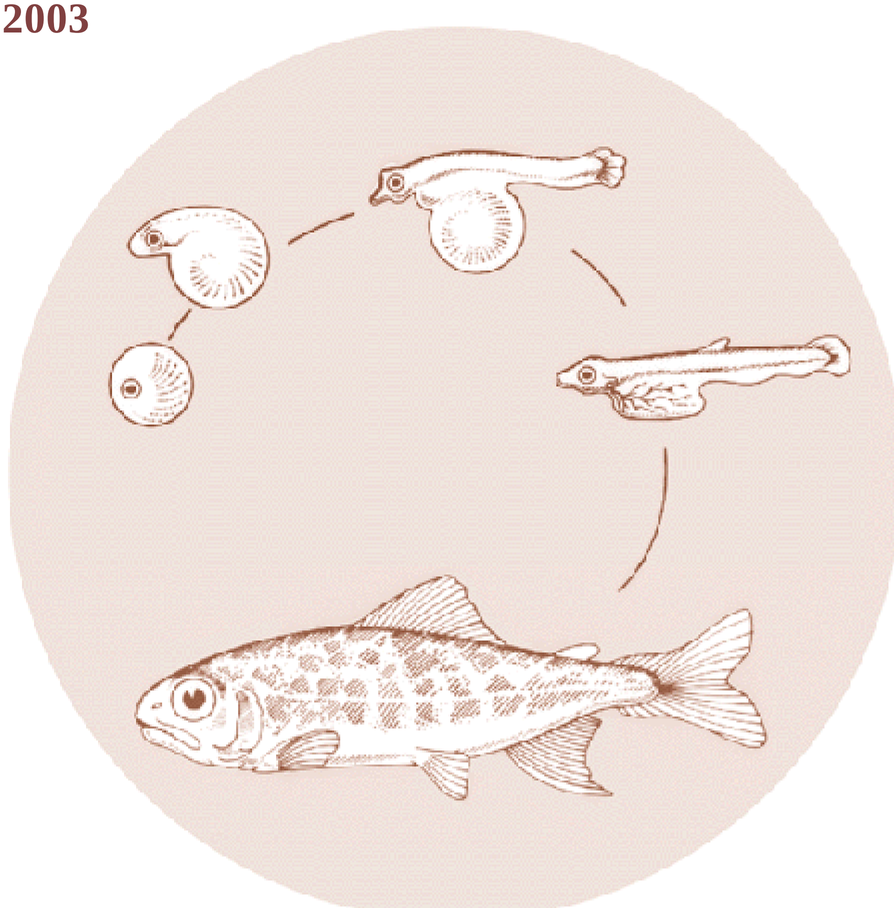
Coeur d'Alene Tribal Production Facility, Volume II of III

Submittal to the Northwest Power Planning Council
Appendices 1

Technical Report
2003



DOE/BP-00006340-3 January 2003

This Document should be cited as follows:

Brannon, Ernest, Paul Anders, William Towey, David Smith, Jason Scott, Dale Ralston, Ron Peters, Jeffery Jordan, Douglas Ensor, John Cussigh, Raymond Beamesderfer, ''Coeur d'Alene Tribal Production Facility, Volume II of III'', Project No. 1990-04402, 653 electronic pages, (BPA Report DOE/BP-00006340-3)

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This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

Three-Step Review Documentation

for the

Coeur d'Alene Tribal Production Facility

June 2002

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Project 199004400 Implement Fisheries Enhancement Opportunities--Coeur d'Alene Reservation

1999 Project Review

ISRP Evaluation: Inadequate as a whole, but some portions are adequate
Although the ISRP recommends combining integrated projects in one proposal, this proposal is too diffuse and divergent and lacks focus. The habitat study and restoration aspects of the project appear beneficial, but these activities appear to be limited to provision of production and harvest opportunities. The proposal does not make clear the scientific need for or likely efficacy of the hatchery, as described. If the habitat work is done properly, stocking may not be necessary. However, the habitat manipulation techniques described in the proposal appear misguided. The proposal discusses evaluation of the need for supplementation, but it appears the proposers intend to implement hatchery production before completing their background study or watershed analysis. The budget does not appear to be consistent with the objectives. The ISRP does not support this proposal.

2000 Project Review

ProjectID: 9004400
Implement Fisheries Enhancement Opportunities: Coeur D'alene Reservation
Coeur d'Alene Tribe
Short Description: Enhance critical watershed habitat to mitigate limiting factors for westslope cutthroat and bull trout in the Coeur d'Alene subbasin. Maintain compensatory harvest opportunities and develop environmental educational programs in local schools.
ISRP Recommendation - Fund in Part / CBFWA Tier 1 / ISRP Comparison with CBFWA: Partially agree-fund in part
Sponsor Funding Request = $685,254 / CBFWA Funding Recommendation = $685,254
Recommendation:
Fund in part. Objectives 1, 2, and 4 are OK for multi-year review cycle, review in FY2003 for reporting of results. Do not fund objective 3 (24% of budget), the put-and-take trout pond objectives, until they are better justified and subjected to environmental review for potential impacts to native biota.
Comments:
This project is basically a habitat restoration and education program to enhance the natural reproduction of native westslope cutthroat trout to mitigate losses of Pacific salmon and steelhead. It has many strengths: a strong watershed/ecosystem approach in collaboration with other projects, a well thought out scientifically rational approach, a strong monitoring program, an emphasis on improvement through natural processes compared to human technological intervention, an emphasis on native species of fish and plants, and an awareness of the need to obtain public support, over a relatively long time frame, via education and demonstration of success. We stand to learn and gain a lot from this project.
This was a well written and comprehensive proposal. Reviewers especially commended the project's emphasis on the conservation/enhancement of native species, and on habitat improvement as a mechanism. In addition, the relationship to other projects is very strong and well documented. The project history is clearly explained. Objectives and methods are concisely related (although they could have been better "cross-walked" with the budget). Taken on balance, this project proposal is very compelling, well thought out and clearly articulated.
The FWP and 12 other planning documents are referenced. This is one of three CDA Tribe projects (9004401, 9004402) that could use an umbrella. There is a good history of accomplishments (many the same as 9004402, which suggests that an umbrella proposal might have been appropriate). There are good objectives and tasks for 4 target watersheds. Cost sharing with EPA and USDA is a definite plus,

considering the high temperatures and high sediment loads. There are good sections on background and rationale, as well as excellent history, and objectives narratives. The methods narrative of objectives by tasks is excellent. Facilities and budget seem reasonable. The resumes look good, as do the plans for information transfer.

ISRP Comments to the Coeur d'Alene Tribe's response FY 2000

ProjectID: 9004400

Implement Fisheries Enhancement Opportunities: Coeur D'Alene Reservation

Coeur d'Alene Tribe

Short Description: Enhance critical watershed habitat to mitigate limiting factors for westslope cutthroat and bull trout in the Coeur d'Alene subbasin. Maintain compensatory harvest opportunities and develop environmental educational programs in local schools.

CBFWA Funding Rec.: $685,254 Sponsor Request: $685,254

ISRP Response Evaluation:

Fund. The original proposal was generally excellent. The response to the ISRP's questions about Objective 3, the construction of put-and-take trout ponds, was of equally high quality. It is clear that the Tribe has thought through their management strategy, has emphasized native stocks, but also needs some interim fishing opportunities to take pressure off the native fish restoration efforts. The put-and-take ponds seem well located (in closed basins not accessible to native species) and are designed to avoid the problems that concerned the ISRP.

Additional FY2000 comments

Perceived ISRP Bias Against Hatchery Projects

Several responses from sponsors of artificial production projects raised the suggestion that the ISRP is biased against funding hatchery projects. The ISRP does not believe this to be true. Indeed, several artificial production projects in the "Fix-It Loop" were recommended for funding after careful responses from the sponsors adequately addressed the ISRP's original review comments. These include for example, projects 9004400 (Implement Fisheries Enhancement Opportunities: Coeur d'Alene Reservation); 9107300 (Idaho Natural Production Monitoring and Evaluation), and 9700100 (Captive RearingInitiative for Salmon River Chinook Salmon).

Resident Fish Substitutions

The ISRPs scientific misgivings with respect to the use of non-native species, particularly in the resident fish substitution program, has been an area of some concern for the resident fish managers. In previous reports, the ISRP has recommended focusing on and using native species and stocks wherever possible, rather than non-native species. However, this recommendation has not been for a total prohibition on non-native species as some have interpreted it.

The ISRP would like to specifically acknowledge project 9004400 (Implement Fisheries Enhancement Opportunities: Coeur d'Alene Reservation) as a good example of careful use of off-site mitigation using non-native species that adequately safeguards against interactions with natives species.

2002 Project Review

ProjectID: 199004400

Implement Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation
Sponsor: Coeur d'Alene Tribe
Subbasin: Coeur d'Alene
FY02 Request: $1,174,365
3 YR Estimate: $3,540,071
Short Description: Enhance critical watershed habitat to mitigate limiting factors for westslope cutthroat in the Coeur 'd Alene subbasin. Compile physical, chemical and biological trend data and implement an environmental education and outreach program.
Response to ISRP comments requested: Yes
Comments:
Do not fund in present form. A response is needed that addresses the ISRP's concerns. The proposal and the project(s) it entails were difficult to review. The proposal and the presentation were filled with loosely linked information and observations, and were very difficult to find major themes and projects within. The proposal needs to be tightened significantly. Background material in the first section of proposal needs to be referenced and discussed without its present excessive detail. For example, the proposed objectives and methods begin on page 24 of the proposal.

Parts of the proposed program of fisheries enhancement appear to be well justified from subbasin analyses; others appear to be a potpourri of fisheries activities that may or may not address critical factors limiting salmonid abundance. Taken together, the activities do not add up to a coherent approach to subbasin level fisheries enhancement activities.

The program appears to lack a clear focused approach that is based strongly in the fisheries literature and on regional analyses of factors limiting salmonid distributions and abundance. The program appears disjointed. The proposed fisheries enhancement program would benefit from involvement and input from a senior fisheries ecologist. Development of a suite of focused fisheries activities strongly linked to the subbasin analyses needs to occur.

Specific comments and questions:
This project has been implementing watershed restoration - sediment retention ponds, riparian plantings, etc. - since 1990 on 4 small tributaries, with the primary goal of increasing numbers of westslope cutthroat trout. The original problem was identified as a decline in abundance of native salmonids caused by reduced streamflow, elevated water temperature, and increased fine sediment in stream substrates.

1. Please provide a concise description of the extent to which restoration activities have increased summer base flows, reduced water temperature, and reduced fine sediments. Such a description was lacking from the proposal and presentation.

2. Please provide average (and range) for trout density in the four streams that represent abundance prior to the restoration efforts.

3. Is there evidence that fish abundance has significantly increased as a result of this program?

4. What are the endpoints of this program? How will program/project managers know when they have met their goals and objectives?

5. Revegetation is used extensively in this program. Is there evidence that revegetation is necessary or effective? A good experimental design and monitoring program could and should address these.

6. Benthic samples are notoriously variable. Do the results to date show promise as a monitoring tool or are the results so variable that detection of a trend in any reasonable time seems unlikely?

7. Non-native brook trout are abundant in at least one stream (Alder Creek) and cutthroat trout restoration efforts elsewhere in the West generally have not been effective without eliminating or suppressing them. What is the basis for, and expectation of, the ongoing program, which is apparently based solely on habitat modification?

FYI: The goals objectives and tasks were almost completely cut and pasted from 2000 to 2002. The overall concept and theme are identical Interestingly, there are two distinct interpretations of the same basic proposal.

Project 199004402 Coeur d'Alene Tribe Trout Production Facility

FY 1999 ISRP Comments

This project originally was part of 199004400, as a result of ISRP comments this project was separated out into its own separate project.

ProjectID: 9004402
Coeur D' Alene Tribe Trout Production Facility
Coeur d' Alene Tribe
Short Description: Produce fish in support of on-going Coeur d'Alene Tribal fisheries enhancement projects. Complete Step 3-Final Cost Determination of the NPPC 3-step process, construct and begin hatchery operation. Evaluate effectiveness of fish production facility.

ISRP Recommendation - Fund / CBFWA Tier 1 / ISRP Comparison with CBFWA: Agree-fund
Sponsor Funding Request = $1,553,244 / CBFWA Funding Recommendation = $1,500,000
Recommendation:
Fund, but only if the construction plans are approved and NEPA findings are favorable. OK for review by BPA COTR.
Comments:
Although this is supposed to be a proposal to acquire funds for the construction of a salmonid fish hatchery, the majority of the proposal addresses other, albeit related, issues: e.g. perceived biological and mitigation need for the hatchery, land acquisition and habitat improvement projects, an emphasis on using native populations for supplementation purposes, hatchery operation including spawning procedures, and monitoring and evaluating effectiveness of hatchery releases in helping obtain mitigation objectives. In terms of construction, therefore, it is very difficult to evaluate. The hatchery appears to be an integral part of a larger well thought out and potentially valuable mitigation program.
The proposal was well written and comprehensive, in the midrange of quality of those reviewed. The FWP and 13 other planning documents are referenced as justification. The proposal discusses a good history of accomplishment for this project, including much survey work with recommendations, demonstration projects for stream rehabilitation, fish stocking, stock identification using genetics, and development of the hatchery master plan. It is all well documented in literature citations. There is excellent background and rationale, and the need for the hatchery is presented in the project history. Objectives and tasks are well laid out. Monitoring is planned well. The budget is well justified, but skewed toward the hatchery construction. Resumes of staff are provided and there are good plans for information transfer. This would be a good candidate for multi-year funding.
The use of native stocks is a particularly attractive part of the proposal. Are effects on other fish being monitored? The project involves a watershed assessment and habitat restoration. There is good coordination with habitat restoration and protection of wetlands and riparian habitat. About 2/3 of the budget is for construction but adequate information is not provided on the construction activities, schedule, or contractors. These should be handled in NEPA review and other processes for approval of construction. Where is the hatchery going to be located?
The set of three interrelated Coeur d'Alene Tribe proposals (including 9004400, 9004401, 9004402) might have benefited from an umbrella.

Additional Information

- ISRP Comment- Despite previous reviews (FY 1999, 2000, 3-Step), the contents of this proposal and discussion during the presentation have led the ISRP to be increasingly convinced that the proposed hatchery program for adfluvial cutthroat trout does not appear to be scientifically justified.

Response- The Tribe feels that the documents and reports used in the previous reviews by the ISRP, Council, Columbia Basin Fish and Wildlife Authority, and the Environmental Assessment Interdisciplinary Team[1] have sufficiently outlined the scientific validity of the Tribes management direction for the production facility. Furthermore, the intent of the Three-Step process was to provide scientific review and ways in which to improve upon the effectiveness of the hatchery. The Tribe has taken the approach of addressing the issues articulated in the Step 1 review document of the Council and is looking forward to submitting the Step 2 documents for further review. Moreover, in the general comments section of the ISRP 2000-1 document the following assessments were made:

> **"Despite the ISRP recommendation for the Coeur d' Alene to consider the use of a single stock described above, the reviewers were impressed by the willingness of the Coeur d' Alene Tribe to support supplementation activities on four individual tributaries and the westslope cutthroat trout populations endemic to each tributary. The plan recognizes and responds to many scientists' concerns about local adaptation, the uniqueness (or potential uniqueness) of individual populations, and maintenance of the fitness of individual populations. Some fisheries managers have been reluctant to manage artificial production facilities at this scale (that of the individual population) due to the expense and logistical difficulties. The Coeur d' Alene tribe is to be commended for their foresight and concern about the future of specific populations within the reservation."**

The document goes on to say:

> **" Finally, the Three-Step process includes numerous questions and criteria that the ISRP considered in its review of the master plan documents but are not elaborated on here. The ISRP found the Coeur d' Alene Tribe adequately addressed these and other questions and criteria in the master plan documents or in subsequent communications with the ISRP."**

It is concerning to the Tribe that such complimentary and constructive comments towards the hatchery can degenerate to comments such as "does not appear to be scientifically justified". The Tribe feels confident that the attached water quantity report, the cost effectiveness of the rainbow trout to the catch out ponds report, and comments contained herein, will validate the Tribes continuing efforts to address specific ISRP/Council concerns.

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[1] Comprised of scientists representing the NWPPC, U.S.F.W.S, Idaho Department of Fish and Game, and the Bonneville Power Administration.

FY 2002 Review

ProjectID: 199004402

Coeur D' Alene Tribe Trout Production Facility
Sponsor: Coeur d' Alene Tribe
Subbasin: Coeur d'Alene
FY02 Request: $775,469
3 YR Estimate: $2,516,120
Short Description: Enhancement of native stocks of CTT into natal tributaries by utilizing native CTT broodstocks and providing RBT for an interim fishery.
Response to ISRP comments requested: Yes
Comments:
A response is needed. The proposal was not clearly constructed and showed very little evidence of substantive results from work completed to date. The technical background section was identical to that of proposal 199004400, an indication of the redundancy and lack of clarity here.

The proposal does not adequately reflect input provided by the ISRP during Step One of the Three Step Review Process (ISRP 2000-1). The Step One review process included conversations with the project sponsors responsible for this project. The sponsors provided responses to a number of questions the ISRP posed. This process resulted in the ISRP's final recommendations, which specified a set of four conditions we thought needed to be met before the project moved to Step Two (or as part of the Step Two process). We also proposed two amendments to the Production Facility Master Plan that were to be considered by the tribe. The proposal should have discussed these, explaining how the conditions had been met and the proposed amendments dealt with. The ISRP notes that the proposal does state that the Coeur d'Alene Tribe proposes that the BPA fund a monitoring and evaluation program consistent with the recommendations of the NWPPC and the ISRP reviews of the project during the 3-step process. However, the response should specifically state how the proposed plan addresses the ISRP's Step One review regarding M&E.

About 10% of the proposed annual M&E budget is to monitor cutthroat trout abundance and rainbow trout catch from the put-and-take pond fisheries. The remainder ($303K) is for vaguely described data gathering on Coeur d'Alene Lake and tributaries that appears hugely redundant with work proposed by proposal 199004400. The proposal states that some of that work apparently would be done on Hangman Creek in the Intermountain Province (p 31 & 33); is that intended?

Despite previous reviews (FY 1999, 2000, 3-Step), the contents of this proposal and discussion during the presentation have led the ISRP to be increasingly convinced that the proposed hatchery program for adfluvial cutthroat trout does not appear to be scientifically justified. As Rieman and Apperson point out in their 1989 review of the status of westslope cutthroat trout in Idaho, no hatchery program has ever been successful for a stream-dwelling population of the subspecies. To be effective this program will need to be particularly well designed and executed. At this point in time, we are seeing more, rather than less cause to be skeptical of the possibility of success of this portion of the hatchery program.

The larger program is based on a premise that westslope cutthroat populations are depressed because of degraded habitat and, if the habitat is renovated, the populations will respond favorably. If that is the case, why is it logical to stock hatchery fish? Great effort in the proposal is put into overcoming what seems to be an assumption that stream conditions are limiting the target populations. What evidence is there to support that assumption? What consideration is given to possibility that space, food, predation, competition, or water quality in downstream waters is actually limiting population size?

We identify three alternative approaches to bolstering cutthroat populations as a basis for soliciting a response from the Tribe:

1. Enhance adfluvial cutthroat trout but without a hatchery. Three of the four study streams (Benewah, Alder and Evans creeks) seem especially poorly suited for adfluvial cutthroat trout restoration, because the migrating trout must transit through low gradient, warmer rivers or lakes such as Cave and Chatcolet lakes that hold abundant warmwater and coolwater predators before they enter Coeur d'Alene Lake. As the proposal notes, smallmouth bass are quickly expanding in the system following their illegal introduction a decade ago, and other predators seem abundant. A better approach to restoring adfluvial fish might be the continued focus of activities on Lake Creek and those few similar higher-quality (albeit off-reservation) tributaries that have existing adfluvial runs but no brook trout. These activities include a combination of habitat restoration, fish translocation, and selective lakeshore predator removal at critical periods to increase trout survival.

2. Concentrate on resident cutthroat (with habitat restoration, as is currently being done under proposal 199004400) instead of the adfluvial form. The probability of increasing their population size appears good, much better than the high risks involved with adfluvial fish and, as we pointed out in our review of 22 February 2000, doing this may also enhance adfluvial runs.

3. Acquire adfluvial fish for stocking, but from an outside source such as IDFG. This would alleviate fiscal concerns, which are not central to the ISRP but should be considered. Under the current hatchery proposal, each of the cutthroat fingerlings that would be stocked into the four target streams would cost approximately $10. An alternative approach might be to purchase cutthroat fingerlings elsewhere for stocking by Tribal staff.

Other specific questions to be addressed the response:

Page 3, line 4: "Usable spawning habitat comprises 4.1% of the total stream area in 2nd order tributaries." Is this conclusion based on a biologist's view of what is "usable" or is it based on the areas used by fish when the spawning population is large? Spawning site selection is influenced by factors that cannot be seen even by experienced observers. A value of 4.1% of stream area may be excessive of actual fish needs.

What is the goal of the rainbow trout stocking (angler hours? return percentage?).

What does a limiting factor analysis in Coeur d'Alene Lake entail? What results expected from Objectives 3a, 3b, 3c will help to conclude what is limiting?

We anticipate potential further interaction with the personnel involved in this project after they respond to our comments.

FRANK L. CASSIDY JR.
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Draft
(Version March 10, 2000)

MEMORANDUM

TO: Fish and Wildlife Committee

FROM: Mark Fritsch, Fish Production Coordinator

SUBJECT: Step 1 Review of the Master Plan for Coeur d'Alene Tribe Trout Production Facility

Recommendations

1. A.) Recommend that a sufficient sustainable water supply be verified as required by the conceptual plan for the hatchery.

   B.) Recommend that BPA and the Coeur d'Alene Tribe make a determination and provide a recommendation on the most cost effective means to provide trout for the catch out ponds.

2. Recommend that Bonneville Power Administration fund preliminary designs of the Coeur d'Alene Tribe Trout Production Facility after 1A and 1B are resolved.

3. Recommend that additional information be developed relative to three technical areas for consideration during the Step 2 review. These include: 1) the development of a harvest plan in conjunction with the monitoring and evaluation plan, 2) monitoring behavior of the Facility-produced trout to prevent displacing wild-spawned trout from stream habitats, and 3) monitoring interactions between Facility-produced and wild-spawned trout in Lake Coeur d'Alene, and resulting displacement of wild-spawned trout from limited habitat.

Significance

The Master Plan for Coeur d'Alene Tribe Trout Production Facility, submitted by the Coeur d'Alene Tribe (CDA), was intended to provide information for a plan to artificially rear westslope cutthroat trout for release into rivers and streams in the Coeur d'Alene Lake basin (i.e. Lake, Benewah, Evans, and Alder creeks) with the express purpose of restoration by increasing the numbers of fish spawning, incubating and rearing in the natural environment. It will use the technology that artificial production offers to overcome the mortality resulting from habitat degradation in lakes, rivers, and streams after eggs are laid in the gravel. This effort will be completed in conjunction with effective habitat restoration.

The Coeur d'Alene Tribe is also proposing that the Bonneville Power Administration (BPA) fund the artificial production of rainbow trout for release into five catch out ponds for a 'put and take' fishery on the reservation. The purpose of this artificial production is for augmenting the subsistent and sport fisheries. This interim fishery will be used for subsistence harvest needs for tribal members. It will also provide an alternative sport fishery for the surrounding community. These activities will also reduce fishing pressure on weak native stocks allowing recovery. When self-sustaining natural fish populations can support all subsistence and sport harvest needs this phase of the program will be discontinued.

Budgetary/Economic Effects

Planning to date has cost $199,490 and includes master plan completion and submittal, conceptual engineering designs and costing, partial staffing to complete necessary work for the submission of the master plan and to provide appropriate training for future hatchery personnel, and genetic analysis. Earlier efforts that assisted in the development of this project were covered in several projects these cost are not reflected in the above cost. Additional planning expenses include costs for compliance with National Environmental Policy Act (NEPA), staffing costs, planning costs associated with Step 2 and 3 for preliminary and final designs, and construction management. The amount currently budgeted for these activities are $651,781 through September 2000. However, the estimated total cost of completion for this phase of the project will be $932,221 and will take until the spring of 2001.

Construction of the Coeur d'Alene Trout Production Facility is estimated to cost $2,756,160. This includes the following items, construction of the facility, construction of four acclimation sites, construction of expansion of the well field to meet water needs and a 10 percent design and a 10 percent construction contingency fund. This cost does not reflect land acquisition costs for the acclimation sites or for the well field expansion sites or easement costs related to water delivery system. Land acquisition and easement costs are estimated to be about $64,000. Annual operation and maintenance costs after all facilities are fully developed would cost about $401,000, excluding additional start up costs. Monitoring and evaluation is estimated to cost about $300,000 annually. These cost figures are based on the estimates from the data that was provided by the proponents in their response to the three-step review process questions.

Costs[1]

FY	99	00	01	02	03	04	05	06	07	08	09
Planning	134	798									
Land Purchase		64									
Capital			2,756								

[1] Costs are in thousands of dollars.

O&M		200	200	601	401	401	401	401	401	401	401
M&E				300	300	300	300	300	300	300	300

Background

1. History of the development of the Coeur d'Alene Tribe Trout Production Facility

The initial measures for establishing a Coeur d'Alene fish production facility for native trout were amended into the Northwest Power Planning Council's (Council) in 1987. First steps in this process included a baseline stream survey of tributaries located on the Coeur d'Alene Indian Reservation [section 903 (g)(1)(B)].

In 1994, the Council adopted the recommendations of the Coeur d'Alene Tribe to improve the reservation fishery that were based on the baseline stream surveys. These recommendations included: 1.) Implement habitat restoration and enhancement measures in Lake, Benewah, Evans, and Alder creeks; 2.) Purchase critical watershed areas for protection of fisheries habitat; 3.) Conduct an educational/outreach program for the general public within the Coeur d'Alene Indian Reservation to facilitate a "holistic" watershed protection process; 4.) Develop an interim fishery for tribal and non-tribal members of the reservation through construction, operation and maintenance of five trout ponds; 5.) Design, construct, operate and maintain a trout production facility, and 6.) Implement a five-year monitoring program to evaluate the effectiveness of the hatchery and habitat improvement projects (see Program Sections: 10.8B; 10.8B.1; and 10.8B.20). The master plan submitted by the tribe addresses all of these recommendations to some extent, but focuses especially on recommendations 4, 5 and 6.

In July 1997, Congress directed the Council to conduct a review of all federally funded fish hatchery programs in the Columbia River Basin. The purpose of the review was to provide recommendations to Congress for a coordinated policy for future operation of these programs and recommendations for how to obtain such a policy. As this Artificial Production Review (APR) for the Columbia River Basin proceeded, the Council called for artificial production initiatives to be reviewed at three significant stages in development – conceptual design (Step 1, conceptual planning and development of a master plan development and approval), preliminary design (Step 2, preliminary design and cost estimation, as well as environmental [NEPA and ESA] review), and final design (Step 3, final design review prior to construction). This interim process was developed to respond to concerns of the Independent Scientific Review Panel regarding planning and implementation of artificial production projects as well as other Council concerns.

The Council adopted the APR report (Document 99-15) at its October 13, 1999 meeting. This report contains a set of policies intended to guide the use of artificial production in the future as well as recommendations for how to implement the policy reform. The Council intends to continue to use the three-step process for review of proposed new artificial production programs while incorporating the APR recommendations, as appropriate. The Council believes that the substantive elements of that review process have been improved by the recently adopted APR report, and that the APR reflects the best available science on this topic. As such, it is important that new production initiatives such as that for the Coeur d'Alene Tribe Trout Production Facility take into account the contribution of the APR report in the current process.

On November 15, 1999 the Coeur d'Alene Tribe submitted to Council a master plan, as the first step in the three-step review process. The role of the Coeur d'Alene Trout Production Facility is mitigation for the loss of anadromous fish harvest as a result of elimination/blockage of salmon habitat through construction and operation of Grand Coulee Dam. Additionally, given the extent of habitat loss from the encroachment of man into the riparian and adjacent lands of tributaries on the Coeur d'Alene Indian Reservation, it is unlikely that natural production in a recovered ecosystem would support all tribal subsistence, and sports harvest interests.

The Coeur d'Alene Tribe stresses the need to restore the natural functions of the Coeur d'Alene subbasin ecosystem that produce salmonid fishes, as opposed to circumventing natural ecological processes. The Coeur d'Alene Tribal Fish, Water and Wildlife program is based on watershed management that equally protects and enhances fish and wildlife resources throughout the Reservation. Overarching goals for the program includes: 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 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. 5.) Keep ecological and genetic impacts to non-targeted fish populations to a minimum. These five concepts will provide the framework to guide planning and implementation of the Coeur d'Alene Tribe's Fisheries Management Plan.

Adfluvial cutthroat trout are the target species for supplementation. They are species of special concern throughout the region. The status of westslope cutthroat trout as threatened or endangered over its entire range is currently under review by the U.S. Fish and Wildlife. This program will participate in as well as help to develop any recovery plans for ESA listed species located on the Reservation or affected by activities conducted.

The proposed project will address partial mitigation (out-of-place, out-of-kind) for anadromous fish losses in the Upper Columbia River basin through a resident fish substitution program[2]. The Coeur d'Alene Tribe Trout Production Facility construction project is one of many ongoing efforts directed at mitigating losses attributed to construction of Grand Coulee and Chief Joseph Dams.

The artificial production program will be designed to produce 10,000 catchable sized rainbow trout for the five catch out ponds and up to 100,000 fingerling cutthroat trout for restoration efforts in the target tributaries (i.e. Alder, Benewah, Evans and Lake creeks). The hatchery will also support up to 2000 adult cutthroat trout for use as broodstock (Table 1).

Table 1. Maximum Production Capacity of Coeur d'Alene Trout Production Facility

Number of Fish	Ave. Size/ Ave Weight	Species/Life Stage	Pounds Produced Annually
2,000	20 inch/2.8 lbs.	CTT/ Broodstock	5,600 lbs.
100,000	4 inch/22.6 lbs. per 1000	CTT/ Fingerling	2,260 lbs.
10,000	12.5 inch/780 lbs. per	Rainbow Trout/	7,800 lbs.

[2] Policies and measures for resident fish substitution are in Sections 10.1 and 10.2 of the Council's Fish and Wildlife Program. The intent of this policy is to replace losses of anadromous fish in areas now permanently blocked to salmon and steelhead with resident fish species.

	1000	Adult	
Total 122,000			14,660 lbs.

Broodstock will be collected from each of the four target tributaries. These fish will be collected as migrating juveniles and held until adults in order to minimize affects on the natural populations. Each year, initially, 100-200 juveniles will be collected from the same sites in the target watersheds. These fish will be individually marked and placed into separate raceways. As these fish mature they will be used as broodstock.

Westslope cutthroat trout will be initially stocked as juveniles. They will be placed in a stream fed acclimation pond adjacent to the individual target tributary and allowed to leave the pond on their own volition. If adult returns are poor from this stocking strategy then other types of stocking will be experimented with (i.e. fry plant). Certified eyed rainbow trout eggs will be purchased and raised in the hatchery. When ready the fish will be outplanted into the five catch out ponds. As fish are removed from the pond, more will be added with a maximum of up to 2,000 per pond annually.

The monitoring plan as outlined in the master plan will be revised and amended to address the insights gained from the effort. In the face of scientific uncertainty, monitoring and evaluation provides this insight into the actual result of an action, as well as, explains the outcome in achieving predicted results. The Coeur d' Alene Tribal Fish, Water and Wildlife project biologists and managers will initiate an artificial production program that will ensure the experimental studies provide reliable results, and that risks associated with uncertainties are minimized.

Expected benefits from the Coeur d'Alene Tribal Trout Facility include:

- Production of up to 10,000 catchable sized rainbow trout for stocking in five Tribal catch out ponds.
- Increases in the current distribution of westslope cutthroat trout on the Reservation and in Coeur d'Alene Lake.
- Using habitat restoration in conjunction with supplementation to increase the abundance of westslope cutthroat trout on the Reservation and in Coeur d'Alene Lake.
- Double the current number of naturally produced returning adults in each of the four target tributaries, while providing a harvestable surplus, within 10 years of construction of the facility.
- Reduce the risk of extinction for westslope cutthroat trout in the four target tributaries such that there is a 95 percent probability of persistence over 100 years for each target tributary.
- Provide over 80,000 angler hours of opportunity with a catch rate of 0.5 fish/hour at the five Tribal catch out ponds annually.

The proposed facility will contain an indoor central incubation and early life stage rearing facility. This building will also house the main offices, wet and dry analytical laboratory, and interpretive center. Four outdoor production raceways will be constructed to hold juvenile fish until they are ready to move to the satellite acclimation facilities. In addition, four raceways will be constructed to hold broodstock from each of the four tributaries. Four offsite satellite acclimation facilities will also be constructed to hold the fish for acclimation and volitional releases.

Two earthen grow out ponds to support the rainbow trout for the catch out ponds will be constructed. They will be kept in the grow out ponds for an additional period of about 1.5 years, at which time (year 2) they will be outplanted into the five catch out ponds. The rainbow trout catch out ponds will be approximately 75 feet wide and 190 feet long each. Total pond depth will vary from 15 ft at the supply end to 16 ft at the drain end to facilitate drainage

2. The Three-Step Review Process

The annual prioritization process for projects funded under the Fish and Wildlife Program included a review by the Independent Scientific Review Panel starting in Fiscal Year 1998. During this review, the Independent Scientific Review Panel recommended that a comprehensive basinwide review of artificial production occur. This review is currently underway and scheduled for completion in June 1999. The ISRP recommended that until completion of the review the Council "not approve funding for the construction and operation of new artificial propagation programs," with this exception:

> "To prevent a complete moratorium on new production, the ISRP recommends that the Council permit funding for an individual project only if the project proponents can demonstrate they have taken measures 7.0D, 7.1A, 7.1C, and 7.1F into account in the program design and the Council concurs. To ensure that standard is met, the individual projects should be funded only after a positive recommendation from an independent peer review panel."

The Council responded with an interim approach to this issue called the three-step review process. This process is built upon the existing multi-step design and review process recognized in the program and used by Bonneville for the design, review, approval and implementation of new production initiatives. The steps of this process are: Step 1 -- conceptual planning, represented under the Program primarily by master plan development and approval; Step 2 -- preliminary design and cost estimation, as well as environmental (NEPA and ESA) review; and Step 3 -- final design review prior to construction and operation.

For purposes of the three-step review process, "new production initiatives" is defined generally to include projects that propose to: (a) construct significant new production facilities; (b) begin planting fish in waters they have not been planted in before; (c) increase significantly the number of fish being introduced; (d) change stocks or the number of stocks; or (e) change the location of production facilities. It also includes initiation of funding existing facilities with ratepayer funds that were formerly funded otherwise.

In adopting the three-step review process, the Council also agreed with the ISRP's recommendation to make use of independent peer review for projects as they move through each stage of the development process, although the scope of the independent review and the questions asked during the review will be different at the different stages. Initially the Council intended to utilize a production peer review group that was to be appointed to assist the ISRP in the annual prioritization review process. Issues related to timeliness, workload size and priorities, and funding demonstrated that this avenue for independent peer review would not provide for this need. For this reason, an alternative approach needed to be used to procure peer review.

Congress amended Section 4(h)(10) of the Power Act in 1996 to add additional procedural and substantive requirements to this project selection and funding process, especially the addition of an independent science review. Congress acted primarily to insulate the funding process from a perceived conflict of interest -- the fish and wildlife agencies and tribes review and prioritize the projects for funding and are also the primary funding recipients. The amendment directed the Council to appoint (from nominations submitted by the National Academy of Sciences) an 11-member Independent Scientific Review Panel "to review projects proposed to be funded through that portion of the Bonneville Power Administration's annual fish and wildlife budget that implements the Council's fish and wildlife program." The Council and the Region has three full years of experience in implementing the process mandated by the 1996 amendment to the Act. The Council believes that this review and selection process has brought, and will continue to bring, additional credibility to the Program and its implementation.

Peer review for the three-step review process was accomplished using Pacific Northwest National Laboratory as a facilitator through Fiscal Year 1999. In Fiscal Year 2000 the Council requested the assistance of the ISRP. This action not only complements the exiting reviews that have been conducted by the ISRP, but is intended to provide consistency to the anticipated rolling reviews for the Columbia River basin. The three-year rolling ISRP review will provide peer review of activities in each province and subbasins within a province. The ISRP step review includes several steps. The ISRP selected three members to conduct the review. These three members individually reviewed the Coeur d'Alene's Master Plan and supporting documents, including the Supplementation Feasibility Report and the Program Management Plan. The reviewers commented on each of the responses by the Coeur d'Alene Tribe to the questions asked by the Council as part of the three-step review. The ISRP members then discussed their reviews via teleconference and identified areas where more information was needed from the Coeur d'Alene Tribe and drafted a preliminary review. This preliminary review was discussed with the full ISRP. Consensus was reached on the approach, and questions to obtain further information from the Coeur d'Alene Tribe were refined. After exchanges between the ISRP and the sponsor on the information needs the ISRP reviewers then presented their findings to the entire ISRP and consensus was reached. The results of the peer review are reviewed with the project proponents and form the basis for Fish and Wildlife Committee recommendations to the Council on the scientific aspects of each project.

The Master Plan for Coeur d'Alene Tribe Trout Production Facility peer review resulted in 34 questions and responses to technical and procedural issues. The ISRP recommended that additional clarification and information was needed on certain aspects of the project. This include the following:

- Goals of the project as it related to overcoming the physical and biological issues, and lake habitat
- Factors limiting production of the target species and the methodology employed in determination
- Alternatives for resolving the resource problem as it related to lake habitat, flow regulation, physical constraints and predator control of introduced species. In addition the need to explore the use of as single brood stock.
- Conceptual design of the proposed production and monitoring facilities, including an assessment of the available and utility of existing facilities as it relates to the proposed water supply

The above information requests were resubmitted to the proponents for additional clarification. The Coeur d'Alene Tribe provided a written response to the questions. The ISRP reviewed the responses and developed a second set of questions to discuss with the Coeur d'Alene representatives via teleconference. The additional information needs focused on the following

- The detrimental effects of hatchery-bred trout on existing trout populations
- The hatchery's water supply

The teleconference took place on February 7, 2000. The ISRP reviewers then presented their findings to the entire ISRP and consensus was reached. The above requests and responses, and conclusions are in the ISRP's review document (attachment 1). The results of the ISRP review and conditions regarding the water supply, rainbow trout costs and information needs were reviewed with the project proponents and form the basis for the Fish and Wildlife Committee recommendations to the Council on the proposed actions for this project.

3. <u>Issue paper review and comment</u>

Council staff prepared an issue paper (document 99-17) on the master plan and released it on December 7, 1999. The intent of this issue paper was to invite comment on the issue paper and the master plan. In particular, public comments on the key issues listed in this issue paper were requested. The Council invited comment on the issue paper at the January 12 and February 1, 2000 meetings and accepted written comments through February 4, 2000. The key issues focused on genetic and ecological risk, habitat, basin planning, catch out ponds, ESA listing and harvest management. The issue paper is not intended to constrain alternatives the Council may consider or limit Council action on this project, but to initiate dialogue with interested parties in the basin. No oral comments were made regarding this project at the two meetings where a request was made. The only comment received occurred on February 4, 2000 in written form from Idaho Fish and Game (IDFG). Many of issues inherent in IDFG comments were addressed in the ISRP review process. In addition IDFG offered to assist the Tribe with the use of its hatchery system.

Analysis

1. <u>A.) Recommend that a sufficient sustainable water supply be verified as required by the conceptual plan for the hatchery.</u>

   <u>B.) Recommend that BPA and the Coeur d'Alene Tribe make a determination and provide a recommendation on the most cost effective means to provide trout for the catch out ponds.</u>

The conditions listed above can only be satisfied by further engineering studies and economic analysis. Although the conditions are separate they are explicitly link to the proposed facility and the competition of a limited resource in times of short supply. At this point in time it is difficult to make a determination on these issues until further information is developed.

A report should be submitted to the Council for consideration prior to any other activity associated with the development of preliminary designs. This report should provide a detailed analysis of the studies that determined the yields of test wells and the additional cost of delivering the water to the facility.

The report also needs to clearly provide an analysis on the most cost effective and efficient means to provide trout for the catch out ponds. This report needs to clearly address the issues raised in the issue paper (document 99-17) and ISRP review (ISRP document 2000-1), especially as it relates to the limiting water supply.

2. <u>Recommend that Bonneville Power Administration fund preliminary designs of the Coeur d'Alene Tribe Trout Production Facility after 1A and 1B are resolved.</u>

The program requirements for this project appear to have been met. . Master planning elements have been addressed. ISRP step review has found these efforts to adequately address the program except for some minor issues that can be addressed during preliminary design and reviewed as part of the Step 2 review. In addition, the National Environmental Policy Act and has been addressed as appropriate at this time.

This recommendation would call for the completion of preliminary design to meet the needs of this project. This recommendation be made conditioned on BPA and the Coeur d'Alene Tribe completing the analysis and report regarding the water supply for the facility and costs of providing rainbow trout for the catch-out ponds.

3. <u>Recommend that additional information be developed relative to three technical areas for consideration during the Step 2 review. These include: 1) the development of a harvest plan in conjunction with the monitoring and evaluation plan, 2) monitoring behavior of the Facility-produced trout to prevent displacing wild-spawned trout from stream habitats, and 3) monitoring interactions between Facility-produced and wild-spawned trout in Lake Coeur d'Alene, and resulting displacement of wild-spawned trout from limited habitat.</u>

The peer review resulted in a recommendation that additional clarification was needed on certain aspects of the project. Specifically, the reviewers recommended that the status of the project regarding harvest plans and monitoring and revaluation elements be discussed in the project documentation. Staff believes that it is important to fully address these questions to minimize and eliminate unreasonable risk. Therefore, it is recommended that the Council call for the development of additional information for review at Step 2 of the project on the following topics:

- Effects on wild-spawned adfluvial trout of fisheries directed at hatchery-released trout can be minimized by harvest regulation. Trout produced from the Facility will be identifiable by external marks (excised adipose fins.) Anyone catching an unmarked trout can be required to release it unharmed. Specific harvest regulations, coordinated with the Idaho Department of Fish and Game who manage part of the Lake's fisheries, remain to be developed. This condition can be met by further development of a harvest plan in conjunction with the monitoring and evaluation plan

- Trout produced by the Facility will be prevented from displacing wild-spawned trout from stream habitats by a volitional release strategy by which only trout competent to migrate directly to the Lake will exit the holding ponds into migration corridors near the stream mouths. The behavior of the trout will be monitored by a trap-sampling program both above and below the release location to document the degree of upstream and downstream migration. This condition can be met by further development of the monitoring and evaluation plan

- Interactions between Facility-produced and wild-spawned trout in Lake Coeur d'Alene, and resulting displacement of wild-spawned trout from limited habitat there, are not expected. Any potential ecological interactions can and will be monitored by sampling fish in the Lake. This condition can be met by further development of the monitoring and evaluation plan.

Alternatives

1. <u>Reject funding for Step 2 (preliminary design) activities.</u>

The Council might terminate the Coeur d'Alene Tribe Trout Production Facility at this time if the project:

- costs are too high for the expected benefits,
- production is not needed,
- expected benefits can be obtained in some other manner,
- risks are unacceptable and cannot be reduced

Staff does not believe that any of these factors apply to the Coeur d'Alene Tribe Trout Production Facility based on information presented in background documents and in the ISRP review. For this reason, staff does not recommend this alternative

2. <u>Require Further Review to Address Unanswered Concerns</u>

The Council could decide that there are significant concerns and risks that are unacceptable and need to be further addressed. This could be due to cost and/or biological concerns.

Staff believes that the current reviews, coordination, and study designs to date have addressed concerns sufficiently to justify the proposed expansion of the project's production. Therefore, staff does not recommend this alternative

Attachment 1

Independent Scientific Review Panel

for the Northwest Power Planning Council

Review of Coeur d'Alene Tribe
Trout Production Facility Master Plan

Step One of the Northwest Power Planning Council's
Three-Step Review Process

Charles C. Coutant
Daniel Goodman
Susan S. Hanna
Nancy Huntly
Dennis Lettenmaier
James Lichatowich
Lyman McDonald
Brian Riddell
William Smoker
Richard R. Whitney
Richard N. Williams

ISRP 2000-1
February 22, 2000

ISRP Review of Coeur d'Alene Tribe Trout Production Facility Master Plan

REVIEW PROCESS

The Coeur d'Alene Trout Production Facility Master Plan was the first project reviewed by the ISRP as part of the Northwest Power Planning Council's Three-Step Review. The ISRP review included several steps. The ISRP selected three members to conduct the review. These three members individually reviewed the Coeur d'Alene's Production Facility Master Plan and supporting documents, including the Supplementation Feasibility Report and the Program Management Plan. The reviewers commented on each of the responses by the Coeur d'Alene Tribe to the questions (or criteria) asked by the Council as part of the Three-Step review. The ISRP members then discussed their reviews via teleconference and identified areas where more information was needed from the Coeur d'Alene Tribe and drafted a preliminary review. This preliminary review was discussed with the full ISRP. Consensus was reached on the approach, and questions to obtain further information from the Coeur d'Alene Tribe were refined. The ISRP then submitted a request for additional information to the Coeur d'Alene Tribe (attachment 1). The Coeur d'Alene Tribe provided a written response to the questions (attachment 2). The ISRP reviewed the responses and developed a second set of questions to discuss with the Coeur d'Alene representatives via teleconference (attachment 3). The teleconference took place on February 7, 2000 and included Ron Peters, and Kelly Lillengreen, representing the tribe, Mark Fritsch and Erik Merrill from the Council, and the three ISRP subcommittee members. The ISRP reviewers then presented their findings to the entire ISRP and consensus was reached. The ISRP findings are described below.

RECOMMENDATION

The ISRP recommends that planning for the Facility proceed from Step 1 to Step 2 if the following conditions are met.

CONDITIONS

The ISRP, in its review of the Plan, had several concerns that were alleviated by correspondence and conversation with Tribal Staff. The ISRP recommendation stated above is given with the understanding that:

1. Effects on wild-spawned adfluvial trout of fisheries directed at hatchery-released trout can be minimized by harvest regulation. Trout produced from the Facility will be identifiable by external marks (excised adipose fins.) Anyone catching an unmarked trout can be required to release it unharmed. Specific harvest regulations, coordinated with the Idaho Department of Fish and Game who manage part of the Lake's fisheries, remain to be developed. This condition can be met by further development of a harvest plan in conjunction with the monitoring and evaluation plan. *(Three-Step Question 8. Harvest Plan)*

2. Trout produced by the Facility will be prevented from displacing wild-spawned trout from stream habitats by a volitional release strategy by which only trout competent to migrate directly to the Lake will exit the holding ponds into migration corridors near the stream mouths. The behavior of the trout will be monitored by a trap-sampling program both above and below the release location to document the degree of upstream and downstream migration. This condition can be met by further development of the monitoring and evaluation plan. *(Three-Step Questions 1-3. Goals and Limiting Factors; Question 20. Monitoring and Evaluation Plan)*

3. Interactions between Facility-produced and wild-spawned trout in Lake Coeur d'Alene, and resulting displacement of wild-spawned trout from limited habitat there, are not expected. Any potential ecological interactions can and will be monitored by sampling fish in the Lake. This condition can be met by further development of the monitoring and evaluation plan. *(Three-Step Questions 1-3. Goals and Limiting Factors; Question 20. Monitoring and Evaluation Plan)*

4. A sufficient sustainable water supply must be available to provide the 60 gallons per minute required by the conceptual plan for the hatchery. This condition can only be satisfied by further engineering studies to determine the yields of test wells and the additional cost of delivering the water to the facility. *(Three-Step Question 21. Conceptual Design)*

POTENTIAL AMENDMENTS

In addition to the conditions described above, the ISRP recommends that the Tribe consider two amendments to its plan that may enhance its effectiveness.

1. Rather than producing rainbow trout at the Facility for planting in ponds for an interim fishery, it may be more efficient and safer to purchase such trout from another source. If these trout were cultured in the Facility simultaneously with the native cutthroat trout, they would compete for resources (water and others) in times of short supply, and they would present a potential pathogen source for the native cutthroat trout. Furthermore, it seems likely that rainbow trout can be purchased from a commercial source at lower cost than they could be produced in this Facility. Sterile rainbow trout are available at large sizes, which could add to the interest by participants in the program. *(Three-Step Question 5. Alternatives)*

2. Maintain a single stock of adfluvial cutthroat trout in the Facility, rather than maintaining four groups whose differences are probably negligible. This would simplify operation of the Facility and is probably justified by the relatively homogenous genetic structure of trout in the streams around the Lake. *(Three-Step Question 5. Alternatives, Point B; Question 19. Constraints and uncertainties, including genetic and ecological risk assessments and cumulative impacts.)*

Specifically, based on information presented in Appendix C of the Coeur d'Alene Master Plan (Knudsen and Spruell 1999, and the appended letter and dendrogram from Spruell), there appears to be little geographic structure in the genetic variation observed among the populations as well as little genetic distance. Work by Spruell et al. (1999, also in appendix C) examined westslope cutthroat trout from 16 sites for evidence of hybridization with rainbow trout. They identified six populations that appeared free of introgression and might be used as broodstock sources. The remaining ten sites showed evidence of hybridization with rainbow trout, although the levels of introgression were quite low.

Spruell and colleagues' genetic work suggest that while genetic distances are very small among populations, overall genetic diversity is high minimizing the concern that mixing fish from different local populations will result in a decrease of fitness associated with outbreeding depression. While small genetic differences were observed among populations, the genetic data suggest that prior to recent fragmentation, considerable gene flow likely occurred among the Coeur d'Alene populations.

General Comments

The approach to restoration of Coeur d'Alene westslope cutthroat trout populations on reservation lands might be most successful if it focused on stream habitat restoration and on the resident, rather than the adfluvial, life history pattern. While an overall project goal is to increase adfluvial fish, which due to their larger size present the best harvest opportunity consistent with the tribe's goals, a biologically viable approach might be to focus on increasing resident westslope cutthroat trout abundance in tributary streams – including reintroduction into streams where they have been extirpated or are at very low numbers.

At first glance, the focus on resident fish – in order to bolster adfluvial production – may seem counterintuitive. However, a hallmark of trout and salmon biology, particularly within the genus *Oncorhynchus*, is a high level of behavioral and life history plasticity and diversity. It is not uncommon in cutthroat and rainbow trout populations to find several life histories including resident, fluvial, adfluvial, and even anadromous forms co-occurring, assuming the fish have downstream access to either a lake or the ocean. Seemingly, the life history patterns within the population expand to take advantage of the various habitats that are available. Examples exist in the literature where one life history form is introduced to a new location then other life histories appear subsequently. Therefore, reestablishment of viable resident westslope cutthroat trout populations in numerous Lake Coeur d'Alene tributary streams could provide the population base for additional expression of the adfluvial cutthroat trout life history pattern.

Despite the ISRP recommendation for the Coeur d'Alene to consider the use of a single stock described above, the reviewers were impressed by the willingness of the Coeur d'Alene tribe to support supplementation activities on four individual tributaries and the westslope cutthroat trout populations endemic to each tributary. The plan recognizes and responds to many scientists' concerns about local adaptation, the uniqueness (or potential uniqueness) of individual populations, and maintenance of the fitness of individual populations. Some fisheries managers have been reluctant to manage artificial production facilities at this scale (that of the individual population) due to the expense and logistical difficulties. The Coeur d'Alene tribe is to be commended for their foresight and concern about the future of specific populations within the reservation.

Finally, the Three-Step process includes numerous questions and criteria that the ISRP considered in its review of the master plan documents but are not elaborated on here. The ISRP found the Coeur d'Alene Tribe adequately addressed these other questions and criteria in the master plan documents or in subsequent communications with the ISRP.

References Cited

Knudsen, K. L. and P. Spruell. 1999. Genetic analysis of westslope cutthroat in tributaries of Coeur d'Alene Lake. Final Report WTSGL99-106, pp. 17. Wild Trout and Salmon Genetics Laboratory, Missoula, Montana. June 1999.

Spruell, P., K. L. Knudsen, J. Miller, and F. W. Allendorf. 1999. Genetic analysis of westslope cutthroat trout in tributaries of Coeur d'Alene Lake. Progress Report WTSGL99-101, pp. 17. Wild Trout and Salmon Genetics Laboratory, Missoula, Montana. January 1999.

Attachment 1. First ISRP Request for Additional Information

INDEPENDENT SCIENTIFIC REVIEW PANEL

Northwest Power Planning Council
851 SW Sixth Avenue, Suite 1100
Portland, Oregon 97204
Emerrill@nwppc.org
1.800.452.5161

January 18, 2000

MEMORANDUM

TO: Mark Fritsch, NWPPC

FROM: Rick Williams, ISRP Chair

SUBJECT: ISRP Questions for Coeur d'Alene Tribe as Part of Step 1 Review Process

The Coeur d'Alene Tribe has assembled a meritorious set of documents for review by the ISRP as part of the Council's Step 1 process. The documents are full of interesting information. However, we found ourselves unsure on some points. Accordingly, we assembled the following list of subject matter and questions that we need clarification on to complete our Step 1 review. These are numbered in the same order that the questions were given in the Council's letter "Program Language Regarding Master Planning Requirements".

(1). Goals of the Project
The goals of the project are not entirely clear. Part of the problem might stem from the format of the request from the council for elements that are to be part of the Master Plan. The goal might very broadly be stated as an intention to mitigate for fishing opportunity lost as a result of development of the hydroelectric system. On the other hand, for technical review by the ISRP what is needed is a full description of the specific end point desired, i.e., the fish that will constitute mitigation, the tasks that need to be undertaken to achieve mitigation, and how the hatchery fits into the program. For this purpose, the goals and rationale need to be closely linked. Our questions that follow are aimed at accomplishing this linkage.

The ISRP understands the goal with westslope cutthroat trout to be to increase abundance of spawners in four selected streams by supplementing each stream with juvenile cutthroat trout developed from brood stock taken from each stream. There appears to be spawning area available that is not being fully used. The concept appears to be to enhance populations of adfluvial cutthroat trout that eventually (by the year 2007) will return to the streams in sufficient abundance to provide a surplus of fish for harvest. Reference is made in the documents both to "smolts" and "returning adults". Meanwhile stream improvement measures will be undertaken to increase productive capacity of the tributaries.

Question. If, as we are given to understand in various places in the documents, temperature and interactions in the lake with introduced species limit the abundance of adfluvial cutthroat trout, how can supplementation in the tributaries overcome this problem?

Question. There is a suggestion in the documents that conditions are improving in the lake, but we can find no explanation for this, nor is there any discussion of efforts that might be underway to improve conditions in the lake. Is anything being done to improve cutthroat habitat in the lake?

(3). Factors limiting production of the target species;
Reference is made to the calculation of HSIs (Habitat Suitability Indices), but no description of the method is provided.

Question. How was this methodology employed?

Question. Is there an extension of this or a similar method to the lake habitat?

(5). Alternatives for resolving the resource problem
Point A. We feel that alternatives should be explored on a larger scale than those discussed in this proposal in order to place the hatchery proposal in a larger perspective. For example, it might seem appropriate to include at least a discussion of the pros and cons of providing fish passage at Chief Joseph and Grand Coulee dams that were considered at the time these projects were constructed. The arguments used against such provision at the time of their construction may or may not be valid any longer.

Question. Given the proposal at hand, since the greatest potential for increased production of cutthroat trout probably exists in the lake rather than the tributaries, has the tribe investigated the feasibility of physical manipulations to improve lake habitat, such as regulation of lake elevation in time and space and/or diking of the southern, shallow portion of the lake?

Question. What is the relationship between operations at Post Falls Dam and introduction into Lake Coeur d'Alene of warm water from Round Lake and other sources?

Question. What other sources of pollution are present in the watershed, in addition to the high temperature water from the shallow bays and southern end of the lake?

Question. Has the tribe considered biological manipulations, such as trapping of northern pike populations to reduce predation on cutthroat trout in the lake?

Point B. Some finer scale alternatives should also be explored.

Question. Given the genetic information available (i.e., very small genetic distances and evidence suggesting that CDA cutthroat populations were physically linked until recent times), could the project objectives be reached with a single brood stock developed from a mixture of the genetically pure westslope cutthroat trout populations on CDA lands? Is it necessary to maintain separate brood stocks for cutthroat from the four tributaries that have been chosen?

(6). Conceptual design of the proposed production and monitoring facilities, including an assessment of the availability and utility of existing facilities.

It is clear that adequate water is not available at the site chosen. If more water is not found, there would have to be radical changes in the conceptual design before proceeding to Step 2 in the Council's process. Even more to the point, the basic concept of supplementing westslope cutthroat trout by means of a hatchery at this location might have to be scrapped. Therefore, until the water supply problem is solved, the ISRP feels that it cannot recommend moving this project out of Step 1.

Our finding that the section on alternatives needs to be enlarged becomes even more relevant.

Question. Is there additional information available as to the water supply, or relocation of the hatchery site?

Coeur d'Alene Tribe

850 A Street P.O. Box 408 Plummer, ID 83851

TO: Erik Merrill
ISRP Coordinator
Northwest Power Planning Council

FROM: Kelly Lillengreen
Trout Production Facility Project Manager

SUBJECT: Additional clarification for completion of ISRP Step 1 review of the Coeur d'Alene Tribe Trout Production Facility Master Plan

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The Coeur d'Alene Tribe is pleased that the ISRP was able to participate in the NWPPC's Step review process for our proposed Trout Production Facility. We hope that the following responses adequately address the ISRP's list of subject matter and questions that you sent us. Each response is numbered in the same order that the questions were given in the ISRP's letter to you regarding this subject

1.) Goals of the Project

Response to comments on subject matter

As stated the broad goal of the project is to partially mitigate for lost fishing and subsistence harvest opportunities resulting from the development of the Columbia River hydroelectric system. Some of the specific technical goals that will achieve partial mitigation needed for your review are found in the master plan section 4.2.

Table 4.2.1 Biological and harvest objectives for adfluvial cutthroat trout in tributaries of the Coeur d'Alene Reservation

Tributary	Target Level[a] (percent)	Escapement[b] Target	Harvest Target[c]	Biological[d] Objective	Year
Alder Creek	25	1,708	920	2,628	2007
	50	3,416	1,840	5,256	2012
	75	5,123	2,759	7,882	2016
	100	6,831	3,679	10,510	Beyond
Benewah Creek	25	2,179	1,174	3,353	2007
	50	4,357	2,347	6,704	2012
	75	6,534	3,519	10,053	2016
	100	8,713	4,692	13,405	Beyond
Evans Creek	25	984	530	1,514	2007
	50	1,968	1,060	3,028	2012
	75	2,951	1,589	4,540	2016
	100	3,935	2,119	6,054	Beyond
Lake Creek	25	2,002	1,078	3,080	2007
	50	4,004	2,156	6,160	2012
	75	6,006	3,234	9,240	2016
	100	8,008	4,312	12,320	Beyond

The previous table represents the harvest and escapement targets necessary for completing the stepped approach described in the master plan resulting in the specific goal of having self-sustaining harvestable populations of naturally reproducing westslope cutthroat trout in the target tributaries described in the master plan. These fish constitute partial mitigation.

The harvest goal is 35% of the total numbers of adults returning to the target tributaries once the populations have stabilized and it has been determined that the trend is increasing. Until the 75% objective is met only hatchery fish will be harvested. Total allowable tributary harvest will be based on meeting spawning escapement goals. No changes to the limited harvest mixed stock fishery in Coeur d'Alene Lake are anticipated until populations of tributary stocks have stabilized and the 75% objective has been met.

Response to question 1:

The Tribe is currently focussing restoration efforts toward eliminating the limiting factors in the target watersheds as well as increasing our understanding of what is happening in the lake. At this point, we know that productivity is limited in both the stream and lake environments. We know that egg to juvenile survival is poor thus, we are proposing to release fish as migrating juveniles. Lake survival is unknown but we would be able to determine lake survival by reconstructing the runs based on brood year returns of hatchery raised fish. This information would allow us to better target our efforts in the lake. It also must be understood that the conditions in the lake only limit the population (to some degree that currently has not been defined) not eliminate it. Thus, the intent of the Tribe is to use supplementation to increase the survival rate of the population during its early life history (egg through juvenile) relative to its survival rate under natural conditions in the stream while exploiting the niche that these fish have established in the lake.

There is no doubt that inter-specific species competition occurs between cutthroat trout and other fish species, especially the introduced ones (Griffith 1974,1988; Marnell 1986, 1987, 1988; and others). Two mechanisms are controlling the population of cutthroat trout competitive exclusion and species replacement due to rapid changes in the environmental conditions within the lake. The extent that each individual mechanism controls the population has yet to be worked out. However, the fact that the adfluvial population has not been extirpated from the lake shows that these fish have some resiliency to the detrimental effects from interactions with the introduced species. Petroskey and Bjornn (1985) demonstrated that cutthroat in the St. Joe River system show little detrimental effects from the introduction of hatchery reared rainbow trout. Griffith (1988) postulated that this resiliency may be attributed to the fact the cutthroat trout are not existing in habitat that is optimal for them but existing in habitat that is sub-optimal for the other species.

We understand the supplementation in itself will not overcome the habitat problems these fish face. We also understand that by eliminating the limiting factors governing the habitat these fish will have a much better chance of survival. This however, will take many decades (50-100 years). In the mean time, these fish, given the current population trend may go extinct. Thus, from a strictly biological point of view supplementation is necessary. Secondarily, harvest is also an issue with the Tribe. The Tribe is not willing to wait 50-100 years for harvestable surpluses of fish thus, any returning fish not needed for spawning in both the natural setting as well as the hatchery would be available for harvest.

Response to question 2:

Trophic state indices calculated in 1975 (U.S. EPA, 1977) classified Coeur d'Alene Lake as mesotrophic lakewide. Data collected in 1989 (Breithaupt, 1990) classified the southern lakes area as eutrophic during the peak runoff period and mesotrophic for the other times of the year. Woods (1994) classified Coeur d'Alene Lake as oligotrophic for all parameters except secchi disk transparency, which classified the lake as mesotrophic. Our data classified the lake as oligotrophic in the north and meso-eutrophic in the south with water quality parameters associated with eutrophic conditions increasing in a southerly direction.

The Clean Water Act (CWA) is the tool used by regulatory agencies to set standards for water quality on the Reservation and in the State of Idaho. As such, enforcement of the CWA has been and still is the primary tool used to clean up Coeur d'Alene Lake. The reduction of the mining and smelting activities along the South Fork Coeur d'Alene River has also had a dramatic effect on the quality of the water in Coeur d'Alene Lake. Historically high levels of heavy metals would flow through the system decreasing the habitat suitability for cutthroat trout throughout the entire sub-basin including Coeur d'Alene Lake. Additionally, municipal waste contributed large quantities of phosphates and nitrogen that accelerated the eutrophication process in Coeur d'Alene Lake. However, over the last 25 years work has been completed (as a result of enforcement of the CWA) to reduce the annual load of these materials. Wastewater treatment facilities have also been established near all major municipalities in and around the basin. These combinations of factors have led to a general increase in water quality in Coeur d'Alene Lake as it relates to cutthroat trout production.

The Tribe is currently assessing 36 sites encompassing approximately six miles of shoreline throughout the lake. The primary goal of this assessment is to determine the habitat suitability of the littoral zone for cutthroat trout. We are assessing several different habitat parameters and associating them with habitat suitability for cutthroat trout. We hope to be able to use this information to predict what type of habitat in the lake will be able to support the highest populations of cutthroat trout. Thus, in the future, we would be able use this information to determine what habitat manipulations (if any) need to take place to increase suitability for cutthroat trout throughout the lake.

3.) Factors limiting production of the target species

Response to comments on subject matter

The HSI methodology was referenced in the supplementation feasibility report.
A modified habitat suitability index (HSI) model was used to evaluate the effect of water quality parameters on cutthroat trout populations within and among the target watersheds and Coeur d'Alene Lake. A HSI was calculated for the water quality subcomponent of the model described by Hickman and Raleigh (1982). Model variables included: average maximum water temperature (V_1); average minimum dissolved oxygen (V_3); annual maximal or minimal pH (V_{13}); and average annual base flow as a percentage of the average annual daily flow (V_{14}). Individual suitability index (SI) values were calculated for each variable using curves published in Hickman and Raleigh (1982). The following equation was used to calculate the final HSI score:

$$C_{OQ} = (V_1 x V_3 x V_{13} x V_{14})^{1/4}$$

Where; C_{OQ} = HSI for water quality component, and

V_n = suitability index for water quality parameters.

Water quality data collected in 1997 and in 1998, when available, were used as input variables. The following modifications were made to address site specific conditions: a seven-day running average of maximum temperature was used; and average minimum dissolved oxygen was calculated for the period of greatest average water temperatures. Continuous discharge measurements were only available for the two sample sites on Lake Creek. For the remaining sites, average annual daily flow was calculated based on a minimum of 12 discharge measurements taken during the year, and average annual base flow was calculated for the period of low flow which corresponded to the greatest average water temperatures.

The final HSI was calculated using both a compensatory and a non-compensatory method. The compensatory method assumes that moderately degraded water quality conditions can be partially compensated for by good physical habitat conditions. The non-compensatory method assumes that degraded water quality conditions cannot be compensated for, and variables with suitability indices (SI) < 0.4 become limiting factors on habitat suitability. For purposes of interpretation, HSI with values ranging from 0 - 0.25 were considered very poor; 0.25 – 0.4 were poor; 0.4 – 0.6 were good; and 0.6 – 1.0 were very good.

Response to question 1:

The suitability index (SI) values for individual water quality parameters vary considerably between sample locations (Table 3.20). The greatest variability occurs for the temperature parameter (V_1), where the SI ranges from 0 to 1.0. Water temperatures are limiting for the mainstem of Benewah Creek, lower Lake Creek, and lower Windfall Creek. The SI for the base flow parameter (SI_{14}) is < 0.4 for all sample locations except for Evans Creek and mainstem Benewah Creek, indicating that base flow is also a limiting factor at most locations. The SI for dissolved oxygen (SI_3) and pH (SI_{13}) are generally greater than 0.8, and therefore are not considered limiting. The exception occurs in School House Creek where dissolved oxygen is limiting (SI_3=0.3) during the period of warmest water temperatures.

Table 3.20 Habitat Suitability Index (HSI) calculations for riverine cutthroat trout.

Location	V1	SI1	V3	SI3	V13	SI13	V14	SI14	Comp HSI	Non-Comp HSI
L. Lake	22.6	0	9.5	1	6.8/7.7	1	9	0.2	0.00	0
U. Lake	17.9	0.78	7.9	0.9	6.5/7.5	1	13	0.25	0.65	0.25
L. Benewah	23	0	8.9	1	7.0/8.3	1	18	0.4	0.00	0
U. Benewah	22.8	0	7.7	0.87	6.7/7.6	1	18	0.4	0.00	0
S.E. Benewah	14.7	1	9.7	1	6.6/7.6	1	16	0.32	0.75	0.32
School House	16.4	0.92	5.7	0.3	6.8/7.4	1	6	0.15	0.45	0.15
W.F. Benewah	16.6	0.9	9.3	1	6.7/7.5	1	11	0.25	0.69	0.25
Windfall	25.1	0	7.8	0.89	6.7/7.6	1	13	0.25	0.00	0
Evans	16.4	0.92	9.6	1	6.3/7.7	0.95	28	0.6	0.85	0.6
Alder	20.6	0.45	9.6	1	6.8/7.8	1	16	0.32	0.62	0.32

HSI scores that are calculated using the non-compensatory method show a very poor to poor rating for all sample locations, with the exception of Evans Creek, which is considered good. In other words, when habitat suitability is rated based on water quality parameters alone, then all sample locations, with the exception of Evans Creek, are rated very poor to poor with regard to cutthroat trout preferences. In six of ten locations, however, differences between HSI calculations using the compensatory versus non-compensatory method indicate that good habitat conditions have the potential to partially compensate for short-term degradation in water quality. These sites include upper Lake Creek, S.F. Benewah Creek, School House Creek, W.F. Benewah Creek, Evans Creek, and Alder Creek. Lower Lake Creek, the mainstem of Benewah Creek, and lower Windfall Creek are considered very poor regardless of the method used.

Response to question 2:

A habitat based model developed by Hickman and Raleigh (1982) was used to evaluate the suitability of lacustrine habitat types for cutthroat trout. The lacustrine model consists of two components: water quality and reproduction. The water quality component takes three variables into consideration, including temperature, dissolved oxygen and pH. Water quality data collected in 1997 were used to calculate the individual suitability index (SI) values using published curves. The reproduction component was not examined in this report.

Results from the water quality component of the HSI model indicated that there is suitable habitat for cutthroat trout in the lake (Table 3.19). The quantity of suitable habitat, however, decreases as water temperature increases during the year. The suitability index was poor or very poor (<0.25) in the shallow portion of the water column at all sample stations. While water quality does not directly exclude cutthroat trout from these shallow areas, unsuitable habitat exerts added stress on cutthroat trout making foraging runs into the upper 10 meters of the water column.

Table 3.19 Habitat suitability index for lucustrine cutthroat trout based on water quality.

Location	Depth	HSI[a]		Suitability Index
Rockford Bay	0-7 Meters	$(0.25x1x1)^{1/3}$	=	0.25 SI
	7-11 Meters	$(0.60x1x1)^{1/3}$	=	0.845 SI
	11-Bottom (14)[b]	$(1x1x1)^{1/3}$	=	1.0 SI
Windy Bay Shallow	0-7 Meters	$(0.0x1x1)^{1/3}$	=	0.0 SI
	7-10 Meters	$(0.85x1x1)^{1/3}$	=	0.94 SI
	10-Bottom (15)	$(1x1x1)^{1/3}$	=	1.0 SI
Windy Bay Deep	0-10 Meters	$(0.0x1x1)^{1/3}$	=	0.0 SI
	10-15 Meters	$(0.85x1x1)^{1/3}$	=	0.94 SI
	15-Bottom (33)	$(1x1x1)^{1/3}$	=	1.0 SI
Coeur d'Alene River	0-Bottom (10)	$(0.0x1x1)^{1/3}$	=	0.0 SI

Mid-Lake Coeur d'Alene	0-10 Meters	$(0.0x1x1)^{1/3}$	=	0.0 SI
	10-13 Meters	$(0.85x1x1)^{1/3}$	=	0.94 SI
	13-Bottom (17)	$(1x1x1)^{1/3}$	=	1.0 SI
Carey Bay	0-10 Meters	$(0.0x1x1)^{1/3}$	=	0.0 SI
	10-12 Meters	$(0.85x1x1)^{1/3}$	=	0.94 SI
	12-Bottom (13)	$(1x1x1)^{1/3}$	=	1.0 SI
Conkling Park	0-10 Meters	$(0.0x1x1)^{1/3}$	=	0.0 SI
	10-13 Meters	$(0.85x1x1)^{1/3}$	=	0.94 SI
	13-Bottom (16)	$(1x1x1)^{1/3}$	=	1.0 SI
Hidden Lake	0-5 Meters	$(0.0x1x1)^{1/3}$	=	0.0 SI
	5-7 Meters	$(0.8x1x1)^{1/3}$	=	0.92 SI
	7-Bottom (10)	$(1x0.0x1)^{1/3}$	=	0.0 SI
Round Lake	0-Bottom (1.5)	$(0.0x1x1)^{1/3}$	=	0.0 SI
Chatcolet Lake	0-6 Meters	$(0.0x1x1)^{1/3}$	=	0.0 SI
	6-9 Meters	$(0.85x1x1)^{1/3}$	=	0.94 SI
	9-Bottom (11)	$(1x0.0x1)^{1/3}$	=	0.0 SI
Chatcolet Shallow	0-Bottom (1.5)	$(0.0x1x1)^{1/3}$	=	0.0 SI
Benewah Lake	0-Bottom (4.5)	$(0.0x1x1)^{1/3}$	=	0.0 SI
St. Joe River	0-Bottom (12.5)	$(0.4x1x1)^{1/3}$	=	0.4 SI

[a] Habitat Suitability Index (HSI).
[b] Numbers in parenthesis represent the bottom in meters.

5.) Alternatives for resolving the resource problem

Response to comments on subject matter point A:

Multiple alternatives to the current program were explored and described in the documents:

Scholz, A.T., D.R. Geist, and J.K. Uehara. 1985. Feasibility report on restoration of Coeur d'Alene Tribal Fisheries. Upper Columbia United Tribes Fisheries Center. Cheney, WA. 85 pp

The 1987 and 1994 NWPPC Fish and Wildlife Program

In January 1995 the Coeur d'Alene Tribe submitted an application for amendment to the fish and wildlife program. Document # 95-2/0020 in NWPPC Recommendations to Amend the Resident Fish and Wildlife Sections of the Columbia River Basin Fish and Wildlife Program. 95-1 dated February 2, 1995. Within this document alternatives of both broad scale (i.e. fish passage at Chief Joseph, Grand Coulee, and all six Spokane River Dams) and finer scale (i.e. terminal fisheries for exotic adfluvial resident chinook salmon in Coeur d'Alene Lake) were explored. It was determined that the current program provided the most cost-effective means for partial mitigation of lost fishing opportunities while meeting Tribal goals and objectives. It was also determined that the current program provided the greatest chance for success over the other alternatives.

The following alternatives were explored:

Restore anadromous fish runs into the Upper Columbia Basin. Estimated cost to be 500+ million in capital construction costs for fish ladders and juvenile bypass systems at 8 dams. Fifty to sixty million in lost power revenues annually. And 12 million in capital construction with 3-5 million annual operations and maintenance costs for four anadromous salmon hatcheries for the reintroduction of salmon into the upper basin. It was also determined that the chances of success were small due to probable fish passage problems at an additional eight dams as well as, downstream harvest management problems and probable lack of appropriate genetic strains. Most likely not enough fish would return to produce a viable subsistence, commercial and/or sport fishery to warrant the expense at this time.

Operations of a chinook salmon hatchery on Coeur d'Alene Lake for terminal fisheries for exotic resident adfluvial chinook salmon. Estimated cost would be 3-5 million in capital construction and 1 million operations and maintenance cost. Idaho Fish and Game is already stocking chinook salmon into Coeur d'Alene Lake and from this two feral runs have established themselves in two of the best resident fish producing rivers in the basin. It is predicted that these runs will have some impact on the native species in the basin. Exotic species introduction is also contrary to the native fish management policy employed by the Tribe. As well, declining growth rates of the chinook salmon and exceptionally low numbers of kokanee salmon indicate that the productivity of Coeur d'Alene Lake for chinook salmon production may already be maximized. Therefore, stocking the lake with additional chinook salmon is not recommended at this time.

