Coeur d'Alene Tribe Fisheries Program

Research Monitoring and Evaluation Plan

Coeur d'Alene Tribe Department of Natural Resources
Fish, Water, and Wildlife Program
850 A Street, P.O. Box 408
Plummer, ID 83851-0408

Coeur d'Alene Tribe
Fisheries Program

Research Monitoring and Evaluation Plan

Prepared For
BPA Project #1990-044-00
Implementation of Fisheries Enhancement Efforts on the Coeur d'Alene Reservation

Prepared By

Angelo J. Vitale
Dave Lamb
Ronald L. Peters
with the
Coeur d'Alene Tribe

and
Dr. Dale Chess

November 2002

Coeur d'Alene Tribe Department of Natural Resources
Fisheries Program
850 A Street, P.O. Box 408
Plummer, ID 83851-0408

PHONE: (208) 686-5302
FAX: (208) 686-3021

CONTENTS

List of Figures

List of Tables

I. INTRODUCTION

BACKGROUND

Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) and bull trout (*Salvelinus confluentus*) are currently of special concern regionally and are important to the culture and subsistence needs of the Coeur d'Alene Tribe. The mission of the Coeur d'Alene Tribe Fisheries Program is to restore and maintain these native trout and the habitats that sustain them in order to provide subsistence harvest and recreational fishing opportunities for the Reservation community.

The adfluvial life history strategy exhibited by westslope cutthroat and bull trout in the Lake Coeur d'Alene subbasin makes these fish susceptible to habitat degradation and competition in both lake and stream environments. Degraded habitat in Lake Coeur d'Alene and its associated streams and the introduction of exotic species has lead to the decline of westslope cutthroat and listing of bull trout under the endangered species act (Peters et al. 1998). Despite the effects of habitat degradation, several streams on the Reservation still maintain populations of westslope cutthroat trout, albeit in a suppressed condition (*Table 1*).

The results of several early studies looking at fish population status and habitat condition on the Reservation (Graves et al. 1990; Lillengreen et al. 1993, 1996) lead the Tribe to aggressively pursue funding for habitat restoration under the Northwest Power Planning Council's (NWPPC) resident fish substitution program. Through these efforts, habitat restoration needs were identified and projects were initiated. The Coeur d'Alene Tribe Fisheries Program is currently involved in implementing stream habitat restoration projects, reducing the transport of sediment from upland sources, and monitoring fish populations in four watersheds on the Coeur d'Alene Reservation (*Figure 1*). Restoration projects have included riparian plantings, addition of large woody debris to streams, and complete channel reconstruction to restore historical natural channel forms. In addition, ponds have been constructed to trap sediment from rill and gully erosion associated with agricultural practices, and to provide flow enhancement and ameliorate elevated stream temperatures during the summer base flow period.

Table 1. Mean annual population estimates, the estimated mean annual variance in the infinitesimal rate of population growth, and probabilities of persistence over 100 years for westslope cutthroat trout populations monitored on the Coeur d'Alene Reservation. The 95% confidence interval is shown in parentheses.

Stream	Years	Mean Annual Population Estimate	Variance	Probability Of Persistence
Alder Creek	1996-1998	808	0.03 (0.02-0.04)	0.58
Benewah Creek	1996-1998	5,553	0.16 (0.04-0.36)	0.67
Evans Creek	1996-1998	2,675	0.33 (0.05-0.71)	0.45
Lake Creek	1996-1998	4,946	0.14 (0.02-0.26)	0.70

The implementation of restoration efforts that target the key habitats and lifestages for resident westslope cutthroat trout on the Coeur d'Alene Reservation is one means the Tribe is using to partially mitigate for lost anadromous fisheries. In this context, restoration is consistent with the definition provided by Ebersole et al. (1997), who described stream restoration as the reexpression of habitat capacity in a stream system. At the reach scale, habitat capacity is affected by biotic (e.g., riparian vegetation) and physical (e.g., flooding) processes. Superimposed on the natural biotic and physical processes are anthropogenic stressors (e.g., logging, roads and grazing) that suppress habitat capacity and can result in simplified, degraded stream reaches. The effectiveness of habitat restoration, measured as an increase in native trout abundance, is dependent on reducing limiting factors (e.g., passage barriers, high water temperatures, sediment transport from source areas) in areas that are critical for spawning and rearing lifestages.

This plan outlines a monitoring strategy to help determine the effectiveness of specific restoration/enhancement treatments and to track the status of trout populations in four target watersheds.

STUDY AREA

The following description of the study area is intended to provide an overview for the target watersheds with regard to geographic setting, environmental factors, and anthropogenic disturbances. More detailed discussions of watershed conditions and limiting factors for salmonids can be found in several key publications, including:

- Coeur d’Alene Tribe Fisheries Program Management Plan (Lillengreen et al. 1998);
- Supplementation Feasibility Report on the Coeur d'Alene Indian Reservation (Peters et al. 1998);
- Lake Creek Watershed Assessment (CDA Tribe 1998); and
- Coeur d’Alene Subbasin Summary (CDA Tribe and others 2000)

The study area is located in the Coeur d'Alene subbasin, which encompasses approximately 3,840 square miles and extends from Coeur d'Alene Lake upstream to the Bitterroot Divide along the Idaho-Montana border. Elevations range from 2,120 feet at the lake to over 7,000 feet along the divide. This area formed the heart of the Coeur d’Alene Tribe’s aboriginal territory, and a portion of the subbasin lies within the current boundaries of the Coeur d’Alene Indian Reservation.

Coeur d'Alene Lake is the principle waterbody in the subbasin. The lake is the second largest in Idaho and is located in the northern panhandle section of the state. The lake lies in a naturally dammed river valley with the outflow currently controlled by Post Falls Dam. The lake covers 129 square kilometers at full pool with a mean depth of 22 meters and a maximum depth of 63.7 meters.

The four tributaries currently targeted by the Tribe for restoration are located almost exclusively on the Reservation and have a combined basin area of 34,853 hectares (86,123 acres) and include 529 kilometers (328 miles) of intermittent and perennial stream channels (*Figure 1*). The climate of the target watersheds has the characteristics of a cold coastal type during the winter, and mild arid interior conditions during the summer. Average precipitation is approximately 50.8 cm (20 inches) per year, and annual precipitation increases with elevation to approximately 115 cm at 1220 meters above mean sea level. A seasonal snow pack generally covers the landscape at elevations above 4,500 feet from late November to May. Snow pack between elevations of 3,000 and 4,500 feet falls within the "rain-on-snow zone" and may accumulate and deplete several times during a given winter due to mild storms. The precipitation that often accompanies these mild storms is added directly to the runoff, since the soils are either saturated or frozen, causing significant flooding.

Natural disturbance and succession regimes in the target watersheds have been severely altered during the last 100 years and are consistent with commodity-induced patterns described for much of the Interior Columbia Basin (USDA Forest Service 1996). Exclusion of fire and introduction of blister rust virtually eliminated western white pine as a dominant species, increased intervals between fires, and increased severity of fires. Conversion of forestlands for homesteads, pasture, and agriculture, beginning as early as 1910, has enhanced the rain-on-snow phenomenon and accelerated the rate of snow pack depletion. In Lake Creek for example, where nearly 40 percent of the basin area has been cleared for agriculture, peak discharges have increased by an estimated 55% for 100-year events when compared with the pre-settlement period (CDA Tribe 1998). Lesser amounts of forest clearing have occurred in the other target watersheds, however, measurable increases in peak discharges have likely occurred for those areas as well.

Alteration of riparian/wetland cover types is widespread and has led to localized lowering of ground water tables, increases in water temperature, channel instability and loss of instream habitat diversity. Approximately 80% of historic wetlands demonstrate some loss of functional value (CDA Tribe 2000).

One of the more profound disturbances that the watersheds have been subjected to is from road construction. The road network includes five state highways, numerous county and municipal roads, and an extensive network of unimproved roads. Those areas with the highest density of roads occur on lands managed primarily for timber production. Portions of this road system have been constructed in some of the most sensitive locations (floodplains, and unstable land types) within the watersheds and the density of unimproved roads exceeds 2.5-miles/mile^2 in each of the affected watersheds.

Physical/environmental indicators for the target watersheds are summarized in *Table 2*.

GOALS AND OBJECTIVES FOR THE TRIBAL FISHERY

Overarching goals for Tribal Fisheries Program include: 1) Protection, mitigation, and enhancement of Columbia River Basin native resident fish resources; 2) Develop, increase, and reintroduce natural spawning populations of westslope cutthroat trout and bull trout into Reservation waters; 3) Provide both short and long-term harvest opportunities for the reservation community; 4) Sustain long-term fitness and genetic integrity of targeted fish populations; and 5) Minimize the ecological and genetic impacts to non-targeted fish populations. These management goals and corollary objectives were further defined in the Coeur d'Alene Subbasin Summary submitted to the NPPC during the rolling review process and will serve as a point of reference for the objectives for research, monitoring and evaluation discussed in this plan.

Goal 1 Fully mitigate aquatic resource losses caused by hydropower development (both FCRPS and FERC dams).

Objective 1 Fully mitigate impacts associated with the development and operation of the Federal and non-federal hydropower system by 2020.

Goal 2 Mitigate and compensate the Coeur d'Alene Tribe for salmon and steelhead extirpation in the Upper Columbia River using a multiple resource approach.

Objective 1 As the highest priority, protect, restore, and enhance existing terrestrial and aquatic resources in order to meet the increased demands (i.e., cultural, subsistence, and recreational) on these resources associated with the extirpation of traditional anadromous fisheries from previously occupied areas of the Upper Columbia River Basin. This priority is necessary to meet the obligation of the hydropower system to the Tribal and non-tribal communities of the upper Columbia River basin.

Goal 3 Protect, enhance, and restore native fish populations to maintain stable, viable levels, to ensure they are not vulnerable to extinction, and to provide ecological and sociological benefits. *Target Species*: bull trout, westslope cutthroat trout

Objective 1 By 2015, restore bull trout populations to a level where adult escapement is well distributed and at any one time at least six of the St. Joe River spawning tributaries support healthy spawning populations, and spawning is occurring in the Coeur d’Alene River portion of the basin. By 2020, harvest 1,000 fish annually from the Coeur d’Alene subbasin.

Objective 2 By 2015, protect and restore remaining stocks of genetically pure westslope cutthroat trout to ensure their continued existence in the basin, and to provide catch rates of over 1.0 fish per hour in the St. Joe, Coeur d’Alene and St. Maries rivers, an annual catch of over 1,000 fish in Coeur d’Alene Lake, an annual catch of 11,000 fish from Lake, Benewah, Evans and Alder Creeks, and populations well distributed throughout tributaries to the basin.

Goal 4 Provide both short and long-term harvest opportunities that support Tribal subsistence activities and sport-angler harvest.

Objective 1 Maintain fisheries for introduced species to include an annual harvest of greater than 500,000 kokanee, greater than 5,000 chinook salmon, greater than 10,000 rainbow trout in Tribal catch-out ponds, and average catch rates of greater than 0.5 fish per hour for largemouth bass.

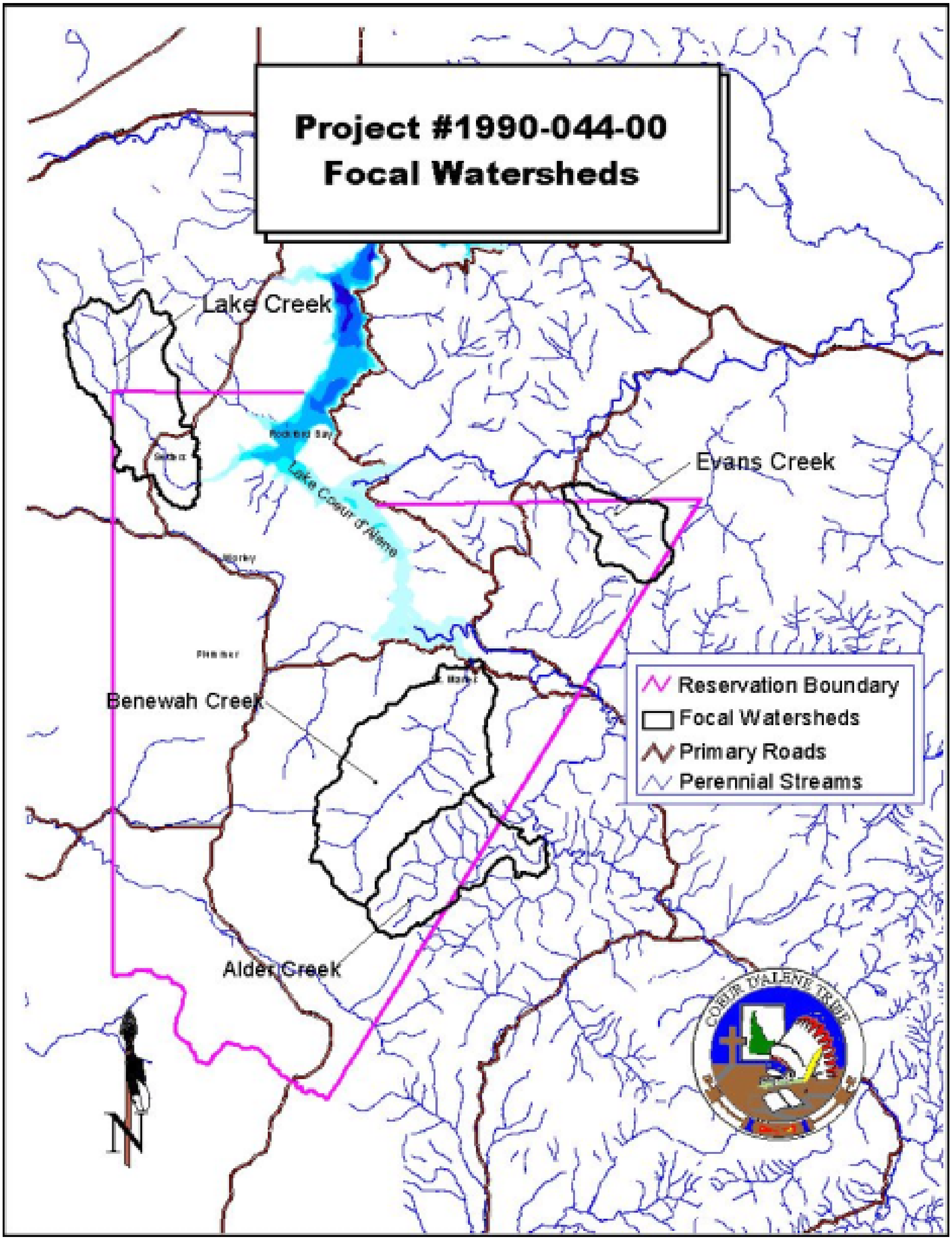


Figure 1. Locations of focus watersheds on the Coeur d'Alene Reservation.

Table 2. Baseline condition matrices for target watersheds (from Lillengreen et al. 1998).

Lake Creek

Condition Indicator	Population/Environmental Condition		
	GOOD	MOD	POOR
Elevation (% below 4500)			97.7
Rain on Snow (% between 3000-4500)	29.6		
% Sensitive Landtype			X
Exotic Species	X		
Road Density (m/m^2)			3.4
Riparian Harvest		X	
% Forest Openings			X
Connectivity	X		
Stream Temperature		X	
Integrated Condition		X	

Benewah Creek

Condition Indicator	Population/Environmental Condition		
	GOOD	MOD	POOR
Elevation (% below 4500)			99.6
Rain on Snow (% between 3000-4500)		58.0	
% Sensitive Landtype			X
Exotic Species		X	
Road Density (m/m^2)			5.4
Riparian Harvest			X
% Forest Openings		X	
Connectivity	X		
Stream Temperature		X	
Integrated Condition		X	

Alder Creek

Condition Indicator	Population/Environmental Condition		
	GOOD	MOD	POOR
Elevation (% below 4500)			99.4
Rain on Snow (% between 3000-4500)			75.0
% Sensitive Landtype			X
Exotic Species			X
Road Density (m/m^2)			5.7
Riparian Harvest		X	
% Forest Openings		X	
Connectivity			X
Stream Temperature		X	
Integrated Condition			X

Evans Creek

Condition Indicator	Population/Environmental Condition		
	GOOD	MOD	POOR
Elevation (% below 4500)			86.9
Rain on Snow (% between 3000-4500)		60.2	
% Sensitive Landtype			X
Exotic Species	X		
Road Density (m/m^2)			5.3
Riparian Harvest	X		
% Forest Openings	X		
Connectivity	X		
Stream Temperature	X		
Integrated Condition	X		

PURPOSE OF RM&E

The construction and operation of specific dams directly led to the complete and immediate extirpation of all anadromous and some resident fish populations as well as the permanent destruction of thousands of acres of critical fish and wildlife habitat throughout portions of the Upper Columbia River and its tributaries. The loss of biomass, hydrological alteration, and subsequent management of the landscape in ways not possible were it not for the existence of the dams, has severely altered the natural processes and ecosystem functions that defined and maintained the natural resources that the Coeur d'Alene Tribe relied on.

In its analysis of the contribution of the hydropower system to salmon and steelhead losses (see Council documents 87-15, 87-15A and 87-15B), the NWPPC has addressed the extent to which resident fish substitutions should be used to mitigate losses of salmon and steelhead production in these areas. The NWPPC has concluded that: 1) compensation mitigation in blocked areas is appropriate where salmon and steelhead were eliminated by the development and operation of the hydroelectric projects; 2) to treat the Columbia River and its tributaries as a system, substitutions are reasonable for lost salmon and steelhead in areas where in-kind mitigation cannot occur; and 3) flexibility in approach is needed to develop a program that complements the activities of the fish and wildlife agencies and tribes and is based on the best available scientific knowledge.

The implementation actions discussed in this plan have occurred as off-site protection, mitigation, enhancement and compensation activities called for under Section 4(h) of the Pacific Northwest Electric Power Planning and Conservation Act and the Northwest Power Planning Council Fish and Wildlife Program. These activities provide partial mitigation for the extirpation of anadromous fish resources from the Tribe's usual and accustomed harvest areas and Reservation lands.

The specific purpose of this plan is to document a monitoring and evaluation strategy for measuring the effectiveness of restoration work on the Coeur d'Alene Reservation and to track trends in fish populations. When viewed from this perspective, a successful RM&E Plan will help identify whether the Tribe's mitigation goals are being met. Our working hypothesis is that ongoing stream and lake habitat restoration efforts combined with reduction of anthropogenic processes that reduce habitat capacity, will increase the abundance and distribution of westslope cutthroat trout such that one day they might again contribute to the subsistence needs of the Tribe. Additionally, these actions could potentially allow bull trout to re-colonize stream reaches they once inhabited.

INTEGRATION OF ISRP RECOMMENDATIONS

"As specified in the 1996 Amendment to the Power Act, a primary review function of the ISRP is to determine if projects are based on sound scientific principles and are likely to benefit fish and wildlife. Integral to this determination is whether projects monitor and evaluate progress and report results allowing measurement of benefits" (ISRP 2002-11). In 2001, the Coeur d'Alene Tribe's restoration project, entitled "Implement Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation" (BPA#1990-044-00) was reviewed by the ISRP and the following recommendation was made: "The project was considered fundable, with qualification that a plan is provided for how the project sponsors are going to monitor progress. The plan should include an experimental design to test the major hypotheses concerning habitat condition and resident trout production. The Council and the BPA contracting officers should ensure that a monitoring and evaluation plan is provided that is suitable for evaluating progress". Commensurate with this recommendation, the Coeur d'Alene Tribe is completing this RM&E plan such that the results of implementation actions will be measurable and allow for evaluation of progress and determination of benefits relative to Tribal goals for recovering fish populations.

The ISRP (2002-11) has stated that four levels of monitoring should be considered: 1) implementation and/or compliance monitoring, 2) trend monitoring of project results (corresponds closely and may contribute to NMFS Tier 1 - Landscape Scale Status Monitoring), 3) statistical monitoring of habitat and fish and wildlife populations (NMFS Tier 2 – Population Scale Status Monitoring), and 4) research monitoring in experiments (NMFS Tier 3 – Action Effectiveness Monitoring). It is the intent of this plan to address the specific levels of monitoring described by the ISRP that are pertinent to this mitigation project and correlate them to implementation actions taken as a result of this project.

As written, this plan primarily addresses trend monitoring and statistical monitoring of habitat and fish populations (levels 2 and 3) as defined by the ISRP. This plan, however, uses an applied research approach to enhancement evaluation that is intended to accommodate both the short-term planning requirements that facilitate the continued implementation of enhancement projects and the long-term needs that provide a logical connection to more intensive research. For example, the observed habitat and/or fish responses to specific restoration actions will be evaluated based on the response of nearby reference reaches, and eventually, successful actions will be applied to geomorphically similar stream reaches in other areas. As this type of data is collected over time, specific questions regarding cause and effect relationships may be formulated to assist in the development of more focused and intensive research projects as the need arises. Inherent in this approach is recognition of the feedback loop that exists between intensive "research" evaluations and well-grounded, reduced risk, management decisions to plan and implement certain enhancement projects or measures.

This plan does not specifically address implementation and compliance concerns (level 1). Monitoring at this level is generally qualitative in nature and is most useful for validating the successful completion of specific projects and in defining the short-term needs expressed in annual funding requests. These actions will be best described in annual and/or quarterly reports submitted to the appropriate funding agencies for their consideration and are therefore not discussed in this plan.

II. MONITORING AND EVALUATION DESIGN

OVERVIEW

In its broadest sense, monitoring encompasses the routine measurement of environmental indicators to sense the condition and trends of functions and components of an ecosystem (Bisbal 2001). Monitoring may be conducted for a number of different purposes including baseline characterization, risk assessment, trend assessment and performance evaluation (FISRWG, 2001). The implementation, effectiveness and validation components of performance evaluation provide a process through which it can be determined if proper actions were taken and if these actions were effective in providing the desired results. In this document, the "actions" being monitored and evaluated are habitat restoration/enhancement projects and water pollution (non-point source) control projects, and the anticipated "results" are improved habitat for fish and wildlife. The fact that improved water quality may also result from habitat restoration and/or enhancement, and that these results also support human beneficial uses, is assumed to be a corollary benefit that is not specifically evaluated by this monitoring and evaluation plan.

> **"A properly designed monitoring plan is an essential element of effective natural resource management programs. In a broad sense, monitoring can be defined as the collection of information necessary to sense the condition and trends of components and processes of a system of interest. To be most meaningful, this information requires adequate interpretation and effective inclusion into the decision –making process. This sensory function of monitoring provides the basis for understanding the system, and for recognizing possible problems and their potential solutions" (Bisbal 2001).**

The monitoring and evaluation design described in this plan will test hypotheses regarding the effects of management actions on physical/environmental indicators and trout population response. Monitoring is proposed at two different spatial scales – the watershed scale as well as the reach scale. At the watershed scale, trout abundance and distribution as well as a suite of physical/environmental habitat indicators will be measured to track trends in population and habitat status over time. Also, migration of adfluvial fish will be monitored to evaluate change in condition factor over time. At the reach scale, monitoring will be done for specific treatments at paired treatment and control sites to measure and compare the current habitat capacity of target streams and to measure change in population characteristics (e.g., abundance, distribution and survival or condition factor) in response to the reexpression of habitat capacity.

Because adfluvial westslope cutthroat trout life expectancy is a maximum of eight years in streams on the Coeur d'Alene Reservation (Peters et al. 1998), changes in abundance will likely not be detectable until several generations have completed their lifecycles. Gowan and Fausch (1996) provide an example of a long-term (i.e., six years post-restoration) resident trout population response to habitat manipulation. They found an increase in adults in the restored reaches, however, immigration from beyond the reach boundaries explained the increase in abundance. No significant biological changes (i.e., recruitment, survival, or growth) occurred within six years. Similarly, we expect that initial responses to habitat restoration in mainstem reaches of Reservation streams will be immigration of trout from the tributaries to the mainstem reaches. Currently, during summer baseline flow, most trout are found in the cooler, higher quality habitat of tributary reaches (Peters et al. 1998). This type of immigration response from adjacent tributary reaches will likely occur in Lake and Benewah Creeks where mainstem reaches are being restored following decades of riparian zone clearing and stream channel manipulation. We suspect, as Gowan and Fausch (1992) found, that a population response would not be immediately detectable. As a result, the monitoring and evaluation plan that is presented in this document is designed to detect the relationship of habitat improvement and trout population response over a period of ten years or more.

MONITORING ISSUES

Tribal fisheries managers have identified several important issues to provide direction in the long-term implementation of RM&E objectives on the reservation. To best facilitate adaptive management at different levels within the Tribe's Natural Resources Department, research, monitoring and evaluation activities need to produce information that addresses each of these issues.

Issue 1: Effectiveness of Restoration and Enhancement Measures at the Reach or Project Scale. A wide range of restoration and enhancement measures have been applied to date, including fencing, riparian plantings, addition of large woody debris to streams, wetland construction and complete channel reconstruction. Additional measures, or alternatively, only a few of these measures, may be needed in the future as new information and better understanding of ecosystem and fisheries needs becomes available. Ultimately, these measures are intended to restore or enhance aquatic resources or the physical processes that support them to meet Tribal fisheries goals and objectives. Managers want to know how various measures perform under different sites conditions and how fish respond to these measures. Monitoring information should help managers select measures that achieve aquatic resource objectives when designing projects, applying BMP's, or developing management prescriptions.

Issue 2: Effectiveness of Management Systems at the Watershed Scale. Land management systems need to be designed to protect Tribal trust resources including fish, water and wildlife and implemented in a manner that helps achieve Tribal goals and objectives. Examples of management systems that are being applied and/or developed for reservation lands include landscape level plans (e.g., TMDL's, Tribal IRMP), USDA sponsored programs such the Wetland Reserve Program (WRP) and Conservation Reserve Program (CRP), and forest practice rules. Tribal decision makers and managers need information to evaluate whether management systems are successful in achieving aquatic resource protection objectives and the role that fisheries enhancement measures play in meeting these objectives. This information will help determine whether aquatic resources are protected from individual and cumulative effects as multiple practices occur throughout a watershed over time.

Issue 3: Trends in Aquatic Resource Conditions. Limited information is available on trends in aquatic resource conditions in the watersheds on the Reservation. Without adequate information, it is impossible to evaluate whether resource conditions are improving, declining or remaining stable. In order to effectively manage Tribal aquatic resources such as cutthroat trout and water, managers need to know how habitat and water quality conditions and populations change over time and be able to report these observations with an acceptable level of confidence.

OBJECTIVES

Objectives of the Coeur d'Alene Tribe's Fisheries Program monitoring and evaluation plan are:

1. Measure physical habitat of stratified, randomly selected reference stream reaches to quantify habitat change through time and estimate the natural habitat variability for important indicators.

2. Measure physical habitat of stratified treatment stream reaches to measure the habitat variability and quantify habitat change through time as a means of determining project effectiveness.

3. Compare the rate of change and annual variation of physical habitat indicators between control and treatment reaches for selected treatments.

4. Measure fish population characteristics in reference stream reaches and treatment stream reaches. Detect changes in fish populations and statistically test for correlation between changes in habitat and changes in fish populations at both the reach and watershed scales.

5. Measure sediment retention of constructed sediment ponds and determine the effectiveness of sediment ponds to ameliorate temperature and augment flow to stream reaches in Lake Creek.

6. Evaluate the effectiveness of large woody debris treatments. Measure cutthroat trout population characteristics and physical habitat indicators in response to addition of large woody debris at paired treatment-control sites.

7. Monitor watershed conditions and water quality parameters at select sites to track trends in the target watersheds.

OBJECTIVE 1:Measure physical habitat indicators of stratified, reference stream reaches on an annual basis to quantify habitat change through time and measure the natural habitat variability.

Following Frissell et al. (1986), we will measure physical habitat at the reach scale, which has been identified as the most useful scale for describing medium and long-term effects of human activities. Several key physical habitat indicators have been selected for measurement based on the data needs for making channel type designations (Rosgen 1996) and based on the recommendations of Hillman and Giorgi (2002) for meeting effectiveness research needs (*Table 3*). Measurements will be made at the reaches that make up the sampling frame for evaluating habitat changes at the watershed scale as well as for the subset of reaches that serve as valid references for treatment-control pairings.

Stream reaches have been stratified using the system offered by Paulsen et al. (2002) that incorporates factors that influence physical/environmental stream features and allows for assessment of differential responses of indicator variables to management actions within different classes of streams and watersheds (*see* Sample Site Classification). To accommodate a balance between sampling effort and staffing requirements, sampling preference will be given to reaches that can be shown to have some measure of independence from treatment reaches and also meet other requirements for paired treatment-control designs. Physical and biological parameters will be monitored annually at these sites to coincide with the sample schedule for treatment sites. The remaining sites that make up the sampling frame for watershed scale monitoring will be sampled at less frequent intervals (every three years).

At the time of this writing, the temporal and spatial variation for many of the physical habitat indicators is unknown. This makes it difficult to finalize any experimental design especially with respect to estimation of sample size. A pilot study will be needed during the initial year of implementation of this plan to help define the variability, effect size and sample size for the various sample parameters. A power analysis will then be completed to finalize the remaining statistical considerations.

This objective is linked to Issue 1: Effectiveness of Restoration and Enhancement Measures at the Reach or Project Scale and to Issue 2: Effectiveness of Management Systems at the Watershed Scale as discussed above.

Table 3. Selected monitoring variable and specific indicators common to reference reaches and restored reaches.

Monitoring Variables*	Specific Indicator	Sample Considerations	Plan Reference
Photographic Documentation[2]	N/A	all pertinent locations, annual	Section III; Volume II
Water Quality	MDMT, TSS, pH, DO, Nitrogen, Phosphorus	14 locations; MDMT continuous, other parameters bi-weekly	Section III
Stream Flow[2]	Change in base Q	14 locations; bi-weekly	Section III; Volume II
Longitudinal "Thalweg" Profile[1]	Pool frequency/quality	500-ft. long reaches; annual or every 3 years	Section III; Volume II
Stream/Valley Cross Section Profile[1]	Bank stability; width/depth ratio; entrenchment	6 cross-sections per 500-ft. reach; annual or every 3 years	Section III; Volume II
Channel Substrate[1]	Dominant substrate	6 cross-sections per 500-ft. reach; annual or every 3 years	Section III; Volume II
Large Woody Debris[2]	LWD volume	500-ft. long monitored reach; annual or every 3 years	Section III; Volume II
Stream Canopy[2]	Canopy density	6 cross sections per 500-ft. reach; annual or every 3 years	Section III; Volume II
Stream Bank cover[2]	Percent overhang	6 cross-sections per 500-ft. reach; annual or every 3 years	Section III; Volume II
Riparian Vegetation Cross-Section Composition[2]	Plant community type	6 cross sections per 500-ft. reach; every 5 years	Section III; Volume II
Riparian Greenline Composition[2]	Plant community type, bank stability	6 cross-sections per 500-ft. reach; every 5 years	Section III; Volume II
Stream Fish Population[2]	Density, condition, age	200-ft. long reach; annual	Section III; Volume II
Adfluvial migration	Number, condition, age	All watersheds; annual	
Pond Sediment Trapping[3]	Depth fines	selected constructed ponds	Section III; Volume II
Pond Water Quality Profiles[3]	Nitrogen, Phosporus, Turbidity	selected constructed ponds	Section III; Volume II
Pond Receiving Water Temperature Profiles[3]	MDMT	selected streams below pond discharge	Section III; Volume II
Upland Vegetation Survey[2]	Percent survival	selected plots	Section III; Volume II

*The monitoring variables shown will be collected for both reference and restored reaches: [1] indicates variables required for channel type delineation; [2] indicates additional variables chosen to reflect restoration project effectiveness; [3] indicates variables chosen for effectiveness monitoring at pond sites.

OBJECTIVE 2: Measure the physical habitat of treatment stream reaches on an annual basis to measure the habitat variability and quantify habitat change through time as a means of determining project effectiveness.

The effectiveness of restoration projects will be evaluated by comparing the natural background variability at reference reaches to restored reaches. Effectiveness criteria were developed for various types of restoration projects based on: 1) relevance to Tribal project types; 2) ability to demonstrate change within a ten-year time frame; 3) general acceptance by the scientific community; and 4) their economic and technical feasibility to measure. Criteria were linked to biophysical properties of streams and riparian zones to inform the selection of appropriate monitoring protocols. Results, including recommendations for effectiveness criteria for all project types are presented in *Appendix C*.

After development of effectiveness criteria, physical and biological indicators (i.e., quantitative and/or qualitative parameters) were selected, as well as the protocols for data collection for the various parameters (*Table 3*). These protocols will be used to determine if effectiveness criteria are being achieved. As indicated in *Appendix D*, several different project types have similar effectiveness criteria and consequently, will be monitored in similar ways. Over time, we expect that the measures of natural background variability at reference reaches will allow for development and refinement of specific performance measures for various effectiveness criteria that are relevant to the stream types found on the Reservation.

Prior to initiating future restoration projects, the habitat variables in *Table 3* will be measured so that a pre-restoration habitat baseline will exist to compare to the reference reaches. After the restoration projects have been implemented, the same physical habitat measurements will be made on an annual basis.

This objective is linked to Issue 1: Effectiveness of Restoration and Enhancement Measures at the Reach or Project Scale and to Issue 2: Effectiveness of Management Systems at the Watershed Scale as discussed above.

