	4.8
214	52	LVF	2001	73	9.4	NA
215	52	LVF	2001	95	5.1	10.4
215.5	52	LVF	2001	95	9.5	9.9
217	13	HOH	2001	119	3.1	NA
218	13	HOH	2001	117	6.8	1.0
219	13	HOH	2001	125	0.7	9.0
220	13	HOH	2001	125	1.3	4.0
221	13	HOH	2001	125	3.1	10.0

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Site ID	Region	Coop Code ID	Year	Annual Precip (inches)	Pd Area (acres)	Ch-Pd (meters)	
222	13	HOH	2001	125	2.9	1.0	
223	13	HOH	2001	125	0.1	2.0	
224	13	HOH	2001	119	4.9	1.0	
225	13	HOH	2001	125	7.6	22.0	
226	13	HOH	2001	125	84.7	0.0	
227	13	HOH	2001	125	17.0	2.0	
228	13	HOH	2001	135	3.2	1.0	
229	13	HOH	2001	155	0.3	NA	
230	13	HOH	2001	125	1.6	0.0	
231	13	HOH	2001	125	0.3	0.0	
232	13	HOH	2001	125	0.6	1.0	
233	13	HOH	2001	125	1.7	NA	
234	13	HOH	2001	125	0.6	15.0	
235	13	HOH	2001	125	NA	3.0	
236	13	HOH	2001	NA	NA	NA	
237	13	HOH	2001	135	NA	1.0	
238	13	HOH	2001	135	4.2	7.1	
80	300	COL	2002	15	68.0	0.0	Repeat Surveys
81	300	COL	2002	15	56.0	587.0	Repeat Surveys
82	300	COL	2002	15	20.0	0.0	Repeat Surveys
83	300	COL	2002	19	289.0	84.0	Repeat Surveys
83.5	300	COL	2002	23	235.0	187.0	Repeat Surveys
84	300	COL	2002	23	94.0	0.0	Repeat Surveys
85	300	COL	2002	29	143.0	0.0	Repeat Surveys
86	300	COL	2002	21	66.0	11.0	Repeat Surveys
87	300	COL	2002	19	10.0	102.0	Repeat Surveys
88	300	COL	2002	23	211.0	0.0	Repeat Surveys
89	300	COL	2002	29	9.0	22.0	Repeat Surveys
90	300	COL	2002	27	49.0	217.0	Repeat Surveys
91	300	COL	2002	37	41.0	0.0	Repeat Surveys
300	300	COL	2002	41	136.0	1153.0	
301	300	COL	2002	43	84.0	0.0	
302	300	COL	2002	47	29.0	0.0	
303	300	COL	2002	17	421.0	794.0	
304	300	COL	2002	63	8.0	0.0	
305	300	COL	2002	59	7.0	0.0	
306	300	COL	2002	63	16.0	0.0	
307	300	COL	2002	37	3.0	0.0	
308	300	COL	2002	33	32.0	30.0	
217	13	HOH	2002	119	1.4	15.0	Repeat Surveys
218	13	HOH	2002	117	4.3	67.0	Repeat Surveys
220	13	HOH	2002	125	1.3	5.0	Repeat Surveys
223	13	HOH	2002	125	1.0	2.0	Repeat Surveys
225	13	HOH	2002	125	7.2	13.0	Repeat Surveys
229	13	HOH	2002	155	1.4	70.0	Repeat Surveys
231	13	HOH	2002	125	1.6	0.0	Repeat Surveys
232	13	HOH	2002	125	5.8	30.0	Repeat Surveys
236	13	HOH	2002	NA	3.0	2.0	Repeat Surveys
237	13	HOH	2002	145	1.0	1.0	Repeat Surveys
238	13	HOH	2002	135	13.0	8.0	Repeat Surveys
309	300	YAK	2002	35	0.4	0.0	
310	300	YAK	2002	39	67.5	0.0	

Site ID	Region	Coop Code ID	Year	Annual Precip (inches)	Pd Area (acres)	Ch-Pd (meters)
311	300	YAK	2002	39	1.8	0.0
312	300	YAK	2002	39	2.2	0.0
313	300	YAK	2002	39	18.2	0.0
314	300	YAK	2002	39	168.7	0.0
315	300	YAK	2002	33	9.5	0.0
316	300	YAK	2002	39	25.3	14.4
317	300	YAK	2002	39	10.5	0.0
318	300	YAK	2002	39	51.0	166.0
319	300	YAK	2002	39	49.2	0.0
320	300	YAK	2002	39	26.0	NA
321	300	YAK	2002	39	85.1	0.0
322	300	YAK	2002	39	84.3	0.0
323	300	YAK	2002	39	11.3	0.0
324	300	YAK	2002	39	7.1	0.0
325	300	KAL	2002	51	22.4	0.0
326	300	KAL	2002	27	604.0	3145.0
327	300	KAL	2002	37	40.8	49.0
328	300	KAL	2002	37	26.9	0.0
329	300	KAL	2002	37	62.8	100.0
330	300	KAL	2002	39	26.8	165.0
331	300	KAL	2002	41	5.5	35.0
332	300	KAL	2002	49	144.5	0.0
333	300	KAL	2002	31	124.8	0.0
334	300	KAL	2002	33	49.6	0.0
335	300	KAL	2002	53	27.1	0.0
336	300	KAL	2002	39	154.3	38.0
337	300	KAL	2002	39	161.2	69.0
338	300	KAL	2002	49	34.4	0.0
339	300	KAL	2002	39	74.4	473.0
340	300	KAL	2002	33	69.9	0.0
341	300	KAL	2002	45	13.8	0.0
342	300	KAL	2002	37	8.4	89.0
Count						
292				283	262.0	208.0
			Average	68	49	53
			Median	69	10.5	7.9