Habitat restoration of all streams (20) located on the reservation without the aid of a hatchery. Costs would be similar to existing proposal and biological outcome would be similar. However, it would take 50-100 years longer to rebuild stocks and the Tribe is not willing to wait this long for harvestable surpluses. Furthermore, given the general poor quality of habitat it is conceivable that within the 50-100 year time frame for restoration these stocks could go extinct.

Also,

This project is a resident fish substitution project. In 1987, the NWPPC prioritized the areas above both Chief Joseph and Grand Coulee Dams as resident fish substitution areas.

Response to question 1.

Work conducted by the Coeur d'Alene Tribe Fish, Water and Wildlife Program has helped determine that habitat components utilized in each of the three critical life history phases, as well as interactions with introduced species, potentially limit production of adfluvial fishes. These components include spawning habitat and juvenile rearing habitat in tributary streams, and adult rearing habitat in the lake. In order to effectively increase populations of westslope cutthroat trout, habitat restoration must take place in natal streams. However, restoration of the critical tributary habitat does not guarantee increases in adfluvial trout production because adfluvial westslope cutthroat trout reside in Coeur d'Alene Lake for two-thirds of their life cycle. Evidence suggests that production of cutthroat trout is indirectly limited by lake habitat features, but the extent of this limitation is not fully understood. We feel that our best shot at increasing productivity in the short term (5-20 years) is to focus our restoration efforts on the streams. Given the geomorphology of Coeur d'Alene Lake any physical manipulations (restoration opportunities) available to us are long term projects (25-50 years to produce an effect).

Diking the southern end is not feasible economically. Results would not justify the expense. Natural levees protect the migration corridors in the St. Joe and Coeur d'Alene Rivers. Some protection from degradation of these natural levees should be afforded in the near future. This is something that the Tribe is currently working on.

Response to question 2:

Regulation of the lake level by Post Falls Dam occurs 5-7 months of the year. Avista Corporation currently operates the Dam. Post Falls Dam is up for FERC relicensing in 2007 thus, lake elevational issues will be addressed through that process. Typically Avista maintains the lake at summer elevation (2128) after spring runoff through the first part of September. Avista then attempts to lower the lake by 7.5 feet by the end of January. Depending on weather, Coeur d'Alene Lake discharges naturally until after runoff. Lake level during this time frame depends entirely upon precipitation and temperature. Post Falls Dam does not effect the lake's outlet capacity under high flow conditions, the natural restriction controls the flow. Without Post Falls Dam summer mean lake elevations would be 7.5-9 feet lower and the surface area would be 7km^2 smaller. Thus, Post Falls Dam controls the introduction of warm water to the lake during the summer months when it controls lake level for recreation.

Response to question 3:

Over 100 years of mining activities in the Silver Valley have previously had devastating effects on the quality of the water in the Coeur d'Alene River drainage and Coeur d'Alene Lake. Effluent from tailings and mining waste have contributed vast quantities of trace heavy metals to the system. Since the secession of most of the mining activities along the South Fork Coeur d'Alene River dissolved heavy metal concentrations have decreased. However, contaminated sediments throughout the river corridor and Coeur d'Alene Lake north of the Coeur d'Alene River still remain. The deposition of trace elements in the sediments of Coeur d'Alene Lake is well documented by (Funk 1973; Rieman 1980; Woods 1989; Woods and Beckwith 1996). Lakebed geochemistry analyses revealed that most of the trace elements in surficial and subsurface sediments are associated with a ferric oxide phase thus, under reducing (anoxic D.O. values at 0.0) conditions, the trace elements would be readily solubilized and available for release to the overlying water column (Woods and Beckwith, 1996). The fact that trace metals are found in the sediments at the mouth of the river and north causes us some concern when sample points just north and south of the river mouth have dissolved oxygen values below 6.0 mg/L and a measurable hypolinetic oxygen deficit during periods of thermal stratification.

Poor agricultural and forest practices have also contributed to the degradation of water quality and habitat suitability for resident salmonids. Increased sediment loads from agricultural runoff and recent and recovering clearcuts, and riparian canopy removal may be one of the most important problems currently affecting westslope cutthroat trout. Increases in water temperature have reduced the range of resident salmonids to a fraction of its historic extent. Within this new range, sediment has reduced the quality of both spawning and rearing habitats. Historically, municipal waste contributed large quantities of phosphates and nitrogen that accelerated the eutrophication process in Coeur d'Alene Lake. However, over the last 25 years work has been completed (as a result of enforcement of the CWA) to reduce the annual load of these materials. Wastewater treatment facilities have been established near all major municipalities in and around the basin.

Response to question 4:

The Tribe has considered different management options for exotic piscivorous fishes. The current alternative being employed is having liberal bag, both daily and possession, limits on all exotic species. A typical limit is one that is higher than what could normally be caught in one day.

Point B some finer scale alternatives should also be explored.

Response to point B:

As stated above several alternatives were explored and it was determined that the current program was the most cost effective and efficient way to provide harvest opportunities to the Reservation community in both the short and long term.

Response to question 1:

We are currently exploring the possibility that project objectives could be reached with a single adfluvial brood stock. A brood stock management strategy is currently being technically reviewed. Additionally, this idea is currently being explored with all agencies that have jurisdiction. We intend to use the most cost effective and genetically sound brood stock management plan whether it is a single brood stock for release in all four streams or individual stocks for each individual stream.

6). **Conceptual design of the proposed production and monitoring facilities, including an assessment of the availability and utility of existing facilities.**

Response to comments on subject matter:

As stated in Appendix A of the Master Plan water is a main concern however, we feel that the plan stated should alleviate any of these concerns. The plan is to draw water from three separate aquifers near the hatchery compound as well as, withdraw water from Rock Creek when necessary. This should sufficiently supply the facility with all the water needed. Water from these different sources is currently being analyzed for critical elements (quality and quantity), ensuring that a dependable long-term supply of high quality water will be provided to the facility.

We have drilled one test well on site that exceeded one hundred gallons of water per minute, although, the recovery test of this well indicated that it could not sustain this rate (100 GPM) for a long period of time. The recovery test did indicate that it could sustain 10 GPM indefinitely. There will also be an additional well drilled on site, located approximately ¼ of a mile away in a easterly direction from the first test well. The second well field area will be located one mile to the north, well one for this area will be in T47NR04W29 in the NW quarter and the second well for this area will be in T47NR04W19, approximately ½ mile away in a northwesterly direction. The third well field area also in T47NR04W will be approximately ¾ of a mile to the north. Well one will be located in the northeast quarter of section nineteen, and the second well will be located in northwest quarter of section 20, the approximate distance between these wells is about ¾ mile.

In conclusion, the design of the hatchery requires 60 GPM at full production. There will be a total of six production wells producing water year around as well as, diverted water from Rock creek during the winter and spring months. The plan is to withdraw on the average 10 GPM per year from each well to ensure that the facility receives the required 60 GPM while not exceeding the recharge capacities of the affected aquifers. Wells will be managed and utilized in a manner that best suits the available water. Thus, if the well field complex and pipeline are implemented as planned 60 GPM to the facility will not be a problem.

Attachment 3. ISRP Questions for Teleconference

INDEPENDENT SCIENTIFIC REVIEW PANEL

Northwest Power Planning Council
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Date:	February 3, 2000
To:	Mark Fritsch
From	Rick Williams, ISRP Chair
Sub;	ISRP review of Trout Production Facility Master Plan

Thanks to Kelly Lillengreen for the helpful additional clarifications. The ISRP members reviewing the plan still, however, have some questions. Two of them have to do with possible direct detrimental effects of hatchery-bred trout on existing trout populations; the third with the hatchery's water supply.

1. If the facility is successful in producing harvestable numbers of adfluvial trout, how will fishery managers prevent fishermen from taking wild trout? We are reading in particular the passage of the memo "Until the 75% objective is met only hatchery fish will be harvested". How will this directed fishery be achieved? Will all hatchery trout be externally marked and will fishermen be required to release unharmed all unmarked trout? Will the fishery be allowed each year only after spawning ground escapement goals have been met and then be allowed on an indiscriminate mixture of hatchery and wild trout? If the latter, how will the inseason census of the spawning populations be maintained? Can the fishing season be opened and closed on short notice?

2. How will hatchery-produced trout be prevented from displacing wild trout from their limited habitat in the streams? We understand that the hatchery intends to release trout only when they are ready to migrate into Lake Coeur d'Alene. If successful this would eliminate the displacement of wild trout from their limited fluvial habitat. But we remain concerned about two potential problems. First we are not convinced that it will be possible to determine that "the fish are ready to migrate into Lake Coeur d'Alene", and we remain concerned that these hatchery-released trout may displace wild-spawned trout from their lacustrine habitat. And second, we read in the memo that, "[e]vidence suggests that production of cutthroat trout is indirectly limited by lake habitat features, but the extent of this limitation is not fully understood" and "conditions in the lake only limit the population (to some degree that currently has not been defined) not eliminate it." Physical limitations (incipiently lethal and extraordinarily stressful temperatures and oxygen supplies—the elements of the habitat suitability indices) are roughly known in the lake, but no other ecological dimensions (food and growth potential, predation) are known. A small likelihood of displacement of wild trout from the lake may be a reasonable risk to take given the agency's local knowledge of the lake and its productivity, but should the plan for the facility proceed without a plan to detect displacement of introduced trout both in the streams and in the lake?

3. Is the project assured of an adequate (quantity and quality) water supply? We read in the memo "The plan is to draw water from three separate aquifers near the hatchery compound as well as, withdraw water from Rock Creek when necessary. This <u>should</u> sufficiently supply the facility with all the water needed. Water from these different sources is currently being analyzed for critical elements (quality and quantity), ensuring that a dependable long-term supply of high quality water will be provided to the facility" (emphasis added). Are the aquifers independently recharged? Will they indefinitely supply the hatchery for the six months out of the year that we understand is necessary? Are the aggregate costs of supply from three wells known, including piping, pumping and maintenance? If quality and quantity and costs are not yet known, should the plan for the facility proceed? We are concerned that it may be necessary to change the concept of the hatchery if the water supply required by it can not be assured.

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Coeur d'Alene Tribe Response to ISRP Comments on Project # 199004402

The Coeur d' Alene Tribe greatly appreciates the constructive comments that have presented themselves through the Northwest Power Planning Council's (Council) Three-Step and Rolling Provincial Review Processes. We also appreciate the accountability and deliberate decision making that has been applied to our very important supplementation project.

We would like to take this opportunity to: 1) summarize prior decision making processes and results of the Council 2) progress to date in addressing Council and Independent Scientific Review Panel (ISRP) concerns/comments and 3) respond to comments outlined in the report ISRP 2001-2 Preliminary Mountain Columbia Proposal Review.

The Tribe has progressed through the Council's Three-Step process with due diligence. At each step of the review, including an interdisciplinary team that developed a successful Environmental Assessment, we considered and acted upon recommendations that were outlined by the Council/ISRP as well as many other State and Federal Agencies including the USFWS and IDFG. The policies and management directions of the Tribe have come from a holistic approach involving habitat restoration and protection, hatchery supplementation, minimizing fishing pressure by offering rainbow trout ponds, and careful monitoring and evaluation.

<u>Summary of prior decision making processes and results</u>

In an April 5, 2000 Memorandum from Mark Fritch to the Power Council Members, several recommendations were made based on the Step 1 Review of the Master Plan for the Coeur d' Alene Tribe Trout Production Facility. The recommendations were:

1. A.) Recommend that a sufficient sustainable water supply be verified as required by the conceptual plan for the hatchery.
   B.) Recommend that BPA and the Coeur d' Alene Tribe make a determination and provide a recommendation on the most cost effective means to provide trout for the catch out ponds.

2. Recommend that Bonneville Power Administration fund preliminary designs of the Coeur d' Alene Tribe Trout Production Facility after 1A and 1B are resolved.

3. Recommend that additional information be developed relative to three technical areas for consideration during the Step 2 review. These include: 1) the development of a harvest plan in conjunction with the monitoring and evaluation plan, 2) monitoring behavior of the facility-produced trout to prevent displacing of wild-spawned trout from the stream habitats, and 3) monitoring interactions between facility-produced and wild-spawned trout in Lake Coeur d' Alene, and resulting displacement of wild-spawned trout from limited habitat.

As you know, these recommendations are the culmination of past review efforts that included : 1) a review of Council measures addressing the need to establish a Coeur d' Alene fish production facility for native trout. This process called for a baseline stream survey of tributaries located on the Coeur d' Alene Reservation. 2) Council adoption of fishery improvement recommendations based on the baseline studies and 3) A Council/ISRP Step 1 review of a Three-Step process.

Progress to date on addressing Step 1 recommendations by the Council/ISRP

The Coeur d' Alene Tribe has been actively engaged in addressing these concerns expressed by the peer review process.

1. A.) Recommend that a sufficient sustainable water supply be verified as required by the conceptual plan for the hatchery.

Progress to date- The Coeur d' Alene Tribe initiated an extensive well field exploratory investigation in order to effectively meet the targeted goal of 60gpm continuous. As a result of those investigations a report documenting favorable results of a sufficient water supply has been submitted to the Council as partial compliance of the Step one conditions. Additional data collection efforts were specified in the report that would greatly improve the long-term sustainability issues. This report can be found as an appendices to this letter.

B.) Recommend that BPA and the Coeur d' Alene Tribe make a determination and provide a recommendation on the most cost effective means to provide trout for the catch out ponds.

Progress to date- The Coeur d' Alene Tribe has done an analysis, based on peer review comments received in Step 1, on the cost effectiveness of the rainbow trout production for the trout ponds. As with the water supply issue, the Tribe has issued a report to the Council analyzing various options of maximizing the rainbow trout component of the hatchery. This report/analysis is also included as an appendices to this letter. Using the report as a basis the modified program will reduce the water requirements of the facility by 15 GPM for 7 months of the year. Given the results of the well field analysis sufficient water exists to support the facility.

2.) Recommend that Bonneville Power Administration fund preliminary designs of the Coeur d' Alene Tribe Trout Production Facility after 1A and 1B are resolved.

Progress to date- The Coeur d' Alene Tribe has been pursuing the information necessary to satisfy the requirements stated in 1A and 1B. However, in the April 5, 2000 document it states that the program requirements for this project appear to have been met and that master planning elements have been addressed. ISRP step review has found these efforts to adequately address the program except for some minor issues that can be addressed during the preliminary design and reviewed as part of the Step 2 process. These issues are being addressed and will be forthcoming in the Tribe's submittal of the Step 2 preliminary design.

3.) Recommend that additional information be developed relative to three technical areas for consideration during the Step 2 review. These include: 1) the development of a harvest plan in conjunction with the monitoring and evaluation plan, 2) monitoring behavior of the facility-produced trout to prevent displacing wild-spawned trout from stream habitats, and 3) monitoring interactions between facility-produced and wild-spawned trout in Lake Coeur d' Alene, and resulting displacement of wild-spawned trout from limited habitat.

Progress to date- As a priority, the Coeur d' Alene Tribe has been gathering and analyzing information on the availability of ground water and the cost effectiveness of the rainbow component of the preliminary plans. However, the Tribe recognizes the issues raised by the Council and ISRP and has been developing a more specific monitoring and evaluation plan that will be submitted with the Step 2 design plans.

<u>Response to comments outlined in the report ISRP 2001-2 Preliminary Mountain Columbia Proposal Review.</u>

- ISRP Comment- The proposal does not adequately reflect input provided by the ISRP during Step One of the Three Step Review Process (ISRP 2000-1)

Response: As mentioned before, the Coeur d' Alene Tribe has recognized the issues and concerns raised in Step One of the Three-Step Review process. Unfortunately the well field investigations and research took longer than was expected due to the number of wells that were drilled, mobilization, weather limitations, and land access permission process. The Tribe has just recently submitted a water availability report to the Council to be included as in the review process.

The Tribe has also considered the rainbow trout cost effectiveness issue, as mentioned earlier in our letter, and a report will accompany the water quantity report.

The Tribe has been in the process of developing a comprehensive monitoring and evaluation plan that effectively addresses those concerns articulated in condition number three. These monitoring and evaluation methods have been described in our <u>Trout Production Facility Master Plan</u> (Master Plan) and will serve as the foundation for more specificity in our final submittal of the Step 2 documents.

The Tribe has also amended its original operations plan based on the following ISRP comment:

> Maintain a single stock of adfluvial cutthroat trout in the Facility, rather than maintaining four groups whose differences are probably negligible. This would simplify operation of the Facility and is probably justified by the relatively homogenous genetic structure of trout in the streams around the Lake. (Three-Step Question 5. Alternatives, Point B; Question 19. Constraints and uncertainties, including genetic and ecological risk assessments and cumulative impacts.) Specifically, based on information presented in Appendix C of the Coeur d'Alene Master Plan (Knudsen and Spruell 1999, and the appended letter and dendrogram from Spruell), there appears to be little geographic structure in the genetic variation observed among the populations as well as little genetic distance. Work by Spruell et al. (1999, also in appendix C) examined westslope cutthroat trout from 16 sites for evidence of 3 hybridization with rainbow trout. They identified six populations that appeared free of introgression and might be used as broodstock sources. The remaining ten sites showed evidence of hybridization with rainbow trout, although the levels of introgression were quite low. Spruell and colleagues' genetic work suggest that while genetic

distances are very small among populations, overall genetic diversity is high minimizing the concern that mixing fish from different local populations will result in a decrease of fitness associated with outbreeding depression. While small genetic differences were observed among populations, the genetic data suggest that prior to recent fragmentation, considerable gene flow likely occurred among the Coeur d'Alene populations (ISRP 2000-1).

and

The approach to restoration of Coeur d'Alene westslope cutthroat trout populations on reservation lands might be most successful if it focused on stream habitat restoration and on the resident, rather than the adfluvial, life history pattern. While an overall project goal is to increase adfluvial fish, which due to their larger size present the best harvest opportunity consistent with the tribe's goals, a biologically viable approach might be to focus on increasing resident westslope cutthroat trout abundance in tributary streams – including reintroduction into streams where they have been extirpated or are at very low numbers (ISRP 2000-1).

Based on these comments by the ISRP the Tribe amended their plan in part. The Tribe modified its plans to hold four individual populations of broodstock to having two populations, one derived from fish from Evans and Alder Creek (resident) and the second derived from fish from Benewah and Lake Creeks (adfluvial). The Tribe is intending to initially focus supplementation efforts on the resident form in Evans and Alder Creeks. The Tribe is still not convinced that restoration of the adfluvial form of cutthroat trout in Lake and Benewah Creeks should be abandoned in favor of a resident fish program. Adfluvial forms of this sub-specie are still found in both of these creeks (Lake and Benewah) and the Tribe feels that in order to meet goals for viable subsistence harvest and mitigation for the hydropower system adfluvial fish are a priority.

In all of these situations, it was never our intent for the ISRP to believe that the Tribe was not aggressively pursuing the issues raised in Step One and previous reviews, and for that we apologize for the misunderstanding.

- ISRP Comment- About 10% of the proposed annual M&E budget is to monitor cutthroat trout abundance and rainbow trout catch from the put-and-take pond fisheries. The remainder ($303K) is for vaguely described data gathering on Coeur d' Alene Lake and tributaries. The proposal states that some of that work apparently would be done on Hangman Creek in the Intermountain province, is that intended?

Response- Again, as part of the Step 2 requirements, the Tribe is developing a comprehensive monitoring and evaluation plan. As the data gathering described may be general in nature at this point in the Three-Step process, the stated M&E components of the Master Plan will be addressed more specifically and an updated probable cost opinion will be part of the Step 2 product. Part of Hangman Creek is in the Intermountain province and this is the basin in which the catch-out ponds will be located. The Tribe is initiating baseline fish habitat assessments with recommendations for habitat restoration in Hangman Creek (Intermountain Province Project # 21018). It is our intent to specify a consistent M&E protocol from watershed to watershed. However, no funds identified in this proposal are earmarked for the baseline fish habitat assessments planned for Hangman Creek. Additionally, in order to avoid redundant sampling with project # 199004400 M&E was separated by the Reservation boundary. All on Reservation M&E is conducted through the project 199004400 and off reservation M&E is conducted through Project # 199004402 in cooperation with IDFG. The Tribe has acknowledged the concern and will present the material for further review as part of the Step 2 submittal.

ISRP Comment- Despite previous reviews (FY 1999, 2000, 3-Step), the contents of this proposal and discussion during the presentation have led the ISRP to be increasingly convinced that the proposed hatchery program for adfluvial cutthroat trout does not appear to be scientifically justified.

Response- The Tribe feels that the documents and reports used in the previous reviews by the ISRP, Council, Columbia Basin Fish and Wildlife Authority, and the Environmental Assessment Interdisciplinary Team[1] have sufficiently outlined the scientific validity of the Tribes management direction for the production facility. Furthermore, the intent of the Three Step process was to provide scientific review and ways in which to improve upon the effectiveness of the hatchery. The Tribe has taken the approach of addressing the issues articulated in the Step 1 review document of the Council and is looking forward to submitting the Step 2 documents for further review. Moreover, in the general comments section of the ISRP 2000-1 document the following assessments were made:

> **"Despite the ISRP recommendation for the Coeur d' Alene to consider the use of a single stock described above, the reviewers were impressed by the willingness of the Coeur d' Alene Tribe to support supplementation activities on four individual tributaries and the westslope cutthroat trout populations endemic to each tributary. The plan recognizes and responds to many scientists' concerns about local adaptation, the uniqueness (or potential uniqueness) of individual populations, and maintenance of the fitness of individual populations. Some fisheries managers have been reluctant to manage artificial production facilities at this scale (that of the individual population) due to the expense and logistical difficulties. The Coeur d' Alene tribe is to be commended for their foresight and concern about the future of specific populations within the reservation."**

The document goes on to say:

> **" Finally, the Three-Step process includes numerous questions and criteria that the ISRP considered in its review of the master plan documents but are not elaborated on here. The ISRP found the Coeur d' Alene Tribe adequately addressed these and other questions and criteria in the master plan documents or in subsequent communications with the ISRP."**

A 1999 ISRP Review reveals:

> **"Although this is supposed to be a proposal to acquire funds for the construction of a salmonid fish hatchery, the majority of the proposal addresses other, albeit related, issues: e.g. perceived biological and mitigation need for the hatchery, land acquisition and habitat improvement projects, an emphasis on using native populations for supplementation purposes, hatchery operation including spawning procedures, and monitoring and evaluating effectiveness of hatchery releases in helping obtain mitigation objectives. In terms of construction, therefore, it is very difficult to evaluate.**

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[1] Comprised of scientists representing the U.S.F.W.S, Idaho Department of Fish and Wildlife, and the Bonneville Power Administration.

The hatchery appears to be an integral part of a larger well thought out and potentially valuable mitigation program. The proposal was well written and comprehensive, in the midrange of quality of those reviewed. The FWP and 13 other planning documents are referenced as justification. The proposal discusses a good history of accomplishment for this project, including much survey work with recommendations, demonstration projects for stream rehabilitation, fish stocking, stock identification using genetics, and development of the hatchery master plan. It is all well documented in literature citations. There is excellent background and rationale, and the need for the hatchery is presented in the project history. Objectives and tasks are well laid out. Monitoring is planned well. The budget is well justified, but skewed toward the hatchery construction. Resumes of staff are provided and there are good plans for information transfer. This would be a good candidate for multi-year funding. The use of native stocks is a particularly attractive part of the proposal.

Are effects on other fish being monitored? The project involves a watershed assessment and habitat restoration. There is good coordination with habitat restoration and protection of wetlands and riparian habitat. About 2/3 of the budget is for construction but adequate information is not provided on the construction activities, schedule, or contractors. These should be handled in NEPA review and other processes for approval of construction."

It is concerning to the Tribe that such complimentary and constructive comments towards the hatchery can degenerate to comments such as "does not appear to be scientifically justified". The Tribe feels confident that the attached water quantity report, the cost effectiveness of the rainbow trout to the catch out ponds report, and comments contained herein, will validate the Tribes continuing efforts to address specific ISRP/Council concerns.

- ISRP Comment- The larger program is based on the premise that westslope cutthroat populations are depressed because of degraded habitat and, if the habitat is renovated, the populations will respond favorably. If that is the case, why is it logical to stock hatchery fish?

Response: *During the Step 1 review process the ISRP asked this same question in which the Tribe responded. Based on that response the ISRP stated, "Finally, the Three-Step process includes numerous questions and criteria that the ISRP considered in its review of the master plan documents but are not elaborated on here. The ISRP found the Coeur d'Alene Tribe adequately addressed these other questions and criteria in the master plan documents or in subsequent communications with the ISRP."(ISRP 2000-1)*

The long term goal of the Coeur d'Alene Tribe is to have harvestable self-sustaining naturally reproducing populations of westslope cutthroat trout as to support subsistence harvest by Tribal members to partially mitigate for the loss of salmon as a result of the hydropower system.

Analysis based on results previously reported by Peters et.al. (1999 and 2000) demonstrates that gains resulting from population increases due to natural production most likely will not be realized for three generations (15 years) and significant gains will not be achieved possibly for fifty years or more. The Tribe is unwilling to wait that long.

The Tribe feels that through the current habitat restoration program the carrying capacities of each of the four target tributaries can be increased by an average of 34% by the year 2012 and 118% by the year 2016. (see section 4.0 of the Master Plan for a complete explanation) It is our intention to have enough spawning adults to fully seed habitat in these streams such that the benefits of this increased carrying capacity can be realized. Thus, the Tribe intends to use supplementation to "jump start" the population so enough adults will return to spawn such that the benefits from habitat restoration can be immediately realized.

Through supplementation increases in population size resulting from habitat gains can be realized within one generation with strong recruitment to the population each year. Natural recruitment to wild populations is notoriously variable in size. Additionally, westslope cutthroat trout populations are particularly susceptible to angling pressure. There is a body of evidence that suggests that westslope cutthroat trout populations have a difficult time sustaining heavy fishing pressure in catch and keep fisheries. Supplementation of these populations will ensure that adequate escapement occurs for natural spawning and rearing. Without supplementation it is difficult to imagine any management scenario that would support subsistence harvest and adequate escapement given the current habitat conditions.

- ISRP Comment- What evidence is there to support the assumption that stream conditions are limiting the target populations? What consideration is given to possibility that space, food, predation, competition, or water quality in downstream waters is actually limiting population size?

Response: Analysis found in Peters et.al (1999) and Vitale et.al. (2000) show that peak flows in Lake Creek and Benewah Creek have been identified as a potential limiting factor for trout production. Generally, increased flows during egg incubation will be favorable until they reach the point when scouring and other flood damage may take place (Allen 1969). Spikes in stream discharge during the early spring, as is characteristic of the Lake Creek and Benewah Creek watersheds, may cause redd scouring and egg damage, although no attempt has been made to quantify this source of mortality. For example, stream flows in upper Lake Creek during spring of 1997 exceeded the sheer stress of spawning gravels (5 cm geometric mean particle diameter) for 4 consecutive days during the incubation period. It is conceivable that flow events of this magnitude could scour trout redds and result in complete year class failures. Although flood damage is a natural source of mortality, canopy reduction in each of the target watersheds has probably contributed to higher storm runoff peaks. Scouring of trout redds is certainly a more frequent occurrence than in the recent past.

Habitat availability in the target watersheds is not likely to be limiting for fry life stages. It has been demonstrated that young-of-the year cutthroat trout are conspicuous inhabitants of slow-water areas near the margins of streams. Low velocity and low flow characterize these habitats. Moore and Gregory (1988) studied Cascade mountain streams and found that only about 35% of the total number of fry were observed at velocities greater than 1 cm/second, and no fry were observed at velocities greater than 15 cm/second. Focal depth for these fish increased rapidly from mid-August to early September, but the average depth was always less than 35 cm. Griffith (1972) reported similar focal points for cutthroat trout in north Idaho streams. These preferences of fry for depth and velocity are easily met during base flow conditions in the target tributaries.

The abundance of juvenile cutthroat trout is greatest in first and second order tributaries, suggesting a close link to the most heavily utilized spawning areas. Downstream displacement, *however, has been recognized as a common occurrence when stream flows approach zero in the principle spawning tributaries. While not being unique, this mechanism has not been commonly reported for most salmonid populations in the Pacific Northwest. For most salmonid species, it has been demonstrated that instream movement is minimal; individuals may remain in limited areas for several weeks or months and may return to the same locations in successive years (Edmundson et al. 1968; Bachman 1984). Limiting migration in this way is thought to confer an adaptive advantage by maximizing the net energy intake of individuals (Puckett and Dill 1985). Typical base flow conditions in the target watersheds force juvenile trout into small pools where competition for limited space and food may occur. Other authors have suggested that at high densities, competition for space among juveniles may lead to dispersal, downstream displacement or mortality in salmonids (Chapman 1962; Mason and Chapman 1965; Everest 1971; Erman and Leidy 1975; LeCren 1973). In water quality limited systems, such as Lake Creek, Benewah Creek, and Alder Creek, dispersal to downstream areas exposes juvenile cutthroat trout to suboptimal temperature conditions that increase stress, weaken individuals and may result in mortality.*

Anecdotal evidence cited by residents (Ness personal communication; Hodgson personal communication) suggests that historic base flows in Lake Creek and Benewah Creek were often much lower than those considered optimal for trout production (Hickman and Raleigh, 1982; Binns and Eiserman 1979). This is most likely true for Alder Creek as well. This is not surprising considering the relatively small sizes of the target watersheds, the elevations, and the regional climate. It is conceivable that base flow conditions provided the selective pressure that encouraged genetic differentiation of adfluvial stocks in the Coeur d'Alene basin.

In addition, much of the conversion of forested land to agricultural or pasture land, and removal of riparian canopy occurred prior to 1950. This suggests that stream temperatures have played a part in limiting cutthroat trout abundance and distribution within the target watersheds for at least 50 years. The range of suitable summer rearing habitat for cutthroat trout in each target watershed is significantly reduced when compared with the historic range of these fish. HSI calculations published in this report, however, indicate that improving habitat condition through restoration and protection has the potential to partially compensate for short-term degradation in water quality. In considering this information, it appears that the native strains of westslope cutthroat trout are adapted to local conditions and display a high degree of resiliency.

Historically, cutthroat trout in Coeur d'Alene Lake probably utilized the littoral zone of the lake until they were large enough to move offshore and feed, most likely, on mid water prey and fish when available. Nilsson and Northcote (1981) noted that cutthroat trout in allopatry with other salmonids were found throughout the lake and in sympatry, they were located primarily in the littoral zone. It has been shown that introduction of kokanee salmon will also have detrimental effects on the cutthroat trout population (Gerstung, 1988; Marnell, 1988). Marnell (1988) determined that declines in westslope cutthroat trout populations in lakes in Glacier National Park where kokanee were introduced were caused by competition for planktivorous food. Thus, the introduction of non-native species into Coeur d'Alene Lake, at the minimum, altered the normal behavioral pattern of the cutthroat trout in both the littoral and pelagic zones of Coeur d'Alene Lake.

Based on the relative abundance information from 1994-1997 it appears that cutthroat trout are more successful in the pelagic zone than the littoral zone. In the pelagic zones with depths greater than 10 meters cutthroat trout were the third most abundant fish species caught. In the littoral zones of these same areas cutthroat trout were one of the least abundant species caught.

Introduced species made up over 68% of the catch in relative abundance studies from 1994-1997 while cutthroat trout comprised less than 1% of the catch. In the littoral zones problems associated with temperature and inter-specific interactions are maximized. In the pelagic zone there is some relief from the effects of temperature however, problems associated with introduced species still exist. In relative abundance studies completed in the pelagic zones greater than ten meters deep from 1994-1997 introduced species (kokanee salmon) made up only 32% of the catch. There appears to be some association with the locations where cutthroat trout are caught in both the littoral and pelagic zones. It appears that in areas where fish are found in the pelagic zones they are also found in the littoral zones located nearby. This could mean that these fish are avoiding high temperatures in the upper waters by making foraging runs into the littoral zones during times when the water temperatures cool slightly at night. This could also be a predator avoidance mechanism as well.

The Tribe feels that, most likely, all of the factors stated by the ISRP in some form or another limit or suppress the populations. We also believe the ones stated above influence density and distribution to the greatest extent. Removal of identified limiting factors in the stream (sediment, lethal temperatures, low minimum base flow) will have positive benefits for the fish; there should be no doubt about that. Will it alleviate every problem facing these populations? I doubt it. However, it will go along way towards stabilizing the populations and decreasing the chances of local extinction. The Tribe is committed to continued development of monitoring and evaluation protocols that better direct implementation efforts.

- ISRP Comment- Enhance adfluvial cutthroat trout but without a hatchery.

Response: *The Tribe agrees with the ISRP partially . The Tribe has modified its plans to hold four individual populations of broodstock to two populations, one derived from fish from Evans and Alder Creek (resident) and the second derived from fish from Benewah and Lake Creeks (adfluvial). The Tribe is intending to initially focus supplementation efforts on the resident form in Evans and Alder Creeks. The Tribe is still not convinced that plans for the restoration of the adfluvial form of cutthroat trout in Lake and Benewah Creeks be abandoned in favor of a resident fish program. Adfluvial forms of this sub-specie are still found in both of these creeks (Lake and Benewah) and the Tribe feels that in order to meet goals for viable subsistence harvest and mitigation for the hydropower system adfluvial fish are a priority. Again, each approach identified by the ISRP has merit and the Tribe intends implement some of them. However, the Tribe is not convinced that these measures will result in harvestable surpluses that support the annual subsistence harvest needs identified by the Tribe in earlier documents (Scholz et.al. 1985) in the near future. Additionally, none of these approaches takes into the consideration the effects that catch and keep fishing regulations have on cutthroat trout populations, in particular, resident stream dwelling populations .*

- ISRP Comment- Concentrate on resident cutthroat (with habitat restoration) instead of the adfluvial form.

Response: Again, this alternative, at best, will take many generations (possibly 50 – 100 years) before harvestable numbers are available to support a sustained Tribal subsistence fishery. The Tribe is not prepared to abandon its plans for restoration of adfluvial populations. Some management agencies are too quick to pull the plug on native species in favor of more lucrative exotic fisheries. That is one of the main problems in the Coeur d'Alene Subbasin. The Tribe has taken the hard line on restoration of native species and is committed to seeing it through even in *the face of more lucrative exotic fisheries. The Tribe is committed to continuing its habitat restoration program focussing in removing factors that limit the native salmonid populations on the reservation as well as providing, to the maximum extent possible, subsistence harvest opportunities (both short and long-term) for the individual members.*

- ISRP Comment- Acquire adfluvial fish for stocking, but from an outside source such as IDFG.

Response- The Coeur d'Alene Tribe appreciates and supports previous ISRP concerns about local adaptation, the uniqueness of individual populations, and maintenance of the fitness of individual populations. The ISRP states:

> **"The plan recognizes and responds to many scientists' concerns about local adaptation, the uniqueness (or potential uniqueness) of individual populations, and maintenance of the fitness of individual populations. Some fisheries managers have been reluctant to manage artificial production facilities at this scale (that of the individual population) due to the expense and logistical difficulties. The Coeur d' Alene tribe is to be commended for their foresight and concern about the future of specific populations within the reservation." (ISRP 2000-1)**

The Tribe stands firm in its desire to maintain the fitness of the unique populations within the Reservation. The Coeur d'Alene Tribe's policy towards stocking of fish from different subbasins is quite clear. This perspective was the specific focus of praise from the ISRP during the Step –1 review. Additionally, IDFG does not have any locally adapted stock to plant in the Coeur d'Alene Subbasin. This alternative was considered in the EA (DOE/EA –1275) and eliminated from study because of the genetic risks involved in transferring fish from their facility located outside the subbasin into the Coeur d'Alene subbasin. Additionally, this did not alleviate any environmental concern associated with the proposed program.

- ISRP Comment- Usable spawning habitat comprises 4.1% of the total stream area in 2nd order tributaries." Is this conclusion based on a biologist's view of what is "usable" or is it based on the areas used by fish when the spawning population is large? Spawning site selection is influenced by factors that cannot be seen even by experienced observers. A value of 4.1% of stream area may be excessive of actual fish needs.

Response: Potential spawning habitat was identified from samples taken over a six-year period as well as migration patterns and population surveys. Habitat features were measured according to methods described by Hankin and Reeves (1988). Potential spawning gravels were measured and defined according to methods described by Magee et. al. (1966). In tailouts and riffles substrate composition with pebble count measurements were made using the technique defined by Wolman (1954). Quantification of substrate conditions near emergence sites were collected using McNeil hollow core sampler (Platts et. Al. 1983). Expression of substrate composition was made as recommended by Chapman (1988) and Young et.al. (1991). Thus the Tribe agrees with the ISRP that spawning site selection is influenced by factors that cannot be detected by the most experienced observers. In some cases the cues are so discrete that nobody knows what they are. Based on the previous mentioned methodology 4.1 % was the estimate of usable spawning habitat when compared to the rest of the stream. This may be excessive of actual fish needs however, this value (an assumption based on previously mentioned methods) is what we used to estimate the number of fish needed to fully seed available habitat in each of the *target tributaries. We used the valued to calculate the surface area available to spawning trout, then calculated the average size of a fish redd and divided it by the surface area available for spawning. Several other assumptions were also made in this calculation. The assumptions are explained in full detail in the Hatchery Master Plan Peters et.al. (1999).*

- ISRP Comment- What is the goal of the rainbow stocking (angler hours/ Return percentage)?

Response: The Tribe has addressed this concern in the Master Plan in the monitoring and evaluation section. The plan calls for a subsistence fishery of 0.5 fish/hr in the catch out ponds. It also calls for obtaining a rainbow trout creel condition factors ($K>152X10^{-7}$). The Coeur d'Alene Fisheries Program would like to stock approximately 2000 to 2500 fish in each pond depending on the size of the fish each year. Worley Pond was stocked on June 26, 2000 with approximately 1500 fish one month later on July 27, 2000 a population estimate was performed by seining the pond, only 65 rainbow trout remained. The Coeur d'Alene Fisheries Program would like to see 80-85% of the fish returned to the creel on all ponds during the season. Based on preliminary results from the Tribes existing catch out pond these goals will be easily attainable.

- ISRP Comment- What does a limiting factor analysis in Coeur d' Alene Lake entail? What results expected from Objectives 3a, 3b, 3c will help to conclude what is limiting?

Response: The Tribe contends that the hypothesis, "Habitat preference for cutthroat trout within Coeur d'Alene Lake is distinct and discernable and its current boundaries can be determined" is true and attainable using the methods outlined in the proposal.

To implement a limiting factor analysis on Coeur d'Alene Lake there are many things that the Fisheries Program must take into account. The first is to identify habitat preference by westslope cutthroat trout within the lake. Based on the findings management or biological methods may be used to enhance cutthroat trout habitat. Predator/prey interactions need to be addressed in Coeur d'Alene Lake. Currently there are 22 species of fishes within the Lake and only seven are native (Peters et al., 1999 and Vitale et al., 1999). Water quality in the northern section of Coeur d'Alene Lake has the potential to be a limiting factor due to the high levels of dissolved metals. As cutthroat trout populations start to increase around the Coeur d'Alene Subbasin the food base of Coeur d'Alene Lake will have to be monitored so that it does not become a limiting factor.

Objective 3. Conduct limiting factor analysis for hatchery westslope cutthroat trout in Coeur d'Alene Lake.

Task 3a. Coordinate with local agencies to gather baseline predator prey relationships between large piscivorous fish and their prey located in Coeur d'Alene Lake.

The results from task 3a will give us an idea of the relative abundance of fish species and the specific locations of where westslope cutthroat trout inhabit on the northern section of Coeur d'Alene Lake. The Northern section of Coeur d'Alene Lake has very different habitat then the southern 1/3 of Coeur d'Alene Lake. It lacks the vast littoral zones characteristic of the southern 1/3 created by the inundation of Coeur d'Alene Lake by Post Falls Dam in 1906. Vitale et al., (2000) states that the inundation of 3.6m of shoreline has created prime habitat for northern pike, largemouth and smallmouth bass, which has increased the interaction of these species with *cutthroat trout. Currently, the only fish sampling efforts that take place on the Northern section of Coeur d'Alene Lake are conducted by the Idaho Department of Fish and Game in which they trawl the pelagic zones for kokanee.*

Relative abundance is an index of population density. Relative abundance assumes that catch per unit effort (CPUE) is proportional to stock density. To make sure CPUE is reliable we will standardize our sampling efforts by electroshocking the same sites for the same amount of time. Each transect that is established will be electrofished using the standard guidelines and procedures described by Reynolds (1983). Gillnets which are a type of passive sampling method can not be used to determine species composition due to species and size selectivity. Passive capture gears have been used to estimate a variety of life history parameters such as, growth, reproductive cycles, diurnal activity trends, distribution with in a water body and diet (Huber 1983). Electroshocking is not efficient in sampling young of the year fish (age 0). To sample young of the year fish the Fisheries Program plans on beach seining the shoreline in addition to electroshocking. By using a combination of electrofishing, gillnetting, and beach seining the Fisheries program feels that our relative abundance estimates will be more accurate than if we were to rely on only one method.

The following fish sampling techniques along with methods as described in Peters et al., 1999 and Vitale et al., 2000 will be used to sample the shoreline and deep-water zones of the northern section of Coeur d'Alene Lake. Approximately 13 transects will be identified in the initial surveys of the northern section of Coeur d'Alene Lake. Each transect will be broken into sample reaches that encompass all habitat types within the selected transect. Each transect will have from 1 to 4 sample reaches. The reach locations will be determined by visual habitat characteristics and transect size. These reaches will be chosen in order to best represent the shoreline habitat within the transect area.

It is important to determine what is there and in what proportion. This will give us an idea if the population is limited at all. Currently, we do not know if habitat is limiting in the lake. We do know that mortality occurs at several life stages in the lake but we are not sure if it truly limits the population. As previously stated in Peters et.al. (1999) the lake most likely suppresses the population but does not fully limit and currently is not at its carrying capacity.

Task 3b. Compare eutrophication in the northern section of Coeur d'Alene Lake to the southern section of Coeur d'Alene Lake by gathering baseline productivity information (nutrients, TKN, TP, turbidity, TSS, metals and chlorophyll$_a$.

By gathering water quality data on Coeur d'Alene Lake the Coeur d'Alene Fisheries Program will be able to monitor long term water quality trends related to the clean up efforts currently taking place in the Coeur d'Alene River basin, monitor increased shoreline development and recreational use.

In 1975, Coeur d'Alene Lake was classified as mesotrophic during the National Eutrophication Survey. In 1991-92 the lake was classified as oligotrophic on the basis of geometric mean concentrations of total phosphorus, total kjeldahl nitrogen and chlorophyll$_a$ (Woods and Beckwith, 1996). The shift in trophic status from 1975 to 1992 was a direct result of apparent reductions in nutrient loading. As BMP's (Best Management Practices) are implemented and continued improvements are made in septic systems and water treatment plants the trophic status of Coeur d'Alene Lake needs to be monitored. Trophic status of Coeur d'Alene Lake will be monitored using total phosphorus, total nitrogen, chlorophyll$_a$, and secchi disc transparency.

These parameters were used to set Coeur d'Alene Lake's current trophic status which was based on an open boundary trophic state classification system (Woods and Beckwith, 1997). Water samples will be taken to continue to establish current baseline conditions.

In addition to taking water samples the Fisheries Program plans to monitor the physical properties, as well as primary productivity, nutrients and metals in Coeur d'Alene Lake see Peters et al., 1999 and Vitale et al., 2000 for a detailed description of methodology.

Temperature, dissolved oxygen and pH water quality results will be used to establish the available habitat for westslope cutthroat trout using the Lacustrine Habitat Suitability Index Model from Hickman and Raleigh (1982). Within the southern 1/3 of Coeur d'Alene Lake the lower 7 to 10 m depending upon the site has unsuitable habitat for cutthroat trout (Vitale et al., 2000 and Peters et al., 1999). This is not to say that cutthroat trout won't use this area just that they probably won't spend an extended amount of time at these depths.

This information will help determine if heavy metal contamination found within the northern section of Coeur d'Alene Lake is limiting or just have suppressive effects on the population residing in the lake. This will also help quantify usable habitat in the northern section of the lake.

Task 3c. Monitor phytoplankton, zooplankton, and aquatic macrophytes within Coeur d'Alene Lake.

Once westslope cutthroat trout populations begin increasing in the watersheds associated with Coeur d'Alene Lake there is a need to maintain an available food source in the lake.

The northern section of Coeur d'Alene Lake is heavily influenced by heavy metals as a result of over 100 years of mining in the upper reaches of the Coeur d'Alene River. The mining tailings tend to settle out at the mouth of the Coeur d'Alene River but what doesn't gets carried down stream towards the mouth of the Spokane River. The accumulation of metals might have an affect on phytoplankton, zooplankton and aquatic macrophyte growth in the northern section of Coeur d'Alene Lake. Kuwabara and others, 1994 showed that phytoplankton growth was strongly inhibited by zinc concentration greater than the basal media treatment.

Information gained will help determine food availability throughout the year. At this time it is not believed that food availability limits cutthroat populations. However, as these populations increase and potentially reach carrying capacity within the lake baseline information will be needed to determine the limiting effects.

Once again it unlikely that the conditions in the lake currently limit the populations. It is believed that conditions have suppressive effects and these sampling efforts will lead us in the right direction in determining exactly what they are. This will be extremely important in the future given the focus on habitat restoration within the subbasin in both the Coeur d'Alene and St. Joe River system forecasted with the mining cleanup.

- ISRP Comment- We anticipate potential further interaction with the personnel involved in this project after they respond to our comments.

Response- The Tribe appreciates this opportunity to clarify issues presented in the ISRP 2001-2 comments. Unfortunately our progress to date to address ISRP's earlier concerns and issues *were not made clear. For this, we again apologize. We look forward to further interacting with the ISRP, and others, towards implementing a scientifically sound production facility.*

In conclusion, the Tribe again appreciates the peer review process and is pleased with the progress we have made thus far in addressing the concerns of the Council and the ISRP. We look forward to continued constructive dialogue in the future with the Council and the ISRP.

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Attachment A Water Quantity Report

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ANALYSIS OF WELL YIELD POTENTIAL FOR A PORTION OF THE COEUR D'ALENE RESERVATION NEAR WORLEY, IDAHO

Prepared for
J-U-B Engineers, Inc.
Spokane, Washington

February 2001

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INTRODUCTION

This report provides a summary of the information gained from the drilling and hydraulic testing of a series of test wells drilled in the Worley, Idaho area as part of a hatchery development program on the Coeur d'Alene Indian Reservation. The goal of the ground water investigation program is to develop a well field that will supply a continuous flow of about 60 gpm (gallons per minute) for hatchery uses. This yield may be obtained from one or more wells pumping continuously or from a number of individual wells pumped sequentially.

Two objectives must be considered during the ground water evaluation program. First, the production wells must yield sufficient water to meet project objectives. Second, the wells must be capable of yielding these amounts over long periods of time. The first objective may be satisfied by penetrating portions of the subsurface that have large enough openings (pores in unconsolidated sediments or fractures in consolidated rock) to yield the desired discharge rate. The selection of drilling sites to meet this objective is based on understanding the subsurface geologic conditions. Data obtained from aquifer tests may be used to estimate individual well yields.

The second objective of long-term productivity is more difficult to evaluate. Prior to the construction and operation of wells, ground water systems are in a state of dynamic equilibrium; natural recharge is equal to natural discharge. Ground water recharge in the Worley area is from precipitation and stream losses within the watershed. Natural ground water discharge in the Worley area occurs as springs and seeps in the deep canyons tributary to Coeur d'Alene Lake to the east and as ground water outflow to the west. Annual ground water pumpage from wells must necessarily be less than annual recharge for long-term water production to be possible. Development of a new well necessarily causes some decline in ground water levels and ultimately decreased ground water discharge. Ground water levels will decline then ultimately stabilize if the amount of water removed by pumping is less than recharge rates. However, mining of ground water with associated continuous water level decline will occur if pumpage exceeds recharge rates. Thus, long-term well operation for hatchery operations in the Worley area depends on understanding ground water flow systems and recharge-discharge relationships.

The assessment of long-term well productivity is based on three different evaluation approaches. First, how large is the aquifer? A large, laterally extensive aquifer has a greater surface area for recharge and more water in storage. Long-term development of a production well (or well field) is much more likely in a large aquifer than in an aquifer that is closely bounded by low permeability rocks. Second, how does the aquifer respond to water removal during an aquifer test? The critical aspect here is whether the aquifer water levels fully recover in a reasonable period of time after pumping has stopped. Significant residual drawdown long after the end of the test is evidence of a highly bounded aquifer that would not be suitable for long-term development. The third evaluation approach is to monitor ground water levels during one or more annual recharge events. An aquifer where water levels respond to spring snowmelt related recharge events is a much better candidate for long-term development than one that appears to be isolated from surface recharge events.

This report presents an evaluation of data collected to date from the drilling and testing of a number of wells following the procedures outlined above. This type of ground water study always suffers from a lack of detailed subsurface information. Extrapolation of the existing data is a necessary investigation approach.

A report entitled **"Ground Water Development Potential For A Portion of The Coeur d'Alene Reservation Near Plummer And Worley, Idaho"** (Ralston, 2000) presents a summary of the site geology and the results of the drilling and testing of the first two test wells. A portion of the information from the Ralston (2000) report is presented within the current document.

HYDROGEOLOGIC SETTING

The area of interest is located where an ancestral topography composed mostly of metamorphic rocks was inundated by a sequence of basalt flows and associated sediments. Figure I is a partial copy of a draft geologic map in preparation by the Idaho Geological Survey. The metamorphic basement rocks outcrop at numerous locations and underlie the basalt and sediments at depth. Figure I shows the basement rocks with a "Y" followed by several additional letters (Yrb, Ywml, Ywu, Ysp, Ysr and Yxq). Relative to a ground water development project, the differences between these geologic map units are insignificant. Sediments are shown over much of the mapped area. The sediments are identified either as Ts or Oal (gold and yellow colors). Basalt of the Priest Rapids member of the Wanapum Formation (Tpr - brown color) outcrop in the northern portion of the area and in the canyons. Deeper basalt units *(Ted* - dark brown: Tgn2 - salmon color) outcrop in the canyons and along the lake.

The basalt is the most viable target for well development within the area of interest. Aquifers (water producing zones) are located along contact zones between successive flows. The individual basalt flows vary in thickness but average 150 to 250 feet over much of northern Idaho and eastern Washington. Variations occur where the basalt laps up on ancestral highs or where the flows filled canyons in the ancestral topography. Two regional basalt aquifers are present in much of northern Idaho and eastern Washington. The upper of these two aquifers occurs in the Wanapum Formation while the lower is in the Grande Ronde Formation (Tpr and Tgn2 on Figure 1). Typically, water levels are 50 to 150 feet lower in the underlying Grande Ronde aquifer than in the overlying Wanapum aquifer. Higher well yields generally are obtained in the Grande Ronde unit.

Most of the sediments found in the basalt sequence in the area of interest are fine-grained, representing deposition in a low-energy environment. The logs show primarily clay and shale. Thus, the sediments are not good water producing zones.

Most of the metamorphic rocks have low hydraulic conductivity and are not viable targets for large yield water supply development. The metamorphic rocks typically are identified on well driller logs as shale or granite. However, in some localized areas shale sequences within the metamorphic rocks allow higher water production levels.

The bedrock (metamorphic rock) outcrops shown on Figure I represent the ancestral ridges or high lands that were not covered by the basalt and sediments. The thickness of basalt and associated sediments is greatest at the locations of the ancestral valleys. The approximate locations of these valleys may be inferred from the geologic map. The present location of Plummer Creek probably overlies an ancestral valley in the basement rock. The creek has eroded a deep canyon and basement rocks are not exposed, A second basement valley probably is located east of Worley near the present alignment of Squaw Creek. The area northwest of Worley probably is a third ancestral valley.

A review of the well logs from the test wells plus the older existing wells indicates that the subsurface is a complex mosaic of basalt flows and sedimentary interbeds overlying irregular bedrock topography. The basalt flows probably filled in a steep upland drainage, causing rapid deposition of sediment and, in places, invasion into the sediments by the encroaching basalt flows. As a further complication, the metamorphic rocks in the area are highly weathered. Some of the sediments below the lowermost basalt flow may be weathered basement rocks.

The complex subsurface geology results in a very complex network of local aquifers, possibly with a limited lateral interconnection. This makes extrapolation of ground water conditions from well to well very difficult. The key to meeting the project objectives is to find areas where well yields are high enough and where there is a reasonable degree of interconnection of aquifers over a large area.

ANALYSIS OF WELL DATA

Seven test wells were constructed as part of this project. The locations of the wells are shown on Figure 2. In addition, a new well for the City of Worley was constructed in 1999 and an aquifer test conducted. Table I presents construction information for these wells. The following sections describe the construction and hydraulic testing of the project test wells plus the new City of Worley well.

Well S-1

Well S-1 is the southernmost of the test wells constructed for the project (Figure 2). This well was drilled near Sunny Slope Road in a small valley surrounded on three sides by hills composed of metamorphic rocks. Basalt was intercepted in the well starting at 58 feet to the bottom of the well at 160 feet. The basalt likely is part of the Wanapum Formation (Tpr on Figure 1). The basalt aquifer likely has limited areal extent because of the nearby location of the metamorphic rock ridges. The static depth to water is about 33 feet below land surface. A copy of the well log for well S-1 is presented in Appendix A.

An aquifer test was run using well S- I as the pumping well and an existing well as the observation well. A pump in well S-1 was turned on September 7, 1999 and pumped continuously until September 23, 1999. Figure 3 shows the water level record for well S-1. The pumping rate was held near 60 gpm for about 12 days and then stepped briefly up to about 80 and then about 95 gpm (Figure 4). Water level data were obtained intermittently for about 42 days after the end of the test. Figure 5 presents the water level response pattern for the observation well located less than 100 feet from S- 1.

The S- I aquifer test demonstrates that the well can yield about 60 gpm with a demonstrated pumping period of about 16 days (Figure 4). However, both the pumping and observation wells show incomplete water level recovery that is characteristic of small, bounded aquifers. Well S- I had recovered only within about three feet of the original static level after a recovery period roughly equal to the pumping period. The residual drawdown was more than 1.6 feet after more than 42 days of recovery (as compared to about 16 days of pumping). The observation well showed a similar lack of full water level recovery (Figure 5). **Questions related** to the long-term productivity of this well as a water supply source for the hatchery are addressed in a later section of the report.

Well A-1

Well A- I was drilled to a depth of 433 feet at a site slightly south of the Conkling Road (Figure 2). According to the well log submitted by the driller, well A- I only obtained water from a basalt layer in the depth range of 393 to 433 feet. Well A- I is located north of the small basin penetrated by well S- I but relatively near the deep canyons that provide drainage to the east toward Coeur d'Alene Lake. The Ralston (2000) report provides a conceptual geologic cross section that includes the A- I well. The lower basalt aquifer penetrated by well A-I likely is part of the Grande Ronde Formation (Tgn2 on Figure 1). The lateral continuity of this aquifer probably is limited because of the metamorphic ridge to the south and the presence of the deep canyons to the east.

An aquifer test was conducted by pumping well A- I in the time period of April 28 to May 18, 2000. The water level and discharge records for this test are presented in Figures 6 and 7. The pumping rate was held at near 60 gpm. The linear nature of the water level pattern shown on Figure 6 in the time period of five to 20 days after the start of pumping indicates the presence of negative boundaries formed by the truncation or edge of the aquifer. The bounded nature of the aquifer also is shown by the lessened pattern of water level recovery shown on Figure 6. Only about one week of recovery data was taken after about 20 days of pumping. However, the water levels appear to be trending toward a stable level five to ten feet below the original static. More information on long-term recovery of water levels in this well is presented in a later section of the report.

Well A-2

Well A-2 was drilled at a location slightly less than one-half mile north of well AI near the boundary of sections 19 and 20 (Figure 2). The drillers log (Appendix A) shows basalt in the depth interval of 18 to 295 feet with a small aquifer in the depth range of 275 to 285 feet. The well penetrated clay then shale to total depth. According to the well log, an aquifer was penetrated in the shale in the depth range of 3 10 to 3 65 feet. The depth to water in the well is slightly less than 70 feet.

A 24-hour aquifer test was run on well A-2 in September 2000. Figure 8 shows the water level pattern in the well during and after the test. Figure 9 illustrates that the pumping rate was held at about 70 gpm. The water level in the pumping well dropped relatively rapidly about 60 feet and then started to stabilize. One day after the end of the pumping test the water levels had recovered to within two feet of the original static. The short length of the pumping period prevents detailed interpretation of the long-term productivity of this well.

Wells B-1 and B-2

The focus of the test drilling and aquifer-testing program moved closer to the City of Worley in late 2000. This was in part because of high reported well yields from several City of Worley wells. Also a well drilled near the silos in the east portion of Worley had high reported yields.

Well B-1 was drilled in November 2000 to a depth of 344 feet at a location near the old silo well (Figure 2). This well intercepted mostly basalt in the depth range of 24 to 338 feet but the driller reported only small water production. His estimated well yield is 50 to 60 gpm (Table I and Appendix A).

The B-2 notation was given to the old well located at the silo. The original drillers log for this well (drilled in 1976) shows a depth of 305 feet with basalt from 20 feet to the bottom of the well (Appendix A). Water producing zones were noted in the depth intervals of 70 to 100 feet and 160 to .180 feet. A drilling rig was set over well B-2 in December 2000 and the well was cleaned out to a reported depth of 300 feet. A section of 4-inch diameter PVC casing was set in the well with perforations in the depth range of 200 to 240 feet. The perforations consist of reported 1/8-inch by 6-inch saw cuts in the 4-inch diameter casing. This gives an estimated open area of about 0.8 square feet and a design yield (at an entrance velocity of 0. 1 ft/sec) of about 3 7 gpm. The drillers log indicates that the annular space between the PVC casing and the drilled hole was backfilled with "pea gravel."

A 2 1 -day aquifer test was conducted in December 2000 and January 2001 where well B-2 was pumped and water level data were collected on wells B-1 and B-2. Figures I I and 12 provide the water level and pump discharge data for well B-2. Water level data for well B- I are presented on Figure 13. Figure 12 shows that well B-2 was pumped at a rate of about 70 gpm at the start of the test decreasing to 65 gpm at the end of the test. About 90 feet of drawdown was measured in the pumping well. The total drawdown in well B-1, located within 200 feet of well B-2 was slightly over 40 feet. The water level in well B-2 recovered to within about 0.3 feet of the original static about 26 days after the well was shut off (Figure 10). A comparison of the initial and final water level for well B- I is confusing and probably represents measurement error in the data record. The depth to water in well B-I prior to the aquifer test on December 15, 2000 was reported as 68.67 feet. The water level reading on January 30, 2001 (about 25 days after the pump was turned off) was 77.04 feet. This would show about 9 feet of residual drawdown if correct. The water levels in both wells were measured on January 30, 2001 and the approximate difference between the casing elevations was determined. These figures indicate that the water level elevations are within 0.2 feet of being the same in the two wells. The static depth to water of 76 feet in B-2 prior to the start of the test should have corresponded to a similar level in well B-1. Likely, the lack of full water level recovery shown for well B-I on Figure 12 probably represents water level measurement error early in the test period.

The estimated long-term yield that can be obtained from well B-2 is discussed in a later section of the report. A recommended well field pumping program also is presented in that section.

Well B-3

Well B-3 is located several thousand feet northeast of the B-2/B-1 well pair. This well was drilled to a depth of 405 feet in January 2001. Basalt was penetrated in the depth range of about 3 to 296 feet. Clay was found under the basalt in the depth interval of about 296 to 330 feet. About 70 feet of shale was penetrated in the bottom of the well. Water producing zones are identified on the drillers log from the basalt in the depth ranges of 65 to 69 feet and 235 to 242 feet and from the shale in the depth range of 330 to 405 feet. The casing used in the well is described on Table 1.

A 24-hour aquifer test was conducted on well B-3 on January I I - 12, 200 1. Figure 13 presents the water level data while Figure 14 presents a plot of the discharge rate. The water level plot for well B-3 is very irregular because the discharge rate had to be continually adjusted downward to keep the water level above the pump. Figure 14 shows that the initial pumping rate was about 70 gpm with a gradual reduction to about 3 5 gpm at the end of the test. Water level data show that the water level in the well was about 6.7 feet below the original static level one day after the pump was turned off. A water level measurement taken eight days after the pump was turned off shows that the water level was about 2.2 feet higher than the static level at the start of the test. The water level in the well may have still been rising on January 11, 2001 (the start of the aquifer test) because drilling (including airlift pumping) was not completed until January 5, 200 1. As is discussed later in the report, this well is not a good candidate for inclusion in a well field for the hatchery.

Well B-4

Well B-4 was drilled north of the City of Worley near the sewage lagoons (Figure 2). The well was drilled to a depth of 445 feet and penetrated layers of basalt and clay (see Appendix A for the drillers log). Basalt was penetrated in the depth intervals of 14 to 237 feet and 325 to 414 feet. The driller reported a low yield (12 gpm) with water noted only in the depth range of 237 to 321 in an interval logged as "clay and clay with wood". An aquifer test was not run in this well because of the small reported yield.

Worley City Well

The City of Worley relies on three wells for their municipal water supply, Information on these wells is given in Table 1. According to the available records, the first of the three wells was drilled in 1954 with the second in 1977 and the third in 1999. The well log for the 1999 well is included in Appendix A.

An aquifer test was run on the newest City of Worley well in September 2000. Figure 15 presents the water level data from the test while Figure 16 is a plot of the discharge rate. A step drawdown test was run on the well. The well was pumped at 200 gpm for two hours at which time the rate was increased to 250 gpm. A third rate of 300 was achieved starting four hours into the test. The total testing period was about eight hours. Water level recovery data were taken for 30 minutes after the pump was turned off. Maximum drawdown was about 19 feet with only about 1.7 feet of residual drawdown after 30 minutes of recovery. There is no doubt that this is an excellent well.

The City of Worley was contacted in an effort to obtain historic well discharge and water level data. Apparently no water level data are available for any of the city wells. The limited pump discharge data that was found are presented in Figure 17. Average well discharge, in gallons per day, were calculated from roughly monthly readings of well discharge totalizing meters. The new city well (West Park) was the dominant source of water for the city after it was put on line in 2000,

WATER QUALITY

Water quality data are available from the test wells and the newest City of Worley well. Table 2 presents the results of analyses of well water analyzed at the Spokane Tribal Laboratories for wells S-1, A-1, A-2, B-2 and B-3. Anatek Labs results for the City of Worley well drilled in 1999 also are included. Some important constituents were not included in most of the analyses. These include calcium on the cation side and bicarbonate/carbonate on the anion site. The total dissolved solids reported for the samples are low. The water likely is a calcium-bicarbonate type.

ANALYSIS OF WELL FIELD PRODUCTIVITY

The target yield of 60-gpm continuous flow probably cannot be maintained from any single one of the test wells constructed to date. However, there is a good chance that the desired yield can be obtained by operation of three or four of the wells as a well field. The most likely well field operation would include sequential operation of the wells with rest periods equal to or exceeding the pumping times. The two dominant questions are as follows. First, what is the reasonably expected yield of each well? Second, what on/off pumping cycle will be required for each well to operate over a long time period as part of the well field? These questions are addressed in the following paragraphs.

The amount of water that can be pumped from an individual well is dependent on the following factors: 1) the transmissive characteristics of the aquifer, 2) the hydraulic efficiency of the well and 3) the available drawdown (distance between the static water level and the pump setting). Specific capacity is the discharge of the well divided by drawdown and is a measure of the first two of these factors. A highly efficient well that penetrates a high transmissivity aquifer will have a high specific capacity value in gallons per minute per foot of drawdown. The efficiency of an uncased well is high. Within cased wells, the entrance velocity of the water moving through the perforations dominantly impacts the efficiency of the well. An entrance velocity greater than about one foot per second leads to low efficiency wells.

The specific capacity characteristics of the test wells and the newest City of Worley well are presented on Figure 18 for the first two days of pumping. The plot shows that the City of Worley well has a much higher specific capacity than any of the test wells. Wells A-I and S- I have specific capacity values in the range of three to four gpm/ft while wells A-2 and B-2 have specific capacity values near one gpm/ft. Well B-3 is the least productive of the test wells that were pumped.

Long-term operation of the test wells in a well field depends on the size and location of boundaries on the aquifer(s) penetrated and on the annual recharge to those aquifers. The size of an aquifer can be deduced by examination of the hydrogeologic setting. For example, well S-1 probably penetrates the aquifer with the most limited areal extent. The deeper aquifer penetrated by well A- I also probably is of limited areal extent. The second way to assess the long-term productivity of a specific well is by examination of long-term water level recovery patterns. Figure 19 presents a plot of residual drawdown (the difference between the recovering water level and the original static level) versus the ratio of the time since the pump was turned on divided by the time since the pump was turned off (t/t'). The time ratio values are presented on a logarithmic scale.

Several interesting concepts can be derived from an analysis of Figure 19. First, the extrapolation of the data plots to a residual drawdown value of zero (complete recovery) gives a measure of the long-term productivity of the penetrated aquifer. Water levels in a highly productive, large-scale aquifer should nearly fully recover in a time period equal to the pumping period (th'=2). Only the Worley City well and test well B-2 have this characteristic. Second, the amount of residual drawdown as the lines are extrapolated to a t/t' value of about two gives a measure of the long-term water level decline that might be expected with operation of the well as part of a well field. The length of the aquifer test represented by the field data also is a consideration. For example, well B-3 was pumped for only one day yet has about five feet of residual drawdown at t/t'= 2. This would be a very poor long-term water supply source. On the other extreme, well B-2 has nearly full recovery at t/t'=2 yet was pumped for 21 days. This well would be a reliable component of a hatchery well field. Wells S- I and A-2 have similar residual drawdown values at t/t'=2 but well S- I was pumped for 16 days while well A-2 was only pumped for one day.

Analysis of the discharge and water level data collected to date indicates that well B-2 has the best long-term yield characteristics. Wells S-1 and A-2 appear suitable for inclusion in a well field design although there are questions relative to long-term yield characteristics of these wells. Well A-I has better specific capacity characteristics than wells A-2 and B-2 but the excessive residual drawdown causes concern with respect to long-term well yields. The short and long-term yield characteristics of well B-3 are poor; this well should be removed from any further consideration in the well field.

All of the test wells were measured on January 30, 2001. A comparison of these data to previous measurements can provide insight with respect to long-term well productivity. This comparison of depth to water values is shown below.

Well	First measurement	Last measurement	
S-1	9/7/99 3)2.65 ft	1/30/01	32.34 ft
A-1	2/28/00 132.70 ft	1/30/01	133.81 ft
A-2	9/26/00 69.05 ft	1/30/01	64.71 ft
B-2	12/15/00 76.00 ft	1/30/01	76.00 ft
B-3	1/11/01 32.02ft	1/30/0132.3)4 ft	

All of the measurements of depth to water are within about one foot of the first measurement except for well A-2. The January 2001 measurement is five feet above the static level taken just before the aquifer test in September 2000. The reasons for this water level difference are unknown. The fact that the January 2001 measurements in all wells are near or above the original supports the idea that the tested aquifers in the Worley area do receive some annual recharge.

Long-term measurement of water levels in all of the wells is a useful way to further document the productivity of the aquifers in the area. Water level measurement on at least a monthly frequency is needed. Hydrographs based on these data may show responses to snowmelt or precipitation events and thus provide an additional level of understanding of recharge amount and locations.

CONCLUSIONS AND RECOMMENDATIONS

The ground water systems in the area in and southeast of Worley are very complex. The ground water complexity rises from the complex nature hydrogeologic framework of basalt, sediments and basement rocks. The primary concern with respect to water supply for the hatchery is long-term yield of the wells. The short-term yield characteristics have been documented as part of the aquifer-testing program.

The potential is good that operation of a well field using wells B-2, S- I and A-2 will yield the desired continuous pumping rate of 60 gpm. The available aquifer test data indicate that well B-2 has the best combination of suitable yield rate and nearly full water level recovery after testing. This well probably can be operated perhaps fifty percent of the time to supply the target yield. The remainder of the time the desired yield can be achieved by alternate operation of wells S- I and A-2. Possible lack of full water level recovery is a problem in both of these wells. In particular, our understanding of the longterm yield characteristics of well A-2 is limited because only a one-day aquifer test was conducted. Well A- I can contribute to the hatchery program but probably cannot be pumped at a rate of 60 gpm for any more than one or two months per year because of the slow water level recovery rate of this aquifer. Well B-3 does not have the yield characteristic to be included in the well field design.

Additional data collection efforts would greatly improve our understanding of4he ground water systems and the long-term reliability of a well field. These efforts are listed below.

- At least monthly water level data collection in all wells -- The seasonal and annual water level fluctuations would provide important information relative to aquifer recharge characteristics.
- Continuous water level data collection in well B-2 -- A data logger installed and operated in well B-2 would provide information relative to possible hydraulic connection with the City of Worley wells.
- Long-term aquifer test of well A-2 -- A 15 to 25 day aquifer test is needed on well A-2 in order to assess the long-term productivity of this well.
- Water quality sampling and analysi -- A more complete analysis of water quality within the target wells is needed. The analysis should include all common ions (such as bicarbonate and carbonate) in addition to specific constituents of importance to hatchery operation.

Table 2 Water Quality Data From Test Well

Well		S-1	A-1	A-2	B-2	B-3	B-3	Worley
Sampling date		5/17/00	4/28/00	10/5/00	114101	1/11/01	1/12/01	9/16/99
Laboratory		-------Spokane Tribal Laboratories ---- - -						Anatek
Total dissolved solids	mg/l	110	130		120	180	210	94
Total suspended solids	mg/1	<2	<2	4	<2	264	8	
Turbidity	NTU	0.5	1.1	4.6	2.0	220.0	73.1	1.7
Hardness (as CaC03)	mg/l							102
pH								7.85
Conductivity	US/cm							270
Chloride	mg/l	0.89	0.76	1.75	0.94	2.21	1.51	1.90
Fluoride	mg/1	0.38	0.26	0.42	0.16	0.33	0.49	0.38
Nitrate as N	mg/l	0.01	0.07	0.03	0.00	0.33	0.49	<.5
Nitrite as N	mg/1	<. 005	<,005	<.005	<.005	<.005	<. 005	
Total phosphorous	mg/1		0.04	0.04	0.04	0.04	0.03	
Ortho-phosphorous as P	mg1l	<.005	0.02	0.02	0.04	0.03	0.04	
Sulfate	mg/l	1.67	2.86	14.90	2.97	6.25	5.84	4.91
Ammonia as N	mg/l							<. 1
TKN	mg/l			<.030	0.040	0.159	0.072	
Total alkalinity as CaC03	mg1l	102.0	106.0	144.0	97.6	120.0	115.0	110.0
Bicarbonate as CaC03	mg/l							
Carbonate as CaCO3	mg/l							
Aluminum	mg/l	<.010	<.010	<.010	<.010	<.010	<.010	<.001
Antimony	mg/l							<,001
Arsenic	mg/l	<.020	<.020	<.020	<.020	<.020	<~020	<.005
Barium	mg/l	0.03	0.04	0.06	0.03	0.03	0.03	0.05
Beryllium	mg/l	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Cadmium	mg/l	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.001
Calcium	mg/l							20.8
Chromium	mg/l	<.002	<.002	<.002	<.002	<.002	<.002	<.005
Cobalt	mg/l							
Copper	mg/l	<.002	<.002	<.002	<.002	<.002	<.002	0.002
Iron	mg/l	0.09	0.44	0.04	0.35	<.002	0.00	0.59
Lead	mg/l	<.001	<.001	<.001	<.001	0.005	0.002	<.001
Magnesium	mg/l	8.71	8.98	15.20	8.11	10.50	10.40	11.40
Manganese	mg/l	0.03	0.04	0.05	0.04	0.04	0.04	0.03
Mercury	mg/l		<. 0002					<.001
Nickel	mg/l	<.005	<.005	<.005	<.005	<.005	<.005	<.001
Potassium	mg/l	3.21	3.24	2.61	3.55	2.15	1.98	3.00
Selenium	mg/l			<.002	<. 002	<.002	<.002	<.005
Silicon	mg/1							
Silver	mg/l	<.002	<.002	<.002	<.002	<.002	<.002	<.01
Sodium	mg/1	9.73	9.35	14.20	8.74	13.20	12.40	10.90
Thallium	mg/l							<.001
Zinc	mg/1			0.09	0.01	<,002	<.002	0.03

Coeur d'Alene Tribe
Fisheries Program

Rainbow Trout Feasibility Report
on the
Coeur d'Alene Indian Reservation

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

Coeur d'Alene Tribe Fisheries Program

Rainbow Trout Feasibility Report
on the
Coeur d'Alene Indian Reservation

Prepared By

Ronald L. Peters

February 2001

Coeur d'Alene Tribe Department of Natural Resources
Fisheries Program
850 A Street, P.O. Box 408
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1.0 Introduction

Declining native salmonid fish stocks, in particular, westslope cutthroat trout (Oncorhynchus clarki lewisi) and bull trout (Salvelinus confluentus) in the Coeur d'Alene Basin caused the elimination of traditional subsistence fisheries by Coeur d'Alene Tribal members. The annual runs of anadromus salmon and steelhead are now extinct from traditional Coeur d'Alene Tribal fishing areas. Dams were constructed on the Spokane River at Monroe Street in the City of Spokane and Little Falls farther downstream which initially cut-off the anadromus fish runs from the Coeur d'Alene Tribe. These fisheries were further removed by the construction of Chief Joseph and Grand Coulee Dams. These actions forced the Tribe to rely solely on the resident fish resources of Coeur d'Alene Lake. Over the last several years, poor fishing conditions have severely limited the ability of the Tribal Community to harvest desirable fish species in any acceptable numbers. The reasons for this condition were described in the project proposal (9004400 and 9004402). The Coeur d' Alene Tribe has made the difficult decision to maintain a strict wild fish management policy for traditional fishing areas, primarily important cutthroat trout streams on the Reservation. The emphasis is to restore these areas in order to optimize conditions for expansion of wild stocks (restoration of habitat). However, substantial increases to these populations to support any sizable harvest goals are not expected for some time and may require supplementation to rebuild these stocks.