OBJECTIVE 3: Compare annual variation of physical habitat indicators between reference reaches and restored reaches.

There is considerable uncertainty surrounding of the question of how long it takes for restored sites to express the habitat capacity of natural reference sites (Ebersole et al., 1997). To answer this question, we need to estimate the natural variance of selected variables at reference sites with similar valley type, channel type, and riparian cover and test whether those variances are different than in the selected treatment reaches (*See Objectives 1 and 2*).

In treated reaches, we expect an initial high rate of change in physical variables, i.e., mean depth, thalweg depth and substrate size, until the reach begins to stabilize. We expect that over some time interval the natural variation of habitat attributes at restored sites will not be significantly different than the variation expressed at the reference sites.

This objective is linked to Issue 1: Effectiveness of Restoration and Enhancement Measures at the Reach or Project Scale and to Issue 2: Effectiveness of Management Systems at the Watershed Scale as discussed above.

OBJECTIVE 4: Estimate fish populations in reference stream reaches and treatment stream reaches. Detect changes in fish populations at the watershed level and reach level.

In order to collect non-biased population estimates to compare with habitat measures, we will perform population estimates at the same stratified, random selected sites where physical habitat measures are made. This will allow for correlation analysis of fish abundance with physical habitat measures. At this time, 101 sites have annual fish population estimates dating from 1996 to 2001.

A power analysis was performed on these data using the program *MONITOR* (Gibbs 1995) to: 1) determine the current power to detect changes in the westslope cutthroat trout population; 2) evaluate sample size and precision needs for reference stream reaches; 3) and estimate statistical power assuming that population estimates continue to be conducted on an annual basis for the next five and ten year periods. We ran three types of simulations. In the first simulation, we compared the power of the existing data set to the power obtained by increasing sample size by up to 5 additional sample sites per watershed. The second type of simulation evaluated how power changed when doubling the within-year sample frequency (the current method is to sample once per year). The third type of simulation estimated the power of continuing the current sample regime for five and ten year time frames, respectively. We used alpha levels of 0.05, 0.1 and .20 in all simulations.

With existing data (1996-2001) collected using the current sampling regime, all streams except Lake Creek have at least an 80% probability to detect a 10% increase in the cutthroat trout population at an alpha level of 0.20. When population estimates are combined at the Coeur d'Alene -basin scale, the power to detect fine trends is much higher, such that the probability of committing a Type II error is only 5%. At the watershed scale, however, adequate power (at least .80) only exists for detecting coarse population change (i.e. 8-10%). Simulations that added five sample sites did not improve the resolution to detect more subtle changes (i.e. 0-3%) in any of the watersheds. Increasing the within-year sample frequency did not increase power as effectively as did the addition of five extra sites.

Simulating power to detect changes in westslope cutthroat trout populations in the next five or ten years is especially important because this time frame corresponds to the period when benefits from habitat restoration are likely to be realized. These additional five and ten year simulations reveal the dramatic effect that sampling consistently over time has toward increasing the power to detect changes in populations. For example, in Benewah Creek an additional five years of population sampling results in an 80% probability of detecting a +4%, or a –4% change at an alpha level of 0.05. An additional 10 years of sampling on Benewah Creek results in a 90% probability of detecting a +3% or –7% change at an alpha level of 0.05. For Lake Creek, an additional five years of population estimate sampling allows an 80% probability of detecting a +8% change at an alpha level of 0.05. Alder and Evans Creeks exhibit similar increases in power with higher levels of confidence.

When weighing an increase of sample size or sample frequency with effort and cost, relatively limited benefit would be realized from changing the existing sample regime. Additional sample sites will likely not be needed because of the substantial increase in power to detect population changes when annual population sampling is continued over the next five to ten years. We don't expect any increase in westslope cutthroat trout population until at least several generations have benefited from the restoration projects. Since it takes an adfluvial westslope cutthroat trout 6-8 years to reproduce, we will have sampled populations of westslope cutthroat trout annually at least that many years, dramatically increasing the power to detect changes in the population. We will continue to track fish populations at the existing 101 reference sites. Additional power analyses will be conducted in the future, incorporating additional data as it is generated, to verify the power estimate simulations reported here.

More detail on the complete power analysis is presented in Appendix B.

This objective is linked to Issue 1: Effectiveness of Restoration and Enhancement Measures at the Reach or Project Scale; Issue 2: Effectiveness of Management Systems at the Watershed Scale; and Issue 3: Trends in Aquatic Resource Conditions, as discussed above.

OBJECTIVE 5: Measure sediment retention of constructed sediment ponds and effectiveness of sediment ponds to ameliorate temperature and augment flow to stream reaches.

Five sediment retention ponds have been constructed in the Lake Creek watershed and additional ponds are proposed for construction (*see Appendix A*). These ponds function to trap sediment from sheet, rill and gully erosion associated with agricultural practices and store water that can be released to provide flow enhancement to ameliorate the effects of elevated water temperature during the summer base flow period. Simultaneous monitoring of inflow and out flow for TSS and turbidity during spring runoff events will be used to partially quantify the trapping efficiency for the ponds. To supplement this analysis, a series of sediment traps placed at various depths across several cross-sections will physically measure sediment deposition consistent with methods developed by Hardy et al. (1996). We will use the results from this initial experiment to develop a refined sample design for measuring trapping efficiency at other locations.

This objective is linked to Issue 1: Effectiveness of Restoration and Enhancement Measures at the Reach or Project Scale as discussed above.

OBJECTIVE 6: Evaluate the effectiveness of woody debris treatments. Measure cutthroat trout population characteristics and physical habitat indicators in response to addition of large woody debris treatments at paired treatment-control sites.

Several reports have already documented the importance of rearing habitats and their relative contribution to the production of native salmonids in the target watersheds (Lillengreen et at. 1998, Peters et al. 1998). The cumulative effects of recent disturbances have reduced habitat complexity and degraded water quality in significant portions of the areas that served as historic rearing habitats. The principle strategy of this enhancement project, therefore, has been to provide for increased salmonid production by improving the quality and quantity of rearing habitat for the resident and adfluvial life history types present in the study area. Many of these areas are characterized by a paucity of large woody debris (LWD) in the channel and by altered riparian plant communities with little potential for producing recruitable wood in the near future. The significance and function of large wood, particularly in small and medium sized streams, with respect to shaping stream morphology, maintaining habitat complexity, providing cover for salmonids and in stream energy budgets has been well-documented (Beschta and Platts 1986; Richmond and Fausch 1995; Hauer et al. 1999; Murphy and Meehan 1991).

Westslope cutthroat trout exhibit two life history strategies in the CDA basin. Resident fish remain in their natal stream and only exhibit seasonal migrations within the stream. Cutthroat that exhibit the lacustrine-adfluvial life history strategy undergo outmigration downstream to lake habitats where they mature and return annually to spawn in their natal streams. These lacustrine-adfluvial fish exhibit strong spawning site fidelity (Northcote 1998). Salmonids undergo seasonal migrations within streams, especially during fall and winter, often traveling many kilometers downstream several times over a winter depending on ice development (Cunjak 1996, Brown and Mackay 1995, Jakober et al. 1998).

The following experimental design has been developed to evaluate the effectiveness of LWD addition to stream reaches by measuring physical habitat and fisheries responses over a long period of time. This type of treatment was selected for intensive monitoring because of the overall need for LWD in many of the target areas and because active planting of riparian zones has been ongoing and is expected to increase LWD recruitment in the future. Physical habitat indicators, including LWD volume, pool volume, channel depth and substrate size will be measured in paired treatment and control reaches. Cutthroat trout abundance, biomass, survival and condition factor and movement are the response variables we plan to measure in the same reaches.

<u>METHODS</u>: Treatments will consist of placing large woody debris in 500-foot reaches that are lacking natural LWD. Control reaches will have no LWD addition and will have no other artificial habitat alterations. None of the treatments have been installed to date, however potential treatment and control reaches have been located in the mainstem of Benewah Creek and in Windfall Creek, a second order tributary to Benewah Creek. Control and treatment reaches have been stratified following the criteria outlined in this document and the characteristics of the treatment and control reaches are presented in Appendix E. The habitat variables will be measured throughout the treatment and control reaches following protocols described in Section III of this document.

Cutthroat trout abundance and biomass will be estimated yearly using the removal–depletion method (Seber and LeCern 1967, Zippen 1958). Block nets will be placed at the upstream and downstream boundaries of the reach to prevent immigration and emigration from the reach. Fish will be collected by using a Smith-Root Type VII pulsed-DC backpack electrofisher. Westslope cutthroat trout collected during the electroshocking will be anesthetized using MS-222. Each fish will be measured (total length), weighed (0.1 gram) and scale samples will be taken from the side of the body just behind the dorsal fin and above the lateral line (Jearld 1983). Scales will be analyzed for age determination and to calculate growth rates. To enable detection of migration and calculate survival, all sampled cutthroat trout >100 mm will be tagged using passive integrated transponders (PIT). Age-0 cutthroat trout (50-90 mm TL) are generally too small to PIT tag, but all other age classes will be tagged. The PIT tags allow efficient data collection and management because the PIT tag is detected by an antenna and stored in the reader or laptop computer, making capture history easier to track. Fish will be allowed to recover in live-baskets then released no further than 20 meters from their location of capture. Population estimates and 95% confidence limits will be calculated using equations in Armour et al. (1983). Biomass of westslope cutthroat trout in treated and control reaches will be estimated for each age class by multiplying the population estimate of each age class by the mean weight of each age class.

At present, these streams are closed to fishing, thus bias from angler mortality in treated and control reaches should not be an issue.

<u>STATISTICAL ANALYSES AND SURVIVAL MODELS</u>: Differences in habitat measures between treatment and controls will be tested by single-factor analysis of variance (ANOVA). A repeated measures multivariate analysis of variance (MANOVA) will be used to test for differences in biomass and abundance between treatment and control reaches post-restoration. Use of the MANOVA is recommended because of the high potential for the population being auto-correlated among successive years, which violates the repeated measures ANOVA (Milliken and Johnson 1992). Growth rate in treatment and control reaches will be analyzed from PIT tag recoveries using analysis of covariance (ANCOVA). Significance of all statistical tests will be judged at $\alpha = 0.05$.

Gowan and Fausch (1996) reported and increase in abundance and biomass of adult fish in treated reaches compared to control reaches after six years post-LWD introduction in Colorado streams. However, even after six years Richmond and Fausch (1995) concluded no actual demographic population changes happened, and the increase in fish abundance in treatment reaches was due to immigration from other reaches. We anticipate a similar dynamic described by Gowan and Fausch (1996) in the first years of this study. For this reason, we propose that a pilot study will be required to measure the effects of LWD addition upon westslope cutthroat trout populations during the first four years following the LWD introduction. At the conclusion of the pilot study, we will perform a power analyses for Analysis of Variance tests associated with habitat measures and cutthroat biomass and abundance. The results of this analysis will determine how many successive years will be needed to detect differences in habitat and fish abundance between treatment and control reaches.

We will use maximum likelihood multistate models to estimate movement and site-fidelity after Hestbeck et al. (1991). Use of the program MSSURVIV (Brownie et al. 1993) will allow us to estimate capture, survival and movement probabilities of fish in treatment and control reaches for all recaptured, PIT tagged fish. We expect to see seasonal migrations, especially during the winter, and will use traps to sample downstream and upstream fish movements, allowing for estimation of the seasonal migrations. This will allow a test of seasonal migration at two levels. The first, between treatment and control reaches within Benewah and Windfall creeks, and secondly between the Benewah and Windfall systems. We will also account for seasonal migration in the survival models following methods of (Kendall et al. 1997).

This objective is linked to Issue 1: Effectiveness of Restoration and Enhancement Measures at the Reach or Project Scale as described above.

OBJECTIVE 7: Monitor water quality parameters at select sites and watershed conditions to track trends in the target watersheds.

Select water quality parameters have been monitored at 21 sites in the target watersheds since 1997 (Table 4, Figure 2). Sample parameters include discharge, temperature, dissolved oxygen, pH, conductivity, turbidity, total suspended solids, nutrients, total phosphorous, and total kjeldahl nitrogen. Discharge, temperature, dissolved oxygen, pH, and conductivity are monitored on a bi-monthly basis from March 1 through October 31 and all rain on snow events between November 1-February 28. Turbidity, total suspended solids, nutrients, total phosphorous, and total kjeldahl nitrogen are sampled on a monthly basis from March 1 through October 31 and all rain on snow events between November 1-February 28.

Continued monitoring of water quality parameters will facilitate the tracking of water quality trends over time and allow the Tribe to monitor the effectiveness of watershed restoration activities as they are carried out to enhance cutthroat trout fisheries and achieve the goals of attaining full support of the beneficial use.

Periodic monitoring of additional watershed conditions is warranted to help interpret the effects of different land-use activities, such as development, transportation systems, and timber harvest to the response of other physical/environmental indicators that will be monitored at finer spatial scales. Four specific indicators have been selected for this purpose as recommended by Hillman and Giorgi (2002), including road density, riparian-road index, equivalent clearcut area, and percent vegetation altered. The protocols and sample considerations for these indicators are shown in Table 5.

This objective is linked to Issue 3: Trends in Aquatic Resource Conditions as discussed above.

Table 4. Summary of water quality monitoring parameters and sample locations for the target watersheds.

Location	Discharge	Temperature[A]	Dissolved Oxygen	PH	Conductivity	Turbidity	Total Suspended Solids	Nutrients	Total Phosphorous	Total Kjeldahl Nitrogen
Lower Lake Creek	X	X*	X	X	X	X	X	X	X	X
Upper Lake Creek	X	X	X	X	X	X	X	X	X	X
Bozard Creek	X	X*	X	X	X	X	X	X	X	X
Lower Evans Creek	X	X*	X	X	X	X	X	X	X	X
Upper Evans Creek	X	X*	X	X	X	X	X	X	X	X
East Fork Evans Creek	X	X*	X	X	X	X	X	X	X	X
Alder Creek	X	X*	X	X	X	X	X	X	X	X
North Fork Alder	X	X*	X	X	X	X	X	X	X	X
Lower Benewah Creek	X	X	X	X	X	X	X	X	X	X
Mid Benewah Creek	X	X*	X	X	X	X	X	X	X	X
Upper Benewah Creek	X	X*	X	X	X	X	X	X	X	X
Cable Creek	X	X	X	X	X	X	X	X	X	X
Coon Creek	X	X	X	X	X	X	X	X	X	X
Bull Creek	X	X*	X	X	X	X	X	X	X	X
Waddell Creek	X	X	X	X	X	X	X	X	X	X
Whitlock Creek	X	X	X	X	X	X	X	X	X	X
Whitetail Creek	X	X*	X	X	X	X	X	X	X	X
Gore Creek	X	X	X	X	X	X	X	X	X	X
Windfall Creek	X	X*	X	X	X	X	X	X	X	X
Schoolhouse Creek	X	X*	X	X	X	X	X	X	X	X
West Fork Benewah	X	X*	X	X	X	X	X	X	X	X

[a] Sample locations denoted with an asterix are monitored continuously for temperature from April-November.

Table 5. Summary of indicators, protocols and sample frequency for monitoring watershed condition in the target tributaries.

General Indicator	Specific Indicator	Sample Protocol	Sample Frequency
Road Density	Watershed road density Riparian-road index	WFC (1998); Reeves et al. (2001)	Every 5 years
Disturbance	Equivalent clearcut area	USFS (1974); King (1989)	Every 5 years
Riparian Habitat	Percent vegetation altered	Platts et al. (1987)	Every 5 years

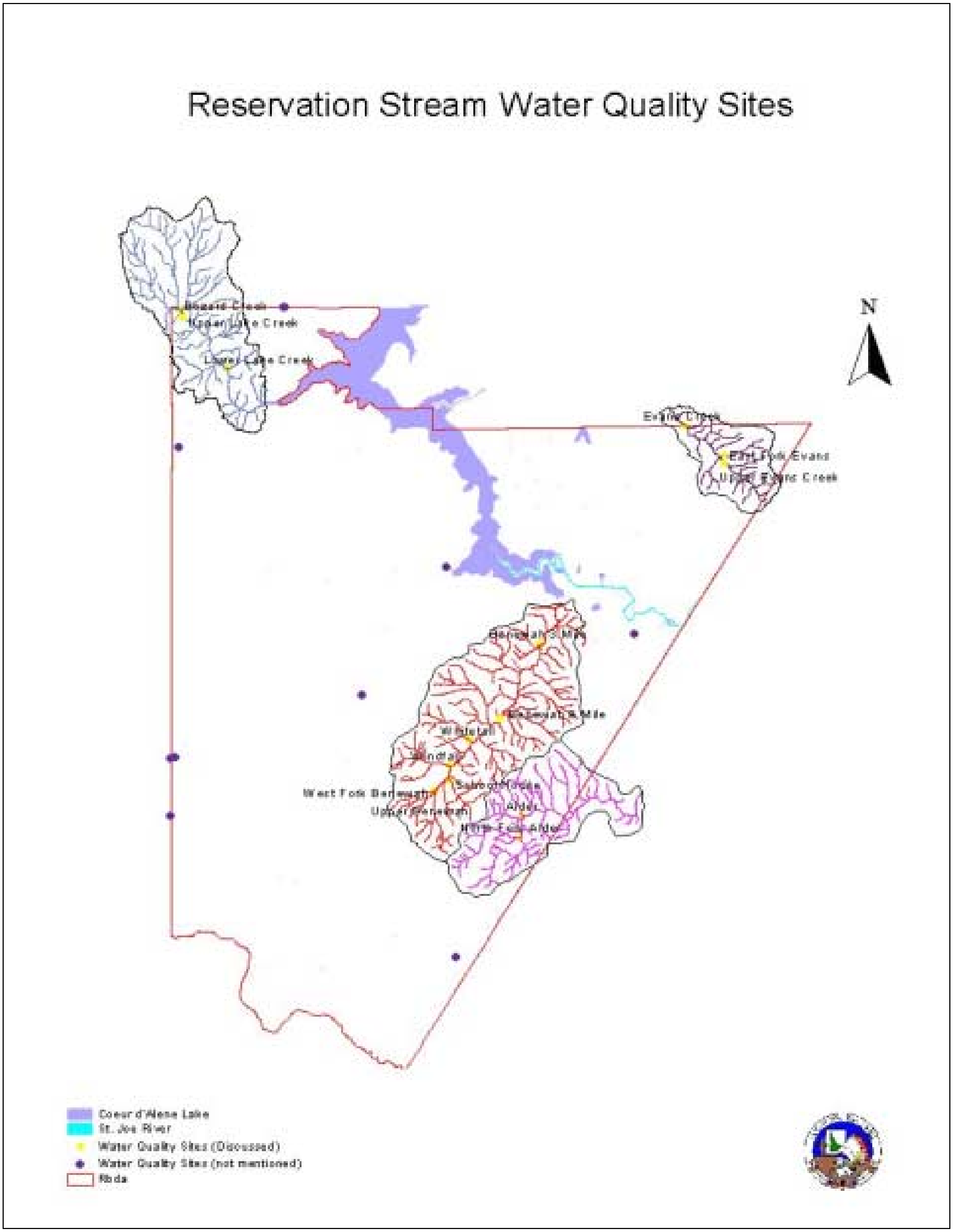


Figure 2. Locations of water quality sample sites in the target watersheds.

SAMPLE SITE CLASSIFICATION (STRATIFICATION)

Much recent literature has been devoted to and purports the use of hierarchical classification schemes for providing the conceptual and practical foundation for understanding the structure and processes of fluvial systems (Naiman et al. 1992; Bisson and Montgomery 1996). An understanding of process allows streams to be viewed in a larger spatial and temporal perspective, and to infer the direction and magnitude of potential changes due to disturbance and/or response to management. With regard to monitoring and evaluation, adhering to a consistent and well-documented classification scheme allows the investigator to assess differential responses of indicator variables to proposed actions within different classes of streams and watersheds.

An initial stratification of 101 sample reaches has been completed using a hierarchical approach that incorporates both ultimate and proximate control characteristics (*Table 4*). The stratification method used is consistent with the guidelines provided by Paulsen et al. (2002) and Hillman and Giorgi (2002) so as to be useful in furthering regional efforts to develop a multi-component monitoring program to assess the effects of actions called for in the NMFS 2000 Federal Columbia River Power System Biological Opinion. Stratification at this level of detail may prove useful to researchers working outside the Coeur d'Alene basin who are interested in pooling data to increase the overall statistical power of monitoring programs. A complete listing of sample sites that have been stratified using all of these variables can be found in Appendix x.

Table 6. List of stratification variables applied to tributary habitats on the Coeur d'Alene Reservation (from Hillman and Giorgi 2002).

Spatial Scale	General Characteristics	Stratification Variable	Recommended Protocol
Regional Setting	Ecoregion	Bailey classification	Bain and Stevenson (1999)
		Omernik classification	Bain and Stevenson (1999)
	Physiography	Province	Bain and Stevenson (1999)
	Geology	Geologic districts	Overton et al. (1997)
Drainage Basin	Geomorphic features	Basin area	Bain and Stevenson (1999)
		Basin relief	Bain and Stevenson (1999)
		Drainage density	Bain and Stevenson (1999)
Valley Segment	Valley characteristics	Valley bottom type	Cupp (1989); Naiman et al. (1992)
		Valley bottom width	Naiman et al. (1992)
		Valley bottom gradient	Naiman et al. (1992)
		Valley containment	Bisson and Montgomery (1996)
Channel Segment	Channel characteristics	Elevation	Overton et al. (1997)
		Channel type	Rosgen (1996)
		Bed-form type	Bisson and Montgomery (1996)
		Channel gradient	Overton et al. (1997)

TREATMENT/CONTROL STREAM REACHES

In 1993, the Fisheries Program stratified stream reaches in four watersheds by channel type after methods developed by Rosgen (1985). Subsequently, annual fish population estimates have been made at 101 randomly selected sites, which include mainstem and tributary segments in Lake, Benewah, Evans and Alder creeks (*Figures 2-5*). The data from these sites provide important baseline characterizations of fish populations at the watershed scale and continued sampling is critical to increasing the statistical power to detect changes in populations. Additional uses for this data in refining habitat-species relationships, and validating the effectiveness of restoration efforts may be realized when population estimates are coupled with more detailed measurement of habitat indicators as described above in Objectives 1-4.

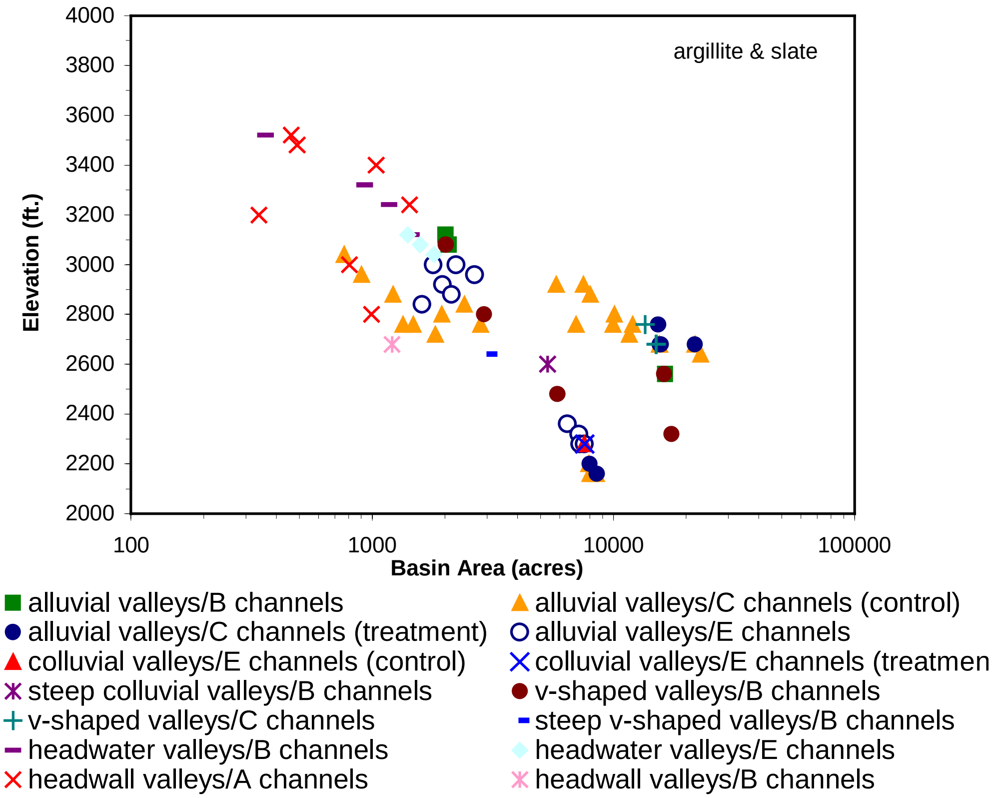
Use of the hierarchical classification scheme discussed in the previous section has been used to develop logical groupings of these sample sites with existing treatment areas for use in paired treatment-control studies. Preliminary groupings have been made using geologic district, basin area, elevation, valley segment type and channel type as the ultimate and proximate controls (*Figure 6*). Final selection of paired sites should also consider microhabitat conditions such as substrate and riparian cover, which is also available for each site.

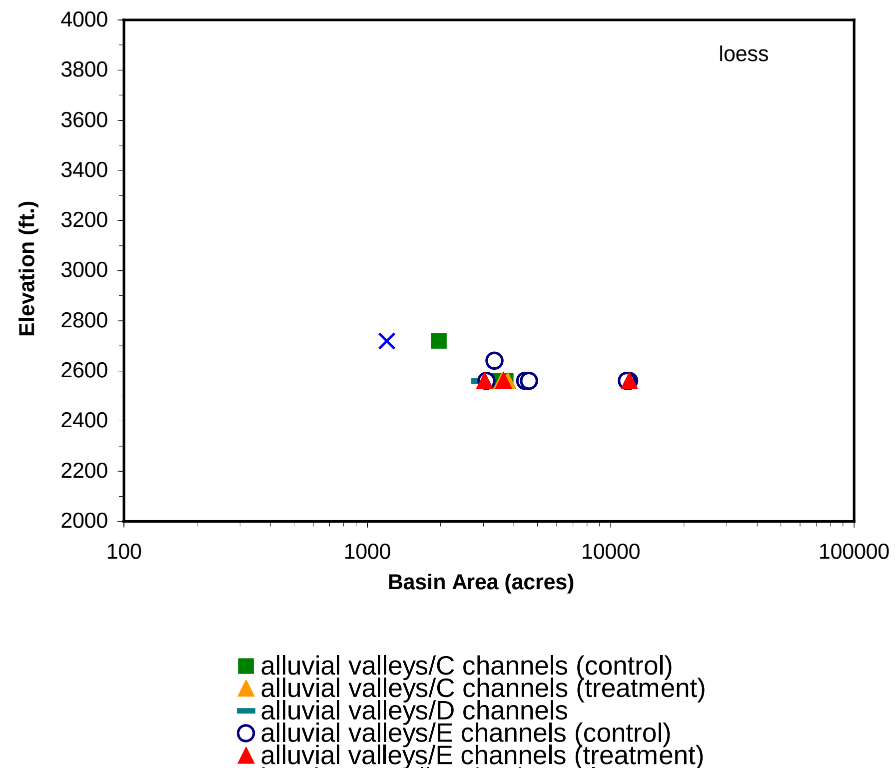
The results of these groupings are consistent with small watersheds in close proximity to one another and many of the general characteristics of the classification are shared among the various watersheds. The watersheds encompass 4 geologic districts, with mafic volcanic flows common in lower elevations and argillite and slate forming the parent material in middle and upper reaches of Alder, Benewah, and Evans creeks, respectively. Moderate to deep loess deposits are a common feature in the middle reaches of Lake Creek with some deposition evident in both Benewah and Alder creeks as well. The sample sites occur within a relatively narrow range of basin areas and elevations. The mean basin area for the sites is 9,345 acres and 64% of the sample sites are located in small 2^{nd} or 3^{rd} order tributaries subject to similar hydrologic regimes. The mean elevation of sample sites is 2,708 ft. and the sites are normally distributed around this mean. Nine different valley segment types and 15 different channel types are found in the watersheds, however, 66% of the sites are low gradient, meandering, riffle/pool type channels occurring in gently sloping, broad alluvial valleys.

All of the treatments that have been implemented to date occur in the most common valley/channel type groupings, resulting in many options for identifying valid treatment-control pairings. Potential pairings are listing in Appendix x and these sites can be cross-referenced on the watershed maps that depict sample locations (*Figures 2-5*).

Much of the valley segment classification for this exercise was made using USGS 7.5 minute topographic maps and only 30% of the classifications were field verified. Channel type designations were most recently made in 1998 and due to localized instability may not reflect current types. Both of these variables should be validated prior to finalizing study designs.

The principle effect of this stratification should be to further reduce the variability of biological and physical habitat indicators. The clustering of sample sites suggested by this stratification is a necessary part of the experimental design of this monitoring plan because natural variability of physical habitat indicators will be measured and compared within similar sample units and the resulting data will subsequently be nested in the same manner for statistical analysis.


4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
Elevation (ft.)
argillite & slate
100
1000
10000
100000
Basin Area (acres)
alluvial valleys/B channels
alluvial valleys/C channels (control)
alluvial valleys/C channels (treatment)
alluvial valleys/E channels
colluvial valleys/E channels (control)
colluvial valleys/E channels (treatmen
steep colluvial valleys/B channels
v-shaped valleys/B channels
v-shaped valleys/C channels
steep v-shaped valleys/B channels
headwater valleys/B channels
headwater valleys/E channels
headwall valleys/A channels
headwall valleys/B channels


4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
Elevation (ft.)
loess
100
1000
10000
100000
Basin Area (acres)
alluvial valleys/C channels (control)
alluvial valleys/C channels (treatment)
alluvial valleys/D channels
alluvial valleys/E channels (control)
alluvial valleys/E channels (treatment)

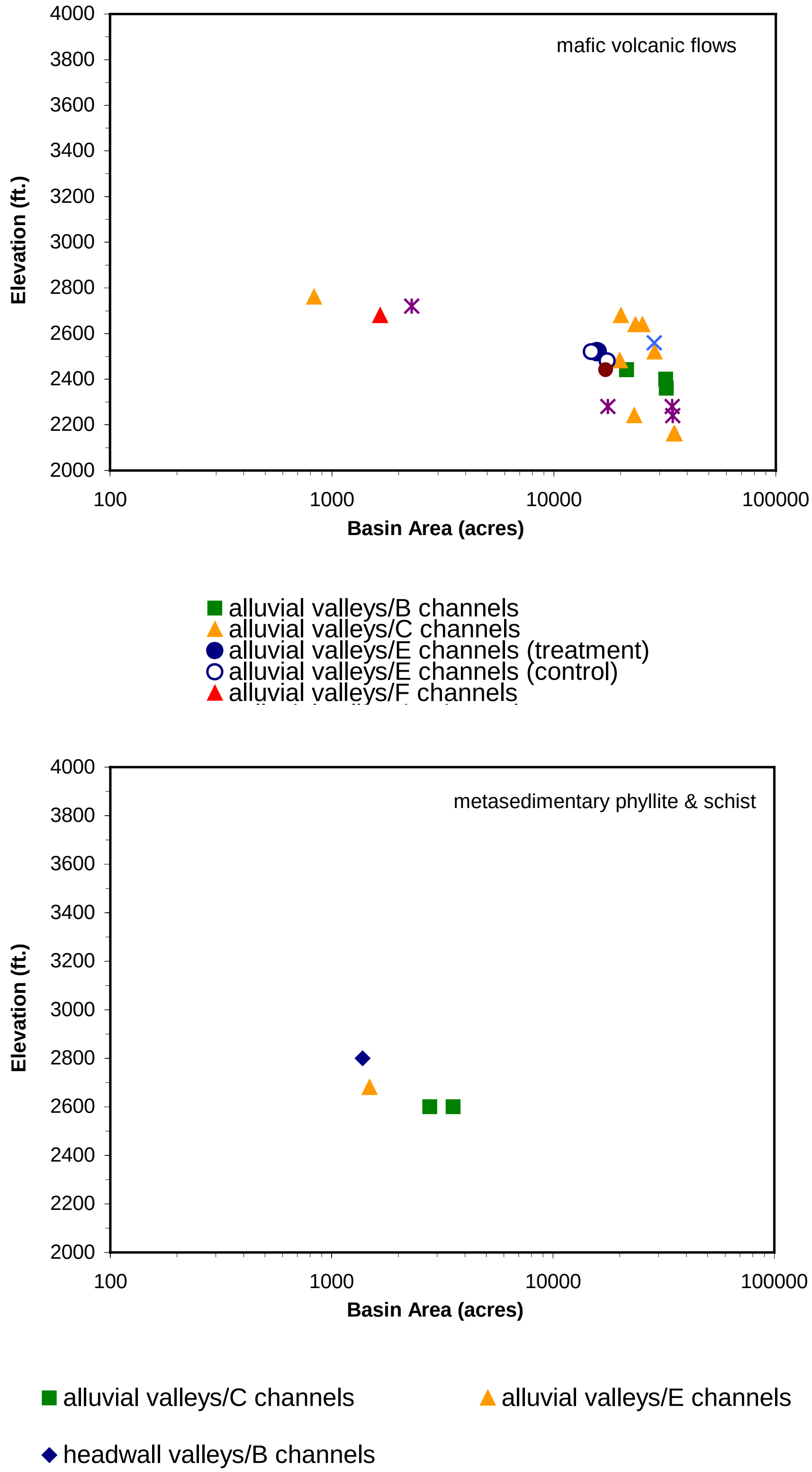


Figure 3 Hierarchical groupings of reference and treatment sites by geologic district, valley segment type, channel type, basin area and elevation for 101 reference reaches and 14 treatment sites.

TREATMENT SITES

Project Categories Effectiveness Monitoring

The effectiveness of restoration activities will be monitored through the repeated measure of specific parameters made at selected sites, which represent larger categories of projects (*Table 5*). These categories of projects have similar goals and can be monitored across differing environmental settings. For example, a selection of projects involving placement of large wood in streams could be monitored across a series of different stream classes. Or, selection of a riparian planting project in Benewah Creek could be monitored to determine climatic influences on their effectiveness across the other watersheds of interest. Oregon's effectiveness monitoring program selects projects in a similar way; based on their objectives, rather than their design (Jacobsen and Thom 2001; Lacy and Thom, 2000). The main reason for monitoring categories of projects is to be able to make statistical inferences about restoration effectiveness in general. It is also more efficient and practical than trying to monitor each and every project. From year to year, the focus of the monitoring effort can change as additional projects are developed.

In either case, restoration projects would be selected and monitored to test specific hypotheses, drawing on the replicate samples taken over time at the network of 101 reference reaches to serve as control sites. The locations of restoration/enhancement projects are shown in *Figures 8-10*.

Single Project Effectiveness Monitoring

As future projects are developed, there may be a need to monitor the effectiveness of specific restoration projects. This would be done on a case by case basis using criteria such as project importance to fish or to habitat, potential environmental impacts or consequences of failure, accessibility, or others, as determined by Tribal staff during pre-project planning. Fish passage or fish screening projects, especially in critical locations, are examples of projects that might be individually monitored. At this time, no single projects have been selected for this type of monitoring.

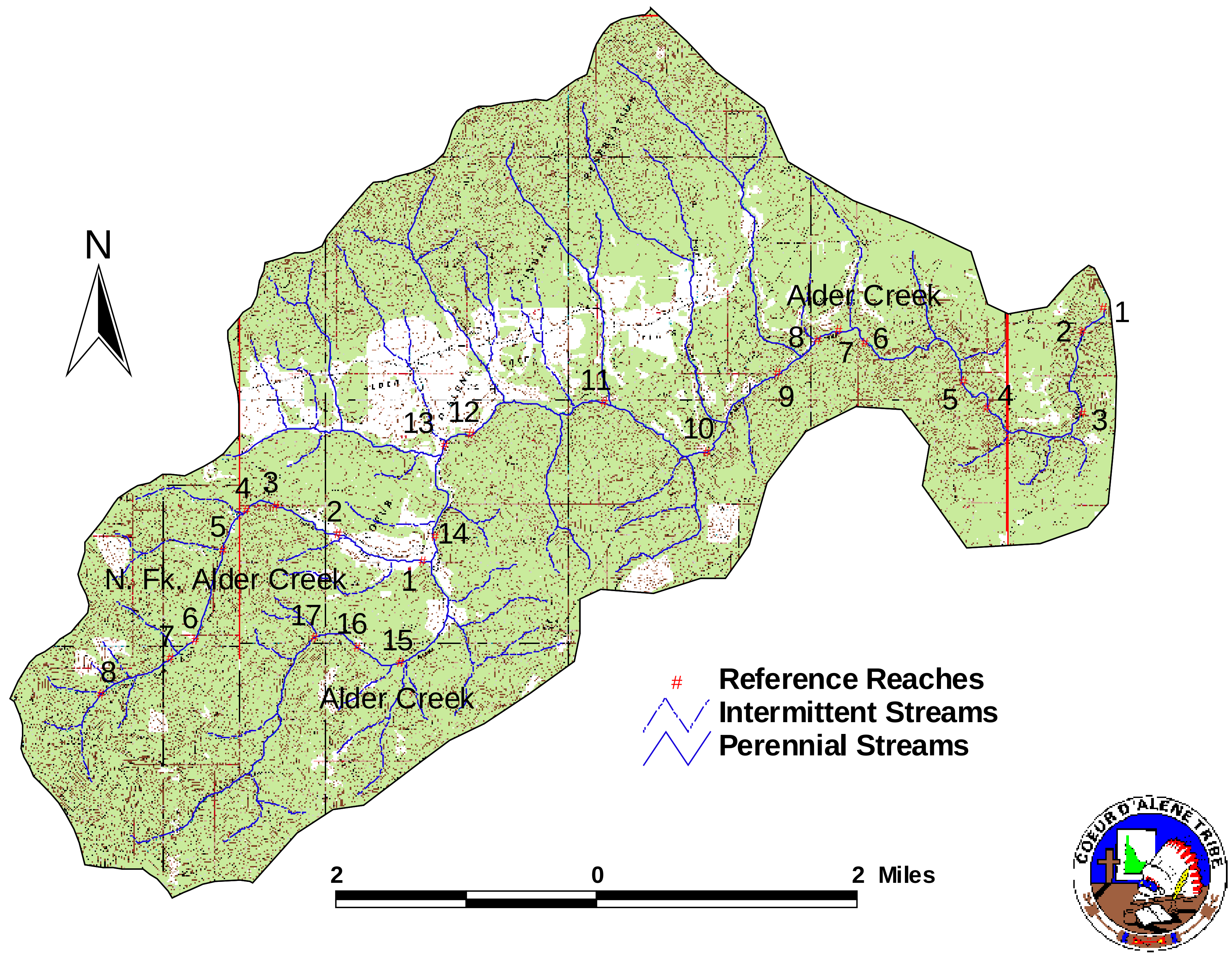
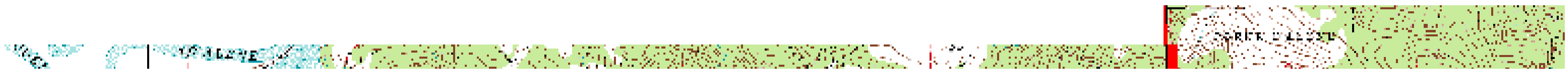


Figure 4. Reference reach locations in Alder Creek



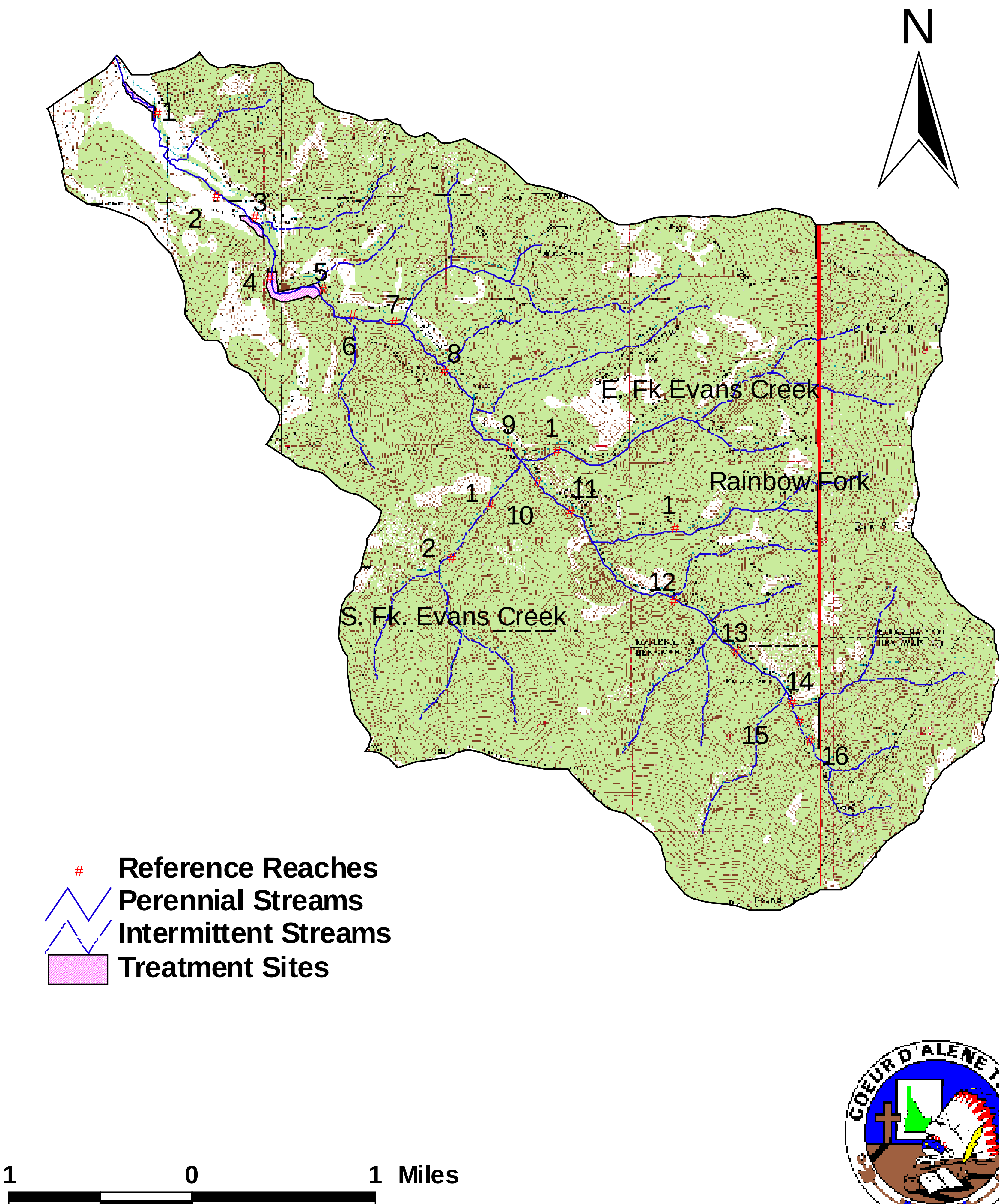


Figure 5. Reference reach locations in Evans Creek.

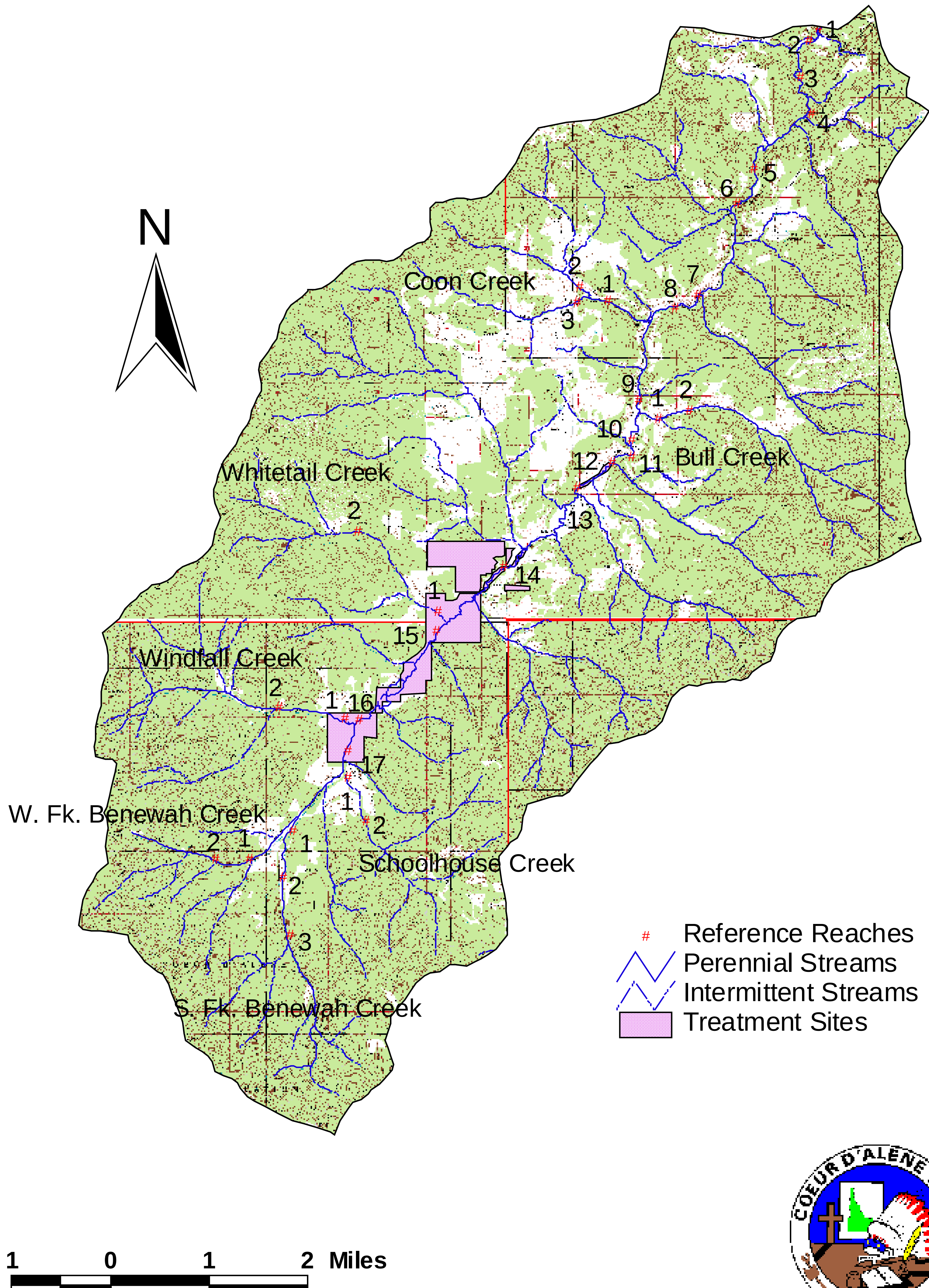


Figure 6. Reference reach locations in Benewah Creek

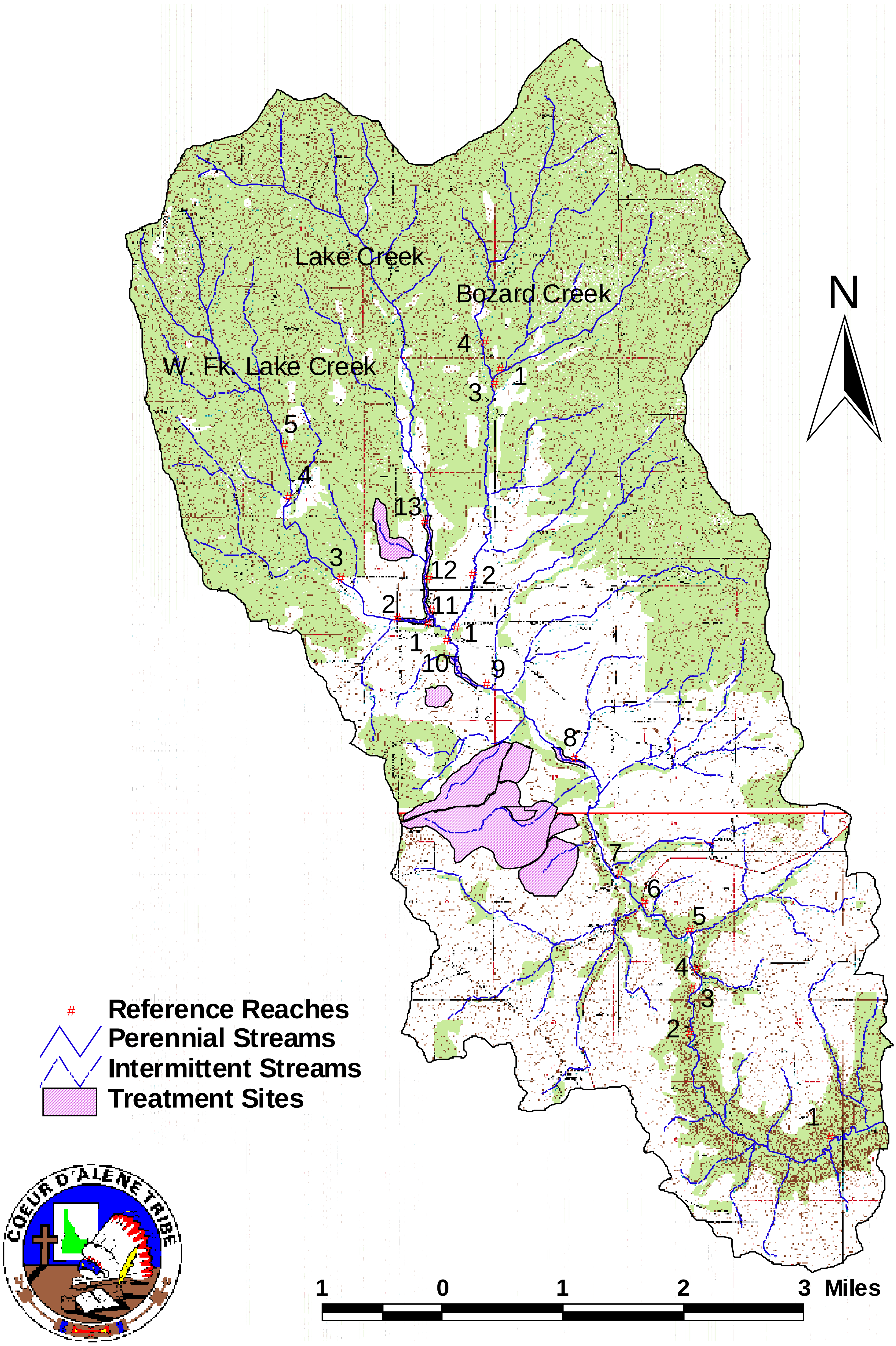


Figure 7. Reference reach locations in Lake Creek

Table 7. Restoration/enhancement projects listed by project category and treatment type.

Project Category/Treatment Type	***Project ID*[1]**	***Goal***
Instream		
Streambank Stabilization	*B_8.1* *B_8.5* *E_1.3* *E_1.6*	Increase streambank stability by reducing stream power or protecting erodible surfaces
Instream Structure	*B_8.5* *L_8.2*	Increase cover, habitat complexity, habitat types
Channel Construction/Modification	*B_6.5* *B_8.1*	Increase stream interaction with floodplain; increase habitat complexity; reduce downstream flooding
Fish Passage		Improve fish passage
Riparian		
Planting	*B_6.5* *B_8.1* *B_8.5* *B_8.9* *E_0.1* *L_6.0* *L_7.3* *L_7.6/0.0* *L_8.2* *L_8.5* *L_8.8*	Increase stream channel shading; increase LWD and/or allocthonous nutrient inputs; increase streambank stability
Vegetation Management		Increase native and/or desirable plant species composition; reduce dominance by exotic plants
Grazing Management	*B_8.5* *B_8.1* *B_6.5*	Manage riparian pastures to reduce impacts to vegetation and streambank stability
Water Storage	*L_5.2/0.2* *L_5.4/0.1* *L_6.7/0.2/0.0* *L_8.7/0.1* *L_6.5/0.1*	Increase water retention time; reduce nutrient and sediment input to stream channels
Upland		
Slope Stabilization	*B_8.1/0.0* *B_8.5/0.0* *B_8.5/0.2* *L_5.9/0.4/0.0* *L_7.3/0.2* *L_8.2/0.0/0.0*	Increase upslope stability; decrease erosion/stream sedimentation
Gully Repair	*L_5.9/0.4*	Reduce the rate of head-cutting and incision; decrease erosion and stream sedimentation

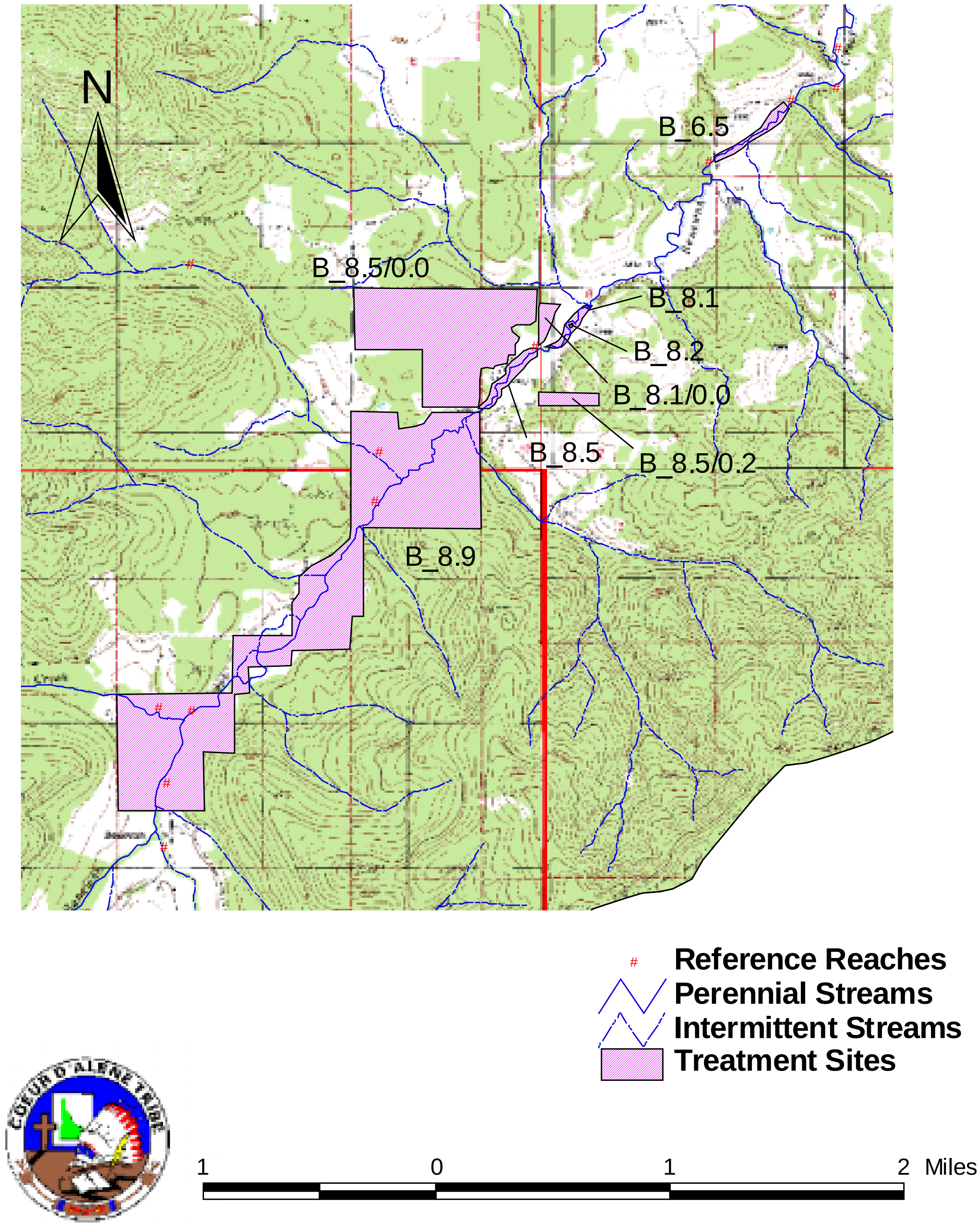


Figure 8. Locations of restoration/enhancement sites in the Benewah Creek watershed.

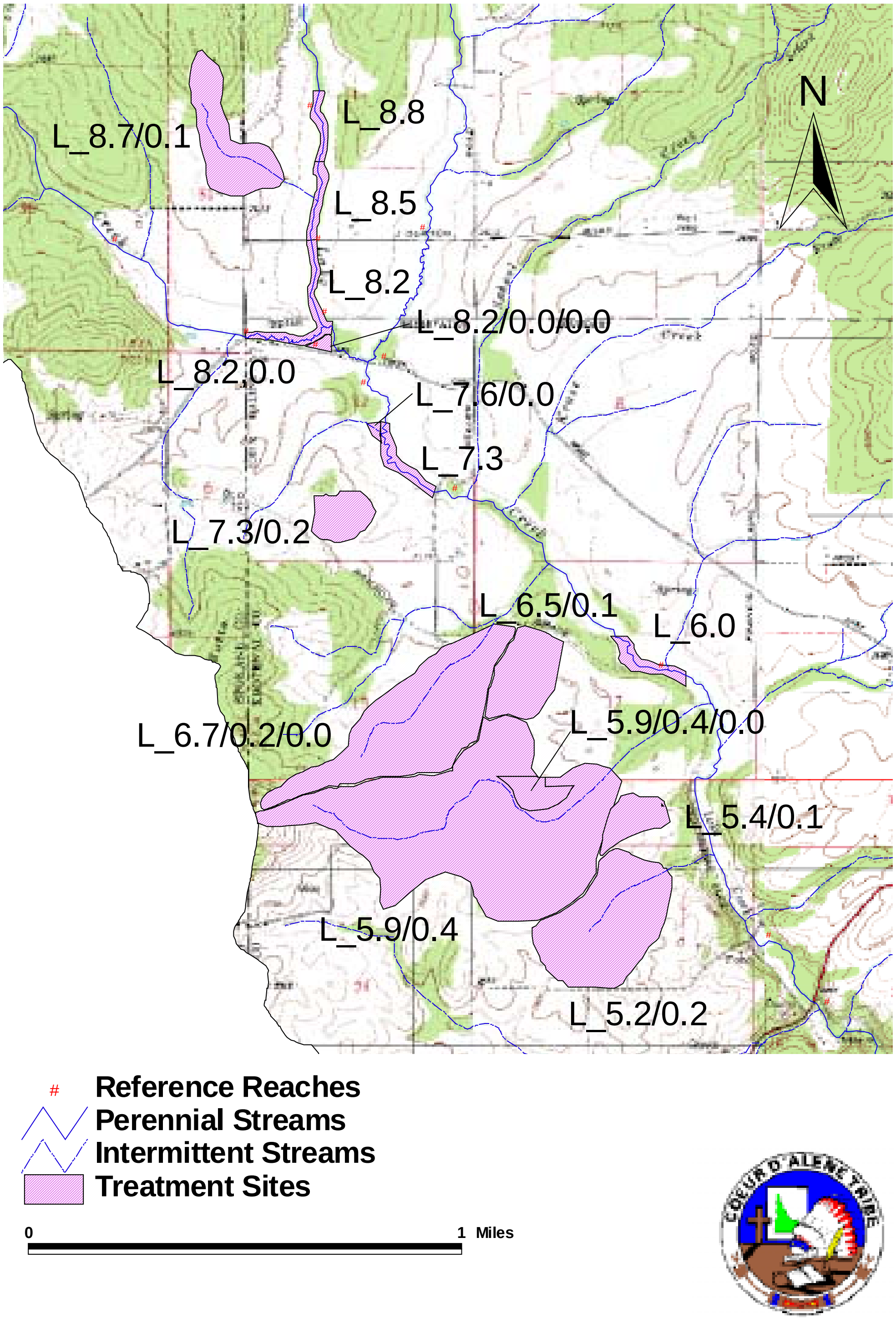


Figure 9. Location of restoration/enhancement sites in the Lake Creek watershed.

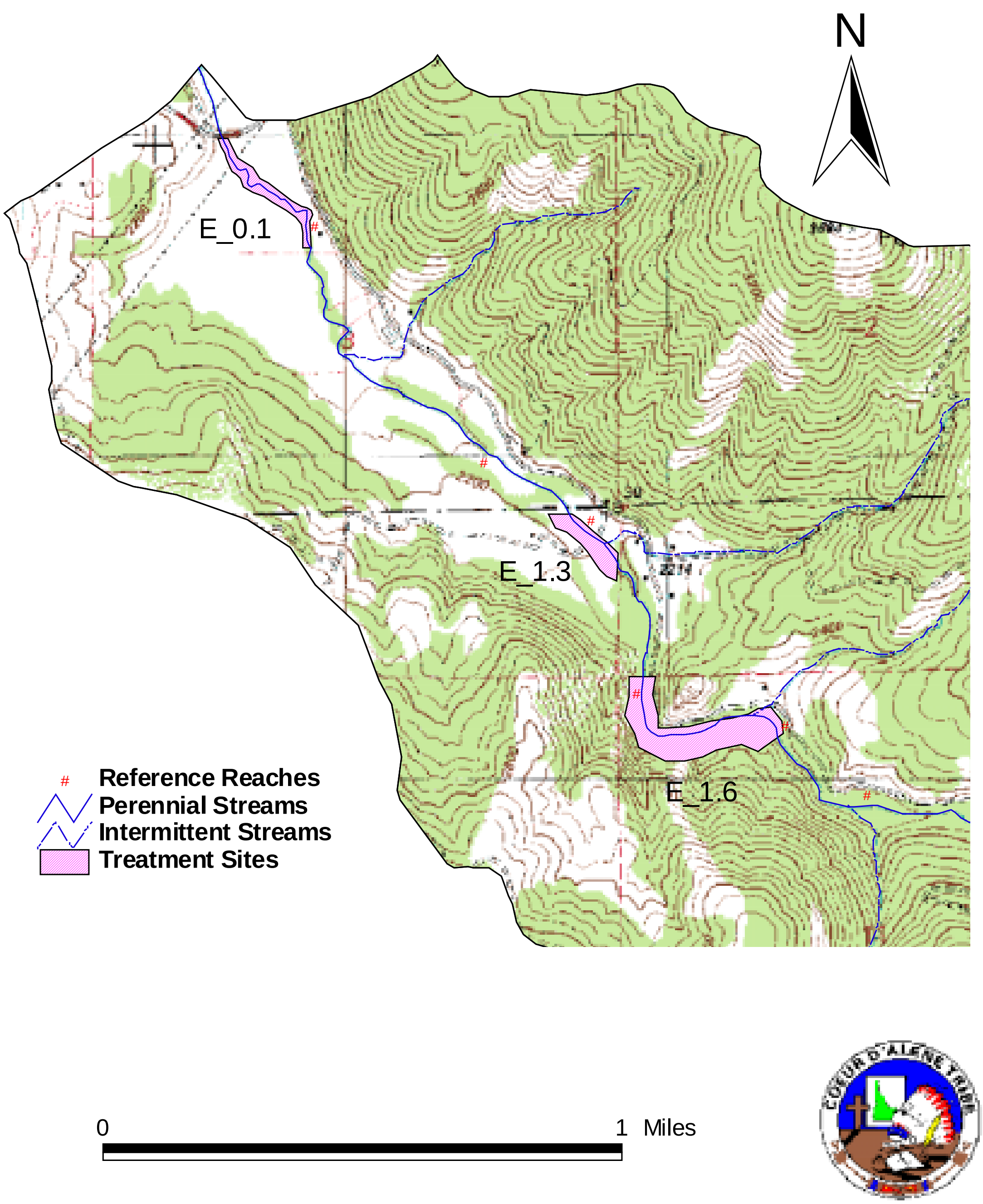


Figure 10. Location of restoration/enhancement sites in the Evans Creek watershed.

TIMELINE FOR IMPLEMENTATION & SAMPLING SCHEDULE/FREQUENCY

This will be further developed as the project is initiated. Implementation of tasks related to specific monitoring objectives will be described in Scopes of Work submitted to respective funding agencies. The intent is to continue monitoring for the life of the project or until such time as it is not warranted.

DATA REDUCTION, ANALYSIS & MANAGEMENT

By doing the monitoring and evaluation associated with the five objectives, we will measure variables that allow testing hypotheses at the watershed scale, as well as at the reach scale within, and among watersheds. At the watershed scale, we will test hypotheses with regard to physical habitat variables and cutthroat and eastern brook trout populations between Alder, Benewah, Evans and Lake Creeks (*Table 6*). At the reach scale we will test hypotheses with regard to physical variables within reference and restored reaches, and test hypotheses with regard to comparisons between reference and restored reaches (*Table 6*).

An essential part of the experimental design is the use of randomly selected, stratified reference stream reaches that will act as controls to test the effectiveness of restored stream reaches, and to measure the time needed for restored reaches to exhibit the reexpression of habitat capacity (Ebersol et al. 1997). Under this experimental design, it is important that reference reaches are nested by Valley Segment Type, Rosgen Channel Type, and by Riparian Cover Group. The channel type designation integrates the channel morphology and the longitudinal placement of the channel with respect to the basin. This will reduce the error involved by comparing reaches that are affected by similar physical processes (i.e., discharge, stream energy, valley slope, etc.) and other longitudinal effects. Thus, statistical parameters of variables in restored reaches within mid-basin alluvial valleys will not be compared to high-gradient, confined reference reaches in the upper basin.

The statistics selected to test hypotheses for objectives 1-5 are parametric statistics. As data is produced from monitoring and measurement of variables in *Table 3*, we will determine if the variables meet the assumptions of parametric statistics, i.e. they are normally distributed, and variances are homogeneous. If the data does not meet the assumptions of parametric statistics, then non-parametric statistics will be used. For example, nonparametric Kruskal-Wallis test will replace the single factor ANOVA, nonparametric Spearman’s rank correlation will replace Pearson’s correlation and nonparametric Mann-Whitney test will replace the t-Test (Zar 1984).