Since the Coeur d'Alene decided to close streams to harvest in sensitive drainages on the Reservation as the principal method of protecting and promoting wild stock expansion, a hatchery oriented "put and take" fisheries program was implemented. To provide for reasonable harvest of desired species in the near future it was decided that a series of trout fishing ponds located in strategic areas would best serve the need for an alternative fishery on an interim basis. To protect the integrity of the wild fish restoration projects none of these ponds would be placed in drainages (or entire watersheds) where restoration is occurring. This will minimize the chance of interaction between hatchery and native fish species. Additionally, all ponds would be closed basin fisheries to prevent genetic introgression as well as spread of disease.

2.0 Application of the Conceptual Approach to the Pond Program

A minimum of five ponds will be developed over the next three years. One pond (Worley pond) is currently operational, two ponds will be completed during FY99 and two ponds will be completed during FY00. Potential pond sites were submitted to other Natural Resource Programs, the Natural Resources Committee, the Planning Department, and the Tribal Council for review, coordination and final approval. All approved pond sites are located in the Hangman Creek watershed and completely isolated from any westslope cutthroat or bull trout bearing waters.

Duration of the program will be dependent on other aspects of the overall program. Since these ponds are intended to relieve pressure from weak stocks in the area, alternative fisheries will be maintained until populations of weak stocks are determined to be able to withstand previously stated harvest goals. If it is determined through monitoring that the current pond program is not reliving fishing pressure on weak stocks, alternative measures will be explored to meet program objectives.

3.0 Site Selection

Site selection for the proposed fishponds is a very important part of the pond planning process. The following criteria was used to determine pond locations:

- Must have a source of cool clean water adequate for trout survival. This means that enough water must be available to fill the pond and recharge the supply throughout the year.
- Pond sites should be located near the tribal communities on the reservation (Worley, Plummer, Desmet).
- Pond should be easily accessible to people of all ages.
- Must meet all requirements of a cultural resource review.
- The trout pond must meet the goals of the program established by tribal council for the protection, conservation, and enhancement of native fishes.
- The trout pond must be able to meet the needs of the fish during all life stages.

4.0 Trout Pond Design

Once the general locations of the ponds were determined and the water source identified, the exact location, size, and shape of the pond were determined. All the necessary details for completion of the ponds were worked out in this phase of the planning process. The following steps outlined the procedures for planning the construction of the ponds.

I.) A drawing of the pond including depths, contours, and shape will be completed. Detailed drawings of the water inflow, outflow, and retention structures will also be included. The design will be consistent with standard trout pond construction guidelines of the Natural Resource Conservation Service.

II.) Necessary permits will be applied for. If wetland habitat is being disturbed some mitigation under section 404 may be required before a permit for construction will be issued. Considerable attention will be given to habitat improvements (i.e. shoreline contours, grade and shape banks, tree brush and grass landscaping, location of primary fishing sites around the pond, and develop pathways around the pond).

III.) The following items will also be addressed in the final design proposal:
i.) Access road and parking development,

ii.) Shoreline degradation and erosion potential, and
iii.) Fish planting problems (getting fish truck near enough to the shore for planting).

Upon completion of the above steps, the design will be submitted to the Coeur d'Alene Tribe's Natural Resource Committee and Tribal Council for approval. The proposal will then be submitted to BPA to complete NEPA. Once all steps have been completed construction will begin

5.0 Pond Construction

Once the approved plan has been obtained the following procedures will be used to complete the construction phase:

a.) Request for Bids

Three bids will be requested and the contract will be let to the lowest eligible bidder.

b.) Let contract and Implement construction

Fish and Wildlife will provide personnel in the event that extra help is needed. Fish and Wildlife personnel will oversee all phases of construction.

c.) Inspect completed construction/ approve final product

Items which will be addressed are
Completeness of shoreline development
Dam stability
Water leakage
Construction Cleanup

Only after a complete inspection of the work will payment for services be rendered.

d.) Complete landscaping and riparian plantings

Fish and wildlife personnel will use the best management practices in revegetating the shoreline riparian area. Only native plants will be used for maximum fish and wildlife benefits.

e.) Approve pond for planting of fish

Once all the above items have been completed the pond will be approved for planting of fish. Fish will be planted according to the procedures outlined in this section

6.0 Pond Development and Management Plan

Concurrently with construction, specific trout pond management plans will be developed. The plans will address total number of fish per pond and the planting schedule;

The total number of fish needed for each of the ponds will be determined at the start of each fiscal year. It is anticipated that upon construction of the Coeur d'Alene Tribal Hatchery, fish will be secured from our own hatchery.

A schedule for planting of fish into each of the ponds will be completed. Each pond will be planted at least once a year. The number and size of the plantings for each individual pond will be determined by past use, and anticipated fishing pressure for the upcoming season.

The number of fish needed and the timing of the plantings for each pond will be determined by the following factors: The maximum number of fish each pond can hold, the ability of the pond to sustain a population without food supplementation, and the expected rate of removal.

7.0 Desired Species and Stocking Strategy

Rainbow trout are the preferred species for stocking because the species has one of the highest temperature tolerances (25.5°C) of the salmonid family (Piper et. al. 1982, Miko et. al. 1995), large numbers are produced by federal, state, and private hatcheries, and they are readily available and usually can be delivered on demand.

The primary management goal to determine stocking strategy will be angler satisfaction and success. Angler satisfaction and success is directly correlated to catch and/or harvest rates and fishing effort. Mean catch rates necessary to achieve an excellent fishing success rating would be around 2.88 fish/hour (Miko et. al. 1995). This would be stocking densities of about 12,000 fish/ha. However, researchers have shown that mean catch rates peak at about 0.6-0.7 fish/hour, and catch rates needed for angler satisfaction (trip satisfaction) ratings to be considered excellent are much lower. Weithman and Katti 1979, Hicks et. al. 1983, and Miko et. al. 1995 have shown that stocking densities around 1400 fish/ha will provide good to excellent angler satisfaction ratings, and that anglers would be satisfied with their trip quality even if they were dissatisfied with their fishing success. The management strategy employed by the Coeur d'Alene Tribe will be to provide fish catch rates of about 0.5 fish/hour. This is a conservative management strategy, since averages of 1.0 fish/hour at the existing Tribal pond are currently being achieved.

8.0 Source of fish for stocking

It is the intent of the Tribe to implement the suggestions provided by the ISRP (2000 – 1). *Rather than producing rainbow trout at the Facility for planting in ponds for an interim fishery, it may be more efficient and safer to purchase such trout from another source. If these trout were cultured in the Facility simultaneously with the native cutthroat trout, they would compete for resources (water and others) in times of short supply, and they would present a potential pathogen source for the native cutthroat trout. Furthermore, it seems likely that rainbow trout can be purchased from a commercial source at lower cost* *than they could be produced in this Facility. Sterile rainbow trout are available at large sizes, which could add to the interest by participants in the program. (Three-Step Question 5. Alternatives).*

and the BPA – DOE/EA 1275 analysis:

The Cutthroat Trout Only Alternative eliminates the incubation and rearing of rainbow trout at the proposed facility and associated rainbow trout rearing ponds. Catchable-sized rainbow trout would be purchased for direct release into catch-out ponds at several different locations. Thus, the environmental effects should be the same as those described for the Proposed Action Alternative. The only exception is that the potential for an outbreak of whirling disease or ceratomyxosis at the hatchery is significantly reduced with the elimination of the earthen ponds. Given the fact that these fish will not be released into the wild in the unlikely event of an outbreak it would most likely be confined to the rainbow trout only rearing ponds and would not extend beyond the hatchery.

According to the Environmental Assessment Completed by BPA (DOE/EA – 1275) eliminating the rainbow trout program from the facility would save approximately $12,000 annually. Accordingly, overall construction cost of the facility would be reduced by about $100,000.

9.0 Conclusion

The Tribe is proposing two alternatives in that central distribution will be constructed to temporarily hold the rainbow trout for redistribution to the catchout ponds. Fish will be held in the central distribution pond for up to 5 months and second, removing the rainbow component completely out of the facility. .

Alternative 1. Given the remote location of the Reservation and distance from commercial rearing facilities the Tribe will purchase catchable sized fish then hold them in a pond at the facility. This will act as a central distribution center for the other catch-out ponds. It is the intent of the Tribe to distribute at least 10,000 fish annually. This pond will be completely separate from the proposed cutthroat portion. This plan will save $15,000 annually in transportation costs. The closest certified fish farm is about 150 miles away. We estimate that it would take about 14.5 round trips to supply the trout ponds with fish with an annual cost of $32,123 if we picked up the fish 700 at a time. With the central clearing house theory it would only cost $ 15,000 to 18,000 to have the fish delivered. The Tribe could distribute these fish as needed in conjunction with the individual pond stacking strategy. This would also reduce the water needs at the facility by 15 GPM for 7 months out of the year.

Alternative 2.
This alternative would cost about $32,123 annually plus additional costs associated with growing to catchable size but this would be minimal. This would also save about $ 160,000 in construction costs. It would also reduce the water needs for the facility from 60 GPM to 35 GPM.

Cost Estimates

Columbia Fish Farm
Columbia River Road
Nespelem, WA.

Ed Shellanberger, 509-634-4228

Rainbow trout @ $1.31/lb.
12.5 in. To 13.5 in. RBT weighing ~ 1.6 lbs.
1.6 X 10,000 = 16,000 lbs.
16,000 lbs. X $1.31 = $20,960

Transportation not available from the Columbia Fish Farm.

Total distance from the fish farm to trout production facility, 146 miles.
Mileage for costs for this trip one way, $0.345/mile equals $50.37, round trip $100.74.
Estimated time from fish farm to trout production facility, approximately four hours, eight hours round trip.
Hour wage for transportation, $85.00/hour, equaling $680.00/round trip.
With an 11 ft. diameter tank, carrying 700 pounds of fish would require 14.3 trips.

10K RBT (12.5-13.5 inches) @ $1.31/lb.	$ 20,960.00
Mileage 14.3 trips X $100.74	$ 1,439.14
Wage $85.00/hr X (8X14.3)	$ 9,724.00
	$32,123.14

Trout Lodge
Soap Lake, WA.

Bill Wit, 509-246-1421

$1.95/1lb.
12-13 inch RBT ~ $1.50 - $1.80 per fish
$1.50 X 10,000 = @ $15,000 $1.80 X 10,000 = $18,000
Transportation included, although shipments need to be 3-5 thousand fish per order and one stop delivery.

At this point in time the Tribe is leaning towards alternative one however, if water concerns continue the Tribe would focus on alternative two. This will be worked out in the Step Two submittal. Given the Tribally imposed moratorium on subsistence harvest (or any type of harvest) of fish in traditional areas this program represents a reasonable and prudent alternative means to maintain compensatory harvest opportunities for the Reservation community.

Over the life of the project (20 years) alternative one would save BPA $ 140,000.

March 27, 2001

Mark Fritsch, Fish Production Coordinator
Northwest Power Planning Council
851 S. W. Sixth Avenue, Suite 1100
Portland, Oregon 97204-1348

Dear Mr. Fritsch:

The Coeur d' Alene Tribe respectfully submits the following information pursuant to the questions raised in the Step 1 review of the Coeur d' Alene Tribe Trout Production Facility. The first issue was to verify a sufficient sustainable water supply as required by the conceptual plan, and the second, to provide a recommendation on the most cost effective means to provide trout for the catch out ponds. Results of these questions are presented here, with responses to the ISRP and a copy of the water quantity report, *Analysis of Well Yield Potential for a Portion of the Coeur d' Alene Reservation Near Worley, Idaho,* attached for your reference.

Verification of a Sufficient Sustainable Water Supply

The Coeur d' Alene Tribe initiated an extensive well field exploratory investigation, led by Dale Ralston, Ph.D., in order to effectively meet the targeted goal of 60 gpm continuous. In his report Dr. Ralston concludes that the potential is good that operation of a well field using three wells (B-2, S-1 and A-2), will yield the desired continuous pumping rate of 60gpm. The Coeur d' Alene Tribe is also securing access to the Worley City Well, which Dr. Ralston reports is an excellent well. This source would primarily be used as backup water in the event of an emergency. The report also recommends that additional data collection efforts would greatly improve the understanding of the ground water systems and the long-term reliability of a well field. These efforts are as follows:

- At least monthly water level data collection in all wells
- Continuous water level data collection in well B-2
- Long-term aquifer test of well A-2
- Water quality sampling and analysis

The Tribe fully supports the findings and recommendations of this report. The Tribe has approached the water quantity issue using careful consideration and scientific findings. The follow up testing only provides for solid monitoring and evaluation of the operating wells to ensure that long term sustainability can be realized.

As an added security measure for the successful operation of the cutthroat trout production facility, the Tribe has decided to approach water consumption very conservatively. Although the Tribe is confident that with proper rotation and adherence to monitoring 60 gpm continuous is feasible, the Tribe would like to phase the construction of the facility. The first phase would be to construct and operate a cutthroat only production facility, utilizing a 35 gpm continuous water supply. The Tribe would monitor recharge rates at the wells and would ascertain the well field recharge potential over a period of hatchery use. This information will determine the feasibility of bringing another 25gpm continuous use for rainbow trout production. Based on the positive results of a 60 gpm scenario, the Tribe is very confident that a 35 gpm is extremely practical. If water availability, based on several years of cutthroat production at 35 gpm, warrants the additional use of 25 gpm, the Tribe would like to implement the rainbow trout pond portion of the project.

This decision point not only minimizes water consumption and allows for recharge analysis, it reduces the overall cost of the initial construction phase. It also addresses the issue of the most cost-effective means to provide trout for the catch out ponds.

Cost Effective Means to Provide Trout for the Catch Out Ponds

As mentioned in the earlier discussion, the Tribe has decided to remove from Phase I consideration, the construction of the rainbow production ponds. Phase II construction would be to implement the rainbow production ponds if favorable results of well recharge capabilities are forthcoming. This particular elimination reduces both the total needed water for the production facility, and the initial construction costs.

As mentioned earlier, the elimination of the rainbow ponds results in a 41.6% reduction in water need. This added flexibility to the system will provide the Tribe with more than enough water to support the cutthroat production, and provide necessary monitoring as recommended in the water quantity report.

The construction costs for the rainbow trout ponds would be earmarked for the Coeur d' Alene Tribe until a decision point has been made relative to the water quantity issue. These funds would amount to approximately $164,780.

Given the Tribally imposed moratorium on subsistence harvest of native fish in traditional use areas, the intent is to purchase rainbow trout from a commercial rearing facility for stocking in already established catch out ponds. This alternative would cost approximately $32,000 annually and would be included in the operation and maintenance budget.

The Tribe has faithfully engaged in the Three-Step process, the ISRP review, and the provincial review. At each step of the review, including a successful Environmental Assessment, we considered and acted upon the many recommendations that were outlined. We appreciate the scientific review and strongly feel that with these modifications outlined herein, the facility is now ready for preliminary design work as called for in Step 2 of the process.

Respectfully submitted,

Ronald L. Peters
Fisheries Program Manager
Coeur d'Alene Tribe Natural Resources Department

Attachments (water quantity report, letter from Ralston, ISRP response to comment)

Step 1
Review of the
Coeur d'Alene Production Facility

March 2001

Submitted to: Mr. Mark Fritsch
Fish Production Coordinator
Northwest Planning Council

Submitted by: Mr. Ronald Peters
Coeur d'Alene Tribe

REFERENCE:

COEUR D'ALENE TRIBE

850 A STREET
P.O. BOX 408
PLUMMER, IDAHO 83851
(208) 686-1800 • Fax (208) 686-1182

March 27, 2001

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Northwest Power Planning Council
851 S. W. Sixth Avenue, Suite 1100
Portland, Oregon 97204-1348

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Respectfully submitted,

Ronald L. Peters
Fisheries Program Manager
Coeur d'Alene Tribe Natural Resources Department

Attachments (water quantity report, letter from Ralston, ISRP response to comment)

Appendix A

Water Quantity Report/Dr. Ralston Letter

RHS Ralston Hydrologic Services, Inc.

GROUND WATER CONSULTING AND EDUCATION

1122 East B Street, Moscow, ID USA 83843
Voice and FAX 208-883-0533, E-mail ralston@moscow.com

ANALYSIS OF WELL YIELD POTENTIAL FOR A PORTION OF THE COEUR D'ALENE RESERVATION NEAR WORLEY, IDAHO

Prepared for
J-U-B Engineers, Inc.
Spokane, Washington

February 2001

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APPENDICES

INTRODUCTION

This report provides a summary of the information gained from the drilling and hydraulic testing of a series of test wells drilled in the Worley, Idaho area as part of a hatchery development program on the Coeur d'Alene Indian Reservation. The goal of the ground water investigation program is to develop a well field that will supply a continuous flow of about 60 gpm (gallons per minute) for hatchery uses. This yield may be obtained from one or more wells pumping continuously or from a number of individual wells pumped sequentially.

Two objectives must be considered during the ground water evaluation program. First, the production wells must yield sufficient water to meet project objectives. Second, the wells must be capable of yielding these amounts over long periods of time. The first objective may be satisfied by penetrating portions of the subsurface that have large enough openings (pores in unconsolidated sediments or fractures in consolidated rock) to yield the desired discharge rate. The selection of drilling sites to meet this objective is based on understanding the subsurface geologic conditions. Data obtained from aquifer tests may be used to estimate individual well yields.

The second objective of long-term productivity is more difficult to evaluate. Prior to the construction and operation of wells, ground water systems are in a state of dynamic equilibrium; natural recharge is equal to natural discharge. Ground water recharge in the Worley area is from precipitation and stream losses within the watershed. Natural ground water discharge in the Worley area occurs as springs and seeps in the deep canyons tributary to Coeur d'Alene Lake to the east and as ground water outflow to the west. Annual ground water pumpage from wells must necessarily be less than annual recharge for long-term water production to be possible. Development of a new well necessarily causes some decline in ground water levels and ultimately decreased ground water discharge. Ground water levels will decline then ultimately stabilize if the amount of water removed by pumping is less than recharge rates. However, mining of ground water with associated continuous water level decline will occur if pumpage exceeds recharge rates. Thus, long-term well operation for hatchery operations in the Worley area depends on understanding ground water flow systems and recharge-discharge relationships.

The assessment of long-term well productivity is based on three different evaluation approaches. First, how large is the aquifer? A large, laterally extensive aquifer has a greater surface area for recharge and more water in storage. Long-term development of a production well (or well field) is much more likely in a large aquifer than in an aquifer that is closely bounded by low permeability rocks. Second, how does the aquifer respond to water removal during an aquifer test? The critical aspect here is whether the aquifer water levels fully recover in a reasonable period of time after pumping has stopped. Significant residual drawdown long after the end of the test is evidence of a highly bounded aquifer that would not be suitable for long-term development. The third evaluation approach is to monitor ground water levels during one or more annual recharge events. An aquifer where water levels respond to spring snowmelt related recharge events is a much better candidate for long-term development than one that appears to be isolated from surface recharge events.

This report presents an evaluation of data collected to date from the drilling and testing of a number of wells following the procedures outlined above. This type of ground water study always suffers from a lack of detailed subsurface information. Extrapolation of the existing data is a necessary investigation approach.

A report entitled "**Ground Water Development Potential For A Portion of The Coeur d'Alene Reservation Near Plummer And Worley, Idaho**" (Ralston, 2000) presents a summary of the site geology and the results of the drilling and testing of the first two test wells. A portion of the information from the Ralston (2000) report is presented within the current document.

HYDROGEOLOGIC SETTING

The area of interest is located where an ancestral topography composed mostly of metamorphic rocks was inundated by a sequence of basalt flows and associated sediments. Figure 1 is a partial copy of a draft geologic map in preparation by the Idaho Geological Survey. The metamorphic basement rocks outcrop at numerous locations and underlie the basalt and sediments at depth. Figure 1 shows the basement rocks with a "Y" followed by several additional letters (*Yrb, Ywml, Ywu, Ysp, Ysr* and *Yxq*). Relative to a ground water development project, the differences between these geologic map units are insignificant. Sediments are shown over much of the mapped area. The sediments are identified either as *Ts* or *Qal* (gold and yellow colors). Basalt of the Priest Rapids member of the Wanapum Formation (*Tpr* – brown color) outcrop in the northern portion of the area and in the canyons. Deeper basalt units (*Ted* – dark brown: *Tgn2* – salmon color) outcrop in the canyons and along the lake.

The basalt is the most viable target for well development within the area of interest. Aquifers (water producing zones) are located along contact zones between successive flows. The individual basalt flows vary in thickness but average 150 to 250 feet over much of northern Idaho and eastern Washington. Variations occur where the basalt laps up on ancestral highs or where the flows filled canyons in the ancestral topography. Two regional basalt aquifers are present in much of northern Idaho and eastern Washington. The upper of these two aquifers occurs in the Wanapum Formation while the lower is in the Grande Ronde Formation (*Tpr* and *Tgn2* on Figure 1). Typically, water levels are 50 to 150 feet lower in the underlying Grande Ronde aquifer than in the overlying Wanapum aquifer. Higher well yields generally are obtained in the Grande Ronde unit.

Most of the sediments found in the basalt sequence in the area of interest are fine-grained, representing deposition in a low-energy environment. The logs show primarily clay and shale. Thus, the sediments are not good water producing zones.

Most of the metamorphic rocks have low hydraulic conductivity and are not viable targets for large yield water supply development. The metamorphic rocks typically are identified on well driller logs as shale or granite. However, in some localized areas shale sequences within the metamorphic rocks allow higher water production levels.

The bedrock (metamorphic rock) outcrops shown on Figure 1 represent the ancestral ridges or high lands that were not covered by the basalt and sediments. The thickness of basalt and associated sediments is greatest at the locations of the ancestral valleys. The approximate locations of these valleys may be inferred from the geologic map. The present location of Plummer Creek probably overlies an ancestral valley in the basement rock. The creek has eroded a deep canyon and basement rocks are not exposed. A second basement valley probably is located east of Worley near the present alignment of Squaw Creek. The area northwest of Worley probably is a third ancestral valley.

A review of the well logs from the test wells plus the older existing wells indicates that the subsurface is a complex mosaic of basalt flows and sedimentary interbeds overlying irregular bedrock topography. The basalt flows probably filled in a steep upland drainage, causing rapid deposition of sediment and, in places, invasion into the sediments by the encroaching basalt flows. As a further complication, the metamorphic rocks in the area are highly weathered. Some of the sediments below the lowermost basalt flow may be weathered basement rocks.

The complex subsurface geology results in a very complex network of local aquifers, possibly with a limited lateral interconnection. This makes extrapolation of ground water conditions from well to well very difficult. The key to meeting the project objectives is to find areas where well yields are high enough and where there is a reasonable degree of interconnection of aquifers over a large area.

ANALYSIS OF WELL DATA

Seven test wells were constructed as part of this project. The locations of the wells are shown on Figure 2. In addition, a new well for the City of Worley was constructed in 1999 and an aquifer test conducted. Table 1 presents construction information for these wells. The following sections describe the construction and hydraulic testing of the project test wells plus the new City of Worley well.

Well S-1

Well S-1 is the southernmost of the test wells constructed for the project (Figure 2). This well was drilled near Sunny Slope Road in a small valley surrounded on three sides by hills composed of metamorphic rocks. Basalt was intercepted in the well starting at 58 feet to the bottom of the well at 160 feet. The basalt likely is part of the Wanapum Formation (*Tpr* on Figure 1). The basalt aquifer likely has limited areal extent because of the nearby location of the metamorphic rock ridges. The static depth to water is about 33 feet below land surface. A copy of the well log for well S-1 is presented in Appendix A.

An aquifer test was run using well S-1 as the pumping well and an existing well as the observation well. A pump in well S-1 was turned on September 7, 1999 and pumped continuously until September 23, 1999. Figure 3 shows the water level record for well S-1. The pumping rate was held near 60 gpm for about 12 days and then stepped briefly up to about 80 and then about 95 gpm (Figure 4). Water level data were obtained intermittently for about 42 days after the end of the test. Figure 5 presents the water level response pattern for the observation well located less than 100 feet from S-1.

The S-1 aquifer test demonstrates that the well can yield about 60 gpm with a demonstrated pumping period of about 16 days (Figure 4). However, both the pumping and observation wells show incomplete water level recovery that is characteristic of small, bounded aquifers. Well S-1 had recovered only within about three feet of the original static level after a recovery period roughly equal to the pumping period. The residual drawdown was more than 1.6 feet after more than 42 days of recovery (as compared to about 16 days of pumping). The observation well showed a similar lack of full water level recovery (Figure 5). Questions related to the long-term productivity of this well as a water supply source for the hatchery are addressed in a later section of the report.

Well A-1

Well A-1 was drilled to a depth of 433 feet at a site slightly south of the Conkling Road (Figure 2). According to the well log submitted by the driller, well A-1 only obtained water from a basalt layer in the depth range of 393 to 433 feet. Well A-1 is located north of the small basin penetrated by well S-1 but relatively near the deep canyons that provide drainage to the east toward Coeur d'Alene Lake. The Ralston (2000) report provides a conceptual geologic cross section that includes the A-1 well. The lower basalt aquifer penetrated by well A-1 likely is part of the Grande Ronde Formation (*Tgn2* on Figure 1). The lateral continuity of this aquifer probably is limited because of the metamorphic ridge to the south and the presence of the deep canyons to the east.

An aquifer test was conducted by pumping well A-1 in the time period of April 28 to May 18, 2000. The water level and discharge records for this test are presented in Figures 6 and 7. The pumping rate was held at near 60 gpm. The linear nature of the water level pattern shown on Figure 6 in the time period of five to 20 days after the start of pumping indicates the presence of negative boundaries formed by the truncation or edge of the aquifer. The bounded nature of the aquifer also is shown by the lessened pattern of water level recovery shown on Figure 6. Only about one week of recovery data was taken after about 20 days of pumping. However, the water levels appear to be trending toward a stable level five to ten feet below the original static. More information on long-term recovery of water levels in this well is presented in a later section of the report.

Well A-2

Well A-2 was drilled at a location slightly less than one-half mile north of well A-1 near the boundary of sections 19 and 20 (Figure 2). The drillers log (Appendix A) shows basalt in the depth interval of 18 to 295 feet with a small aquifer in the depth range of 275 to 285 feet. The well penetrated clay then shale to total depth. According to the well log, an aquifer was penetrated in the shale in the depth range of 310 to 365 feet. The depth to water in the well is slightly less than 70 feet.

A 24-hour aquifer test was run on well A-2 in September 2000. Figure 8 shows the water level pattern in the well during and after the test. Figure 9 illustrates that the pumping rate was held at about 70 gpm. The water level in the pumping well dropped relatively rapidly about 60 feet and then started to stabilize. One day after the end of the pumping test the water levels had recovered to within two feet of the original static. The short length of the pumping period prevents detailed interpretation of the long-term productivity of this well.

Wells B-1 and B-2

The focus of the test drilling and aquifer-testing program moved closer to the City of Worley in late 2000. This was in part because of high reported well yields from several City of Worley wells. Also a well drilled near the silos in the east portion of Worley had high reported yields.

Well B-1 was drilled in November 2000 to a depth of 344 feet at a location near the old silo well (Figure 2). This well intercepted mostly basalt in the depth range of 24 to 338 feet but the driller reported only small water production. His estimated well yield is 50 to 60 gpm (Table 1 and Appendix A).

The B-2 notation was given to the old well located at the silo. The original drillers log for this well (drilled in 1976) shows a depth of 305 feet with basalt from 20 feet to the bottom of the well (Appendix A). Water producing zones were noted in the depth intervals of 70 to 100 feet and 160 to 180 feet. A drilling rig was set over well B-2 in December 2000 and the well was cleaned out to a reported depth of 300 feet. A section of 4-inch diameter PVC casing was set in the well with perforations in the depth range of 200 to 240 feet. The perforations consist of reported 1/8-inch by 6-inch saw cuts in the 4-inch diameter casing. This gives an estimated open area of about 0.8 square feet and a design yield (at an entrance velocity of 0.1 ft/sec) of about 37 gpm. The drillers log indicates that the annular space between the PVC casing and the drilled hole was backfilled with "pea gravel."

A 21-day aquifer test was conducted in December 2000 and January 2001 where well B-2 was pumped and water level data were collected on wells B-1 and B-2. Figures 11 and 12 provide the water level and pump discharge data for well B-2. Water level data for well B-1 are presented on Figure 13. Figure 12 shows that well B-2 was pumped at a rate of about 70 gpm at the start of the test decreasing to 65 gpm at the end of the test. About 90 feet of drawdown was measured in the pumping well. The total drawdown in well B-1, located within 200 feet of well B-2 was slightly over 40 feet. The water level in well B-2 recovered to within about 0.3 feet of the original static about 26 days after the well was shut off (Figure 10). A comparison of the initial and final water level for well B-1 is confusing and probably represents measurement error in the data record. The depth to water in well B-1 prior to the aquifer test on December 15, 2000 was reported as 68.67 feet. The water level reading on January 30, 2001 (about 25 days after the pump was turned off) was 77.04 feet. This would show about 9 feet of residual drawdown if correct. The water levels in both wells were measured on January 30, 2001 and the approximate difference between the casing elevations was determined. These figures indicate that the water level elevations are within 0.2 feet of being the same in the two wells. The static depth to water of 76 feet in B-2 prior to the start of the test should have corresponded to a similar level in well B-1. Likely, the lack of full water level recovery shown for well B-1 on Figure 12 probably represents water level measurement error early in the test period.

The estimated long-term yield that can be obtained from well B-2 is discussed in a later section of the report. A recommended well field pumping program also is presented in that section.

Well B-3

Well B-3 is located several thousand feet northeast of the B-2/B-1 well pair. This well was drilled to a depth of 405 feet in January 2001. Basalt was penetrated in the depth range of about 3 to 296 feet. Clay was found under the basalt in the depth interval of about 296 to 330 feet. About 70 feet of shale was penetrated in the bottom of the well. Water producing zones are identified on the drillers log from the basalt in the depth ranges of 65 to 69 feet and 235 to 242 feet and from the shale in the depth range of 330 to 405 feet. The casing used in the well is described on Table 1.

A 24-hour aquifer test was conducted on well B-3 on January 11-12, 2001. Figure 13 presents the water level data while Figure 14 presents a plot of the discharge rate. The water level plot for well B-3 is very irregular because the discharge rate had to be continually adjusted downward to keep the water level above the pump. Figure 14 shows that the initial pumping rate was about 70 gpm with a gradual reduction to about 35 gpm at the end of the test. Water level data show that the water level in the well was about 6.7 feet below the original static level one day after the pump was turned off. A water level measurement taken eight days after the pump was turned off shows that the water level was about 2.2 feet higher than the static level at the start of the test. The water level in the well may have still been rising on January 11, 2001 (the start of the aquifer test) because drilling (including airlift pumping) was not completed until January 5, 2001. As is discussed later in the report, this well is not a good candidate for inclusion in a well field for the hatchery.

Well B-4

Well B-4 was drilled north of the City of Worley near the sewage lagoons (Figure 2). The well was drilled to a depth of 445 feet and penetrated layers of basalt and clay (see Appendix A for the drillers log). Basalt was penetrated in the depth intervals of 14 to 237 feet and 325 to 414 feet. The driller reported a low yield (12 gpm) with water noted only in the depth range of 237 to 321 in an interval logged as "clay and clay with wood". An aquifer test was not run in this well because of the small reported yield.

Worley City Well

The City of Worley relies on three wells for their municipal water supply. Information on these wells is given in Table 1. According to the available records, the first of the three wells was drilled in 1954 with the second in 1977 and the third in 1999. The well log for the 1999 well is included in Appendix A.

An aquifer test was run on the newest City of Worley well in September 2000. Figure 15 presents the water level data from the test while Figure 16 is a plot of the discharge rate. A step drawdown test was run on the well. The well was pumped at 200 gpm for two hours at which time the rate was increased to 250 gpm. A third rate of 300 was achieved starting four hours into the test. The total testing period was about eight hours. Water level recovery data were taken for 30 minutes after the pump was turned off. Maximum drawdown was about 19 feet with only about 1.7 feet of residual drawdown after 30 minutes of recovery. There is no doubt that this is an excellent well.

The City of Worley was contacted in an effort to obtain historic well discharge and water level data. Apparently no water level data are available for any of the city wells. The limited pump discharge data that was found are presented in Figure 17. Average well discharge, in gallons per day, were calculated from roughly monthly readings of well discharge totalizing meters. The new city well (West Park) was the dominant source of water for the city after it was put on line in 2000.

WATER QUALITY

Water quality data are available from the test wells and the newest City of Worley well. Table 2 presents the results of analyses of well water analyzed at the Spokane Tribal Laboratories for wells S-1, A-1, A-2, B-2 and B-3. Anatek Labs results for the City of Worley well drilled in 1999 also are included. Some important constituents were not included in most of the analyses. These include calcium on the cation side and bicarbonate/carbonate on the anion site. The total dissolved solids reported for the samples are low. The water likely is a calcium-bicarbonate type.

ANALYSIS OF WELL FIELD PRODUCTIVITY

The target yield of 60-gpm continuous flow probably cannot be maintained from any single one of the test wells constructed to date. However, there is a good chance that the desired yield can be obtained by operation of three or four of the wells as a well field. The most likely well field operation would include sequential operation of the wells with rest periods equal to or exceeding the pumping times. The two dominant questions are as follows. First, what is the reasonably expected yield of each well? Second, what on/off pumping cycle will be required for each well to operate over a long time period as part of the well field? These questions are addressed in the following paragraphs.

The amount of water that can be pumped from an individual well is dependent on the following factors: 1) the transmissive characteristics of the aquifer, 2) the hydraulic efficiency of the well and 3) the available drawdown (distance between the static water level and the pump setting). Specific capacity is the discharge of the well divided by drawdown and is a measure of the first two of these factors. A highly efficient well that penetrates a high transmissivity aquifer will have a high specific capacity value in gallons per minute per foot of drawdown. The efficiency of an uncased well is high. Within cased wells, the entrance velocity of the water moving through the perforations dominantly impacts the efficiency of the well. An entrance velocity greater than about one foot per second leads to low efficiency wells.

The specific capacity characteristics of the test wells and the newest City of Worley well are presented on Figure 18 for the first two days of pumping. The plot shows that the City of Worley well has a much higher specific capacity than any of the test wells. Wells A-1 and S-1 have specific capacity values in the range of three to four gpm/ft while wells A-2 and B-2 have specific capacity values near one gpm/ft. Well B-3 is the least productive of the test wells that were pumped.

Long-term operation of the test wells in a well field depends on the size and location of boundaries on the aquifer(s) penetrated and on the annual recharge to those aquifers. The size of an aquifer can be deduced by examination of the hydrogeologic setting. For example, well S-1 probably penetrates the aquifer with the most limited areal extent. The deeper aquifer penetrated by well A-1 also probably is of limited areal extent. The second way to assess the long-term productivity of a specific well is by examination of long-term water level recovery patterns. Figure 19 presents a plot of residual drawdown (the difference between the recovering water level and the original static level) versus the ratio of the time since the pump was turned on divided by the time since the pump was turned off (t/t'). The time ratio values are presented on a logarithmic scale.

Several interesting concepts can be derived from an analysis of Figure 19. First, the extrapolation of the data plots to a residual drawdown value of zero (complete recovery) gives a measure of the long-term productivity of the penetrated aquifer. Water levels in a highly productive, large-scale aquifer should nearly fully recover in a time period equal to the pumping period (t/t'=2). Only the Worley City well and test well B-2 have this characteristic. Second, the amount of residual drawdown as the lines are extrapolated to a t/t' value of about two gives a measure of the long-term water level decline that might be expected with operation of the well as part of a well field. The length of the aquifer test represented by the field data also is a consideration. For example, well B-3 was pumped for only one day yet has about five feet of residual drawdown at t/t' = 2. This would be a very poor long-term water supply source. On the other extreme, well B-2 has nearly full recovery at t/t'=2 yet was pumped for 21 days. This well would be a reliable component of a hatchery well field. Wells S-1 and A-2 have similar residual drawdown values at t/t'=2 but well S-1 was pumped for 16 days while well A-2 was only pumped for one day.

Analysis of the discharge and water level data collected to date indicates that well B-2 has the best long-term yield characteristics. Wells S-1 and A-2 appear suitable for inclusion in a well field design although there are questions relative to long-term yield characteristics of these wells. Well A-1 has better specific capacity characteristics than wells A-2 and B-2 but the excessive residual drawdown causes concern with respect to long-term well yields. The short and long-term yield characteristics of well B-3 are poor; this well should be removed from any further consideration in the well field.

All of the test wells were measured on January 30, 2001. A comparison of these data to previous measurements can provide insight with respect to long-term well productivity. This comparison of depth to water values is shown below.

Well	First measurement		Last measurement	
S-1	9/7/99	32.65 ft	1/30/01	32.34 ft
A-1	2/28/00	132.70 ft	1/30/01	133.81 ft
A-2	9/26/00	69.05 ft	1/30/01	64.71 ft
B-2	12/15/00	76.00 ft	1/30/01	76.00 ft
B-3	1/11/01	32.02 ft	1/30/01	32.34 ft

All of the measurements of depth to water are within about one foot of the first measurement except for well A-2. The January 2001 measurement is five feet above the static level taken just before the aquifer test in September 2000. The reasons for this water level difference are unknown. The fact that the January 2001 measurements in all wells are near or above the original supports the idea that the tested aquifers in the Worley area do receive some annual recharge.

Long-term measurement of water levels in all of the wells is a useful way to further document the productivity of the aquifers in the area. Water level measurement on at least a monthly frequency is needed. Hydrographs based on these data may show responses to snowmelt or precipitation events and thus provide an additional level of understanding of recharge amount and locations.

CONCLUSIONS AND RECOMMENDATIONS

The ground water systems in the area in and southeast of Worley are very complex. The ground water complexity rises from the complex nature hydrogeologic framework of basalt, sediments and basement rocks. The primary concern with respect to water supply for the hatchery is long-term yield of the wells. The short-term yield characteristics have been documented as part of the aquifer-testing program.

The potential is good that operation of a well field using wells B-2, S-1 and A-2 will yield the desired continuous pumping rate of 60 gpm. The available aquifer test data indicate that well B-2 has the best combination of suitable yield rate and nearly full water level recovery after testing. This well probably can be operated perhaps fifty percent of the time to supply the target yield. The remainder of the time the desired yield can be achieved by alternate operation of wells S-1 and A-2. Possible lack of full water level recovery is a problem in both of these wells. In particular, our understanding of the long-term yield characteristics of well A-2 is limited because only a one-day aquifer test was conducted. Well A-1 can contribute to the hatchery program but probably cannot be pumped at a rate of 60 gpm for any more than one or two months per year because of the slow water level recovery rate of this aquifer. Well B-3 does not have the yield characteristic to be included in the well field design.

Additional data collection efforts would greatly improve our understanding of the ground water systems and the long-term reliability of a well field. These efforts are listed below.

- <u>At least monthly water level data collection in all wells</u> -- The seasonal and annual water level fluctuations would provide important information relative to aquifer recharge characteristics.
- <u>Continuous water level data collection in well B-2</u> -- A data logger installed and operated in well B-2 would provide information relative to possible hydraulic connection with the City of Worley wells.
- <u>Long-term aquifer test of well A-2</u> -- A 15 to 25 day aquifer test is needed on well A-2 in order to assess the long-term productivity of this well.
- <u>Water quality sampling and analysis</u> -- A more complete analysis of water quality within the target wells is needed. The analysis should include all common ions (such as bicarbonate and carbonate) in addition to specific constituents of importance to hatchery operation.

Table 1 Test Well and Worley City Well Information

Well ID	Location	Well Elev. (feet)	Well Depth (feet)	Depth to Water (feet)	Water Elev. (feet)	Rep. Yield (gpm)	Tested Yield (gpm)	First string of casing Depth (feet)	First string of casing Diameter (inches)	Second string of casing Depth (feet)	Second string of casing Diameter (inches)	Perforated Interval (feet)	Aquifer Description
S-1	47/4 31 NW NE	2745	160	25	2720	100	60	0 to 58	6" steel	0 to 157	4" PVC	117 to 157	basalt
A-1	47/4 30 NE NE	2740	433	145	2595	50	60	0 to 65	8" steel	0 to 433	4" PVC	398 to 433	basalt
A-2	47/4 19 NE SE	2677	383	69	2608	150	70	0 to 18	8" steel			open 18 to 383	shale
B-1	47/5 24 NW SW	2660	344	69	2591	50		0 to 87	8" steel			open 87 to 344	basalt
B-2	47/5 24 NW SW	2660	240	76	2584	100	70	0 to 60	8" steel	18 to 242	4" PVC	200 to 240	basalt
B-3	47/5 24 NE SW	2640	405	32	2608	45	35	0 to 20	8" steel			open 20 to 405	basalt/shale
B-4	47/5 23 NE NE	2622	445	100	2522	12		0 to 18	8" steel	0 to 442	4" PVC	open 442 to 445	clay
W-1954	47/5 23 NE SE		508	345				0 to 400	8" steel				
W-1977	47/5 23 NE SE		204			350		0 to 38	8" steel	0 to 152	6" steel	open 152 to 204	basalt
W-1999	47/5 23 NE SE	2655	242	90	2565	300	300	0 to 242	8" steel			220 to 242	basalt

Notes:
1 Well elevations are estimated from USGS topographic maps
2 Depth to water values for test wells S-1, A-1, A-2, B-1, B-2 and B-3 are from aquifer test data
3 Well B-2 was drilled originally in 1976 to a depth of 305 feet and recompleted in 1999 to 240 feet
4 Tested yields are after about 24 hours of pumping
5 Well depths, casing information, reported yields and aquifer descriptions are from driller logs
6 The three City of Worley wells are listed by the reported date of drilling
7 Depth to water measurements for test well B-4 and the three City of Worley wells are from the drillers logs

Table 2 Water Quality Data From Test Wells

Well		S-1	A-1	A-2	B-2	B-3	B-3	Worley
Sampling date		5/17/00	4/28/00	10/5/00	1/4/01	1/11/01	1/12/01	9/16/99
Laboratory		----------------Spokane Tribal Laboratories					------------------	Anatek
Total dissolved solids	mg/l	110	130		120	180	210	94
Total suspended solids	mg/l	<2	<2	4	<2	264	8	
Turbidity	NTU	0.5	1.1	4.6	2.0	220.0	73.1	1.7
Hardness (as CaCO3)	mg/l							102
pH								7.85
Conductivity	uS/cm							270
Chloride	mg/l	0.89	0.76	1.75	0.94	2.21	1.51	1.90
Fluoride	mg/l	0.38	0.26	0.42	0.16	0.33	0.49	0.38
Nitrate as N	mg/l	0.01	0.07	0.03	0.00	0.33	0.49	<.5
Nitrite as N	mg/l	<.005	<.005	<.005	<.005	<.005	<.005	
Total phosphorous	mg/l		0.04	0.04	0.04	0.04	0.03	
Ortho-phosphorous as P	mg/l	<.005	0.02	0.02	0.04	0.03	0.04	
Sulfate	mg/l	1.67	2.86	14.90	2.97	6.25	5.84	4.91
Ammonia as N	mg/l							<.1
TKN	mg/l			<.030	0.040	0.159	0.072	
Total alkalinity as CaCO3	mg/l	102.0	106.0	144.0	97.6	120.0	115.0	110.0
Bicarbonate as CaCO3	mg/l							
Carbonate as CaCO3	mg/l							
Aluminum	mg/l	<.010	<.010	<.010	<.010	<.010	<.010	<.001
Antimony	mg/l							<.001
Arsenic	mg/l	<.020	<.020	<.020	<.020	<.020	<.020	<.005
Barium	mg/l	0.03	0.04	0.06	0.03	0.03	0.03	0.05
Beryllium	mg/l	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Cadmium	mg/l	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.001
Calcium	mg/l							20.8
Chromium	mg/l	<.002	<.002	<.002	<.002	<.002	<.002	<.005
Cobalt	mg/l							
Copper	mg/l	<.002	<.002	<.002	<.002	<.002	<.002	0.002
Iron	mg/l	0.09	0.44	0.04	0.35	<.002	0.00	0.59
Lead	mg/l	<.001	<.001	<.001	<.001	0.005	0.002	<.001
Magnesium	mg/l	8.71	8.98	15.20	8.11	10.50	10.40	11.40
Manganese	mg/l	0.03	0.04	0.05	0.04	0.04	0.04	0.03
Mercury	mg/l		<.0002					<.001
Nickel	mg/l	<.005	<.005	<.005	<.005	<.005	<.005	<.001
Potassium	mg/l	3.21	3.24	2.61	3.55	2.15	1.98	3.00
Selenium	mg/l			<.002	<.002	<.002	<.002	<.005
Silicon	mg/l							
Silver	mg/l	<.002	<.002	<.002	<.002	<.002	<.002	<.01
Sodium	mg/l	9.73	9.35	14.20	8.74	13.20	12.40	10.90
Thallium	mg/l							<.001
Zinc	mg/l			0.09	0.01	<.002	<.002	0.03

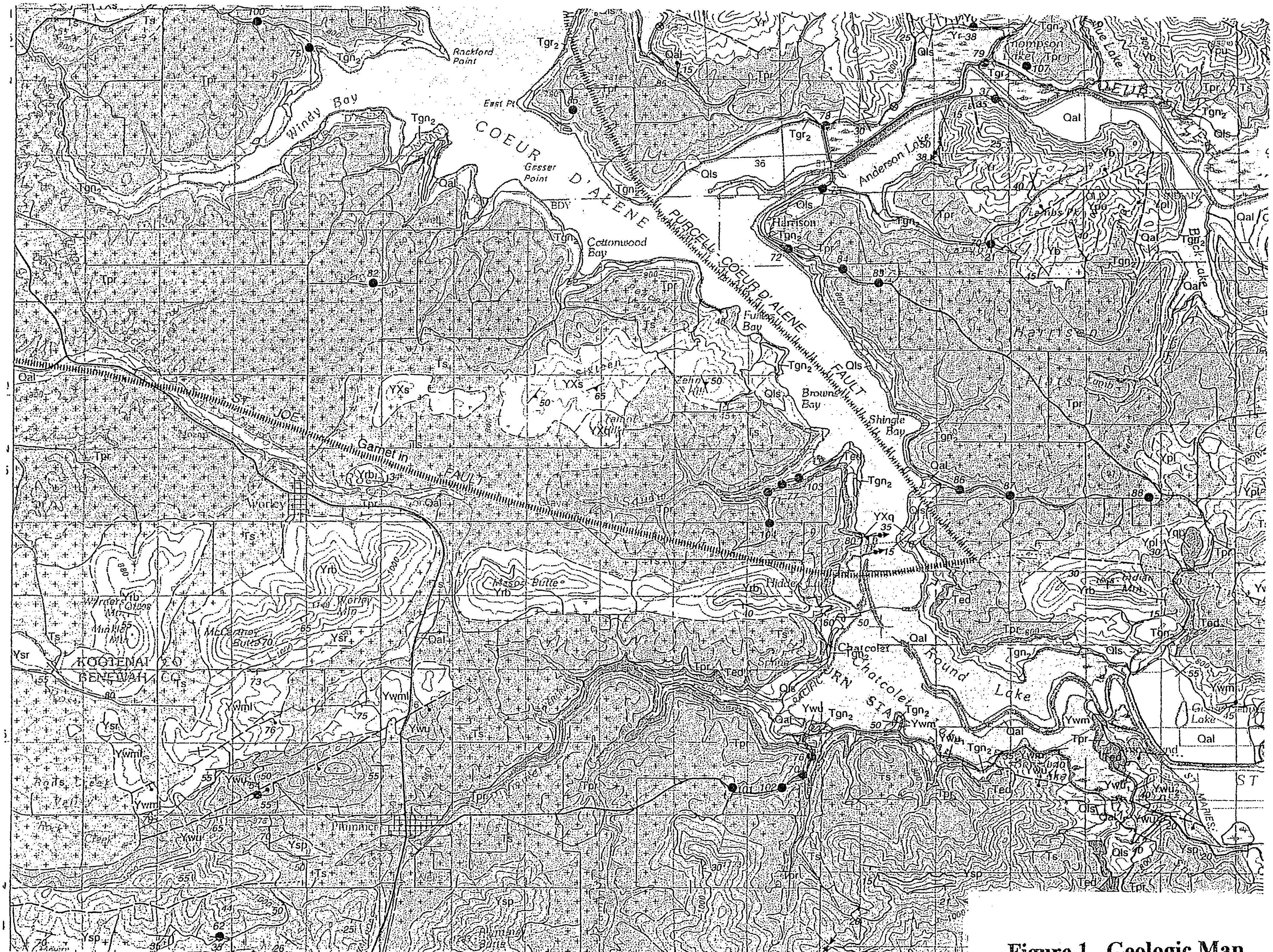


Figure 1 Geologic Map

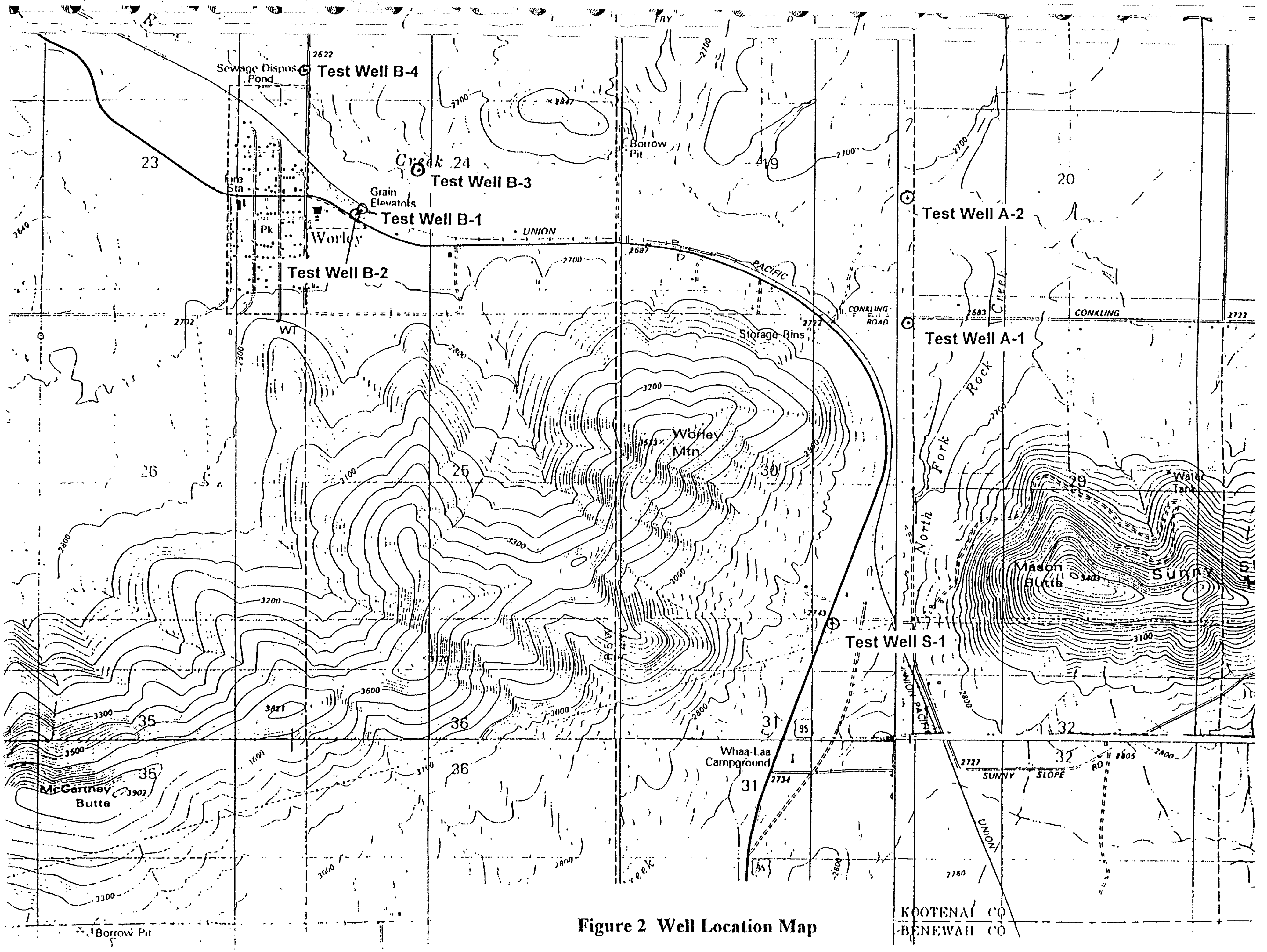


Figure 2 Well Location Map

Figure 3 Well S-1 Depth to Water Plot (9/7 to 9/23/99 Aquifer Test)

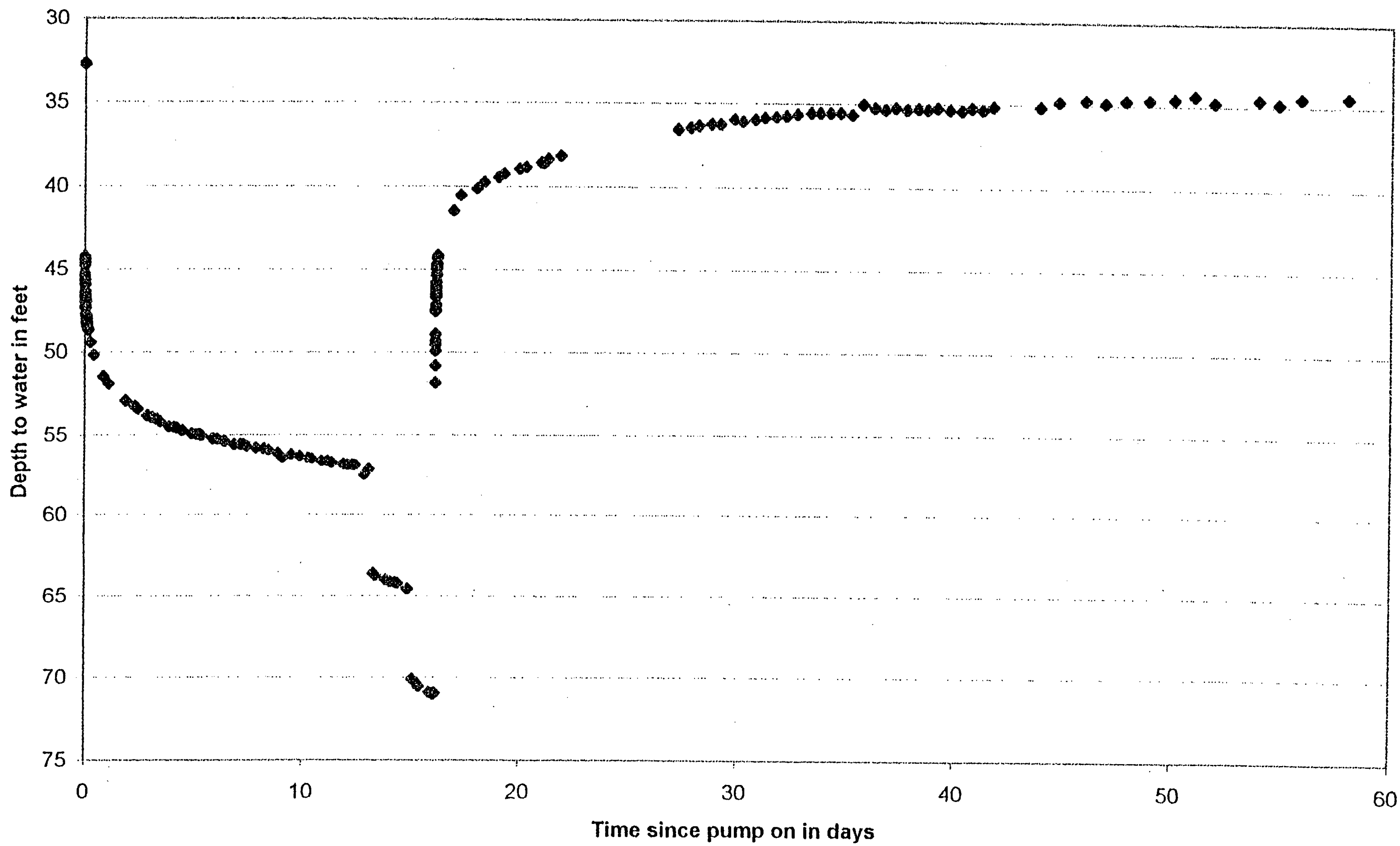


Figure 4 Well S-1 Discharge Plot (9/7 to 9/23/99 Aquifer Test)

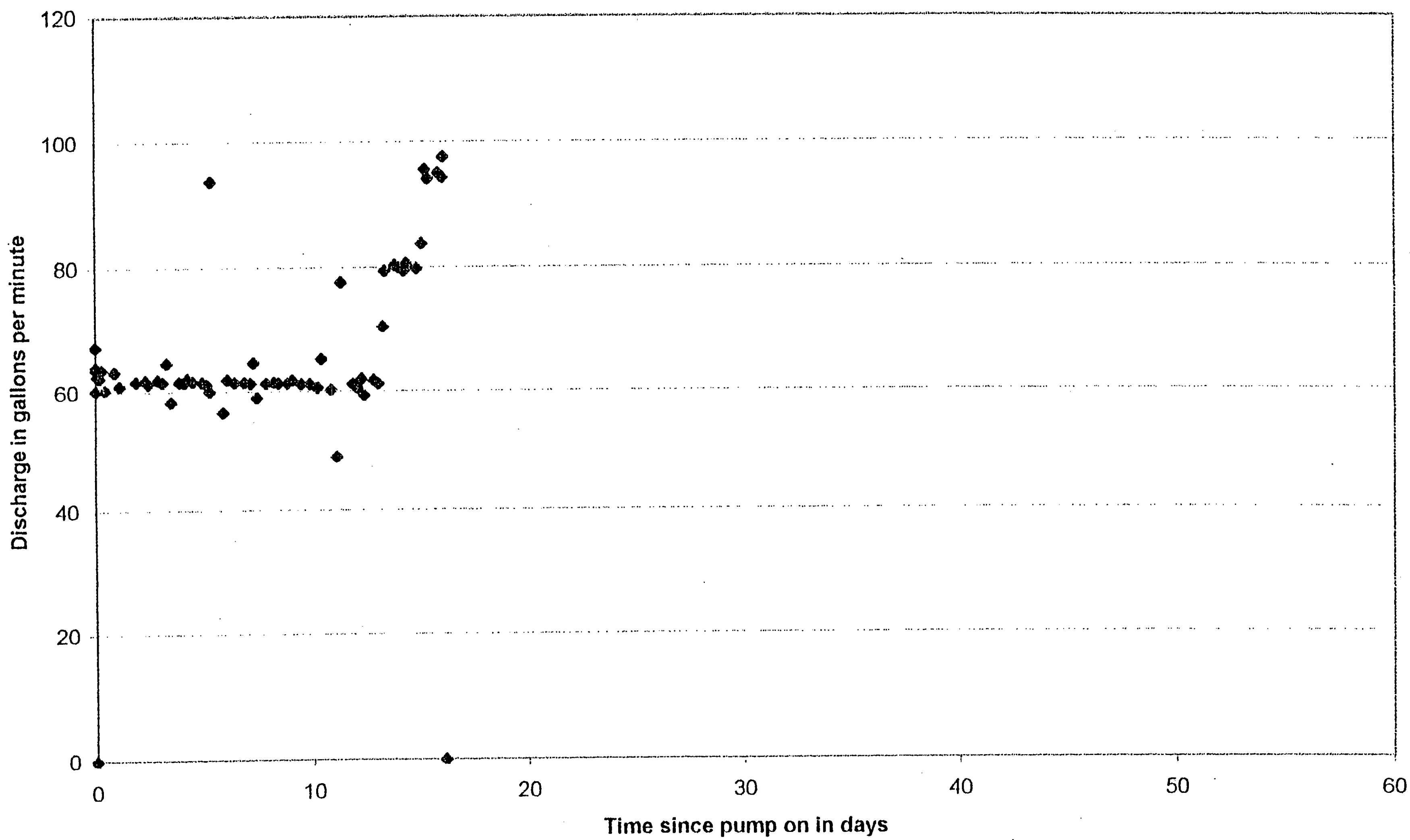


Figure 5 Observation Well Depth to Water Plot From S-1 Aquifer Test

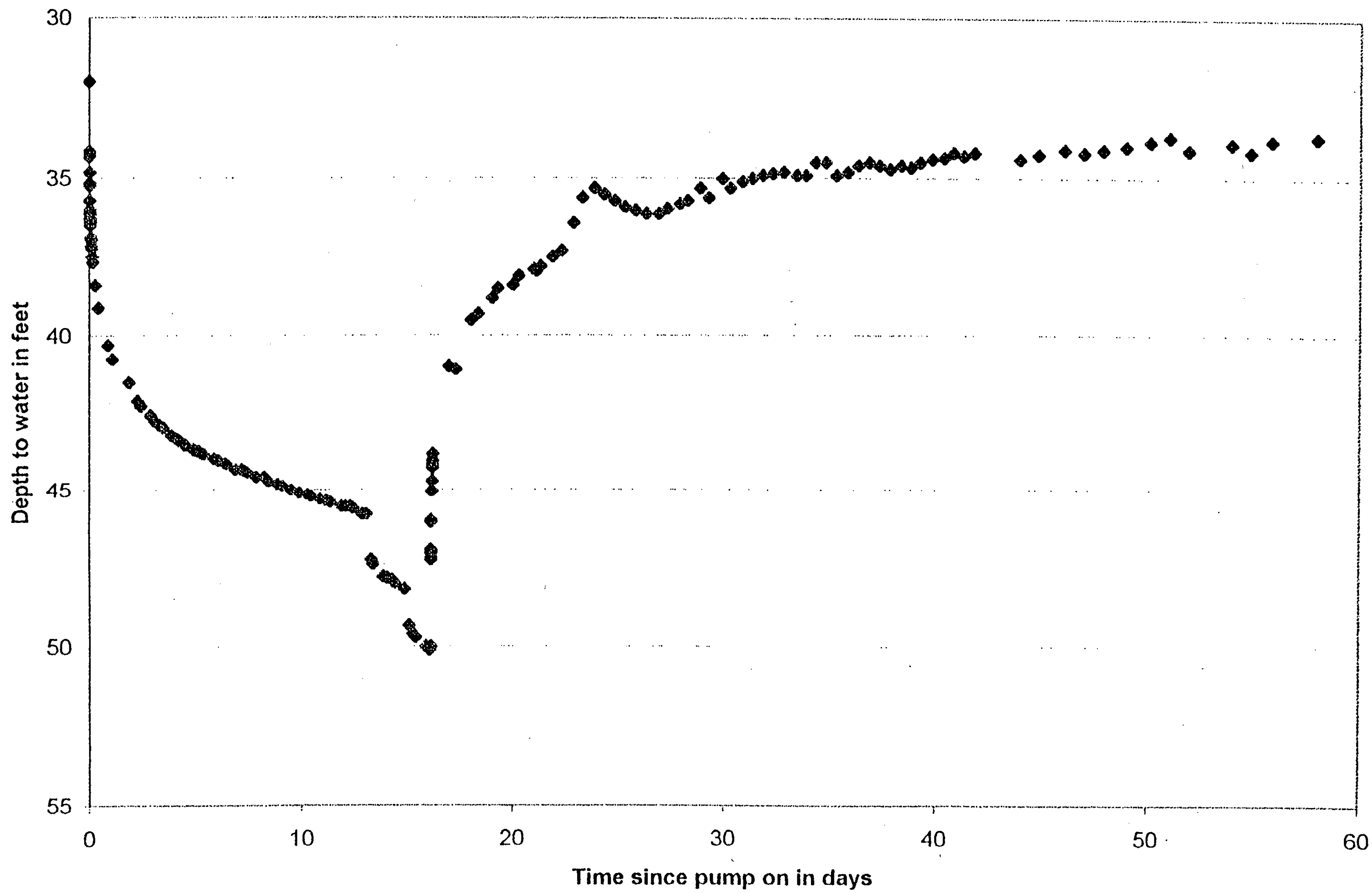


Figure 6 Well A-1 Depth to Water Plot (4/28 to 5/18/00 Aquifer Test)

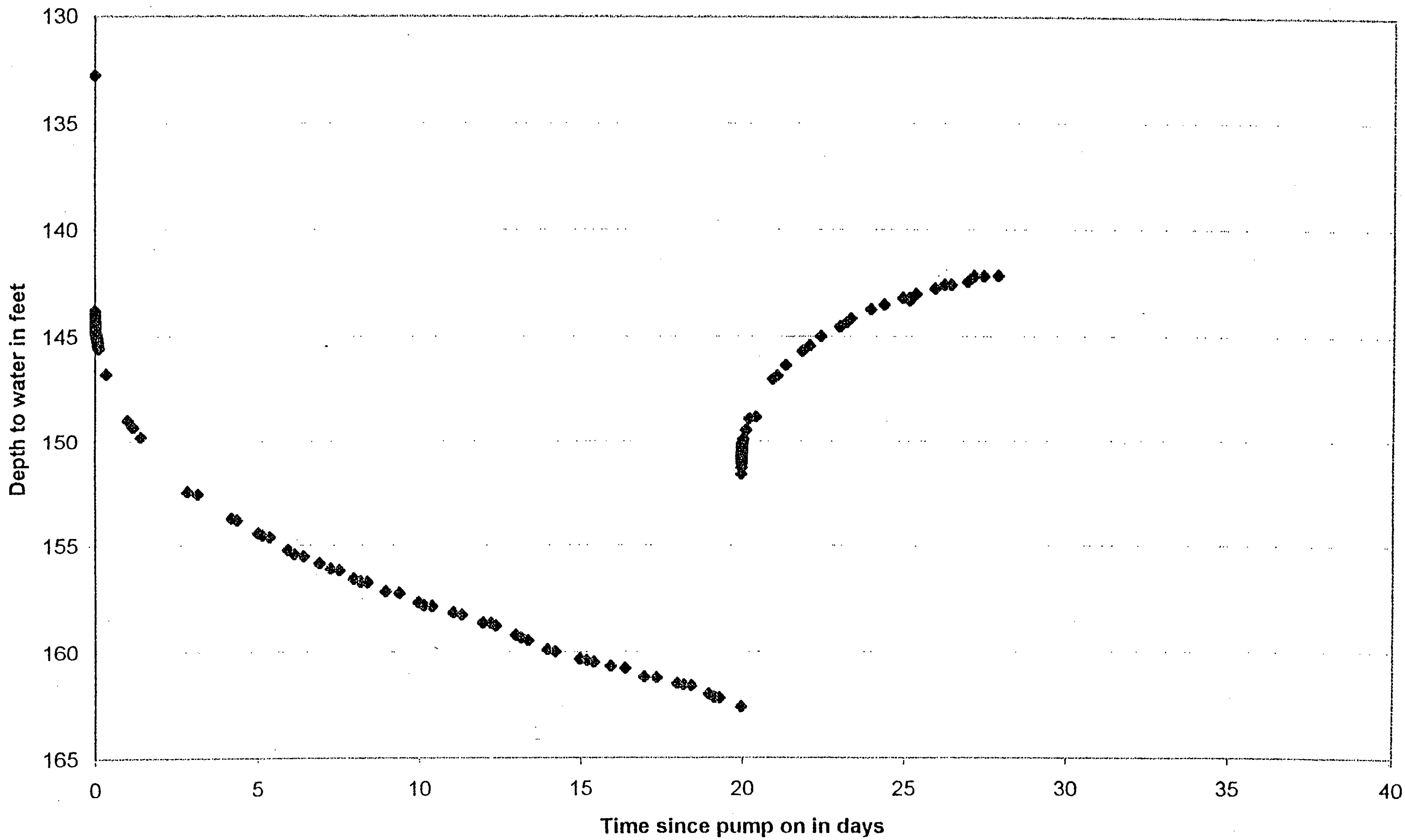


Figure 7 Well A-1 Discharge Plot (4/28 to 5/18/00 Aquifer Test)

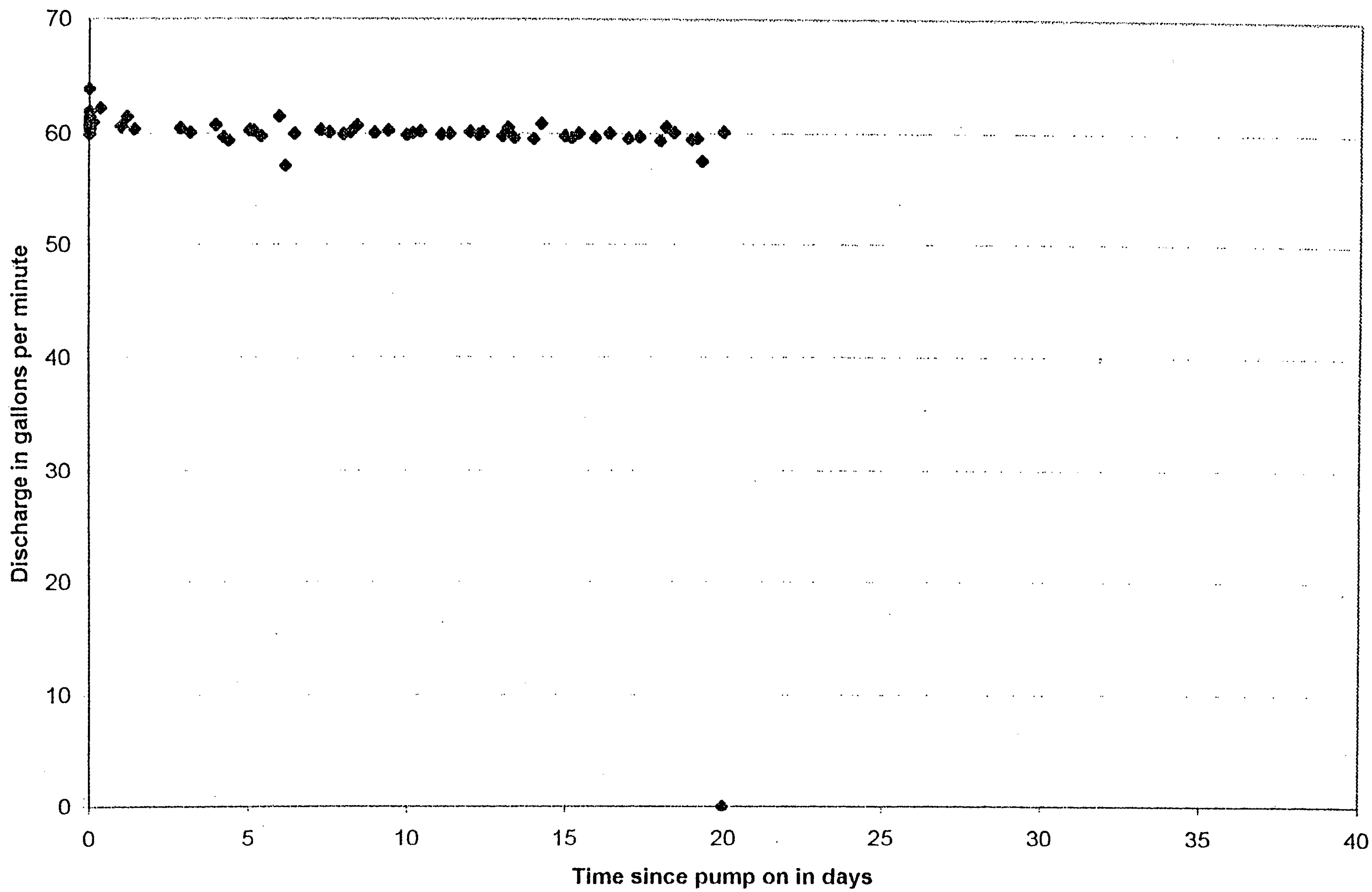


Figure 8 Well A-2 Depth to Water Plot (9/26 to 9/28/00 Aquifer Test)

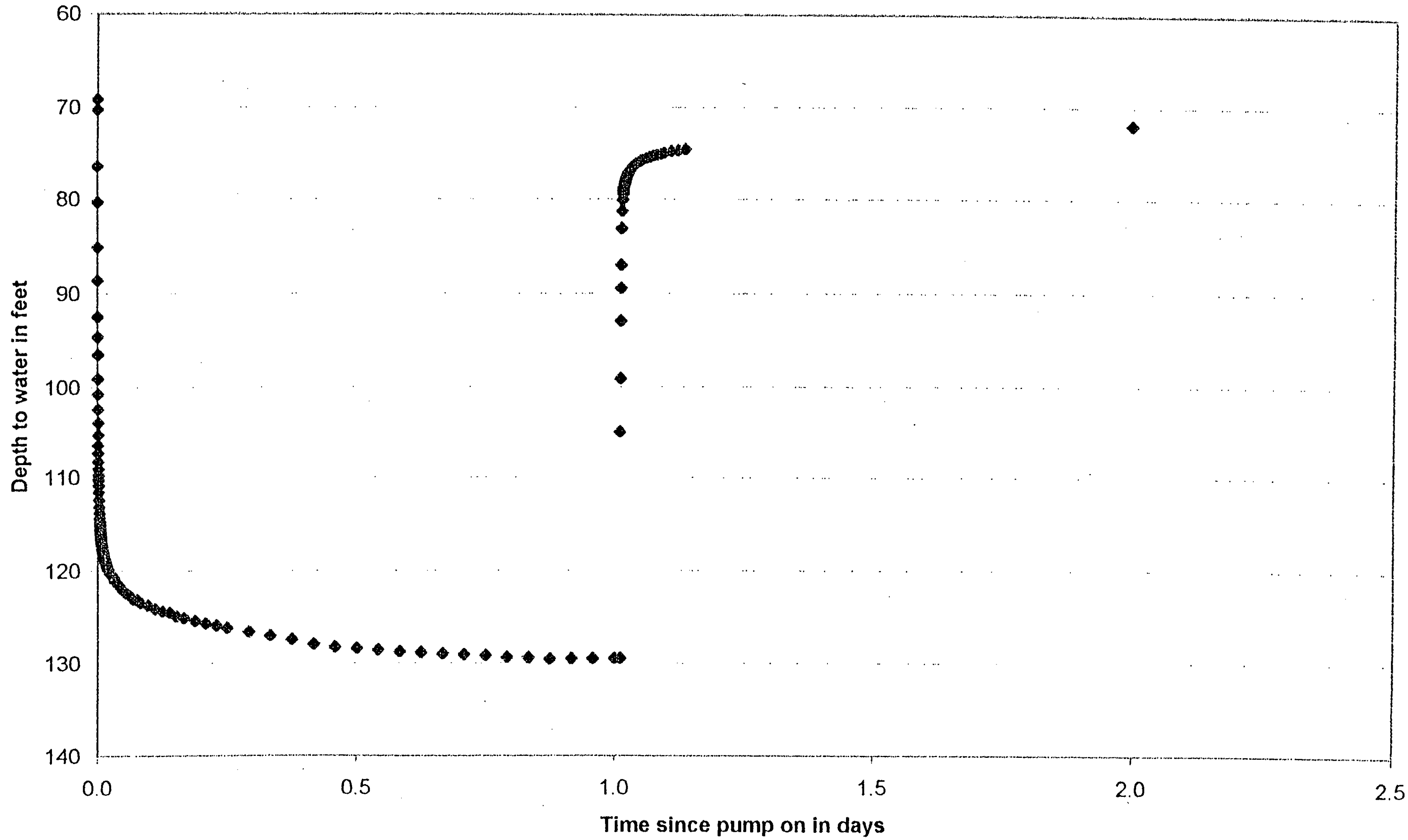


Figure 9 Well A-2 Discharge Plot (9/26 to 9/28/00 Aquifer Test)

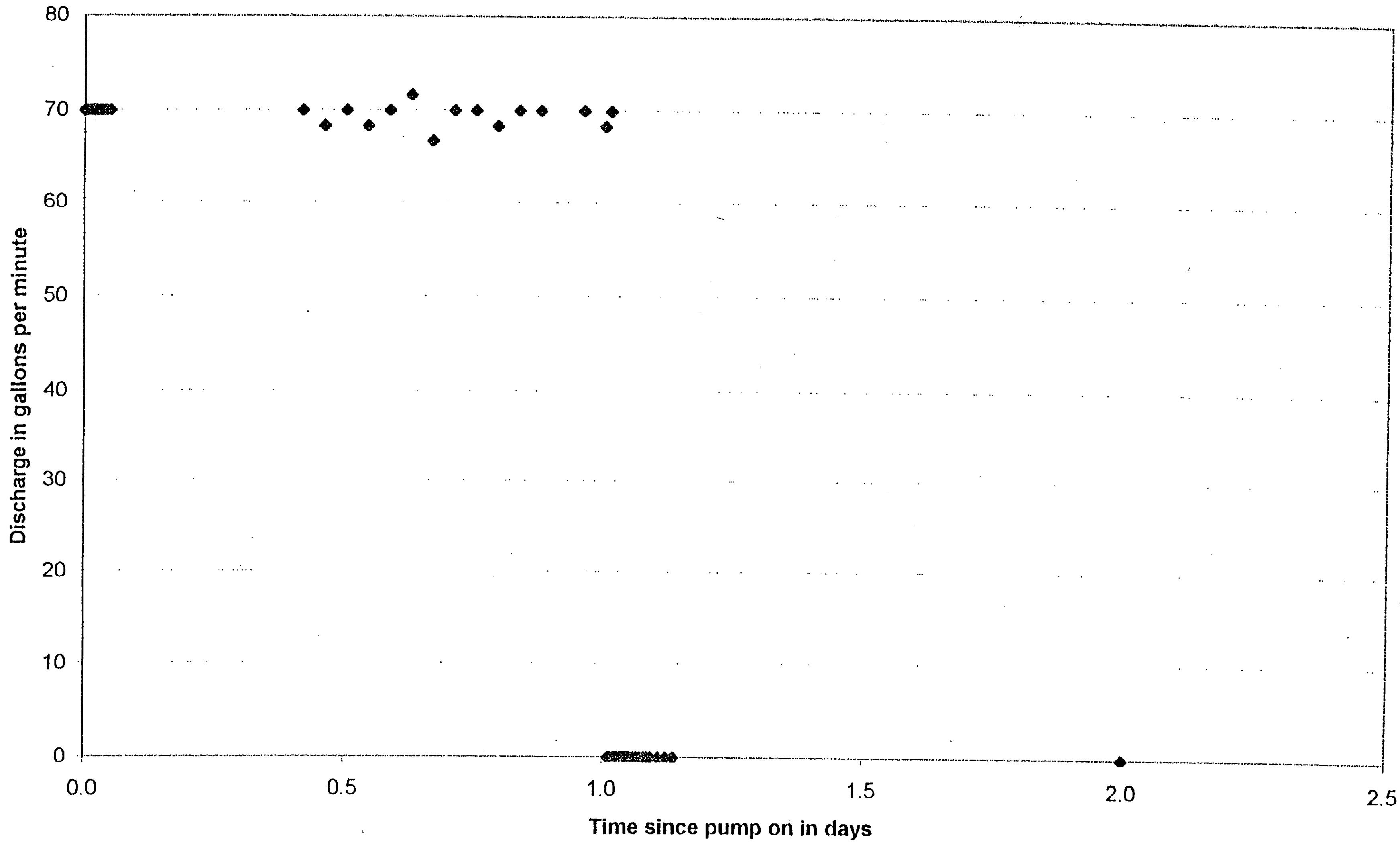


Figure 10 Well B-2 Depth to Water Plot (12/15/00 to 1/5/01 Aquifer Test)

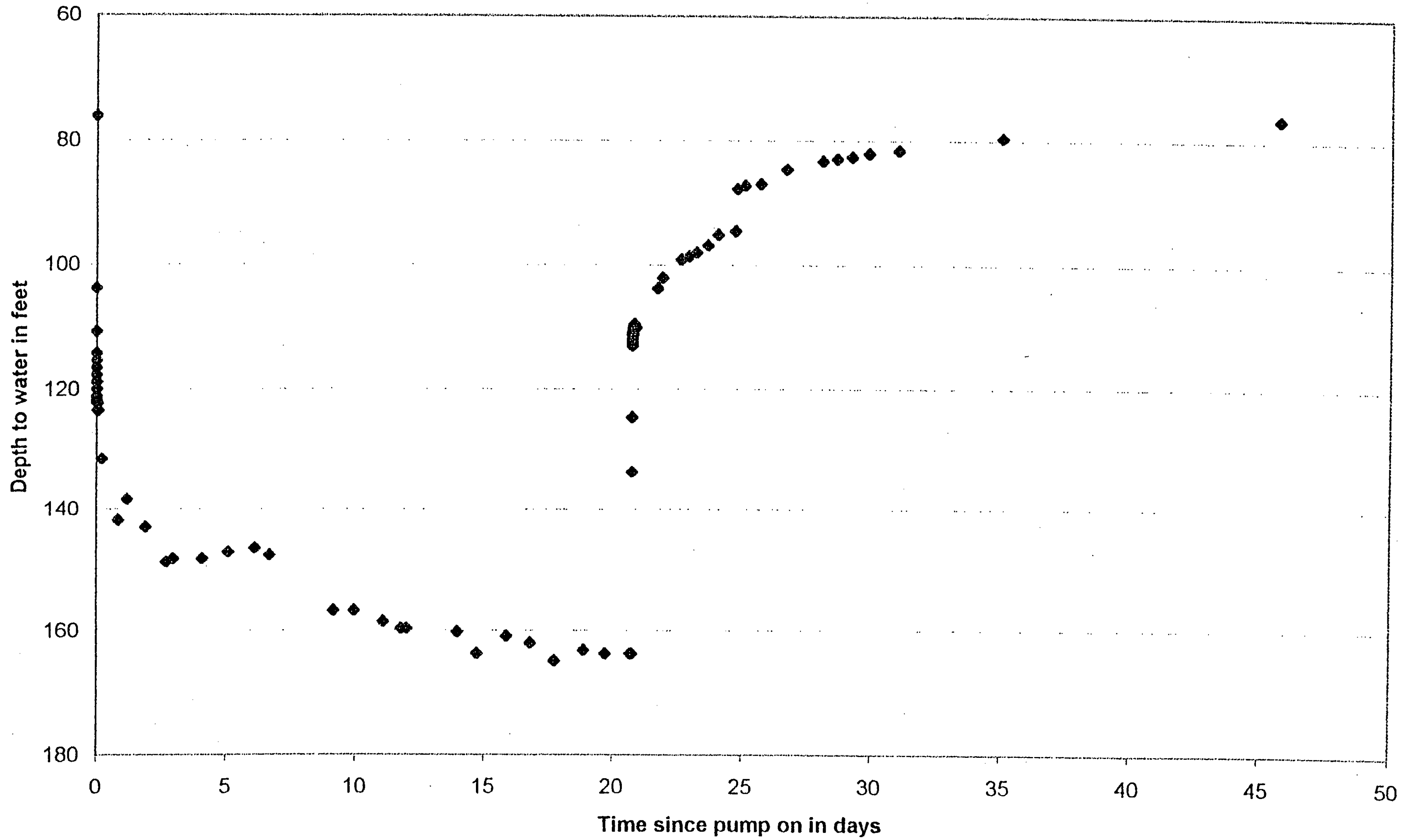


Figure 11 Well B-2 Discharge Plot (12/15/00 to 1/5/01 Aquifer Test)

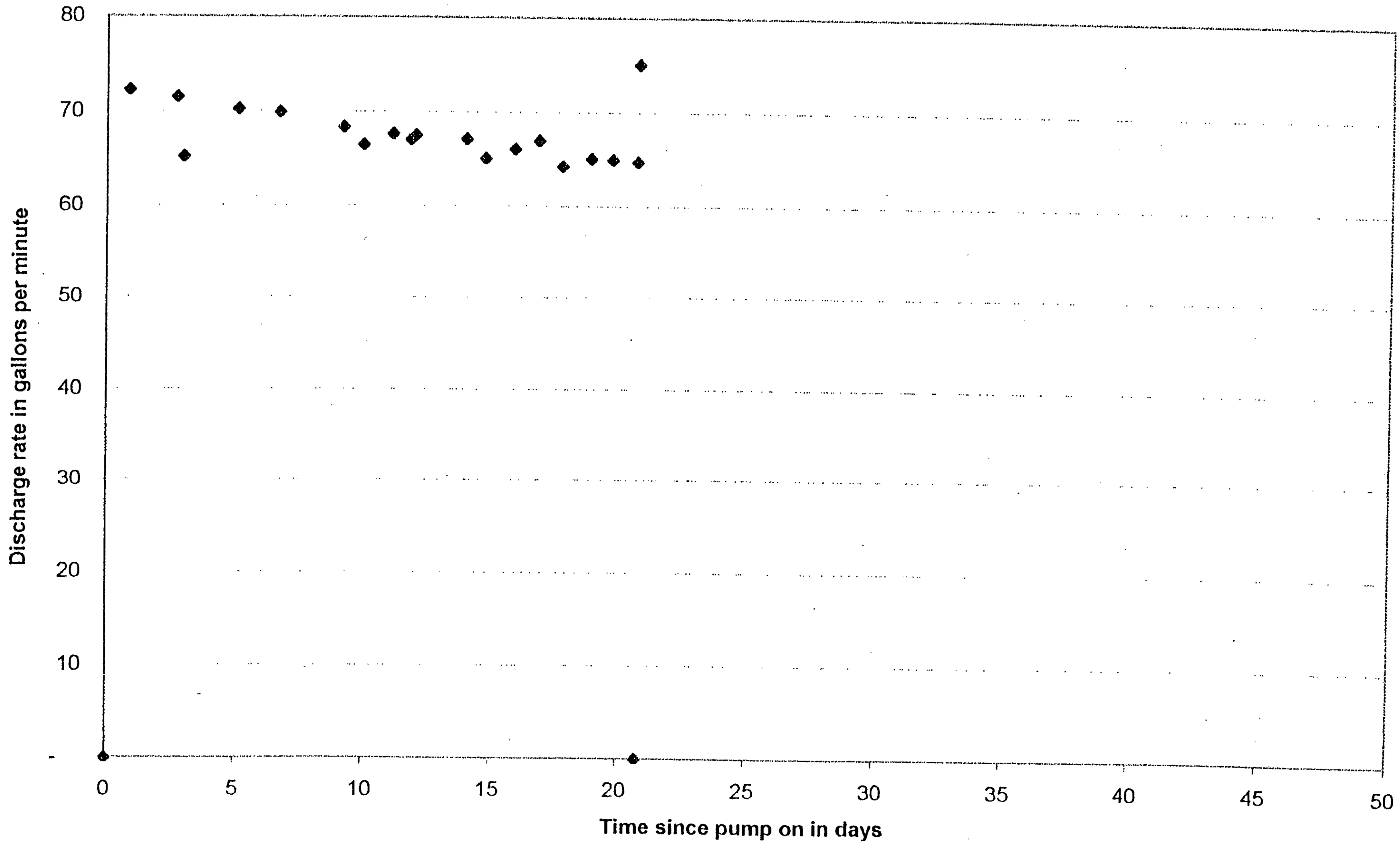


Figure 12 Well B-1 Depth to Water Plot From B-2 Aquifer Test

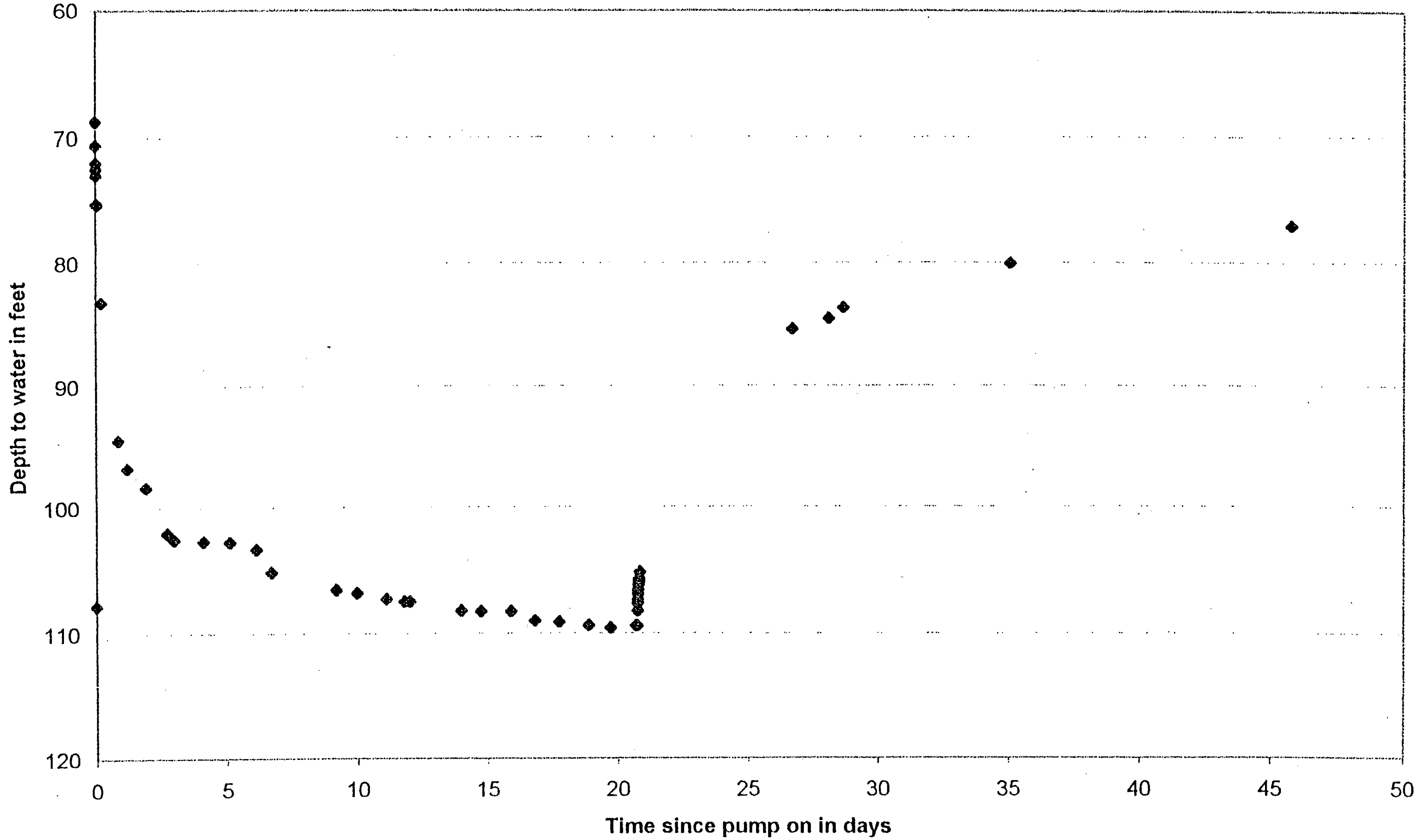


Figure 13 Well B-3 Depth to Water Plot (1/11 to 1/12/01 Aquifer Test)

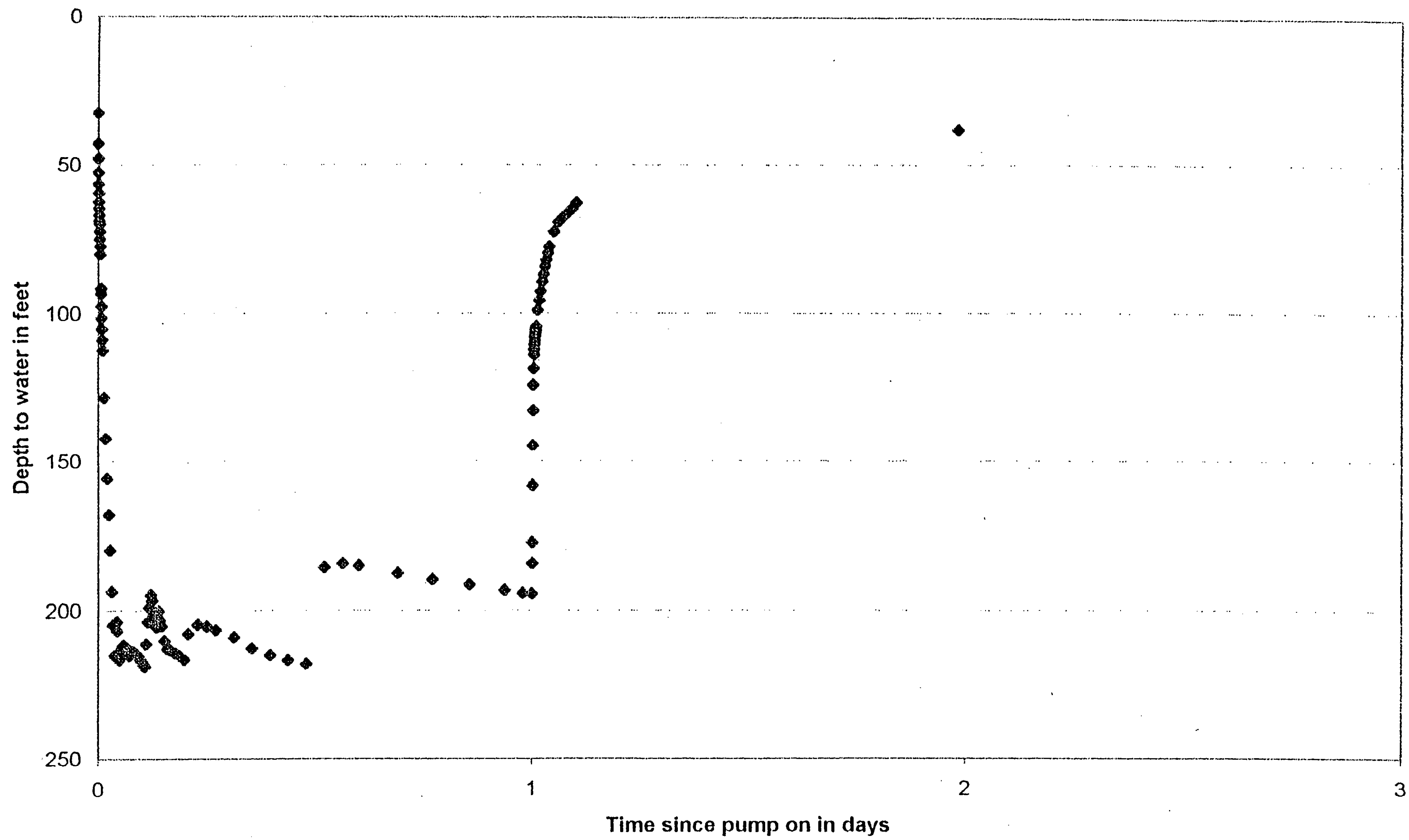


Figure 14 Well B-3 Discharge Plot (1/11 to 1/12/01 Aquifer Test)

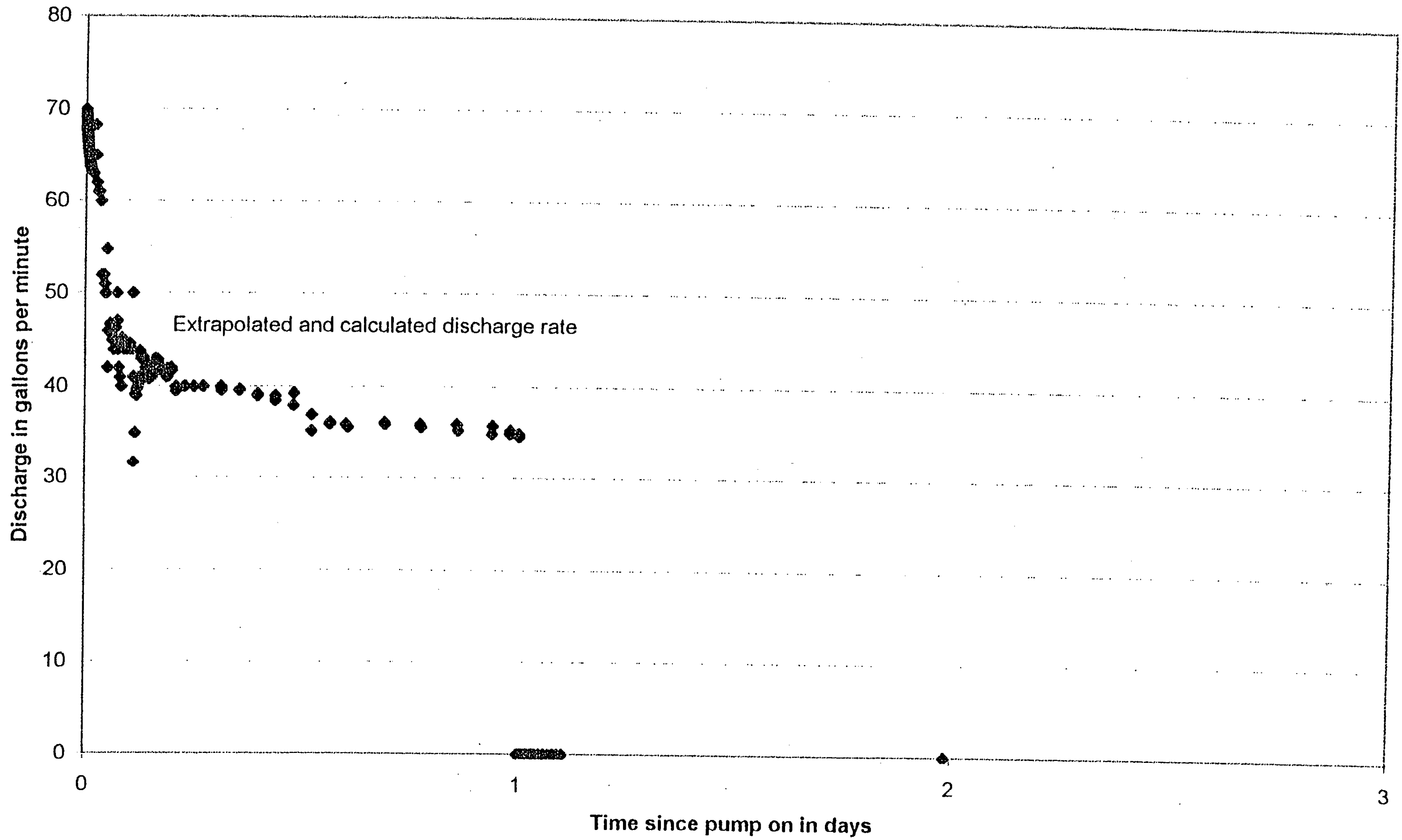


Figure 15 Worley West Park Well Depth to Water Plot (9/26/00 Aquifer Test)

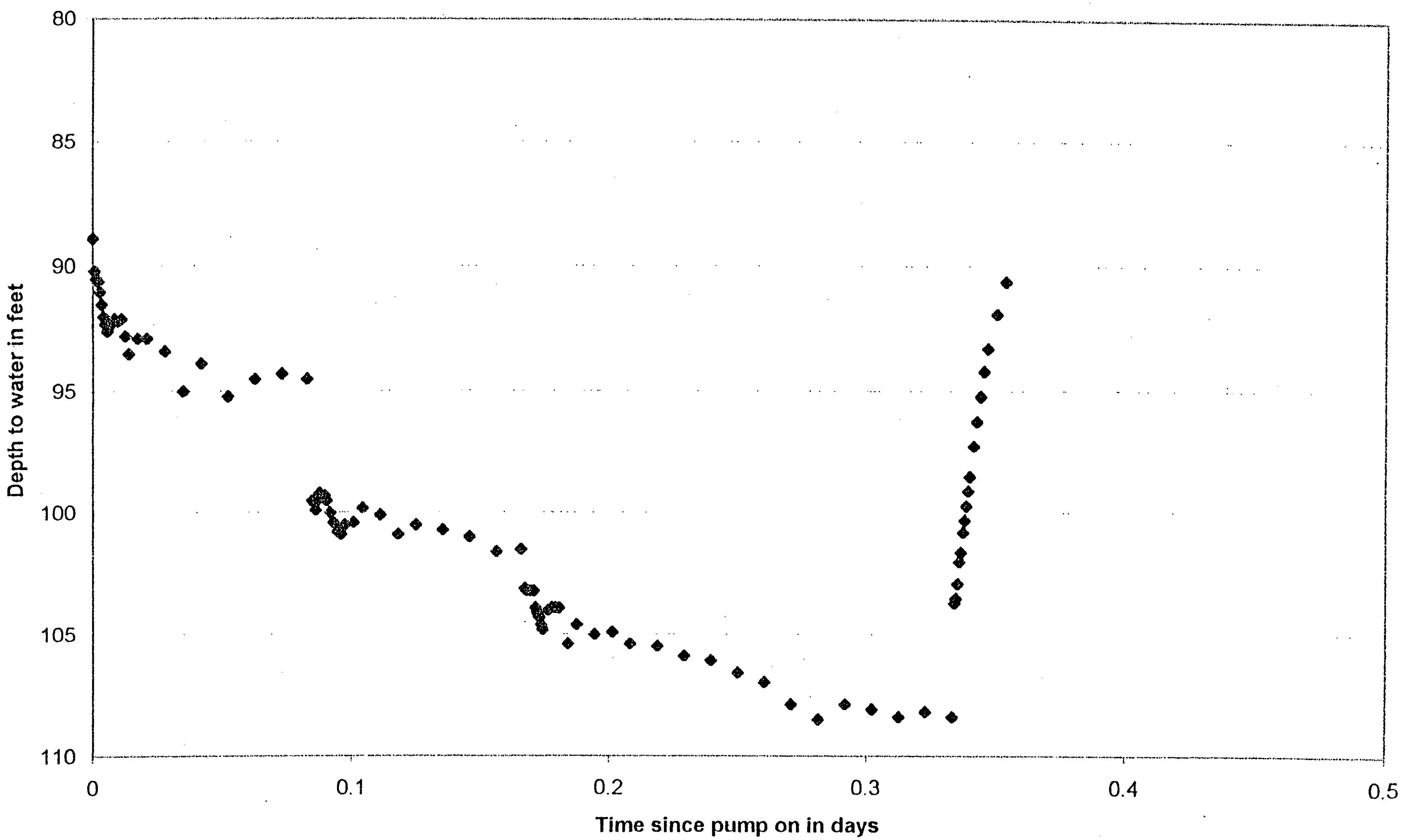


Figure 16 Worley West Park Well Discharge Plot (9/26/00 Aquifer Test)

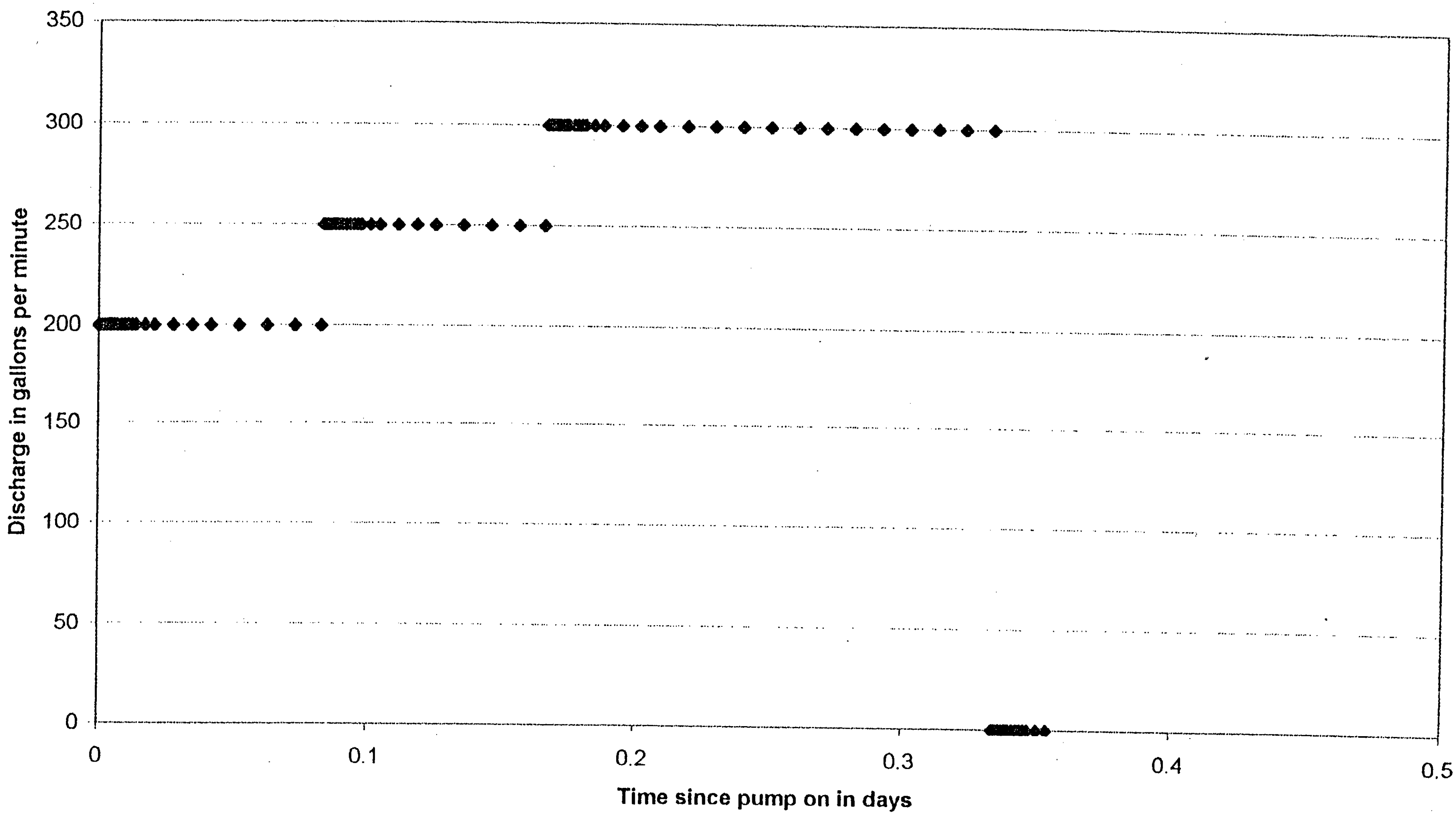


Figure 17 City of Worley Well Pumpage Plot

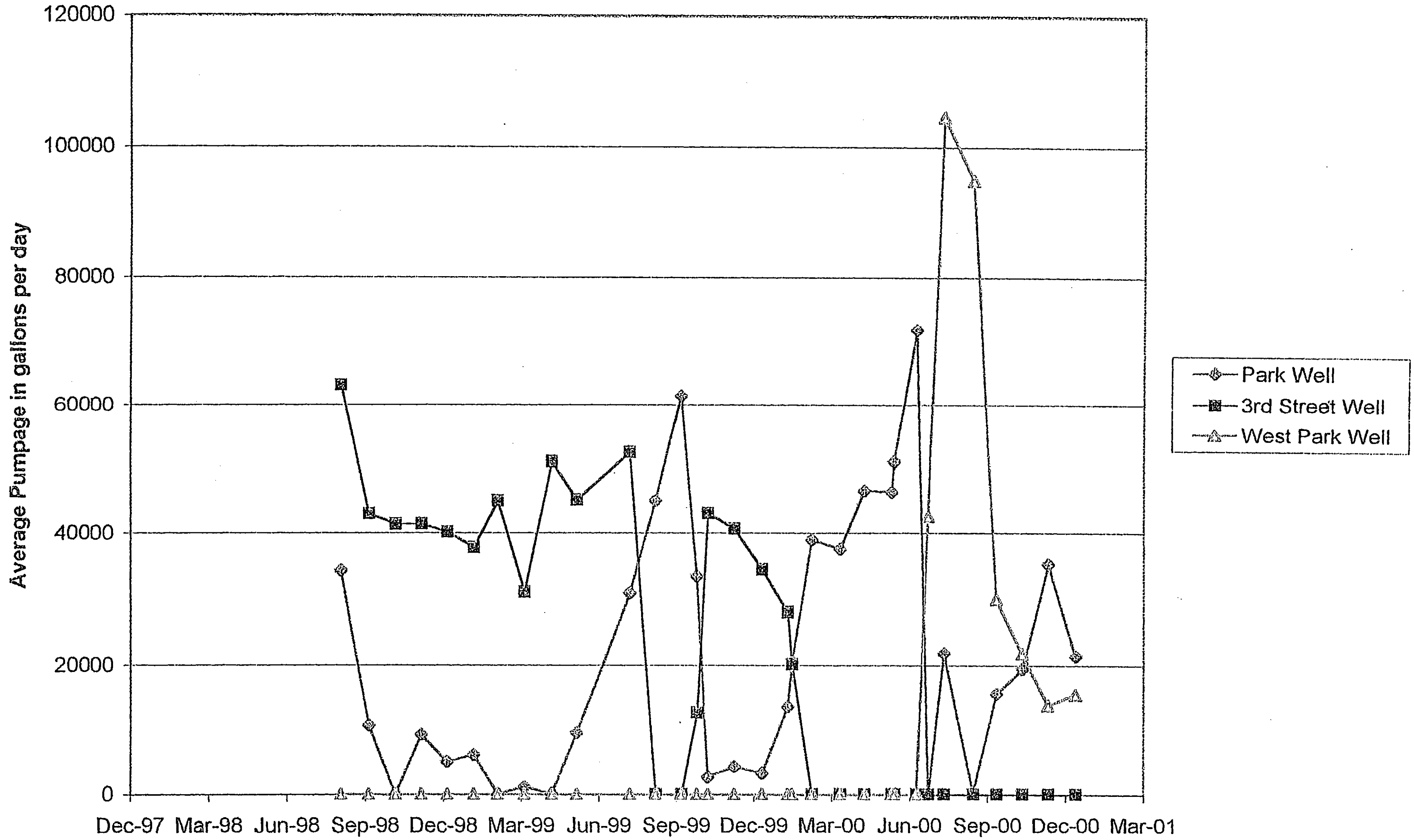


Figure 18 Specific Capacity Data For Two Days of Pumping

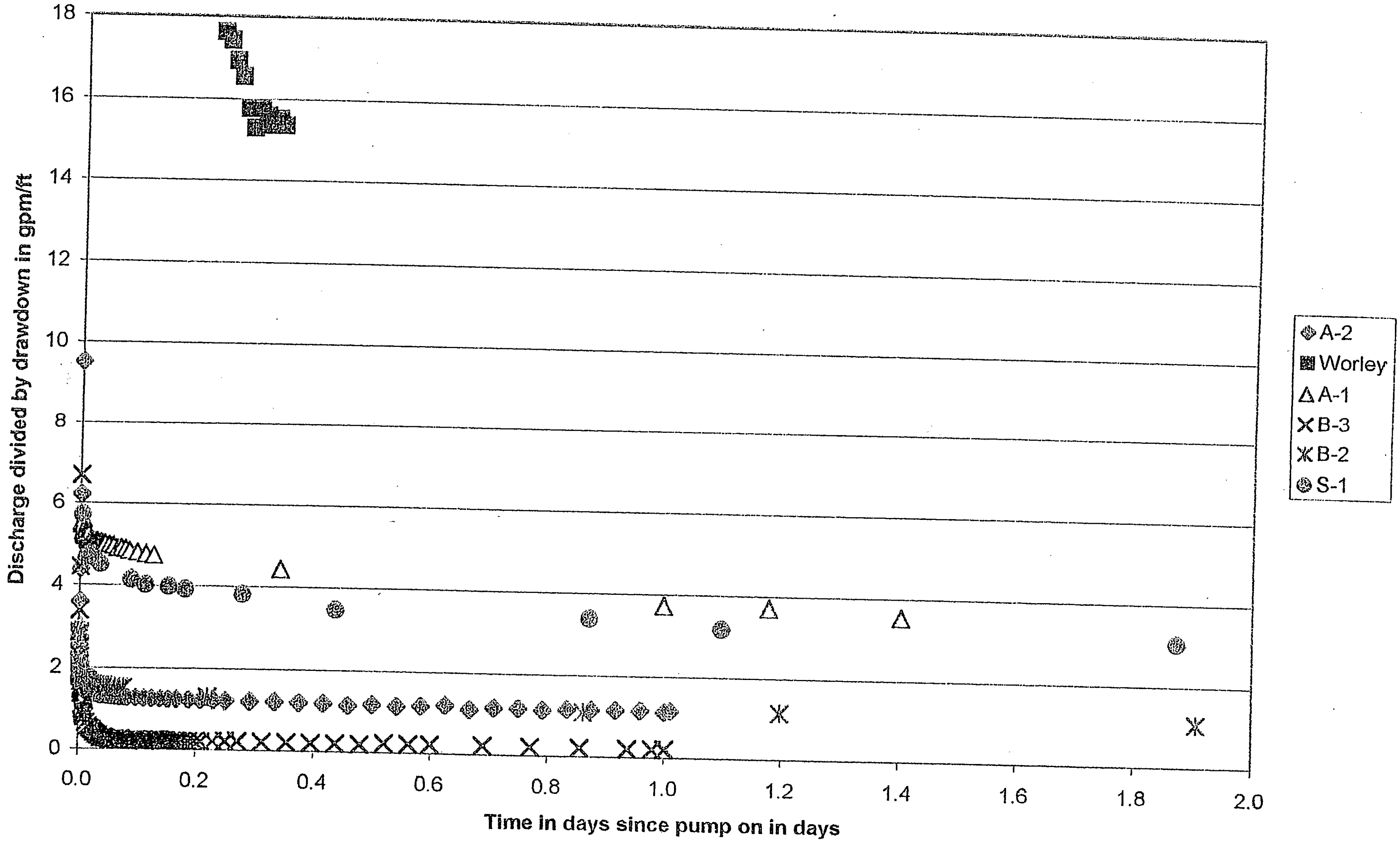
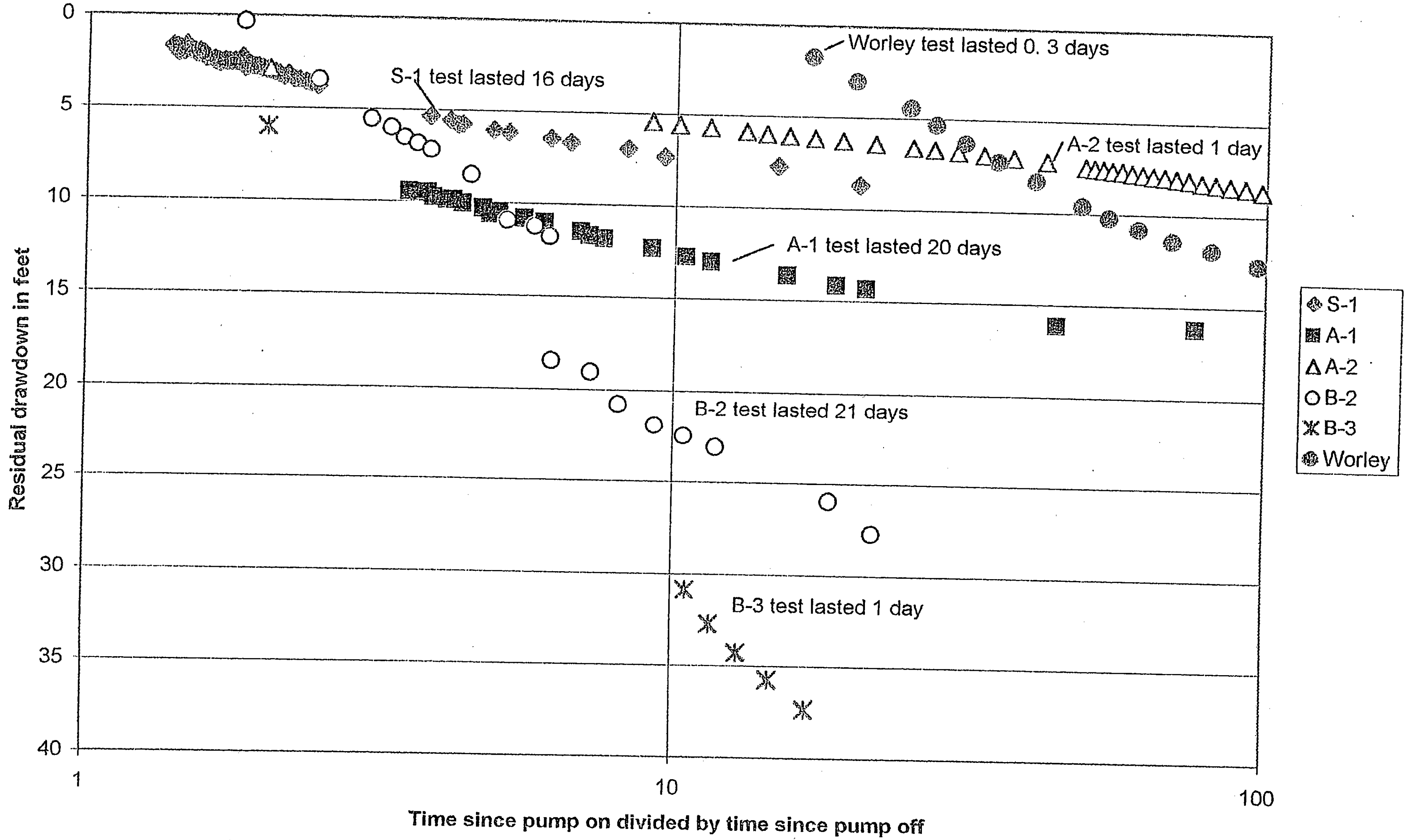


Figure 19 Residual Drawdown Analysis



Appendix A Logs For Test Wells and 1999 Worley West Park Well

7/96
Starships Consulting and Management Services

WELL DRILLER'S REPORT

Inspected by____ Only
Twp____ Rge__
____1/4____1
Lat: : :

1. WELL TAG NO. D10541
Drilling Permit No:
Other IDWR No.

2. OWNER — Well Number: 926
Name J-U-B ENG/INDIAN HEALTH
Address W 422 RIVERSIDE STE 722
City SPOKANE State WA Zip 99201

3. LOCATION OF WELL by legal description
sketch map location must agree with written location

N / E / S (sketch map, X marked in upper section)

Twp. 47 ☑ North or ☐ South
Rge. 04 ☐ East or ☑ West
Sec. 31 ____1/4 NW 1/4 NE 1/4
Gov't Lot ______ County KOOTENAI
Lat: : : Long: : :
Address of Well Site CDA INDIAN RESERV FISH HATCHERY City ______
(Give at least name of road + Distance to Road or Landmark)
Lt.______ Blk. ______ Sub. Name ______

4. USE:
☑ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ______

5. TYPE OF WORK check all that apply (Replacement, etc.)
☑ New Well ☐ Modify ☐ Abandonment ☐ Other ______

6. DRILL METHOD
☑ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ______

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
BENTONITE	0	20	100 LBS	OVERBORE

Was drive shoe used? ☐ Y ☐ N Shoe Depth(s)______
Was drive shoe seal tested? ☐ Y ☐ N How?______

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
6	+2	58	.250	STEEL	☑	☐	☑	☐
4	-2	157	.160	PVC	☐	☑	☐	☐

Length of Headpipe ______ Length of Tailpipe ______

9. PERFORATIONS/SCREENS
☑ Perforations Method SKILLSAW
Screens Screen Type ______

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
117	157	1/8X4	170	4	PVC	☐	☑

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
25 ft. below ground Artesian pressure______ lb.
Depth flow encountered ______ ft. Describe access port or control devices: ______

11. WELL TESTS:
☐ Pump ☐ Bailer ☑ Air ☐

Yield gal./min.	Drawdown	Pumping Level	Time
100+ GPM		160	1 HR

Water Temp. ______ Bottom Hole Temp ______
Water Quality test or comments: ______
______ Depth first Water encountered 55'

12. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
8	0	25	Clavish Topsoil		✓
8	25	31	Clay W/Basalt Gravel		✓
8	31	48	Clay Yellowish Tan		✓
8	48	58	Clay W/Basalt Gravel W/Water 8-10	✓	
6	58	91	Basalt Medium		✓
6	91	95	Basalt Fractured W/Water 8 GPM	✓	
6	95	115	Basalt Medium		✓
6	115	119	Basalt Broken W/Brown Clay Seems	✓	
6	119	125	Basalt Medium		✓
6	125	160	Basalt Brown W/Caleche Honeycomb	✓	

Completed Depth 157' (Measurable)
Date: Started 8/23/99 Completed 8/24/99

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.
Firm Name H2O WellService, Inc. Firm No. 448
Firm Official [signature] Date 8/24/99
and
Supervisor or Operator [signature] Date 8/24/99
(Sign Once if Firm Official and Operator)
(Louie Hanner)

TEST WELL S-1

...tnerships Consulting and ...agement Services

WELL DRILLER'S REPORT

Inspected by ______
Twp____ Rge____ Sec____
____1/4 ____1/4 ____1/4
Lat: : : Long: : :

1. WELL TAG NO. D13143
...ing Permit No: ______
...r IDWR No. ______

2. OWNER — Well Number: 4
...ne J.U.B./Indian Health
...ress W 422 Riverside, Ste. 772
City Spokane State WA Zip 99201

3. LOCATION OF WELL by legal description
...sketch map location must agree with written location

Twp. 47 ☑ North or ☐ South
Rge. 4 ☐ East or ☑ West
Sec. 31 ____1/4 NW 1/4 SW 1/4
Gov't Lot ______ County KOOTENAI
Lat: : : Long: : :
Address of Well Site Conklin Park Road
City Worley
(...e at least name of road + Distance to Road or Landmark)
L... ______ Blk. ______ Sub. Name ______

4. USE:
☐ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ______

5. TYPE OF WORK check all that apply (Replacement, etc.)
☐ New Well ☐ Modify ☐ Abandonment ☐ Other ______

6. DRILL METHOD
☐ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ______

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
...TONITE	0	18	9 Sacks	Overbore
3/8 PEA GRAVEL	370	433		

Was drive shoe used? ☑ Y ☐ N Shoe Depth(s) 65
Was drive shoe seal tested? ☐ Y ☐ N How? ___

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
4	-10	433	200	PVC	☐	☑	☐	☐
	2	65	.250	Steel	☑	☐	☑	☐

Length of Headpipe ______ Length of Tailpipe ______

9. PERFORATIONS/SCREENS
☐ Perforations Method Skill Saw
☐ Screens Screen Type ______

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
398	433	1/8 x 6	100	4	PVC	☐	☑

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
145 ft. below ground Artesian pressure ______ lb.
Depth flow encountered ______ ft. Describe access port or control devices: ______

11. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
50			1 Hr

Water Temp. Cold Bottom Hole Temp ______
Water Quality test or comments: clear
______ Depth first Water encountered 393

12. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
10	0	3	Topsoil		✓
10	3	18	Clay brown		✓
10	18	59	Clay brown w/some basalt		✓
10	59	65	Clay w/basalt		✓
8	65	88	Basalt		✓
8	88	100	Basalt broken w/hard clay		✓
8	100	111	Clay hard gray		✓
8	111	123	Shale Gray		✓
8	123	376	Basalt		✓
8	376	389	Clay gray w/wood		✓
8	389	393	Clay brown hard		✓
8	393	433	Basalt	✓	

Completed Depth 443 (Measurable)
Date: Started 4/3/00 Completed 4/5/00

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H20 WellService, Inc. Firm No. 448
Firm Official ______ Date ______
and
Supervisor or Operator ______ Date ______
(Sign Once if Firm Official and Operator)

TEST WELL A-1

Starship Consulting and Management Services

WELL DRILLER'S REPORT

Inspected by ______
Twp ____ Rge ____ Sec ____
____ 1/4 ____ 1/4 ____ 1/4
Lat: : : Long: : :

1. WELL TAG NO. D0013718
Drilling Permit No: 766313
Other IDWR No.

2. OWNER — **Well Number:** 95
Name JUB Engineers/Indian Health
Address W 422 Riverside, #772
City Spokane State WA Zip 99201

3. LOCATION OF WELL by legal description
sketch map location must agree with written location

Twp. 47 ☑ North or ☐ South
Rge. 04 ☐ East or ☑ West
Sec. 20 ____ 1/4 NE 1/4 SW 1/4
Gov't Lot ____ County KOOTENAI
Lat: : : Long: : :
Address of Well Site CDA Indian Reservation
City Worley
(Give at least name of road + Distance to Road or Landmark)
Lt. ____ Blk. ____ Sub. Name ____

4. USE:
☐ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☑ Other Fish Propagation

5. TYPE OF WORK check all that apply (Replacement, etc.)
☑ New Well ☐ Modify ☐ Abandonment ☐ Other ____

6. DRILL METHOD
☑ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK			AMOUNT	METHOD
Material	From	To	Sacks or Pounds	
BENTONITE	0	18	5 sacks	overbore

Was drive shoe used? ☑ Y ☐ N Shoe Depth(s) 18
Was drive shoe seal tested? ☑ Y ☐ N How? Air

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
8	0	18	.250	steel	☑	☐	☑	☐

Length of Headpipe ____ Length of Tailpipe ____

9. PERFORATIONS/SCREENS
☐ Perforations Method ____
☐ Screens Screen Type ____

From	To	Slot Size	Number	Diameter	Material	Casing	Liner

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
69 ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ____

11. WELL TESTS:
☐ Pump ☐ Bailer ☑ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
150+			

Water Temp. cold Bottom Hole Temp cold
Water Quality test or comments: ____
Depth first Water encountered 275

12. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
10	0	5	Topsoil	☐	☑
10	5	18	Basalt w/clay, brown	☐	☑
8	18	275	Basalt	☐	☑
8	275	285	Basalt w/H2O apx. 20 gpm	☑	☐
8	285	295	Basalt w/clay, gray	☐	☑
8	295	310	Hardpan clay, gray	☐	☑
8	310	320	Shale gray w/H2O apx. 15 gpm	☑	☐
8	320	345	Shale gray & green w/H2O 50 gpm	☑	☐
8	345	365	Shale gray w/H2O apx. 100+ gpm	☑	☐
8	365	383	Shale gray	☐	☑

Completed Depth 383 (Measurable)
Date: Started 8/31/00 Completed 9/1/00

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H20 WellService, Inc. Firm No. 448
Firm Official ____ Date ____
and
Supervisor or Operator ____ Date ____
(Sign Once if Firm Official and Operator)
Michael Halterman

TEST WELL A-2

7/98
Partnerships Consulting and Management Services

IDAHO DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

Office Use Only
Inspected by______
Twp____Rge____Sec____
____1/4____1/4____1/4
Lat: : : Long: : :

1. WELL TAG NO. D0013960
Drilling Permit No:
Other IDWR No.

2. OWNER — Well Number: 148
Name J.U.B./Indian Health
Address W 422 Riverside, Ste. 772
City Spokane State WA Zip 99201

3. LOCATION OF WELL by legal description
sketch map location must agree with written location

Twp. 47 ✓ North or _ South
Rge. 05 _ East or ✓ West
Sec. 24 ____1/4 NE 1/4 SE 1/4
Gov't Lot ____ County KOOTENAI
Lat: : : Long: : :
Address of Well Site CDA Indian Reservation City Worley
(Give at least name of road + Distance to Road or Landmark)
Lt.____ Blk.____ Sub. Name ____

4. USE:
_ Domestic _ Municipal _ Monitor _ Irrigation
_ Thermal _ Injection ✓ Other Fish Propagation

5. TYPE OF WORK check all that apply (Replacement, etc.)
✓ New Well _ Modify _ Abandonment _ Other ____

6. DRILL METHOD
✓ Air Rotary _ Cable _ Mud Rotary _ Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
WELL SEAL				
BENTONITE	0	40	10 bags	overbore

Was drive shoe used? ✓ Y _ N Shoe Depth(s) 87
Was drive shoe seal tested? _ Y _ N How?_

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
8	+2	-87	.250	STEEL	✓		✓	

Length of Headpipe ____ Length of Tailpipe ____

9. PERFORATIONS/SCREENS
_ Perforations Method ____
_ Screens Screen Type ____

From	To	Slot Size	Number	Diameter	Material	Casing	Liner

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
75 ft. below ground Artesian pressure____lb.
Depth flow encountered ____ ft. Describe access port or control devices:

11. WELL TESTS:
_ Pump _ Bailer ✓ Air _ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
est 50-60			

Water Temp. Cold Bottom Hole Temp cold
Water Quality test or comments: good, clear
Depth first Water encountered 24

12. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
10	0	3	Topsoil		✓
10	3	24	Clay w/gravel, tan, w/H2O	✓	
10	24	48	Basalt broken		✓
10	48	65	Basalt gray soft		✓
10	65	87	Basalt gray medium hard		✓
8	87	98	Basalt gray medium hard		✓
8	98	110	Basalt broken w/orange clay, hard		✓
8	110	130	Basalt dark gray hard		✓
8	130	138	Basalt broken w/H2o apx 25 gpm	✓	
8	138	150	Basalt gray hard		✓
8	150	173	Basalt honeycomb brn & gray w/H2O a	✓	
8	173	240	Basalt dark gray hard		✓
8	240	265	Basalt fractured w/H2O apx 20-30 gp	✓	
8	265	338	Basalt gray hard		✓
8	338	344	Clay dark brown w/basalt gravel		✓

Completed Depth 344 (Measurable)
Date: Started 11/15/00 Completed 11/20/00

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H20 WellService, Inc. Firm No. 448
Firm Official ____ Date ____
and
Supervisor or Operator ____ Date ____
(Sign Once if Firm Official and Operator)
Louie Hanner

TEST WELL B-1

7/98
Starships Consulting and Management Services

WELL DRILLER'S REPORT

Inspected by ______
Twp____ Rge____ Sec____
____1/4____1/4____1/4
Lat: : : Long: : :

1. WELL TAG NO. ______
Drilling Permit No: ______
Other IDWR No. ______

2. OWNER — Well Number: 158
Name J.U.B./Indian Health
Address W 422 Riverside, Ste. 772
City Spokane State WA Zip 99201

3. LOCATION OF WELL by legal description
sketch map location must agree with written location

Twp. ______ North or South
Rge. ______ East or West
Sec. ____ ____1/4____1/4____1/4
Gov't Lot______ County KOOTENAI
Lat: : : Long: : :
Address of Well Site Carmen Well
City Worley
(Give at least name of road + Distance to Road or Landmark)
Lt.______ Blk.______ Sub. Name ______

4. USE:
☐ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☑ Other Fish Propagation

5. TYPE OF WORK check all that apply (Replacement, etc.)
☐ New Well ☑ Modify ☐ Abandonment ☐ Other ______

6. DRILL METHOD
☑ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ______

7. SEALING PROCEDURES

SEAL/FILTER PACK			AMOUNT	METHOD
Material	From	To	Sacks or Pounds	

Was drive shoe used? ☐ Y ☑ N Shoe Depth(s)______
Was drive shoe seal tested? ☐ Y ☐ N How?______

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
4	-18	292	.160	pvc	☐	☑	☐	☐

Length of Headpipe ______ Length of Tailpipe ______

9. PERFORATIONS/SCREENS
☑ Perforations Method Saw Cut
☐ Screens Screen Type______

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
-200	-240	1/8x6	160	4	pvc	☐	☑

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
140 ft. below ground Artesian pressure______lb.
Depth flow encountered ______ ft. Describe access port or control devices: ______

11. WELL TESTS:
☐ Pump ☐ Bailer ☑ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
extimate 100		240	2 hours

Water Temp. ______ Bottom Hole Temp ______
Water Quality test or comments: ______
______Depth first Water encountered______

12. LITHOLOGIC LOG:(Describe repairs or abandonment)

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
8	0	210		☐	☐
6	210	240		☐	☐
			Clean out hole and set liner	☐	☐
			Set pea gravel 50' to 300'	☐	☐
			4" 160 PVC Liner set at -18 to -242	☐	☐
		0	224' total	☐	☐

Completed Depth 240 (Measurable)
Date: Started 12/7/00 Completed 12/8/00

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H20 WellService, Inc. Firm No. 448
Firm Official______ Date______
and
Supervisor or Operator ______ Date ______
(Sign Once if Firm Offical and Operator)
Louie Hanner

TEST WELL B-2

USE TYPEWRITER OR BALL POINT PEN

State of Idaho
Department of Water Resources

WELL DRILLER'S REPORT

State law requires that this report be filed with the Director, Department of Water Resources within 30 days after the completion or abandonment of the well

1. WELL OWNER

Name ~~Coeur D'Alene Tribe, U.S.E. Division~~

Address Rt. #1 Box 1-A, Worley, Ida. 83876

Owner's Permit No. EDA #2

2. NATURE OF WORK 93-76-N-7

☒ New well ☐ Deepened ☐ Replacement

☐ Abandoned (describe method of abandoning)

3. PROPOSED USE

☒ Domestic ☐ Irrigation ☐ Test ☐ Other (specify type)

☐ Municipal ☐ Industrial ☐ Stock ☐ Waste Disposal or Injection

4. METHOD DRILLED

☐ Cable ☒ Rotary ☐ Dug ☐ Other

5. WELL CONSTRUCTION

Diameter of hole 8 inches Total depth 305 feet

Casing schedule: ☐ Steel ☐ Concrete

Thickness	Diameter	From	To
¼ inches	8 inches	1 feet	60 feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet
inches	inches	feet	feet

Was casing drive shoe used? ☐ Yes ☐ No

Was a packer or seal used? ☐ Yes ☒ No

Perforated? ☒ Yes ☐ No

How perforated? ☐ Factory ☐ Knife ☐ Torch

Size of perforation ____ inches by ____ inches

Number	From	To
perforations	feet	feet
perforations	feet	feet
perforations	feet	feet

Well screen installed? ☐ Yes ☒ No

Manufacturer's name

Type ____ Model No. ____

Diameter ___ Slot size ___ Set from ___ feet to ___ feet

Diameter ___ Slot size ___ Set from ___ feet to ___ feet

Gravel packed? ☒ Yes ☐ No Size of gravel ____

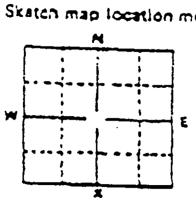
Placed from ____ feet to ____ feet

Surface seal depth 50 Material used in seal ☒ Cement grout ☐ Puddling clay ☐ Well cuttings

Sealing procedure used ☐ Slurry pit ☒ Temporary surface casing ☐ Overbore to seal depth

6. LOCATION OF WELL

Sketch map location must agree with written location. 93



Subdivision Name ____

Lot No. ____ Block No. ____

County Benewah

¼ SW ¼ Sec. 24 T. 47 N. R. 5 W

7. WATER LEVEL

Static water level 40 feet below land surface

Flowing? ☐ Yes ☒ No G.P.M. flow ____

Temperature ____ °F. Quality ____

Artesian closed-in pressure ____ p.s.i.

Controlled by ☐ Valve ☐ Cap ☐ Plug

8. WELL TEST DATA

☐ Pump ☐ Bailer ☒ Other Air Lift

Discharge G.P.M.	Draw Down	Hours Pumped
75		

9. LITHOLOGIC LOG

Hole Diam.	Depth From	Depth To	Material	Water Yes	Water No
8	0	3	Top Soil		
	3	20	Clay Brown		
	20	60	Broken Basalt & Clay		
	60	70	Hard Basalt		
	70	100	Broken Basalt	x	
	100	160	Hard Basalt		
	160	180	Broken Basalt	x	
	180	305	Hard Basalt		

10. Work started 5-15-76 finished 5-19-76

11. DRILLERS CERTIFICATION

Firm Name Carman Development Co Firm No. 228

Address E 6010 Broadway, Spo. Wn. Date 6-28-76

Signed by (Firm Official) [signature]

and

(Operator) [signature]

TEST WELL B-2

7/98
Starships Consulting and
Management Services

IDAHO DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

Office Use Only
Inspected by____
Twp____ Rge____ Sec____
____1/4____1/4____1/4
Lat: : : Long: : :

1. WELL TAG NO. D0013996
Drilling Permit No:
Other IDWR No.

2. OWNER **Well Number:** 166
Name J.U.B./Indian Health
Address W 422 Riverside, Ste. 772
City Spokane State WA Zip 99201

3. LOCATION OF WELL by legal description
sketch map location must agree with written location

Twp. 47 ☑ North or ☐ South
Rge. 05 ☐ East or ☑ West
Sec. 24 ____1/4 NE 1/4 SE 1/4
Gov't Lot ____ County KOOTENAI
Lat: : : Long: : :
Address of Well Site CDA Indian Reservatio
City Worley
(Give at least name of road + Distance to Road or Landmark)
Lt.____ Blk. ____ Sub. Name ____

4. USE:
☐ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☑ Other Fish Propagation

5. TYPE OF WORK check all that apply (Replacement, etc.)
☑ New Well ☐ Modify ☐ Abandonment ☐ Other ____

6. DRILL METHOD
☑ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK			AMOUNT	METHOD
Material	From	To	Sacks or Pounds	
WELL SEAL				
BENTONITE	0	18	6 bags	10" overbore

Was drive shoe used? ☑ Y ☐ N Shoe Depth(s) 19
Was drive shoe seal tested? ☐ Y ☐ N How?

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
8	+2	-20	.250	steel	☑	☐	☑	☐

Length of Headpipe ____ Length of Tailpipe ____

9. PERFORATIONS/SCREENS
☐ Perforations Method ____
☐ Screens Screen Type ____

From	To	Slot Size	Number	Diameter	Material	Casing	Liner

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
50 ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ____

11. WELL TESTS:
☐ Pump ☐ Bailer ☑ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
estimate 45		405	1 hour

Water Temp. Cold Bottom Hole Temp cold
Water Quality test or comments: good up in rock
Depth first Water encountered 65

12. LITHOLOGIC LOG:(Describe repairs or abandonment)

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
10	0	3	Clayish top soil		☑
10	3	19	Basalt dark gray medium hard		☑
8	19	65	Basalt dark gray medium hard		☑
8	65	69	Basalt fractured w/H2O apx 30 gpm	☑	
8	69	235	Basalt dark gray medium hard		☑
8	235	242	Basalt fractured w/H2o apx 15 gpm	☑	
8	242	296	Basalt dark gray medium hard		☑
8	296	301	Clay blue gray w/basalt gravels		☑
8	301	330	Clay gray		☑
8	330	405	Shale tan & red medium soft w/H2O ap	☑	

Completed Depth 405 (Measurable)
Date: Started 1/4/01 Completed 1/5/01

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H20 WellService, Inc. Firm No. 448
Firm Official ____ Date ____
and
Supervisor or Operator ____ Date ____
(Sign Once if Firm Official and Operator)
Louie Hanner

TEST WELL B-3

7/98
Starships Consulting and
Management Services

DEPARTMENT OF WATER RESOURCES

WELL DRILLER'S REPORT

Office Use Only
Inspected by____
Twp____ Rge____ Sec____
____1/4____1/4____1/4
Lat: : : Long: : :

1. WELL TAG NO. D0013717
Drilling Permit No: 766313
Other IDWR No.

2. OWNER — **Well Number:** 101
Name J.U.B. Engineers/Indian Health
Address W 422 Riverside, Ste. 772
City Spokane State WA Zip 99201

3. LOCATION OF WELL by legal description
sketch map location must agree with written location

N / S / E (sketch grid)

Twp. 47 ☑ North or ☑ South
Rge. 5 ☐ East or ☑ West
Sec. 23 ____1/4 NE 1/4 NE 1/4
Gov't Lot____ County KOOTENAI
Lat: : : Long: : :
Address of Well Site Cave Bay Road
City Worley
(Give at least name of road + Distance to Road or Landmark)
Lt.____ Blk.____ Sub. Name____

4. USE:
☐ Domestic ☐ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☑ Other Fish Propagation

5. TYPE OF WORK check all that apply (Replacement, etc.)
☐ New Well ☑ Modify ☐ Abandonment ☐ Other ____

6. DRILL METHOD
Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
BENTONITE	0	18	5 Sacks	overbore

Was drive shoe used? ☑ Y ☐ N Shoe Depth(s) 18
Was drive shoe seal tested? ☐ Y ☐ N How?

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
8	1	18	.250	steel	☑	☐	☑	☐
4	-2	442	.160	pvc	☐	☑	☐	☐

Length of Headpipe ____ Length of Tailpipe ____

9. PERFORATIONS/SCREENS
Perforations Method ____
Screens Screen Type ____

From	To	Slot Size	Number	Diameter	Material	Casing	Liner

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
100 ft. below ground Artesian pressure____ lb.
Depth flow encountered____ ft. Describe access port or control devices: ____

11. WELL TESTS:
☐ Pump ☐ Bailer ☑ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time
12			1 hour

Water Temp. Cold Bottom Hole Temp ____
Water Quality test or comments: clear
____ Depth first Water encountered 445

12. LITHOLOGIC LOG:(Describe repairs or abandonment)

Bore Diam	From	To	Remarks: Lithology, Water Quality, Temperature	Water Y	Water N
10	0	2	Topsoil	☐	☑
10	2	11	Clay brown	☐	☑
10	11	14	Clay with Basalt	☐	☑
10	14	18	Basalt	☐	☑
8	18	237	Basalt	☐	☑
8	237	321	Clay & clay with wood	☑	☐
8	321	325	Clay with Basalt	☐	☑
8	325	414	Basalt	☐	☑
8	414	445	Clay	☐	☑
			Sounded hole and hole stayed open	☐	☐
			Set liner & gravel packed	☐	☐
			440' of 160 PVC liner	☐	☐
			Apx 4 yards gravel from -30 to -440	☐	☐

Completed Depth 440 (Measurable)
Date: Started 12/8/00 Completed 12/8/00

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Firm Name H20 WellService, Inc. Firm No. 448
Firm Official ____ Date ____
and
Supervisor or Operator ____ Date ____
(Sign Once if Firm Offical and Operator)
Louie Hanner

TEST WELL B-4

Form 238-7
11/97

IDAHO DEPARTMENT OF WATER RESOURCES
WELL DRILLER'S REPORT

Office Use Only	
Inspected by	
Twp ____ Rge ____ Sec ____	
____ 1/4 ____ 1/4 ____ 1/4	
Lat: :	Long: : :

1. WELL TAG NO. D 0005702
DRILLING PERMIT NO. ____
Other IDWR No. 93-07056

2. OWNER:
Name City of Worley
Address PO Box 169
City Worley State ID Zip 83876

3. LOCATION OF WELL by legal description:
Sketch map location must agree with written location.

Twp. 47 North ☒ or South ☐
Rge. 05 East ☐ or West ☒
Sec. 23 NE 1/4 SE 1/4 ____ 1/4
Gov't Lot ____ County Kootenai
Lat: : : Long: : :
Address of Well Site ____
(Give at least name of road + Distance to Road or Landmark)
City ____
____ Blk. ____ Sub. Name ____

4. USE:
☐ Domestic ☒ Municipal ☐ Monitor ☐ Irrigation
☐ Thermal ☐ Injection ☐ Other ____

5. TYPE OF WORK check all that apply (Replacement etc.)
☒ New Well ☐ Modify ☐ Abandonment ☐ Other ____

6. DRILL METHOD
☒ Air Rotary ☐ Cable ☐ Mud Rotary ☐ Other ____

7. SEALING PROCEDURES

SEAL/FILTER PACK Material	From	To	AMOUNT Sacks or Pounds	METHOD
Aqua Guard	0	50	20 bgs	Press. Grt.
Hole Plug	50	55	3 bgs	Hole Plug

Was drive shoe used? ☐ Y ☒ N Shoe Depth(s) ____
Was drive shoe seal tested? ☐ Y ☒ N How? ____

8. CASING/LINER:

Diameter	From	To	Gauge	Material	Casing	Liner	Welded	Threaded
8	+2	220	322	Steel	☒	☐	☒	☐
					☐	☐	☐	☐
					☐	☐	☐	☐

Length of Headpipe ____ Length of Tailpipe 2'

9. PERFORATIONS/SCREENS
Perforations Method ____
Screens Screen Type Johnson, stainless Pipe size

From	To	Slot Size	Number	Diameter	Material	Casing	Liner
220	240	.060		8	ss	☐	☐
240	242			8	sump	☐	☐
						☐	☐

10. STATIC WATER LEVEL OR ARTESIAN PRESSURE:
90 ft. below ground Artesian pressure ____ lb.
Depth flow encountered ____ ft. Describe access port or control devices: ____

11. WELL TESTS:
☐ Pump ☐ Bailer ☐ Air ☐ Flowing Artesian

Yield gal./min.	Drawdown	Pumping Level	Time

Water Temp. ____ Bottom hole temp. ____
Water Quality test or comments: ____
Depth first Water Encounter ____

12. LITHOLOGIC LOG: (Describe repairs or abandonment)

Bore Dia.	From	To	Remarks: Lithology, Water Quality & Temperature	Water Y	Water N
12	0	11	Clay Brown Hard		x
12	11	42	Brown Clay W/Broken		
			Basalt Silt W/Water	x	
12	42	50	Basalt Brown Black Med		x
10	50	66	Basalt Gray Fractured		
			Hard		x
10	66	68	Claystone Green Medium		x
10	68	116	Basalt Gray Fractured		
			Hard		x
10	116	119	Basalt Black Fractured		
			Medium		x
10	119	190	Basalt Black Hard		x
10	190	192	Basalt Black Frac. Hard		x
10	192	197	Basalt Black Hard		x
10	199	214	Basalt Black Frac. Hard		x
10	214	219	Basalt Black Frac. Med.	x	
10	219	227	Basalt Black Medium		x
10	227	232	Basalt Black Frac. Med.	x	
10	232	242	Basalt Gay Hard		x

Completed Depth 242 (Measurable)
Date: Started 8-27-99 Completed 9-13-99

13. DRILLER'S CERTIFICATION
I/We certify that all minimum well construction standards were complied with at the time the rig was removed.

Company Name Fogle Pump & Supply Inc. Firm No. 537
Firm Official [signature] Date 11/23/99
and
Driller or Operator [signature] Date 11-23-99
(Sign once if Firm Official & Operator)

FORWARD WHITE COPY TO WATER RESOURCES

RHS Ralston Hydrologic Services, Inc.

GROUND WATER CONSULTING AND EDUCATION

1122 East B Street, Moscow, ID USA 83843
Voice and FAX 208-883-0533, E-mail ralston@moscow.com

March 26, 2001

Doug Ensor PE
J-U-B Engineers, Inc.
W 422 Riverside, Suite 722
Spokane, WA 99201

Dear Doug:

The purpose of this letter is to provide you with additional clarification relative to the long-term dependability of ground water as the supply source for the Coeur d'Alene Reservation hatchery proposed to be located near Worley, Idaho. The ground water resources of the area are described in my February 2001 report entitled "**ANALYSIS OF WELL YIELD POTENTIAL FOR A PORTION OF THE COEUR D'ALENE RESERVATION NEAR WORLEY, IDAHO**." My letter dated March 2, 2001 provides additional comments relative to the reduction of the target yield from 60 to 35 gallons per minute (gpm). This letter addresses the reliability of projections of long-term yields from proposed project wells by examining the basic hydraulic characteristics associated with ground water development.

A cone of depression within the aquifer water level (hydraulic gradient towards the well from all horizontal directions) is created as soon as water is withdrawn from a pumping well. At any point in time, the amount of water pumped (discharge rate multiplied by time) must be equal to the volume of the cone of depression multiplied by the storativity coefficient of the aquifer. Continued pumping of the well must necessarily result in continued growth of the cone of depression. Water levels decline with time both within the pumped well and in the aquifer in the general area of the well. This water level decline will continue until the pumping rate is balanced by either an increase in natural recharge to the aquifer (infiltration from precipitation and/or leakage from streams or lakes) or a decrease in natural discharge from the aquifer (springs, discharges to streams and lakes or evaporation/transpiration). The ground water pumping can continue for an infinite period of time once this new balance is reached.

General predictions of long-term aquifer productivity can be based on a review of site conditions. For example, development of a large-yield production well in a small basin in a desert environment will result in long-term water level decline and mining of the ground water resource. The effective life of the well depends on the annual withdrawal rate and the amount of water in storage within the aquifer. On the other extreme, development of a large-yield production well in a large basin in a humid environment likely will result in a period of water level decline followed by development of a new, ground water equilibrium. The ground water pumping will have been balanced by an increase in recharge and/or a decrease in natural discharge. A large-yield production well drilled near a large river or lake ultimately will obtain water indirectly from the river. Pumping will cause a drop in ground water levels, which will either reduce the natural water discharge to the stream or lake or increase the rate of water movement from the stream or lake to the ground water system.

The ground water conditions near Worley are suitable for long-term development of a small production well field. The following statement is included in my March 2, 2001 letter. "I believe that a long-term, 35-gpm water supply can be obtained from the four wells noted above with a high degree of certainty." This statement is based on the following observations.

1. The Worley area probably receives one to three inches per year of recharge to the uppermost ground water system. This estimate is based on research done in the Moscow-Pullman area located about 50 miles to the south. The precipitation-evaporation-transpiration rates for the two areas should be similar. Except for the canyons area to the east, the land surface near Worley is relatively flat leading to more recharge and less runoff than in the Moscow-Pullman area. An infiltration rate of one inch per year would give an annual recharge of about 17 million gallons per year per square mile. Continuous operation of a 35-gpm supply well would result in the annual withdrawal of about 18 million gallons per year. Based on this estimate, a recharge area of multiple square miles is needed to meet the hatchery needs. The aquifers penetrated by the existing wells are continuous over an area probably exceeding five square miles.