Stream habitat variables will be measured on an annual basis. During the annual sampling, many of the variables, e.g., thalweg depth, substrate size and large woody debris volume will be measured multiple times over the distance of a reach. However, the stream reach scale is the finest level we are testing. So, a mean and associated variance will be reported from multiple measures of a variable within each reach. Statistical tests will be done on the means. Reaches within a stream system will be replicated (n=3) based on channel type. After we have a measure of variance among the variables, a power analysis will be performed. The power analysis will focus on the number of samples needed to detect a significant difference among reaches at an alpha significance level of 0.05, and the known variance. If more or less sites are needed, then number of sample sites will be adjusted. A complete power analysis of all cutthroat population data has been done and is included in this RM&E plan.

Table 8. Monitoring and evaluation objectives, associated hypotheses and statistical analyses. Note: to reduce size of table, only Null hypotheses are included, and when appropriate, multiple variables are included in a single hypothesis.

Objective	Hypotheses	Statistical Analyses
1). Measure physical habitat of random selected reference stream reaches on an annual basis to quantify habitat change through time and measure the natural habitat variability.	*Among stream systems* Ho: Large woody debris volume, thalweg depth and substrate size are equal between Lake, Benewah, Alder and Evans Creeks. Combined reaches, all streams Ho: A relationship exists between large woody debris volume and substrate size, thalweg depth and width to depth ratio. Ho: A relationship exists between substrate size and thalweg depth and width to depth ratio.	Single Factor ANOVA, α=0.05 then, Tukey Multiple Comparisons to detect which streams differ. Pearson Correlation, α=0.05
2). Measure physical habitat of restored stream reaches on an annual basis to quantify habitat change through time and measure the habitat variability.	*Within restored reaches* Ho: Large woody debris volume, thalweg depth and substrate size are equal between years.	Single Factor ANOVA, α=0.05
3). Compare annual variation of physical variables between reference reaches and restored reaches.	*Within stream system* *Restored vs. reference reaches* Ho: After 5 years post-restoration, large woody debris volume, thalweg depth and substrate size is equal between restored and reference reaches. NOTE: This test will be repeated each year new habitat measures are made.	Variance Ratio test α=0.05 and, Single Factor ANOVA, α=0.05

Table 6. cont.

Objective	Hypotheses	Statistical Analyses
4). Estimate fish populations in reference stream reaches and restored stream reaches. Detect changes in fish populations at the stream level and reach level.	*Within Stream Systems* Ho: After 3 years post-restoration, Westslope cutthroat trout population will not change from pre-restoration levels. Ho: After 5 years post-restoration, Westslope cutthroat trout population will not change from pre-restoration levels. Ho: After 10 years post-restoration, Westslope cutthroat trout population will not change from pre-restoration levels.	Power Analysis to detect population changes of 1%, 3% 5% and 10% at α=0.05, 0,1 and 0.2 then, Single Factor ANOVA, α=0.05
5). Measure sediment retention of constructed sediment ponds and effectiveness of sediment ponds to ameliorate temperature and augment flow to stream reaches.	Ho: Sediment accumulation in traps at deep sites will equal accumulation at shallow sites. Ho: Stream temperature above pond discharge will be equal to temperature below pond discharge	Single Factor ANOVA, α=0.05 Paired Student's t-Test, α=0.05

III. MONITORING PROTOCOLS

OVERVIEW

The selection of monitoring protocols for this RM&E plan was informed by the development of effectiveness criteria, which were linked to biophysical properties of streams and riparian zones. Over 100 documents were reviewed to determine their applicability to Reservation watersheds and the anticipated restoration projects. Of particular help with this search and review was information presented by Johnson et al. (2001), which evaluated over 400 salmon habitat-related protocols applicable to the Pacific Northwest. The parameters described herein are applicable to specific restoration sites as well as to reference stream reaches, as indicated elsewhere in this Plan. A summary of the parameters to be measured is presented in *Table 7* below. We believe the protocols and procedures presented in this plan represent a balance of qualitative and quantitative measures judged necessary to ensure consistency, minimize observer bias, and maximize repeatability.

Table 9. Habitat monitoring parameters and primary protocol references.

	References to Methods
Stream channel Projects:	
a. Photographic documentation	CDAT*
b. Flow (discharge)	Peck et al., 2001
c. Channel Gradient & Habitat Typing	
Longitudinal "Thalweg" Profile	Peck et al., 2001
d. Channel Substrate	
Substrate	Wolman, 1954; Rosgen, 1996
e. Channel Type Classifications	
Entrenchment Ratio	Rosgen, 1996
Floodprone Width	Rosgen, 1996
Width to Depth Ratio	Rosgen, 1996
Sinuosity	Rosgen, 1996
Stream Type Classification	Rosgen, 1996
f. Instream Cover and Food (Organic debris)	Platts et al., 1987
g. Streambank/shoreline cover & stability	
Canopy Cover	Platts et al., 1987
Bank cover	Platts et al., 1987
h. Biomonitoring fish	
Electrofishing	Peck et al., 2001
Pond Projects:	
a. Photo documentation	CDAT
b. Sediment Trapping	Hardy et al., 1996
c. Water Quality Profiles	Hydrolab Inc., 1997
d. Receiving Water Temperature Profile	CDAT
Riparian Projects:	
a. Photo documentation	CDAT
b. Vegetation Composition	Winward, 2000
Upland Projects:	
a. Photo documentation	CDAT
b. Vegetation Survival	CDAT

* CDAT indicates protocol methodology to be developed by Coeur d'Alene Tribe

STREAM CHANNEL PROJECTS

Photographic Documentation:

Although photographs do not provide all the information needed to fully assess the effectiveness of restoration measures on chemical and biological components of streams, they can indicate trends in woody vegetation, streambank stability and cover (US EPA, 1993). The ability to extract useful information from a photograph will depend on: the photo subject, the quality of the image, proper storage of the image, knowledge of the photo's existence, and the ability to retrieve and view the image (Osprey Environmental Services, 1996). This manual addresses project documentation using only ground-based photography.

Consistency is necessary to assure that photographs taken over time are comparable and this can be achieved through the use of "photo points". The establishment of permanent photo points will be based on the presence of either monitoring sites or other points of interest. Whenever possible, photo points will include permanent vertical and horizontal landmarks (e.g., points on the horizon) so that the scene can be relocated by a different observer. All photo points will be located using GPS and their coordinates and a description shall be logged into a project database. To avoid problem stemming from obstructed views in future years the potential growth of vegetation will be considered prior to the placement of photo points. Photo subjects may include:

- Sampling sites (cross sections) for measuring physical and biological parameters,
- Stream channel at upstream end, downstream end and mid-reach of fish survey reaches (one photo looking upstream from mid-channel at the downstream end, one photo looking downstream from mid-channel at upstream end and two photos looking both up and downstream from mid-channel at the mid-reach point),
- Permanent benchmarks, including photo point locations,
- Habitat improvement sites.
- Defining characteristics of site or reach,
- All major barriers/obstructions,
- Riparian characteristics,
- Other important habitat components,
- Typical or atypical channel morphology,
- Evidence of bank failure, scouring, major debris or sediment movement events,
- Fish and wildlife uses,
- Other bank features (*e.g.*, undercuts, flood signs, height, slope, texture),
- Substrate characteristics,
- Land uses near site.

Flow (discharge):

Discharge will be determined using the "Velocity-Area Procedure" and/or "Neutrally-Buoyant Object Procedure" (both adapted from USEPA 2001). Discharge is determined in the "Velocity-Area Procedure" by measuring the velocity of the water in units of 'feet per second' within portions or intervals of a cross section based on depth and width that are measured in units of 'feet' (parts of a foot are measured in 'tenths of a foot'). The "Neutrally-buoyant Object Procedure" will be used as an alternative method in small, shallow streams (Provide descriptive example) where the "Velocity-Area Procedure" cannot be applied. In either case, stream flow will be measured at one cross section within each monitored stream reach.

"Velocity-Area Procedure":

Because water velocity and depth vary across the width of a stream, accuracy is achieved by measuring velocity and area of many intervals across a channel. Typically, 15 to 20 intervals are necessary to provide the desired accuracy (Rantz 1982). In narrow streams the interval width should not be less than four inches (Rantz 1982). It is important to choose a channel cross section that is as much like a canal as possible. Other qualities that help make streamflow measurements accurate are depths mostly greater than six inches and velocities mostly greater than 0.5 feet per second, with no eddies, backwaters or excessive turbulence. A straight run or glide area with a "U" shaped cross section that is free of obstructions provides the best conditions for measuring discharge by this velocity-area method. Note that obstructions may be removed from the channel to make the flow measurements easier but this must be done before any depth or velocity measurements are made and not as you proceed across the stream taking measurements.

"Neutrally-Buoyant Object Procedure":

This protocol will be used only where the previous method will not work due to shallow water or the presence of obstructions in the selected cross section. The measurements taken in the neutrally buoyant procedure are mean flow velocity and cross-sectional area of the flow, so this is basically very similar to the "Velocity-Area Procedure". Mean flow velocity will be estimated using a floating object (i.e., an object that floats at the water surface but does not project up above the water surface) and timing its movement along a measured length of the stream channel. The channel cross sectional area is determined from a series of depth measurements along one or more cross sections.

Channel Gradient & Habitat Typing:

The slope of the water surface is a major determinant of river channel morphology, and of the related sediment, hydraulic, and biological functions (Leopold 1994). A longitudinal profile surveyed along a selected channel reach is recommended to be established for slope determinations (Rosgen 1996). With a sufficient array of longitudinal profile data, specific characteristics of rifles, runs, glides, and pools can be compared between each feature and between features of other stream types.

This effort involves the measurement of the water surface elevation and width and stream channel bottom elevation along the entire study reach (modified from Peck et al. 2001). Measurements require the use of a surveyor's level and rod. Operating and note taking procedures for this equipment are described in *Appendix F*. Since the reach will most likely be longer than can be seen from a single level setup, it will also be necessary to use turning points as described below. Also included in this protocol is the determination and documentation of the various habitat types along the reach.

Longitudinal "Thalweg" Profile:

"Thalweg" refers to the flow path of the deepest water in a stream channel. The longitudinal thalweg profile is a survey of the stream bottom and water surface elevations along the entire monitoring reach. Given the 500-foot reach length established for reference reaches, there will be a series of 50 measurements collected every 10 feet along the stream, plus measurements at the boundaries between stream habitat types. Data from this survey will allow calculation of the proportion of all habitat types, channel sinuosity, and channel complexity. This procedure will also establish the upstream end of the monitored reach as well as preliminary locations of cross sections that will be used for monitoring other stream characteristics. It is advantageous to have GPS equipment available to document the location of the downstream and upstream ends of the stream reach and also the cross section locations.

Valley Cross Section Profiles:

The cross section profile will be measured at (or near) six locations that were staked and flagged during the "thalweg" profile work described in the previous protocol. This information is necessary to complete the determination of channel type for each monitoring reach. The cross section profile will be used to calculate both the bankfull width/depth ratio and the floodprone width.

Because of the importance that bankfull flow has in shaping and controlling the stream channel character, the stage or elevation of bankfull discharge (flow) is considered to be the single most important parameter used in stream type classifications (Rosgen 1996). The term "bankfull" refers to the flow that fills the channel to the top of it's banks at that point where water begins to spill out onto floodplain and generally corresponds to the US Army corps of Engineers field interpretation of "ordinary high water" which is expected to occur every one to two years. The bankfull stage and its corresponding flow occur frequently enough to serve as consistent indices that can be related to the formation, maintenance, and dimensions of the channel as it currently exists (Rosgen). This measure is required to estimate two of the five primary criteria needed to determine stream type using the Rosgen classification system, namely width to depth ratio and entrenchment ratio.

By comparison, "flood prone area" or "flood plain" is the widest extent that the stream channel gets and it is associated with the infrequent, high magnitude flood discharges (Rosgen 1996). While it is desirable to have the valley cross sections include the full extent of the flood prone area this will not be possible in all areas.

The key to locating the cross sections will be to make sure that they are distributed in proportion to the primary habitat types found in the reach (*Table 8*). Once the distribution of habitat types is identified the initial cross section locations will be adjusted as necessary to match this distribution. This adjustment will be performed as the survey crews proceeds upstream during the cross section survey work. All cross sections will be monumented with permanent pins to allow for consistent measurement during collection of all measurements.

Table 10. Stream habitat type descriptions (IDEQ 1999).

Habitat type	Description
Riffle	A portion of the stream with swiftly flowing, shallow water. The water surface in a riffle is turbulent and this is caused by completely or partially submerged obstructions. Cascades are one class of riffle characterized by swift current, exposed rocks and boulders, considerable turbulence and stepped drops over steep slopes. Riffle areas with standing waves are called rapids.
Pool	A portion of the stream with reduced current velocity (average velocity is generally less than 1 foot per second), and often, but not always, with water deeper than surrounding areas. Pools usually have flat-water surfaces with no surface agitation and often the bottom is concave such that it would hold water if there was no flow. Pools usually occur at outside bends in the channel and around large obstructions. Water impounded upstream of channel blockages, typically a logjam or beaver dam, is classed as a dammed pool. Pools end where the stream bottom approaches the water surface and this is also known as a "pool tailout".
Run / glide	A portion of the stream with moderate to swift velocity and without surface agitation (runs display "laminar" or uniform flow patterns). Runs and glides typically occur immediately upstream and downstream of riffles. Pool tailouts are typically classed as runs in small high-gradient streams. Glides also occur where the channel widens allowing the stream to shallow and slow. Glides are most commonly found in low gradient streams associated with elongated pools.
Shallows or side channels	A portion of the stream where side channels enter or leave the main channel and shallow, border areas used by young fish.

Entrenchment Ratio:

Entrenchment describes the relationship of the river to its valley and landform features. Entrenchment is qualitatively defined as the vertical containment of a river and the degree to which it is incised in the valley floor (Kellerhalls et al. 1972). The term “entrenchment ratio” has been quantitatively defined by Rosgen (1994) to provide a consistent method for field determination. Entrenchment ratio will be estimated as the typical flood width divided by the bankfull channel width. Bankfull width, or the stream volume at bankfull stage, is determined by the elevation of the top of the "highest depositional feature"; this could be a change in size distribution of substrate or bank particles, a break in the slope of the bank or a stain on rocks in the bank. The bankfull width may not be always evident but should be able to be identified somewhere within the reach, at least on one side of the channel. Flood width is frequently not evident, especially where floodplain features have been obscured by agriculture or other human activities. However, flood width has been defined by Rosgen (1994) as the width at the elevation that is twice the maximum bankfull depth.

Width to Depth Ratio:

The width/depth (W/D) ratio is defined as the ratio of the bankfull surface width to the mean depth of the bankfull channel. The width/depth ratio is key to understanding the distribution of available energy within a channel, and the ability of various discharges occurring within the channel to move sediment (Osterkamp et al. 1983; Osborn and Stypula 1987). Stream channel width to depth ratio will be determined for bankfull discharge condition. It will be advantageous for permanent cross sections to be established for long term monitoring of this characteristic. Using the previously determined "bankfull width" and "bankfull depth", we will calculate width to depth ratio by dividing the width by the depth for the cross section (Rosgen 1996)

Sinuosity:

Sinuosity is the ratio of stream length to valley length. It can also be described as the ratio of valley slope to channel slope. Meander geometry characteristics are directly related to sinuosity, consistent with the principle of minimum expenditure of energy (Langbein and Leopold 1966). We will estimate the sinuosity of a given stream reach as the ratio of the stream channel length to valley length. Rosgen (1996) described this procedure for the entire stream basin but the procedure can also be applied at the reach scale. A 1:24,000 map, orthophoto and ruler, or GIS map in measure option or GPS will be used to measure the length of the basin as the straight-line distance from where the stream enters the study reach to where it leaves the reach.

We will use the "total stream length" in the study reach that was measured for the longitudinal thalweg profile (this should be 500 feet) and calculate the sinuosity by dividing this length by the reach length.

Channel Substrate:

While channel bed and bank materials influence the cross-sectional form, plan-view, and longitudinal profile of rivers, they also determine the extent of sediment transport and provide the means of resistance to hydraulic stress (Ritter 1967). We will measure channel substrate using a modified version of Wolman’s (1954) pebble count method as described by Rosgen (1993). The modified method adjusts the material sampling locations so that various bed features are sampled on a proportional basis along a given stream reach. This requires that the six cross sections be located as described in the method for Valley Cross Section Profiles.

The pebble count substrate analysis will be performed along each of the six cross sections within the monitored reach. At each cross section the actual substrate materials will be determined at 20 points spaced uniformly across the bank full width. At each of these points the measuring stick will be placed on the substrate and the one particle the tip touches is picked up and the size measured. Following the original method, particle size will be determined as the length of the "intermediate axis" of the particle; that is the middle dimension of its length, width and height. Substrate size classes that will be recorded are shown in *Table 9*.

Stream Type Classification:

The Rosgen stream type classification will be determined using the results of the longitudinal profile (slope), average entrenchment ratio, average width to depth ratio and estimate of sinuosity as described above. Calculated characteristics will be compared to the stream type descriptions presented in *Table 10* to identify the stream type.

Table 11. Substrate size classes for streambed and bank analyses from Rosgen (1996).

Class Name	Size Range*	Description
Silt/Clay	<0.062 mm	Silt / Clay
Sand	0.062 - 0.125 mm	Very fine sand
"	0.125 - 0.25 mm	Fine sand
"	0.25 - 0.50 mm	Medium sand
"	0.50 - 1.0 mm	Coarse sand
"	1.0 - 2.0 mm	Very coarse sand
Gravel	2.0 - 4.0 mm	Very fine gravel
"	4.0 - 5.7 mm	Fine grave
"	5.7 - 8.0 mm	Fine gravel
"	8.0 - 11.3 mm	Medium gravel
"	11.3 - 16.0 mm	Medium gravel
"	16.0 - 22.6 mm	Coarse gravel
"	22.6 - 32.0 mm	Coarse gravel
"	32.0 - 45.0 mm	Very coarse gravel
"	45.0 - 64.0 mm	Very coarse gravel
Cobble	64.0 - 90.0 mm	Small cobble
"	90.0 - 128 mm	Small cobble
"	128 - 180 mm	Large cobble
"	180 - 256 mm	Large cobble
Boulder	256 - 362 mm	Small boulder
"	362 - 512 mm	Small boulder
"	512 - 1024 mm	Medium boulder
"	1024 - 2048 mm	Large - very large boulder
Bedrock	>2048 mm	Bedrock

* Measured as median dimension, not largest or smallest)

LEVEL I: GEOMORPHIC CHARACTERIZATION

Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landform/ Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0 to 1.1	>.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	.04 to .10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>1.2	.02 to .039	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate w/scour pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains.	>2.2	>12	>1.4	<.02	Broad valleys w/terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	>40	n/a	<.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment, w/abundance of sediment supply. Convergence/divergence bed features, aggradational processes, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	>2.2	Highly variable	Highly variable	<.005	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.4	<.02	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	.02 to .039	Gullies, step/pool morphology w/moderate slopes and low width/depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

Table 12. General stream type descriptions and delineative criteria (Rosgen 1996).

Instream Cover & Food:
Organic matter is generally described in four size categories: dissolved organic material less than 0.02 inch in diameter, fine particulate matter between 0.02 and 0.09 inch in diameter, coarse particulate matter greater than 0.1 inch but less than four inches in diameter and large woody debris greater than four inches in diameter. The monitoring performed under this Plan will focus on the inventory of the two larger size classes modified from methods described by Platts et al. (1987).

Large Woody Debris Survey:
This survey will be an inventory of the number and size of individual pieces of woody material observed along a longitudinal transect through the reach. For the large woody debris (LWD) this data will be converted into volumes of material so it will be necessary to collect data on the lengths and diameters of the material to allow this calculation. Tree root wads will be tallied separately as these typically provide additional habitat benefits because of their size and complexity. For this protocol the definition of a root wad is that it is dead, that it is detached from its original position, that it has a diameter where the tree trunk meets the roots of at least eight inches and that it is less than six feet long from the base of the root ball to the farthest extent of the trunk (Schuett-Hames, 1999).

Organic debris survey transect will be a walked zig-zag path from waters edge to waters edge starting at the downstream or upstream end of the reach. The zig-zag will consist of straight line segments that intersect the opposite shore at a distance (length) of approximately twice the wetted width, at (or near) baseflow condition. The appropriate interval is determined visually and a straight course will be achieved either by sighting a point on the opposite shore to head for, or by using a compass and setting the line of travel indicator to follow a set direction.

As the surveyor/observer is walking the transect, he/she will note and tally any organic (woody) debris which has a diameter of more than 0.1 inch, that is essentially laying on the channel bed and crosses the line of the transect. In addition, all LWD (that organic material that is greater than 4 inches in diameter) shall be tallied and measured whether or not it crosses the line of the transect. While this should include material that is suspended above the water surface and may extend outside of the wetted stream width, it will not include living trees or shrubs that may hang over the water.

For all observed LWD, the orientation to the channel will be recorded. Orientation will be noted as parallel to channel (basically laying along the line of the channel), oblique (roughly 45 degrees off the line of the channel) or perpendicular to channel (roughly 90 degrees from the line of the channel). Other measurements to be taken of all LWD are the diameter at the large end, diameter at the small end and the length between these two ends. The small end diameter will not be less than four inches even though the LWD may have parts that are less than this and the length will be of the portion that is greater than four inches. The large end diameter shall be measured immediately above the roots, if there are roots attached.

Since root wads are especially important, these will be tallied separately as to their presence, their location (using GPS) and whether they are connected to (part of) a piece of LWD (for example the rest of the tree) that is more than six feet long. If a root wad is connected to part of a tree but is less than six feet long overall, this is considered to be "not connected". The diameter of root wads (whether or not they are the large end of a piece of LWD) should be at least eight inches just above the roots.

This assessment requires that the observer determine when course debris that crosses the transect is connected to the same unit (branch or plant). For example, whether one twig or 10 twigs of a single branch cross the transect, the tally would only indicate one item. This is especially important when small branches or even roots that cross the transect are actually part of a large tree that fits within the large woody debris category (that is, has a small end diameter of at least four inches). In this case, the large unit would need to be measured and recorded as LWD even though the larger portion (that portion with a diameter greater than 4 inches) did not actually cross the transect. (In the case of a whole tree the length would be measured between the large end and the point where the diameter was four inches.)

Streambank / Shoreline Cover:
Riparian canopy cover over streams is important not only for its role in moderating stream temperatures through shading, but also as an indicator of conditions that control bank stability and the potential for inputs of course and fine organic material. As indicated in the previous section, organic inputs from riparian vegetation become food for stream organisms and structure for complex channel habitat.

The equipment needed for the Bank / shoreline cover and stability assessments is:

- Convex spherical densiometer (Model B) taped to limit grid intersections to 17
- Clinometer
- Surveyors rod
- Survey notebook with **Data Form IV-G**, blank write-in-the-rain paper and pencil.

Canopy Cover:
Vegetative canopy cover (or shade) will be determined using a conical spherical densiometer, as described by Platts et al. (1987). Instrument use procedures are described in **Appendix B**. The Densiometer determines relative canopy "closure" or canopy density, depending on how the readings are taken. This monitoring will be only for canopy density, which is the amount of the sky that is blocked within the closure by vegetation. Canopy density can change drastically through the year if the canopy vegetation is deciduous.

Canopy cover over the stream will be determined at each of the six cross sections established during the longitudinal thalweg survey. At each cross section densiometer readings will be taken at the following locations: once facing the left bank, once facing upstream at the middle of the channel, once facing downstream at the middle of the channel and once facing the right bank. Readings will be averaged for the entire reach.

At each bank on each of the six cross sections bank angle will be determined using a surveyors rod and a clinometer. The rod will be extended so that is it six feet long to provide a constant slope-width. The use of a clinometer is described in **Appendix B**.

The bank slope is measured in relation to the horizontal not the water surface. Therefore a vertical bank will be 90 degrees and gradually sloped banks will be less than 90 degrees. Since the clinometer only reads angles between 0 and 90 degrees any bank which is less than vertical will require only a direct reading from the clinometer. With undercut banks it will be necessary to turn the clinometer over and then subtract the resulting reading from 180 degrees.

If the bank is undercut horizontal depth of the undercut and the vertical water depth will be measured, using a surveyors rod, beneath the bank. The horizontal depth is the distance from the waters edge (the deepest part of the undercut which may or may not be underwater) out to the point where a vertical plumb line from the bank would hit the water surface. The vertical depth of water will be measured at the point where a vertical plumb line from the bank would hit the water surface.

Fish Populations:

Monitoring fish populations will continue to be a primary focus of the Coeur d'Alene Tribe's natural resource management efforts. This importance stems from the Tribe's traditional reliance on the fishery for sustenance, and the status of this project as part of the NWPPC Resident Fish Mitigation Program. More generally, the importance of fish population monitoring is reflected in the aquatic life use-support designations of many states (Barbour et al., 1999).

Fish population monitoring protocols used by the Coeur d'Alene Tribe are based on a fixed-distance method (Barbour et al. 1999) with a reach length of 200 feet to correspond with existing Tribal methods used at fish population index sites. Conceptually, this approach will provide a mixture of habitats in the reach and provide, at a minimum, duplicate physical and structural elements such as riffle/pool sequences.

The designated reach length will be a continuous, measured length (not broken up according to habitat units) and will be included within the 500-foot reference stream reach described in the **Sample Site Selection** section. During sampling/observation both upstream and downstream ends of the sampling reach will have nets placed across the channel to prevent fish from entering or leaving the study reach.

The collection or observation of a representative sample of the fish assemblage is essential, and fish monitoring procedures will address all habitat types in a sampled stream reach. However, effort will be made when setting up monitoring reaches to avoid regionally unique natural habitat. Each sampled reach will contain riffle, run and pool habitat, when available. Whenever possible, monitoring reaches will be located sufficiently upstream of any bridge or road crossing to minimize the hydrological effects on overall habitat quality.

Electrofishing

While all fish sampling methods can be considered selective to some degree, electrofishing is considered to be the most comprehensive and effective single method for collecting stream fishes. Some of the reasons for this are that electrofishing allows greater standardization of catch per unit of effort, it is appropriate in a variety of habitats and it is generally less selective than seining (collecting fish with nets) for different fish species (Barbour et al., 1999). Fish population monitoring (i.e., electrofishing and snorkeling) will be performed once per year during July and August as suggested by Hayslip (1993). Electrofishing procedures will follow those of Peck et al. (2001).

Electrofishing will be conducted using removal-depletion methods (Seber and LeCren 1967, Zippen 1958). Prior to starting fish collection, two block nets will be set across the channel at the upstream and downstream ends of the sampling reach. These will be anchored securely to the channel bottom and be supported above the water surface as well. After completing the first pass through the fish monitoring reach all collected fish will be processed (i.e., length (millimeters), weight (grams) and marked (clip dorsal fin). For fish that are 200 mm or more in length a "spaghetti" tag will be attached and the code number for this tag recorded and scale samples collected. After processing, all fish will be released outside of the study reach enclosure.

Fish population estimates require that a minimum of two shocks be made through the study reach. In addition, if the catch from the second pass is greater than 50% of the first pass a third and fourth pass must also be made. These additional passes ensure that all fish within the study reach are collected and documented.

POND PROJECTS

Photographic documentation:
General information on photographic documentation is presented in Section **1. a**., above. The subjects for pond project photo documentation include some required items and some that are optional. All required photos shall be taken from established photo points while optional photos may or may not. All photos must be logged on the **Data Form IV-A Photograph Log,** a copy of which appears in **Appendix C**.

The required photo subjects for ponds are:

- Permanent benchmarks, including photo point locations,
- Habitat improvement features.

Other optional but recommended photograph subjects are:

- Defining characteristics of site,
- Other important habitat components,
- Wildlife uses,
- Land uses near site.

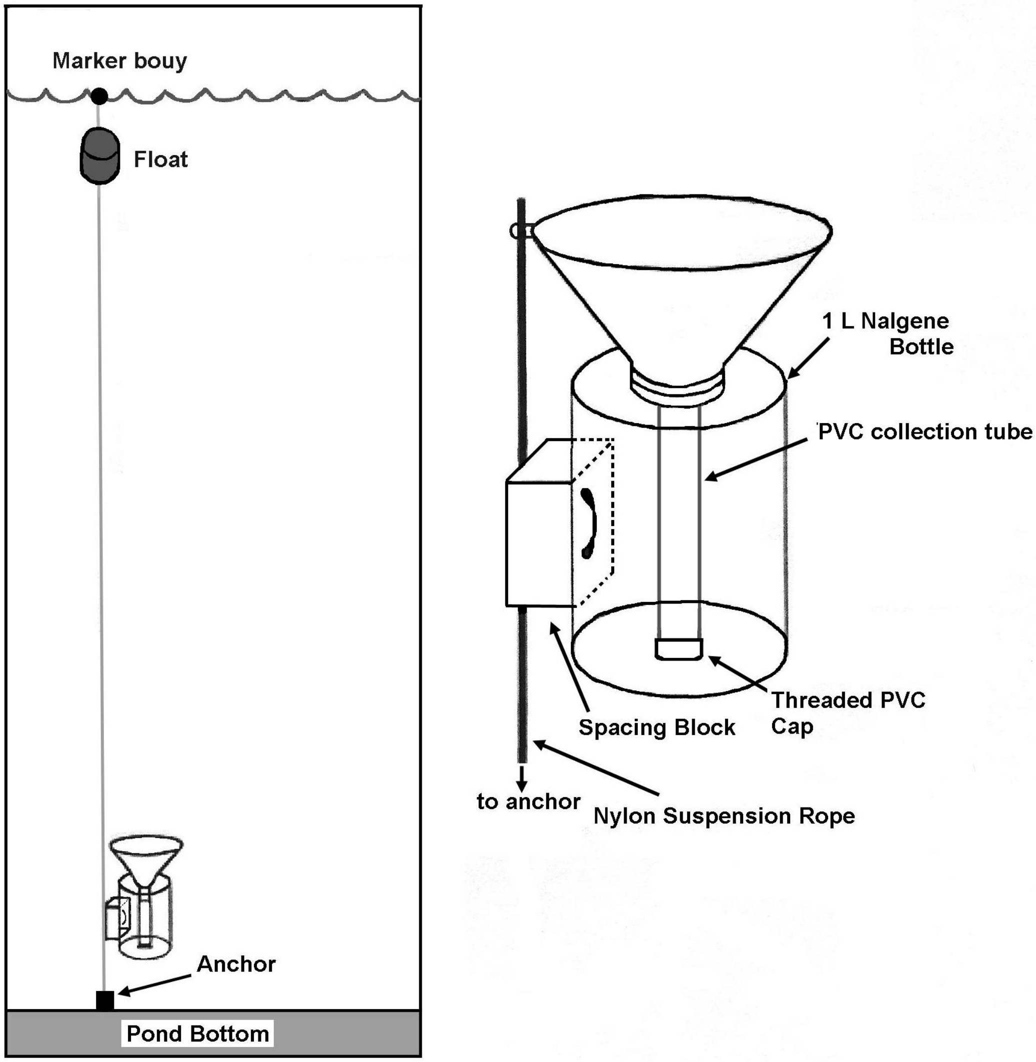
Sediment Trapping:
One of the expected benefits of constructing off-channel ponds is the trapping of silt that would otherwise enter main stem channels through tributaries. Sediment has been documented to be a primary pollutant of concern as documented by the State of Idaho 303d list of water bodies not meeting water quality standards (CDA Tribe 1998). For this reason it is important to document the effectiveness of constructed pond systems in trapping sediment.

Figure 1 presents the design of a sediment trap that has been used for research in the arctic, as described by Hardy et al. (1996). It is a simple design and will allow for the collection of particulate matter collected and subsequent analysis of total suspended solids (TSS). The TSS method will provide milligrams per liter value from a diluted subsample from the collection tube. The value is then multiplied by the dilution factor to estimate total dry weight sediment collected. The total dry weight sediment collected will then divided by the surface area of the sediment trap funnel to estimate the amount of sediment deposited in the pond during a time period. However, if the trap is deployed for extended periods, multiple TSS filters will be used to measure all sediment collected throughout the time period.

Although some sediment ponds have inflow through culverts, an unknown amount of sediment is delivered to the ponds via rill and over-land erosion directly from the agriculture fields. For this reason, sampling the discharge from the culvert will underestimate the amount of sediment the pond is trapping. Thus, we will deploy the sediment traps at two different depths, two meters, and four meters along the mooring line. The four meter trap is intended to sample far enough above the pond bottom to not sample the re-suspended sediment from wind events. To measure the variability of sediment depostion in the ponds, we will moor multiple traps across two axes in a pond. Three traps will be at mid-pond sites and three traps will be at peripheral, shallow pond sites. We will use the results from this initial experiment to develop a refined sample design for sediment traps at the other four ponds.

Physical Water Quality Profiles

The monitoring of water quality in ponds will be performed using the Hydrolab MiniSonde® and the PRO4000® or Allegro® dataloggers to test for the following parameters: conductivity, dissolved oxygen, pH and temperature.



RIPARIAN PROJECTS

<u>Photographic documentation:</u>
All required photos will be taken from established photo points The photo subjects will include:

- Each end of vegetation cross sections and transects (including where cross sections cross the stream channel),
- Permanent benchmarks, including photo point locations,
- Habitat improvement sites.
- Defining characteristics of site or vegetative cross sections / greenline,
- Unusual or obviously disturbed areas,
- Other important habitat components,

- Wildlife uses,
- Land uses near site.