2. Likely, long-term operation of the planned well field would cause some water level decline but would ultimately lead to stable water levels. The lower water levels in the pumped aquifers would increase downward water movement from near-surface systems and probably decrease some water discharge in the canyons to the east. These system adjustments would allow a new water balance and the ability to produce the water over a long time period.

3. Based on the aquifer test results, well B-2 penetrates an aquifer that is productive enough to supply the required yield for most of the year. Wells S-1 and A-2 are located at considerable distance from well B-2. Water level declines in these wells caused by well B-2 should be minimal. A pumping schedule that includes alternating operation of the three wells (with possible inclusion of well A-1) has a high probability of meeting the hatchery needs for a long time period.

Monitoring of ground water levels prior to and during the operation of the well field will allow real-time analysis of ground water impacts and allow adjustment of operation of individual wells. For example, water level monitoring during a normal spring recharge event will provide important information on recharge locations and amounts.

Please contact me if you have any questions relative to the information presented in this letter. Thank you.

Sincerely,

Dale R. Ralston Ph.D. PE PG

RHS Ralston Hydrologic Services, Inc.

GROUND WATER CONSULTING AND EDUCATION

1122 East B Street, Moscow, ID USA 83843
Voice and FAX 208-883-0533, E-mail ralston@moscow.com

March 2, 2001

Doug Ensor PE
J-U-B Engineers, Inc.
W 422 Riverside, Suite 722
Spokane, WA 99201

Dear Doug:

The purpose of this letter is to provide you with follow-up comments relative to my report entitled "ANALYSIS OF WELL YIELD POTENTIAL FOR A PORTION OF THE COEUR D'ALENE RESERVATION NEAR WORLEY, IDAHO" (February 2001). My report was written based on the goal of developing a well field that would supply a continuous flow of 60 gpm (gallons per minute) for hatchery uses. In your telephone call of February 28, 2001, you asked that I reevaluate the yield potential if the desired flow was 35 rather than 60 gpm. This letter presents that reevaluation.

The reduction in the planned well yield from 60 to 35 gpm greatly increases my assessment of the long-term productivity of the target aquifers described in the report. It is likely that well B-2 could be used to supply the desired yield for 70 to 90 percent of the year. Wells S-1 and A-2 can be used for the remaining portions of the year. These wells, plus possibly well A-1, also would serve as a redundant water supply source.

I believe that a long-term, 35-gpm water supply can be obtained from the four wells noted above with a high degree of certainty. As described in my previous report, long-term data collection efforts are an essential part of well field operation. Water level monitoring data obtained during the first few months of hatchery operation would provide the basis for designing a well pumping schedule that best fits the water resource in the area.

Please contact me if you have any questions relative to the information presented in this letter. Thank you.

Sincerely,

Dale R. Ralston Ph.D. PE PG

Appendix B

Cost of Rainbow Purchase Alternative

APPENDIX B

Rainbow trout purchase option[1]:

As an interim alternative to constructing rainbow trout ponds at the Coeur d' Alene Production Facility, the Tribe would transport approximately 16,000 lbs. of rainbow trout to existing trout ponds on the reservation. The estimated cost breakdown for the **rainbow trout** are as follows:

Rainbow trout @$1.31/lb.
12.5 inch to 13.5 inch trout weighing approximately 1.6lbs.
1.6lbs. multiplied by 10,000 fish = 16,000 lbs.
16,000 lbs. multiplied by $1.31= **$20,960**

Total distance from the fish farm to the Coeur d' Alene reservation would be approximately 146 miles. Mileage costs for a round trip would be approximately $100.74 . Therefore, the following budget is necessary for **transportation**:

14.3 Trips @ $100.74= **$1,439.14**

Additionally, at an estimated 8 hrs.for round trip transportation **personnel costs** are:

$85/hr multiplied by 8 hrs multiplied by 14.3 trips= **$9,724**

Total Alternative Cost Estimate- $32,123

This particular alternative would, in the interim, defer approximately $164,780 in construction costs until water quantity and hatchery performance information was available. This alternative would likely be included in the annual operation and maintenance budget for the production facility. It is important to note, however, that this alternative does not fully address the Coeur d' Alene Tribe's rainbow fish production goals.

[1] Cost estimates were derived from communications with Columbia Fish Farms, Nespelem, Washington

FRANK L. CASSIDY JR.
"Larry"
CHAIRMAN
Washington

Tom Karier
Washington

Mike Field
Idaho

Jim Kempton
Idaho

NORTHWEST POWER PLANNING COUNCIL
851 S.W. SIXTH AVENUE, SUITE 1100
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1-800-452-5161

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ERIC J. BLOCH
VICE CHAIRMAN
Oregon

John Brogoitti
Oregon

Stan Grace
Montana

Leo A. Giacometto
Montana

March 28, 2001

MEMORANDUM

TO: Ronald Peters, Fisheries Biologist
Coeur d'Alene Tribe

FROM: Mark Fritsch

SUBJECT: Verification of Sustainable Water Supply for the Coeur d'Alene Tribe Trout Production Facility and determination on the most cost effective means to provide trout for the catch out ponds

On February 5, 2001 Council received from J-U-B Engineers, Inc a report entitled *Analysis Of Well Yield Potential For A Portion of the Coeur D'Alene Reservation Near Worley, Idaho*. This report was followed by an additional report, from the Coeur d'Alene Tribe on March 28, 2001, that include a memo addressing the well analysis report (with additional attachments) and cost effectiveness regarding trout for the catch out ponds. The report and additional document are intended to address the condition placed (i.e. Recommendation #1) on the project as part of the step two approval by Council on April 5, 2000.

The water report seems to confirm the complex nature on the dynamics of the hydrogeologic setting of the well network in the vicinity of the proposed facility. The report concludes that additional evaluations are needed (e.g. aquifer test, analysis and etc.) to understand the nature of the proposed ground water system.

As discussed with you on March 5, 2001 these evaluations should also include the evaluation of alternative facility locations. It is critical that the water quality/quantity is not a weak link for the proposed facility.

The Council is anticipating a decision regarding the Mountain Columbia Provincial Review in May 2001. This would include the direction regarding the water analysis and rainbow cost effectiveness document (pre-step 2 submittal) and your anticipated step 2 submittal. In the interim it would be useful for the CDA Tribe to evaluate alternative sites for the proposed facility in context to previous plans and goals, and address the additional data needs on well A-2 and the water quality sampling and analysis effort as recommended by Dr. Ralston. In addition it would be useful to reconfigure the current facility design level to address your proposed removal of rainbow production. Authorization to proceed to preliminary design will be addressed as part of the provincial review.

If you have any questions or concerns please feel free to contact me.

cc: Stacy Horton, NPPC
Rayola Jacobsen, NPPC
Bob Lohn, NPPC
Doug Marker, NPPC
William Towey, J-U-B Engineers, Inc
Brad Miller, BPA
John Ogan, NPPC
Karl Weist, NPPC

w:\mf\ww\hatchery\cda\021501waterrespond.doc

April 18, 2001

Frank L. Cassidy, Jr., Chair
Northwest Power Planning Council
851 SW 6th Avenue, Suite 1100
Portland, OR 97204-1348

Dear Chairman Cassidy:

The Coeur d' Alene Tribe would like to respond to the March 28, 2001 memorandum from Mark Fritsch to the Tribe regarding the verification of Councils receipt of our responses to the step-one review. The Tribe would like to clarify its position on several statements made in the letter and articulate our understanding of the review process initiated by the Northwest Power Planning Council (Council).

Response to memorandum-

The following italicized text outlines the statements made in the memorandum and is followed by our responses.

> *The water report seems to confirm the complex nature on the dynamics of the hydrogeologic setting of the well network in the vicinity of the proposed facility. The report concludes that additional evaluations are needed (e.g aquifer test, analysis and etc.) to understand the nature of the proposed ground water system.*

The groundwater resources within the project area are very dynamic. Because of this, and comments received through the three step process, the Tribe initiated a fairly intense exploratory exercise to determine the likelihood to obtain a continuous 60 gpm from a collection of various wells. The results of Dr. Ralston's analysis were favorable for this level of production, as long as certain precautionary well monitoring measures were implemented during hatchery operation. Furthermore, based on the elimination of the rainbow trout ponds at the facility (due to cost effectiveness issues and the volume of water issues), the Tribe is suggesting utilizing a 35 gpm continuous water supply. Along with this reduced water consumption rate, the Tribe will also monitor the recharge rates and water quality parameters as prescribed by Dr. Ralston. Again, during operation of the facility. Additionally, the Tribe will be able to access a tremendously strong City of Worley well, if ever a situation arises.

The Tribe appreciates the effectiveness of the Council's three-step process to allow these uncertainties and technical questions to be resolved. The Tribe is completely confident that the well field assessment was thorough and the resulting recommendations are scientifically valid. By using proper rotation among the test wells defined in the report, based on the well monitoring program, the Tribe is fully confident that the long-term sustainability goal will be met. With this said, the Tribe has unequivocally decided that the well field **will** provide above and beyond the volume of water needed to successfully operate the production facility.

> *As discussed with you on March 5, 2001 these evaluations should also include the evaluation of alternative facility locations. It is critical that the water quality/quantity is not a weak link for the proposed facility.*

Our understanding of the Three-Step Review Process, as outlined in your memorandum (April 5, 2000) to the fish and wildlife committee, is "to make use of independent peer review for projects as they move through each stage of the development process". More specifically the memo reads, "The steps of this process are: Step 1—conceptual planning, represented under the Program primarily by master plan development and approval; Step 2—preliminary design and cost estimation, as well as environmental (NEPA and ESA) review; and Step 3—final design review prior to construction and operation." This process has been hugely successful for the Coeur d' Alene production facility. As a matter of fact, the recent Tribal decision to phase out the rainbow trout production ponds, decrease water use by 41.6%, move towards a single broodstock, and a successful NEPA compliance process are due to the feedback received through the step 1 review of the project.

Moreover, the Tribe as part of the preliminary step 1 process, updated our Master Plan (approved by both the Council and ISRP) for the Coeur d' Alene Tribe Trout Production Facility based on a site feasibility plan dated September of 1999 by J-U-B Engineering Inc. In the feasibility study, several highly positive attributes were outlined for the present site location they included:

- Good topography for hydraulic flow path of water in and out of the hatchery
- Good topography for effluent discharge and effluent polishing
- Enhanced wetlands creation and mitigation due to existing wetlands on-site
- The Rock Creek flows are significant and available six to nine months out of the year to supplement groundwater supply. (This has been eliminated in favor of an additional groundwater source in the City of Worley)
- And now, sufficient ground water to supply all the hatchery production needs.

Also discussed in the development of the hatchery site was the availability issue. This site has been preserved over time as a one time Pow-Wow ground, and most recently, as a wetland habitat area for natural resource protection. This unique situation makes it an ideal location for a upland hatchery site, with the hatchery effluent augmenting the existing wetlands. Property with similar topography, location for effluent discharge, and ownership is non-existent. The Tribe had thought of an alternative at the shoreline of Lake Coeur d' Alene, however, land ownership and high property values, quickly eliminated the alternative site concept.

The Tribe would conduct an evaluation of alternative facility locations if appropriate levels of funding were allocated to initiate such studies. The Tribe has earmarked the budget for design, NEPA, personnel, and planning costs associated with Step 2 and 3 for **preliminary** and **final** designs, not conceptual Step 1 designs (per April 2000 memorandum). However, the additional tasks as a result of the Three-Step process (water quantity report, rainbow trout cost effectiveness) have been unfunded and have been extracted from the dollars programmed for the conceptual design. Therefore it becomes imperative that additional funding be allocated in order to address this Northwest Power Planning Council request.

Current understanding of the Three-Step Council Process and evidence of how the project has successfully met each step-

Three- Step Council Process Initiated

The Tribe develops a Supplementation Feasibility Report on the Coeur d' Alene Indian Reservation (1998, DOE document 10544-54154). This report concludes with two results: 1) Supplementation is necessary and 2) To propose a production facility for the Coeur d' Alene Reservation.

November 15, 1999 the Tribe submits to the Council a master plan as the first step in the three-step process.

Tribe develops a Coeur d' Alene Tribal Fish Hatchery Site Feasibility Study/Conceptual design for incorporation into the Hatchery Master Plan.

Council directs Coeur d' Alene Tribe to submit Master Plan

The Coeur d' Alene Tribe submits the amended Hatchery Master Plan and supporting documents (including the Supplementation Feasibility Report and the Program Management Plan) to the ISRP for their review. The reviewers (ISRP) commented on each of the responses by the Coeur d' Alene Tribe to the questions asked by the Council as part of the three-step review. The ISRP members then discussed their reviews via teleconference and identified areas where more information was needed from the Coeur d' Alene Tribe and drafted a preliminary review. This preliminary review was discussed with the full ISRP. Consensus reached on the approach, and questions to obtain further information from the Coeur d' Alene Tribe were refined. After exchanges between the ISRP and the sponsor on the information needs the ISRP reviewer then presented their findings to the entire ISRP and consensus was reached. The results of the peer review are reviewed with the project proponents and form the basis for Fish and Wildlife Committee recommendations to the Council on the scientific aspects of the project.

The Master Plan peer review resulted in 34 questions and responses to technical and procedural issues. The ISRP recommended that additional clarification and information was needed on certain aspects of the project. This included the following

- Goals of the project as it related to overcoming the physical and biological issues, and lake habitat

- Factors limiting production of the target species and the methodology employed in determination
- Alternatives for resolving the resource problem as it is related to lake habitat, flow regulation, physical constraints and predator control of introduced species. In addition the need to explore the use of a single brood stock.
- Conceptual design of the proposed production and monitoring facilities, including an assessment of the available and utility of existing facilities as it relates to the proposed water supply.

The above information requests were resubmitted to the proponents for additional clarification. The Coeur d' Alene Tribe provided a written response to the questions. The ISRP reviewed the responses and developed a second set of questions to discuss with the Coeur d' Alene representative via teleconference. The additional information needs focused on the following:

- The detrimental effects of hatchery-bred trout on existing trout populations
- The hatchery's water supply

The teleconference took place on February 7, 2000. The ISRP reviewers then presented their findings to the entire ISRP and consensus was reached.[1]

The results of the ISRP review and conditions regarding the water supply, rainbow trout costs and information needs were reviewed with the project proponents and formed the basis for the Fish and Wildlife Committee recommendations to the Council on the proposed actions for this project. The recommendations by the Council and the Tribe's efforts to address them are listed below:

> "Recommend that a sufficient sustainable water supply be verified as required by the conceptual plan for the hatchery"

Results-The Tribe initiated a year long study with the results described in the report entitled *Analysis of Well Yield Potential for a Portion of the Coeur d' Alene Reservation near Worley, Idaho.* Subsequent letters of definition and clarification have also been provided by Dr. Dale Ralston, hydrogeologist.

> "Recommend that BPA and the Coeur d' Alene Tribe make a determination and provide a recommendation on the most cost effective means to provide trout for the catch out ponds"

Results-The Tribe has reviewed the cost effectiveness of the rainbow trout ponds and have elected to defer the construction of the ponds due to initial cost-savings, and more importantly, a substantial decrease in the water consumptive rates needed by a cutthroat only facility.

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[1] Excerpts from memorandum from Mark Fritsch to Fish and Wildlife Committee

> "Recommend that the Bonneville Power Administration fund preliminary designs of the Coeur d' Alene Tribe Trout Production Facility after the water quantity and rainbow trout issues are resolved"

The Coeur d' Alene Tribe has effectively dealt with the issues and feel that they have met the criteria in the Three-Step process to move forward with the development of preliminary designs. The Council has stated in the April 5 memorandum "the program requirements for this project appear to have been met. Master planning elements have been addressed. ISRP step review has found these efforts to adequately address the program except for some minor issues that can be addressed during preliminary design and reviewed as part of the Step 2 review.

The Council direction to the Tribe is further articulated by the following recommendation:

> "Recommend that additional information be developed relative to three technical areas for consideration during the Step 2 review. These include: 1) the development of a harvest plan in conjunction with the monitoring and evaluation plan, 2)monitoring behavior of the facility produced trout to prevent displacing wild spawned trout in Lake Coeur d' Alene, and resulting displacement of wild spawned trout from limited habitat"

The Tribe fully intends on addressing these issues once the approval is given to proceed to preliminary design work.

<u>Alternatives reviewed and rejected by the Council</u>

1. Reject funding for Step 2 (preliminary design) activities

The Council might terminated the production facility at this time if the project:

- Costs are too high for the expected benefits
- Production is not needed
- Expected benefits can be obtained in some other manner
- Risks are unacceptable and cannot be reduced

The Council staff expressed that they did not believe that any of these factors apply to the production facility based on information presented in background documents and in ISRP review. For those reasons, the staff did not recommend this alternative.

2. Require further review to address unanswered concerns

The Council could decide that there are significant concerns and risks that are unacceptable and need to be further addressed. This could be due to cost/ and or biological concerns. The Council staff believed that the current reviews, coordination, and study designs to date have addressed concerns sufficiently to justify the proposed expansion of the project's production. The staff recommended against this alternative as well.

Provincial Rolling Review/ISRP Review

As part of the Council's provincial rolling review, the Coeur d' Alene production facility underwent a separate review, outside of the three-step process, to evaluate the project in context with the other provincial projects. A project review/ISRP presentation was conducted in Kalispell, Montana and written comments were made by the ISRP. The ISRP raised questions that were being addressed in the Three-Step process by the Tribe. Additionally, the Tribe provided responses to ISRP comments. These issues were covered in the step 1 process, and those that were not have not been authorized as a Step 2 activity. The Tribe feels that the Three-Step process has worked, and has led to some very important decisions, such as water quantity understandings, deferring rainbow production ponds, maintenance of a single stock of adfluvial cutthroat trout in the facility. The Tribe prefers to progress positively through the identified benchmarks established by the Council.

Current Status of Review

Consistent with the Council's Three-Step Process, the Coeur d' Alene Tribe recently submitted the water quantity report and results of the rainbow trout production cost effectiveness. Both responses moved the project towards a more effective, responsible, and cost-effective facility. However, it appears that the Provincial Review and an additional round of ISRP review and comments are precluding the decision on moving forward with preliminary designs.

It is understood that there is some efficiencies in allowing the information from the provincial review to be considered in the development of the preliminary designs (within Step 2). The Tribe understands that the review results will be made available sometime in May. With that understood the Tribe fully intends to incorporate constructive concerns into the preliminary design elements, once the Council has approved the work done required in Step 1 review.

Furthermore, the Council has added that an evaluation of alternative facility locations be implemented during the time between now and May. The Tribe welcomes that level of information going into the development of the preliminary plans and is requesting additional funding to ascertain such an assessment. The Tribe will also be working on incorporating into the conceptual design, the deferment of the rainbow trout ponds and the associated infrastructure changes.

The Tribe looks forward to including all of this important information and review into our Step 2 preliminary designs. We have clearly understood the function, benchmarks, expectations, and deliverables of the Three-Step process and truly feel that the process provides a higher level of scientific accountability and accountability. By our meeting each and every expectation contained herein, we look forward to the construction of our peer reviewed facility.

The Tribe would like to conclude by clearly stating our expectations. Based on the results and modifications throughout the three-step process, the facility will be built. This facility will provide partial mitigation for lost anadromous resources above the blocked areas. These expectations are based on our clear understanding of the three-step process (to allow for the best possible peer reviewed design of a facility). The Tribe has, in good faith, met each and every element of the Council's Three Step process and feels that the results and modifications made thus far, should allow the Tribe to move through the preliminary design phase as called for in the three-step process. Without question, the production facility is clearly being developed using the best scientific foundation for the subbasin and should be commended for that. Despite previous comments all the agencies and Tribes with the legal responsibility for management of the fisheries resources (Coeur d'Alene Tribe, IDFG and USFWS) in the subbasin agree that this facility is scientifically justified and with as much certainty as can be assured believe that it will meet its goals for both production and harvest. We welcome the additional review (with the understanding that it may take longer and require additional funding to complete) and comments through the remaining steps of the Council's process.

Sincerely,

Ernest L. Stensgar
Chairman
Coeur d'Alene Tribe

cc: NWPPC Members
Bob Lohn, Mark Fritsch, and Doug Marker, NWPPC
Sarah McNary, Bob Austin and Brad Miller, BPA
Rodney W. Sando, IDFG
USFWS

Attached document: NPPC Response Letter to the Tribes conditional step 1-2 submittal.

RP/rp

Apparently habitat condition has been monitored for at least several years as a basis for identifying and implementing locally based watershed restoration projects. Details of these assessments and how they are used to set priority should be described in the proposal.

Part of the proposal is a new position to develop and implement methods and strategies for limiting human-bear conflicts. Such a position seems like a logical step to help prevent bear-human conflicts, but is difficult to assess from a technical point-of-view. The FTE required depends on the magnitude of the problem. If each project is tracked after completion, however, why not create documentation of these post-project effects for future planning and evaluation?

There is a policy issue on how this relates to Montana's wildlife program under the Fish and Wildlife Program, some of this is like traditional wildlife property acquisition, but this issue appears to be explained in the CBFWA comment below.

CBFWA Comments: There is an agreement between BPA and MDFWP regarding wildlife credits for the state of Montana. The CSKT is not a signatory to that agreement and believe that most of the credits to date have occurred in areas that are not accessible to tribal members. An adequate M&E plan is presented in the proposal, but a direct link to objectives is not clear.

ProjectID: 199004402

Coeur D' Alene Tribe Trout Production Facility
Sponsor: Coeur d' Alene Tribe
Subbasin: Coeur d'Alene
FY02 Request: $775,469
3 YR Estimate: $2,516,120
Short Description: Enhancement of native stocks of CTT into natal tributaries by utilizing native CTT broodstocks and providing RBT for an interim fishery.
CBFWA Recommendation: High Priority
ISRP Recommendation: Do not fund
ISRP Comparison with CBFWA: Disagree - do not fund
ISRP Comments:
Do not fund. Despite the volume of the response, little was provided to clarify the ISRP's major uncertainties with regard to the proposed project. The proposal, presentation, and response did not instill confidence that this project would be successful. The tribes' overall program, including the "sister" proposal 199004400 Implement Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation, is based on a premise that westslope cutthroat populations are depressed because of degraded habitat and, if the habitat is renovated, the populations will respond favorably. However, if that is the case, why is it logical to stock hatchery fish? The proposers gave limited consideration to the possibility that other downstream factors (e.g. predation) may actually be limiting population size.

The objectives of the program, as presented in the original proposal and the response, focus nearly exclusively on attempting to reestablish adfluvial westslope cutthroat trout to harvestable levels in the target streams. Despite relatively encouraging previous reviews (FY 1999, 2000, Step 1 review of the 3-Step process), the contents of this proposal, discussions during the oral presentation, and the review response have led the ISRP to be increasingly convinced that the proposed hatchery program for adfluvial cutthroat trout does not appear to be scientifically justified. The ISRP believes the project's objectives are not likely attainable for the following reasons.

In spite of the general lack of consideration of downstream mortality factors in the proposal and response, the proposers made a case for the adfluvial cutthroat using the Lake Coeur D'Alene littoral zone as a critically important part of their post-migration life cycle. The wide, shallow south-shore littoral zone of Lake Coeur D'Alene has a large population of primarily non-native predatory fish that are thought to exert significant predation pressure on the young adfluvial cutthroat trout. The proposal fails to address this ecological issue in any meaningful way; thus increased smolt outmigration from the proposed hatchery facility likely will simply feed a downstream predator trap. Consequently, the ISRP believes the proposed project will fail to meet its short- or long-term objectives. This point was the basis of the ISRP general comment in Step 1 of the 3-Step review for the project to focus on resident life history patterns:

> *"The approach to restoration of Coeur d'Alene westslope cutthroat trout populations on reservation lands might be most successful if it focused on stream habitat restoration and on the resident, rather than the adfluvial, life history pattern. While an overall project goal is to increase adfluvial fish, which due to their larger size present the best harvest opportunity consistent with the tribe's goals, a biologically viable approach might be to focus on increasing resident westslope cutthroat trout abundance in tributary streams – including reintroduction into streams where they have been extirpated or are at very low numbers."* (ISRP 2000-1: Review of Coeur d'Alene Tribe Trout Production Facility Master Plan, page 3).

Although this predator problem was raised as "general comment" in the 3-Step rather than a specific condition, after this provincial review process the ISRP has become increasingly convinced of the potential severity of this problem and now raises the adfluvial component as a critical shortcoming of the proposed approach.

The second issue is the assessment of the fish abundance goals set for fully recovered trout populations in the four target streams. The goals provided (described in the "sister" proposal 199004400 Implement Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation) are those generated by the Tribe's Habitat Quality Index model. It appears that these target values would guide the use of hatchery supplementation (proposed here) and habitat restoration (proposed in 199004400) to achieve maximum fish density in each square meter of stream, especially in the lower stream portions that historically were probably only passage corridors. Thus, the review panel is concerned that these fish abundance goals might be inflated and unattainable.

An additional problem that emerged in the presentation was that the proposers data strongly support habitat as a primary limiting factor for their fish, in which case a hatchery-stocking program is counterproductive. The statements in the 3-Step materials that suggest it will take 50-100 years for habitat recovery to occur are unsubstantiated with the data, and the data the proposers presented in Kalispel suggest the opposite; that habitat actions have very quick effects. The proposers have provided inadequate evidence that the current environment can support the numbers of fish they want to add, and they have good evidence that wild fish increase well when habitat factors are not limiting. Adding hatchery fish to a system that cannot support more fish now is likely to further reduce the remaining wild native fish (apparently healthy in a few streams).

In the preliminary review, we noted that we anticipated potential future interaction with personnel in this project following the response loop; however, after reviewing the response the ISRP did not consider further communication necessary to make this recommendation.

CBFWA Comment: This project is requesting a placeholder for a hatchery facility that is currently moving through the 3-step process. Several questions were raised about the proposal during the provincial review process that will be addressed during the 3-step process. The scientific validity of this project will be determined during the 3-step process. The objectives stated in the proposal are tasks and do not indicate the overall objective of the proposal. Monitoring and evaluation are proposed but whether they will meet objectives cannot be determined if those objectives have not been presented. The proposal is for a supplementation hatchery to provide harvest for the CDAT. The hatchery is clearly being developed using the best scientific foundation for the subbasin and should be commended for that. It is difficult to apply these criteria based on science when the ultimate goal of the project is for harvest benefit. IDFG and MDFWP support much of the proposal, but has difficulty supporting the supplementation component of putting fish into the streams based on the cost effectiveness aspect.

May 7, 2001

Mr. Mark Walker, Director of Public Affairs
Northwest Power Planning Council
851 SW 6th Avenue, Suite 1100
Portland, Oregon 97204-1348

Dear Mr. Walker:

The Coeur d' Alene Tribe would like to submit the following information pursuant to the ongoing provincial review process and the Three-Step hatchery review. The Tribe has been actively engaged with staff of the Northwest Power Planning Council, Bonneville Power Administration and regional scientists towards maximizing the positive design of our habitat restoration programs and our cutthroat production facility. To this end, we have collectively identified the following areas for continued discussion- 1) Cutthroat Trout Facility (199004402) including; ISRP comments relevant to the facility Monitoring and Evaluation Plans, and harvest targets, potential site alternatives and water availability options, and adjusted budgets for FY 2001 and 2002 and 2) Implement Fisheries Enhancement Opportunities on the Coeur d' Alene Indian Reservation (199004400)

The Tribe specifically acknowledges the extremely valuable products that have been produced to date and would like to work with the Council and the ISRP to further define the conceptual merits of the hatchery facility. The following represent the successes of the Three-Step review process:

- A conceptual design of a Coeur d' Alene Tribe cutthroat facility.
- Feasibility report outlining conceptual needs of facility
- Ground-water availability for several geographic locations on the Coeur d' Alene Reservation
- Elimination of the rainbow trout pond facilities at the hatchery. (Thus allowing for the discussion of an alternate lake site location based on the eliminated risk of introduction into Coeur d' Alene Lake)
- Successful Environmental Assessment for the facility
- Further development of project Monitoring and Evaluation components
- Interdisciplinary Team interactions, input (USFWS, BPA, IDFG, regional scientists)
- Updated timelines and budgets based on review results

These results and products reaffirm the validity and usefulness of a Council directed Three-Step process. These products can be used as a foundation for any additional facility improvements.

CUTTHROAT TROUT FACILITY

The ISRP final report for the Mountain Columbia Province recommends that the westslope cutthroat hatchery on the Coeur d' Alene Indian Reservation not be funded because the project does not appear to be scientifically justified. The ISRP has several concerns with hatchery operations, thus this concept paper is an effort to incorporate those concerns within the Three-Step Process and move forward with the project using, in part, ISRP knowledge to assist the Tribe reach harvest objectives.

The Coeur d' Alene Tribe has responsibly chosen to utilize native, locally adapted populations of westslope cutthroat as a subsistence fishery. Using native, locally adapted species allows the Tribe to realize a subsistence fishery of cultural significance while limiting risks to wild populations. Therefore, hatchery operations and wild fish restoration efforts are not conflicting.

The ISRP has revealed potential factors that may prevent the Tribe from achieving harvest objectives. The Tribe views the ISRP concerns as a constructive means of reaching desired project objectives. Therefore the Tribe proposes to address ISRP concerns in the following way:

1. Predation Issues

The Coeur d' Alene Tribe has collected relative abundance data in Coeur d' Alene Lake since 1994. However, predator diet analysis has not been done, thus conclusions regarding cutthroat mortality due to predation are speculative by both the Tribe and the ISRP. The Tribe has interpreted results of relative abundance data, concluding predation was not likely to limit hatchery success.

- Beach seining surveys completed through September 2000 captured 16 species and a total of 2,716 fish. Potential predators of juvenile westslope cutthroat included largemouth bass, northern pikeminnow, northern pike, and chinook salmon. These potential predators accounted for less than 5 % of the total catch. Yellow perch comprised 37% of the catch and westslope cutthroat comprised 2% of the catch.
- Electrofishing surveys conducted through October 2000 collected a total of 13,077 fish. Potential predators of juvenile westslope cutthroat sampled using electrofishing gear included largemouth bass (12%), chinook salmon (<1%), northern pike (<1%), northern pikeminnow (8%), and smallmouth bass (<1%) for a total relative abundance catch of 21%. Further, yellow perch comprised 22% of the catch versus 1% westslope cutthroat.
- Gillnet surveys conducted through October 2000 collected a total of 2,321 fish. Potential predators of westslope cutthroat included northern pike (2%), northern pikeminnow (20%), and chinook salmon (<1%) for a total relative abundance catch of 22%. Yellow perch comprise 43% of the gillnet catch versus 1% comprised of cutthroat.

These data are the most recent, best available science and are representative of annual data collected since 1994. Depressed populations of westslope cutthroat found in the catch are commensurate with depressed tributary outmigrations. Thus, qualitative analysis of the data suggests that cutthroat populations are not experiencing severe depletions from predation. Throughout all of the sampling gear methods, cutthroat maintain roughly 2% of the catch. Predation on cutthroat likely occurs opportunistically, however yellow perch are likely the target prey.

Recognizing that this analysis is speculative, the Tribe recommends, as part of a Monitoring and Evaluation Plan, to conduct a thorough diet analysis of potential cutthroat predators, which include largemouth bass, northern pikeminnow, northern pike, smallmouth bass, and chinook salmon. If the results of the diet analysis suggest that predation will negatively impact the hatchery success, then the Tribe will begin programs targeting the management of predatory fish such that cutthroat objectives are met.

Further the Tribe has identified the following options to address potential predator limitations:

a. Experimental acclimation facility as the project approaches full capacity: The current hatchery operation calls for fingerlings to be acclimated in water in each of the respective target watershed. The release strategy is volitional with expectations of fish returning as adults. Donor hatchery stock will be derived from each respective target watershed. For this reason, achieving the full hatchery capacity will take several years. During the time, from start up to full capacity, we will be able to examine the effectiveness of acclimation/volitional release design on one target tributary, thus determining the effectiveness of this operation at achieving stated objectives.
b. Experimental net pen facility to compare successes: In addition to testing the acclimation/volitional release design, we recommend testing a net pen operation. If it is found that volitional release strategies are contributing to the predator trap in the Lake, then over wintering fingerlings to catchables may alleviate predatory pressure and facilitate the harvest target.

2. Harvest/Targets

It is necessary to re-emphasize that the proposed hatchery facility is designed to support a subsistence harvest resource. The Tribe has identified a harvest objective of 42,000 fish annually. This harvest is projected to occur among three age classes (2-4) and is based on historic tribal harvest estimates outlined in Scholz et al. (1985). It may be appropriate to re-adjust harvest objectives to accommodate community objectives, such as catch per unit effort targets rather than total harvest.

Population models may allow us to more precisely estimate harvest availability. Population models are only as good as the data, therefore, model development will take many years. While diet information is being collected, we will collect cohort and mortality information that will establish a baseline. As experimental release options are examined we will develop the most successful operation strategy relative to objectives.

Coeur d' Alene Lake is capable of supporting cutthroat populations that meet and exceed current harvest estimates. However, as the ISRP has acknowledged, many factors may prevent harvest objectives from being met. Using tools and data available, the Tribe further proposes to examine current resource demands, refine harvest objectives to reflect tribal goals, and propose hatchery and ecological management strategies that will meet stated objectives.

3. Potential Site Alternative Analysis and Water Availability Options

Pursuant to recent comments/discussions, the Tribe agrees to compile additional information for Step 1. This information would address a cost opinion that reflects needs associated with potential sites immediately adjacent to Coeur d' Alene Lake. This alternative site analysis becomes much more acceptable based on recent Tribal land purchases and the elimination of risks associated with the previous plans of rainbow trout ponds. A cost to benefit analysis will reveal the most effective approach. Additional funding will be required to develop the total cost of such an alternative.

4. Additional Step- 1 Needs

Based on the needs identified during the provincial review process, additional funding will be required for proper implementation. They include:

2001- Revise scope of work to include all work associated with additional Three-Step process needs. (Diet analysis, revised M&E plan, potential modifications to hatchery objectives, alternative site evaluation) Estimated budget- $320,000

2002-2004- Preliminary Habitat assessments for potential streams to be stocked for mitigation purposes. Included are all low elevation tributaries of Coeur d' Alene Lake as described in the project proposal. Approximate budget as described in project proposal- $375,000 (with an additional 116,000 annual O&M) and increased 5% annually.

IMPLEMENT FISHERIES ENHANCEMENT OPPORTUNITIES

Project 199004400 – Implement Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation

We appreciate this opportunity to respond to the reviews of Project 199004400 - Implement Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation. In general, we have been appreciative and supportive of all opportunities for independent and scientific review of this project and acknowledge the value of this process in developing a successful program. This project has been reviewed twice before by the ISRP and receives regular review from the regional managers involved with CBFWA, as well as the local scientific and management community. In fact, researchers at the University of Idaho and Washington State University received a USDA grant specifically designed to study and develop the restoration process in one of our target watersheds. We have made sincere attempts to expand and modify the scope of our project to accommodate the constructive responses that are derived from these evaluations and we have a history of adapting our approach in response to the ISRP review process:

> *"The original proposal was generally excellent. The response to the ISRP's questions…was of equally high quality. It is clear that the Tribe has thought through their management strategy, has emphasized native stocks, but also needs some interim fishing opportunities to take pressure off the native fish restoration efforts." (ISRP 1999-4).*

As proponents of a habitat enhancement project, we have been especially cognizant of the need to balance implementation efforts with project monitoring to demonstrate benefits over time. We have taken pride in always forwarding a program that is rooted in improving natural processes and applying restoration principles at the watershed scale to maximize the benefits to native fish and wildlife. We are successfully implementing projects that address the non-point source pollutants and critical habitat problems that limit fish populations in our target areas. Monitoring activities to date have focused on project-level evaluations, which establish baseline values and track trends in populations and water quality parameters over time. This approach has been commended by the ISRP in past reviews:

> *"(This project) has many strengths: a strong watershed/ecosystem approach in collaboration with other projects, a well thought out scientifically rational approach, a strong monitoring program, an emphasis on improvement through natural processes compared to human technological intervention, an emphasis on native species of fish and plants, and an awareness of the need to obtain public support, over a relatively long time frame, via education and demonstration of success. We stand to learn and gain a lot from this project.*
>
> *This was a well-written and comprehensive proposal. Reviewers especially commended the project's emphasis on the conservation/enhancement of native species, and on habitat improvement as a mechanism. In addition, the relationship to other projects is very strong and well documented. The project history is clearly explained.*

Objectives and methods are concisely related. Taken on balance, this project proposal is very compelling, well thought out and clearly articulated.

There is a good history of accomplishments. There are good objectives and tasks for 4 target watersheds. There are good sections on background and rationale, as well as excellent history, and objectives narratives. The methods narrative of objectives by tasks is excellent." (ISRP Project Review 2000).

The current ISRP recommendation to fund this project, contingent upon providing a monitoring plan for tracking progress, is understandable and may be reasonable, but it should be noted that this comment represents a departure from the direction given in past review cycles. The condition of our target watersheds has dictated an approach to restoration in which we work with landowners to remove the principle causes of habitat degradation and manage riparian and upland plant communities to improve functional processes over time. This approach has certainly been influenced by the comments and recommendations we have received during this review process. Monitoring restoration efforts in this context requires the commitment to be both large in area and long in duration to provide the spatial and temporal context needed for policy adjustments. It is unreasonable to expect measurable increases in cutthroat populations in the time frame in which this project has been implemented.

We maintain, however, that the current level of project monitoring is well justified and is sufficient to show trends in fish abundance and distribution, macroinvertebrate community indices, and water quality variables over time. For example, EPA's Rapid Bioassessment Protocols for assessing macroinvertebrate communities comprise one part of our project level-monitoring plan. This approach has been widely acknowledged to yield more insight into the ecological health of watersheds than single species population estimates as they integrate organism and community responses over time and space. These same protocols are currently used by all states in the Pacific Northwest to assess and monitor habitat and water quality improvement initiatives. Similarly, the effectiveness of riparian treatments is assessed by measuring cover, density and biomass over time as described by Platts and 12 other authors (1987) and in the Standard Methodology for Conducting Watershed Analysis (Washington State Forest Practices Board 1997). Abundance and distribution of fishes is assessed annually at 95 sample sites within the four target watersheds. Also, spawner abundance and number of juvenile offspring are tracked for each migratory population. We are hopeful that this data can be used to develop a parent-offspring relationship to reflect habitat productivity, as called for by the ISRP. No single evaluation method is perfect, however, the techniques we are employing represent a comprehensive set of peer-reviewed methods.

The ISRP is now calling for "an experimental design to test major hypotheses concerning habitat condition and resident trout production." We are prepared to implement such a monitoring program, however, the NPPC should be aware of the implied tradeoffs in this approach. Implementing the more intensive monitoring approach advocated by the ISRP may require a shift in the relative amount of effort delegated between implementation versus monitoring and evaluation in our program. Initially it will mean providing additional training for technical staff as well as the time to standardize new monitoring protocols.

We have already developed and published a fisheries management plan pertaining to this project, in which a monitoring strategy, guidelines and techniques are identified (Lillengreen, Vitale, and Peters 1998). We are well prepared to initiate this integrated multi-level monitoring and evaluation program that combines baseline, implementation, effectiveness and project level monitoring. Some of the specific monitoring techniques and strategies employed in this project were described and justified in our proposal and in our initial response to the ISRP review. We remain committed to reviewing the scientific literature to identify additional methods that could improve our existing monitoring strategy. We will work with our BPA contracting officer in 2002 to develop a scope of work that integrates these and other techniques into a cohesive mechanism for continuing to monitor project progress. As requested, an analysis of the data generated from monitoring efforts will be provided in annual reports and during the next review process.

The ISRP expressed some concern with project accountability and the demonstrable benefits given the duration of the project. We are particularly concerned with the perception that this project "does not demonstrate significant benefits" and that "benefits to fish and wildlife are marginally justified". We feel these comments may be the result of a misconception about the duration and nature of project activities in that, while this project has been ongoing since 1990, implementation did not begin until 1995 and 1996. During the first five years of this project, a tremendous amount of data was collected to assess watershed conditions, identify limiting factors and prioritize restoration efforts. The data and resulting analyses are well documented and culminated in the planning document, *Coeur d'Alene Tribe Project Management Plan: Enhancement of Resident Fish Resources within the Coeur d'Alene Indian Reservation* (Lillengreen, Vitale and Peters 1998). These efforts have been invaluable in establishing the need for restoration on a watershed scale and in preparing the affected landowners for the uniform implementation of our restoration strategy. As an assessment and planning tool, the importance of this effort cannot be underestimated.

Additionally, work has progressed on 42 individual projects implemented between 1995 and 2000. Long-term agreements have been signed with 12 landowners in three watersheds, providing protection and enhancement for more than 850 acres of upland and riparian habitat and 4 miles of stream channel. Eight acres of constructed wetlands have reduced non-point source pollution from 630 acres of farm land and vegetative treatments have been applied to a total of 127 acres of riparian wetlands affected by agriculture or described as under stocked forestlands. More than 50,000 trees and shrubs have been planted over a five year period to enhance water retention and riparian function. Instream habitat improvements have elicited positive responses from target fish stocks at many sites.

These accomplishments represent an unprecedented level of activity to restore native habitats and species in the Coeur d'Alene Subbasin and have wide-ranging implications. Partnerships have been developed with seven federal and state agencies and local universities that provide cost shares for implementation, monitoring and evaluation activities. Through these partnerships, this project has helped to shape the work of adjacent land managers and foster a more cohesive approach to landscape level restoration on the Reservation. Education and outreach efforts have involved more than 3000 students from four counties and six school districts in our project during the past six years alone. This work is having the largely immeasurable benefit of shaping a conservation ethic in the biologists, teachers, and natural resource managers of tomorrow. Moreover, the voluntary participation of private landowners today represents a long-term commitment to changing land management on some of the most degraded lands in the target watersheds. These results represent benefits that do not readily and/or immediately translate into numbers of fish, but nevertheless are attributable to our efforts and provide the backdrop for making significant changes over time.

The basis for this project is mitigation for lost anadromous fisheries 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. We intend to apply our management principles within the Coeur d'Alene subbasin until such time that viable subsistence fisheries are supported within our homelands. We would like to acknowledge the constructive review efforts of the ISRP and CBFWA and are confident that we can incorporate some of their suggestions into the scope of work for this project. We hope that we have provided additional information that may shed light on our approach to fisheries enhancement activities as embodied in our proposal and supporting documentation, as well as identify a clear direction for this project in the future.

CONCLUSION

Again, these project specific comments represent the continued effort to address issues raised as a result of the Council's provincial review process. We feel that this iterative approach for project design will provide the necessary assurance for the Tribe to realize their mitigation goals. We look forward to your continued support and review of these important Tribal programs and look forward to providing additional specificity as necessary.

Sincerely,

Ronald L. Peters, Fisheries Program Manager
Natural Resource Department, Coeur d' Alene Tribe

Comments for Fish 4

The Coeur d'Alene Tribe would like to offer an approach to funding projects # 199004400 and # 199004402 that specifically makes use of the extremely valuable products that have been produced to date. The Tribe would also like to work with the Council and the ISRP to further define, through the Step process, the conceptual merits of the Tribes very important mitigation program.

199004400

The Tribe feels that project 4400 should be funded in whole. To break the project up into specific components and fund only portions would create undue burdens for the project proponents. The Tribal staffs duties cross over all four phases of the project thus, eliminating one phase arbitrarily would create inefficiencies that most likely would jeopardize the success of the entire project. A reduction in funding would require a complete restructuring of the project objectives and tasks. The current expansion of the project is in two areas 1) Implementation – in response recent opportunities the Tribe is proposing to step up the implementation schedule. And 2) Monitoring and Evaluation – in response to recent ISRP concerns we reevaluated our M and E program and made appropriate changes.

199004402

Pursuant to recent comments/discussions, the Tribe agrees to compile additional information for Step 1. This information would address a cost opinion that reflects needs associated with potential sites immediately adjacent to Coeur d' Alene Lake. This alternative site analysis becomes much more acceptable based on recent Tribal land purchases and the elimination of risks associated with the previous plans of rainbow trout ponds. A cost to benefit analysis will reveal the most effective approach. Additionally, the Tribe recommends, as part of a Monitoring and Evaluation Plan, to conduct a thorough diet analysis of potential cutthroat predators, which include largemouth bass, northern pikeminnow, northern pike, smallmouth bass, and chinook salmon. If the results of the diet analysis suggest that predation will negatively impact the mitigation programs success, then the Tribe will begin programs targeting the management of predatory fish such that cutthroat objectives are met.

Additional funding will be required to develop the total cost of such an alternative.

Based on the needs identified during the provincial review process, additional funding will be required for proper implementation. They include:

2001- The Tribe will need to revise the current scope of work to include all work associated with additional Three-Step process needs. (Diet analysis, revised M&E

plan, potential modifications to hatchery objectives, alternative site evaluation) Estimated budget- $320,000 to be contracted from the $ 3,545,000 currently reserved for construction of the facility.

2002-2004- Preliminary Habitat assessments for potential streams to be stocked for mitigation purposes. Included are all low elevation tributaries of Coeur d' Alene Lake as described in the project proposal. Approximate budget as described in project proposal- $375,000 (with an additional 116,000 annual O&M) and increased 5% annually.

Based on the results of the Three-step process the Tribe would like a placeholder for the appropriate amount of funds to construct a facility, if warranted. The Tribe would also desire that it be recognized that this is a continuing effort (Ongoing Project) by the Tribe, Council and BPA to move the project through the Three-step process and not a new initiative.

Scope of Work/Budget
for the
Coeur d'Alene Trout Production Facility
for
FY 2001 –2004

Prepared for: Mark Fritsch
Prepared by: Ron Peters

May 2001

Investigations of alternative site feasibility study for the

Coeur d' Alene Trout Production Facility

Scope of Work

Need Statement/Background

The Northwest Power Planning Council, the Bonneville Power Administration and the Coeur d' Alene Tribe agree that further investigations into alternative site locations need to be performed. Due to the complexities of groundwater resources in the project area the Tribe wishes to quantify the added benefits (if any) of moving the production facility to a different location. Cost-effectiveness determinations of this alternative site, compared with the original site, will certainly lend itself to the Tribe's final determination.

Project Goals

Determine if an alternative site conclusively provides a comparable site with cost-effective infrastructure. A demonstrable increase (or decrease) in facility reliability, water quality and quantity, water transmission and cost-effectiveness parameters will be ascertained. An Interdisciplinary Team (IT)[1] will be used to review information as a result of the study. This review effort will be similar to Environmental Assessment study review that was performed for the original site. Final analysis will provide an updated cost opinion, and results of the objectives herein. Results of the analysis will be ultimately incorporated into the Facility Master Plan.

Objective 1:

<u>Identify Potential Sites</u>- Potential sites near Lake Coeur d'Alene will be assessed. Proper topography, stormwater review, land availability, and accessibility issues will guide area selection. A parcel investigation will be included in the analysis detailing legal ownership, and assessor information. The primary product will be the selection of a priority site for additional assessments. These sites will be reviewed by the IT.

[1] The Interdisciplinary Team is comprised of the Bonneville Power Administration, Northwest Power Planning Council staff, Idaho Department of Fish and Game, United States Fish and Wildlife Service, Coeur d' Alene Fisheries staff, scientists, and other appropriate stakeholders.

Objective 2:

Preliminary Geotechnical analysis- Geotechnical information will be gathered, consistent with work done for the initial site, to ascertain soil characteristics of the alternative site.

Objective 3:

Water Quality Evaluation- Water from Lake Coeur d' Alene will be sampled to determine the water quality at the determined site. Water quality results will determine the water treatment processes needed for an alternate site.

Objective 4:

Recirculation/Single Pass Assessment- Based on the alternate site location, preliminary analysis will determine whether the facility would use recirculation or a single pass operation.

Objective 5:

Water Transmission/Pumping Requirements- Based on the information available on site topography, location relevant to the lake, pumping requirements will be calculated. Transmission lines from the lift station to the facility will be assessed.

Objective 6:

Water Treatment- Based on the water quality results, proper filtration needs will be assessed and determined.

Objective 7:

Effluent Discharge Analysis- Based on the chosen alternative site location, beneficial usage of the facility effluent will be investigated (e.g. natural wetland opportunities, constructed wetlands, streams, etc.)

Objective 8:

Analysis of alternatives- Based on the results of the aforementioned studies, the newly developed site alternative will be compared to results of the previously described site (Pow-Wow site) and comparisons will be made in each respective area. A modification of project costs (revised engineer's probable cost opinion) for the alternative site will be determined based on the changes anticipated. The IT will consider the results and prepare a final determination based on the results.

Investigations of the Food Habits of Piscivorous Fishes in Coeur d'Alene Lake

Scope of Work

Need Statement/Background

The Independent Scientific Review Panel (ISRP) has expressed concern that adfluvial westslope cutthroat trout (*Oncorhynchus clarki lewisi*) produced by the proposed Coeur d'Alene Tribal Hatchery may enter a predator trap upon outmigration from tributaries into Coeur d'Alene lake. Here we propose to conduct an assessment of the annual food habits of piscivorous fishes in the lake to address this concern.

Based upon piscivorous feeding habits and species composition in the south end of the lake (Coeur d'Alene Indian Tribe unpublished data), chinook salmon (*Oncorhynchus tshawytscha*), northern pikeminnow (*Ptychocheilus oregonensis*), largemouth bass (*Micropterus salmoides*), and northern pike (*Esox lucius*) are presumed to be the principal predators in Coeur d'Alene Lake. The northern pikeminnow is the only species listed above that is native to the Coeur d'Alene Basin. Several studies in the Columbia River Basin have demonstrated the detrimental effects northern pikeminnow predation may have on migrating salmonids (Gray et al. 1984; Poe et al. 1986; Poe and Rieman 1988; Nigro 1989; Petersen et al. 1990a; Petersen et al. 1990b; Willis et al. 1994; Shively et al. 1996; Zimmerman 1999; Petersen 2001).

Although chinook salmon were native to the Spokane River, their migration into Coeur d'Alene Lake was blocked by a migration barrier at Spokane Falls (Scholz et al. 1985). Since 1991, 285,311 chinook salmon have been stocked into Coeur d'Alene Lake (IDFG 2001), an average of 25,831 each year. Chinook salmon are known to be piscivorous (Scott and Crossman 1973; Wydoski and Whitney 1979), therefore, it is important that they are studied and considered a potential predator to cutthroat trout.

Northern pike were first encountered in the Lateral Lakes of the Coeur d'Alene River in 1974 (IDFG 1974). It is thought that they were illegally introduced from Montana waters by anglers. Since this time, pike populations have increased and spread into Coeur d'Alene Lake.

The United States Fish Commission/Bureau of Fisheries stocked largemouth bass in the late 1800s into the Coeur d'Alene System. Currently, the largemouth bass population in the south end of the lake seems to be quite large. Based on Coeur d'Alene Indian Tribe relative abundance data since 1994, 2,760 largemouth bass were captured via electrofishing out of a total of 20,302 fish. Largemouth bass are also in northern reaches of the lake.

Another potential cutthroat trout predator in the Coeur d'Alene System is the native bull trout (*Salvelinus confluentus*). Populations of bull trout are in decline throughout the Columbia River Basin (Skeesick 1989; NPPC 1991). Once abundant in the Coeur d'Alene System, they are now rarely encountered. For example, since 1994, the Coeur d'Alene Tribe has collected 22,048 fish by electrofishing and gill nets from the south end of the lake and only 2 bull trout were collected. Their infrequent occurrence has prompted the United States Fish and Wildlife Service to list bull trout on the Endangered Species list.

Introduced rainbow trout (*O. mykiss*), brown bullhead (*Ameirus nebulosus*), channel catfish (*Ictalurus punctatus*), tiger muskellunge (*E. lucius x E. masquinongy*) and smallmouth bass (*Micropterus dolomieui*) are all potential predators on cutthroat trout as well (Scott and Crossman 1973; Wydoski and Whitney 1979; Becker 1983). Rainbow trout, including kamloops trout, have been stocked widely throughout Idaho, including the Coeur d'Alene System (IDFG 2001). Similar to largemouth bass, brown bullhead were stocked into the Coeur d'Alene System over a century ago. They are abundant in the Coeur d'Alene Tribe's surveys in the south end of the lake. Channel catfish have been heavily stocked into the Coeur d'Alene System for the past two decades. Between 1987-1993, 69,024 were stocked into tributaries of Coeur d'Alene Lake. In 2000, 9,011 more were stocked into the Lateral Lakes of the Coeur d'Alene River. Tiger muskellunge have also been stocked into tributary rivers of Coeur d'Alene Lake. Between 1989-1991, 2,124 were stocked into the St. Joe River. The Coeur d'Alene Tribe has not encountered any tiger muskellunge in their surveys since 1994, however tiger muskellunge may live up to 18 years (Becker 1983), so it is probable that they are still in the system. Smallmouth bass did not occur in the Coeur d'Alene Tribe's relative abundance data until 1997. Since this time, the number captured has steadily increased (Coeur d'Alene Indian Tribe unpublished data). No stocking records for smallmouth bass into the Coeur d'Alene System were found. This indicates that smallmouth bass were likely illegally introduced prior to 1997.

Bioenergetics modeling is becoming a standard practice to investigate the impacts of predators on their prey (Boisclair and Leggett 1989; Hansen et al. 1993; Ney 1993; Bowen 1996; Brandt 1996; Madenjian et al. 2000). Bioenergetics models estimate food consumption based upon species specific physiological data such as respiration (basal and active metabolism), specific dynamic action, energy lost to excretion of wastes, and energy converted into somatic or gonadal growth; all are functions of temperature (Warren and Davis 1967; Kitchell et al. 1974; Brett and Groves 1979; Stewart et al. 1983; Adams and Breck 1990). Bioenergetics models can be used to determine the impact of predatory fish on specific prey (Kitchell et al. 1974; Kitchell and Breck 1980; Rice 1981; Stewart et al. 1983; Rice and Cochran 1984; Boisclair and Leggett 1989; Petersen and Ward 1999; Hansen et al. 1993; Ney 1993; Petersen and Gadomski 1994; Whitledge and Hayward 1997; Zimmerman and Ward 1999).

Bioenergetics models developed for one species in a particular region of the country often work reasonably well in other regions as well (Rice and Cochran 1984; Boisclair and Leggett 1989; Hansen et al. 1993; Whitledge and Hayward 1997). Bioenergetics models for predators found in Coeur d'Alene Lake include: 1) northern pikeminnow (Gray et al. 1984; Poe et al. 1986; Vigg and Burley 1989; Petersen and Gadomski 1994; Willis et al. 1994; Petersen and Ward 1999; Zimmerman and Ward 1999), 2) largemouth bass (Rice 1981; Rice and Cochran 1984; Whitledge and Hayward 1997), and 3) northern pike (Niimi and Beamish 1974; Diana 1983; Armstrong 1986; Lucas and Armstrong 1991; Lucas et al. 1993). At this point, models have not been found for chinook salmon, tiger muskellunge, smallmouth bass, channel catfish, brown bullhead, rainbow trout, or bull trout.

To be useful for determining the impact of a predator on its prey, in addition to requiring specific physiological data, bioenergetics models require information about the population sizes of the predator and prey being modeled (Stewart et al. 1983; Hansen et al. 1993; Ney 1993). This information is not currently available for Coeur d'Alene Lake.

Because models are not developed for all species being considered and population information for both predators and prey are unavailable for Coeur d'Alene Lake, bioenergetics modeling is a practical impossibility with limited funding. (An estimate to collect all of the data required for a bioenergetics model for each predatory species in a system the size of Coeur d'Alene Lake would be approximately $500,000 to $1,000,000). Consequently, the focus of the proposed study will be to collect food habits data as recommended by the American Fisheries Society (Bowen 1996).

The annual food habits for each of the major predators (chinook salmon, northern pike, northern pikeminnow, and largemouth bass) will be estimated, as well as other potential predators (bull trout, rainbow trout, smallmouth bass, channel catfish, brown bullhead, tiger muskellunge) when encountered. Indices based on frequency of occurrence, relative numbers, and relative weight (wet and dry) of prey items in the diet will be reported and combined into a relative importance index. Relative weight and the relative importance index of cutthroat trout in predator diets will indicate the significance of cutthroat trout in the diet. This will necessitate collecting information about organisms other than fish in the diets.

Relative abundance of prey fish data will be collected based on randomized electrofishing and gill net surveys. Prey selectivity will be calculated using an electivity index that compares the relative abundance of cutthroat trout in the piscivore diets to the relative abundance of cutthroat trout in the environment (Ivlev 1961; Strauss 1979; Crowder 1990; Bowen 1996). This index will also provide a measure of the importance of cutthroat trout in predator diets. For example, if cutthroat trout are relatively abundant in predator diets in comparison to the environment, it could indicate that predators are selecting cutthroat trout over other species

Because skin and muscle of fish prey is digested more rapidly than the carapace and exoskeletons of zooplankton and benthic macroinvertebrate prey, fish identification will need to be made using a key of diagnostic bones for fish known to occur in Coeur d'Alene Lake. Regressions of bone length to total fish length will be made in order to estimate the size of the prey fish eaten by the predator (Scott 1977; McIntyre and Ward 1986; Scharf et al. 1997). This regression will enable us to determine the sizes of particular prey eaten by different sizes of predators. Such information may be used by hatchery managers in determining the size of fish to be stocked that will result in the lowest frequency of predation.

Project Goals

1. Determine if cutthroat trout are an important component in the diet of the four principle predators (chinook, largemouth bass, northern pikeminnow, and northern pike) in Coeur d'Alene Lake. Data will also be collected on other potential predators (bull trout, channel catfish, tiger muskellunge, brown bullhead, rainbow trout, smallmouth bass) when encountered.
2. Provide baseline data about current diets of predatory fish that can be used for comparison after stocking of hatchery reared cutthroat commences.

Objectives &Tasks (methods)

Objective 1:

Construct a bone key for fishes in the Coeur d'Alene System that can be used for identifying digested fish prey in the diet of piscivorous fishes. Previously published bone keys will also be utilized in this study (Harrington 1955; Crossman and Casselman 1969; Scott 1977; McIntyre and Ward 1986; Scharf et al. 1997).

- Task 1.1

  Fish species known to occur in the Coeur d'Alene System will be collected for a fish bone key. A combination of hatchery fish and fish collected in the field will be used. Total length (mm) and weight (g) will be measured for each fish collected. For each species, five to ten fish from 100 mm length intervals will be collected and given identifying metal tags.

- Task 1.2

  Fish skeletons will be prepared using a colony of dermestid beetles and cleaned with a mild bleach solution.

- Task 1.3

  Diagnostic bones will be determined based on their uniqueness in identifying prey species and their persistence in the predator stomachs.

- Task 1.4

  Lengths will be measured for selected diagnostic bones. Bone length will be plotted against the total length of the fish to determine a regression equation. From this information, lengths of prey fish eaten by predators can be estimated.

- Task 1.5

  Total fish length will be related to total weight using length/weight regressions outlined in Carlander (1969; 1977; 1997). Bone length to weight regressions will also be developed to estimate the weight of the prey fish consumed.

- Task 1.6

The above products will be used to a) identify species eaten by predators b) determine the number of each species of prey eaten by a predator (by counting the number of a specific bone from only one side of the body); and c) estimate the length and weight of each individual prey using the regression equations developed in Tasks 1.4 and 1.5.

Objective 2:

The annual feeding habits of predatory fish in Coeur d'Alene Lake will be assessed by combining seasonal data from summer, spring, winter, and fall. From these data, it will be determined if cutthroat trout are an important prey item in predator diets.

- Task 2.1

  A stratified random sampling design will be used for quarterly (seasonal) electrofishing and gill netting surveys from 1 July 2001 to 30 June 2002. The lake shoreline will be divided into 1 km transects. Seventy percent of the total sampling effort will take place from Windy Bay, south because this is the area where cutthroat trout will be stocked. However, chinook salmon and northern pike are more likely to reside in the deeper, northern parts of the lake, so these areas will be sampled also. It is also probable that, like chinook salmon, cutthroat trout migrate to deeper northern waters in the summer where water temperatures in the optimal range for salmonids are available. Equal effort will be placed on transects designated as near river/tributary mouths and those transects not near a river mouth. It is assumed that more predation on cutthroat trout will occur near river and tributary mouths, especially during outmigrations. The pelagic zone will be divided into a 1 km x 1 km grid and research gill net surveys will have equal effort in deep and shallow waters. Vertical (6 x 120 ft with 2.5, 3, 4, and 5 inch research mesh) and horizontal (12 x 150 ft, 10 x 200 ft, and 8 x 200 ft, each with varied mesh from 1-4 inches) gill nets will be set over 24 hour periods and checked every 4-6 hours. Vertical nets will be set from surface to the bottom, and horizontal nets will be set at the surface and near the bottom (Hubert 1996). To reduce problems associated with digestion, nets will be pulled every 4-6 hours depending on the number of fish captured in the nets. Electrofishing and gill net surveys will occur one day each week for the first four weeks of each quarter. One day during each quarter, the assistance of angling clubs will be used to sample the pelagic zone. The Coeur d'Alene Tribal boat will serve as a mobilized processing station, in contact with each angling vessel. When anglers capture fish, the Tribal boat will go to the location and process the fish. For the spring (April-June) and summer (July-September) sampling periods, 70 fish from each major predatory species (chinook salmon, northern pike, northern pikeminnow, and largemouth bass) will be set as the target number of fish needed to analyze food habits. In the fall (October-December) and winter (January-March), 30 of each species will be set as the target. This results in a total of 200 stomachs from each species of the major piscivorous fish in Coeur d'Alene Lake. It is more likely to capture fish with food in their stomachs during the spring and summer sampling periods as the water is warmer and the fish are feeding more due to an increased metabolism compared with fall and winter months. If the target number of each species is not obtained within the first four weeks, sampling will continue until the target is reached.

- Task 2.2

Stomach samples will be collected via gastric lavage (Foster 1977; Hyslop 1980; Light et al. 1983; Bowen 1996) for live fish. Fish will be anesthetized using MS-222 (6.0 mg/liter) for five minutes (Light et al. 1983), then a tube connected to a pump will be inserted into the stomach via the esophagus. Contents will be aspirated and collected on a fine mesh screen. Five percent of all fish lavaged will be killed and stomachs collected to evaluate lavage efficacy. Whole stomachs will be removed by cutting anterior to the esophagus and posterior to the pyloric sphincter. Efficacy is calculated by dividing the wet weight of the contents removed by lavage by the wet weight of the total stomach contents (Light et al. 1983). If bull trout are captured, they will be lavaged only, none killed, as they are a federally listed species under the Endangered Species Act. Efficacy of gastric lavage of various prey found in bull trout stomachs will be corrected using mean values obtained in other bull trout food habits investigations (Boag 1987; Underwood et al. 1995) where comparisons were made to estimate lavage correction factors. Stomach samples will be collected over a 24 hour period to account for diurnal patterns in feeding behavior. Fish will be processed within 15-30 minutes of capture to reduce problems associated with digestion. Stomach samples will be preserved in 10% formalin (Bowen 1996). For all fish captured, total length and weight will be recorded and scales will be taken for aging purposes.

- Task 2.3

In the laboratory, prey items will be identified using a Nikon SMZ 10 dissecting microscope with fiber optics and ring illumination and a Nikon optiphot phase contrast microscope. A microphotography system and camera lucida (drawing tube) for the above microscopes will be used to make representative photographs or drawings of each type of prey item. For each individual predator, prey items will be sorted into separate vials and counted. Fish will be identified to species using taxonomic keys (Wydoski and Whitney 1979; Simpson and Wallace 1982). For partially digested fish remains, the bone key prepared in Objective 1, and other bone keys (Harrington 1955; Crossman and Casselman 1969; Eastman 1977; Newsome 1977; Scott 1977; McIntyre and Ward 1986; Hansel et al 1988; Scharf et al. 1997) will be used. The maximum number of diagnostic bones will be identified, and the side (right or left) with the most of a single diagnostic bone present will be counted and identified to species to yield the total number of fish eaten by the piscivore. Zooplankton will be keyed to genus using Brooks (1957) and Pennak (1989). Benthic macroinvertebrates will be identified to family using Pennak (1989) and Merrit and Cummins (1996). The number of each food type will be counted then wet weight and dry weight for each will be obtained as described by Bowen (1996). Both types of weight will be measured to the nearest 0.1 g with a Mettler AJ100 analytical balance. Wet weight will be found by wetting a piece of filter paper and weighting it, then the organisms will be placed on the wet filter paper and all excess moisture blotted away. The difference between the wet filter paper and the filter paper with organisms will be the wet weight for the organisms. Dry weight will be obtained by drying a piece of filter paper in a drying oven for 24 hours then weighing it with the Mettler balance. Organisms will then be placed on the dried filter paper and placed in the drying oven for 24 hours at 60°C-105°C (Busacker et al. 1990; Bowen 1996) depending on the sample size. Records will be kept of the number of predator fish with prey in the stomach, those that are empty, those that have identifiable prey, those that have partially digested prey, and those that have almost completely digested prey. These data will be compared to the time of day the fish were collected to indicate times of peak feeding activity.

- Task 2.4

  Stomach contents data of individual fish will be analyzed to determine the importance of cutthroat trout and all other prey items to the diet of the predatory fish. For each prey item collected, frequency of occurrence will be calculated by dividing the number of stomachs containing a particular prey item by the total number of stomachs analyzed (Bowen 1996). Frequency of occurrence data illustrates the uniformity in which fish select their diet, but does not indicate selection or importance of prey items (Bowen 1996). Percent composition of prey items by number will be calculated by dividing the number of individuals of a certain prey item in one stomach by the total number of all prey items in the same stomach (Bowen 1996). This index can be biased toward small prey, if a predator eats several hundred invertebrates and only two prey fish, higher importance may be wrongly placed on the smaller prey when in fact they do not provide as much energy as the fish consumed. Percent composition by weight will be calculated for both wet and dry weights by dividing the total weight of a certain prey item in one stomach by the total weight of all prey items in the same stomach (Bowen 1996). In cases where prey weight is too small to be measured on the analytical balance, the items will be pooled from several fish of the same species in the same age/length interval, weighed and divided by the total number of predator fish contributing to the sample. This index tends to be biased toward large prey items. More importance will be placed on one fish than several hundred invertebrates. To account for the biases in the previous analyses, a relative importance index will be calculated (George and Hadley 1979) as follows:

$$Ri_a = \frac{100Ai_a}{\sum_{a=1}^{n} Ai_a}$$

where: Ri_a = relative importance of food item a

Ai_a = % frequency of occurrence + % total numbers + % total weight; and

n = number of food types.

Each of the three previous indices are included in this index. Values for the relative importance index range from 0-100%; larger numbers will be considered more important prey items. To determine what effect various sizes of predators have on cutthroat trout, analysis will be performed by grouping predators into 100 mm size intervals. By comparing the size of the predator with its prey, we will be able to determine the age/length of onset of piscivory for each species.

- Task 2.5

Age and growth analysis will be performed on all scales collected. The age of the each fish will be determined by counting the number of annuli on the scale as in Devries and Frie (1996). The distance from the focus to each annulus and to the outer margin of the scale will be measured. From these data, the growth of the fish will be back-calculated (Lux 1971; Anderson and Neumann 1996) to estimate the length of the fish at each age. Based on these age/length frequency data and the contents of the stomachs analyzed, the age and length at which the predators become piscivorous can be determined for each species. A linear regression will be preformed comparing the predator size verses the size of its prey. This will determine what size prey each size class of predators eats. This will be useful in determining what portion of the predator population is having the greatest impact on cutthroat trout released from the potential hatchery.

Objective 3:

Prey selected by predatory fish will be determined.

- Task 3.1

The relative abundance of each prey fish in the environment at the time stomach samples are taken will be calculated. These data will be compared with the long-term relative abundance data collected by the Coeur d'Alene Indian Tribe (unpublished data) to determine if our samples are representative of the actual species abundance in the lake. An electivity index (Ivlev 1961; Strauss 1979; Crowder 1990; Bowen 1996) will be used to determine if predators select cutthroat trout or other prey using the following formula:

$$L = r_i - p_i$$

where: L = measure of food selection

r_i = relative abundance of prey i in the gut; and

p_i = relative abundance of same prey i in the environment.

Food selection values will range from –1 to +1. Values near 0 indicate that the predator is eating fish prey in proportion to its relative abundance in the environment. Values µ+0.7 indicate that the predator is selecting for that prey, while values [-0.7 indicate selection against (Strauss 1979).

- Task 3.2

  Wisconsin nets will be towed vertically from the bottom to the surface to collect zooplankton samples (Rabeni 1996). Samples will be collected in duplicate at gill netting sites and electrofishing sites each day fish sampling occurs. Collections will be enumerated and compared to the stomach samples collected at the same time with an electivity index described in Task 3.1, comparing zooplankton in the environment to zooplankton from the stomach samples.

- Task 3.3

  Eckman, Peterson, or ponar dredges will be used to collect benthic macroinvertebrates, depending upon the substrate. Samples will be collected in duplicate at gill netting sites and electrofishing sites each day that fish sampling occurs and sorted through a screen to filter out mud and debris. Collections will be enumerated and compared to the stomach samples collected at the same time with an electivity index described in Task 3.1, comparing benthic macroinvertebrates in the environment to benthic macroinvertebrates from the stomach samples.

- Task 3.4

  Synoptic lists of fish, zooplankton, and benthic macroinvertebrates in the environment and in the diets of predatory fish will be prepared to define which and how many of the potential prey species are contributing to the diet of predators in Coeur d'Alene Lake.

Objective 4:

Quarterly and final reports will be prepared.

- Task 4.1

  Quarterly reports will be due on 1 October 2001; 1 January 2002; 1 April, 2002; 1 July 2002; and 1 October 2002. These reports will be 1-2 pages in length and will outline the progress made during the previous quarter. Specifically, the reports will compile statistics on the number of sampling trips, number of predator stomachs collected in the field (by species) and the number analyzed in the laboratory, the number of scale samples collected in the field and the number analyzed in the laboratory, the number of zooplankton samples collected in the field and the number analyzed in the laboratory, and the number of benthic macroinvertebrate samples collected in the field, and the number analyzed in the laboratory. These reports will: 1) be an indicator of progress, 2) describe any problems or deviations from the schedule and, 3) outline alterations made to correct for such deviations.

- Task 4.2

  A final project completion report (thesis) will be due on 1 January 2003. This report will summarize the annual feeding habits of the major predators in Coeur d'Alene Lake. The body of the report will describe the annual feeding habits of predatory fish, the relative abundance of fish, benthic macroinvertebrates, and zooplankton prey available to them, and the efficacy of the lavage technique for sampling each type of prey found in the diet of each type of predator. The report will contain appendices that describe the seasonal feeding habits of predatory fish and development of a bone key. An outline of the report is presented below:

I. INTRODUCTION
   A. Background on why study is needed; steps toward Coeur d'Alene Tribal hatchery.
   B. Background on predatory fish and impacts on native salmonids.
   C. Briefly describe feeding habits analysis.
   D. Description of the study area.

II. METHODS
   A. Describe stratified sampling schedule and how transects were developed.
   B. Describe use of electrofishing, gill nets, and anglers to capture fish.
   C. Describe lavage technique and efficacy for each piscivorous species.
   D. Describe length and weight measurements and how scales were taken.
      1. insert equations to back-calculate age.
   E. Describe how relative abundance data was compiled and collected for fish, zooplankton, and benthic macroinvertebrates.
   F. Describe analysis of stomach contents in the laboratory.
      1. frequency of occurrence equation.
      2. percent composition by number equation.
      3. percent composition by weight equation.
      4. relative importance index equation.
      5. electivity index equation.

III. RESULTS
   A. Relative abundance of prey organisms (fish, benthic macroinvertebrates, and zooplankton) in the environment will be determined.
   B. Annual feeding habits will be presented (compilation of seasonal data)
      1. each piscivorous fish sampled will be broken down into 100 mm length intervals to present their annual feeding habits (F of O, % by #, % by wt, Ri_a, and electivity indices for all prey items). Representative pictures and/or drawings will be made for each prey species will also be included.
      2. Age/length frequency data will be presented for each species, including back-calculated lengths for each cohort.
      3. Age/length at onset of piscivorous behavior will be presented for each species.

IV. DISCUSSION/QUESTIONS ADDRESSED

A. Are adfluvial westslope cutthroat trout entering a predator trap?
B. What is the current rate of predation on cutthroat trout?
C. What prey fish are available for piscivorous fish in Coeur d'Alene Lake?
D. Are zooplankton and benthic macroinvertebrates found in the diets of piscivorous fish?
E. At what age/length do the predatory fish begin eating prey fish?

V. APPENDICES

A. Diagnostic bone key of the fishes of Coeur d'Alene Lake (included as a separate report)
   1. Introduction
      a. why a key is needed.
      b. what makes a bone diagnostic.
      c. use of a dichotomous key.
   2. Methods
      a. how fish were collected.
      b. use of dermestid beetle colony to clean skeletons.
      c. how diagnostic bones were identified and measured.
      d. development of dichotomous key.
      e. regression equation of bone length to total fish length.
      f. regression equation for bone length to total fish weight.
   3. Results
      a. dichotomous key
      b. regressions for each species of bone length to fish length
      c. regressions for each species of bone length to fish weight
   4. Discussion
      a. importance and usefulness of a dichotomous key for the fishes of Coeur d'Alene Lake
B. Summer feeding habits (July-September): includes relative abundance data, frequency of occurrence, percent composition by number, percent composition by weight, relative importance indices, and electivity indices, for each prey species, broken down by 100 mm size intervals
   1. northern pikeminnow
   2. northern pike
   3. chinook salmon
   4. largemouth bass
   5. smallmouth bass
   6. tiger muskellunge
   7. channel catfish
   8. brown bullhead
   9. rainbow trout
   10. bull trout
C. Fall feeding habits (October-December): includes relative abundance data, frequency of occurrence, percent composition by number, percent composition by weight, relative importance indices, and electivity indices, for each prey species, broken down by 100 mm size intervals

11. northern pikeminnow
12. northern pike
13. chinook salmon
14. largemouth bass
15. smallmouth bass
16. tiger muskellunge
17. channel catfish
18. brown bullhead
19. rainbow trout
20. bull trout

D. Winter feeding habits (January-March): includes relative abundance data, frequency of occurrence, percent composition by number, percent composition by weight, relative importance indices, and electivity indices, for each prey species, broken down by 100 mm size intervals

21. northern pikeminnow
22. northern pike
23. chinook salmon
24. largemouth bass
25. smallmouth bass
26. tiger muskellunge
27. channel catfish
28. brown bullhead
29. rainbow trout
30. bull trout

E. Spring feeding habits (April-June): includes relative abundance data, frequency of occurrence, percent composition by number, percent composition by weight, relative importance indices, and electivity indices, for each prey species, broken down by 100 mm size intervals

31. northern pikeminnow
32. northern pike
33. chinook salmon
34. largemouth bass
35. smallmouth bass
36. tiger muskellunge
37. channel catfish
38. brown bullhead
39. rainbow trout
40. bull trout

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Project Schedule

Step 1 (Final submittal October 2002)

- Alternate Site Feasibility Study
- Diet Analysis Study
- Update Master Plan
- Update Conceptual Design

Step 2 (Final submittal Early-mid 2003)

- Preliminary Design and Construction Documents

Step 3 (Mid 2003)

- Final Design Construction Documents

Construction Begin late summer, early fall 2003

Post Construction O & M, M & E FY 2004

Zimmerman, M. P., and D. L. Ward. 1999. Index of predation on juvenile salmonids by northern pikeminnow in the lower Columbia River Basin, 1994-1996. Transactions of the American Fisheries Society 128: 995-1007.