Vegetation Composition:
The two protocols presented in this Section allow the characterization of the basic structure of the riparian vegetation through the documentation of the percent coverage of various plant communities. The first protocol, "Vegetation Cross-Section Composition" will be performed across the monitoring reaches perpendicular to the stream channel, and the second protocol, "Greenline Composition" will be performed along the streambank through the study reaches. Both protocols are taken from Winward (2000) and require trained surveyors to identify the dominant plant species.

Vegetation Cross-Section Composition:
This procedure will allow for the quantification of the percentage of plant communities found across a riparian area and the data collected may be used to indicate how much change (disturbance) has occurred in the riparian area or how closely that area compares to a desired condition. The survey will be performed along the six cross sections that extend across the entire riparian area as described in **Section 1. d**. The extent of each plant community along the cross sections will be measured either by using a measuring tape or by counting the number of steps or paces that is occupied by a community. Pacing cross sections has been found to be as reliable as using a measuring tape for calculating the community type composition using this protocol (Winward 2000). This is because either the measured distance or number of steps is ultimately calculated to percent so length of each step does not need to be known as long as one person performs all of the pacing on any given cross section

Community type composition will be calculated by taking the number of steps encountered (or measured distance) for each apparent community for all six cross sections divided by the total number of steps taken (or total distance). The "community" could be a single species or a group of species. Determination of plant species requires that the surveyors have a basic knowledge of the dominant plants in and around the Coeur d'Alene reservation or experience in plant identification.

Photographs will be taken at each permanent cross section end stakes and will show the general setting of the cross section. Photographs will also be taken where the cross section crosses the stream and at other locations along the cross section where a pictoral record will be useful in visualizing specific features of the area

Greenline Composition:
The "greenline" is "the first perennial vegetation that forms a lineal grouping of community types on or near the waters edge (Winward 2000). Most often this occurs at or slightly below the bankfull stage. Sampling plant communities along this streamside boundary provides useful information over that collected in the cross section survey. The presence of water nearby makes the this area favorable to plant growth and this allows land managers to make early evaluations of the effects of both restoration or disturbance. Perhaps most importantly, however, there has been found to be a strong relationship between the amount and kind of vegetation along the greenline and bank stability. The majority of naturally occurring plant species in this area have rooting characteristics that enhance bank stability. The greenline survey protocol outline below also includes documentation of other stabilizing factors such as LWD and large rocks.

The greenline survey will be performed along each streambank through the entire 500 foot long monitoring reach. The greenline transect will begin on the right bank (looking downstream) and will use the step / pace approach described above for the cross section protocol. If interruptions to the greenline are encountered these must also be paced off and recorded. Examples might be tributaries entering the stream being studies, vehicle crossings or grazed areas.

UPLAND PROJECTS

Photographic documentation:
General information on photographic documentation is presented in Section **1. a**.. The subjects for upland project photo documentation include:

- Permanent benchmarks, including photo point locations,
- Vegetation monitoring plots.
- Defining characteristics of site,
- Other important habitat components,
- Wildlife uses,
- Land uses near site.

IV. MONOTORING COSTS

Detailed cost estimates have not been developed for this document. Because this monitoring plan is expected to be implemented over a long time frame (>10 years) the unit costs for collecting specific monitoring attributes is subject to change. The table below provides a summary of personnel requirements and estimates of collection times for the protocols that will be implemented and these may be useful in developing annual cost estimates.

Table 13. Summary of restoration monitoring attributes, parameters and protocols, and personnel requirements.

Attribute	Parameter/ Protocol	Frequency (time/year)	Collection Time (hours/site)*	Comments	Equipment	Expertise**
I. Water Column a. Temperature	Recording Thermograph	Continuous during summer	1	Provides a complete data record	Recording Thermograph	F: Technician A: Fisheries/ Hydrology
b. Water Quality Profile (ponds only)	Hydrolab, Inc. (1997)	2 times during summer	3		Hydrolab	F: Technician A: Fisheries/ Hydrology
c. Discharge	Peck et al. (2001); Rantz (1982)	1 time during summer	1			F: Technician A: Fisheries/ Hydrology
d. Shade	Canopy Density/ Densiometer Platts et al. (1987)	1	1	Applies to streams with woody vegetation	Densiometer	F: Technician A: Fisheries/ Hydrology
II. Stream Channel/ Streambank a. Channel Morphology	Longitudinal Profile Rod and Level Peck et al. (2001)	Annually for selected sites	2-3		Rod and level	F: Technician A: Fisheries/ Hydrology
	Channel Cross Section Rod and Level or Sag Tape Methods Platts et al. (1987)	Annually for selected sites	2-3	Bankfull level may be difficult to locate.	Rod and level	F: Technician A: Hydrology
	Width/Depth ratio Platts (1983) – 3 point method Rosgen (1996)	Annually for selected sites	1	Water width and depth vary within season	Tape and rod	F: Technician A: Technician
b. Channel Stability	Sediment Supply Pfankuch (1975)	Once every 3 years	2	Rosgen stratified the rating by stream type		F: Technician A:Fisheries/ Hydrology

Attribute	Parameter/ Protocol	Frequency (time/year)	Collection Time (hours/site)*	Comments	Equipment	Expertise**
c. Streambank Stability	Channel Cross-Sections Rod and Level Rosgen (1996)	Annually for selected sites	2-3	Soil alteration measures false, broken, or eroding banks. Bank stability rates bank protective cover.	Tape	F: Technician A: Fisheries/ Hydrology
d. Substrate Sedimentation	Particle Size Distribution - Percent Fines/Pebble Count Wolman (1954); Rosgen (1996)	1	2	Estimates percent of substreate surface area covered by fines.	Rulers	F: Technician A: Hydrology/ Fisheries
e. Vegetative Overhang	Vegetative Overhang (at transect) Platts et al. (1987)	1	<1	Measures length of overhang at each transect.	Measuring rod and tape	F: Technician A: Hydrology/ Fisheries
f. Streambank Angle/ Undercut	Streambank Undercut (at transect) Platts et al. (1987)	1	<1	Measures depth of undercut at each transect.	Measuring rod	F: Technician A: Hydrology/ Fisheries
g. Woody Debris	Platts et al. (1987)	1 every 3 years	2	Measures volume of wood in largest size classes		F: Technician A: Hydrology/ Fisheries
III. Streambank Vegetation a. Vegetative Composition	Green Line Survey Winwood (2000)	1 every 3 years	1-2	Measures length of vegetation community types.	Measuring tape	F: Botany A: Botany/ Fisheries
b. Woody Species Regeneration	Woody Species Regeneration USDA Forest Service (1992)	1 every 3 years	1-4	Measures number of woody plants by age class.	Measuring tape and 2 meter rod	F: Technician A: Botany/Range Fisheries
IV. Biological Evaluation a. Fish Community	Fish Communities Peck (2001)	1 (or seasonal)	2-3		Electrofishing unit, nets, weighing scales	F: Technician A: Fisheries

* Collection time/sample assumes a two-person crew.
** Expertise is described for collection of data in the field, as well as for data analysis.

V. BIBLIOGRAPHY

Armour, C.L., K.P. Burnham, and W.S. Platts. 1983. Field methods and statistical analyses for monitoring small salmonid streams. USDI, Fish and Wildlife Service. FWS/OBS-83/33.

Bain, M.B and N.J. Stevenson (eds). 1999. Aquatic Habitat Assessment: Common Methods. American Fisheries Society, Bethesda, MD.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Beschta, R.L. and W.S. Platts. 1986. Morphological features of small streams—Significance and function. Water Resources Bulletin, v. 22, p. 369–379.

Bisbal, Gustavo A. 2001. Conceptual Design of Monitoring and Evaluation Plans for Fish and Wildlife in the Columbia River Ecosystem. Environmental Management, v 28, No. 4, pp 433-453.

Bisson, P.A. and D.R. Montgomery. 1996. Valley segments, stream reaches, and channel units. Pages 23-52 in: R.R. Hauer and G.A. Lamberti, editors. Methods in stream ecology. Academic Press, New York, NY.

Brown, R.S. and W.C. Mackay. 1995. Fall and winter movements and habitat use by cutthroat trout in the Ram River, Alberta. Trans. Am. Fish. Soc. 124:873-885.

Brownie, C., J.E. Hines, J.D. Nichols, K.H. Pollock, and J.B. Hestbeck. 1993. Capture-recapture studies for multiple strata including non-Markovian transitions. Biometrics 49:1173-1187.

Burton, Timothy A. 1991. Monitoring Stream Substrate Stability, Pool Volumes and Habitat Diversity. Water Quality Monitoring Protocols - Report 3. Idaho Department of Environmental Quality, Boise, ID.

Coeur d' Alene Tribe. 2000. Assessment of Environmental Concerns on and near the Coeur d' Alene Reservation. Executive Summary, Volume 1. U.S. Environmental Protection Agency. 182pp.

Coeur d'Alene Tribe. 1998. Lake Creek Watershed Assessment. Environmental Protection Agency. 27pp.

Cunjak, R.A. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Can. J. Fish. Aquat. Sci. 53(Supplement 1):267-282.

Cupp, C.E. 1989. Valley segment type classification for forested lands of Washington. Washington State Timber/Fish/Wildlife Agreement, TFW-AM-89-001, Department of Natural Resources, Olympia, WA.

Dissmeyer, George, 1994. *Evaluating the Effectiveness of Forestry Best Management Practices in Meeting Water Quality Goals or Standards,* U. S. Department of Agriculture, Forest Service, Miscellaneous Report 1520. 179 pages.

Ebersol, J.L. W.J. Liss and C.A. Frissell. 1997. Restoration of stream habitats in the western United States:restoration as reexpression of habitat capacity. Environmental Management 21:1-14.

Federal Interagency Stream Restoration Working Group (FISRWG). 2001. Stream Corridor Restoration; Principles, Processes, Practices. GPO Item No. 0120-A, SuDocs No. A 57.6/2:EN3/PT.653, ISBN-0-934213-59-3. Internet address: www.usda.gov/stream_restoration.

Fitzpatrick, F.A., I.R. Waite, P.J. D'Arconte, M.R. Meador, M.A. Maupin, and M.E. Gurtz. 1998. Revised Methods for Characterizing Stream Habitat in the National Water-Quality Assessment Program. U.S. Geological Survey Water-Resources Investigations Report 98-4052

Frissell, C.A., W.J. Liss, C.E. Warren, and M.D. Hurley. 1986 A hierarchical framework for stream habitat classification—Viewing streams in a watershed context. Environmental Management, v. 10, p. 199–214.

Gibbs, J.P. 1995. Monitor:Users Manual. http://www.mp1-pwrc.usgs.gov\pocase\monitor.html

Gowan, G., and K.D. Fausch. 1996. Long-term demographic responses of trout populations to habitat manipulation in six Colorado streams. Ecological Applications 6(3):931-946.

Graves, S., K.L. Lillengreen, D.C. Johnson, and A.T. Scholz. 1990. Fisheries habitat evaluation on tributaries of the Coeur d'Alene Indian Reservation. Bonneville Power Administration. Division of Fish and Wildlife. Portland Oregon. Project #90-44. 68p.

Hardy, D.R., R.S. Bradley, and B. Zolitschka. 1996. The climatic signal in varied sediments from Lake C-2, northern Ellesmere Island, Canada. *Journal of Paleolimnology*, 16, 227-238.

Hauer, F.R., G.C. Poole, J.T. Gangemi, and C.V. Baxter. 1999. Large woody debris in bull trout Salvelinus confluentus spawning streams of logged and wilderness watershed in northwest Montana. Can. J. Fish. Aquat. Sci. 56:915-924.

Hayslip, Gretchen (ed). 1993. EPA Region 10 In-Stream Biological Monitoring Handbook (for wadable streams in the Pacific Northwest). Publicatin EPA 910/9-92-013. Environmental Services Division, US EPA, Seattle, WA.

Helfman, Gene. 1983. Chapter 19 Underwater Methods. in : Neilsen, L.A. and Johnson, D.L. (eds) Fisheries Techniques. American Fisheries Society, Bethesda, MD. 468 pp.

Hestbeck, J.B., J.D. Nichols, and R.A. Malecki. 1991. Estimates of movement and site fidelity using mark-resight data of wintering Canada geese. Ecology. 72(2):523-533.

Hillman, T.W. and Giorgi, A.E. 2002. Monitoring Protocols: Effectiveness Monitoring of Physical/Environmental Indicators In Tributary Habitats. Bonneville Power Administration, Portland, OR. 104pp.

Hydrolab Corporation. 1997. DataSonde® 4 and MiniSonde® Water Quality Multiprobes Users Manual. Austin, TX.

Idaho Department of Environmental Quality (IDEQ). 1999. Beneficial Use Reconnaissance Project Workplan for Wadable Streams. BURP Technical Advisory Committee, Boise, ID.

Jacobsen, Paul; Thom, Barry. 2001. *1998-2000 Habitat Restoration Effectiveness Monitoring For The Western Oregon Stream Project.* Oregon Department of Fish and Wildlife, Portland, Oregon. Monitoring Program Report Number OPSW-ODFW-2001-07. 25 pages.

Jakober, M.J., T.E. McMahon, R.F. Thurow, and C.G. Clancy. 1998. Role of stream ice on fall and winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. Trans. Am. Fish. Soc. 127:223-235.

Johnson, David H., N. Pittman, E. Wilder, J.A. Silver, R.W. Plotnikoff, B.C. Mason, K.K. Jones, P. Rogers, T.A. O'Neil and C. Barrett. 2001. Inventory and Monitoring of Salmon Habitat in the Pacific Northwest - Directory and Synthesis of Protocols for Management/Research and Volunteers in Washington, Oregon, Idaho, Montana, and British Columbia. Washington Department of Fish and Wildlife, Olympia, Washington. 211pp.

Johnson, J. E. 1987. Protected fish of the United States and Canada. American Fisheries Society, Bethesda, MD. 42 pp.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries Vol. 66: pp21-27.

Kellerhals, R., C.R. Neill and D.I. Bray. 1972. Hydraulic and geomorphic characteristics of rivers in Alberta. Research Council of Alberta, River Engineering and Surface Hydrology Report 72-1: 52pp.

Kendall, W.L., J.D. Nichols, and J.E. Hines. 1997. Estimating temporary emigration using capture-recapture data with Pollack's robust design. Ecology 78(2):563-578.

Lacy, M. and B. Thom. 2000. Restoration effectiveness monitoring plan for the western Oregon stream project, version 2.0. Oregon Department of Fish and Wildlife, Corvallis, OR.

Langbein, W.B. and L.B. Leopold. 1966. River meanders – Theory of minimum variance. U.S. Geological Survey Prof. Paper No. 422-H: 15 pp.

Leopold, L.B. 1994. A View of the River. Harvard University Press, Cambridge, MA. 298 pp.

Leopold, L.B., M.G. Wolman, M.G., and J.P. Miller. 1964. Fluvial processes in geomorphology. W.H. Freeman, San Francisco, CA. 522 p.

Lillengreen, K.L., A.J. Vitale, R. Peters. 1998. Coeur d'Alene Tribe project management plan: enhancement of resident fish resources within the Coeur d'Alene Indian Reservation. Bonneville Power Administration, Project Number 90-044, Portland, Oregon

Lillengreen, K.L., A.J. Vitale, and R. Peters. 1996. Fisheries habitat evaluation on tributaries of the Coeur d'Alene Indian Reservation, 1993-1994 annual report. USDE, Bonneville Power Administration, Portland, OR. 260p.

Lillengreen, K.L., T. Skillingstad, and A.T. Scholz. 1993. Fisheries habitat evaluation on tributaries of the Coeur d'Alene Indian Reservation. Bonneville Power Administration. Division of Fish and Wildlife. Portland Or. Project # 90-44. 218p.

Meyers, L.H. 1987. Montana BLM riparian inventory and monitoring, Riparian Technical Bulletin #1, Publication #BLM-MT-PT-88-001-4410. Billings, MT.

Murphy, M.L. and W.R. Meehan. 1991. Stream ecosystems. American Fisheries Society Special Publication 19:17-46.

Naiman, R.J., D.G. Lonzarich, T.J. Beechie, and S.C. Ralph. 1992. General principles of classification and the assessment of conservation potential in rivers. Pages 93-123 in: P.J. Boon, P. Calow, and G.E. Petts, editors. River conservation and management. John Wiley and Sons, New York, NY.

Northcote, T.G. 1997. Potamodromy in Salmonidae- Living and moving in the fast lane. N. Am. J. Fish. Manag. 17:1029-1045.

Osborn, J.F. and J.M. Stypula. 1987. New models of hydrological and stream channel relationships. In: Erosion and sedimentation in the Pacific Rim. IAHS Publ. No. 165, Oregon State University, Corvallis, OR.

Osprey Environmental Services. 1996. A guide to photo documentation for Aquatic Inventory: a resources inventory committee publication. B.C. Ministry of Environment, Lands and Parks, Fisheries Branch, Vancouver, BC Canada. Available at internet website http://srmwww.gov.bc.ca/risc/PUBS/AQUATIC/Photodoc/Index.htm.

Osterkamp, W., L.J. Lane and G.R. Foster. 1983. An analytical treatment of channel morphology relations. U.S. Geol. Surv. Prof. Paper 1288: 21pp.

Overton, C. K., S.P. Wollrab, B.C. Roberts, and M.A. Radko. 1997. R1/R4 (Northern/Intermountain Regions) fish and fish habitat standard inventory procedures handbook. USDA Forest Service General Technical Report INT-GTR-346, Ogden, UT.

Paulsen, C., S. Katz, T. Hillman, A. Giorgi, C. Jordan, M. Newsom, and J. Geiselman. 2002 (Review Draft). Guidelines for action effectiveness research proposals for FCRPS offsite mitigation habitat measures.

Peck, D.V., J.M. Lazorchak & D.J. Klemm (eds). 2001. Western Pilot Study DRAFT Field Operations Manual for Wadable Streams. Environmental Monitoring and Assessment Program - Surface Waters, Corvallis, OR.

Peters, R. P., A.J. Vitale and K. L. Lillengreen. 1998. Supplementation Feasibility Report on the Coeur d'Alene Indian Reservation. Dept. of Energy. DOE 10544-4 R118

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross and R.M. Hughes. 1989. Rapid Bioassessment Protocolsfor Use in Streams and Rivers: Benthic Macroinvertebrates and Fish. Publication # EPA/440/4-89/001. Assessment and Watershed Protection Division, US Environmental Protection Agency, Washington D.C.

Platts, W.S., C. Armour, G.D. Booth, M. Bryant, J.L. Bufford, P. Cuplin, S. Jensen, G.W. Lienkaemper, G.W. Minshall, S.B. Monsen, R.L. Nelson, J.R. Sedell and J.S. Tuhy. 1987. Methods for Evaluating riparian Habitats with Applications to Management. General Technical Report INT-221. USDA Forest service, Ogden UT.

Plotnikoff, Robert W. 1998. Stream Biological Assessments (Benthic Macroinvertebrates) for Watershed Analysis, Mid-Sol Duc Watershed Case Study. Publication 98-334. Environmental Investigations & Laboratory Services Program, Washington Department of Ecology, Olympia, WA.

Plotnikoff, R.W. and C. Wiseman. 2001. Benthic Macroinvertebrate Biological Monitoring Protocols for Rivers and Streams, 2001 Revision. Publication #01-03-028. Environmental Assessment Program, Washington Department of Ecology, Olympia, WA.

Rantz, S.E. et al. 1982. Measurement and computation of streamflow: Volume I: Measurement of Stage and Discharge. U.S. Geological Survey Water Supply Paper 2175. U.S. Government Printing Office, Washington, D.C.

Reynolds, James B. 1983. Chapter 8 Electrofishing. In: L.A. Neilsen, D.L. Johnson and S.S. Lampton (eds), Fisheries Techniques. American Fisheries Society, Bethesda, MD468 pp.

Richmond, A.D., and K.D. Fausch. 1995. Characteristics and function of large woody debris in subalpine Rocky Mountain streams in northern Colorado. Can. J. Fish. Aquat. Sci. 52:1789-1802.

Ritter, J.R. 1967. Bed-material movement. Middle Fork Eel River, California. U.S. Geological Survey Prof. Paper 575-C: C219-C221.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Rosgen, D.L. 1994. A classification of natural rivers. Catena, Vol 22:169-199. Elsevier Science, B.V. Amsterdam.

Rosgen, Dave. 1993. Applied Fluvial Goemorphology, Training Manual for River Short course. Wildland Hydrology, Pagosa Springs, CO. 450 pp.

Rosgen, D.L. 1985. A stream classification system. In: Riparian Ecosystems and Their Management. First North American Riparian Conference. Rocky Mountain Forest and Range Experiment Station, RM-120:91-95.

Seber, G.A.F., and E.D. LeCren. 1967. Estimating population parameters from catches large relative to the population. Journal Animal Ecology 36:631-643.

Smith-Root, Inc. 1991, 1993. Type VII POW Backpack Manual. Vancouver, WA.

Schuett-Hames, D., A.E. Pleus, J. Ward, M. fox and J. Light. 1999. TFW Monitoring Program Method Manual for Large Woody Debris Survey. Publication #DNR 106, prepared for WDNR under Timber, Fish and Wildlife Agreement TFW-AM9-99-004.

Spahr, G., L. Armstrong, D. Atwood and M. Rath. 1991. Threatened, endangered and sensitive species in the Intermountain Region. USDA Forest Service, Odgen, UT.

Thurow, Russel F. 1994. Underwater Methods for Study of Salmonids in the Intermountain West. General Technical Report # INT-GTR-307. USDA Forest Service, Odgen, UT. 28 pp.

U.S. Environmental Protection agency (USEPA). 2001. Western Pilot Study DRAFT Field Operations Manual for Wadable Streams. Environmental Monitoring and Assessment Program - Surface Waters. Corvallis, OR.

U.S. Environmental Protection agency (EPA). 1993. Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on western Rangeland Streams, Publication #EPA 910/R-93-017. Water division, Surface Water Branch, Seattle, WA.

Winward, Alma H. 2000. Monitoring the Vegetation Resources in Riparian Areas. Gen. Tech. Rep. RMRS-GTR-47. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Wolman, M.G. 1954. A method of sampling coarse carrier-bed material. Transactions of American Geophysical Union Volume 35, pp 951-956.

Zar, J.H. 1984. Biostatistical Analysis, first edition. Prentice Hall, Upper Saddle River, New Jersey.

Zippen, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-90.

APPENDIX A. LOCATIONS AND DESCRIPTIONS OF HABITAT RESTORATION PROJECTS

Table 1. Summary of restoration/enhancement treatments, goals and project id for restoration projects implemented on the Coeur d'Alene Reservation as of July, 2002. Project Id is a river-mile designation and corresponds to the identifying numbers shown on Figures 1-3 in this appendix.

Project Category/Treatment Type	***Project ID[1]***	**Goal**
Instream		
Streambank Stabilization	*B_8.1* *B_8.5* *E_1.3* *E_1.6*	Increase streambank stability by reducing stream power or protecting erodible surfaces
Instream Structure	*B_8.5* *L_8.2*	Increase cover, habitat complexity, habitat types
Channel Construction/Modification	*B_6.5* *B_8.1*	Increase stream interaction with floodplain; increase habitat complexity; reduce downstream flooding
Fish Passage		Improve fish passage
Riparian		
Planting	*B_6.5* *B_8.1* *B_8.5* *B_8.9* *E_0.1* *L_6.0* *L_7.3* *L_7.6/0.0* *L_8.2* *L_8.5* *L_8.8*	Increase stream channel shading; increase LWD and/or allocthonous nutrient inputs; increase streambank stability
Vegetation Management		Increase native and/or desirable plant species composition; reduce dominance by exotic plants
Grazing Management	*B_8.5* *B_8.1* *B_6.5*	Manage riparian pastures to reduce impacts to vegetation and streambank stability
Water Storage	*L_5.2/0.2* *L_5.4/0.1* *L_6.7/0.2/0.0* *L_8.7/0.1* *L_6.5/0.1*	Increase water retention time; reduce nutrient and sediment input to stream channels
Upland		
Slope Stabilization	*B_8.1/0.0* *B_8.5/0.0* *B_8.5/0.2* *L_5.9/0.4/0.0* *L_7.3/0.2* *L_8.2/0.0/0.0*	Increase upslope stability; decrease erosion/stream sedimentation
Gully Repair	*L_5.9/0.4*	Reduce the rate of head-cutting and incision; decrease erosion and stream sedimentation

Project Category/Type	***Project ID[1]***	***Goal***
Road		
Surfacing		Reduce erosion from road surfaces
Improvement	*E_1.6*	Reduce erosion and stream sedimentation; reduce risks of crossing failures; reduce hydrologic impacts of roads on streams
Decommission		Decrease road density and access; eliminate erosion and stream sedimentation; reduce hydrologic impacts

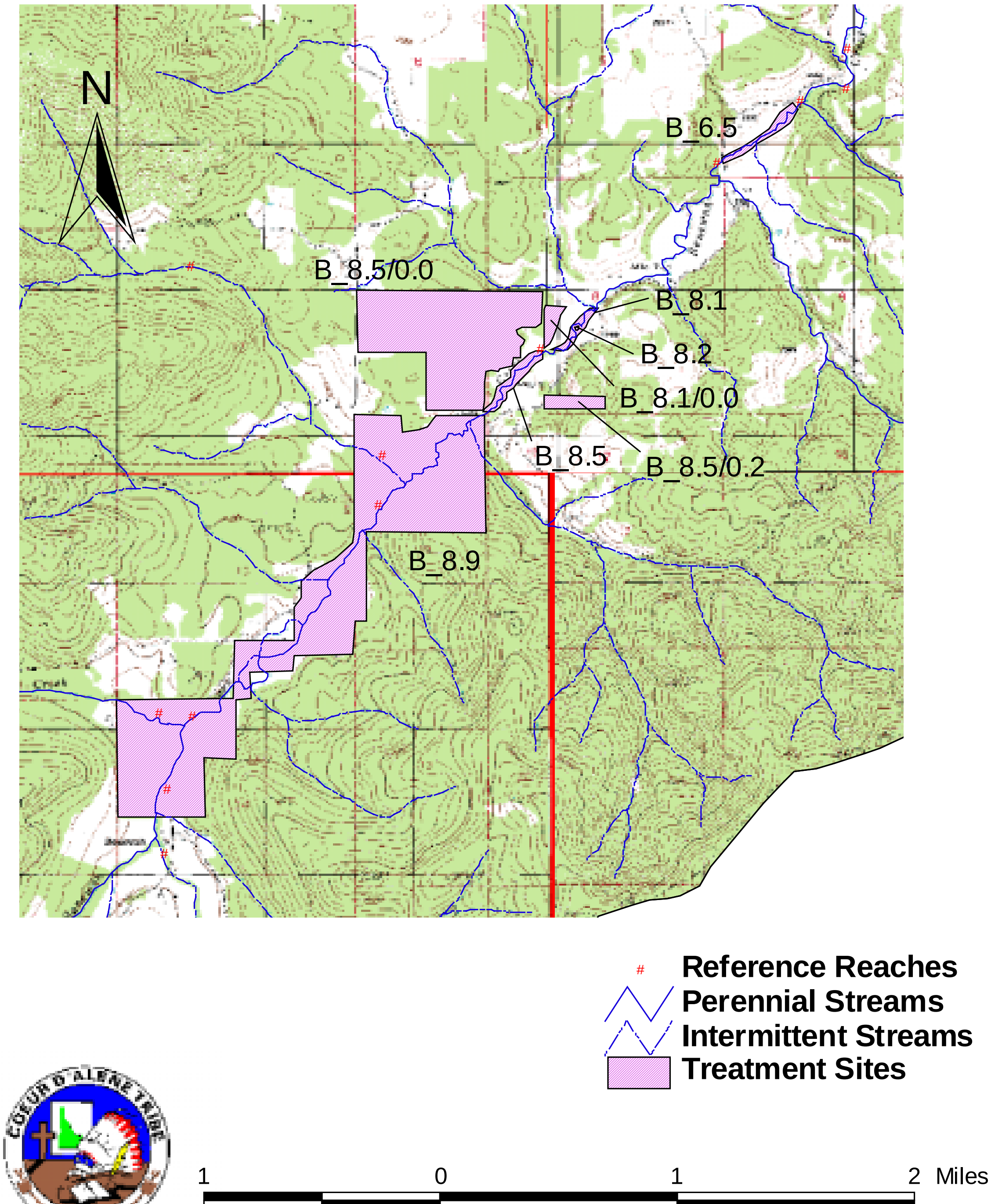


Figure 1. Restoration project locations and project id for the Benewah Creek watershed.

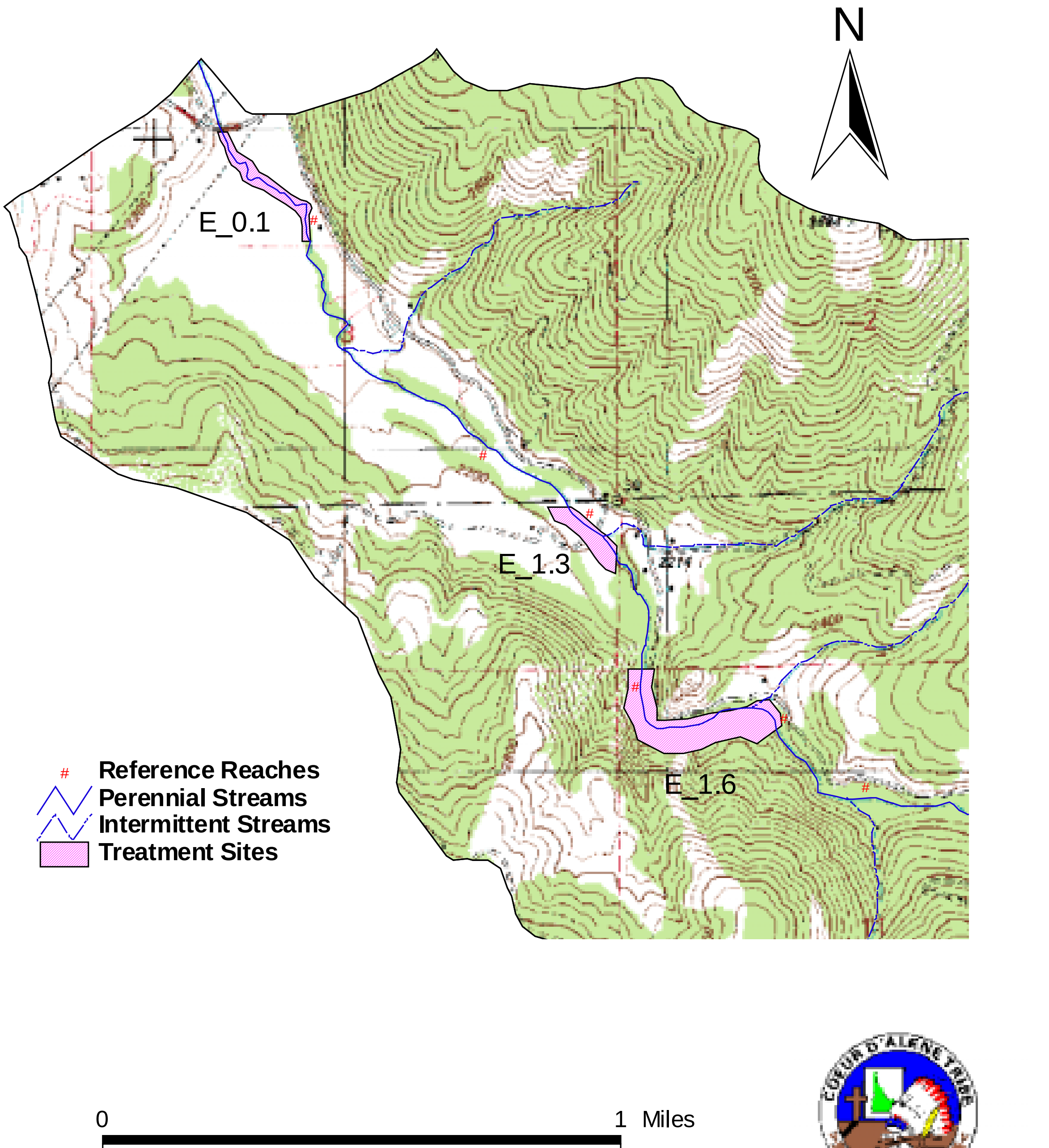


Figure 2. Restoration project locations and project id for the Evans Creek watershed

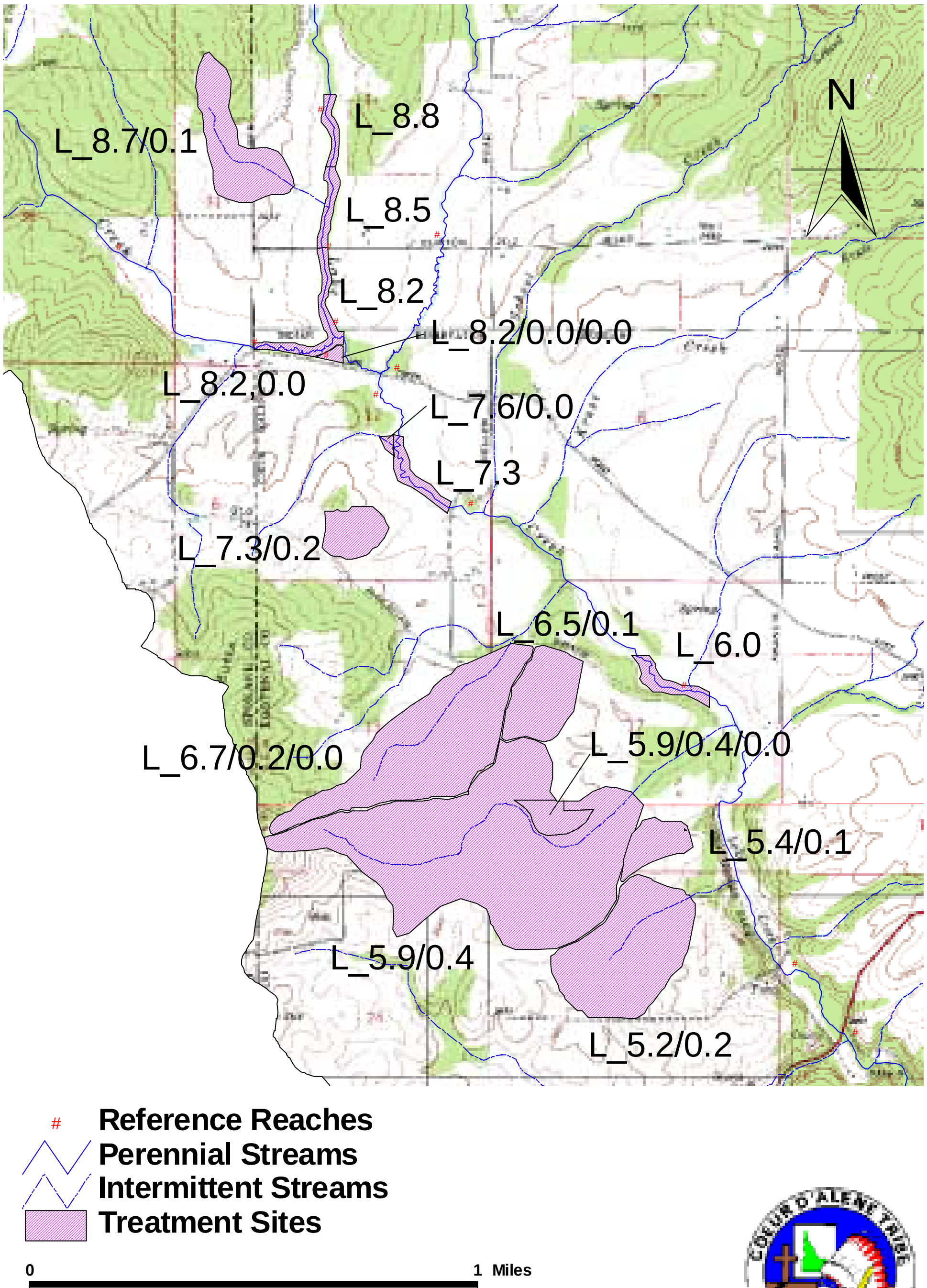


Figure 11. Restoration project locations and project id for the Lake Creek watershed

APPENDIX B: POWER ANALYSIS RESULTS

Introduction

Westslope cutthroat trout populations were estimated on an annual basis in 52 reaches from four streams (Alder, Benewah, Evans and Lake Creeks) on the Coeur d'Alene Reservation from 1996 through 2001. We performed a power analysis using all existing data to determine the current power to detect changes in the westslope cutthroat trout population, determine if additional sites are needed, and estimate power if population estimates continue to be conducted on an annual basis for the next five or ten years.