Attachment C

Outyear Budget 2001-2004

	2001	2002	2003	2004
I. Alternate site feasibility study	73,500			
Well Field Analysis	60,000			
II. Investigations of the food habits of piscivorous fishes in lake Coeur d'Alene	19,121	52,569	20,714	
III. Personnel needs/Travel/Supplies	38,666	146,854	179,517	170,562
IV. Updated Conceptual Design and Land appraisal		45,000		
V. Design and construction documents			160,069	
VI. Construction cost			3,583,000	
VII. M & E, O & M/Trout Purchase			32,000	375,000
Total	**$ 191,287**	**$244,423**	**$ 3,975,300**	**$ 545,562**

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City of Worley
P.O. Box 169 Worley, Idaho 83876
Phone & Fax: (208) 686-1258

May 23, 2001

Jeffery Jordan
Coeur d'Alene Tribal Fisheries Biologist
P.O. Box 408
Plummer, ID 83851

Dear Jeff:

Thank you for your inquiry of May 8, 2001 regarding City of Worley providing a water connection for the Coeur d'Alene Tribe's fish hatchery. At the May 22, 2001 Worley City Council meeting, the Council agreed to have the City attorney, Jerry Mason, draw up an agreement between the City of Worley and the Coeur d'Alene Tribe concerning the City providing a water service connection for the fish hatchery. We will forward a copy of the agreement to Chairman Stensgar for his review as soon as it is completed. We appreciate your patience and look forward to working with you on this project.

Sincerely,

Gayle Dyer
City Clerk/Treasurer

COEUR D'ALENE TRIBE
850 "A" STREET
P.O. BOX 408
PLUMMER, IDAHO 83851
(208) 686-1800 FAX (208) 686-1182

REFERENCE:

September 10, 2002

Mr. Ken Kirkman
Bonneville Power Administration

Dear Ken:

This letter serves as an update of progress pursuant to our Coeur d' Alene Trout Production Facility project. As you may recall, the Coeur d' Alene Tribe, the Bonneville Power Administration and the Northwest Power Planning Council agreed to a specific scope and schedule for this project. The project schedule outlines a "step 1" package to be submitted End of October, 2002. Elements of that package are outlined below, with a brief statement regarding the status of each deliverable (Attached for your reference, please find the agreed upon scope of work and timelines identified for the step 1 submittal).

Alternate Site Feasibility Study **[Completed February, 2002]**

Issue Paper Involving the Enhancement of Resident Fisheries **[Completed February, 2002]**

Updated Master Plan **[Completed draft plan August, 2002. Final review by the PRT continues. Final report October, 2002]**

Updated Conceptual Design **[Completed August, 2002]**

Diet Analysis Study **[Field work completed, Final report November]**

The Coeur d' Alene Tribe appreciates your eagerness to assist in the development of our final master plan document. Please forward any written comments you may have so that they may be addressed in upcoming discussions involving the Project Review Team and subsequently added to the final copy of the master plan.

Sincerely,

Ronald L. Peters, Fisheries Program Manager
Coeur d' Alene Tribe

cc: Mark Fritsch

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

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

For additional copies of thrs report, write to

Bonneville Power Administration
Public Information Center - CKPS-1
P.O. Box 3621
Portland, OR 97208

Please include title, author, and DOE/BP number from the back cover in the request

Fisheries Habitat Evaluation on Tributaries of the Coeur d'Alene Indian Reservation

1990 Annual Report

by:
Suzy Graves
Kelly L. Lillengreen
D. Chad Johnson
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Project Number 90-44
Contract Number DE-BI79-90BP10544

ABSTRACT

Ranking criteria were developed to rate 19 tributaries on the Coeur d'Alene Indian Reservation for potential of habitat enhancement for westslope cutthroat trout, *Oncorhynchus clarki lewisi*, and bull trout, *Salvelinus malma.* Cutthroat and bull trout habitat requirements, derived from an extensive literature review of each species, were compared to the physical and biological parameters of each stream observed during an aerial - helicopter survey. Ten tributaries were selected for further study, using the ranking criteria that were derived. The most favorable ratings were awarded to streams that were located completely on the reservation, displayed highest potential for improvement and enhancement, had no barriers to fish migration, good road access, and a gradient acceptable to cutthroat and bull trout habitation. The ten streams selected for study were Bellgrove, Fighting, Lake, Squaw, Plummer, Little Plummer, Benewah, Aider, Hell's Gulch and Evans creeks.

ACKNOWLEDGEMENTS

Funding was provided by the U.S. Department of Energy, Bonneville Power Adminstration, Contract Number 90 -044-00. Additional financial support for this project was provided by a grant from the U.S. Department of the interior, Bureau of Indian Affairs to the Upper Columbia United Tribes (UCUT) to fund the operation of the UCUT Fisheries Center at Eastern Washington University (Grant No. CO02377). Ail capitol equipment for this project was supplied by the UCUT Fisheries Center. Special thanks go to Bob Austin (BPA Project Manager), Ernie Stensgar (Chairman, Coeur d'Alene Tribal Council), and Deidre Allen, (Coeur d'Alene Tribal Planner) for their assistance. The authors gratefully acknowledge and thank Cindi Abrahamson and Lori Hill for their patience and unending hours of typing.

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1.0 INTRODUCTION

In 1987, the Northwest Power Planning Council amended the Columbia River Basin Fish and Wildlife Program to include: "a *baseline stream survey of tributaries located on the Coeur d'Alene Indian Reservation to compile information on improving spawning habitat, rearing habitat, and access to spawning tributaries for cutthroat and Dolly Varden (bull trout) and to evaluate the existing fish stocks. If justified by the results of the survey, fund the design, construction and operation of a cutthroat and Dolly Varden (bull trout) hatchery on the Coeur d'Alene Reservation; necessary habitat improvement projects: and a three-year monitoring program to evaluate the effectiveness of the hatchery and habitat improvement projects. If the baseline survey indicates a better alternative than construction of a fish hatchery, the Coeur d'Alene Tribe will submit an alternative plan for consideration in program amendment proceedings."* [Section 903 (g)(l)(B)]. The Five Year Action Plan of the Council stated that Bonneville Power Administration (BPA) should commence funding a stream survey; the design, construction, operation, and maintenance of a cutthroat and bull trout hatchery on the Coeur d'Alene Reservation; habitat improvement projects: and a three-year monitoring program [Section 1400 (7.7)]. In 1990, BPA contracted the Coeur d'Alene Tribe to conduct this study. The three-phase study is designed to:

1. Compile information on improving spawning and rearing habitat and accessibility to spawning tributaries for cutthroat and bull trout.

2. Fund the design, construction and operation of a cutthroat and bull trout hatchery and necessary habitat improvement projects.

3. Conduct a three-year monitoring program' to evaluate the effectiveness of the hatchery and habitat improvement projects.

1.1 FISHERIES MANAGEMENT HISTORY OF THE COEUR D'ALENE BASIN

Historically, native species of fish that were abundant in Coeur d'Alene Lake and its tributaries included: westslope cutthroat trout *(Oncorhynchus clarki lewisi)*, bull trout *(Salvelinus confluentus)*, mountain whitefish *(Prosopium williamsoni)*, yellow perch *(Perca flavescens)*, suckers *(Catostomus sp.)*, redside shiner *(Richardsonius balteatus)*, dace *(Rhinichthys sp.)*, northern squawfish *(Ptychocheilus oregonensis)*, and sculpins *(Cottus sp.)* (Jeppson 1960; Mallet 1969; Rankel 1971; Mauser 1972 a, b).

Other fish species introduced into Coeur d'Alene Indian Reservation waters include: kokanee salmon *(Oncorhynchus nerka)*, chinook salmon *(Oncorhynchus tshawytscha)*, rainbow trout *(Oncorhynchus mykiss)*, brook trout *(Salvelinus fontinalis)*, northern pike *(Esox lucius)*, peamouth *(Mylocheilus caurinus)*, tench *(Tinca tinca)*, black bullhead *(Ictalurus me/as)*, brown bullhead *(Ictalurus nebulosus)*, pumpkinseed *(Lepomis gibbosus)*, largemouth bass *(Micropterus salmoides)*, black crappie *(Pomokis nigromaculatus)* (Simpson and Wallace 1982; Rieman 1984).

Lake Coeur d'Alene was an extremely important resident fishing site to the Coeur d'Alene tribe. Fishing from canoes often yielded catches of cutthroat trout, bull trout and whitefish (Walker 1977). A winter ice fishery for whitefish and cutthroat trout was also established on the lake (Peltier 1975). Cutthroat trout were collected in traps during spring spawning from the tributaries. Bull trout, weighing 20-30 pounds, were frequently caught from canoes in winter and early spring in Coeur d'Alene Lake (Scott 1968).

The Coeur d'Alenes and Catholic Priests from Sacred Heart Mission built fish traps at Mission Point on the St. Joe River. During the spring spawning run "they caught thousands of trout and whitefish and dried them for later consumption" (Scott 1968). The trap was operated for over fifty years, supplying fish for the Indians and priests until it was inundated by the construction of Post Falls Dam in 1903.

There are three distinct westslope cutthroat stocks present in the Coeur d'Alene drainage (Thurow and Bjornn 1978; Liknes and Graham 1988; Rieman and Apperson 1989):

1. An adfluvial-lacustrine stock that spends one to three years in the tributaries and then migrates to the open waters of the lake. Once in the lake, feeding occurs on limnetic zooplankton until age four to six years, at which time they migrate back to the tributaries to spawn. This stock of cutthroat generally measures 300-350 millimeters as adults.

2. A fluvial stock which originates in the smaller tributaries, and then migrates to larger streams, such as the St. Joe and Coeur d'Alene rivers. They spend four to six years in the river and return to the smaller tributaries to spawn. As adults, these cutthroat normally measure between 250-350 millimeters.

3. A resident stock that spends its entire life cycle within the smaller tributaries. Adults range between 180-250 millimeters in size.

Cutthroat trout were once the most abundant trout species in the Coeur d'Alene system. Since 1932, the cutthroat population has declined significantly. This population decline has been attributed to heavy metal pollution which originated from mining and processing of silver ore (Ellis 1932), habitat degradation caused by grazing, agriculture and logging (Mallet 1969), overharvest of fish (Rankel 1971), and lake elevation changes that occurred during construction and subsequent operation of Post Falls Dam (Benker 1987). By 1967, Mallet (1968) reported that cutthroat trout comprised only 4 percent of the catch.

The Coeur d'Alene River has been the site of extensive mine pollution since 1885. At that time, the Bunker Hill strike occurred, which resulted in mining and milling wastes being discharged into the South Fork of the Coeur d'Alene River (Ellis 1932). Aquatic life was virtually eliminated on both the South Fork and entire mainstem of the Coeur d'Alene River, extending to the delta at Harrison, Idaho where the river enters Coeur d'Alene Lake. After cessation of mining operation in 1980, conditions in the mainstem of the Coeur d'Alene River have gradually improved, and cutthroat trout have been reported to migrate throughout the drainage (Apperson *et. al.* 1988).

The southwest corner of Coeur d'Alene Lake, including a large portion of the Coeur d'Alene Indian Reservation, is characterized by rich palouse soils. Intensive farming has occurred around most of the streams, which enter Coeur d'Alene Lake on the west shoreline. Heavy sedimentation, high water temperatures and rapid water runoff have attributed to a substantial decrease in water quality (Mallet 1969). Many of the stream outlets have become settling basins, filled with large quantities of sediment.

Streams that have not incurred habitat degradation, as a result of heavy land-use practices, apparently have healthier fish. Oien (1957) performed a pre-logging fisheries survey on four streams in northern Idaho. He found that two tributaries of the St. Joe River, Gold and Simmons creeks, contained extremely healthy native cutthroat trout. In Gold Creek, only cutthroat trout were caught, with the exception of one bull trout caught in the main fork of the St. Joe River. The average condition factor of cutthroat trout in Gold and Simmons creeks was 1.76 and 1.61, respectively. Condition factor is derived from the ratio of weight to length. The higher the weight relative to length, the healthier the fish and the higher the condition number. A trout that exhibits a condition factor of 1 .O-1.3 is considered normal; condition of fish in Gold and Simmons creeks far exceeded the average. Therefore, Oien (1957) concluded that high condition factors could possibly be attributed to the lack of uncontrolled logging and siltation along these creeks.

The construction and operation of Post Falls Dam seriously altered available cutthroat habitat. Tribal fisheries for whitefish, cutthroat and bull trout at Mission Point on the St. Joe River were eliminated when Post Falls Dam went into operation. Raising and lowering the water levels of Coeur d'Alene Lake potentially exposed substrate that was used by spawning trout and prohibited spawning access to tributaries as a result of dewatering.

Rankel (1971) stated that overfishing probably caused the recent decline in the number and size of cutthroat trout harvested from the St. Joe River. In recent years, abundance, size, annual survival rate and proportion of mature females have decreased. Scholz *et a/.* (1985) estimated that historically the Coeur d'Alene Indian Tribe harvested approximately 42,000 cutthroat per year. In 1967, Mallet (1968) reported that 3,329 cutthroat were harvested from the St. Joe River, and a catch of 887 was reported from Coeur d'Alene Lake (Mallet 1969). This catch is far below the 42,000 fish per year the tribe harvested. Based on this comparison and since cutthroat populations declined in all parts of the lake, not just in areas on intensive fishing pressure, overfishing was probably not the primary cause of declining cutthroat stocks. However, overfishing may have contributed to the decline of cutthroat trout, especially where land-use practices had previously impacted and reduced spawning and rearing areas.

The overall cumulative impacts of mining and processing ore, grazing, farming, logging, overfishing, and constructing Post Falls Dam with the resultant dewatering have resulted in the decline of westslope cutthroat population of the Coeur d'Alene drainage.

1.2 STUDY OBJECTIVES

This study will provide baseline data to determine which tributary streams on the Coeur d'Alene Indian Reservation are suitable for rehabilitation and stocking of cutthroat and bull trout, and to provide baseline data to assess the effectiveness of potential habitat restoration and hatchery stocking measures. The objectives of this study were to:

1. Identify tributaries located on the Coeur d'Alene Indian Reservation that could be altered to improve cutthroat and bull trout spawning and rearing habitat.

2. Evaluate the cutthroat and bull trout fisheries of selected tributaries, and estimate available habitat for cutthroat and bull trout in these tributaries.

3. Assess the water quality and benthic macroinvertebrate community of selected tributaries and determine if fisheries and habitat enhancement measures would be profitable.

4. Identify factors limiting cutthroat and bull trout production in each selected tributary; and

5. Suggest habitat modifications to improve spawning and rearing habitat, and accessibility to streams for cutthroat and bull trout migrations.

The objectives of this report included:

1. Development of criteria for ranking nineteen tributaries based on potential for cutthroat and bull trout -habitat enhancement. This was accomplished by a literature review of cutthroat and bull trout habitat requirements, an aerial survey, and an assessment of biological and nonbiological parameters, including road access, gradient, barriers, potential for enhancement and location relative to the reservation.

2. Performance of an aerial survey on nineteen tributaries located on the Coeur d'Alene Indian Reservation. All potential barriers to fish migration were listed, and stream reaches from mouth to upper limit of suitable fish habitat were determined.

3. Determination of ten tributaries for further study by using the above ranking criteria.

2.0 MATERIALS AND METHODS

2.1 DESCRIPTION OF STUDY AREA

The Coeur d'Alene drainage basin is located in the Idaho panhandle and drains approximately 9583.0 square kilometers (3700 mi^2) (Benker 1987). It is divided into two subbasins, which includes the Coeur d'Alene River and the St. Joe River basins. The Coeur d'Alene River basin, located east and north of the lake, drains approximately 3859 square kilometers (1490 mi^2); the St. Joe River basin, located east and south of Coeur d'Alene Lake, drains approximately 4895.1 square kilometers (1890 mi^2) (Figure 2.1). The remaining 9 percent of the drainage basin consists of creeks that flow into Wolf Lodge Bay and Corbin Bay on the east side of the lake, and Windy, Rockford, Mica and Cougar bays on the west side of the lake.

The study area covers nineteen tributaries located within the Coeur d'Alene drainage basin, including: Bellgrove, Fighting, Lake, Cottonwood Bay, Squaw, Plummer, Little Plummer, Pedee, Benewah, Cherry, Alder, John, Little John, Hell's Gulch, O'Gara Bay, Shingle Bay, Black, Willow and Evans creeks, and the St. Joe River.

Bellgrove and Fighting creeks are located on the west shoreline of Coeur d'Alene Lake. These creeks are fourth order tributaries of 4.8 kilometers (3.0 mi) and 8.1 kilometers (5.0 mi) in length, respectively. Bellgrove Creek merges with Fighting Creek at river kilometer 0.8 (RMi 0.5) and empties into Coeur d'Alene Lake (Figure 2.2).

Lake Creek, a second order tributary, is located on the west shoreline of Coeur d'Alene Lake and is approximately 20.4 kilometers (12.7 mi) long. Lake Creek receives most of its flow from the north and west forks of Lake Creek and Bozard Creek (Figure 2.3).

Cottonwood Bay Creek is located in the southeastern corner of Coeur d'Alene Lake. It is a third order stream and drains approximately 4.2 kilometers (2.6 mi) (Figure 2.4).

Squaw Creek is located in the southeastern portion of Coeur d'Alene Lake. It is a second order stream and is approximately 7.6 kilometers (4.7 mi) in length (Figure 2.5).

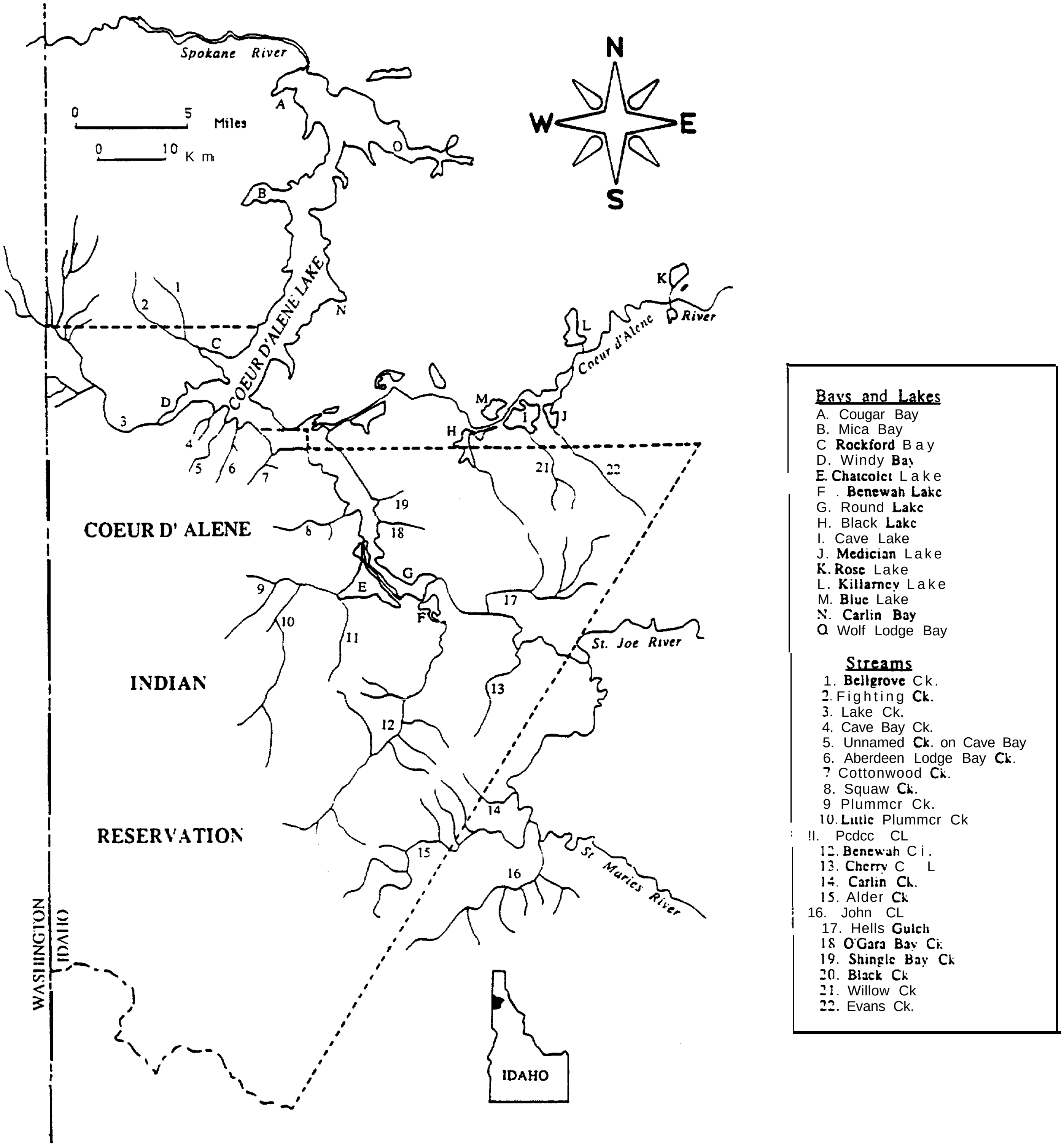

Figure 2.1. **Map of the Coeur d'Alene drainage basin.**

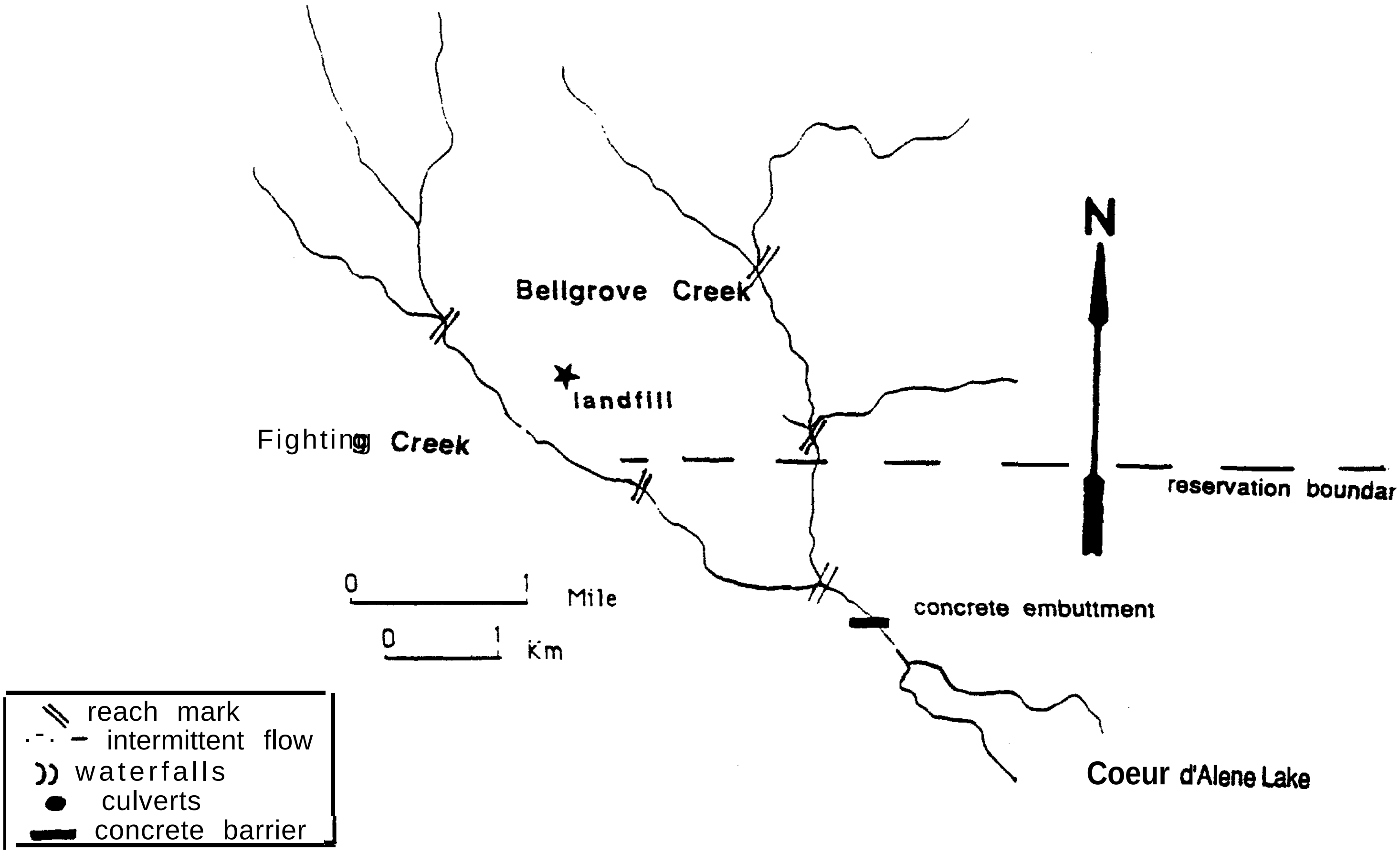

Figure 2.2. **Map of Bellgrove and Fighting Creeks showing barriers and perennial versus intermittent reaches of the streams.**

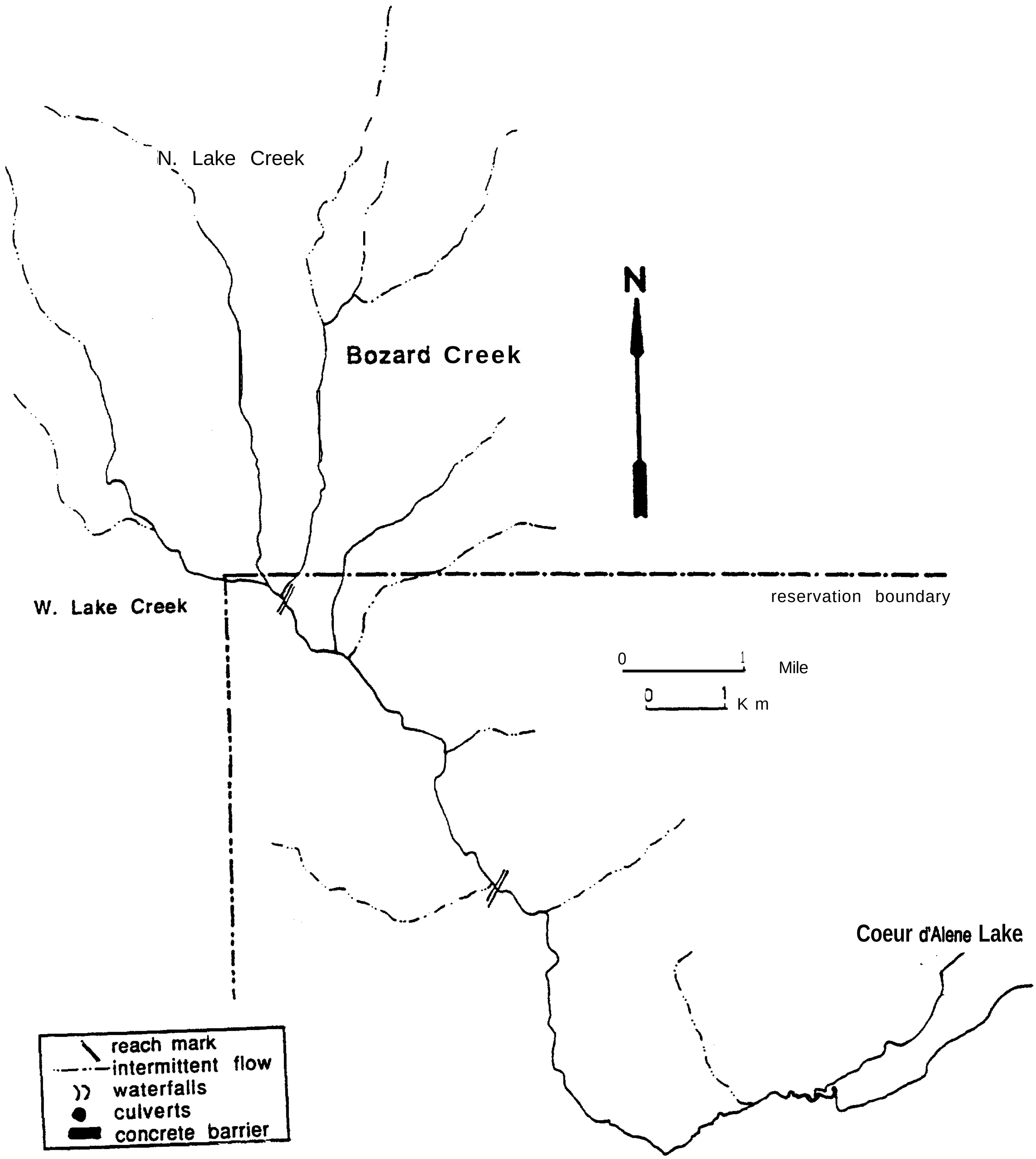

Figure 2.3. Map of Lake Creek showing barriers and perennial versus intermittent reaches of the stream.

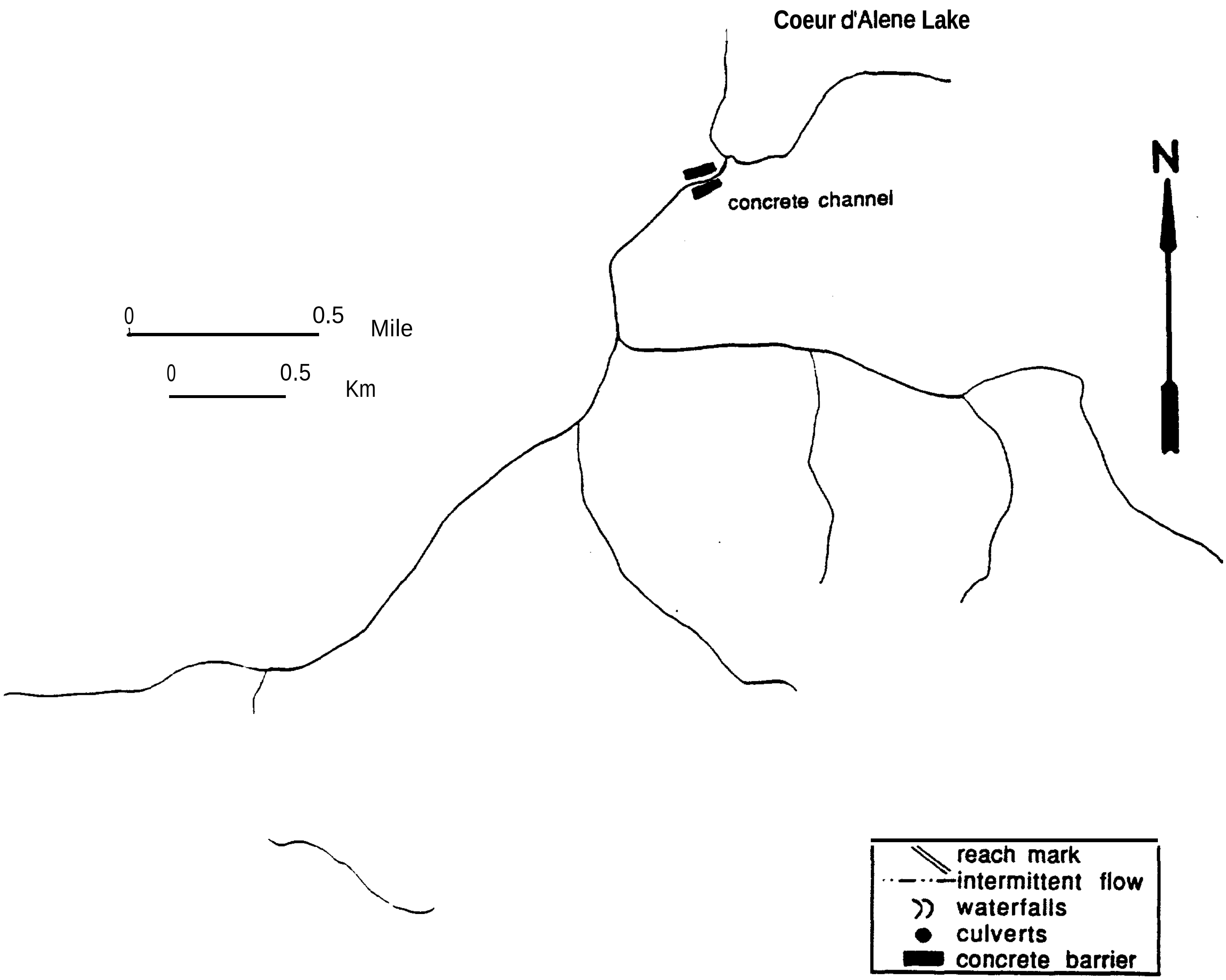

Figure 2.4. **Map of Cottonwood Bay Creek showing barriers and perennial versus intermittent reaches of the stream.**

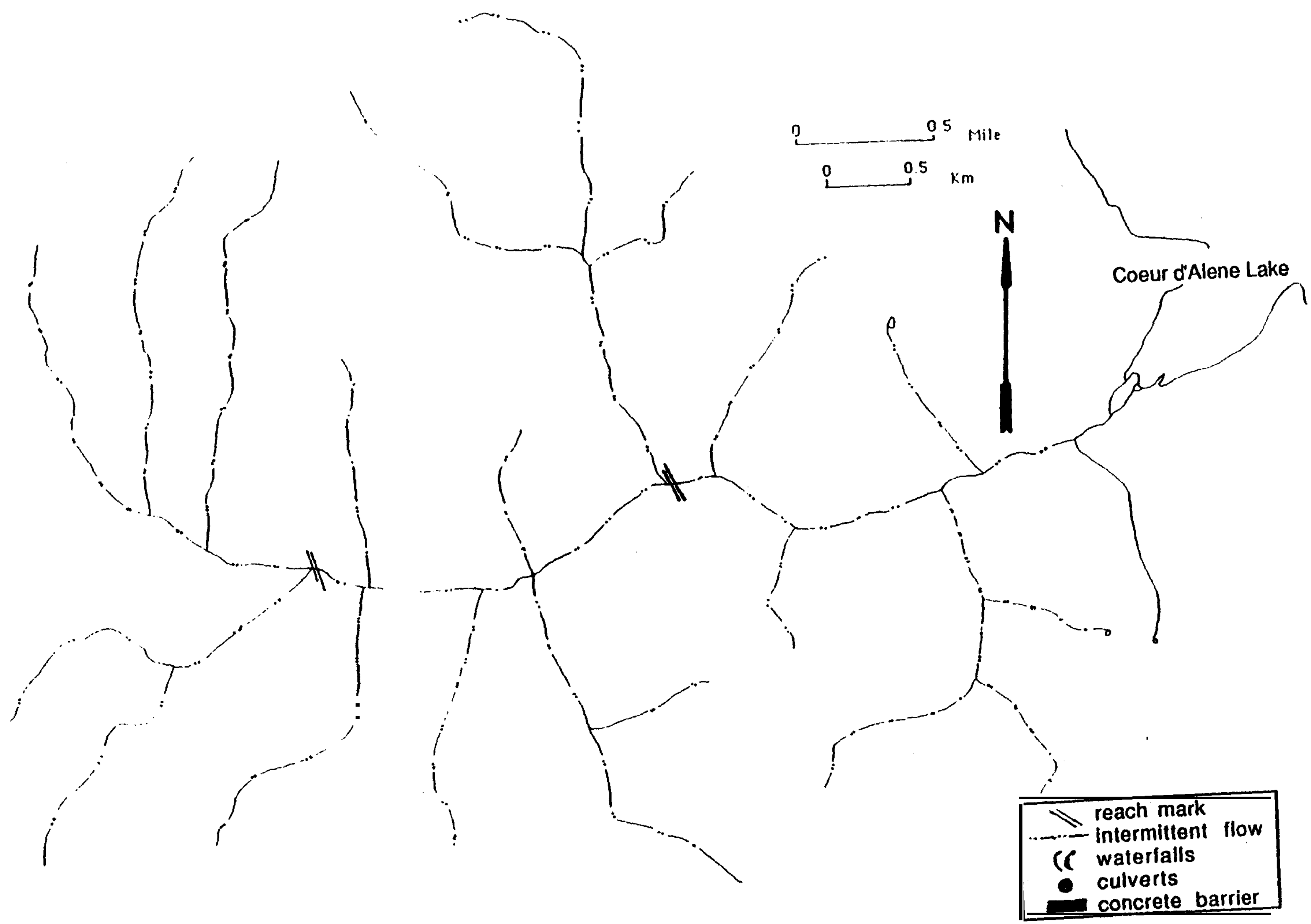

Figure 2.5 Map of Squaw Creek showing barriers and perennial versus intermittent reaches of the stream.

Plummer and Little Plummer creeks are located in the southern portion of the Coeur d'Alene basin and drain into Lake Chatcolet (Figure 2.6). Plummer Creek is a fourth order stream of approximately 6.4 kilometers (4.0 mi) in length. Little Plummer Creek is also a fourth order tributary and is approximately 14.5 kilometers (9.0 mi) long.

Pedee Creek also empties into Lake Chatcolet, and is a third order stream of approximately 4.8 kilometers (3.0 mi) in length (Figure 2.7)

Benewah Creek, a fourth order stream of approximately 24.1 kilometers (15.0 mi), discharges into Benewah Lake, which is also located in the southern portion of the Coeur d'Alene drainage basin (Figure 2.8).

Cherry Creek is located in the St. Joe River basin and is a tributary of the St. Joe River. Cherry Creek is a third order tributary of approximately 6.0 kilometers (3.7 mi) in length (Figure 2.9).

Alder Creek, located in the St. Joe River basin, is a fourth order tributary to the St. Maries River and is approximately 20.1 kilometers (12.5 mi) in length (Figure 2.10).

John and Little John creeks are located within the St. Joe River basin and is a tributary to the St. Marie's River. John Creek drains approximately 17.1 kilometers (10.6 mi) as a fourth order stream (Figure 2.11).

Hell's Gulch Creek, a third order tributary, is located in the northern section of the St. Joe River basin and is approximately 10.5 kilometers (6.5 mi) in length (Figure 2.12).

O'Gara Bay Creek, a third order tributary, is located on the east side of Coeur d'Alene Lake and is approximately 3.2 kilometers (2.0 mi) long (Figure 2.13).

Shingle Bay Creek, located on the east side of the lake, is a third order tributary that is approximately 1.6 kilometers (1 .O mi) in length (Figure 2.14).

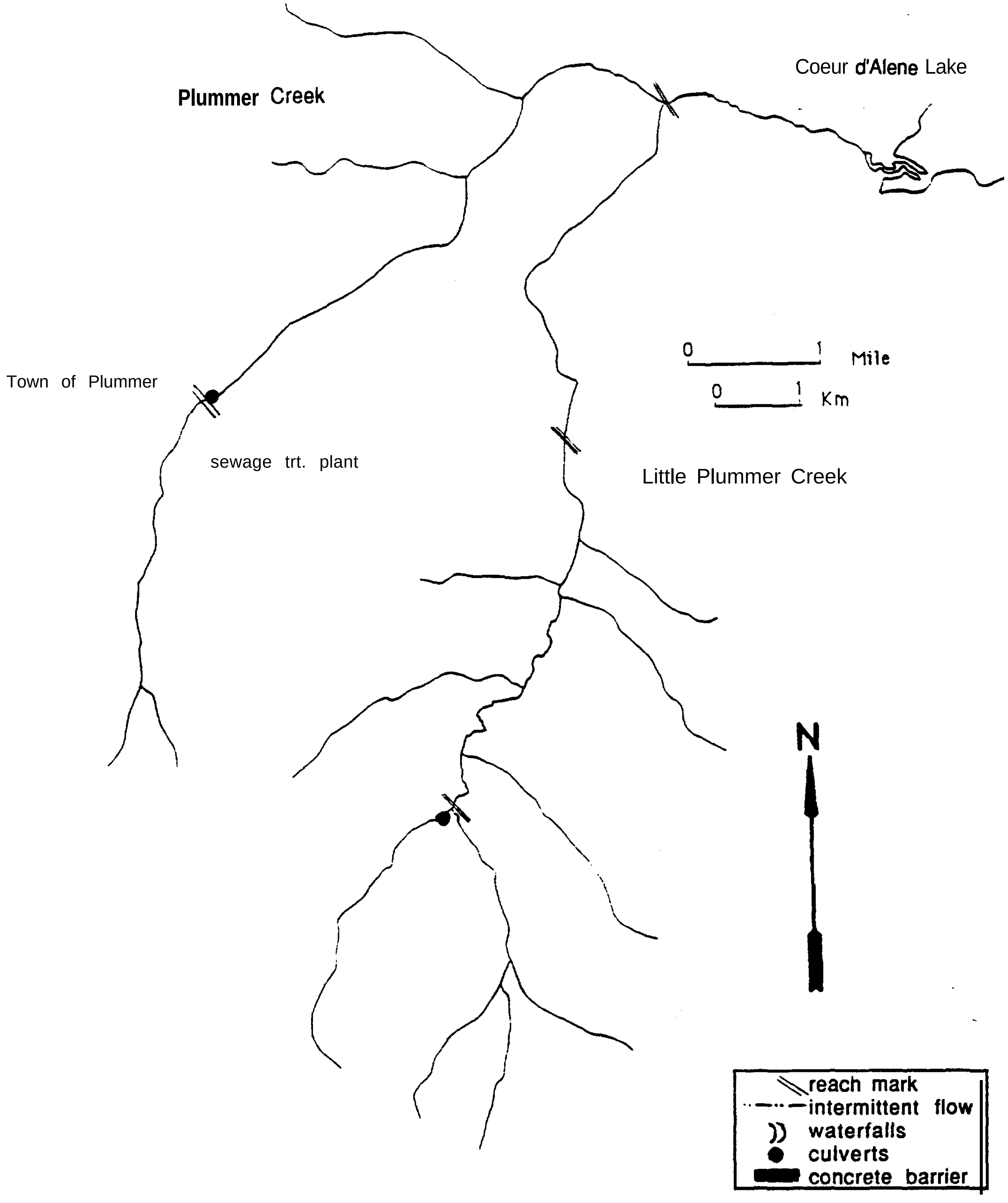

Figure 2.6. **Map of Plummer and Little Plummer creeks showing barriers and perennial versus intermittent reaches of the stream.**

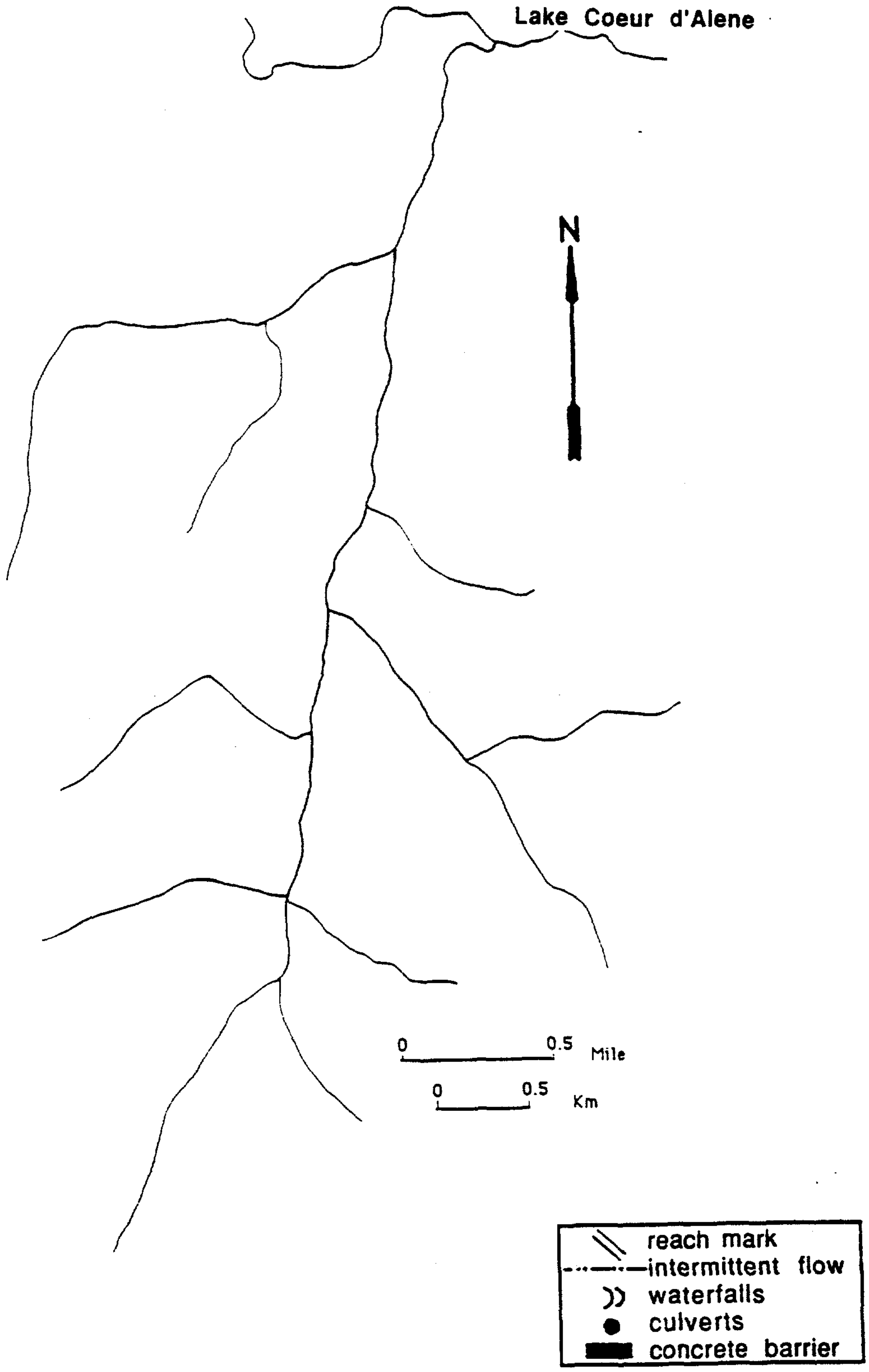

Figure 2.7. **Map of Pedee Creek showing barriers and perennial versus intermittent reaches of the stream.**

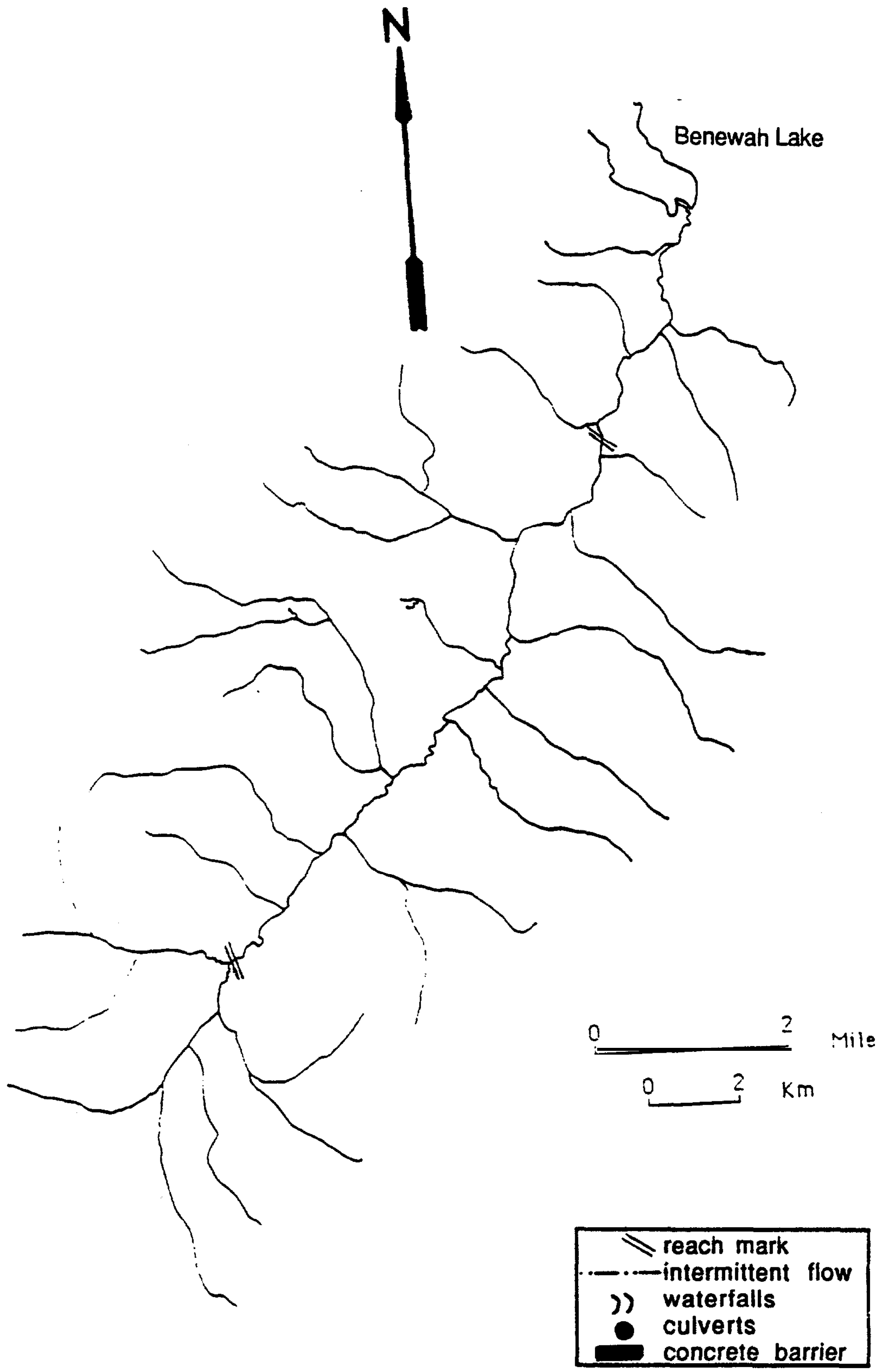

Figure 2.8. **Map of Benewah Creek relative to Benewah Lake showing barriers and perennial versus intermittent reaches of the stream.**

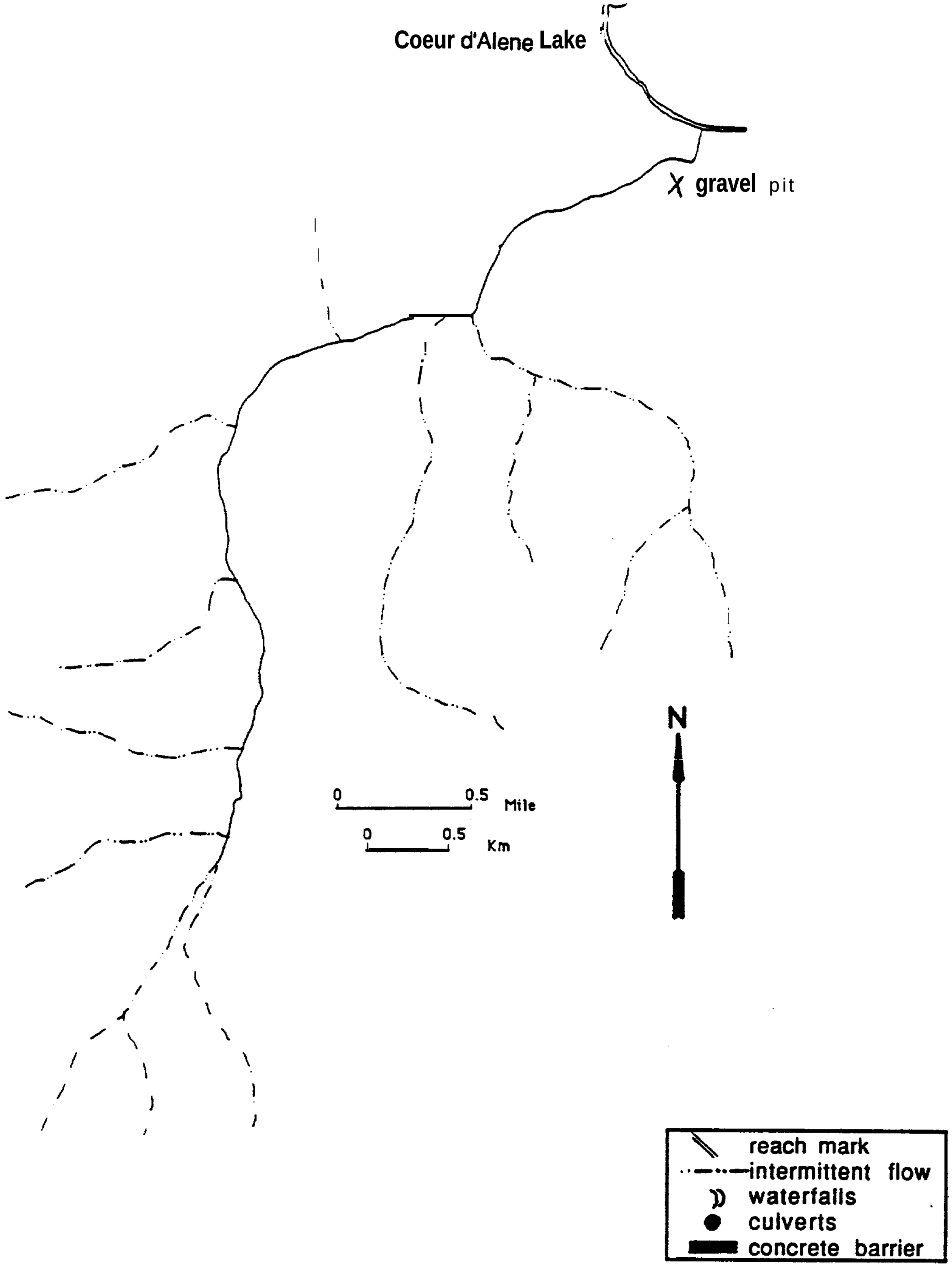

Figure 2.9. Map of Cherry Creek showing barriers and perennial versus intermittent reaches of the stream.

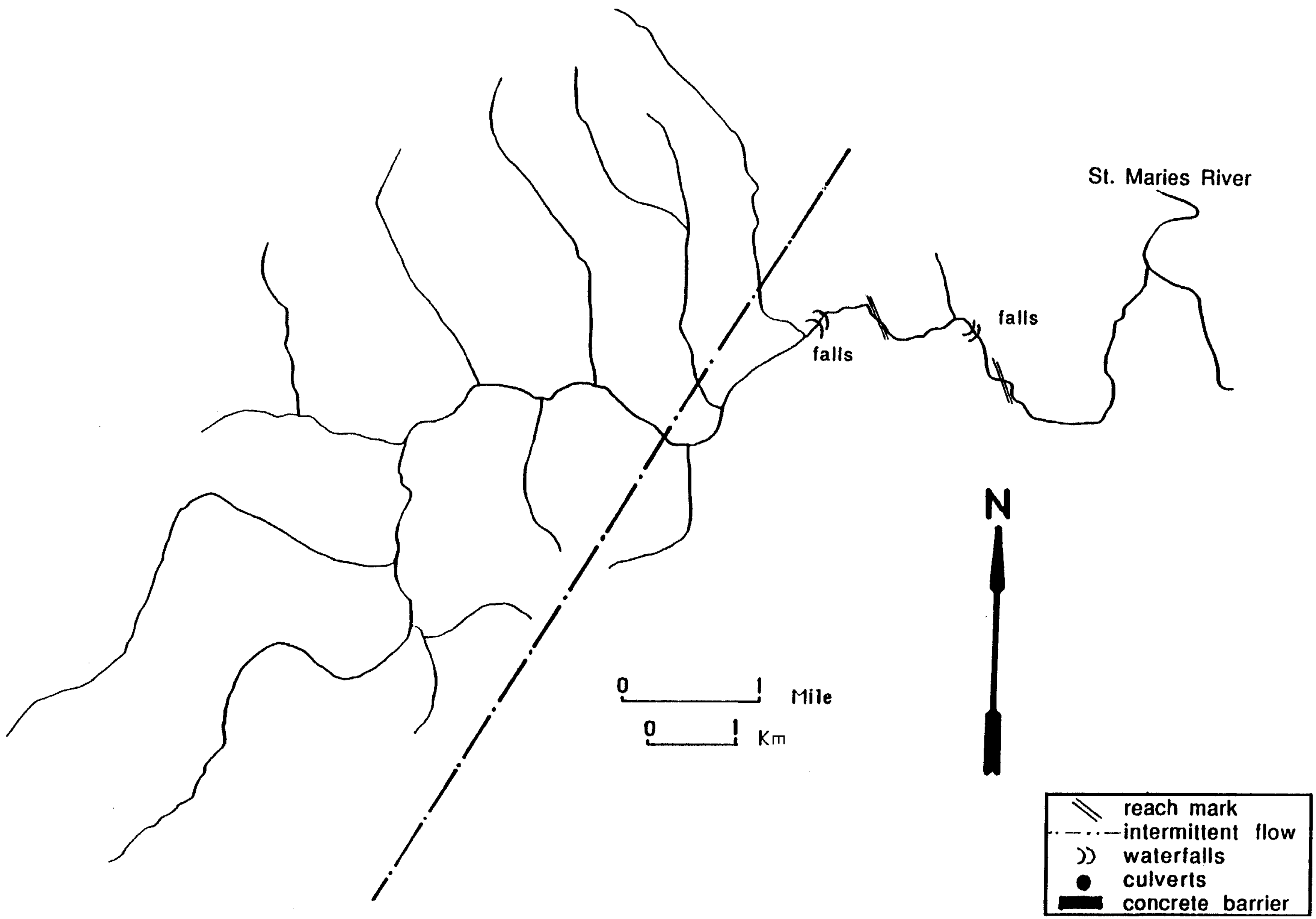

Figure 2.10. **Map of Alder Creek showing barriers and perennial versus intermittent reaches of the stream.**

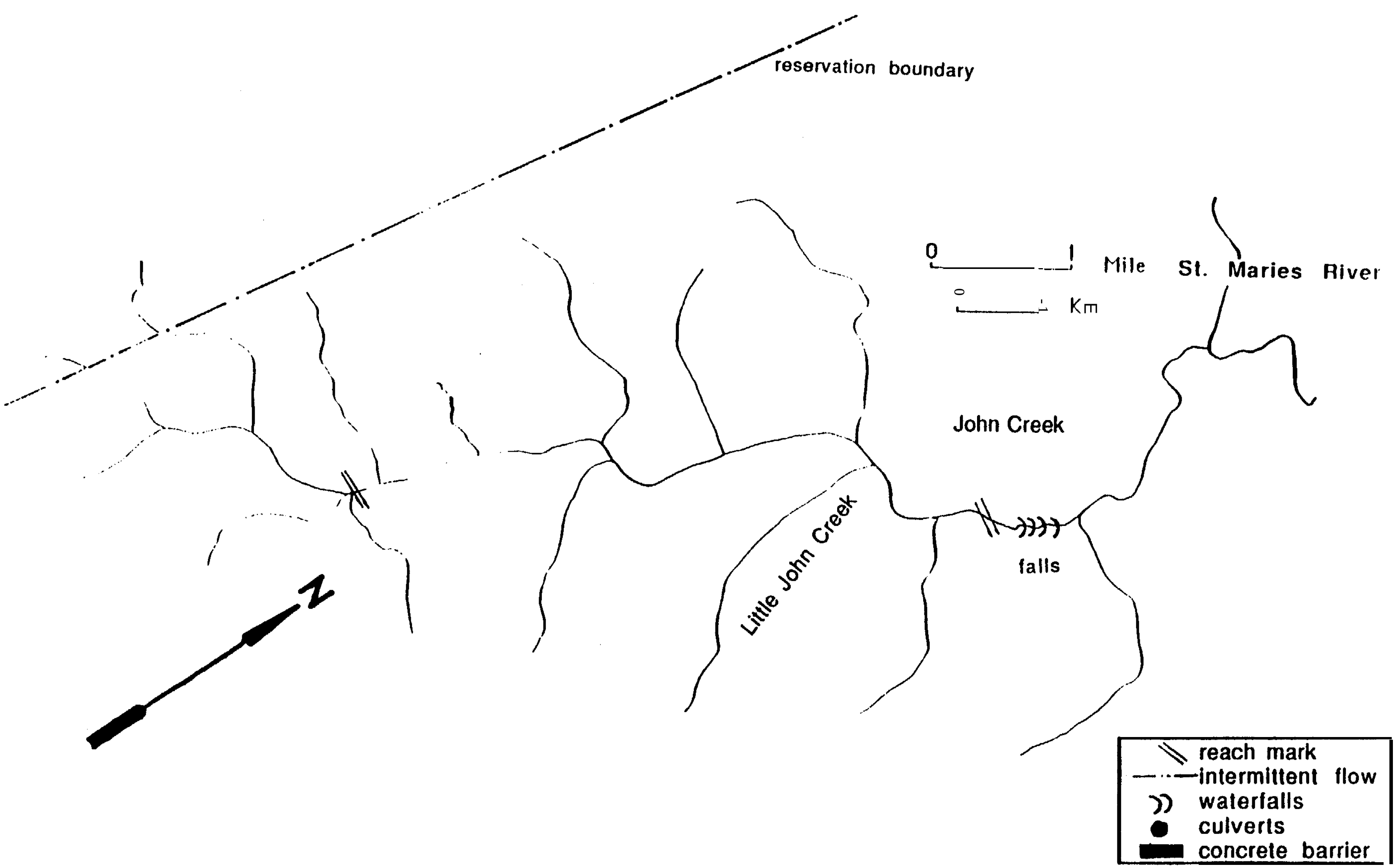

Figure 2.11. Map of John and Little John creeks showing barriers and perennial versus intermittent reaches of the stream.

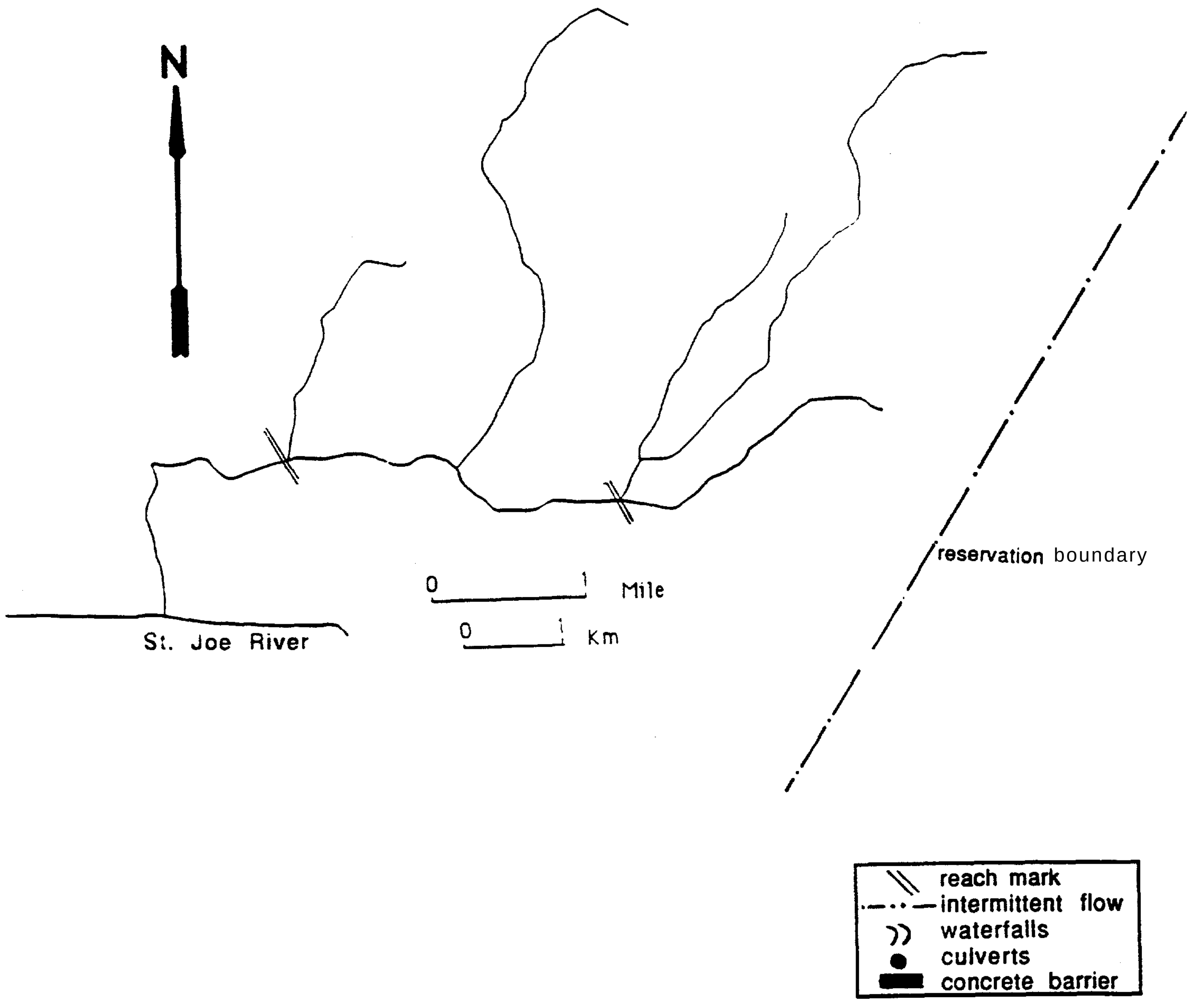

Figure 2.12. Map of Hell's Gulch Creek showing barriers and perennial versus intermittent reaches of the stream.

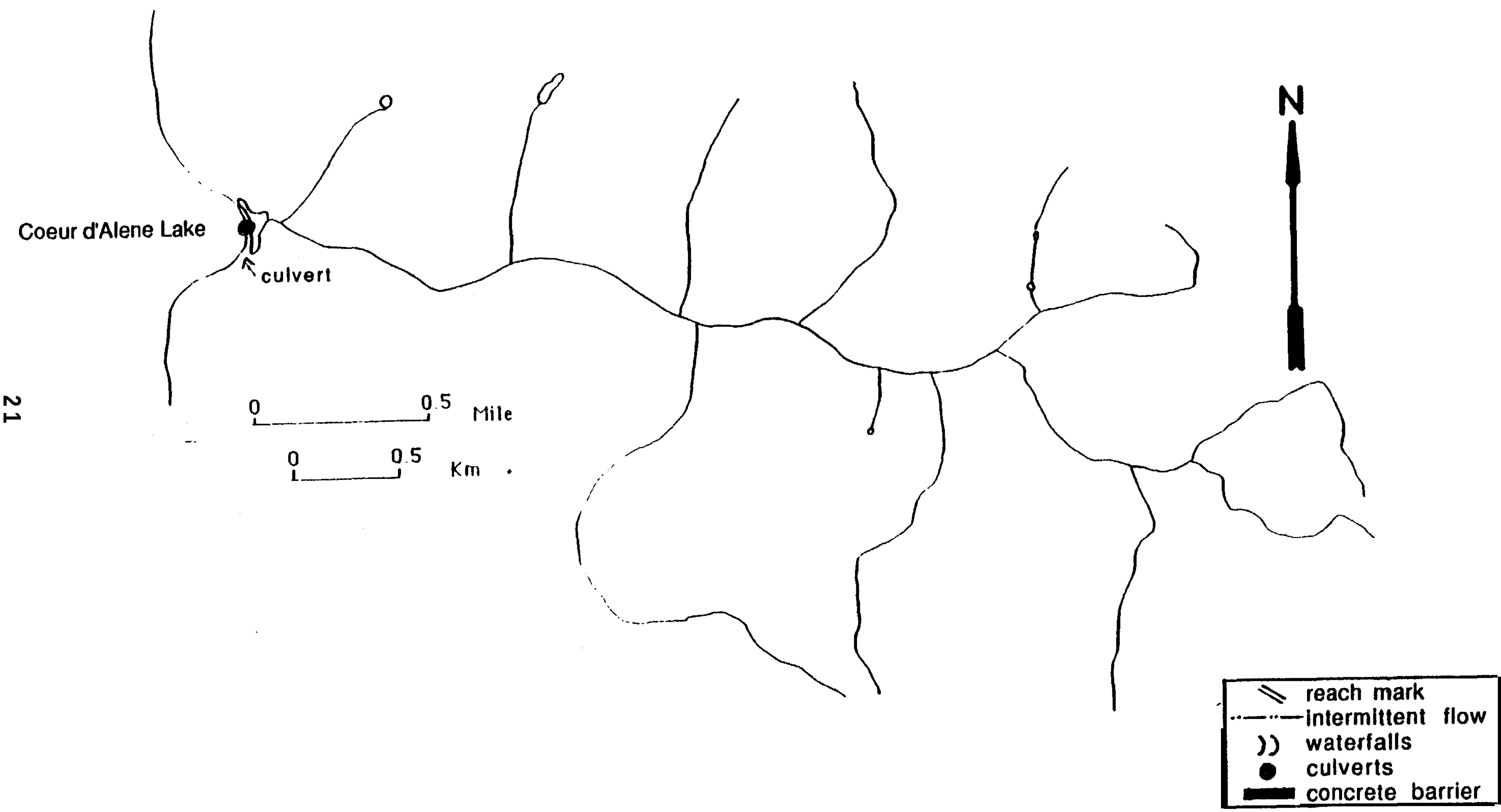

Figure 2.13. Map of O'Gara Bay Creek showing barriers and perennial versus intermittent reaches of the stream.

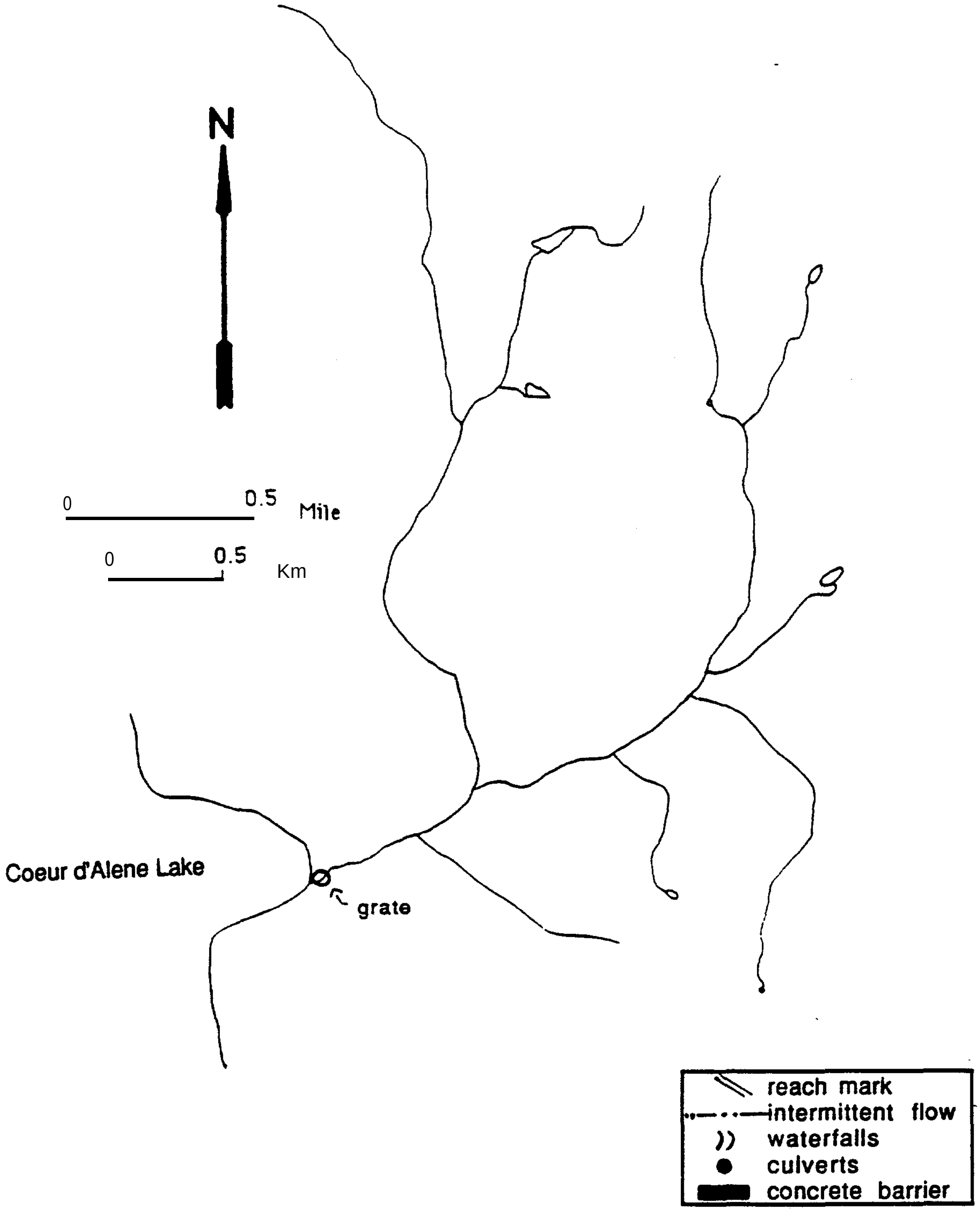

Figure 2.14. **Map of Shingle Bay Creek showing barriers and perennial versus intermittent reaches of the stream.**

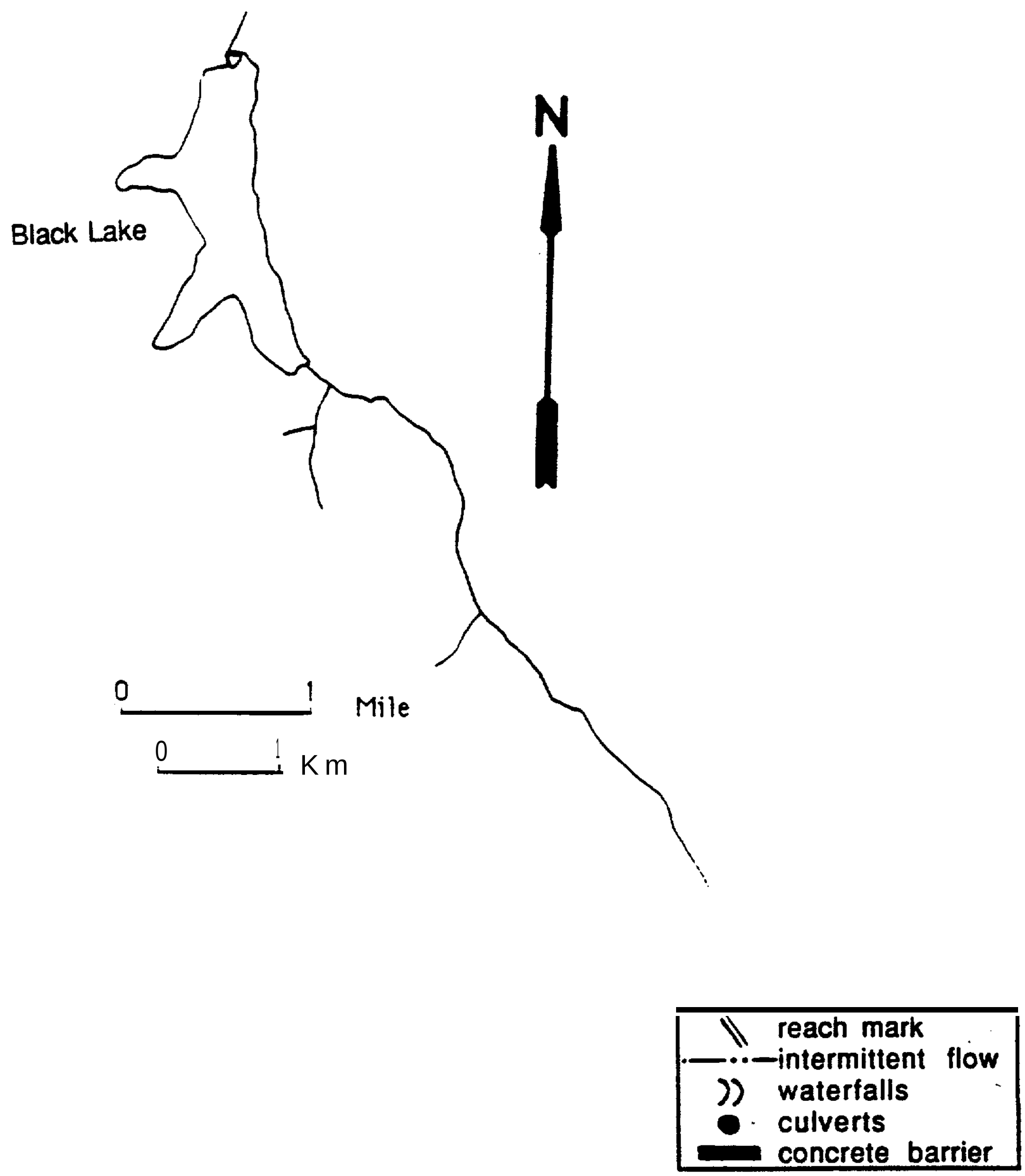

Figure 2.15. Map of Black Creek reiative to Black Lake showing barriers and perennial versus intermittent reaches of the stream.