Methods

We used the program MONITOR (Gibbs 1995) to estimate the power to detect a positive or negative trend in population. The MONITOR program uses Monte Carlo simulations to model count surveys over time. The program then generates detection rates produced from route-regression analysis. (The Monitor program can be downloaded from http://www.mp1-pwrc.usgs.gov\pocase\monitor.html). We ran three types of simulations. In the first simulation, we compared power using the current data, to power when one through five sample sites were added to the current sites. The addition of five sites would increase the number of population estimate sites, and effort by 30% for Benewah Creek, 40% for Alder Creek, and 50% for Evans and Lake Creeks. We used alpha levels of 0.05, 0.1 and 0.20 in all simulations. The second type of simulation was a comparison of power using the current data when each site was sampled one additional time per year. The current method is to sample once per year. Thus, sampling twice a year would effectively double the number of samplings and effort. The third type of simulation estimated power when the current annual estimates were continued for the next five and ten years.

Results

Figures 11-14 show the comparison of an additional five sites added to the current number of sites. At the current sampling program, all streams, except Lake Creek (Figure 14) have at least an 80% probability to detect a 10% increase in the cutthroat trout population at an alpha level of 0.20. Benewah Creek (16 sites) and Evans Creek (10 sites) have the highest power to detect trends in westslope cutthroat trout population (Figure 12). Lake Creek has the lowest power of the four streams, only having 77% power to detect a 10% increase in the cutthroat trout population at an alpha level of 0.20 (Figure 14.) Lake Creek exhibited the highest increase in power to detect positive trends when five additional sites were added (Figure 14). Alder Creek and Lake Creek had the highest increase in power to detect negative trends (Figure 11 and 14). Power did not increase as dramatically for Evans and Benewah Creeks (Figures 11 and 12) when five additional sites were added. One aspect to note in this analysis is that currently, adequate power (at least .80) only exists for detecting coarse population change, i.e. 8-10%. In all four populations, adding five sample sites did not increase the resolution to detect more subtle changes, i.e. 0-3%.

When accounting for all sites, the addition of an extra sample per year in each reach does not increase power as effectively as did the addition of five extra sites (Figures 15-18). Given the fact that it also doubles the effort makes this method less appealing. Even so, Lake Creek would benefit most from the sampling each site twice per year (Figure 18).

Figure 9 presents the power when all current population estimate sites are combined. This gives an estimate of the overall power to detect trends on a basin-wide scale. The increased sample size increases power by detecting moderate trends (6% and 7%) with 80% and even 90% probability at an alpha level of 0.2. At this level there is a > 90% probability of detecting a +10% change at an alpha level of 0.05 (a 5% probability of committing a type II error). Thus, the current data enables detection of coarse trends at a high power on a basin-wide scale.

Figures 20-23 present power to detect trends in cutthroat trout populations if the streams are sampled annually for the next five and ten years. This would produce at least an 11 year long, annual population estimate data set. Simulating power to detect changes in westslope cutthroat trout populations in the next five or ten years is important because this time frame overlaps the habitat restoration projects when they are likely beginning to provide more habitat for rearing and spawning. These additional five and ten year simulations reveal the dramatic effect that sampling consistently over time has toward increasing the power to detect changes in populations. For example, in Benewah Creek an additional five years of population estimate sampling reveals an 80% probability of detecting a +4%, or a –4% change at an alpha level of 0.05 (Figure 21). This is a much finer detection limit at a lower probability to commit a type II error when compared to Figure 2. An additional 10 years of sampling on Benewah Creek allows a 90% probability of detecting a +3% or –7% at an alpha level of 0.05 (Figure 21). For Lake Creek, an additional five years of population estimate sampling allows an 80% probability of detecting a +8% change at an alpha level of 0.05. (Figure 23), a dramatic increase in power compared to the power estimates for Lake Creek in Figure 4. Alder and Evans Creeks (Figures 20 and 22) exhibit the same significant increases in power at lower alpha levels as Benewah and Lake Creeks.

Conclusions

When balancing sample site additions with effort and cost, we believe a small benefit would be gained by adding five sites to Lake Creek and maybe Alder Creek. The addition of an extra sample time for every reach per year didn't have a large benefit, especially when considering that effort and cost would be doubled. However, additional population estimate sites will likely not be needed because of the substantial increase in power to detect population changes when we continue our annual population estimate sampling the next five to ten years. We don't expect any increase in westslope cutthroat trout population until at least several generations have benefited from the restoration projects. Since it takes an adfluvial westslope cutthroat trout 6-8 years to reproduce, we will have sampled populations of westslope cutthroat trout annually at least that many years, dramatically increasing the power to detect changes in the population as the above results in figures 20-23 show. For that reason, we are comfortable with the current population estimate program and we will track the program with new power analyses every year, allowing the truthing of the power estimate simulations.

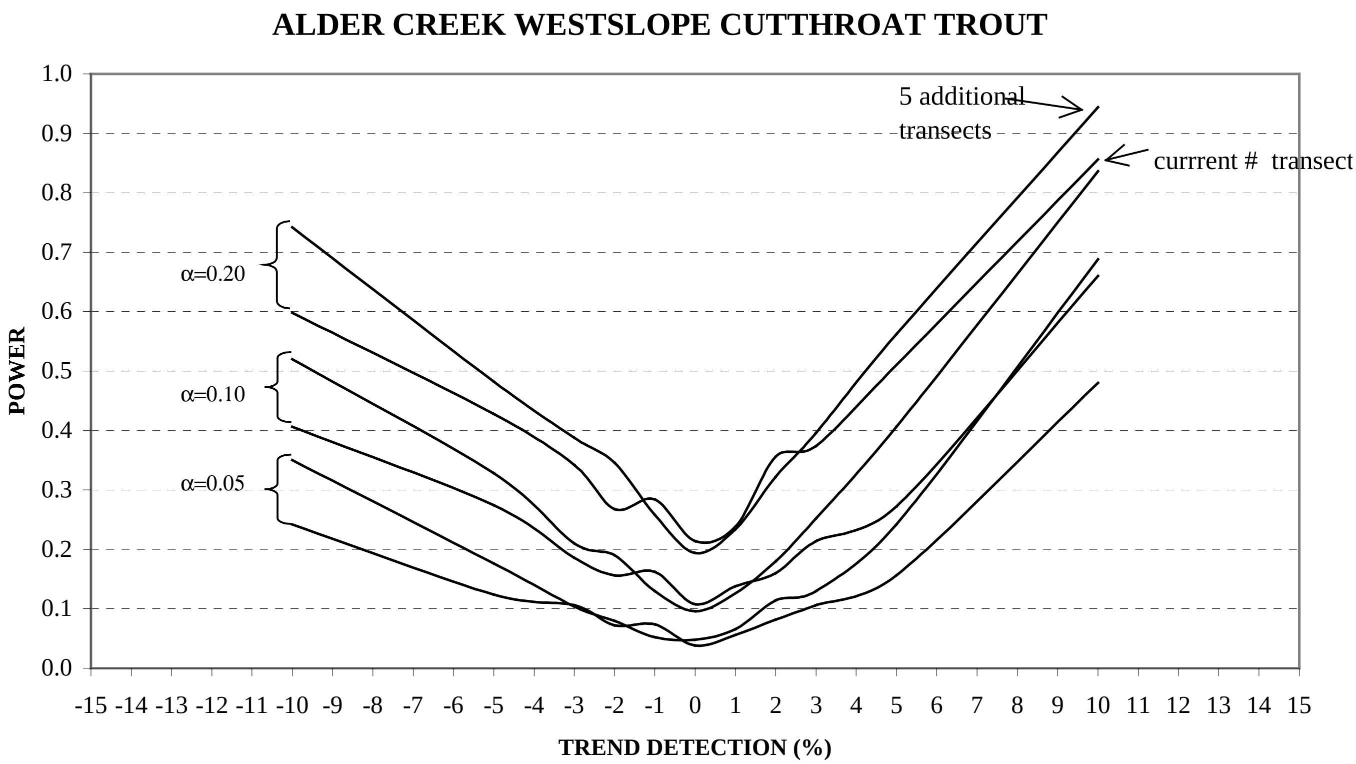


Figure 14. Power analysis of westslope cutthroat trout population estimates from Alder Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 12 sites, and what the power to detect would be if additional sites were sampled. Three levels of significance were simulated, α=0.05, 0.10 and 0.20. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

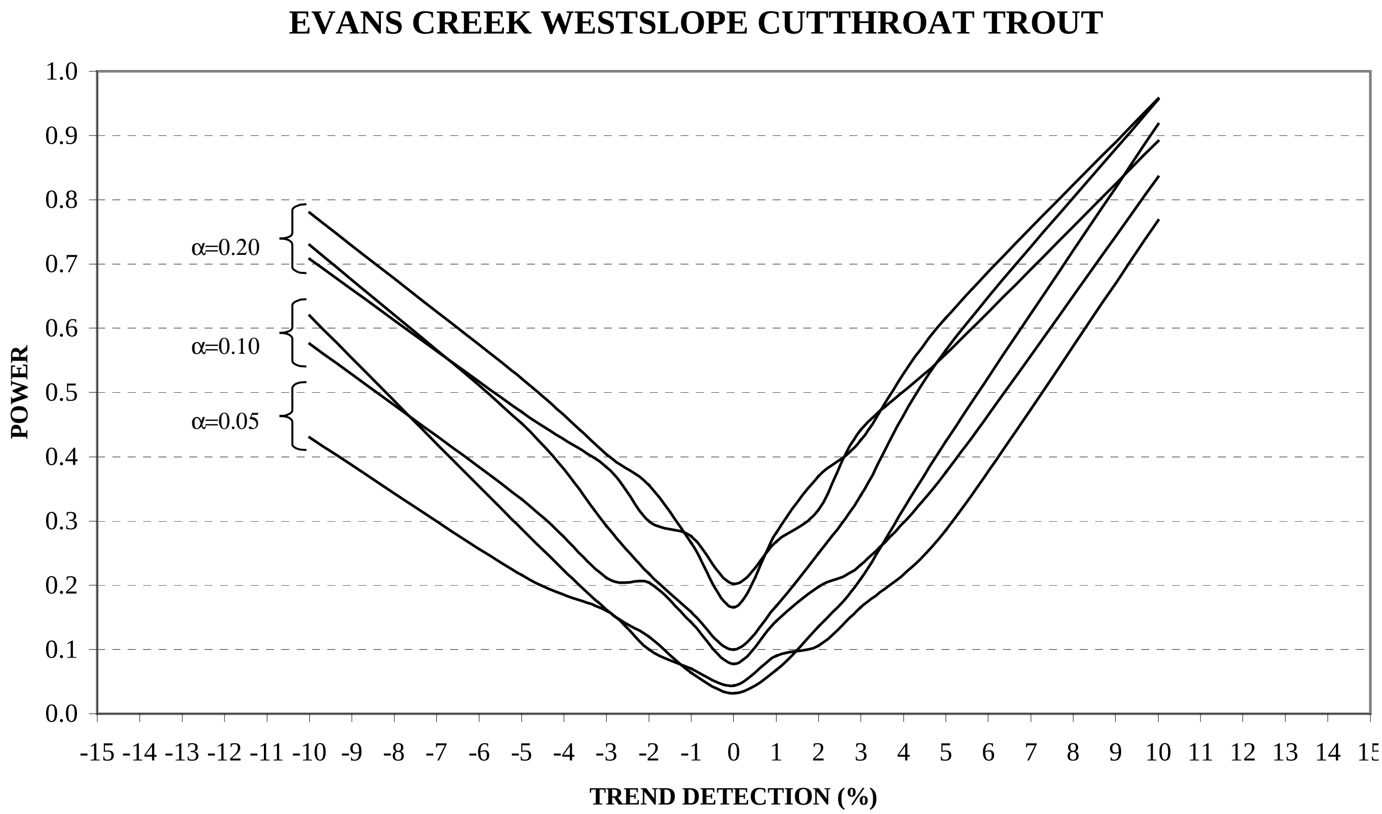


Figure 15. Power analysis of westslope cutthroat trout population estimates from Evans Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 10 sites, and what the power to detect would be if additional sites were sampled. Three levels of significance were simulated, α=0.05, 0.10 and 0.20. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

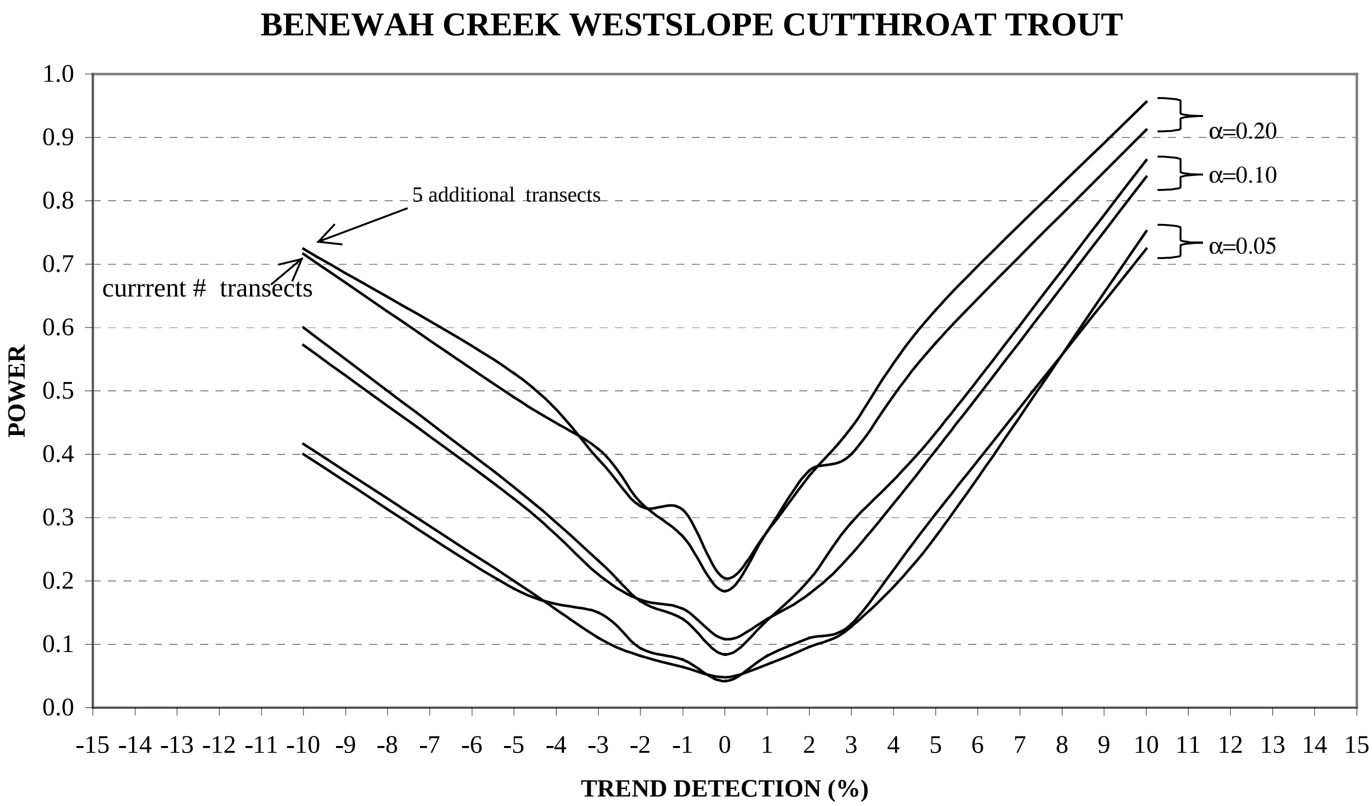


Figure 16. Power analysis of westslope cutthroat trout population estimates from Benewah Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 16 sites, and what the power to detect would be if additional sites were sampled. Three levels of significance were simulated, α=0.05, 0.10 and 0.20. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

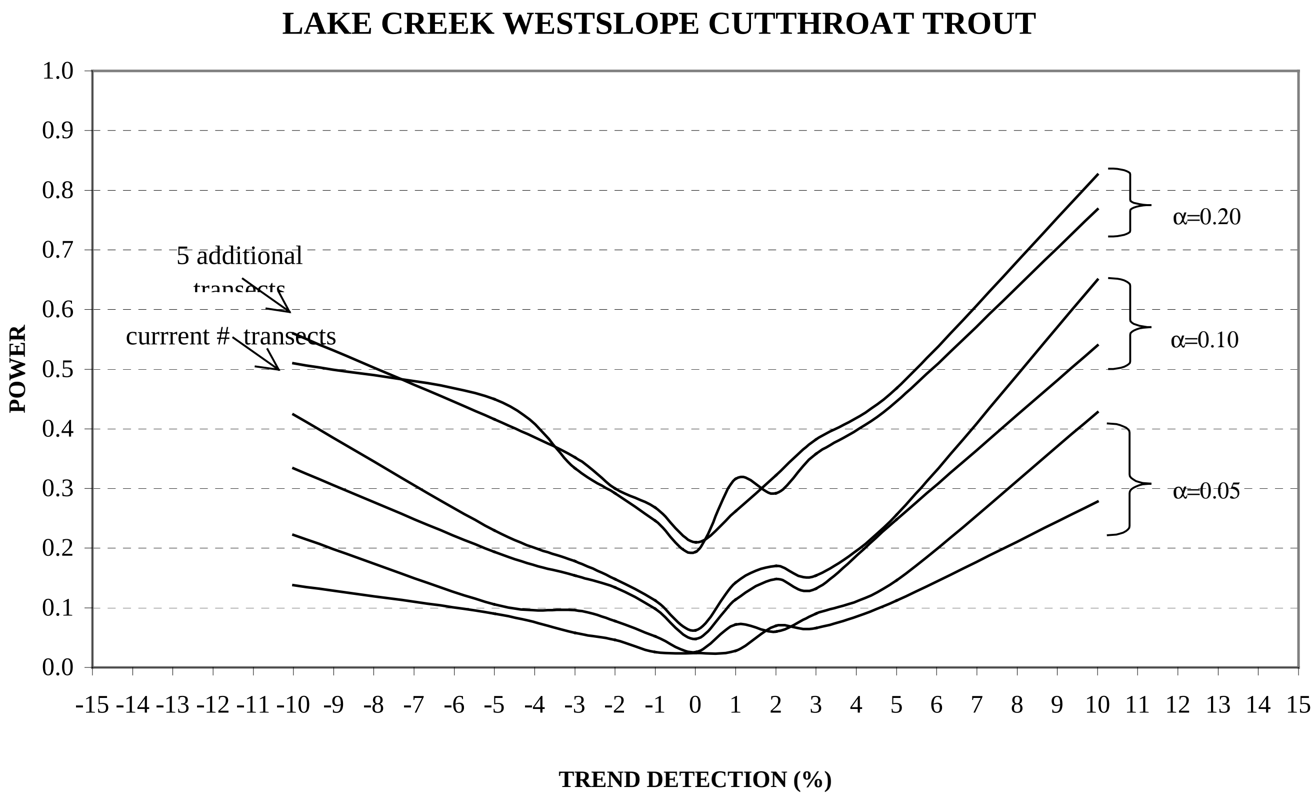


Figure 17. Power analysis of westslope cutthroat trout population estimates from Lake Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 10 sites, and what the power to detect would be if additional sites were sampled. Three levels of significance were simulated, α=0.05, 0.10 and 0.20. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

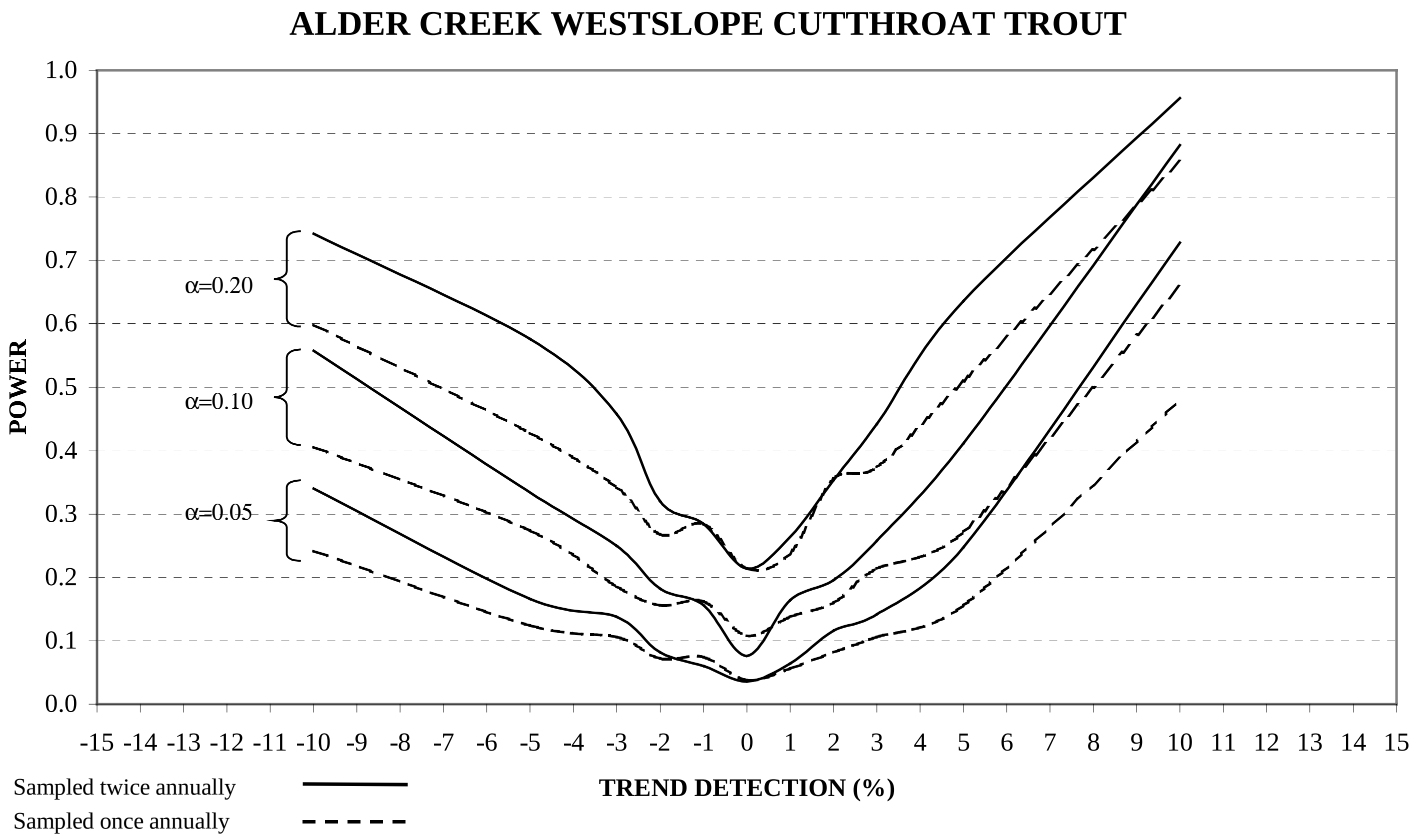


Figure 18. Power analysis of westslope cutthroat trout population estimates from Alder Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 12 sites, and what the power to detect would be if sites were sampled twice per year. Three levels of significance were simulated, α=0.05, 0.10 and 0.20. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

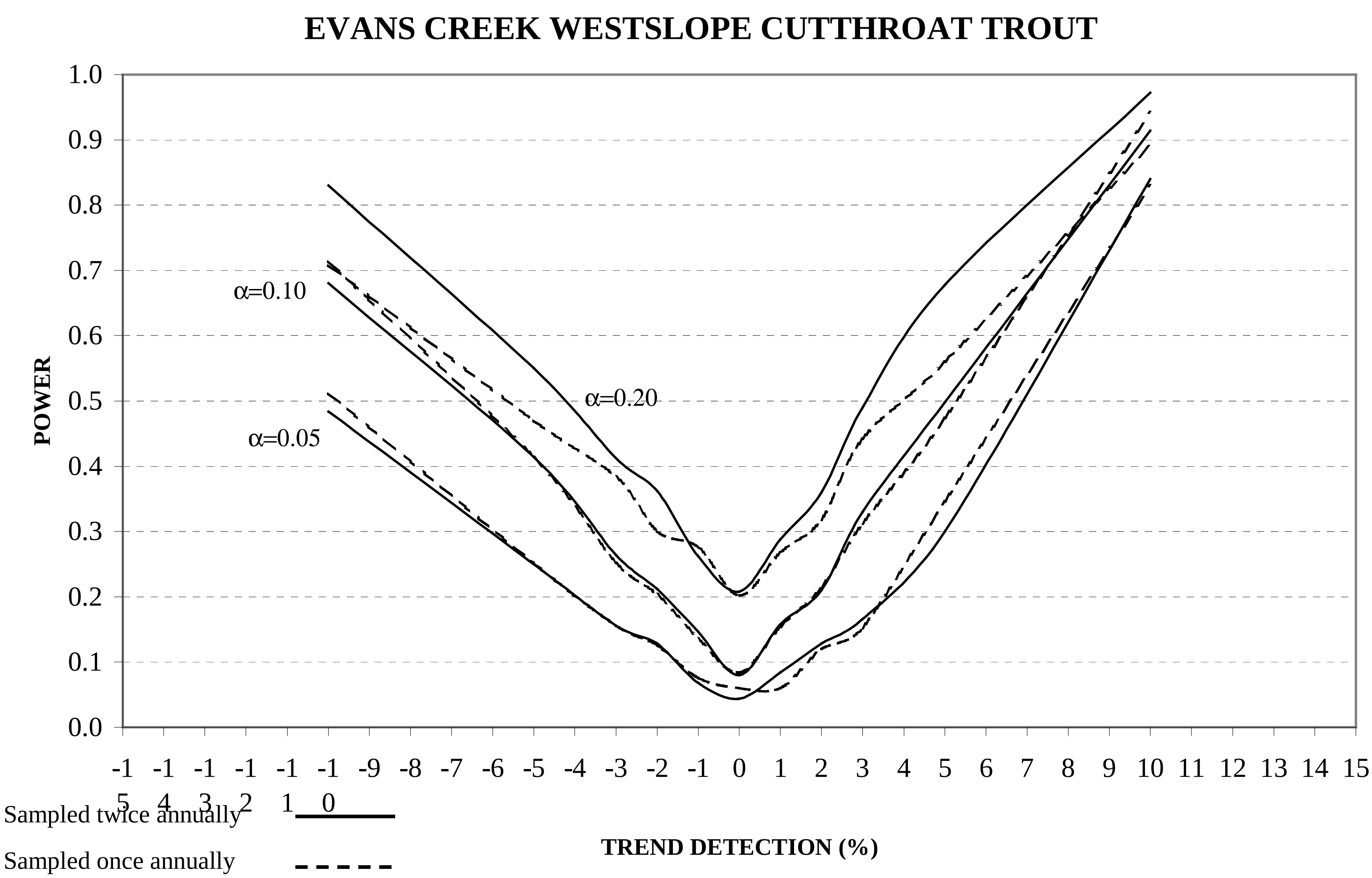


Figure 19. Power analysis of westslope cutthroat trout population estimates from Evans Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 10 sites, and what the power to detect would be if sites were sampled twice per year. Three levels of significance were simulated, α=0.05, 0.10 and 0.20. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

BENEWAH CREEK WESTSLOPE CUTTHROAT TROUT

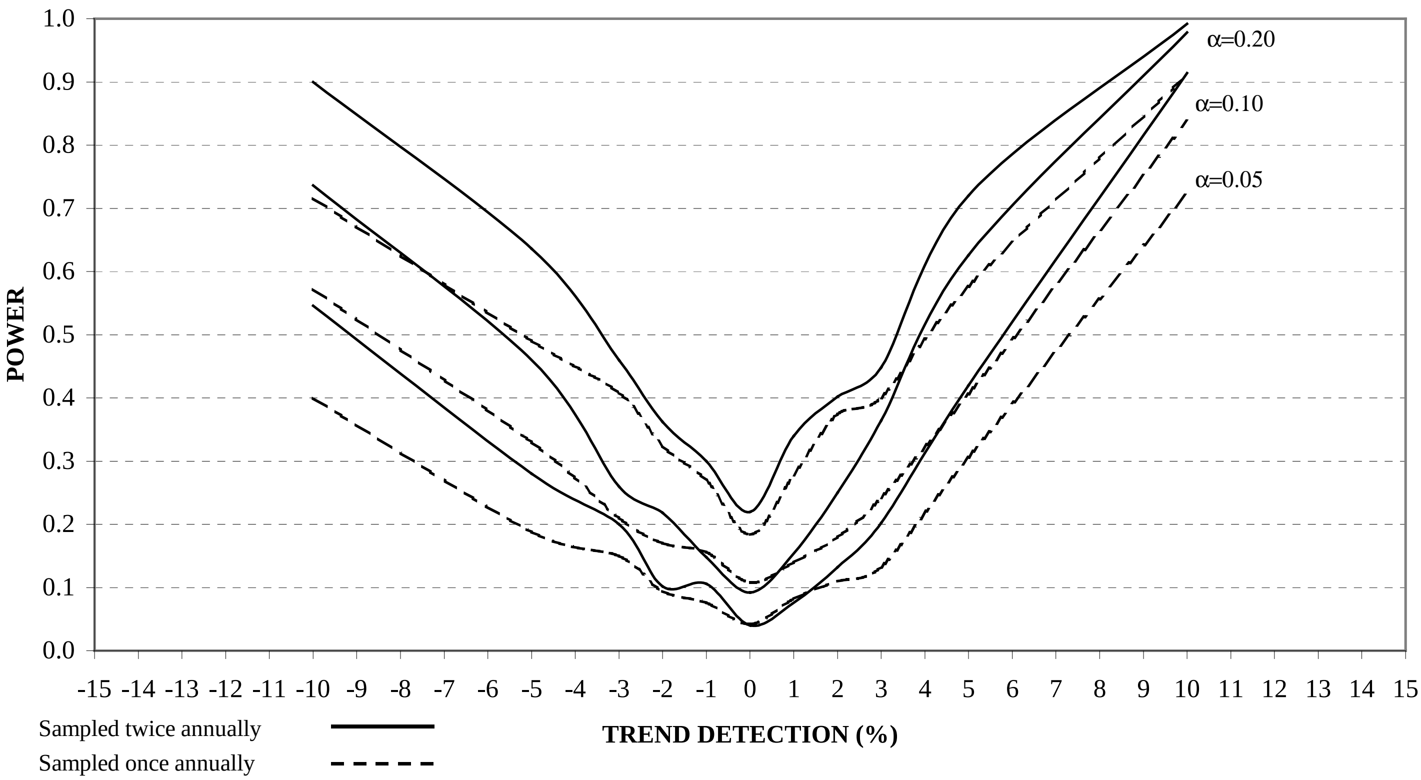


Figure 20. Power analysis of westslope cutthroat trout population estimates from Benewah Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 16 sites, and what the power to detect would be if sites were sampled twice per year. Three levels of significance were simulated, α=0.05, 0.10 and 0.20. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

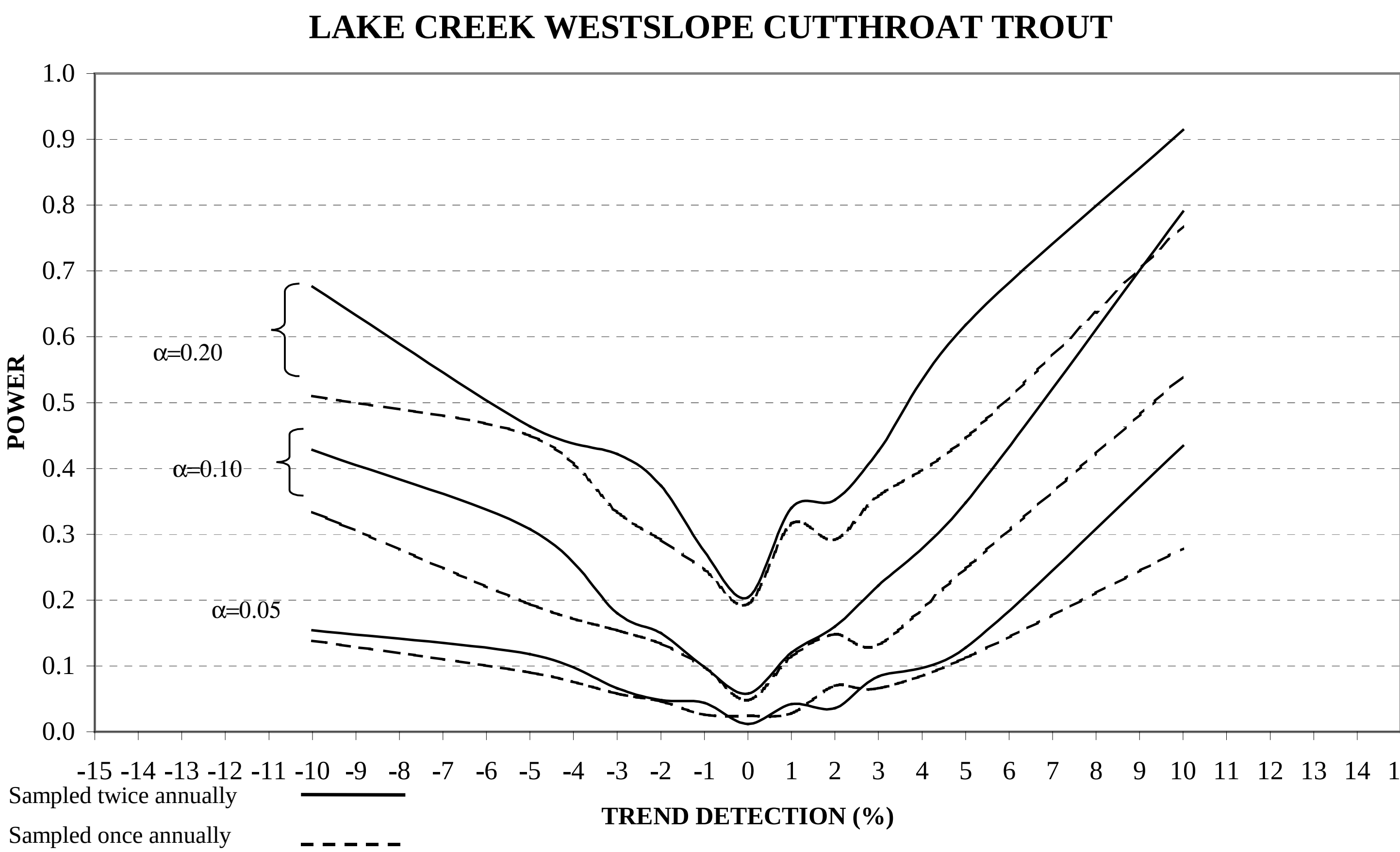


Figure 21. Power analysis of westslope cutthroat trout population estimates from Lake Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 10 sites, and what the power to detect would be if sites were sampled twice per year. Three levels of significance were simulated, α=0.05, 0.10 and 0.20. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

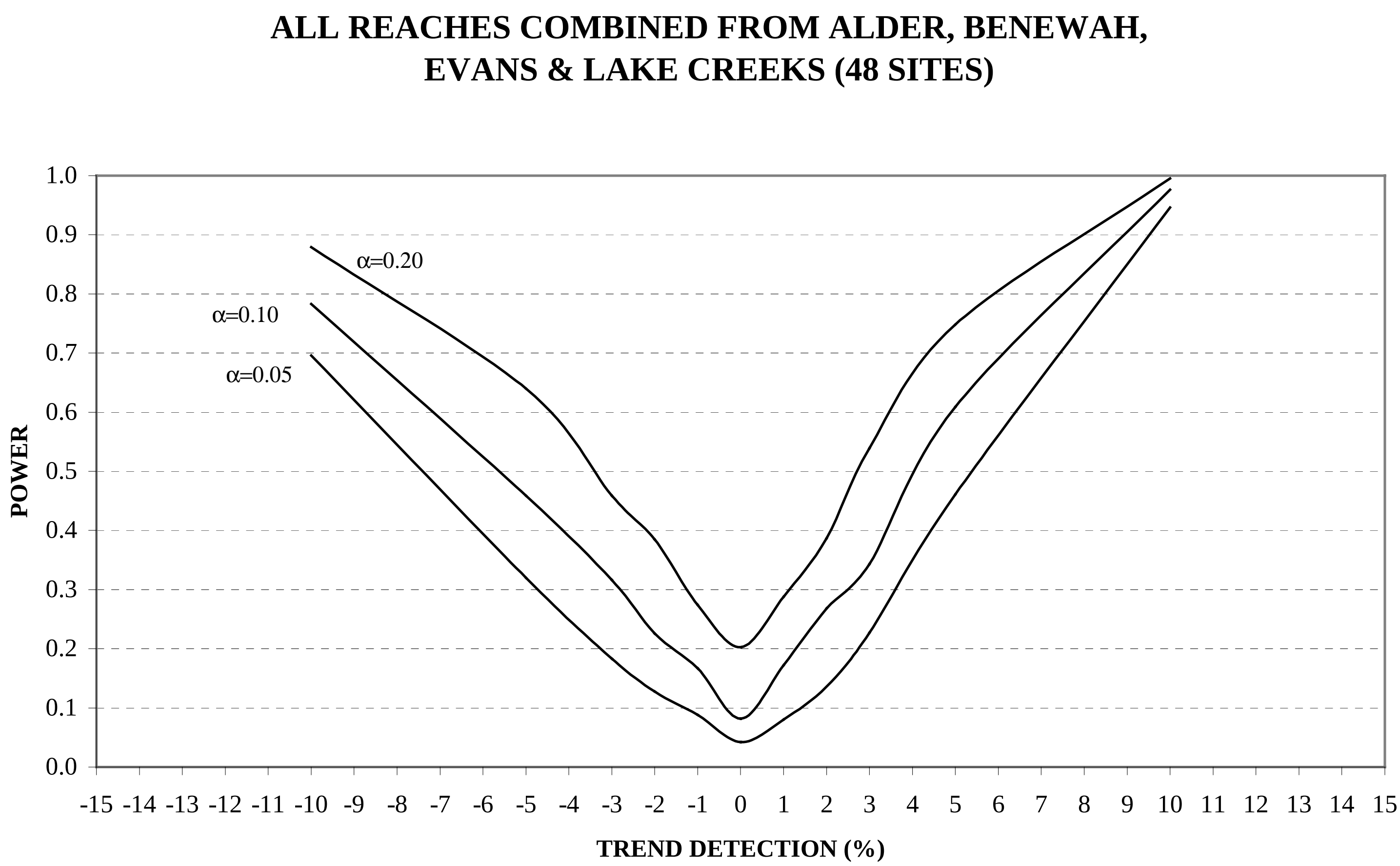


Figure 22. Power analysis of westslope cutthroat trout population estimates from 48 sample reaches, combined from Alder, Benewah, Evans and Lake Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population. Three levels of significance were simulated, α=0.05, 0.10 and 0.20. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

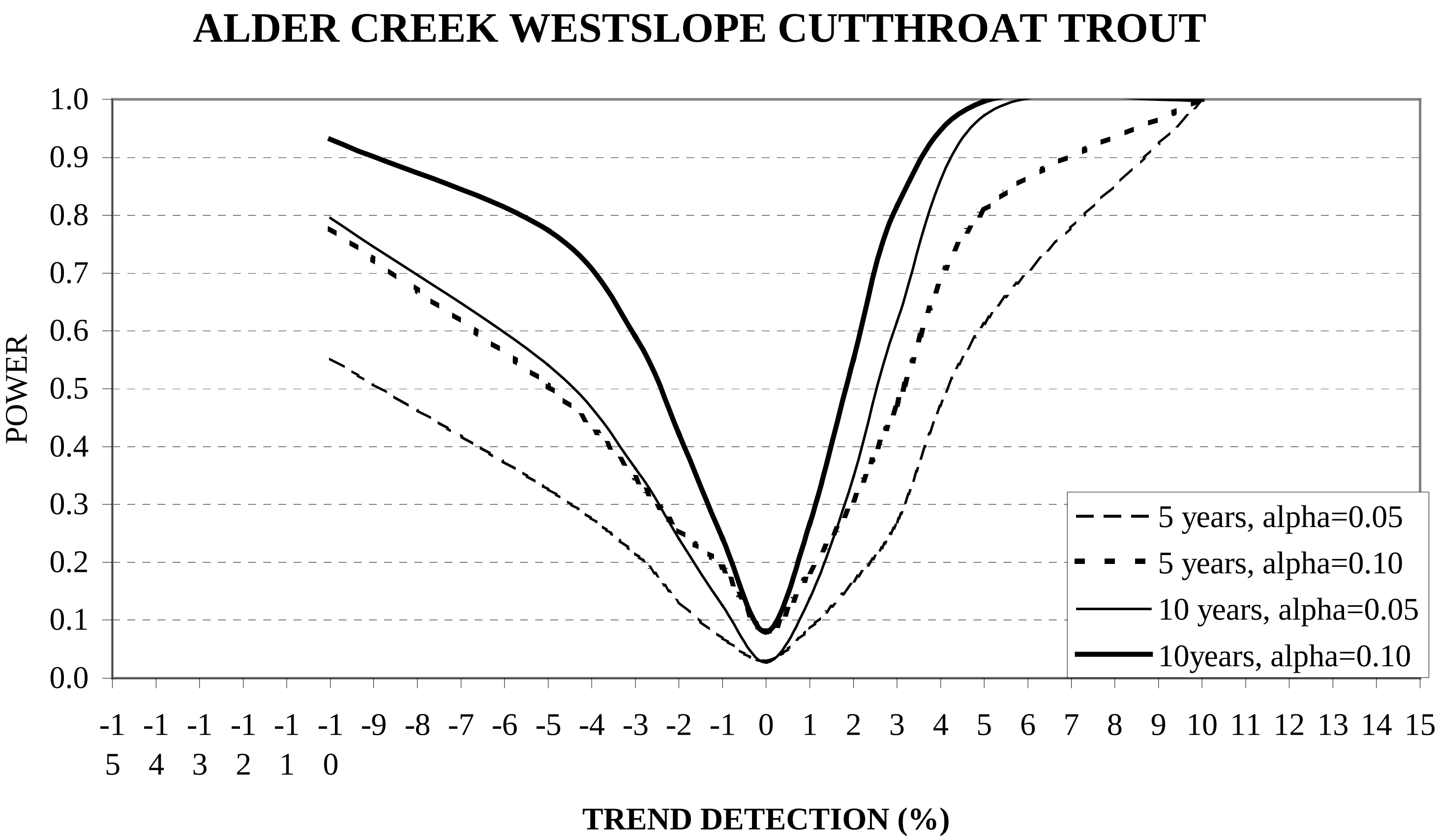


Figure 23. Power analysis of westslope cutthroat trout population estimates from Alder Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 12 sites if they were sampled annually for the next 5 and 10 years. Two levels of significance were simulated, α=0.05, 0.10. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

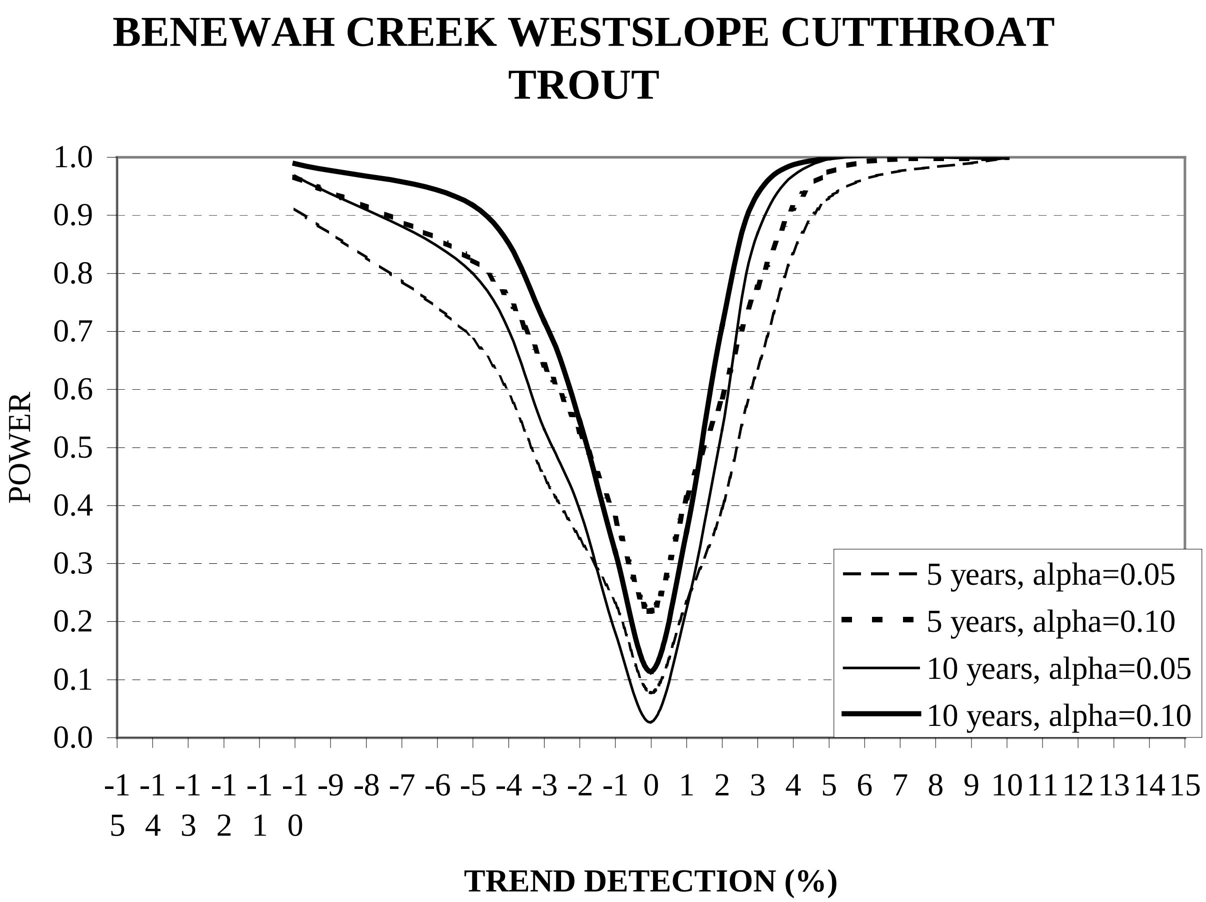


Figure 24. Power analysis of westslope cutthroat trout population estimates from Benewah Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 16 sites if they were sampled annually for the next 5 and 10 years. Two levels of significance were simulated, α=0.05, 0.10. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

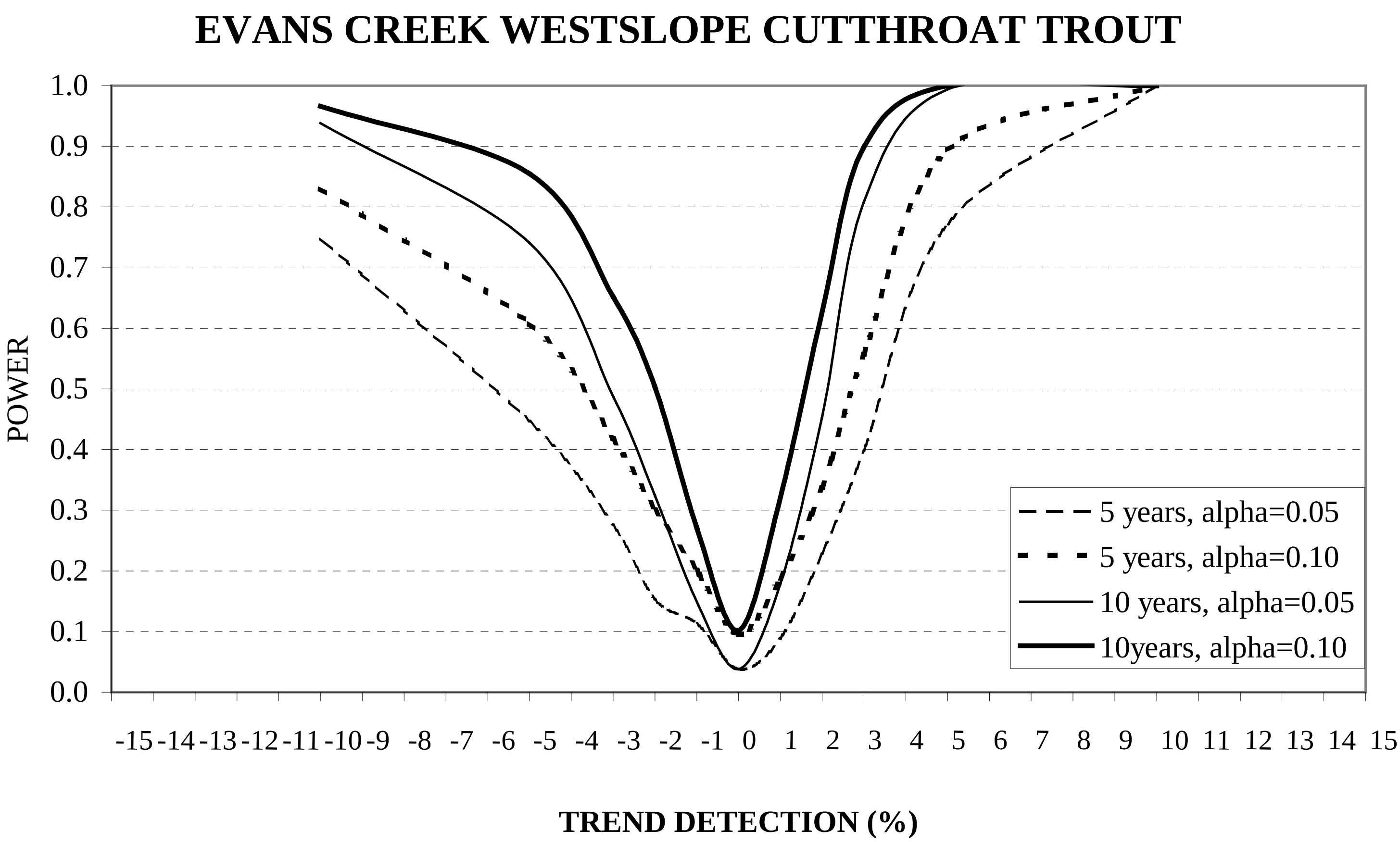


Figure 25. Power analysis of westslope cutthroat trout population estimates from Evans Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 10 sites if they were sampled annually for the next 5 and 10 years. Two levels of significance were simulated, α=0.05, 0.10. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

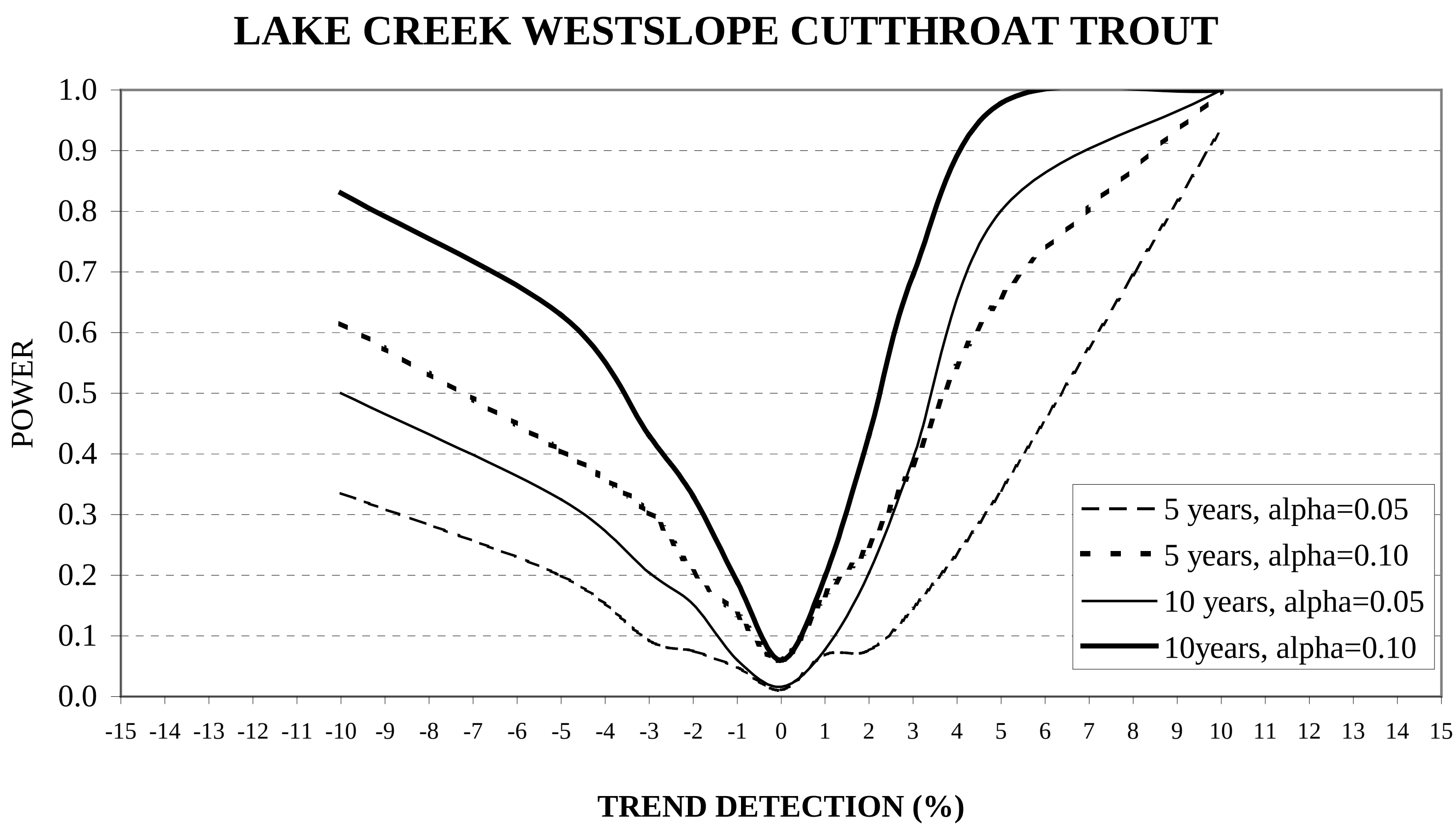


Figure 26. Power analysis of westslope cutthroat trout population estimates from Lake Creek, CDA Tribe Reservation. Power analysis was done to estimate power to detect a positive or negative % change in the population from the current 10 sites if they were sampled annually for the next 5 and 10 years. Two levels of significance were simulated, α=0.05, 0.10. The program used for the Monte Carlo simulations was the MONITOR program (Gibbs, 1995).

APPENDIX C: EFFECTIVENESS MONITORING CRITERIA

Category 1: Instream Work

Fish Passage

Fish Ladder: Improve fish passage by circumventing barrier; improve accessibility to habitat	*Effectiveness Criteria:* • Area of habitat made accessible • No unforeseen adverse effects on habitat such as incision or channel instability or sedimentation • Increased attraction flows during migration periods (for barrier modifications)
Channel Modification *(e.g. build step pool approach to culvert, back flooding weirs):* Improve fish passage by modifying natural channel; improve accessibility to habitat	
Barrier Removal *(e.g. logjam modification, barrier blasting):* Improve fish passage by eliminating natural barrier; improve accessibility to habitat	
Barrier Modification *(e.g. culvert baffles, repositioning, size upgrade):* Improve fish passage by modifying human caused barrier; improve accessibility to habitat	
Fish Screens: Prevent fish passage into stream reaches or man-made facilities to protect them from entrainment and/or mortality	*Effectiveness Criteria:* • No unforeseen adverse effects such as incision or channel instability.

Instream Habitat Restoration

Install structures *(e.g. install boulder/ log/ rootwad structures):* Increase cover, habitat complexity, instream habitat types	*Effectiveness Criteria:* • Project increases targeted habitat parameters within the project reach such as pools, cover, or dissolved oxygen or decreases temperature • Project improves targeted habitat parameters such as pool depths or substrate composition • Project does not impair natural movement of LWD or nutrients downstream • No unforeseen adverse effects on habitat features, substrate, channel geometry or fish passage • Project increases amount of suitable spawning habitat at specified flows
Install gravel: Increase spawning habitat	*Effectiveness Criteria:* • Increased amount of suitable spawning habitat at specified flows • No unforeseen adverse consequences such as gravel migration or scouring, pool filling, net loss of primary pools over reach

Remove structures (e.g., remove concrete riprap, remove dams): Increase stream interaction with floodplain; increase habitat complexity	*Effectiveness Criteria:* • Stream re-establishes and maintains properly functioning geometry and pattern, in relation to Rosgen stream type • No unforeseen adverse erosion or sedimentation or channel instability • Increased quality of the immediate and adjacent instream habitat units, riparian vegetation and substrate • Stream regains access to formerly abandoned floodplain
Construct channel/ breach dikes *(e.g., reconnect stream to floodplain, construct side channels, remove floodplain roads or levees):* Improve stream interaction with floodplain; increase habitat complexity; increase habitat types; improve flood control.	*Effectiveness Criteria:* • Channel re-establishes and maintains properly functioning geometry and pattern, in relation to Rosgen stream type • Stream regains access to formerly abandoned floodplain • Peak flows do not cause adverse erosion or sedimentation, and/or peak flows are reduced • Increase in number, area and type of instream habitat units • Increased riparian vegetation, reduced fine sediment, and reduced water temperature • No reduction in the diversity and quality of instream habitat units over time through a broad range of stream flows

Streambank Stabilization

Deflect streamflow *(e.g., install deflectors):* Increase streambank stability by reducing stream power at erodible surfaces	*Effectiveness Criteria*: • Reduced bank erosion • Improved channel geometry e.g., reduced width/depth ratio • Reduced fine sediment in reach • Increased riparian vegetation
Bioengineering *(e.g. install willow baffles/brush mattress/ stake, resloping and revegetating cut banks):* Increase streambank stability by protecting erodible surfaces with organic matter (living or dead)	
Armoring *(e.g., install rock armor):* Increase streambank stability by protecting erodible surfaces with inorganic matter (rock)	

Category 2: Riparian Work

Land Use Control

Exclude grazing: Reduce livestock access to stream; reduce wildlife access to stream; decrease contaminant input to stream	*Effectiveness Criteria:* • Livestock and/or wildlife successfully excluded from riparian zone and stream • Increased riparian vegetation • Increased riparian connectivity
Install watering sites: Reduce livestock access to stream; decrease contaminant input to stream	

Grazing management: Manage riparian pastures to reduce impacts to riparian vegetation and stream banks	• Increased bank stability • Improved channel geometry e.g., reduced width/depth ratio • Reduced fine sediment in reach • Improved water quality including nutrients, pathogens, temperature, dissolved oxygen • Others as appropriate for conservation easements
Conservation easements: Reduce stresses due to land uses	

Vegetation Management

Remove exotic plants *(e.g. remove noxious weeds/plants, non-native blackberries):* Directly eliminate exotic plants from riparian community	*Effectiveness Criteria:* • Reduced relative abundance of exotic plants • Increased relative abundance of native plants • Increased native plant species richness • Reduced barren ground • Increased riparian canopy cover • If clearing encroachment is involved, reduced vegetation within bankful channel • If clearing encroachment is involved, increased availability of spawning gravels
Plant vegetation: Increase native plant species composition	
Reduce vegetation encroachment into channel: Increase available instream fish habitat	

Riparian Planting or Management

Plant vegetation: Increase shading to stream; increase LWD inputs to stream; increase nutrient inputs to stream; increase stream bank stability	*Effectiveness Criteria:* • Riparian tree composition meets planting or management objectives • Increased riparian canopy cover • Advancement in riparian successional stage from grass-shrub to forest • Increased riparian corridor continuity and patch size
Alter composition *(e.g. promote conifers):* Increase shading to stream; increase LWD inputs to stream; increase nutrient inputs to stream; increase growth of conifers	

Restore Flows

Obtain water rights: Improve stream flows to benefit fisheries and riparian communities	*Effectiveness Criteria*: • Increase low flows, achieve natural peak flow regime • Decreased water temperature during low flows • No adverse changes in downstream stream flows
Manage flows: Improve stream flows to benefit fisheries and riparian communities	

Category 3: Upland/Upslope Work

Slope Stabilization or Erosion Control (including road cut and fill slopes)

Soil engineering *(e.g. toe protection):* Use engineering practices to reduce erosion/stream sedimentation; increase slope stability Bioengineering *(e.g. mulching, planting, seeding):* Use living and dead organic matter to reduce erosion/stream sedimentation; increase slope stability	*Effectiveness Criteria*: • Reduced likelihood of slope failure • Decrease in soil erosion from site • Decreased sediment load near site during peak flow events • If planting involved, reduced bare ground • If a large portion of a watershed is treated, reduced sediment yields
Upland fuels management: *(e.g., understory thinning, brush removal:* Reduce the potential for sedimentation as a result of catastrophic fire	*Effectiveness Criteria:* • Reduced fire hazard • Reduced fire incidence • No significant increase in erosion rate

Gully Repair

Channel modification *(e.g. new channel construction, pond and plug):* Decrease erosion and stream sedimentation by changing stream grade and cross-section Bioengineering *(e.g. brush/rock mattress, vegetation planting):* Use living and dead organic matter as obstructions to reduce the rate of head-cutting and incision Armoring *(e.g. rip-rap):* Use inorganic matter as obstructions to reduce the rate of head-cutting and incision	*Effectiveness Criteria*: • Improved channel geometry e.g., reduced width/depth ratio • No offsite adverse effects on downstream channels such as incision or channel instability • Reduced erosion and sediment yield • Reduced flood flows in channel • Increased vegetation cover

Category 4: Road Work

Road Upgrading or Decommissioning

Road surfacing: Use rock, chip seal and/or asphalt to reduce surface erosion	*Effectiveness Criteria*: • Reduced erosion rate from road surface • Reduced sediment yield in immediately adjacent watercourses • If a large portion of a watershed is treated, reduced sediment yield

<u>Drainage improvements</u> *(e.g. outsloping, installing rolling dips, boulder riprap, and energy dissipaters, removing berms, installing detention basins and check dams, upgrading stream crossings):* Use improvements in road drainage and stream crossings to reduce erosion and potential stream sedimentation; reduce risks of crossing failures; reduce hydrologic impacts of roads on streams <u>Partial decommissioning</u> *(e.g. installing drainage structures, revegetation):* Use improvements in road drainage and stream crossing plus revegetation to eliminate erosion and stream sedimentation due to road; reduce risks of crossing failures; reduce hydrologic impacts of roads on streams	*Effectiveness Criteria*: • Reduced erosion rate from road surface • Reduced number or probability of road related slope failures • No offsite adverse effects on erosion or sedimentation • Improved stream discharge regime in immediately adjacent watercourses • If a large portion of a watershed is treated, reduced actual sediment yield • If a large portion of a watershed is treated, stream discharge regime approaches natural variability and magnitudes