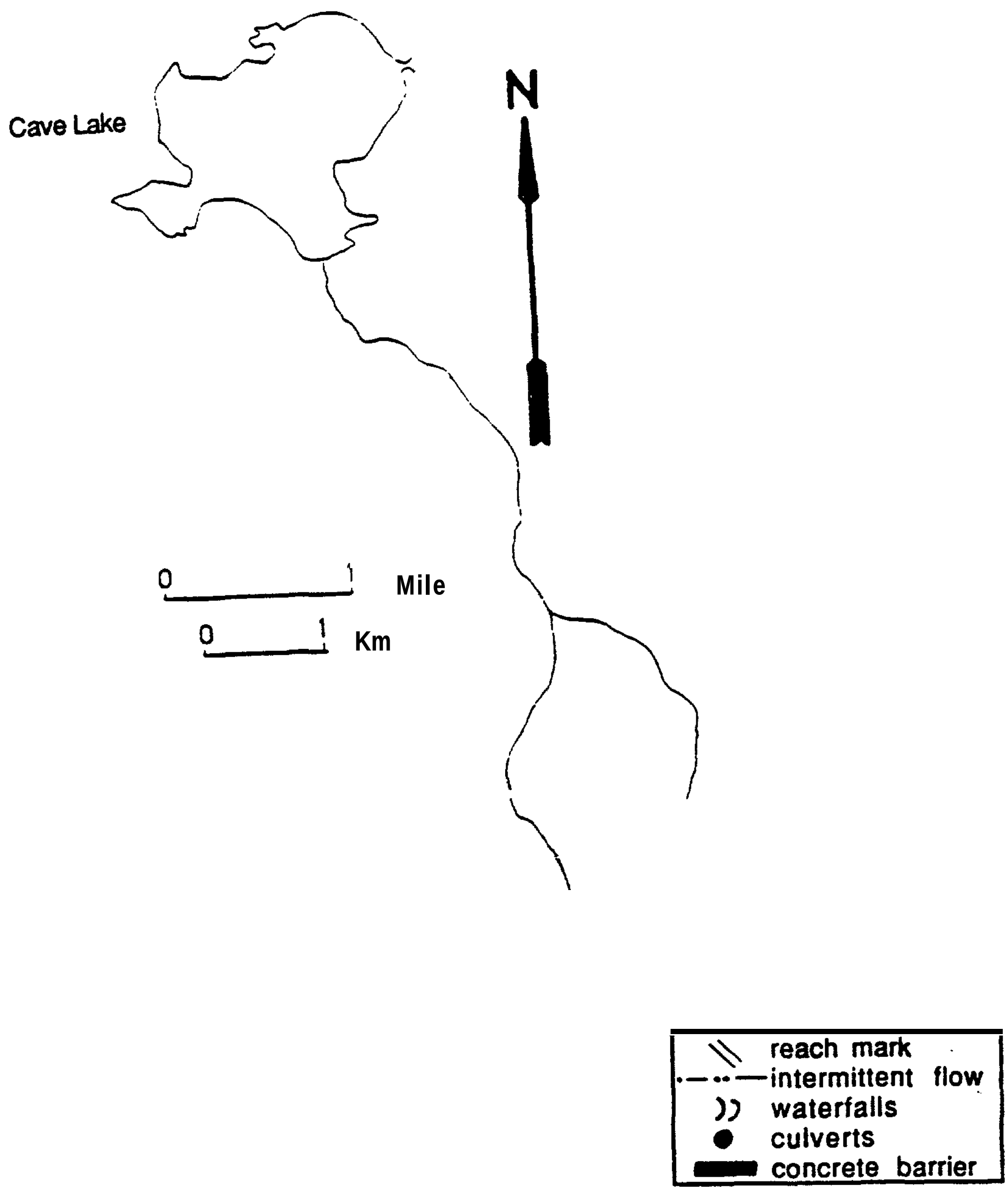

Figure 2.16. Map of Willow Creek relative to Cave Lake showing barriers and perennial versus intermittent reaches of the stream.

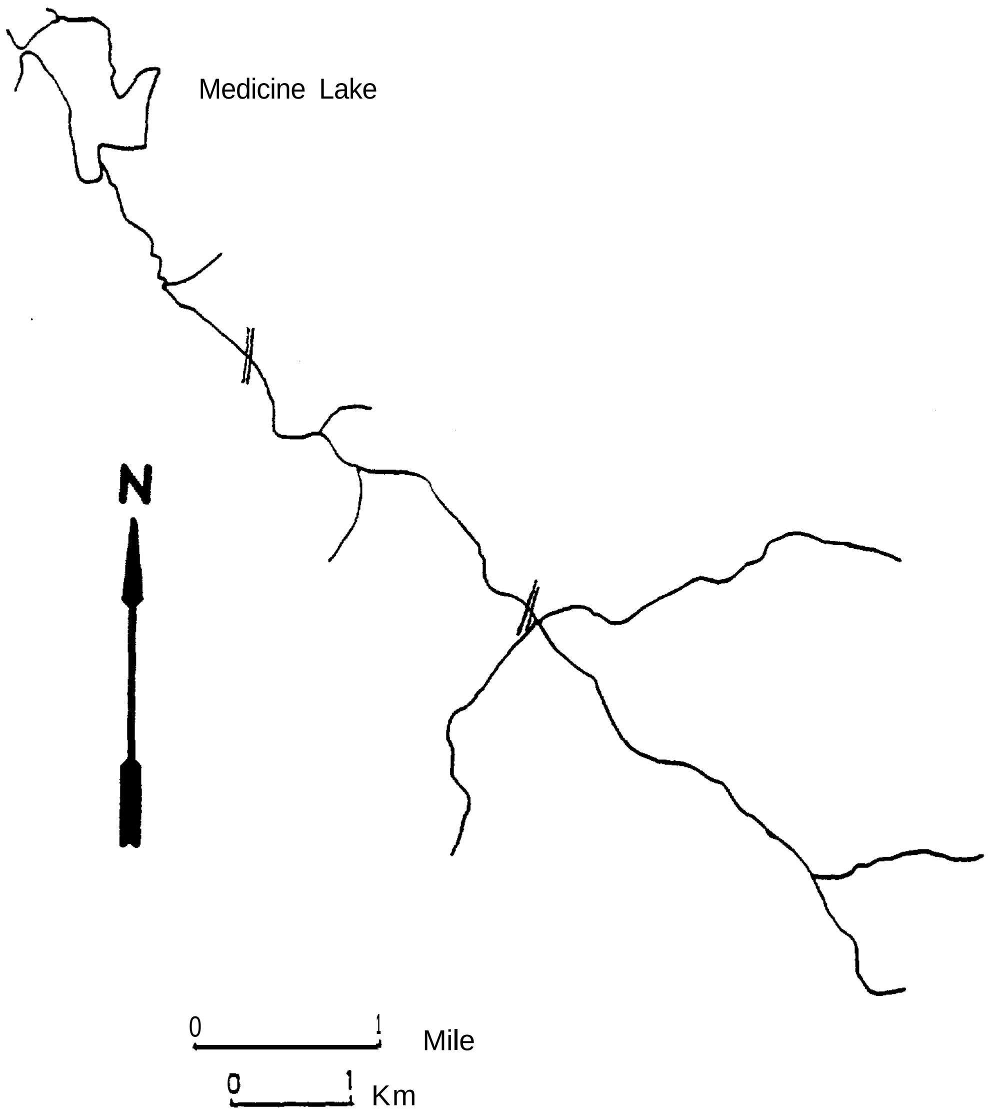

Figure 2.77. **Map of Evans Creek relative to Medicine Lake showing barriers and perennial versus intermittent reaches of the stream.**

Black Creek is located in the Coeur d'Alene River basin and ends at Black Lake, a lateral lake to the Coeur d'Alene River. Black Creek is a third order tributary of approximately 6.4 kilometers (4.0 mi) in length (Figure 2.15).

Willow Creek is a second order tributary that discharges into Cave Lake, one of the lateral lakes of the Coeur d'Alene River. Willow Creek is approximately 6.4 kilometers (4.0 mi) long (Figure **2.16).**

Evans Creek is a second order tributary that discharges into Rose Lake, a lateral lake of the Coeur d'Alene River. Evans Creek is approximately 8.1 kilometers (5.0 mi) long (Figure 2.17).

St. Joe River was too expansive for the scope of this project, therefore, no data was compiled for this body of water.

2.2 DETERMINATION OF NINETEEN STREAMS FOR AERIAL SURVEY.

To select nineteen tributaries located within the boundaries of the Coeur d'Alene Indian Reservation, a ranking criteria was developed. Selection of the nineteen tributaries was based on geographic location relative to tribal jurisdiction and stream geomorphological features.

Most of the tributaries in the northern section of Coeur d'Alene Lake were located only partially on the reservation and were eliminated. Geomorphological parameters were then determined for the remaining tributaries located within reservation boundaries.

2.2.1 Stream Geomorphology

Stream geomorphological features were examined to determine if the stream had the potential to support fish, specifically bull and cutthroat trout. Physical stream parameters examined included: stream length, gradient, elevation and order, basin area and relief ratio, drainage density and sinuosity.

Stream length, gradient and order were determined in order to quantify the stream for potential fish habitat. Since stream length and order are indicators of stream size, these parameters were used to evaluate if the stream was large enough to support a bull and cutthroat trout fishery. Gradient determines the water velocity of a stream; bull and cutthroat trout have specific habitat requirements relative to these parameters.

Elevation, drainage density, basin area and relief provide an estimate of the timing, potential discharge, base and peak stream flows and sediment yields of a stream. This information can help in determining when freshest conditions will occur. Freshets have the potential to cause habitat damage to the stream, as well as, flush juvenile trout downstream. Branson et al. (1981) found that high basin relief, greater channel slope and increased drainage density were negatively related to trout standing stock. Sinuosity is an indicator of the straightness of a stream channel and can be correlated to stream gradient.

Stream length was measured with a map measurer by following the longest perennial watercourse on a 1:24,000 scale topographic map.

Gradient was determined using a 1:24,000 scale topographic map, in which elevation was determined directly from the map and divided by the stream distance. Stream distance was calculated by using a map measurer and proportional divider.

Highest headwater elevation of each stream was determined by directly reading a 1:24,000 scale topographic map.

Stream order was determined by counting stream channels directly from 1:24,000 scale topographical maps (Horton 1945).

Basin area was determined by using the highest elevation on the headwater divide and subtracting the elevation at the confluence with the river of lake (Schumm 1956).

Relief ratio was determined by dividing all the stream channels in a drainage basin by the drainage area (Horton 1945).

Sinuosity was measured from 1:24,000 scale topographical maps and calculated as stream length divided by valley length.

2.3 AERIAL SURVEY

An aerial survey was conducted in December 1990 by applying methods of Montana Department of Fish and Wildlife and Parks (1983) and Platts et *al.* (1983). Parameters observed during the aerial survey included: observed flow, gradient changes, land-use practices, stream barriers, potential spawning areas for bull trout and cutthroat trout, riffle:pool ratio, channel debris, road accessibility, and potential water quality problem sites. These parameters were compared to the habitat requirements specific to cutthroat and bull trout.

2.4 RANKING CRITERIA

Based on biological and nonbiological parameters, ranking criteria were established, which evaluated the nineteen tributaries that were observed during the aerial survey. The nineteen tributaries were narrowed to ten streams for further study by ranking each stream according to the established criteria.

The nineteen tributaries were ranked according to five major areas that included: geographic location relative to tribal jurisdiction, road access, barriers to fish migration, channel gradient, degree of habitat degradation, and potential of enhancement for cutthroat and bull trout.

Geographic location relative to tribal jurisdiction was determined by assessing how much of the stream was located within reservation boundaries. The distance of the stream within tribal jurisdiction was important for establishing control of water rights. Since tribal control exists for waters located completely on the reservation, a rating of 1 .O was given to those streams. Secondary priority, or rating of 2.0, was given to those tributaries partially located on reservation property. Those tributaries located completely off the reservation were given a priority rating of 3.0, since tribal jurisdiction did not exist for these waters.

Road accessibility was determined to be of high priority. Since the final product is to enhance the fishery of the streams, stream access was important for conducting enhancement work and for future angler use. Road access was determined from data collected in the aerial survey and from 7.5 USGS topographic maps. A ranking of 1 .0 was given to those tributaries that seemed to have good access. A ranking of 2.0 was given to those tributaries that had limited access, and a ranking of 3.0 was given to those tributaries that lacked access.

The third category was to assess barriers that affect fish migration. Barriers observed during the aerial survey were divided into two classes: natural barriers and man-made barriers. Those streams with natural obstructions, such as waterfalls, historically would not have had native adfluvial or fluvial, but only resident, cutthroat and bull trout populations above them. Waterfalls that were observed had limited upstream habitat; gradients were steep and unusable by fish populations. Natural barriers, such as extensive gradient cascades, would be quite expensive to correct. Streams with man-made barriers could, historically, have had adfluvial and fluvial populations above the barriers and would be more cost-effective to enhance. The highest rating of 1 .O was given to those streams that lacked barriers to fish migration. Streams with man-made barriers were given the rank of 2.0, because these barriers probably had populations of adfluvial, fluvial, as well as, resident fish above them and would be easier to correct. Streams with natural barriers were given a rating of 3.0. They would be more costly to enhance, and migratory populations did not previously exist upstream: in most cases, suitable habitat was not available above the obstruction.

The fourth parameter examined the extent of habitat degradation, as a result of land-use practices, and potential for rehabilitation based on biological requirements of trout. Streams were ranked favorable or unfavorable "trout habitat", instead of specifically for cutthroat and/or bull trout, because only general information could be obtained from the aerial survey. The biological requirements of trout, clean substrate, good water quality, proper type and amount of instream cover and food, were compared to factors that would adversely affect these habitat essentials, such as sewage treatment facilities, land fills, logging activities, mining activities, quarries, and other land-use practices. Aerial observations of each tributary were tabulated and rated according to quantity and quality of trout habitat and cumulative extent of degradation. Since enhancement of fisheries is the ultimate goal, a rating of 1 .O was given to streams that had slightly degraded trout habitat, but restoration appeared cost-effective. A rating of 2.0 was given to streams that already had good habitat and needed little, if any, restoration work. These streams were given second priority, because trout habitat was currently available, and stocks of cutthroat and bull trout were probably already present. A rating of 3.0 was assigned to those tributaries that had severely degraded trout habitat and expense of enhancement would be considerable.

The fifth parameter considered was gradient, because cutthroat and bull trout have specific. requirements relative to channel slope. Stream gradient indirectly affects velocity of water, ratio of pools to riffles, and amount of cover; these criteria ultimately influence fish populations and distribution. A rating of 1 .O was given to creeks that apparently had suitable gradient for fish habitat. A rank of 2.0 was applied to streams of questionable gradient, and 3.0 was given to creeks with obviously unsuitable channel slope.

Ratings of the first five categories were summed. Those streams receiving the lowest total scores were the top ten choices.

A final category was applied to the top ten scores, which eliminated those streams that had special circumstances associated with them. If the stream were completely frozen or dry in the winter when peak flows should be evident, the stream was eliminated from consideration, because it also would be dry in the summer.

3.0 RESULTS

Data recorded during the aerial survey, along with some of the parameters used to established the ranking criteria, were based on habitat conditions specific to westslope cutthroat and bull trout. Specific habitat requirements were obtained from an extensive literature search of these species. Findings from the literature review of cutthroat and bull trout are summarized in Tables 3.1 and 3.2, respectively. For more comprehensive life history information on cutthroat and bull trout, refer to Appendix A for cutthroat trout and Appendix B for bull trout; this information will be useful in Phase 2 and Phase 3 of this project. A condensed synopsis of each species is provided below.

3.1 LITERATURE REVIEW FOR CUTTHROAT TROUT

3.1.1 General Information

Westslope cutthroat display three distinct life forms. They are:

1. Resident, which inhabit small, unproductive headwater streams and do not migrate.
2. Fluvial, which inhabit larger streams and main rivers, and may show extensive migration between rivers, streams and small tributaries.
3. Adfluvial, which inhabit large lakes and migrate to spawn in tributary streams. Adfluvial stocks generally dominate tributaries to lower reaches of the drainage or small streams directly connected to the lake; they rear in tributaries for two to four years and then migrate to a lake to mature.

3.1.2 Life History

In Idaho, westslope cutthroat deposit their eggs into substrate gravel of streams from March to May. As a result of temperature and differing spawning times, fry emergence can begin between April-June, but may be as late or later than August in coldest waters.

Juvenile cutthroat remain in natal streams for two to four years, then during June-August migrate to rivers or lakes to mature.

Table 3.1 Acceptable and optimal habitat conditions for various life stages of cutthroat trout.

		Egg/Alevin	Frv	Juvenile	Adult	Spawner
Temperature (°C)	maximum range	3-16°C	6-l 2°C	6-12°C	6-12°C	5-11°C March-June
	optimal	7-l 1.5°C	11-15.5°C	11-15.5°C	11-15.5°C	8-10°C
Dissolved oxygen (mg/l)	minimum range	4.5-7.3 (≤15°C) 6.0-9.0 (>1 5°C)	4.5-7.3 (≤15°C) 6.0-9.0 (>15°C)	4.5-7.3 (≤15°C) 6.0-9.0 (>15°C)	4.5-7.3 (≤15°C) 6.0-9.0 (>15°C)	4.5-7.3 (≤15°C) 6.0-9.0 (>15°C)
	optimal	7.3(≤15°C) 9.0(>15°C)	7.3(≤15°C) 9.0(>15°C)	7.3(≤15°C) 9.0(>15°C)	7.3(≤15°C) 9.0(>15°C)	7.3(≤15°C) 9.0(>15°C)
pH	range	5.9-9.0	5.9-9.0	5.9-9.0	5.9-9.0	5.9-9.0
	optimal	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0	6.5-8.0
Velocity (cm/sec)	range	20.0-80.0	O-30.0	9.1-10.3	2.8-29.3	11 .o-92.0
	optimal	30.0-65.0	<8.0	13.1-16.0	10.0-14.0	25.0-70.0
Gradient	range	0.7-10.0	0.7-10.0	0.7-10.0	0.7-10.0	0.7-10.0
	optimal	2.4-5.2	2.4-5.2	2.4-5.2	2.4-5.2	2.4-5.2
Substrate		2.0-6.0 cm gravel <2% fines (5 3mm)	gravel-cobble boulder	gravel-rubble boulder	80-95% rubble (7.6-30.1 cm) and 5-15% coarse gravel (2.5-7.6 cm) w/occ. boulders and fame woody debris	2.0-6.0 cm gravel: <2% line (≤ 3mm
Summer Cover			protected stream edges, lateral habitats, back-waters, deep backwater pools, glides, low-gradient riffles: 34% gravel-cobble-boulder, 24 % shade overhang, 24% fine debris, 17 % woody debris in fess 200m² or 100m³	deep lateral scour and plunge pools, protected stream edges. lateral habitats with 16% cover, protected low gradient riffles: 34% gravel-cobble boulder, 24% shade overhand, 24% fine debris. 17% 17% woody debris in less 200m² or 100m³	1030% pools with 30% bottom obscure with low-velocity (<15 cm/sec) resting for several adults: ≥1.5m deep in streams ≤5.0m wide or >2.0m deep in >5.0m wide. Alternate: moderate velocity (>15cm/sec runs w/80% large organic cover. Low velocity runs and boulders.	small, ephemeral or permanent 1st or 2nd order streams with moderate velocities and low-to high-gradients
Winter and Escape cover		2.0-6.0 cm gravel, <2% fines (≤3mm)	burrow in 10% substrate (10-40cm) at <8°C	burrow in 10% substrate (10-40cm) al <8°C	burrow in 85-95% rubble (7.6-30.1cm) and 515% coarse gravel (2.5-7.6 cm) w/occ. boulders and large woody debris; hide under debris jams. root wads, fogs, boulders, or in negative-velocity pools	boulders: logs; debris.
Diet		yolk sac	large zooplankton, small aquatic insects	small-medium aquatic insects	92% drift insects: Diitera. Trichoptera. Pfecoptera Ephemeroptera; 6-8% allochthonous terrestrial insects: 0-2% fish	very little: eggs. aquatic insects

Males mature one year earlier than females, males reach maturity at age 3-4+, and females mature at age 4-5+.

Size at maturity depends upon environmental conditions and abundance of food. Consequently, adfluvial cutthroat stocks are substantially larger than fluvial stocks, which inhabit the same drainage and are the same age.

Cutthroat return to natal tributaries to spawn. Initiation of spawning is dependent on water temperature, runoff, ice melt, elevation and latitude. Westslope cutthroat may spawn as early as February, or in colder waters as late as August. Most spawn just before and during high-water of April and May in the lower tributaries and from April to June in middle and upper tributaries.

Spawning populations tend to have a higher ratio of females to males, averaging 2.6 females per male. Fecundity of females is similar to other salmonids; number of eggs per female increases with length of fish.

Natural mortality ranges from 30-54 percent for adfluvial and fluvial populations. During early stages of life, it is estimated that 95 percent mortality occurs from emergence to age 1+ fingerlings. Amount of fine sediment (< 3.0 mm) in incubation gravels is a major factor that determines egg to swim-up fry mortality. Optimal percent fines in spawning areas during average summer flows is two percent or less.

3.1.3 Water Quality

3.1.3.1 Temperature

Average maximum daily water temperatures have a greater effect on trout growth and survival than minimum temperatures. During embryo development, average maximum water temperature range is 3.0°-16.0°C, with 7.0°-11.5°C as optimum (Table 3.1). Highest average temperature range during warmest period of the year for juvenile to adult is 6.0-21.0°C, with 11 .0-15.5°C representing optimal conditions.

3.1.3.2 Dissolved Oxygen

For all ages of cutthroat trout, the average minimum dissolved oxygen concentrations during late season, low water period are 4.5-7.3 mg/l for water temperatures up to 15°C. Minimum dissolved oxygen concentrations during late season, low water period are 4.5-7.3 mg/l for water temperatures up to 15°C and 6.0-9.0 mg/l in water above 15°C. Optimal concentrations of dissolved oxygen are 7.3 mg/l in water up to 15°C and 9.0 mg/l in water exceeding 15°C (Table 3.1).

3.1.3.3 Other Water Quality Parameters

Annual pH range for cutthroat trout is 5.9-9.0, with optimal conditions at 6.5-8.0 pH (Table 3.1). Neither pH or total dissolved solids appear to have any influence on limiting distribution of cutthroat trout. Little information is available on total alkalinity and total hardness requirements.

Turbidity is an optical property of water wherein suspended and dissolved materials cause light to be scattered and absorbed rather than transmitted in straight lines. Low turbidities near 10-26 nephelometric turbidity units (NTU) and suspended concentrations near 35 mg/l have deleterious effects on fish and macroinvertebrates. In Idaho, numerical turbidity standard for protection of fish and aquatic habitats is 5 NTU/JTU (Jackson turbidity units) above normal.

3.1.4 Gradient and Velocity

Streambed gradient effects trout populations by influencing stream velocity. Stream velocity effects the quality and quantity of bottom organisms and has a direct influence on fish populations by restricting and influencing the delivery of oxygen-saturated water.

Velocities for spawners range from 11.0-92.0 cm/sec (Table 3.1). During spawning, cutthroat trout are typically found in small, ephemeral or perennial, first and second order streams with moderate velocities and low to high gradients.

Average velocities during embryo development range from 20.0-80.0 cm/sec, with optimal velocities at 30.0-65-O cm/sec.

Fry (age 0+) prefer protected habitats with velocities ranging from O-30.0 cm/sec, optimally with flows less than 8.0 cm/sec. Since fry survival decreases with increased velocity above- optimum, preferred rearing areas are protected stream edges, lateral habitats, backwaters, deep backwater pools, glides, and low gradient riffles.

Juvenile cutthroat of ages 1+ and 2+ use similar habitats with optimal velocity increasing with age. For age 1+ juveniles, preferred velocities are 9.1-10.3 cm/sec, and 13.1-l 6.0 cm/sec are chosen by age 2+ fish. Juveniles choose deep lateral scour and plunge pools, protected stream edges, lateral habitats with optimally 16 percent cover, and protected low-velocity riffles.

Adult cutthroat trout desire velocities of 10.0-14.0 cm/sec, but can be found in areas of 2.8-29.3 cm/sec. They choose habitats with 10-30 percent deep, class-l pools during lowest flow period, but favor areas of 30 percent class-l pools, where low-velocity resting (< 15 cm/sec) for several adult trout, is possible. Deep, class-l pools have greater than 30 percent of bottom obscure due to depth, surface turbulence, presence of structures (e.g., logs, debris piles, boulders), or overhanging banks and vegetation. Depth of class-l pools should be 1.5 meters or greater in streams that are 5.0 meters wide or less, or should exceed 2.0 meters deep in streams greater than 5.0 meters wide. During low water period of summer, 35-65 percent of entire stream should consist of low-velocity pools in some form. Alternate habitat for adults is moderate velocity runs with 80 percent large organic cover.

The lowest flows of late summer to winter, or base flows, are the most critical periods for trout. A base flow of 25-50 percent is acceptable. A base flow of greater than 50 percent of average annual daily flow is optimal for quality trout habitat; anything less than 25 percent is unacceptable. High base flows (≥ 50%) and low flow variability results in optimal habitat (Table 3.1).

Overall gradient for all ages and life stages of cutthroat trout ranges from 0.7-10-O percent, with desired range of 2.4-5.2 percent.

3.1.5 Substrate

Bottom type influences the quantity and quality of macro-invertebrates and is of prime importance in determining the natural production in a stream. In riffle-run areas of food production, optimal substrate consists of 50 percent or greater rubble, small boulders or aquatic vegetation in spring areas, with limited amounts of gravel, large boulders or bedrock.

For successful reproduction, the average optimal substrate is 2.0-6.0 centimeters in diameter, with less than two percent fines (ı 3 mm) in riffle-run spawning areas. Approximately 85 percent mortality of eggs and alevins will occur if 15-20 percent of interstices of substrate is filled with sediment.

Fry (age 0+) are more consistently associated with gravel-cobble-boulder substrate, and juveniles (age 1+ - 2+) favor gravel-rubble-boulder mix. Since small fish move into substrate as temperature drops below 8°C, optimal winter and escape cover for fry and juveniles is a substrate where ten percent ranges between 10-40 centimeters in diameter (Table 3.1).

Subadults and adults prefer substrates of 85-95 percent rubble (7.6-30.1 cm) and 5-15 percent coarse gravel (2.5-7.6 cm), interspersed with boulders and large woody debris.

3.1.6 Cover

Instream cover is recognized as a critical component of stream habitat affecting trout densities. Cover consists of water depth, surface turbulence, loose substrate, large rocks and other submerged obstructions, undercut banks, aquatic and overhanging terrestrial vegetation, downed snags and other debris lodged in the channel, and anything else that allows trout to avoid impacts of elements and enemies.

There are two types of cover that limit trout densities--summer and winter cover. The main use of instream summer cover is for predator avoidance, resting and feeding stations. Summer cover of protected stream edges and backwater pools for fry and juveniles, and deep class-l pools or protected runs for adults has been discussed relative to gradient and velocity in Section 3.1.4. Apportionment of summer cover for fry and juvenile is 34 percent gravel-cobble-boulder mix, 24 percent shade overhang, 24 percent fine debris, and 17 percent woody debris, which occur along pool edges and in habitat units less than 200 m^2 or $100 m^3$. Adults prefer protected pools and low-velocity runs, or boulders (Table 3.1).

In winter, fish inhabit near freezing water temperatures and have lower metabolism, reduced food requirements and less available energy. The resultant hiding **response** is **a means** of avoiding predation, mass ice movements and flooding, and of reducing downstream displacement during freshets to conserve energy. Fry and juvenile cutthroat trout move into the substrate as temperature drops below **8°C.** Subadults and adults often display the same behavior or seek shelter under debris jams, root wads, logs, boulders, or in sheltered negative-velocity pools.

Another form of cover is canopy cover. Canopy cover and streamside vegetation are important in providing temperature control, in contributing to the energy budget and allochthouous input to the stream, in controlling watershed erosion, and maintaining streambank integrity. Approximately **15-90** percent of stream area should be shaded from 1100-1400 hours. For streams less than 50 meters in width, 50-75 percent of stream area was necessary to be shaded at midday for optimal habitat conditions.

3.1.7 Diet

Cutthroat trout are very opportunistic and their diet consists mainly of insects. As fish grow larger, diversity of food items increases and includes terrestrial insects and sometimes small fish.

Fry (< 110 mm) often prefer a diet of larger zooplankton and small aquatic insects. Juvenile trout increasingly consume larger insects. Subadults and adults feed 92 percent **(75-100%)** on drift organisms. The four principal orders of aquatic insects consumed are Diptera (midges and flies), Trichoptera (caddisfiies), Plecoptera (stoneflies) and Ephemeroptera (mayflies) in decreasing order of importance (Table 3.1).

3.2 LITERATURE REVIEW FOR BULL TROUT

3.2.1 General Information

Bull trout display three distinct life history patterns. They are:

1. Resident, which inhabit headwater streams, do not migrate, and are normally isolated by a physical barrier.

2. **Fluvial,** which inhabit large streams and mainrivers, and migrate from main river to natal stream to spawn and rear.

3. Adfluvial, which inhabit large lakes and reservoirs and migrate back to nursery stream to spawn. They rear l-6 years in nursery tributary and mature 2-3 years in lake, before returning to spawn.

3.2.2 Life History

Life history of bull trout can be categorized by advanced age of maturity, increased size, alternate-year spawning, extensive migrations, and separation of juvenile and adult populations. Average age of maturity for bull trout is age 4-7+. Length at maturity is dependent upon environmental productivity, water temperature and life history pattern of stock.

Spawning usually occurs between September and October. Bull trout enter tributaries approximately one month prior to spawning. Upstream migration has been found to coincide with maximum water temperatures (1 O-l 2°C) and minimum flows in O-76-0.80 meter deep water (Table 3.2).

Initiation of spawning appears to be related to declining water temperatures, photoperiod, and possibly stream flow. Most spawning occurs at night, when water temperatures fall below 9°C (av. 5-6°C). Bull trout pairs remain over the nest for one to six days: after spawning, they move downstream within a month.

Fertiliztion rate is estimated to be approximately 90 percent. Fecundity (#eggs/female) is lower than or equal to other charrs of comparable size. Egg retention is 2-5 percent. Sex ratio averages 1 .1 female per male. In the Flathead River system, each redd averaged 3.2 spawners.

Incubation continues throughout winter, with peak hatch occurring by mid-January. Peak emergence of fry generally takes place by 1 May. After l-3 years of rearing in tributary streams, bull trout smolts out-migrate to main rivers (fluvial) or lakes and reservoirs (adfluvial).

Table 3.2 Acceptable and optimal habitat conditions for various life stages of bull trout.

	Egg/Alevin	Frv	Juvenile	Adult	Spawner
maximum range		5-15°C	5-I 5°C	9-1 5°C (resident/fluvial)	5-9°C
Temperature (°C				7.2-I 4.0°C (adfluvial)	
optimal	2-4°C	5-8°C	5-8°C	9-1 0.0°C (resident/fluvial) 8.0-I 2.8°C (adfluvial)	5-6°C Sept. - Oct.
range	fast	low	low- moderate	moderate - fast	moderate - fast
Velocity (cm/sec					
optimal		8-10	8-16		
range				10-20%	
Gradient		low	low		
optimal	<3%				<3%
Substrate	0% unembedded ravel, 3% cobble, 7% boulder; o fines ≤ 6.4 mm,	sand/gravel gravel-cobble-rubble	unembedded, stacked rubble-cobble-boulder with large interstitial spaces between particles	deep pools w/ boulder-rubble substrate	0% unembedded ravel, 3% cobble, 7% boulder: o fines ≤ 6.4 mm
Cover	ubstrate	sidechannels; backwaters: lateral stream margins; pools with submerged debris: substrate: unconsolidated woody debris: submerged and large instream structures.	side-channels; backwaters: lateral habitats: pools with submerged debris substrate: unconsolidated woody debris: submerged and instream structures.	closed-forest canopy shade: overhanging banks and vegetation: woody debris and jams; large deep pool: water depth.	losed-forest anopy shade: verhanging anks and regetation; voody debris nd jams; arge deep pools: vater depth.
Diet	olk sac	1. aquatic insects 2. eggs	1. aquatic insects 2. salmon eggs 3. increasingly piscivorous	1. piscivorous: 2. whitefish 3. kokanee 4. sculpins 5. squawfish 6. chubs 7. suckers 8. yellow perch 9. aquatic and terrestrial insects: Mysis shrimp.	rery little, f anything eggs, insects)

Most fluvial and adfluvial young remain in nursery streams for 1-6 years, generally 2-3 years of age. Time of migration varies depending on age and size of fish, and amount of available habitat. Out-migration occurs in the spring (May-August) to areas where water velocities are lower.

3.2.3 **Water Quality**

3.2.3.1 **Temperature**

All life history stages of bull trout are strongly influenced by temperature (Table 3.2). Bull trout are seldom associated with tributaries where summer temperatures exceed 15°C and are normally associated with cold perennial springs or groundwater influence, and a closed-forest canopy.

Spawning migration coincides with water temperatures around 1 O-l 2°C. During embryo development, optimal incubation temperture is 2-4°C. Highest average temperature range during warmest period of year for fry and juvenile bull trout' is 5-15°C, with optimal range of 5-8°C for fry and 5-12°C for juveniles. For resident and fluvial adult bull trout, the average maximum temperature range is 9-15°C, with 9-10°C as optimum. Adfluvial adults prefer 7.2-l 4.0°C temperatures; 8.0-l 2.8°C range is optimum.

3.2.3.2 **Other Water Quality Parameters**

No conclusive information exists on chemical parameters, such as dissolved oxygen, pH, alkalinity, hardness, total dissolved solids or turbidity.

3.2.4 **Substrate**

Unembedded gravel-cobble-boulder composition (60-23-l 7%) substrate with low compaction, low gradient and no fines below 6.4 millimeters are selected as bull trout spawning sites; these areas have the highest frequency of redds and success of emergent fry (Table 3.2).

Young fry show a preference for sand and gravel, whereas highest density of juveniles will be found in stream segments dominated by clean unembedded, stacked rubble-cobble-boulder substrate with large interstitial spaces between particles.

Adult bull trout are bottom dwellers and prefer deep, cold water pools with boulder-rubble substrates; this type of habitat ensures good winter survival and adequate summer protection.

3.2.5 Velocity and Gradient

Low channel gradient has been significantly correlated with high redd frequency of bull trout; frequency is highest where gradient is less than three percent in a high order stream with groundwater influence (Table 3.2).

Juveniles distribute themselves along the stream bottom, seeking low velocites (10 cm/sec) in association with submerged cover. Since low optimal velocities are found only in small pockets of the stream, it has been found that describing mean velocities by conventional methods has not provided information on available rearing habitat. Extremely high flows reduce survival by flushing fry out of tributaries into mainstem, where predation rates are higher. Conversely, low flows reduce wetted area and reduce amount of space available for rearing fry and juvenile.

Adult bull trout select streams with 10-20 percent gradients and moderate to fast velocity flow.

3.2.6 Cover

Upon emergence, bull trout fry migrate to low-velocity areas that are separated from adults, such as side channels, backwaters, lateral stream margins, and pools (Table 3.2). Fry and juvenile find protection and rest near submerged debris over gravel-cobble-rubble substrate or by burrowing into the interstices of unembedded substrate cobble.

Streams can be manipulated to enhance rearing capacity for juvenile bull trout (40-200 mm). A single piece of submerged debris along the stream margin or a large jam of unconsolidated woody debris can mitigate for rearing capacity; water should flow through the debris jam or root wad, not necessarily over it into a plunge pool. Submerged cover along stream bottoms can create small pockets of slow (10 cm/sec) water, advantageous to fry and juveniles. As juveniles increase in size, they become less dependent on instream cover.

Adults and spawners rely upon closed-forest canopy shade, overhanging banks and vegetation, and woody debris as cover; higher redd frequency is associated with this type of cover. Resident and fluvial adults require large deep pools for cover in summer and winter. Adfluvial bull trout in lakes use depth as cover.

3.2.7 Diet

Bull trout are voracious predators and have been described as opportunistic and adaptive in feeding habits (Table 3.2).

Bull trout larvae remain in gravel until yolk sac absorption is nearly complete. Bull trout begin feeding at emergence and select aquatic insects from the entire water column.

Bull trout fry (< 100 mm) feed exclusively on aquatic insects, however, salmon eggs are important components of juvenile diets. As juveniles reach 11 O-l 14 millimeters, they become increasingly piscivorous. Growth and condition improve after bull trout begin feeding on fish. Sub-adults (< 300 mm) consume small individuals of sculpins, whitefish, kokanee, and incidentally yellow perch, squawfish, peamouth chubs and suckers, and Mysis shrimp, if opportunely available.

Fluvial adults (≥ 400 mm) eat primarily fish and insects. Adult resident trout feed exclusively on insects. Food preferences are Diptera (midges and flies), Trichoptera (caddisflies), Ephemeroptera (mayflies), and Plecoptera (stoneflies), in decreasing order of importance.

Adfluvial populations are highly piscivorous and reach the largest size of all stocks. Preference is for kokanee and whitefish: however, diet preference is altered by availability of prey and season.

Spawning adults eat very little, if at all.

For hatchery produced bull trout, it is difficult to provide a suitable diet; these fish demonstrate clear preferences for certain flavors. Since bull trout feed exclusevely on the bottom, finding palatable sinking food has been difficult, and diseases (gill infections) have been much more difficult to control than in aquaculture of other species.

3.2.8 **Species interactions**

Interactions between bull trout and northern squawfish, cutthroat, rainbow, and lake trout have been recognized.

Both northern squawfish and bull trout shift to a piscivorous diet at 200-300 millimeters and compete for the same food source, if cohabiting together.

Rainbow and bull trout do not compete for food resources or living space, but bull trout and juvenile rainbow trout partition the habitat; rainbow trout choose areas of higher velocity.

Habitat partitioning occurs between juvenile bull and cutthroat trout. Also, in areas of high cutthroat density, bull trout have been repeatedly found, which suggests that cutthroat fry serve as prey for adult and subadult bull trout.

Fluvial populations of bull and brook trout, that cohabitate in the same stream, share the same habitat during at least one stage of their life. Hybridization of the two species is common and extensive. It has been hypothesized that the introduction of brook trout and competition with brown trout have led to the decline of bull trout populations.

Decline of adfluvial bull trout stocks has been attributed to flood damage of spawning and rearing habitat and competition with introduced lake trout.

3.3 GEOMORPHOLOGICAL PARAMETERS

Geomorphological data from 19 streams, which are tributary to Coeur d'Alene Lake, are listed in Table 3.3. Parameters listed include: stream length, stream order, channel gradient, elevation, basin area, basin relief, drainage density and sinuosity. Stream lengths ranged from 1.9 kilometers (1.2 mi) for Shingle Bay Creek to 23.7 kilometers (14.7 mi) for Benewah Creek. The study streams ranged from second to fourth order with gradients ranging from 1.5-6.4 percent. Elevation of streams ranged from approximately 823-1463 meters (2700 to 4800 ft). Area of stream basins ranged from 9.6-135.9 square kilometers (3.7 to 52.5 mi^2). Figure 3.1 shows the gradient based on stream distance versus elevation of each of the nineteen tributaries.

Table 3.3 Results* of geomorphometric data calculated from the tributaries of Coeur d'Alene Lake.

Stream	Length mi (km)	Stream order	Channel gradient	Stream elevation ft (m)	Basin area mi^2 (km^2)	Basin relief ft (m)	Drainage density mi (km)	Sinuosity
Bellgrove	3.0 (4.8)	4	2.5	4001 (1219.5)	4.7 (12.3)	624 (190.2)	2.6 (4.2)	1.10
Fighting	4.9 (7.9)	4	2.6	4004 (1220.4)	6.1 (15.7)	813 (247.8)	3.1 (5.0)	1.12
Lake	12.7 (20.4)	3	1.8	4793 (1460.9)	12.7 (32.8)	462 (140.8)	3.9 (6.3)	1.12
Cottonwood Bay	2.6 (4.2)	3	5.8	2921 (890.3)	5.6 (14.5)	884 (269.4)	1.3 (2.0)	1.01
Squaw	4.7 (7.6)	2	3.4	3903 (1189.6)	12.6 (32.7)	884 (269.4)	1.9 (3.0)	1.01
Plummer	6.8 (10.9)	3	1.5	3395 (1034.8)	21.1 (54.6)	1274 (388.3)	3.0 (4.8)	1.31
Little Plummer	8.8 (14.2)	4	1.6	3603 (1098.2)	21.9 (56.7)	1716 (523.0)	2.0 (3.2)	1.19
Pedee	2.8 (4.5)	3	4.4	3640 (1109.5)	6.9 (17.8)	1599 (487.4)	1.8 (2.9)	1.02
Benewah	14.7 (23.7)	4	1.7	4095 (1248.2)	52.5 (136.0)	2509 (764.7)	3.0 (4.9)	1.17
Cherry	3.7 (6.0)	3	4.9	4000 (1219.2)	8.4 (21.7)	2743 (836.1)	1.8 (2.9)	1.20
Alder	12.6 (20.3)	4	4.5	4295 (1309.1)	26.9 (69.6)	2662 (811.4)	2.3 (3.6)	1.18
John & Little John	10.6 (17.1)	4	2.2	3690 (1124.7)	25.9 (67.1)	1853 (564.8)	2.8 (4.5)	1.09
Hell's Gulch	6.5 (10.5)	3	4.6	4436 (1352.1)	14.8 (38.4)	2704 (824.2)	2.6 (4.2)	1.01
O'Gara Bay	1.8 (2.9)	3	3.7	3058 (932.1)	4.7 (12.3)	657 (200.3)	2.3 (3.6)	1.01
Shingle Bay	1.2 (1.9)	3	6.4	2980 (908.3)	5.6 (14.5)	637 (194.2)	1.5 (2.4)	1.06
Black	3.7 (6.0)	3	3.4	3400 (1036.3)	7.0 (18.1)	1274 (388.3)	2.6 (4.1)	1.03
Willow	4.0 (6.4)	2	5.8	3910 (1191.8)	5.7 (14.7)	2704 (824.2)	1.6 (2.6)	1.01
Evans	5.2 (8.4)	3	4.5	4589 (1398.7)	12.8 (33.2)	3256 (992.4)	1.9 (3.1)	1.03

* Rounded to nearest tenth.

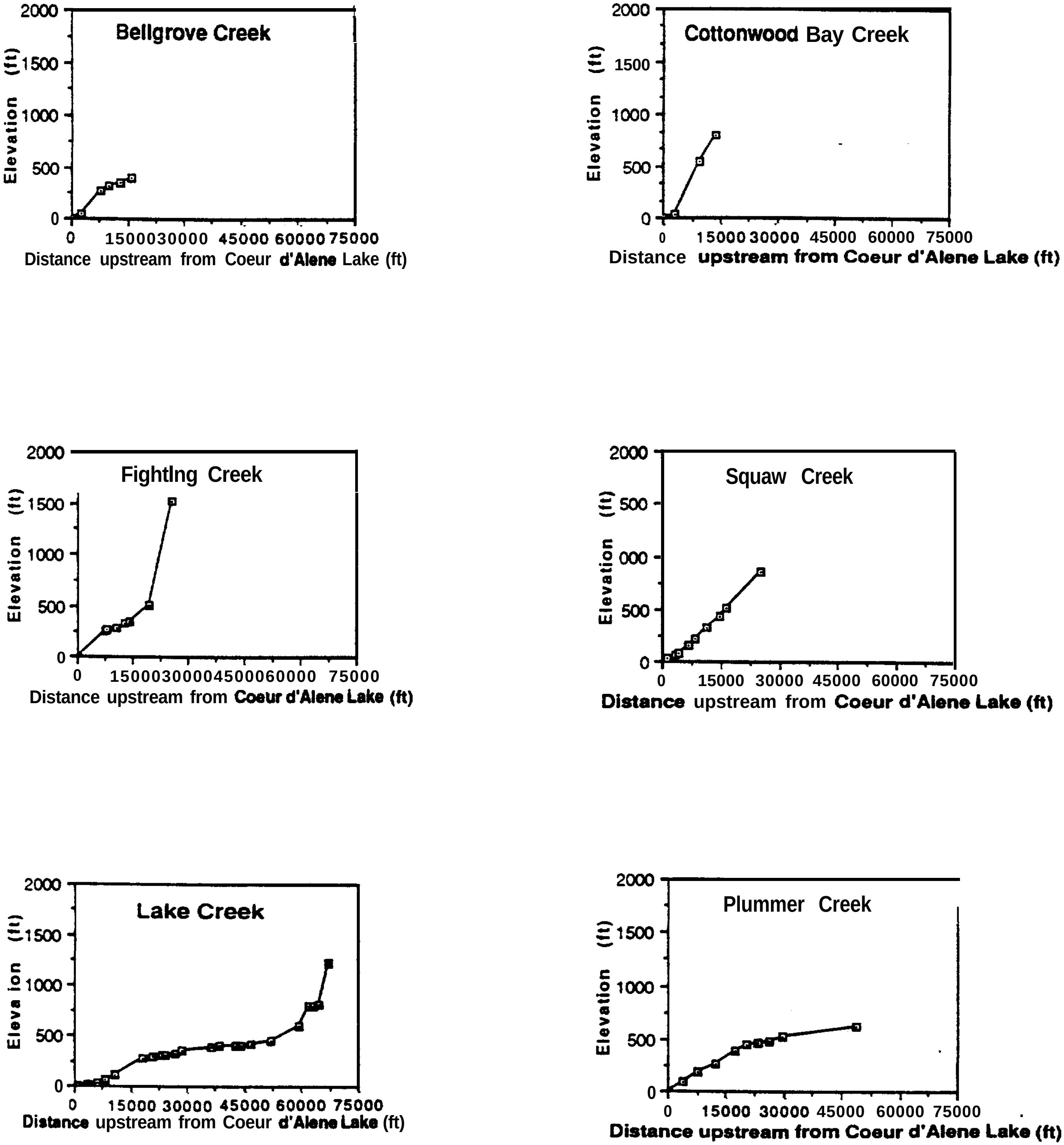

Figure 3.1. Stream gradient profiles for tributaries on the Coeur d'Alene Indian Reservation (no graph for Little John Creek).

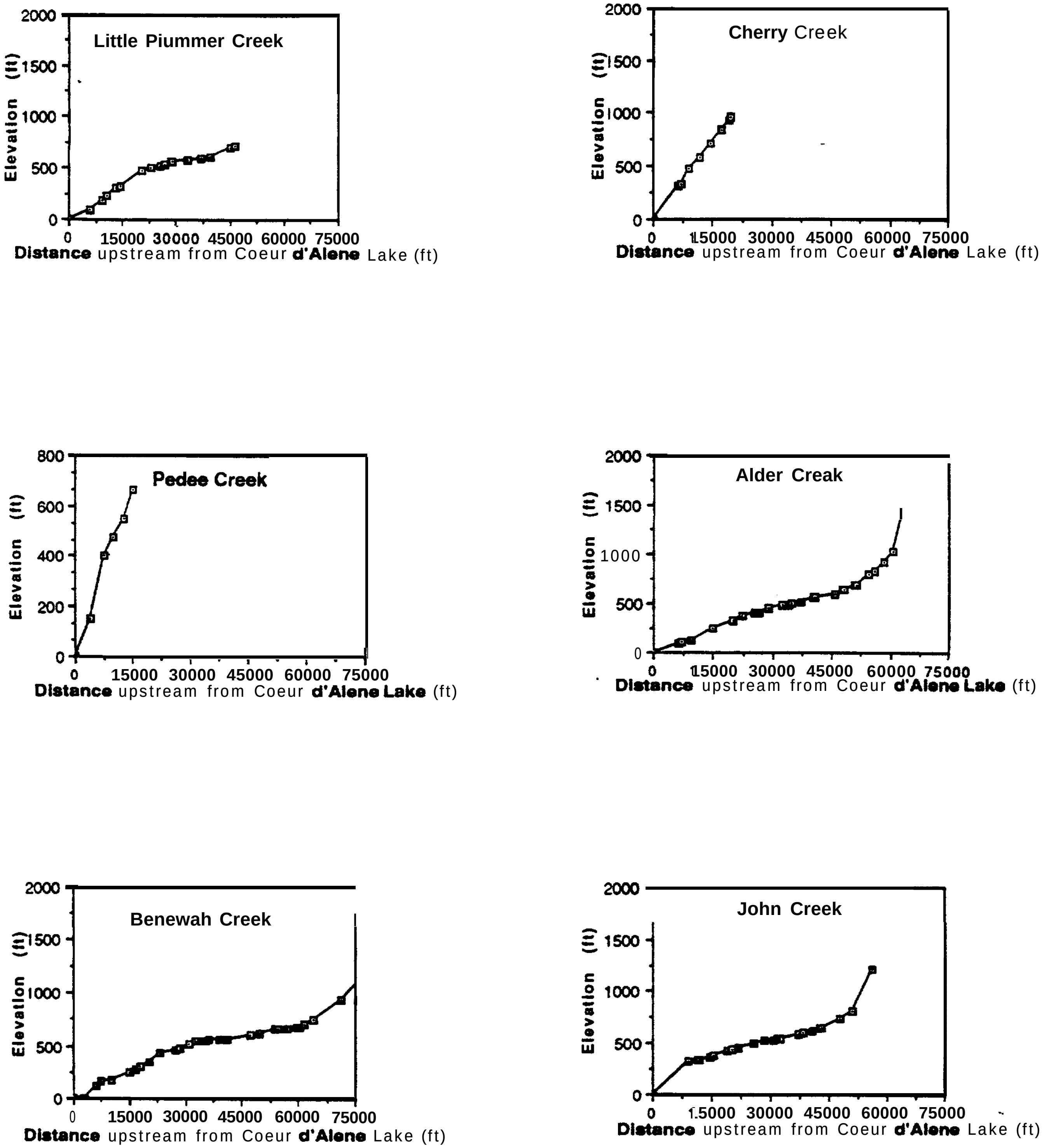

Figure 3.1. (cont.).

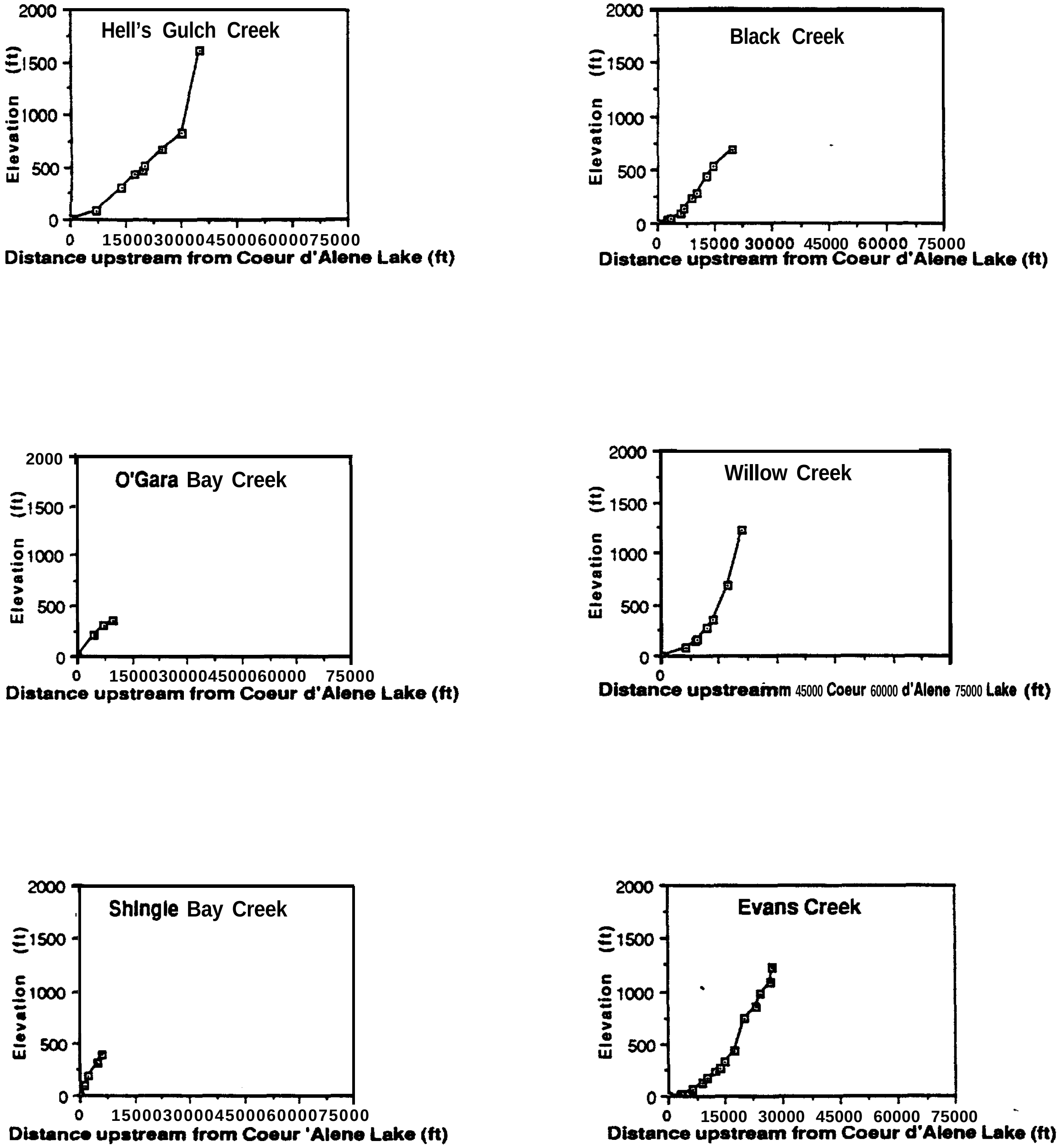

Figure 3.1. (cont.).

3.4 AERIAL SURVEY

Comparison of results observed during the aerial survey for lower, middle and upper reaches of the 19 tributaries are provided in Table 3.4. Summary of each stream is provided below.

3.4.1 Bellgrove Creek

Recreational, residential, agricultural, grazing and timber land-use practices were observed adjacent to Bellgrove Creek. Road access appeared good, especially in the lower reaches where 50 percent was residential. Stream width ranged from approximately 0.6 meters (2.0 ft) in the upper reach to 9.1 meters (30.0 ft) at the mouth. Gradient was steep for most of the stream. Minimal flows were observed during December, indicating summer flow would probably be intermittent. Lack of a riparian zone, along with unstable and wasting banks, allowed meandering of the stream channel throughout the lower valley floor. The instability of the stream channel can be attributed to agricultural, logging and grazing practices adjacent to and within the stream channel. Large woody debris was observed in the stream. A heavy silt load from logging and grazing posed a potential water quality problem. Observed barriers included a concrete embuttment and numerous culverts. At the confluence with Coeur d'Alene Lake, a solid concrete embuttment was observed under the bridge that appeared to be a barrier to fish migration. Numerous improperly graded culverts were noted within the channel. Cumulative land-use impacts were noted along entire length of the stream. At the mouth, heavy recreational use was noted.

3.4.2 Fighting Creek

Land-use practices adjacent to Fighting Creek included recreation, residential, agricultural, grazing, and timber harvest. Road **access was** good. The stream channel was an irregular meander, in which the riparian zone and stream banks were significantly damaged. A moderate gradient, capable of sustaining a fishery, was observed in the middle reach. No vegetative streamside cover remained along the stream channel, except for a few isolated alder groves. The gradient appeared steep with rapids and boulders prevalent in the upper reach, which suggests that this area is not conducive to a bull and cutthroat trout fishery. Observed barriers

Table 3.4. Summary of information recorded during aerial survey for lower, middle and upper reaches of the nineteen tributaries under study (St. Joe River excluded).

Stream & Section		Land-Use	Road Access	Gradient	Flow	Substrate-Riffle:Pool	Soils & Bank Stability	Riparian	Channel	Cover & Woody Debris	Water Quality	Barriers
Bellgrove	Lower	agriculture grazing	good	moderate	low	silted	highly erodible;	none		good	marginal-poor	cement embutiment
	Middle	logging-timber	good	moderate	low		wasted & unstable	none	unstable	good	heavy silt	culverts;
	Upper	recreational residential	good	moderate-high	rapids			none	meander	good	load	cumulative impacts.
Fighting	Lower	agriculture grazing	good	moderate	moderate	silted	highly	damaged	unstable	-	poor	cement embutiment
	Middle	logging & timber	good	moderate	moderate	silted	erodible	to none	meander	-	poor	water quality;
	Upper	recreational residential	good	very high	rapids	boulders				-	poor	cumulative impacts.
Lake	Lower	agriculture grazing	none	gradual/low	moderate	silted substrate	highly erodible;	site-specific	unstable	-	silted;	none
	Middle	logging-timber	limited	moderate/low	moderate	50/50 r:p-high riffle	wasted and	protected	meander;	-	moderate-poor	none
	Upper		good	moderate	moderate-rapids	high riffle	undercut	limited	unstable braided	-		none
Cottonwood Bay	Lower	-	good		none	-	-	-	dry	-	none	concreet channel;
	Middle	-	good	very	none	-	-	-	dry	-	none	no
	Upper	-	good	high	none	-	-	-	dry	-	none	water
Squaw	Lower	agriculture grazing	good	moderate	-	gravel	stable	undamaged			good	none (potential
	Middle	logging-timber	good	moderate	-	50/50 riffle:pool	stable	undamaged	unstable	good;	good	for log jams and intermittent
	Upper		good	moderate	-		stable	none	meander	logs and debris	good	flow in upper)
Plummer	Lower	logging-timber	good	moderate			highly	damaged		good		upper: Town of Plummer;
	Middle	residential	good	moderate	moderate-	50/50 riffle:	erodible;	with	stable	good	muddy-	culverts; sewage ponds + storm
	Upper		good	low-moderate	high	pool	stable	residual snags	meander	good	poor	drain effluent; water quality
Little Plummer	Lower	agriculture grazing	good	low					stable	good	good	gravel pit;
	Middle	gravel mining	good	gradual/moderate	moderate-	gravel	erodible;	undamaged;	stable	good	good	numerous culverts;
	Upper		good	moderate	high	50/50 riffle:pool	stable	stable	stable	good	good	possible log jams
Pedee	Lower	-	good	very high	none	-	-	-	dry	-	none	frozen in
	Middle	-	good	very high	none	-	-	-	dry	-	none	winter;
	Upper	-	good	very high	none	-	-	-	dry	-	none	gradient
Benewah	Lower	agriculture grazing	excellent	low	moderate			site-specific:disturbed	stable	good	good	
	Middle	logging	excellent	gradual/moderate	moderate	50/50 riffle:	erodible;	stable, protected.	stable	good	good	improperly graded culverts;
	Upper		excellent	moderate-very high	moderate rapids	pool	stable	limited	stable	good	good	headwaters: steep gradinet rapids
Cherry	Lower	-	good	very high	none	-	-	-	dry	-	-	no
	Middle	-	good	very high	none	-	-	-	dry	-	-	water;
	Upper	-	good	very high	none	-	-	-	dry	-	-	gradient
Alder	Lower	logging	good	moderate	moderate	high riffle:	stable		stable	good	good	upper: waterfalls;
	Middle		good	moderate	moderate-slightly high	low pool	stable	stable;	stable	good	good	steep gradient;
	Upper		good	high	rapids	cascades	stable	undamaged	stable	good	good	rapid cascades

Table 3.4. (cont.).

Stream & Section		Land-Use	Road Access	Gradient	Flow	Substrate Riffle: Pool	Soils & Bank Stability	Riparian	Channel	Cover & Woody Debris	Water Quality	Barriers
John	Lower	logging	good	high	moderate	50/50 riffle:	stable	stable	stable meander;	good;	good	waterfalls
	Middle	grazing	good	low-moderate	moderate	pool;	stable	stable	sidepools	upstream potential	good	-
	Upper		good	high	moderate-high	good	erodible; unstable	stable	unstable	for downstream scour	good	gradient, flow, woody debris
Little John	Lower	.	limited	high	rapids	poor	unstable	-	-	-	poor	flow
	Middle	.	limited	high	rapids	high riffle	unstable	-	-	-	poor	
	Upper	.	limited	high	rapids		unstable	-	-	-	poor	gradient
Hell's Gulch	Lower	agriculture	good;	moderate-high		silted poor;		damaged-none;	highly erodible;	poor	poor:silted	water quality;
	Middle	logging-timber	south side	moderate-high	low flow	high riffle	erodible; unstable	damaged-none;	mass wasting;	poor	poor:silted	gradient; culverts;
	Upper	gravel mining		very high				forested	unstable;	good	clean	debris jams
O'Gara Bay	Lower	timber	goods	high	minimal	-	.	one side	-	-	-	culvert at mouth;
	Middle		goods	high	minimal	-	.	wooded;	-	-	-	gradient;
	Upper		goods	high	minimal	-	.	other-none	-	-	-	flow
Shingle Bay	Lower	.	good	high	disappeared underground	-	.	-	dry	-	none	stream disappeared
	Middle	.	good	high	into grate at	-	.	-	dry	-	none	into grate;
	Upper	.	good	high	mouths ; no flow	-	.	-	dry	-	none	no flow
Black	Lower	agriculture	poor	moderate	low	silted poor	stable		stable	-	poor	none
	Middle	logging	poor	high	low	50/50 riffle;:pool	stable	very degraded;	stable	-	poor	none
	Upper	+ timber	limited	very high	low-intermittent	high riffle	stable	stable	stable	-	poor	none
Willow	Lower	agriculture; grazing;	good	moderate	moderate	silted	erodible;	none	highly	good	poor	culverts;
	Middle		good	moderate-high	moderate	silted	unstable	none	erodible;	good	poor	water quality;
	Upper	logging -timber	good	high	moderate	riffles		none	meander	good	poor	upper gradient
Evans	Lower	agriculture	good	moderate	low	heavily silted;	unstable;	slightly	unstable meander;	good	silted	none
	Middle		good	moderate-high	moderate	gravel;	erodible	degraded	stable;	good	silted	none
	Upper		good	high	rapids + cascades	boulders			steep		silted	none; possible gradient

included a concrete embuttment, extensive water quality problems, and a landfill site located along the stream.

At the confluence with Bellgrove Creek, a solid concrete under-bridge embuttment was observed that appeared to limit fish access to the creek. Also, extensive water quality problems were possible, as a result of grazing adjacent to and within the stream channel, agricultural land-use practices, and seepage from the landfill site. These water quality problems could pose as a migration barrier to trout.

3.4.3 Lake Creek

At the mouth of Lake Creek, the width was approximately 9.1-10.7 meters (30-35 ft). No road access existed along the lower reaches of Lake Creek. The gradient was gradual. Highly erodible soils allowed the stream channel to meander through the valley, where severely undercut banks, exposed tree roots, and mass wasting were evident. Site-specific damage to the riparian zone was noticed. Heavy sediment loads were observed at the mouth of Lake Creek.

Land-use practices adjacent to the middle reach of Lake Creek, included selective and partial logging with a protected riparian zone. The gradient was gradual with a high riffle:low pool ratio, gradually changing to an equal riffle:pool ratio.

The upper reach of Lake Creek was agricultural, and a limited riparian zone remained. Agricultural and grazing practices allowed for an unstable, braided stream channel, carrying a heavy silt bedload.

3.4.4 Cottonwood Bay Creek

The gradient of Cottonwood Bay Creek was very steep, and no water was observed in the stream channel during the aerial survey. The mouth of Cottonwood Bay Creek had been channelized with concrete.

3.4.5 Squaw Creek

Land-use practices adjacent to Squaw Creek included clear-cut logging, grazing and agriculture. Road access to Squaw Creek was good. At the confluence with Coeur d'Alene Lake, a meandering stream channel was present, resulting in an unstable stream channel. Factors conducive to a trout fishery included a moderate gradient, good gravel deposition, stable streambanks, large- organic debris within the stream channel for cover and pools, and a relatively undamaged riparian area. Site-specific damage to the riparian area was observed in the upper reach of Squaw Creek, where clear-cut logging had taken place. Logging on a 30 percent, south slope increased the possibility of significant sediment loads to the stream. A log jam in the upper portion of the middle reach could result in a blockage to fish migration.

3.4.6 Plummer Creek

Land-use practices adjacent to Plummer Creek included timber, logging and residential. Road access was good. At confluence with Coeur d'Alene Lake, the stream was approximately 12.2 meters **(40** ft) wide. The stream meandered throughout the valley floor. Although the soil **was** highly erodible, the stream integrity appeared relatively stable, as a result of gradual slope and vegetation. Substantial flow was observed, but water was very muddy. The riparian area was damaged, however, it contained a few residual snags for future input of large woody debris to the stream. Large woody debris occurred in the floodplain but **was** marginal within the creek. The gradient, flow, riffle:pool ratio and instream/overhang cover was conducive to good trout habitat. Barriers associated with Plummer Creek include the town of Plummer, culverts, and the sewage treatment facility.

The upper reach of Plummer Creek has been impacted by the city of Plummer. Two sewage ponds and a city storm drain discharged into the stream, indicating a potential water quality problem. Two huge culverts prohibited upstream fish migration past the sewage treatment plant, which were south of the city of Plummer.

3.4.7 Little Plummer Creek

Little Plummer Creek is a tributary to Plummer Creek with gravel mining, agricultural, and grazing land-use practices. Road access was good. Factors conducive to a trout fishery included sufficient spawning gravel, good riffle:pool ratio, streamside cover, stable riparian areas, moderate flow, gradual gradient, and no downstream barriers. Some grazing was noted adjacent to and within the stream channel, causing site-specific erosion and water quality problems. Barriers observed in Little Plummer Creek included culverts and potential log jams.

An out-of-channel culvert located in the upper reach of Little Plummer created a blockage to fish migration.. Numerous other culverts were located in the middle and upper reaches of Little Plummer Creek, possibly causing barriers to fish passage. Potential log jams were also observed.

3.4.8 **Pedee Creek**

In December, Pedee Creek was covered with ice. Maximum length for Pedee Creek was approximately 6.4 kilometers (4.0 mi), and a steep gradient was not acceptable for fish habitat.

3.4.9 Benewah Creek

Land-use practices adjacent to Benewah Creek included agriculture, grazing and logging. Road access to the entire length of the stream appeared excellent. A gradual gradient, adequate stream width and flow, substrate size and **riffle:pool** ratio flavored a fishery in all reaches, except the headwater area. Potential for the installation of fish traps was noted for the majority of Benewah Creek. Damage to the riparian zone was observed occasionally due to logging and grazing, however, it appeared that enough of the riparian zone was left intact to offer shade and erosion control. Large woody debris input to the stream from the riparian area was also noticed. The only barriers observed along the length of the stream included the possibly of improperly graded culverts, and a steep gradient in the headwater region.

A dense stand of alder **was** located near the mouth of the creek; management of the alder grove might enhance the level of water of the slough. Numerous culverts were noted in the upper section of the stream. In the headwater area, a steep gradient and rapids predominated; limited riparian vegetation remained to protect the stream, as a result of grazing.

3.4.10 **Cherry Creek**

The gradient associated with Cherry Creek appeared steep, and no water was observed in the stream channel during the aerial survey.

3.4.11 Alder Creek

The land adjacent to Alder Creek was heavily forested with no prior evidence of timber harvest. Good road access existed along a portion of the stream; new logging roads suggested future timber harvest. The gradient appeared moderate, and riffles were the predominate habitat type. The streambank and riparian zone were stable and undamaged. The presence of large woody debris and instream/overhang cover was noted. Water quality appeared silt-free and clean. Waterfalls were evident in the middle and upper reaches of the stream. A waterfall located in the middle reach appeared not to prohibit fish passage, however a waterfall located in the upper reach was a possible barrier to fish migration. A steep gradient and step-pool cascades were observed above the upper falls.

3.4.12 John Creek

Land-use practices observed adjacent to John Creek included logging and grazing. Road access existed along the entire length of John Creek. Four to five waterfalls were observed approximately two miles upstream, however whether they posed as barriers to fish migration was undetermined. The gradient, flow, and riffle:pool ratio observed in the middle reach of John Creek appeared conducive to a trout fishery. Large woody debris in the stream channel was sufficient to provide instream cover and pool habitat. The presence of meandering, grass-covered side channels provided potential rearing habitat. The middle reach **was** the limit of fish habitat. In the upper reach, the gradient was relatively steep, and stream banks were unstable. Large instream woody debris suggested potential downstream scouring. Grazing activity was noted within the stream channel.

3.4.13 Little John Creek

The observed flow, substrate, and gradient of Little John Creek was unsuitable for fish habitat.

3.4.14 Hell's Gulch Creek

Agriculture, logging, gravel mining, and timber were the predominate land-use practices adjacent to Hell's Gulch Creek. Logging roads provided access on the south side of creek. The lower reach was affected by agriculture, and no riparian zone remained. The substrate **was** heavily silted, and no gravel **was** visibly evident. Gradient was gradual only temporarily, and then steepened significantly. The middle reach was characterized by logging and gravel mining. Mid-reach gradient was steep with a high riffle:low pool ratio. Stream banks were highly erodible and suggested possible water quality problems. Improperly placed culverts and debris jams associated with the culverts were also observed. In the upper reach, heavily forested 2.4-3.0 meter (8-10 ft.) stream banks, located on 30-40 percent slopes, were observed. Water quality appeared clean with large amounts of woody debris located in the floodplain.

3.4.15 O'Gara Bay Creek

A culvert at the mouth of O'Gara Bay Creek prevented any upstream migration of fish. The observed stream flow was minimal with a steep gradient. One side of creek was heavily wooded, and road access was good.

3.4.16 Shingle Bay Creek

The gradient of Shingle Bay Creek appeared steep. The stream disappeared into a grate under the road, and no water was observed in the stream channel.

3.4.17 Black Creek

Agriculture, logging and timber were the land-use practices associated with Black Creek. Stream was accessible by road only in the upper reach. In all reaches, stream width **was** narrow, and flow was limited, which suggested intermittent conditions in summer. Substrate was heavily silted. Although stream banks were stable, riparian areas along most of the creek were degraded. Gradient appeared steep; high riffle:low pool ratio was observed.

3.4.18 Willow Creek

Land-use practices adjacent to Willow Creek included agriculture, grazing and logging. Road access was good. The lower reach of Willow Creek had a moderate gradient. Highly erodible stream banks contributed to the meander of the channel and to the poor water quality of the valley. In the upper reach, a steep gradient with riffles was the predominate habitat type. No riparian area remained along the stream, as a result of logging and grazing. Large organic debris was present adjacent to and within the stream channel. Barriers to fish migration were culverts.