<u>Full road decommissioning</u> *(e.g. removing crossings, excavating fill, removing drainage structures):* Obliterate all evidence of road; decrease road access; decrease road density	*Effectiveness*: • Reduced number or probability of road related slope failures • Reduced erosion from site • Increased infiltration rate on road surface • Reduced sediment yield in immediately adjacent watercourses • No offsite adverse effects on erosion or sedimentation

APPENDIX D: PARAMETERS FOR EVALUATING EFFECTIVENESS CRITERIA

Projects	Effectiveness Criteria	Monitoring Parameters
Category: Fish Passage	• Area of habitat made accessible • No unforeseen adverse effects on habitat such as incision or channel instability or sedimentation • Increased attraction flows during migration periods (for barrier modifications)	• Instream habitat upstream from barrier • Channel slope and width/depth ratios up and downstream from barrier to next control points • Streamflow volume and velocity at inlet and outlet during periods of migration
Category: Instream Habitat Restoration Project Types: Install Structures, Install Gravel	• Project increases targeted habitat parameters within the project reach such as pools, cover, or dissolved oxygen or decreases temperature • Project does not impair natural movement of LWD or nutrients downstream • No unforeseen adverse effects on habitat features, substrate, channel geometry or fish passage • Project increases amount of suitable spawning habitat at specified flows	• Instream habitat within project reach • Water temperature and dissolved oxygen content • Large woody debris within and downstream from project reach • Instream substrate composition • Residual pool depth
Category: Instream Habitat Restoration Project Types: Remove Structures, Construct Channel/ Breach Dikes	• Stream stabilizes and establishes properly functioning geometry and pattern, in relation to Rosgen stream type • No unforeseen adverse erosion or sedimentation or channel instability • Stream re-connects to formerly abandoned floodplain • Peak flows do not cause adverse erosion or sedimentation, and/or peak flows are modified • Sustained increase in number, area, type and quality of instream habitat units • Increased streambank vegetation, reduced fine sediment deposition, and reduced water temperature during low flows • No reduction in the diversity and quality of instream habitat units over time through a broad range of stream flows	• Channel pattern, sinuosity, slope and width/depth ratios • Instream habitat and cover within project reach • Frequency of overbank flooding • Riparian cover • Instream substrate composition • Water temperature

Projects	Effectiveness Criteria	Monitoring Parameters
Category: Streambank Stabilization	• Reduced bank erosion • Improved channel geometry e.g., reduced width/depth ratio • Reduced fine sediment in reach • Increased riparian vegetation	• Bank stability • Width/depth ratios • Instream substrate composition • Riparian cover
Category: Land Use Control	• Increased riparian vegetation • Increased riparian connectivity • Increased bank stability • Improved channel geometry e.g., reduced width/depth ratio • Reduced fine sediment in reach • Improved water quality including nutrients, pathogens, temperature and dissolved oxygen • Others as appropriate for conservation easements	• Riparian cover • Riparian corridor continuity • Bank stability • Width/depth ratios • Instream substrate composition • Water quality
Category: Vegetation Control	• Reduced relative abundance of exotic plants • Increased relative abundance of native plants • Increased native plant species richness Reduced barren ground • Increased riparian canopy cover • If clearing encroachment is involved, reduced vegetation within bankful channel • If clearing encroachment is involved, increased availability of spawning gravels	• Riparian vegetation composition and cover
Category: Plant or Manage Riparian Vegetation	• Riparian tree composition meets planting or management objectives • Increased riparian canopy cover • Advancement in riparian successional stage • Increased riparian corridor continuity and patch size	• Riparian vegetation composition and cover • Riparian corridor continuity and width • Increased frequency of species with soil binding qualities
Category: Restore Flows	• Modify hydrograph to increase low flows and achieve natural peak flow regime • Decreased water temperature during low flows • No adverse of changes in flow on downstream sites	• Streamflow above and below project reach • Water temperature

Projects	Effectiveness Criteria	Monitoring Parameters
Category: Slope Stabilization Project Types: Soil engineering, bioengineering	• Reduced likelihood of slope failure • Decrease in soil erosion from site • Decreased sediment load near site during peak flow events • If planting involved, reduced bare ground If a large portion of a watershed is treated, reduced sediment yields	• Slope stability • Erosion rate • Turbidity in runoff from site • Vegetation cover • Watershed sediment yield
Category: Gully Repair	• Improved channel geometry e.g., reduced width/depth ratio • No offsite adverse effects on downstream channels such as incision or channel instability • Reduced erosion and sediment yield • Reduced flood flows in channel Increased vegetation cover	• Channel slope and width/depth ratios within and downstream from project area • Erosion rate from treated area • Sediment yield • Streamflow • Vegetation cover
Category: Road Upgrading Project Types: Road Surfacing, Drainage Improvements, Partial Decommissioning	• Reduced erosion rate from road surface • Reduced number or probability of road related slope failures • No offsite adverse effects on erosion or sedimentation • Improved stream discharge regime and reduced sediment yield in immediately adjacent watercourses • If a large portion of a watershed is treated, reduced actual sediment yield • If a large portion of a watershed is treated, stream discharge regime approaches natural variability and magnitudes	• Erosion rate from road surface • Slope stability • Runoff rate • Turbidity in runoff from site • Watershed sediment yield • Streamflow
Category: Road Upgrading Project Type: Full Road Decommissioning	• Reduced number or probability of road related slope failures • Reduced erosion from site • Increased infiltration rate on road surface • Reduced sediment yield in immediately adjacent watercourses • No offsite adverse effects on erosion or sedimentation	• Erosion rate from road surface • Slope stability • Runoff rate • Turbidity in runoff from site • Watershed sediment yield • Infiltration rate on road surface

APPENDIX E: HIERARCHICAL CLASSIFICATION OF SAMPLE SITES

Table 1. Hierarchical listing of sample sites by watershed using both ultimate and proximal control characteristics (after Hillman and Giorgi 2002).

Watershed	Site	Omernik Ecoregion	Province	Geologic Distric	Basin Area Acres	Basin Area Sq km	Basin Relief	Density (km/km2)	Valley Segment	Valley Width (ft.)	Valley Gradient	Containment	Elevation	Channel Type	Riparian Cover Group
Alder	1	15	N. Rock Mtns.	mafic volcanic flow	17525	70.9	2640	1.54	E1	109	4.00	Confined	2280	B3	Forested
Alder	2	15	N. Rock Mtns.	argillite & slate	17436	70.6	2600	1.54	E1	80	4.00	Confined	2320	B2	Forested
Alder	3	15	N. Rock Mtns.	mafic volcanic flow	17158	69.4	2480	1.55	E2	78	7.00	Confined	2440	A2	Forested
Alder	4	15	N. Rock Mtns.	argillite & slate	16388	66.3	2360	1.56	E3	90	1.00	Confined	2560	B2	Forested
Alder	5	15	N. Rock Mtns.	argillite & slate	16260	65.8	2360	1.56	E1	99	1.00	Confined	2560	B2	Forested
Alder	6	15	N. Rock Mtns.	argillite & slate	15514	62.8	2240	1.58	E3	183	2.00	Unconfined	2680	C1	Forested
Alder	7	15	N. Rock Mtns.	argillite & slate	15082	61.0	2240	1.58	E1	102	2.00	Moderate	2680	C1	Forested
Alder	8	15	N. Rock Mtns.	argillite & slate	15038	60.9	2240	1.58	E1	119	2.00	Moderate	2680	C1	Forested
Alder	9	15	N. Rock Mtns.	argillite & slate	13529	54.8	2160	1.65	E1	84	0.50	Confined	2760	C4	Forested
Alder	10	15	N. Rock Mtns.	argillite & slate	12005	48.6	2160	1.67	E3	125	0.50	Moderate	2760	C4	Forested
Alder	11	15	N. Rock Mtns.	argillite & slate	10088	40.8	2120	1.73	E3	161	2.00	Moderate	2800	C4	Forested
Alder	12	15	N. Rock Mtns.	argillite & slate	8026	32.5	2040	1.73	E3	111	1.00	Moderate	2880	C1	Forested
Alder	13	15	N. Rock Mtns.	argillite & slate	7512	30.4	2000	1.71	C4	328	1.00	Unconfined	2920	C1	Meadow
Alder	14	15	N. Rock Mtns.	argillite & slate	5797	23.5	2000	1.64	C4	91	2.00	Moderate	2920	C6	Meadow
Alder	15	15	N. Rock Mtns.	argillite & slate	1790	7.2	1920	1.63	C4	210	3.00	Unconfined	3000	E4	Forested
Alder	16	15	N. Rock Mtns.	argillite & slate	1581	6.4	1840	1.61	G1	128	3.00	Confined	3080	E6	Forested
Alder	17	15	N. Rock Mtns.	argillite & slate	1406	5.7	1800	1.48	G1	91	3.00	Confined	3120	E6	Forested
N. Fork Alder	1	15	N. Rock Mtns.	argillite & slate	2657	10.8	1880	1.48	C4	183	2.00	Unconfined	2960	E4	Meadow
N. Fork Alder	2	15	N. Rock Mtns.	argillite & slate	2229	9.0	1840	1.41	C4	145	2.00	Unconfined	3000	E4	Meadow
N. Fork Alder	3	15	N. Rock Mtns.	argillite & slate	2077	8.4	1760	1.41	E3	121	3.00	Moderate	3080	B5	Forested
N. Fork Alder	4	15	N. Rock Mtns.	argillite & slate	2017	8.2	1720	1.41	E3	105	1.00	Moderate	3120	B6	Forested
N. Fork Alder	5	15	N. Rock Mtns.	argillite & slate	1456	5.9	1720	1.27	G1	144	3.00	Confined	3120	B6	Forested
N. Fork Alder	6	15	N. Rock Mtns.	argillite & slate	1173	4.7	1600	1.33	G1	185	6.00	Confined	3240	B6	Forested
N. Fork Alder	7	15	N. Rock Mtns.	argillite & slate	931	3.8	1520	1.29	G1	107	5.00	Confined	3320	B4	Forested
N. Fork Alder	8	15	N. Rock Mtns.	argillite & slate	361	1.5	1320	1.14	G1	129	6.00	Confined	3520	B4	Forested
Benewah	1	15	N. Rock Mtns.	mafic volcanic flow	35017	141.7	2600	1.48	C4	145	1.00	Unconfined	2160	C3	Forested
Benewah	2	15	N. Rock Mtns.	mafic volcanic flow	34767	140.7	2600	1.46	B2	101	1.00	Unconfined	2160	C4	Forested
Benewah	3	15	N. Rock Mtns.	mafic volcanic flow	34377	139.1	2520	1.47	E1	109	6.00	Moderate	2240	B2	Forested
Benewah	4	15	N. Rock Mtns.	mafic volcanic flow	34155	138.2	2480	1.47	E1	106	2.00	Moderate	2280	B3	Forested
Benewah	5	15	N. Rock Mtns.	mafic volcanic flow	32151	130.1	2400	1.44	E3	100	1.00	Moderate	2360	B3	Meadow
Benewah	6	15	N. Rock Mtns.	mafic volcanic flow	31965	129.4	2360	1.44	E3	97	1.00	Moderate	2400	B2	Forested
Benewah	7	15	N. Rock Mtns.	mafic volcanic flow	28437	115.1	2240	1.41	E3	90	3.00	Moderate	2520	C2	Meadow
Benewah	8	15	N. Rock Mtns.	mafic volcanic flow	28375	114.8	2200	1.41	D1	115	2.00	Moderate	2560	B1	Forested
Benewah	9	15	N. Rock Mtns.	mafic volcanic flow	25073	101.5	2120	1.43	B2	98	1.00	Unconfined	2640	C3	Meadow
Benewah	10	15	N. Rock Mtns.	mafic volcanic flow	23331	94.4	2120	1.41	E3	133	1.00	Unconfined	2640	C4	Meadow
Benewah	11	15	N. Rock Mtns.	argillite & slate	23024	93.2	2120	1.41	B2	93	1.00	Unconfined	2640	C3	Meadow
Benewah	12	15	N. Rock Mtns.	argillite & slate	21800	88.2	2080	1.38	B2	163	<.5	Unconfined	2680	C4	Meadow

Watershed	Site	Omernik Ecoregion	Province	Geologic Distric	Basin Area Acres	Sq km	Basin Relief	Density (km/km2)	Valley Segment	Valley Width (ft.)	Valley Gradient	Containment	Elevation	Channel Type	Riparian Cover Group
Benewah	13	15	N. Rock Mtns.	mafic volcanic flow	20069	81.2	2080	1.47	B2	232	<.5	Unconfined	2680	C3	Meadow
Benewah	14	15	N. Rock Mtns.	argillite & slate	15539	62.9	2080	1.33	B2	589	<.5	Unconfined	2680	C4	Meadow
Benewah	15	15	N. Rock Mtns.	argillite & slate	11640	47.1	2040	1.48	C4	211	0.70	Unconfined	2720	C5	Meadow
Benewah	16	15	N. Rock Mtns.	argillite & slate	9969	40.3	2000	1.47	B2	440	0.80	Unconfined	2760	C5	Meadow
Benewah	17	15	N. Rock Mtns.	argillite & slate	7004	28.3	2000	1.47	B2	418	2.00	Unconfined	2760	C4	Meadow
Bull	1	15	N. Rock Mtns.	mafic volcanic flow	1651	6.7	2000	1.47	C4	213	4.00	Moderate	2680	F4	Meadow
Bull	2	15	N. Rock Mtns.	argillite & slate	1480	6.0	1920	1.38	C4	162	4.00	Moderate	2760	C4	Meadow
Coon	1	15	N. Rock Mtns.	mafic volcanic flow	2287	9.3	880	1.40	E1	129	3.00	Confined	2720	B2	Meadow
Coon	2	15	N. Rock Mtns.	argillite & slate	1341	5.4	840	1.55	C4	211	1.00	Unconfined	2760	C4	Meadow
Coon	3	15	N. Rock Mtns.	mafic volcanic flow	831	3.4	640	1.15	C4	153	2.00	Unconfined	2760	C4	Meadow
S. Fork Benewah	1	15	Columbia Plateau	argillite & slate	2131	8.6	1880	1.44	C4	472	2.00	Unconfined	2880	E4	Forested
S. Fork Benewah	2	15	Columbia Plateau	argillite & slate	1959	7.9	1840	1.46	E3	90	3.00	Unconfined	2920	E3	Meadow
S. Fork Benewah	3	15	Columbia Plateau	argillite & slate	1806	7.3	1720	1.45	G1	105	4.00	Confined	3040	E4	Forested
School House	1	15	N. Rock Mtns.	argillite & slate	1944	7.9	1200	1.24	B2	910	2.00	Unconfined	2800	C5	Meadow
School House	2	15	N. Rock Mtns.	argillite & slate	1612	6.5	1160	1.36	C4	242	2.00	Unconfined	2840	E5	Forested
W. Fork Benewah	1	15	Columbia Plateau	argillite & slate	904	3.7	1360	1.58	C4	322	5.00	Unconfined	2960	C4	Forested
W. Fork Benewah	2	15	Columbia Plateau	argillite & slate	765	3.1	1280	1.39	E3	125	5.00	Unconfined	3040	C4	Forested
Whitetail	1	15	N. Rock Mtns.	argillite & slate	1824	7.4	1240	1.39	B2	238	2.00	Unconfined	2720	C4	Meadow
Whitetail	2	15	N. Rock Mtns.	argillite & slate	1221	4.9	1080	1.40	C4	213	3.00	Unconfined	2880	C4	Meadow
Windfall	1	15	N. Rock Mtns.	argillite & slate	2817	11.4	1360	1.49	B2	234	1.00	Unconfined	2760	C4	Meadow
Windfall	2	15	Columbia Plateau	argillite & slate	2407	9.7	1280	1.59	C4	247	3.00	Unconfined	2840	C4	Forested
Evans	1	15	N. Rock Mtns.	argillite & slate	8484	34.3	3240	1.23	B2	1184	1.00	Unconfined	2160	C6	Meadow
Evans	2	15	N. Rock Mtns.	argillite & slate	7989	32.3	3240	1.23	E3	106	3.00	Unconfined	2160	C3	Meadow
Evans	3	15	N. Rock Mtns.	argillite & slate	7923	32.1	3200	1.18	E3	133	3.00	Unconfined	2200	C3	Meadow
Evans	4	15	N. Rock Mtns.	argillite & slate	7581	30.7	3120	1.19	D1	119	3.00	Moderate	2280	E3	Forested
Evans	5	15	N. Rock Mtns.	argillite & slate	7268	29.4	3120	1.17	E3	94	3.00	Moderate	2280	E3	Forested
Evans	6	15	N. Rock Mtns.	argillite & slate	7209	29.2	3080	1.17	E3	136	3.00	Moderate	2320	E3	Forested
Evans	7	15	N. Rock Mtns.	argillite & slate	6447	26.1	3040	1.15	E3	119	3.00	Moderate	2360	E3	Forested
Evans	8	15	N. Rock Mtns.	argillite & slate	5869	23.8	2920	1.14	E1	110	5.00	Moderate	2480	B3	Forested
Evans	9	15	N. Rock Mtns.	argillite & slate	5344	21.6	2800	0.80	D2	120	7.00	Moderate	2600	B3	Forested
Evans	10	15	N. Rock Mtns.	argillite & slate	3017	12.2	2760	1.25	E2	78	12.00	Confined	2640	B2	Forested
Evans	11	15	N. Rock Mtns.	argillite & slate	2913	11.8	2600	1.22	E1	136	5.00	Confined	2800	B2	Forested
Evans	12	15	N. Rock Mtns.	argillite & slate	2022	8.2	2320	1.25	E1	161	5.00	Confined	3080	B3	Forested
Evans	13	15	N. Rock Mtns.	argillite & slate	1430	5.8	2160	1.21	G2	94	10.00	Confined	3240	A4	Forested
Evans	14	15	N. Rock Mtns.	argillite & slate	1037	4.2	2000	1.12	G2	94	10.00	Confined	3400	A4	Forested
Evans	15	15	N. Rock Mtns.	argillite & slate	489	2.0	1920	1.04	G2	84	10.00	Confined	3480	A4	Forested
Evans	16	15	N. Rock Mtns.	argillite & slate	462	1.9	1880	1.00	G2	84	10.00	Confined	3520	A4	Forested
E. Fork Evans	1	15	N. Rock Mtns.	argillite & slate	1209	4.9	2480	1.10	G2	137	10.00	Confined	2680	B3	Forested
Rainbow Fork	1	15	N. Rock Mtns.	argillite & slate	339	1.4	1880	1.32	G2	133	13.00	Confined	3200	A3	Forested
S. Fork Evans	1	15	N. Rock Mtns.	argillite & slate	993	4.0	1880	1.15	G2	101	11.00	Confined	2800	A4	Forested

Watershed	Site	Omernik Ecoregion	Province	Geologic Distric	Basin Area Acres	Basin Area Sq km	Basin Relief	Density (km/km2)	Valley Segment	Valley Width (ft.)	Valley Gradient	Containment	Elevation	Channel Type	Riparian Cover Group
S. Fork Evans	2	15	N. Rock Mtns.	argillite & slate	804	3.3	1680	1.25	G2	80	13.00	Confined	3000	A4	Forested
Lake	1	10	Columbia Plateau	mafic volcanic flow	23074	93.4	2960	1.51	B2	141	2.00	Unconfined	2240	C4	Meadow
Lake	2	10	Columbia Plateau	mafic volcanic flow	21307	86.2	2760	1.50	E3	176	1.00	Moderate	2440	B3	Meadow
Lake	3	10	Columbia Plateau	mafic volcanic flow	21275	86.1	2760	1.50	E3	70	1.00	Moderate	2440	B3	Meadow
Lake	4	10	Columbia Plateau	mafic volcanic flow	19863	80.4	2720	1.59	E3	210	<.5	Moderate	2480	C3	Meadow
Lake	5	10	Columbia Plateau	mafic volcanic flow	19751	79.9	2720	1.51	E3	457	<.5	Moderate	2480	C3	Meadow
Lake	6	10	Columbia Plateau	mafic volcanic flow	17500	70.8	2720	1.53	C4	350	<.5	Unconfined	2480	C3	Meadow
Lake	7	10	Columbia Plateau	mafic volcanic flow	17405	70.4	2720	1.53	C4	245	<.5	Unconfined	2480	E4	Meadow
Lake	8	10	Columbia Plateau	mafic volcanic flow	14765	59.8	2680	1.48	C4	348	1.00	Unconfined	2520	E4	Meadow
Lake	9	10	Columbia Plateau	loess	11910	48.2	2640	1.49	C4	328	<.5	Unconfined	2560	E4	Meadow
Lake	10	10	Columbia Plateau	loess	11674	47.2	2640	1.44	C4	291	<.5	Unconfined	2560	E4	Meadow
Lake	11	10	Columbia Plateau	loess	3228	13.1	2160	1.42	C4	229	<.5	Moderate	2560	C5	Meadow
Lake	12	10	Columbia Plateau	loess	3092	12.5	2160	1.44	C4	137	<.5	Moderate	2560	E5	Meadow
Lake	13	10	N. Rock Mtns.	loess	2993	12.1	2160	1.35	C4	97	<.5	Moderate	2560	D5	Meadow
Bozard	1	10	Columbia Plateau	loess	4628	18.7	2360	1.24	C4	229	<.5	Unconfined	2560	E5	Forested
Bozard	2	10	Columbia Plateau	loess	4464	18.1	2360	1.23	C4	452	<.5	Unconfined	2560	E5	Meadow
Bozard	3	10	N. Rock Mtns.	loess	3334	13.5	2280	1.09	C4	306	5.00	Unconfined	2640	E4	Meadow
Bozard	4	10	N. Rock Mtns.	loess	1204	4.9	2200	1.40	G1	99	7.00	Confined	2720	B4	Forested
E.F. Bozard	1	10	N. Rock Mtns.	loess	1967	8.0	1960	0.88	E3	201	4.00	Moderate	2720	C4	Meadow
W. Fork Lake	1	10	Columbia Plateau	loess	3705	15.0	2640	1.72	C4	236	0.60	Unconfined	2560	C5	Meadow
W. Fork Lake	2	10	Columbia Plateau	metasedimentary phyllite & schist	3545	14.3	2600	1.76	C4	418	0.60	Unconfined	2600	C5	Meadow
W. Fork Lake	3	10	Columbia Plateau	metasedimentary phyllite & schist	2775	11.2	2600	1.85	C4	114	0.60	Unconfined	2600	C5	Meadow
W. Fork Lake	4	10	Columbia Plateau	metasedimentary phyllite & schist	1486	6.0	2520	1.95	E3	254	3.00	Moderate	2680	E5	Meadow
W. Fork Lake	5	10	Columbia Plateau	metasedimentary phyllite & schist	1382	5.6	2400	1.97	G2	168	10.00	Confined	2800	B4	Forested

Table 2. Preliminary groupings of treatment sites with potential control sites using geologic district, basin area, elevation, valley segment type and channel type as the ultimate and proximate controls. Treatment sites are highlighted in bold.

Watershed	Site	Geologic Distric	Basin Area Acres	Basin Area Sq km	Elevation	Valley Segment	Channel Type 1998
Alluvial valleys/B channels							
N. Fork Alder	4	argillite & slate	2017	8.161821625	3120	E3	B
N. Fork Alder	3	argillite & slate	2077	8.404307163	3080	E3	B
Alder	4	argillite & slate	16388	66.32211708	2560	E3	B
Alluvial valleys/C channels							
Whitetail	1	argillite & slate	1824	7.383266529	2720	B2	C
School House	1	argillite & slate	1944	7.868237603	2800	B2	C
Windfall	1	argillite & slate	2817	11.40146556	2760	B2	C
Benewah	17	argillite & slate	7004	28.34572314	2760	B2	C
Evans	1	argillite & slate	8484	34.33446556	2160	B2	C
E_0.1_00		**argillite & slate**	**8544**	**34.577568**	**2160**	**B2**	**C**
Benewah	16	argillite & slate	9969	40.34271832	2760	B2	C
B_8.2_02		**argillite & slate**	**15353**	**62.133591**	**2760**	**B2**	**C**
B_7.8_95		**argillite & slate**	**15539**	**62.886333**	**2680**	**B2**	**C**
Benewah	14	argillite & slate	15539	62.88644077	2680	B2	C
B_7.5_97		**argillite & slate**	**15591**	**63.096777**	**2680**	**B2**	**C**
B_7.4_96		**argillite & slate**	**15735**	**63.679545**	**2680**	**B2**	**C**
B_6.1_00		**argillite & slate**	**21796**	**88.208412**	**2680**	**B2**	**C**
Benewah	12	argillite & slate	21800	88.22571488	2680	B2	C
Benewah	11	argillite & slate	23024	93.17669353	2640	B2	C
W. Fork Benewah	1	argillite & slate	904	3.657722452	2960	C4	C
Whitetail	2	argillite & slate	1221	4.940758953	2880	C4	C
Coon	2	argillite & slate	1341	5.425730028	2760	C4	C
Bull	2	argillite & slate	1480	5.989671488	2760	C4	C
Windfall	2	argillite & slate	2407	9.742158402	2840	C4	C
Alder	14	argillite & slate	5797	23.46070799	2920	C4	C
Alder	13	argillite & slate	7512	30.40266942	2920	C4	C
Benewah	15	argillite & slate	11640	47.10815771	2720	C4	C
W. Fork Benewah	2	argillite & slate	765	3.096568182	3040	E3	C
Evans	3	argillite & slate	7923	32.06290565	2200	E3	C
E_1.3_96		**argillite & slate**	**7966**	**32.238402**	**2200**	**E3**	**C**
Evans	2	argillite & slate	7989	32.33326309	2160	E3	C
Alder	12	argillite & slate	8026	32.48191322	2880	E3	C
Alder	11	argillite & slate	10088	40.82583127	2800	E3	C
Alder	10	argillite & slate	12005	48.58351033	2760	E3	C
Alder	6	argillite & slate	15514	62.78610193	2680	E3	C
Alluvial valleys/E channels							
School House	2	argillite & slate	1612	6.52388292	2840	C4	E
Alder	15	argillite & slate	1790	7.244836088	3000	C4	E
S. Fork Benewah	1	argillite & slate	2131	8.623566116	2880	C4	E
N. Fork Alder	2	argillite & slate	2229	9.021205234	3000	C4	E
N. Fork Alder	1	argillite & slate	2657	10.75297934	2960	C4	E
S. Fork Benewah	2	argillite & slate	1959	7.929555785	2920	E3	E
Evans	7	argillite & slate	6447	26.09274449	2360	E3	E
Evans	6	argillite & slate	7209	29.1735186	2320	E3	E
Evans	5	argillite & slate	7268	29.41321694	2280	E3	E
Colluvial valleys/E channels							
Evans	4	argillite & slate	7581	30.68231749	2280	D1	E
E_1.7_96		**argillite & slate**	**7599**	**30.753153**	**2280**	**D1/E3**	**E**

Watershed	Site	Geologic Distric	Basin Area Acres	Basin Area Sq km	Elevation	Valley Segment	Channel Type 1998
Steep colluvial valleys/B channels							
Evans	9	argillite & slate	5344	21.62580785	2600	D2	B
V-shaped valleys/B channels							
Evans	12	argillite & slate	2022	8.184119146	3080	E1	B
Evans	11	argillite & slate	2913	11.78981405	2800	E1	B
Evans	8	argillite & slate	5869	23.75057576	2480	E1	B
Alder	5	argillite & slate	16260	65.80555785	2560	E1	B
Alder	2	argillite & slate	17436	70.56236226	2320	E1	B
V-shaped valleys/C channels							
Alder	8	argillite & slate	15038	60.85922452	2680	E1	C
Alder	7	argillite & slate	15082	61.03760468	2680	E1	C
Alder	9	argillite & slate	13529	54.75063292	2760	E1	C
Steep V-shaped valleys/B channels							
Evans	10	argillite & slate	3017	12.21067975	2640	E2	B
Headwater valleys/B channels							
N. Fork Alder	8	argillite & slate	361	1.461416667	3520	G1	B
N. Fork Alder	7	argillite & slate	931	3.767351928	3320	G1	B
N. Fork Alder	6	argillite & slate	1173	4.746584711	3240	G1	B
N. Fork Alder	5	argillite & slate	1456	5.891190771	3120	G1	B
Headwater valleys/E channels							
Alder	17	argillite & slate	1406	5.691442149	3120	G1	E
Alder	16	argillite & slate	1581	6.400317493	3080	G1	E
S. Fork Benewah	3	argillite & slate	1806	7.30894146	3040	G1	E
Headwall valleys/A channels							
Rainbow Fork	1	argillite & slate	339	1.373155647	3200	G2	A
Evans	16	argillite & slate	462	1.869275482	3520	G2	A
Evans	15	argillite & slate	489	1.977975895	3480	G2	A
S. Fork Evans	2	argillite & slate	804	3.25357989	3000	G2	A
S. Fork Evans	1	argillite & slate	993	4.017269972	2800	G2	A
Evans	14	argillite & slate	1037	4.196579201	3400	G2	A
Evans	13	argillite & slate	1430	5.788064738	3240	G2	A
Headwall valleys/B channels							
E. Fork Evans	1	argillite & slate	1209	4.894305785	2680	G2	B
Alluvial valleys/C channels							
E.F. Bozard	1	loess	1967	7.959285813	2720	E3	C
Lake	11	loess	3228	13.06448898	2560	C4	C
WL_0.0_99		loess	3579	14.484213	2560	C4	C
W. Fork Lake	1	loess	3705	14.99322452	2560	C4	C
L_12.9_00		**loess**	**3769**	**15.253143**	**2560**	**C4**	**C**
Alluvial valleys/D channels							
Lake	13	loess	2993	12.1131281	2560	C4	D
Alluvial valleys/E channels							
L_13.7_97		**loess**	**3037**	**12.290739**	**2560**	**C4**	**E**
Lake	12	loess	3092	12.51262534	2560	C4	E
Bozard	3	loess	3334	13.49278719	2640	C4	E
L_13.4_97		**loess**	**3633**	**14.702751**	**2560**	**C4**	**E**
Bozard	2	loess	4464	18.06563705	2560	C4	E
Bozard	1	loess	4628	18.72898829	2560	C4	E
L_12.0_00		**loess**	**11910**	**48.19977**	**2560**	**C4**	**E**
Lake	10	loess	11674	47.24658815	2560	C4	E
Lake	9	loess	11910	48.20166529	2560	C4	E

Watershed	Site	Geologic Distric	Basin Area Acres	Sq km	Elevation	Valley Segment	Channel Type 1998
Colluvial valleys/B channels							
Bozard	4	loess	1204	4.871079201	2720	G1	B
Alluvial valleys/B channels							
Lake	3	mafic volcanic flow	21275	86.10001791	2440	E3	B
Lake	2	mafic volcanic flow	21307	86.23008678	2440	E3	B
Benewah	6	mafic volcanic flow	31965	129.3618533	2400	E3	B
Benewah	5	mafic volcanic flow	32151	130.1162528	2360	E3	B
Alluvial valleys/C channels							
Benewah	13	mafic volcanic flow	20069	81.21778994	2680	B2	C
Lake	1	mafic volcanic flow	23074	93.37922934	2240	B2	C
Benewah	9	mafic volcanic flow	25073	101.4713712	2640	B2	C
Benewah	2	mafic volcanic flow	34767	140.7010716	2160	B2	C
Coon	3	mafic volcanic flow	831	3.362280303	2760	C4	C
Lake	6	mafic volcanic flow	17500	70.8225	2480	C4	C
Benewah	1	mafic volcanic flow	35017	141.7146798	2160	C4	C
Lake	5	mafic volcanic flow	19751	79.93289532	2480	E3	C
Lake	4	mafic volcanic flow	19863	80.3872073	2480	E3	C
Benewah	10	mafic volcanic flow	23331	94.42070937	2640	E3	C
Benewah	7	mafic volcanic flow	28437	115.0840076	2520	E3	C
Alluvial valleys/E channels							
Lake	8	mafic volcanic flow	14765	59.75549725	2520	C4	E
L_10.7_96		**mafic volcanic flow**	**15673**	**63.428631**	**2520**	**C4**	**E**
Lake	7	mafic volcanic flow	17405	70.43693871	2480	C4	E
Alluvial valleys/F channels							
Bull	1	mafic volcanic flow	1651	6.682752755	2680	C4	F
Colluvial valleys/B channels							
Benewah	8	mafic volcanic flow	28375	114.8340895	2560	D1	B
V-shaped valleys/B channels							
Coon	1	mafic volcanic flow	2287	9.253471074	2720	E1	B
Alder	1	mafic volcanic flow	17525	70.92562603	2280	E1	B
Benewah	4	mafic volcanic flow	34155	138.2251178	2280	E1	B
Benewah	3	mafic volcanic flow	34377	139.1253802	2240	E1	B
Steep v-shaped valleys/A channels							
Alder	3	mafic volcanic flow	17158	69.43819559	2440	E2	A
Alluvial valleys/C channels							
W. Fork Lake	3	metasedimentary phyllite & schist	2775	11.23144697	2600	C4	C
W. Fork Lake	2	metasedimentary phyllite & schist	3545	14.34845455	2600	C4	C
Alluvial valleys/E channels							
W. Fork Lake	4	metasedimentary phyllite & schist	1486	6.011969008	2680	E3	E
Headwall valleys/B channels							
W. Fork Lake	5	metasedimentary phyllite & schist	1382	5.591103306	2800	G2	B