3.4.19 Evans Creek

Agriculture was the primary land-use along Evans Creek. Good road access was observed. The lower reach of Evans Creek had unstable banks and meandered throughout the valley floor. A heavily silted substrate was observed. Sufficient flow existed in this portion of the stream to allow a possible migratory corridor for fish, however, it was not conducive to a resident trout fishery. The middle reach of Evans Creek was very short; the gradient, flow, width (15 ft), depth, gravel, woody debris cover and riffle:pool ratio appeared to favor a cutthroat, and possibly a bull trout, fishery. The middle reach was the limit of favorable fish habitat. The upper reach of Evans Creek had a steep gradient, and step pool cascades were the predominant habitat type. Along the entire creek, it was noted that vehicular traffic crossed the stream in numerous places.

3.4.20 St. Joe River

Land-use practices adjacent to the St. Joe River included agriculture, grazing, industrial, logging, mining, recreation, residential, and timber. Road access was good. Although gradient was suitable for fish habitat, water quality was good, and no barriers existed to prevent fish migration, the St. Joe River was eliminated from study during the aerial survey. This decision was made because jurisdictionally the river was located only partially on the Coeur d'Alene Indian Reservation, and the study area was too expansive for the scope of this project.

3.5 RATINGS BASED ON THE RANKING CRITERIA

Results of the ranking system that established the top ten tributaries for further study are listed in Table 3.5. Those tributaries selected as future study sites included: Bellgrove, Fighting, Lake, Squaw, Plummer, Little Plummer, Benewah, Alder, Hell's Gulch, and Evans creek.

The St. Joe River ranked low enough to be included as a study site, however it was eliminated. Jurisdictionally, only a small portion of the river was located on the reservation, and the study area was too extensive for the scope of this project.

Those tributaries located completely on the reservation included: Benewah, Black, Cherry, Cottonwood, Hell's Gulch, Little Plummer, Lake, O'Gara Bay, Pedee, Plummer, Shingle Bay and Squaw creeks. Those tributaries located partially on the reservation included: Alder, Bellgrove, Evans, Fighting, and Willow creeks and the St. Joe River. Those tributaries located completely off the reservation included John and Little John creeks.

Road access was acceptable for all the tributaries in question, except for Black and Lake creeks, which were determined to have limited access.

No barriers were apparent on Black, Evans, Lake and Squaw creeks. Natural barriers existed on Alder, Cherry, Cottonwood Bay, John, Little John and Pedee creeks. The remainder of the tributaries had man-made barriers located on some portion of the stream.

Potential for enhancement was established by identifying the level of habitat degradation apparent from the aerial survey. This parameter rated the biological characteristics that could be determined from the aerial survey, such as observed flow, sediment loads, gradient, and ranked them according to how they met the requirements for cutthroat and bull trout habitat. This was a subjective method, that quantified the available habitat for cutthroat and bull trout and determined if restoration would improve the amount and quality of habitat for each species.

The tributaries that had marginal habitat included: Alder, Benewah, Evans, John, Lake, Little Plummer, Plummer and Squaw

Table 3.5. Summary of selected parameters and ratings used in ranking criteria to establish ten tributaries for further study.

Stream	Location to Reservation	Road Access	Barriers	Potential for Enhancement	Gradient	Total Score	Recommended Streams
Bellgrove	2	1	2	3	1	9	+
Fighting	2	1	2	3	1	9	+
lake	1	2	1	1	1	6	+
Cottonwood Bay	1	1	3	3	3	11	
squaw	1	1	1	1	1	5	+
Plummer	1	1	2	1	1	6	+
Little Plummer	1	1	2	1	1	6	+
Pedee	1	1	3	3	3	11	
Benewah	1	1	2	1	1	6	+
Cherry	1	1	3	3	3	11	-
Alder	2	1	3	1	2	9	+
John	3	1	3	1	3	11	-
Little John	3	1	3	3	3	13	-
Hell's Gulch	1	1	2	3	2	9	+
O'Gara Bay	1	1	2	3	3	10	-
Shingle Bay	1	1	2	3	3	10	-
Black	1	3	1	3	3	11	-
Willow	2	1	2	3	2	10	-
Evans	2	1	1	1	2	7	+
St. Joe River	2	1	1	3	1	8	-

Location:
1. Completely on reservation.
2. Partially on reservation
3. Competely off reservation

Road Access:
1. Good accessibility
2. Limited accessibility
3. Poor accessibility

Barriers:
1. No barriers
2. Man-made barriers
3. Natural barriers

Potential for enhancement:
1. Slightly degraded habitat
2. Good habitat
3. Severely degraded habitat

Gradient:
1. Suitable for fish habitat
2. Questionable for fish habitat
3. Not suitable for fish habitat

creeks. The remainder had severely degraded habitat for cutthroat and bull trout.

Stream gradients that were unsuitable for fish habitat included: Black, Cherry, Cottonwood Bay, John, Little John, O'Gara, Pedee, and Shingle Bay creeks. Questionable gradient for fish habitat was present on Alder, Evans, Hell's Gulch, and Willow creeks. The remainder had adequate gradients to support bull and cutthroat trout habitat.

4.0 DISCUSSION

In determining the ten tributaries for further study, priority was given to those streams under tribal jurisdiction based on geographic location. Those streams located partly on, or completely off the reservation have potential for jurisdictional conflicts or resource allocation problems. Therefore, the most favorable rating was given to those streams that were completely on the reservation. Those streams located completely off the reservation were removed from consideration.

Streams displaying the highest potential for improvement and enhancement were ranked higher than those streams showing severe degradation or no need of improvement.

The most favorable ratings were awarded to streams that had good road access, no barriers to fish migration, and a gradient acceptable to cutthroat and bull trout habitation. The following tributaries were chosen for continued study based on the aerial survey, cutthroat and bull trout habitat requirements and the ranking system discussed above:

Bellgrove Creek was only partially located on the Coeur d'Alene Indian Reservation. The headwaters of the creek fell outside the boundaries of the reservation. Road access along entire stream was good. Prior to the confluence of Bellgrove and Fighting creeks, a solid, concrete embuttment under a bridge was observed that spanned the stream; it appeared to be a blockage to fish migration. Degradation of habitat was due to excessive, cumulative land-use practices along the creek. Heavy recreational- and residential-use was noted in the lower 50 percent of the stream, however most habitat could be restored with public education and cooperation. Primary damage to the stream, (ie., poor water quality, heavily silted substrate and wasting unstable riparian zone) was caused by improper agriculture, grazing and clearcut-logging practices. Streambanks were severely damaged by livestock, and the resulting' erosion created a substantial water quality problem. Miles of streamside fencing and revegetation would be necessary to restore the riparian areas and control erosion. In December, the flow was minimal, which indicated summer flow would be minimal or intermittent. Gradient was moderate for majority of the stream, however, conditions appeared unsuitable for bull trout and was questionable for all age-classes of cutthroat trout.

Fighting Creek was located only partially on the Coeur d'Alene Indian Reservation. Headwaters of creek fell outside of boundaries of the reservation. Road access along entire creek was good. Prior to the confluence of Bellgrove and Fighting creeks, a solid concrete embuttment under a bridge created a possible barrier to fish migration. Similar to Bellgrove Creek, habitat degradation of Fighting Creek resulted from cumulative impacts by recreational, residential, logging, grazing and agricultural land-use practices. Riparian vegetation and stream banks were severely damaged, causing water quality problems and wasting streambanks. The gradients in the lower and middle reaches appeared favorable to trout, however gradient in the upper reach was steep. Gradient, boulders, and rapids in the upper reach were unsuitable for fish.

Lake Creek was located completely within reservation boundaries. Road access to lower reach was poor, while road access to middle and upper reaches was adequate. The lower reach was the longest portion of Lake Creek and was very favorable trout habitat. This section had low human influence, protected riparian vegetation and 50 percent pool habitat above and below high riffle-drift production segments. Since a partially open-canopy above riffle segments of a stream supports a greater abundance of macroinvertebrates, Lake Creek could possibly produce a 40 percent drift production.

In the middle reach, the gradient was moderate, and the channel was braided and pooled by beaver dams in grassy farmland fields. This type of habitat is favored in the summer by adult cutthroat trout and by juveniles when stream edges are protected by grass overhang.

In the middle and upper reaches, farming and grazing to stream edge, loss of streamside vegetation and highly erodible soils have caused water quality problems downstream. Landowner education, fences and biotechnical slope and erosion control techniques in the upper reaches would significantly enhance this stream for fish. If erosion were controlled, lateral habitats of undercut banks and exposed tree roots and gradual-low gradients would provide very favorable rearing habitat for cutthroat, and possibly bull trout. Lake Creek has the potential to support a sizable population of fish, especially if the upstream contribution of agricultural silt were rectified.

Squaw Creek was located within reservation boundaries. Logging roads provided road access along entire creek. The habitat was slightly degraded, therefore, potential for improvement was good. Farming in the headwaters and logging along the banks of the middle and lower reaches posed cumulative, but correctable, water quality problems. In the upper portion of the middle reach, a debris jam appeared to be a barrier to fish migration. The headwaters had been clear-cut. Planting riparian vegetation would help to maintain acceptable downstream temperatures and to provide erosion control.

Parameters favorable to cutthroat and bull trout habitat outweighed areas of concern. Gradient was gradual: gravel deposition and riffle:pool ratio appeared suitable for trout habitat. Large organic debris and logs scattered in the creek from logging provided good summer and winter cover and created resting and rearing pools. Riffle-pool-run ratio showed possibility of enhancement by creating more pools within the run ratio. Hawkins *et. al.* (1982, 1983) found that riffles represent feeding stations to drift feeding trout. Macroinvertebrates are most productive in streams with open-canopy riffles. Evidence of logging, adjacent to at least 30 percent of the riffle areas, indicated that sufficient macroinvertebrate production possibly existed. Riparian vegetation with stable bank integrity in the middle reach protected Squaw Creek from severe degradation that might result from logging and farming practices in the headwaters.

Plummer Creek was also located completely within reservation boundaries. Road access extended to all three reaches. Width and apparent depth of the lower reach appeared favorable for bull and cutthroat trout habitat. In some areas, adequate streamside vegetation and gentle slope of adjacent terrain should have aided in controlling erosion, runoff and water temperature. Water quality problems were evident, however, as indicated by the unstable meander of the stream channel and the brown, sediment-laden color of the water.

The middle reach of Plummer Creek was heavily forested with limited degradation of the riparian management zone. A few residual snags and large woody debris were present for future recruitment of cover, food and rearing areas for fish. A gentle stream gradient, 50/50 riffle:pool ratio, adequate aquatic vegetation and overhang cover appeared conducive to good trout habitat. Substrate, however, could not be observed due to the muddiness of the water from adjacent agriculture. If the point source of pollution could be identified and controlled, this creek would increase as a potential fishery stream.

The upper reach of Plummer Creek was heavily impacted by the city of Plummer; structural barriers to fish migration existed. Two huge culverts prohibited fish migration past the sewage treatment plant, located south of the city of Plummer. Two sewage ponds and a city drain discharged directly into the creek; this caused potential water quality problems not only from toxic substances and nutrient loading, but also from fecal coliform (human waste) and fecal streptococci (animal waste) bacteria. Idaho Department of Health and Welfare - Division of Environmental Quality *et. al. (1990)* reported that the water quality standard for secondary contact recreation (< 800 fecal coliform bacteria/l00 ml sample) was exceeded along the mainstem of Plummer Creek. Waste, leaching into the stream from a hog farm, was the major source of animal bacteria. They concluded that the higher counts of fecal coliform and streptococci bacteria were cause for concern and should be corrected (IDHW *et.* al. 1990). Plummer Creek was not removed from consideration as a favorable trout stream; habitat does exist, if the major water quality problems were identified and corrected.

Little Plummer Creek was located completely within reservation boundaries and was a tributary to Plummer Creek. The lower reach began at the confluence of Plummer Creek and ended at the highway, where an out-of-channel culvert had been placed. Factors favoring trout habitat included: sufficient amount and size of spawning gravel for both cutthroat and bull trout, favorable riffle:pool ratio, adequate overhang cover, protected riparian areas, moderate flow and gradient, and lack of any downstream barriers. Due to all these factors, Little Plummer Creek appeared suitable habitat for bull and cutthroat trout.

The middle reach of Little Plummer Creek began past the highway and was characterized by gravel pits, culverts, agriculture, and streamside grazing. This reach of Little Plummer had severely degraded habitat, however, most factors have the potential to be corrected.

A culvert, located in the upper reach, limited any migration of fish past this barrier. This reach was characterized by several intermittent, type 5 streams that drained through farmlands and grazing areas of highly erodible soil. The upper reach did not eliminate Little Plummer Creek as a potential enhancement stream; cutthroat and bull trout do not need to ascent to the headwaters of a tributary to spawn. Adequate spawning and rearing areas were present downstream.

Benewah Creek was located completely on the Coeur d'Alene Indian Reservation. Road access was good along the entire length of the creek. At the mouth of Benewah Creek, alder trees had overtaken the stream bed. The meandering slough was highly silted and unstable. Proper alder management techniques would provide bank reinforcement, help stabilize the channel, control siltation, and yet allow critical shading to control temperatures in the lower portion of the stream. In all stream reaches, culverts that could limit or prevent upstream fish migration, were areas that possibly needed improvement. In the upper reach of Benewah Creek, instream vehicular traffic was of special concern. Driving within the stream channel is damaging to spawning beds and bank integrity; it has the potential to get petroleum products in the water, which are lethal to aquatic life. Logging and grazing in the riparian management zone of the headwater region had potential for downstream water quality problems; fences, riparian vegetation, erosion control and education are possible restorative measures.

The middle reach was the most substantial reach of this stream. The moderate gradient had the potential for good cutthroat and bull trout habitat. Approximately 19.3 kilometers (12 mi) from the mouth the gradient steepened, favoring fluvial and resident cutthroat populations. Width of stream and gravel-rubble substrate created the possibility of installing temporary fry traps. Instream woody debris and standing snags from selectively logged forest ensured recruitment of cover for future generations of the fishery. Stream width, discharge and velocity, large woody debris, cover, bank stability, riffle:pool ratio, spawning gravel, and shade appeared conducive to both cutthroat and possibly a bull trout fishery.

Approximately 60-65 percent of Alder Creek was located on the Coeur d'Alene Indian Reservation; this included the headwater and middle reaches. Road access was adjacent to the stream. Gradient appeared moderate but slightly steep, since the predominate habitat type was riffles. Although riffles provide limited cover and resting areas for trout, this problem has the potential to be corrected. Natural waterfalls were located in the middle and upper reaches. In the middle reach, the fall appeared small and migration may occur past this barrier. The upper fall was substantial and a possible barrier to fish migration. In terms of enhancement, the middle fall appears feasible to bypass and substantial habitat exists above the barrier; the falls, steep gradient, and step-pool cascades in the upper reach prohibit the establishment of favorable trout habitat.

Factors conducive to trout habitat in Alder Creek included a protected riparian management zone for erosion and temperature control, large organic and woody instream debris for cover, resting pools and feeding stations for all ages of trout, and good water quality with moderate flow.

Hell's Gulch Creek was located completely within reservation boundaries and had good road access. The lower reach of Hell's Gulch had been severely impacted by human alteration. No riparian management zone was left along the creek, offering the stream no thermal protection or sediment buffer. Temperatures in excess of optimal range can interfere with reproduction, embryo development or prevent trout habitation completely. With the absence of riparian vegetation acting as a sediment buffer, rain-on-snow winter thaw, and heavy spring rains flowing over highly erodible soil, could reduce egg survival and macroinvertebrate abundance substantially. No spawning gravel was evident, since the substrate was covered in silt. In the lower reach, large debris jams and numerous culverts posed potential barriers to fish migration.

The middle reach of Hell's Gulch Creek was characterized by a moderately steep gradient and predominantly riffle habitat. Since trout require regularly spaced resting areas within a steep channel gradient, the length of riffle habitat would determine if fish could transverse through this reach or if passage would be prohibited. The . middle reach was also braided with bridges, culverts and debris jams that could pose migrational barriers to fish.

The upper reach of Hell's Gulch Creek was heavily forested with 30-40 percent slopes, which made road access a problem. The upper reach appeared favorable for a population of resident cutthroat. There was ample debris within the channel to create cover, resting pools, and feeding stations. Forest canopy was sufficiently open to enhance the macro-invertebrate population for drift-feeding cutthroat trout. Due to barrier problems in the lower reaches, adfluvial and fluvial cutthroat and bull trout could be prohibited from reaching the upper segment of this stream. Since the above mentioned barriers were all man-made and potentially correctable, restoration that is cumulatively cost-effective would have to be considered for the entire creek.

Evans Creek was located only partially within reservation boundaries. Road access was provided along entire length of creek. One area of concern, which should be addressed, was that roads and vehicular traffic transversed the stream in numerous places throughout the drainage. In the lower reach, heavily silted substrate showed evidence of surrounding agricultural land-use and the resulting erosion. Although the middle reach was very short, all habitat parameters appeared to favor both species of trout. Apperson et. *al.* (1988) reported migratory cutthroat trout production in Evans Creek and documented that Idaho Department of Fish and Game used this stream as a source of broodstock between 1970-l 979. Gradient of the upper reach appeared to prohibit fish migration: however, step-pool cascades in upper reach may possibly have a population of resident headwater cutthroat trout.

The following tributaries were removed from consideration based on results obtained from the aerial survey, cutthroat and bull trout habitat requirements and the ranking system discussed above:

John Creek was eliminated based on the premise that those tributaries located within reservation boundaries received priority. John Creek was located completely off the reservation and, therefore, was eliminated.

Shingle Bay Creek was eliminated because the stream flowed into a grate and disappeared underground. No water was present in the stream channel, and the gradient was very steep.

O'Gara Bay Creek was eliminated because of severely low flow in December. The assumption was made that the stream channel would be dry in summer. A culvert at the mouth of the creek limited any fish migration. The gradient was quite steep and not conducive to trout habitat.

Pedee Creek was located completely within reservation boundaries. The creek was covered with ice in December, suggesting minimal depth and flow in winter and no flow in the summer. Pedee Creek was eliminated from consideration, because steep gradient was not acceptable for fish habitat.

Cherry Creek was located completely within reservation boundaries. During the aerial survey, no flow was observed in December, which suggested intermittent or dry conditions in the summer. Also, a steep gradient was not acceptable for fish habitat.

Cottonwood Bay Creek was located completely within reservation boundaries. Access by road was good. This stream was removed from consideration primarily because gradient was very steep, and mouth had been channelized with concrete. Secondary reasons were that the width was less that 1.5 meters (5 ft), and flow was almost non-existent.

Black Creek was located within reservation boundaries. Although there were no barriers to fish migration, and streambanks and stream channel were stable, Black Creek was removed from consideration. Road access was poor. Stream gradient was steep, and flow was low to intermittent. A silted substrate and poor water quality, in addition to the above conditions, eliminated this creek from further study.

Willow Creek was located only partially within reservation boundaries. Although road access was good, habitat was considered severely degraded. Land-use practices were occurring within channel boundaries; numerous culverts transversed the stream. Grazing, farming and logging on highly erodible soil created an evident water quality problem. Severity of channel slope, velocity of water and high riffle:low pool ratio excluded the possibility of a fishery.

The St. Joe River was also eliminated as a future study site. Study of the river would be beyond the limits of this project, and only a portion of the river was located on the reservation.

Ranking criteria were developed to rate 19 tributaries for potential of westslope cutthroat and bull trout habitat enhancement. Cutthroat and bull trout habitat requirements derived from an extensive literature review of each species, were compared to the physical and biological parameters of each stream observed during the aerial survey. Ten tributaries were selected for further study, using the ranking criteria that were derived. The most favorable ratings were awarded to streams that were located completely on the reservation, displayed highest potential for improvement and enhancement, had no barriers to fish migration, good road access, and a gradient acceptable to cutthroat and bull trout habitation. The ten streams selected for study were Bellgrove, Fighting, Lake, Squaw, Plummer, Little Plummer, Benewah, Alder, Hell's Gulch, and Evans creeks.

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APPENDIX A

LITERATURE REVIEW

FOR

CUTTHROAT TROUT

APPENDIX A

A.1. Literature Review for Cutthroat Trout

A.l.l. General Information

The historic range of westslope cutthroat trout (*Oncorhynchus clarki lewisi*) included western Montana, a portion of Wyoming and central and northern Idaho. The range extended into Canada throughout the headwaters on the eastern side of the Continental Divide. In Idaho, it is believed that the historic distribution included all of the Kootenai River drainage above barrier falls and all of the Pend Oreille and Spokane river drainages. Westslope cutthroat were present in upper Clearwater drainage, and Salmon River above and including the South Fork. Westslope cutthroat are currently located in Cpeur d'Alene, St. Joe, Salmon, Cleat-water, Kootenai, and Pend Oreille river drainages in Idaho and in the Spokane River above Spokane Falls in Washington (Behnke 1972, 1979; Behnke and Wallace 1979; Trotter 1987; Liknes and Graham 1988; Rieman and Apperson 1989).

Biologist believe that cutthroat moving into headwaters of the Columbia River were isolated by geologic diversions and ice dams: this resulted in distinct differentiation from the other cutthroat. As many as 16 subspecies, with eight major subspecies, are now recognized (Behnke 1979; Trotter 1987; Allendorf and Leary 1988). Available data from electrophoretic studies suggested that westslope cutthroat trout were phenotypically and genetically more similar to rainbow trout and coastal cutthroat, than they were to the Yellowstone, Snake River, Green River and Colorado cutthroat subspecies (Loudenslager and Thorgaard 1979; Behnke 1979; Loudenslager and Gall 1980; Allendorf and Leary 1988). Allendorf and Leary (1988) believe differences were significant enough to consider westslope cutthroat as a separate species.

Westslope cutthroat exhibit three distinct life history forms based on their behavioral patterns (Averett 1962; Averett and McPhee 1971; Bjornn 1975; Thurow and Bjornn 1978; Liknes and Graham 1988; Rieman and Apperson 1989). They are:

1. Resident, which inhabit small headwater streams and do not migrate. Resident populations occur throughout Idaho.

2. Fluvial, which inhabit larger streams and main rivers, and may show extensive migration between rivers, streams and small tributaries. Fluvial populations represent the dominant form and primarily support current fisheries in Idaho.

3. Adfluvial, which inhabit large lakes and migrate to spawn in tributary streams. Adfluvial stocks generally dominate tributaries to lower reaches of the drainage or small streams directly connected to the lake: they rear in tributaries for two to four years and then migrate to a lake to mature.

All three life history forms often occur in one drainage system.

A.I.2. Life History

In Idaho, westslope cutthroat trout deposit eggs into substrate gravel of streams from March to May. Incubation time of eggs and alevins varies inversely with temperature. Alevins remain in the gravel for 13-16 days after hatching and emerge as fry (Scott and Crossman 1979). With different spawning times, fry emergence can begin between April - June; in very cold waters, emergence can be delayed until August (Scott and Crossman 1979).

Cutthroat trout in northern Idaho remain in natal streams for two to four years, then migrate to rivers or lakes to mature. Shepard et. *al.* (1984) determined that juveniles, primarily of age 2+ and age 3+, emigrated throughout summer, but out-migration peaked in early July.

Once sexually mature, these trout return to natal tributaries to spawn. Generally, cutthroat begin maturing in their third year, with all of the population spawning for the first time by the sixth year. Males usually mature one year earlier than females (Brown 1971; Johnston and Mercer 1977; Mauser 1972a, 1988). In Idaho, male cutthroat trout matured at age 3-4+, and females matured at age 4-5+ in the St. Joe River (Rankel 1971) and in Coeur d'Alene Lake (Lukens 1978).

Size at maturity depends on environmental conditions and abundance of available food. Cutthroat trout matured at a smaller size in cold, unproductive headwater streams (Rankel 1971; Behnke and Zarn 1976; Hickman and Raleigh 1982; Rieman and Apperson 1989). Slow growing resident cutthroat matured at a similar age but at a much smaller size than faster growing fluvial and adfluvial stocks in the same drainage (Mauser 1972a, b; Thurow and Bjornn 1978). Rankel (1971) stated that cutthroat trout grew slower in the St. Joe River than other western streams, probably because of the shorter growing season.

Cutthroat may spawn in consecutive, but generally spawn in alternate, years (Calhoun 1944; Scott and Crossman 1979; Liknes and Graham 1988). In Montana, Huston (1972, 1973) documented the contribution of second time spawners to an annual run and found the range varied between 0.7 to 24.0 percent.

Initiation of spawning is dependent upon water temperature, run-off, ice melt, elevation and latitude (Behnke and Zarn 1976). Adfluvial adults moved into tributary streams during high stream flows and spawned as early as February (Behnke 1979; Roscoe 1974) or as late as August in colder areas where temperatures were near 10°C (Scott and Crossman 1979). In lower tributaries to the St. Joe River, Averett (1963) reported that most cutthroat spawned just before or during high water of April and May. In middle and upper tributaries to the St. Joe River, Rankel (1971) found that spawning occurred just before or during high water of May and June.

Spawning populations of cutthroat trout tend to have a higher ratio of females to males. From one Idaho and three Montana streams, sex ratio was 3.4:1 (Huston et. *al.* 1984; Shepard et. *al.* 1984). Lukens (1978) reported females to male ratios ranging from approximately 2:1.3 to 5:1 for six adfluvial populations; females averaged 2.6 per one male. Bjornn (1957) determined that 64 percent of fish examined in creel surveys were females. Huston *et. al.* (1984) found the higher. female:male ratio persisted even in older age classes.

Fecundity and reproductive effort in westslope cutthroat appear similar to other salmonids; number of eggs per female increases with length of fish. In an extensive synopsis of westslope data, Rieman and Apperson (1989) could find no data demonstrating variability nor differences in fecundity between or within stocks.

Documented fecundities for this subspecies ranged from 200 to about 2000 eggs per female (Averett 1962; Johnson 1963; Smith et. al. 1983). Roscoe (1974) found fecundity to be slightly higher for westslope subspecies, ranging from 1000-1500 eggs for females with a mean length of 355 millimeters.

Estimated growth of westslope cutthroat varies considerably. Comparing resident, fluvial and adfluvial populations, growth estimates were highest among adfluvial populations (Lukens 1978; Pratt 1985). Lukens (1978) found as fish migrated from relatively small, unproductive rearing streams to larger, more productive rivers and lakes, growth increased substantially, and size at maturity was larger. Growth of resident fish from headwater streams was slower, and size at maturity was smaller (Thurow and Bjornn 1978).

Limited data exists to estimate natural mortality. Estimates of natural mortality ranged from 30-54 percent for adfluvial and fluvial populations (Bjornn et. *al.* 1977; Apperson et. *al. 1988;* Mauser 1988). Mortality was not documented from resident cutthroat. During early stages of life, Bjornn and Johnson (1977) estimated 95 percent mortality from emergence to age 1+ fingerlings. Depending upon the amount of fine sediment in incubation gravels, Irving and Bjornn (1984) showed that mortality from egg to swim-up fry was 5.0-99.6 percent.

A.1.3 Water Quality

A.l.3.1. Temperature

Average maximal daily water temperatures have a greater effect on trout growth and survival than minimal temperatures. During embryo development, average maximum water temperature range is 3-16°C, with 7-11.5°C as optimum. Highest average temperature range during the warmest period of the year for juvenile to adult is 6-21 °C, with 1 l-l 5.5°C representing optimal conditions (Table A.l). Most authors found that their study streams fell within these ranges (Oien 1957; Binns and Eiserman 1979; Woodward et. *al.* 1989; Graham et. *al.* 1980; Pratt 1984; Scarnecchia and Bergersen 1986; Baltz et. *al.* 1987).

In studies with an incubation temperature of 10°C, eggs hatched in 28-40 days (Snyder and Tanner 1960; Bell 1973) or

TABLE A.I. **Acceptable and optimal habitat conditions for riverine cutthroat using Habitat Suitability Index criteria***

	Range of Habitat Conditions	Optimal Habitat Conditions
Avg maximum water temp (°C) during warmest period of year (fry - adult)	6° - 21°C	11° - 15.5° c
Avg maximum water temp (°C) during embryo development	3° - 16° C	7° - 11.5° c
Avg minimum dissolved oxygen (mg/l) during late growing season, low water period, and during embryo development (embryo - adult)	4.5 - 7.3 (≤15° C) 6.0 - 9.0 (> 15" C)	7.3 9.0
Annual maximal or minimal pH	5.9 - 9.0	6.5 - 8.0
Avg thalweg depth (cm) during late growing season low water period (sw = stream width)	15 - 30 (≤ 5m wide) 30 - 45 (> 5m wide)	30 45
Avg velocity (cm/sec) over spawning areas during embryo development	25 - 75	30 - 65
Percent cover during late growing season, low water periods at depths > 15cm and velocities < 15cm/sec.	3 - 16 (juvenile) 8 - 24 (adult)	16% 24%
Avg sire of substrate (cm) between 0.3 - 8.0cm diameter in spawning areas	0.5 - 7.5	2.0 - 6.0
Percent substrate size class (10-40 cm) used for winter and escape cover by fry and small juveniles	5 - 10	10%
Dominant (≥ 50%) substrate type in riffle-run areas for food production	A - 0	A
A = rubble or small boulders or aquatic vegetation in spring areas dominant with limited amounts of gravel, large boulders or bedrock.		
B = rubble, gravel, boulders and fines occur in approximately equal amounts or gravel is dominant. Aquatic vegetation may or may not be present.		
C = Fines, bedrock, large boulders are dominanl and rubble and gravel insignihcant (< 25%)		
Percent pools during late growing season bw water period (100-%riffles)	10 - 99	35 - 65%
Avg percent vegetation (trees, shrubs. grass-forb) along streambank during summer for allochthonous input. Veg index = 2(% shrubs) + 1.5 (% grasses) +1(%trees) +0 (% bare ground). (For streams ≤50m wide)	75 - 150	150%
Avg percent root vegetation and stable rocky ground cover along the streambank during summer (erosion control)	40-80	80%
Avg annual base how regime during late summer or winter low Ibw period as percentage of average annual daily flow	25 -50	50%
Percent lines (< 3mm) in rime-run and in spawning areas during average summer flows	2 - 15 (spawning) 15 - 35 (riffle-run)	2% 15%

	Acceptable Habitat Conditions	Optimal Habitat Conditions
Percent of stream area shaded between 1000 and 1400 hours (≤ 50m wide). Not for use on cold (< 18°C) unproductive streams.	15 - 90	50 - 75%
Pool class rating during late growing season bw flow period. Rating based on percent of area containing pools of 3 classes described below.	A - 0	A

A ≥ 30% of area comprised of lst-class pools. 1st-class pool: large and deep. Pod depth and size sufffcffnt for low velocity resting for several adult trout. >30% pool bottom obscure due to depth, surface turbulence, or presence of structures: e.g. fogs, debris piles, boulders, or overhanging banks and vegetation. Or greatest pool depth is ≥ 1.5 m in streams ≤ 5m wide or ≥ 2m deep in streams > 5m wide.

B ≥ 10% - < 30% 1st-class pools or ≥ 50% 2nd-class pools

cc 10% 1st-class pools and < 50% 2nd-class pools

· From Hickman 8 Raleigh (1982): Persons & Buckley (1984).

required 310 temperature units to hatch (Shepard et. *al.* 1984). Calhoun (1966) reported normal development of embryos at approximately 12°C and increased mortalities below 7°C. For juveniles and adults, Binns and Eiserman (1979) reported a maximum temperature range of 12.6-18.6°C to be optimal cutthroat habitat in summer. Summer temperatures of less than 6°C or greater than 26.4°C were considered inadequate to support viable cutthroat trout populations (Scarnecchia and Bergersen 1982). In studying temperature and microhabitat choices of fish, Baltz et. *al.* (1987) concluded that fish choose microhabitat conditions where the temperature gradient favors maximum growth. Hartman (1965, 1968) and Bustard and Naver (1975a) determined that lowering temperatures below 8°C induced a hiding response; at these temperatures, no fish were found active or more than one meter from cover.

A.I.3.2. Dissolved Oxygen

For all ages of cutthroat trout, the average minimum dissolved oxygen concentrations during late season, low water period are 4.5-7.3 mg/l for water temperatures up to 15°C and 6.0-9-O mg/l in water above 15°C. Optimal concentrations of dissolved oxygen are 7.3 mg/l in water up to 15°C and 9.0 mg/l in water exceeding 15°C (Table A.1). At least 5.0 mg/l of dissolved oxygen is required to maintain favorable conditions for cold water fish (Oien 1957; Trojnar 1972). As temperature increases, dissolved oxygen saturation level decreases, while the dissolved oxygen concentration requirement for fish increases. Doudoroff and Shumway (1970) demonstrated that swimming speed and growth rates for salmonids declined with decreasing dissolved oxygen levels. Lantz (1971) showed no food energy was available for growth until all other functional requirements of fish had been met; optimal dissolved oxygen concentration was a major requirement. Oien (1957) reported that decaying bark and slash following logging removed oxygen from streams, thus impacting microhabitats of embryos, fry, adult fish and aquatic invertebrates.

A.I.3.3. Other Water Quality Parameters

Annual pH range for cutthroat trout is 5.9-9.0, with optimal conditions at 6.5-8.0 pH (Table A.1). Hartman and Gill (1968) sampled 66 streams in British Columbia and reported that those streams containing cutthroat trout had pH values of 6.0-8.8. Similar results were obtained in studies by Platts (1979), Petrosky and Bjornn (1988), Oien (1957), Pratt (1984), Baltz et. *al.* (1987), Scarnecchia and Bergersen (1986), and Binns and Eiserman (1979).

Hartman and Gill (1968) reported that neither pH nor total dissolved solids appeared to have any effect on limiting the distribution of cutthroat trout. Total dissolved solid values ranged from 15-192 mg/l between April and October and 15-95 mg/l from November to March. Platts (1974) analyzed three streams in Idaho and reported total dissolved solid values of 41-63 mg/l. Bjornn (1969) reported values of 298 mg/l for an Idaho drainage, and Binns (1977) studied 13 Wyoming streams containing cutthroat trout and reported 38-544 mg/l total dissolved solids.

Little information was available on total alkalinity and total hardness requirements for cutthroat trout. Total alkalinity values in waters in which cutthroat trout were found ranged from 19-544 mg $CaCO_3$/l (Oien 1957; Binns 1977; Pratt 1984). No optimal range for total alkalinity and hardness has been established for cutthroat trout.

Turbidity is an optical property of water wherein suspended and dissolved materials, such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms, cause light to be scattered and absorbed rather than transmitted in straight lines (APHA *et al.* 1980). Suspended solids facilitate the transport of heavy metals and other pollutants (Lloyd *et. al.* 1987). Low turbidities near IO-26 nephelometric turbidity units (NTU) and suspended concentrations near 35 mg/l have deleterious effects on fish and macroinvertebrates (Olson *et. al.* 1973; Bachman 1984; Berg and Northcote 1985). Bachman (1958) reported that at turbidities above 35 mg/l, cutthroat trout stopped feeding and moved to cover. In Idaho, numerical turbidity standard for protection of fish and wildlife aquatic habitats is 5 NTU/JTU (Jackson turbidity units) above normal (API 1980).

A.I.4. Gradient and Velocity

Streambed gradient affects trout populations by influencing stream velocity. Stream velocity, in turn, affects the quality and quantity of bottom food organisms and has a direct influence on fish populations by restricting and influencing the delivery of oxygen-saturated water. During spawning, cutthroat trout are typically found in small, ephemeral or permanent, first and second order streams with moderate velocities and low to high gradients. Velocities for spawners ranged from 1 l-92 cm/sec (Thompson 1972; Hooper 1973; Hunter 1973). Shepard *et. al.* (1984) reported spawning velocities of 30-40 cm/second.

Average velocities during embryo development range from 20-80 cm/sec, with optimal velocities at 30-65 cm/sec (Hickman and Raleigh 1982; Table A.l). Emergent fry prefer shallower water and slower velocities than other life stages (Miller 1957; Horner and Bjornn 1976). Fry were observed in protected habitats with velocities ranging from O-30 cm/sec, but preferred flows less than 8 cm/sec (Griffith 1972, 1988; Horner and Bjornn 1976; Pratt 1984). Since fry survival decreases with increased velocity above optimum (Buckley and Benson 1962; Drummond and McKinney 1965), lateral habitats, backwaters and covered pools with lower flows are preferred as rearing areas (Griffith 1970, 1988; Hanson 1977; Pratt 1984; Irving 1987; Moore and Gregory 1988 a,b). Moore and Gregory (1988 a,b) studied a headwater stream in Oregon with 8.2-10.0 percent gradient and found population size and survival of young-of-year cutthroat trout to be positively correlated with length of stream edge and area of lateral habitat. After emergence, fry established territories in low velocity (<4 cm/sec), shallow (<20 cm deep) protected stream edges.

In studying habitat utilization by salmonids during low streamflow, Bisson *et. a/.* (1981) reported that age 0+ cutthroat preferred low gradient riffles, but in the company of steelhead or coho, the cutthroat trout were displaced and switched to glides and plunge pools. Bisson *et. al.* (1981, 1988) and Glova (1987) reported underyearling cutthroat use backwater pools of 6.3 cm/sec, 194.0 centimeters deep and glides of 20.3 cm/sec, 11 .O centimeters deep.

Juvenile cutthroat of ages 1+ and 2+ were most often found in water depths of 35-65 centimeters (Cochnauer and Elms-Cockrum 1986). Velocities were 9.1-l 0.3 cm/sec for age 1+ and 13.1-l 5.4 cm/sec for age 2+ fish (Hanson 1977). Griffith (1972) reported focal point velocities for juveniles to be between 1 O-12 cm/sec, with a maximum velocity of 22 cm/sec. Pratt (1984) and Hanson (1977) reported typical facing velocities of 1 O-30 cm/sec for juvenile cutthroat. Bustard and Naver (1975a,b) and Bisson *et. al.* (1988) found age 1+ and age 2+ cutthroat trout to use similar habitats; both age groups preferred 24.3 centimeters deep lateral scour pools of 15.3 cm/sec velocity and 37.8 centimeters deep plunge pools of 16.8 cm/sec velocity with abundant cover.

For resident adult cutthroat trout, distribution appears to occur mainly in higher elevation and lower order reaches, such as headwater and mid-drainage areas (Platts 1974, 1979; Fraley and Graham 1981). Some populations of adfluvial and fluvial fish make seasonal use of entire drainages (i.e., Coeur d'Alene River). Griffith (1970, 1972) found cutthroat in higher stream gradients and reported focal point velocities in Idaho streams of 1 O-14 cm/sec, with maximum velocities between 15.6-29.3 cm/sec. Cowley (1987) studied upper Priest River cutthroat populations and reported gradients from 0.7 percent to greater than 10 percent in upper reaches to contain fish. Oien (1957) found cutthroat inhabiting 2.4-5.2 percent gradients with velocities ranging from 2.8-28.0 cm/sec.

It has been shown that abundance of macroinvertebrates and forage tactics of drift-feeding trout are related to water velocities. Foraging tactics of drift-feeding salmonids favored maximizing energy intake while minimizing the effort of maintaining a feeding position (Wilzbach 1985; Bisson *et. al.* 1988). In terms of channel hydraulics, an individual gained in fitness if it could occupy a site where current velocity was slow but where there was ready access to drifting food, the abundance of which was believed to be proportional to water velocity (Elliot 1967; Wankowski and Thorpe 1979; Wilzbach 1985; Bisson *et. al.* 1988). Griffith (1972) showed resident trout were much smaller and slower growing than the adfluvial and fluvial stocks, owing to lower abundance of prey items, colder water, limited growing season and greater expenditure of energy in higher velocity flows.

There is a definite relationship between annual flow regime and quality of trout habitat. The lowest flows of late summer to winter, or base flows, are the most critical periods. A base flow of greater than 50 percent of average annual daily flow is optimal. A base flow of 25-50 percent is acceptable, but less than 25 percent is unacceptable for quality trout habitat (Table A.l). To predict salmonid standing stock and abundance in streams, Lanka *et. al.* (1987) applied drainage basin geomorphology to trout standing stock. Their data confirmed that a small, gently sloping drainage basin produced the best trout habitat. They showed the combined effects of watershed features, such as basin slope, channel slope (gradient) and a more dendritic drainage pattern (drainage density), tended to decrease response time of discharge from rainfall. With these characteristics, sudden amounts of precipitation decreased surface and groundwater storage and lowered base flows (Viessman et. *al.* 1977). According to Binns and Eiserman (1979) low base flows and high flow variability resulted in poor quality habitat for trout. Conversely, high base flows of greater than 50 percent and low flow variability would result in optimal habitat.

A.I.5. Substrate

Bottom type influences the quantity and quality of macroinvertebrates and is of prime importance in determining the natural production in a stream. In riffle-run areas of food production, optimal substrate consisted of ≥50 percent rubble or small boulders or aquatic vegetation in spring areas (Table A.I). For successful spawning and reproduction, cutthroat trout require an adequate amount and size of clean gravel. The average optimal substrate for spawning areas is 2.0-6.0 centimeters in diameter. Abnormal flood action, scouring and siltation of spawning beds are extremely destructive forces that interfere with the standing stock of the stream. Percent fines of (13 mm) in riffle-run spawning areas during average summer flows were found to optimally be two percent (Hickman and Raleigh 1982; Persons and Buckley 1984).

Griffith (1972) and Pratt (1984) found cutthroat fry to be more consistently associated with gravel-cobble-boulder substrate, and juvenile favored a gravel-rubble-boulder mix (Thurow and Bjornn 1975; Graham *et. al.* 1980; Pratt 1984). For optimal winter and escape cover of fry and juveniles, ten percent of substrate ranged between IO-40 centimeters in diameter (Table A.I). In studies, small fish moved into substrate as temperature dropped below 8°C (Chapman and Bjornn 1969; Everest 1969; Bustard and Naver 1975a,b; Bjornn *et. al.* 1977), and depending upon velocity and ice, subadults burrowed 15-30 centimeters in substrate (Everest 1969). In a prelogging inventory of four streams in northern Idaho, Oien (1957) described preferred substrates for cutthroat trout to be 85-95 percent rubble (7.6-30.1 cm diameter) and 5-15 percent coarse gravel (2.5-7.6 cm diameter). Pratt (1984) recommended boulders placed on top of sand and pea-sized gravel as favorable substrate that may Increase habitat for cutthroat. Elser (1968) and Lanka *et.* al. (1987) observed that the transition zone between high gradient, boulder-gravel substrate and low gradient, gravel substrate contained the best quality trout habitat.

Habitat changes influence substrate composition in several ways. Fine sediments (cl mm - ≤10mm) have been negatively correlated with embryo survival (Cordone and Kelly 1961; Bjornn 1969; Platts 1974; Crouse *et. al.* 1981; Bjornn *et. a/.* 1977; Irving and Bjornn 1984). Bell (1973) reported that salmonid eggs will suffer mortality of 85 percent, when 15-20 percent of the interstices of the substrate is filled with sediment; the extent of siltation on egg development depended on type of material deposited and time of occurrence. Gibbons and Salo (1973) attributed low embryo survival to decreased gravel permeability and/or entrapment of alevins and fry, decreased oxygen supply to embryos, and accumulation of toxic metabolic wastes. Persons and Buckley (1984) documented only 2-3 percent as allowable fines for developing embryos. Tappel and Bjornn (1983) and Cederholm and Scarlett (1981) found material finer than 0.085 mm to be most detrimental.

Fine sediments reduce carrying capacity of essential pool habitat, eventually eliminating pools (Bjornn *et.* al. 1977). Fines filled interstices of spawning gravel (embeddedness), eliminated winter cover for young fish, and altered production and composition of forage benthos (Irving *et. al.* 1983). Thurow (1987) reported that total densities of trout were inversely related to gravel embeddedness in streams. Movements of fines into the stream environment resulted from logging, mining and agricultural activities, road construction, and mass wasting, following disturbance of unstable soils (Edwards and Burns 1986; Thurow 1987; Krygier and Hall 1971).

A.I.6. Cover

Instream cover is recognized as a critical component of stream habitat affecting trout densities when considered in combination with other habitat variables (Lewis 1967; Binns and Eiserman 1979; Platts 1979; Cardinal 1980; Fraley and Graham 1981). The importance of debris, substrate and undercut banks in providing fish shelter, escape cover and feeding stations is well documented (Chapman 1962; Hynes 1972; Bustard and Naver 1975a; Meham *et. al.*, 1977; Cardinal 1980; Oswood and Barber 1982).

Binns and Eiserman (1979) identified cover as consisting of water depth, surface turbulence, loose substrate, large rocks and other submerged obstructions, undercut banks, aquatic and overhanging terrestrial vegetation, downed snags and other debris lodged in the channel, and anything else that allows trout to avoid the impacts of elements or enemies. Cover and complex habitats, as described above, have been shown to have a significant effect on cutthroat numbers. Boussu (1954) increased density and biomass of trout in stream sections by adding artificial brush cover and found a marked reduction in trout numbers and biomass by experimental removal of cover and undercut banks. Fraley and Graham (1981) found overhang and instream cover to have the best correlation to trout densities. Elliot (1986) reported that the removal of large logging debris from small streams in southeast Alaska caused initial reductions of larger Dolly Varden and cutthroat trout; lower numbers resulted from habitat loss and the loss of smaller fish during subsequent November freshets. He determined that the amount of instream cover per acre was about 80 percent greater in unaltered sections, and trout abundance varied directly with the amount of cover. Lider (1985) associated the percentage of large woody debris in pools, such as root wads and logs, with the highest cutthroat densities. In studying factors that limit westslope cutthroat trout production in the Coeur d'Alene, St. Joe and St. Maries river systems, Horton and Mahan (1988) observed a direct relationship between cover components, particularly large organic debris, and high fish densities. They found that when pools or runs included large organic cover, these areas had more fish than areas where cover was absent or was provided by boulders, depth or overhanging vegetation. Horton and Mahan (1988) concluded that proper management, which included establishing organic material as cover for fish, was critical to reversing the decline in trout numbers and was essential in restoring Idaho drainage tributaries to higher production levels. Other studies have shown increased trout densities associated with the presence of organic material in stream as cover for fish (White and Brynildson 1967; Chapman and Bjornn 1969; Lestelle and Cederholm 1973; Bryant 1980; Wilzbach and Hall 1985).

Standing crop of cutthroat trout is correlated to the amount of useable cover present in a river or stream. Pools, depth and surface turbulence are forms of habitat cover. Streams that provided 30 percent or greater first-class pools were considered optimum for cutthroat trout (Hunt 1971; Horner and Bjornn 1976; Table A.l). Pool depth and size were, therefore, sufficient for low velocity resting of several adult trout (Lewis 1969; Raleigh *et. al.* 1983). First-class pools were characterized as large and deep; depth varied depending on stream width (Hickman and Raleigh 1982). More than 30 percent of the bottom of a first-class pool is obscure due to depth, turbulence or structures, such as logs, debris piles, boulders or overhanging banks and vegetation. In areas where overhead cover was marginal, Hanson (1977) found cover for cutthroat trout to be provided by substrate, depth and surface breaks. During late season, low water periods, Boussu (1954) and Lewis (1969) reported that juvenile cutthroat trout required 3-16 percent usable pool cover in the form of depth, turbulence or instream structures, and adults required 8-24 percent; useable cover was associated with water at least 15 centimeters deep and less than 15 cm/sec velocity.

There are two types of cover that limit trout densities -- summer and winter cover. The main use of instream summer cover, as described above, is probably for predator avoidance, resting and feeding stations (Hickman and Raleigh 1982; Boussu 1954). In winter, however, fish inhabit near freezing water temperatures and have lower metabolism, reduced food requirements and less available energy (Reimers 1957; Hartman and Gill 1968), and the resultant hiding response is probably a means of avoiding predation, mass ice movement and flooding, and reducing downstream displacement during freshets to conserve energy (Hartman 1965; Everest 1969; Chapman and Bjornn 1969; Bustard and Naver 1975a). In winter, cutthroat occupied different habitat areas than in summer, and the availability of winter habitat had a strong influence on seasonal movements of westslope cutthroat trout (Bjornn and Liknes 1986; Liknes and Graham 1988; Rieman and Apperson 1989). Large autumn movements out of tributary streams with poor winter cover into larger streams with good boulder, debris and log cover or overhanging bank cover have been described by Hartman (1965), Chapman and Bjornn (1969), Bjornn (1971) and Bustard and Naver (1975a,b). Cutthroat trout were found under boulders, log jams, root wads and debris when temperatures dropped to 4°-8°C, depending on velocity (Chapman and Bjornn 1969; Bustard and Naver 1975a). Extensive migrations resulted where high quality pools were found downstream of spawning and rearing habitat (Bjornn and Liknes 1986; Liknes and Graham 1988; Peters 1988). Lewis (1969) reported cutthroat moved to deeper, first-class pools in winter. Wilson *et. al.* (1987) and Peters (1988) found large aggregations of adult and subadult cutthroat trout in pools during winter; trout densities were strongly and positively associated with pool quality (defined width, depth and escape cover) and low to negative velocities. Bjornn (1971) indicated that downstream movement did not occur if sufficient cover was locally accessible. Peters (1988) observed that cutthroat reside the entire year in reaches where both summer habitat and high quality pools are found together. Bustard and Naver **(1975a,b)** and Cunjak and Power (1987) reported that proximity to suitable cover areas appeared to be critical and few fish were found more than one meter from potential cover.

Gravel substrates are especially important for overwintering juvenile cutthroat trout. As winter approached and temperatures dropped, fry moved into rubble (IO-40 cm diameter) as principal cover **(Hartman** 1965; Everest 1969; Chapman and Bjornn 1969; Rankel 1971; Thurow and Bjornn 1975; Bjornn *et. a/.* 1977; Hanson 1977; Wilson *et. a/.* **1987),** and moved in and out daily, relative to temperature (Chapman and Bjornn 1969). .Bustard and Naver (1975a) reported that substrate shifting and increase in mortality resulted when fry used smaller diameter substrate winter cover. While examining the declining cutthroat population in the St. Joe River, Rankel (1971) observed no cutthroat once temperatures dropped below **6°C** in October and attributed their disappearance to downstream migration in search of cover and/or movement into rocky substrate for duration of winter. Hanson (1977) documented cutthroat entering the substrate as winter approached and water temperature dropped below **8°C.** Bustard and Naver **(1975a,b)** and **Hartman** (1965) determined that juvenile cutthroat selected substrate for escape and winter cover that optimally contained ten percent, 1 O-40 centimeter diameter gravel.

Winter mortality among stream salmonids can be substantial for both young (Lindroth 1965) and older fish (Whitworth and Strange 1983; Cunjak and Power 1987). Stream management programs designed to improve species' winter habitat ultimately can increase survival (Cunjak and Power 1987; Hunt 1969; Rieman and Apperson 1989).

Survival during the period following emergence has the greatest influence on population density of cutthroat fry and is related to the amount of immediately available cover (Griffith 1972; Pratt 1984; Elliot 1985; Moore and Gregory **1988a,b).** Moore and Gregory (1988 a,b) studied a headwater stream with 8.2-10.0 percent gradient and found population size and survival of **young-of-**year cutthroat trout to be positively correlated with length of stream edge and area of lateral habitat. They found that after emergence, fry established territories in low velocity (<4 cm/sec), shallow (<20 cm deep), protected stream edges, backwaters and pools; fry remained there for at least six weeks. They determined total biomass and abundance of age 0+ cutthroat increased 2.2 times with a 2.4 increase in lateral habitat area. By end of summer, some age 0+ fish moved laterally in direction of adjacent midchannel pools and riffles. By increasing the area of lateral habitats, Moore and Gregory (1988a, b) provided more territory for resident fish and reduced downstream displacement and emigration. Pratt (1984) and Griffith (1970, 1972) found young cutthroat fry to be consistently associated with cover, in the form of gravel-cobble-boulder mix substrate (34%), shade overhang (24%), fine debris (24%), and woody debris (17%), along pool edges and in habitat units less than $200m^2$ or $100m^3$. They also determined that cutthroat used faster, deeper water as they grew larger, and ventured farther from escape cover as they aged and grew stronger. As winter approached and water temperatures dropped, fry used rubble of IO-40 centimeters in diameter as principal cover (Hartman 1965; Chapman and Bjornn 1969; Rankel 1971; Thurow and Bjornn 1975; Bustard and Naver 1975a,b; Hanson 1977).

Lateral habitats are sensitive areas, vulnerable to natural degradation and man's influence (e.g. logging, grazing, road construction). Enhancement efforts focused on development of spawning areas and midchannel pools may be insufficient to achieve desired objectives, if lateral rearing, areas are not abundant.

Juvenile cutthroat of age 1+ and age 2+ were most often found associated with gravel-rubble-boulder substrate (Thurow and Bjornn 1975; Graham *et. al.* 1980; Pratt 1984). In small streams, larger fish occupied stream areas with larger substrate and deeper water, generally in pools (Griffith 1972; Hanson 1977). Bisson *et. al.* (1981, 1988) and Glova (1987) reported underyearling cutthroat (age 0+) use backwater pools (6.3 cm/sec, 19.4 cm deep) and glides (20.3 cm/sec, 11 .O cm deep). Age 1+ and age 2+ cutthroat used similar habitats, both age groups preferring lateral scour (15.3 cm/sec, 24.3 cm deep) and plunge (16.8 cm/sec, 37.8 cm deep) pools with abundant cover, instead of tench pools where cover was infrequent (Bustard and Naver 1975a,b; Bisson *et. al.* 1988). In studying winter cutthroat cover, Bustard and Naver (1975a) showed winter habitat is different for juveniles than summer cover. Log jams and rubble were important winter cover, as opposed to summer hiding cover of root wads, logs, debris piles, small boulders and overhanging vegetation.

Woody debris is a major component in the development of cover and pools for westslope cutthroat trout habitat (Pratt **1984a,** Lider 1985; Gamblin 1988). Removal of riparian timber has severely limited or eliminated the recruitment of large organic debris to the watershed. As old debris decomposes, is lost, and is not replenished to the system, pools and cover are lost. Large organic debris played an important role in stream stability, habitat complexity, **bedload** storage, rearing habitat protection, and macroinvertebrate densities (Bisson and Sedell 1982; Gamblin 1988).

Canopy cover and streamside vegetation are important in providing temperature control, contributing to the energy budget and allochthonous input to the stream, controlling watershed erosion, and maintaining streambank integrity (Idyll 1942; Chapman 1966; White and Brynildson 1967; Brown 1971; Lantz 1971; Hunt 1975; Moore and Gregory **1988a,** b). Too much shade can restrict primary productivity of a stream; stream temperatures can be increased or decreased by controlling the amount of shade. Hawkins et. *al.* (1982) and Martin *et. al.* (1981) demonstrated that 50-75 percent of midday (1000-I 400 hours) shade was optimal for most cutthroat streams. They showed that shading became less important as gradient and size of stream increased. For stream widths less than 50 meters, a vegetative index was computed that approximated the percentage of vegetation needed for optimal deposition of allochthonous material to the stream annually (Chapman 1966; Hunt 1975). For cutthroat trout habitat, 150 percent vegetation along stream during summer was optimal for the annual energy input of allochthonous materials, with a range of 75-I 00 percent as acceptable habitat (Idyll 1942; Chapman 1966; Hunt 1975; Table A.l). Because trout sheltering and feeding characteristics of natural channels were enhanced by low streamside plants that drape into the water, shrubs are the major contributor to computation of the vegetation index. Also, a well vegetated riparian zone helps control watershed erosion and the presence of fines in substrate. A streamside buffer of approximately 33 meters, of which 80 percent is either well-rooted and vegetated or has stable rocky streambanks, will maintain adequate erosion control and maintain undercut streambanks characteristic of favorable trout habitat (Raleigh and Duff 1981).

Studies by Brown (1970, 1971) and White and Brynildson (1967) showed removal of forest canopy allowed temperature increases and encouraged elevated algae growth. Both of these events had the potential to increase fish production, except when thermal change and algae accumulation became excessive; at this point, production was reduced (Bisson and Davis 1976). Explanation for increased carrying capacity of stream following controlled removal of riparian overstory was confirmed by Hall and Lantz (1969), Lantz (1971), Murphy *et. al.* (1981), Weber (1981), Hawkins *et. al.* (1982); their studies found higher densities of benthic macroinvertebrates in open-canopied streams. By contrast, in less heavily wooded areas where winter icing and high summer water temperatures may be the principal factors limiting cutthroat trout populations and determining overall carrying capacities, Platts and Nelson (1989) showed increased canopy cover may be beneficial to trout production. Under these conditions, cutthroat abundance was more dependent more upon stream canopy influence on water temperature extremes than on its influence on instream primary productivity (Platts and Nelson 1989). Consequently, favorable management policies should combine the benefits of a regulated riparian canopy with maintenance of adequate pools and instream cover, thus sustaining moderate instream temperatures, with the goal of enhancing all species and age-classes of fish.

A.1.7. Diet

Cutthroat trout are very opportunistic (Oien 1957; Griffith 1970; Rankel 1971; Schutz and Northcote 1972; Everest and Chapman 1972; Hanson 1977; Wilzbach 1985; Liknes and Graham 1988), and their diet consists mainly of aquatic insects. In studying four trout streams in northern Idaho, Oien (1 957) found that Diptera (particularly Tipulidae), Trichoptera, Plecoptera and Ephemeroptera (in decreasing order of importance) were the four principal orders of aquatic insects consumed. In studying cutthroat and brook trout interactions, Griffith (1970) found cutthroat diets averaged 92 percent (75-100%) drift organisms, and Diptera was very strongly preferred. Shepard *et. al.* (1984) documented Diptera and Ephemeroptera as the most important dietary components for cutthroat trout; Trichoptera was an important constituent for fish 110mm and larger. As fish grew larger, diversity of food items increased and included terrestrial insects and sometimes small fish (Liknes and Graham 1988; Shepard *et. a/.* 1984; Hanson 1977; Hickman 1977; Rankel 1971; Carlander 1969; McAfee 1966). In a few studies, zooplankton was locally or seasonally important (Carlander 1969; McAfee 1966; Jeppson and Platts 1959).

Since headwater streams are relatively unproductive and cutthroat trout specialize as invertebrate feeders, a large portion of the energy input to lower order streams is allochthonous insects (Chapman 1966; Harrell and Dorris 1968; Wilzbach and Hall 1985; Liknes and Graham 1988); these are especially important to fish greater than 110 millimeters in length (Shepard *et. al.* 1984). Fish less than 110 millimeters prefer a diet of larger zooplankton and smaller aquatic insects (Jeppson and Platts 1959). Studies have shown that the optimum substrate in riffle-run areas for the greatest abundance and diversity in macroinvertebrate populations consisted of a greater than 50 percent mixture of rubble or small boulders or aquatic vegetation in spring areas, with limited amounts of gravel, large boulders or bedrock (Pennack and Van Gerpen 1947; Hynes 1970; Hanson 1977; Binns and Eiserman 1979; Murphy *et. al.* 1981; Table A.l). Although macroinvertebrate biomass was greater and more diverse in riffle areas than in pools, a 1 :1 ratio of pools to riffle habitat provided an optimal proportion of rearing and food producing areas (Hynes 1970; Raleigh *et. al.* 1983; Rieman and Apperson 1989). Lere (1982) found westslope cutthroat trout densities were correlated to pool-riffle periodicity. Studies have shown that in riffle-run areas, the presence of more than ten percent fines reduced standing crop of forage organisms significantly (Cordone and Kelly 1961; Bjornn 1969; Platts 1974; Crouse *et. al.* 1981).

APPENDIX B

LITERATURE REVIEW

FOR

BULL TROUT

APPENDIX B

B.l Literature Review for Bull Trout

B.l.l. General Information

Bull trout (*Salvelinus confluentus*) were historically considered to have originated in the Columbia River basin. Historical distribution of bull trout existed between 41-60 degrees north latitude and was distributed on both sides of the continental divide. Bull trout and Dolly Varden have been identified as different species based on morphometric, meristic and osteological characteristics (Cavender 1978). Three life history patterns are known to occur:

1. Resident, which do not migrate, are normally isolated by a physical barrier, and occupy headwater streams. Resident bull trout are smaller, have lower fecundity, and mature at an earlier age than other stocks of bull trout. They may retain juvenile parr marks (Scott and Crossman 1979).

2. Fluvial, which are associated with rivers and larger streams. Juveniles may remain in nursery stream up to six years before migrating to the river. Fluvial bull trout will spend two or three years in the river before migrating back to the nursery stream to spawn.

3. Adfluvial, which are found in lakes and reservoirs associated with larger tributaries. Juveniles remain in the nursery stream for one to six years before migrating to the lake. They spend approximately two to three years in the lake before returning to the nursery stream to spawn.

Dam construction and habitat degradation, due to logging, agricultural practices, grazing and mining, have influenced bull trout populations in the Pacific northwest.

B.1.2 Life History

The life life history of bull trout can be categorized by advanced age of maturity, increased size, alternate year spawning, extensive migrations, and separation of juvenile and adult populations (McCart 1985). Bull trout mature at age 6-7+ but may mature as early as age 4+ (Fraley and Shepard 1989). Bull trout matured at age 5-6+ in the Swan River system (Leathe and Enk 1985); bull trout on the upper Clark Fork River reached maturity between age 4-7+ (Heimer 1965; Pratt 1985). Length at maturity ranged from 171 millimeters for resident populations of bull trout in Sun Creek, Oregon, to 690 millimeters for an adfluvial population in the Upper Flathead River, Montana. In studying Flathead Lake bull trout, Hanzel (1985) found that adfluvial juveniles emigrated at ages 2-3+ at 102-175 millimeters. Growth rate in the lake increased until age 4+, and then remained constant. Average incremental growth was 70 millimeters (60-132 mm) annually; 450 millimeters delineated the change from subadult to adult in Flathead Lake (Hanzel 1985, Cross 1985).

Spawning usually occurs between September and October, but has been observed as early as July. Bull trout enter tributaries approximately one month prior to spawning (Leggett 1969; McPhail and Murray 1979; Ratliff 1987; Fraley and Shepard 1989). Upstream migration has been found to coincide with maximum water temperatures (IO-12°C) and minimum flows in 0.76-0.80 meter deep water (McPhail and Murray 1979). For the Flathead River basin, timing of spawning migration occurred as follows (Shepard 1985; Carl 1985):

1.	Migrate from lake	April-May
2.	Arrive at tributaries	mid July - late August
3.	Enter tributaries	early August - late September (two hours after dusk)
4.	Spawn	early September - late October
5.	Leave tributaries	mid September - end October
6.	Return to lake	October-November

Initiation of spawning appears to be related to declining water temperatures, photoperiod and possibly stream flow.

In Flathead River tributaries, Montana and in upper Arrow Lakes, British Columbia, spawning began when water temperature fell below 9°C (McPhail and Murray 1979; Weaver and White 1985). Wydoski and Whiting (1979) reported that spawning occurred when water temperatures reached 5 to 6°C in Washington. Most spawning activity occurs at night (Heimer 1965; Weaver and White 1985). Bull trout pairs remain over the nest for up to six days (Aquatico 1976). Oliver (1979) noted females moved downstream soon after spawning was completed, but males remained late into the fall.

Fertilization rate was estimated to be approximately 90 percent (Enk 1985). Fecundity (# eggs/female) for bull trout is lower than or equal to other charrs of comparable size; 610 millimeter fish averaged 5050 eggs. Egg retention was 2-5 percent (Hanzel 1985; Fidler 1985). From numerous studies, distribution of sex ratio averaged 1 .1 females per male (Shepard 1985; Carl 1985). In the Flathead River system, there was an average of 3.2 spawners per redd (Fraley 1985).

Incubation continues through winter months, with peak hatch occurring by mid-January. In tributaries to North Fork Flathead, peak emergence of fry took place by 1 May (MacDonald and Fidler 1985). After one to three years of rearing in tributary streams, bull trout smolts migrated in late September to Flathead Lake.

Most fluvial and adfluvial young remain in nursery, streams for one to six years (Allan 1980). Juveniles in most river systems migrated at 2 to 3 years of age (McPhail and Murray 1979; Oliver 1979; Fraley and Shepard 1989). Time of migration varies depending upon age and size of fish, and amount of available habitat. Migration was observed as early as May and as late as October (Pratt 1985; Aquatico 1976). In the spring, downstream migration occurred to areas where water velocities were lower (McPhail and Murray 1979; Oliver 1979; Allan 1980).

Occasionally upstream migrations have been observed for juvenile bull trout. Fraley and Shepard (1988) observed juvenile bull trout migrating to upper reaches of the stream to rear. These fish were concentrated in spring areas where temperatures did not exceed 15°C, and adult bull trout were absent from the stream reach.

B.1.3 Water Quality

B.1.3.1 Temperature

All life history stages of bull trout are strongly influenced by temperature. They are seldom associated with tributaries where summer temperatures exceed 15°C and are normally associated with cold perennial springs (Allan 1980; Shepard *et. al.* 1984) or groundwater influence (Shepard 1985), and a closed-forest canopy (Pratt 1985).

Spawning migration coincides with water temperatures around 10-12°C. During embryo development, optimal incubation temperature range is 2-4°C (McPhail and Murray 1979; Brown 1985; Carl 1985). Highest average temperature range during warmest period of year for fry and juvenile bull trout is 5-15°C, with optimum range of 5-8°C for fry and 5-12°C for juveniles (Pratt 1985; Carl 1985: Ratliff 1988; Fraley and Shepard 1989). For resident and fluvial adult bull trout, the average maximum temperature range is 9-15°C, with 9-10°C as optimum (Moyle 1976; Shepard 1985; Skeesick 1988). Adfluvial adults prefer 7.2-14.0°C temperatures; 8.0-12.8°C range is optimum (Bjornn 1961; Shepard 1985).

In studies of bull trout culture in British Columbia, Brown (1985) found water temperature to be a major factor in incubation success. During egg development, groundwater supply, which was normally 7-8°C, was chilled to about 4°C for best survival. Conversely, it has been found by most authors, as water temperatures increased, size and survival of eggs and alevins decreased (McPhail and Murray 1979; Brown 1985; Weaver and White 1985). Water temperatures of 8-20°C were found to produce the smallest alevins with the highest mortality rate of 80-100 percent (McPhail and Murray 1979).

For rearing fry, water temperature was increased to 7-8°C in bull trout studies by Carl (1985). Brown (1985) reared fry in 7-8°C for 4-6 weeks, following alevin stage.

Juvenile bull trout can tolerate slightly warmer temperatures, which may vary from 7-12°C. Brown (1985) raised juveniles in 7-11 °C water, but rarely exceeded 12°C, because disease problems were more acute above this temperature. In the Metolius drainage of the Deschutes River in Oregon, juveniles occupied only groundwater-fed tributaries where summer temperatures seldom exceeded 10°C (Ratliff 1988). Similarly, in the Flathead River system in Montana, juveniles were not observed in waters above 15°C (Fraley and Shepard 1989; Fraley *et. al.* 1989). Most authors agreed that water temperatures influenced the distribution of bull trout juveniles and that they grew slowly, as a result of the cold water temperature and low-productivity of nursery streams (Oliver 1979; Allan 1980; Pratt 1984, 1985; Slaney and Martin 1985).

Adult bull trout show a preference for cold water rivers, lakes and reservoirs (Moyle 1976). Summer water temperatures for resident bull trout ranged from 9-15°C in the upper Klamath River (Bond and Long 1979). In upper reaches of the John Day River, bull trout were not observed in waters that exceeded 10°C (Skeesick 1989).

Adfluvial bull trout in Priest Lake, Idaho were reported to occupy the lower thermocline in summer, where temperatures ranged from 7.2-l 2.8°C. In spring and fall, the bull trout moved to near surface waters when temperatures were below 12.8°C (Bjornn 1961). In Libby Reservoir, Montana, adults preferred the water stratum of 8-14°C (Shepard 1985).

B.1.3.2 Other Water Quality Parameters

No conclusive information exists on chemical parameters, such as dissolved oxygen, pH, alkalinity and hardness, total dissolved solids or turbidity.

B.1.4. Substrate

According to Fraley and Shepard (1989) unembedded gravel substrates with low compaction and low gradients were selected as bull trout spawning sites. Substrate composition for the highest redd frequency in the Flathead River tributaries of Montana was gravel-cobble (62%) and boulder (10%) composition (Fraley and Shepard 1989; Graham *et. al.* 1981; Shepard 1985).

If gravel-cobble-boulder substrates contained fines of 6.35 millimeters or less in size at time of redd construction, Weaver (1985) found that higher egg mortality resulted.

Fraley and Graham (1981) found that stream sections of 23 percent cobble and 60 percent gravel contained the highest bull trout densities. Gravel-cobble-boulder substrates are often associated with changes in substrate and geological material. These changes ultimately result in braided, sinuous and/or multiple stream channels, that are sites for groundwater inflections. These inflections result in tributary recharge, which favor bull trout habitation.

Substrate is a critical parameter for bull trout egg and alevin survival. The amount of fine material (<9.5 mm) in the substrate will effect emergence success (Weaver and White 1985). Shepard *et. al.* (1984) found that mortality increased sharply, if the substrate was composed of 30 percent or more fines (≤ 6.35 mm); no survival was recorded at 50 percent fines. Weaver and White (1985) found that even a substrate composition of 44 percent fine material resulted in no emergence.

Oliver (1979, 1985) observed that young fry showed a preference for sand and gravel, whereas highest density of juveniles was found in stream segments dominated by rubble-boulder bed material. Studies by Pratt (1985) showed that juveniles require clean unembedded, stacked rubble-cobble substrate with large interstitial spaces between particles. In assessing the effects of forest and hydropower development in the Swan River drainage in Montana, Enk (1985) showed that densities of juvenile and adult fluvial bull trout in 26 reaches were significantly correlated to substrate quality, as measured by percent fines less that 6.4 millimeters. In modeling the effects of forest sediment on bull trout density, Enk (1985) found losses of potential bull trout production to be 4-12 percent due to road development.

Adult bull trout are bottom dwellers, preferring deep pools of cold water with boulder-rubble substrate (Allan 1980; MacDonald and Fidler 1985), which ensures good winter survival (Carl 1985).

B.1.5 Velocity and Gradient

Low channel gradient has been significantly correlated with high redd frequency of bull trout; frequency is highest where gradient is less than three percent (Fraley and Graham 1981; Graham *et. al.* 1981; Shepard 1985; Fraley and Shepard 1989). Most authors agreed that spawners most often selected areas in stream channel characterized by low gradient, generally in high order streams with groundwater influence (Fraley and Graham 1981; Graham *et. al.* 1981; Shepard 1985; Weaver 1985; Carl 1985: Oliver 1985; Fraley and Shepard 1989). Graham *et. al.* (1981) found that bull trout spawned immediately downstream of a high-low gradient interface.

Juveniles distribute themselves along the stream bottom, seeking low velocities (10 cm/sec) in association with submerged cover (Brown 1985; Pratt 1985; Fraley 1985). Pratt (1985) found that water depth was not as important as wetted surface area, because increasing water volume and velocity did not necessarily increase rearing capacity for juveniles. Optimal water velocities were found only in small pockets, therefore describing mean velocities by conventional methods did not provide velocity information on available rearing habitat (Pratt 1985). In discussing early rearing of juveniles, Pratt (1985) and Fraley (1985) agreed that extremely high flows may reduce survival rates by pushing fry out of tributaries and into mainstem, where predation rates maybe higher. On the other extreme, Pratt (1985) and Fraley (1985) agreed that low flows reduce wetted area and, therefore, reduce the amount of space available for rearing fry and juveniles.

Adult bull trout inhabit streams with IO-20 percent gradients and moderate to fast currents (Bond and Long 1979).

Variable velocities were reported in the literature for bull trout. Carl (1985) found that bull trout in Alberta, British Columbia preferred unstable, cold and unproductive streams, even though such streams were vulnerable to habitat degradation, erosion, occasional flooding and low winter flow. Adults spawned in groundwater fed streams; advantaged to these streams were warmer winter temperatures, stable winter velocities, low sediment loads and lack of winter anchor ice. The large size of female spawners allowed deeper placement of eggs. This increased chances of egg survival in fast-flowing streams, where spring flooding may scour smaller gravel on river bottom or where low flows in winter may leave redds, that were dug along stream edge, stranded (Carl 1985; Weaver 1985; Enk 1985). Weaver (1985) reported that low flow and stranding accounted for 25-30 percent loss of production in some Flathead River tributaries in Montana. Oliver (1985) found that females selected redd sites in shallow depths, characteristic of low surface velocities, within an average of 2.5 meters of the streambank.

B.1.6. Cover

Upon emergence, bull trout fry migrate to low-velocity areas that are separated from adults, such as side channels, back waters, lateral stream margins, and pools (McPhail and Murray 1979; Allan 1980; Fraley and Graham 1981; Shepard 1985; Pratt 1985; Elliot 1986; Skeesick 1989; Fraley and Shepard 1989).

Most authors have found that juveniles, also, relied on gravel-cobble-rubble substrate for cover and resting areas (McPhail and Murray 1970; Allan 1980; Fraley and Graham 1981; Shepard 1985; Pratt 1985; Elliot 1986; Heifetz *et. al.* 1986; Skeesick 1989; Fraley and Shepard 1989). Pratt (1985) reported that bull trout fry (cl00 mm) remained near bottom, close to streambed materials and submerged debris, or burrowed into interstices of unembedded substrate cobble. Juveniles (>100 mm) remained near large instream debris and cover. Pratt (1984, 1985) discovered that woody debris used by bull trout for cover can be a single piece of submerged debris along stream margins or a large jam of unconsolidated woody debris; flow should go through the debris jam or root wad, not necessarily over it into a plunge pool. Streams can be manipulated to enhance rearing capacity for juvenile bull trout (40-200 mm). Submerged cover (<0.2 m) along the stream bottoms in the Flathead River basin, Montana created slow (0.1 mps) water and increased rearing and small pockets of hiding capacity of tributaries (Pratt 1985). Skeesick (1989) found that juveniles were very territorial and became quite aggressive under high fry densities. In a study conducted by Elliott (1986), cover resulted in visual isolation of juveniles; aggressiveness was decreased, and smaller habitat spaces were occupied. As bull trout increased in size, Pratt (1984, 1985) found that juveniles became less dependent upon instream cover.

Adult spawners depend upon closed forest-canopy shade and overhanging banks and vegetation as cover. Shepard (1985) found generally that higher redd frequency was associated with this type of cover. · Skeesick (1988) reported that adults used woody debris and overhanging banks for shelter, during upstream migration and while waiting to spawn. These areas are characterized by low velocity and shallow depths (<50 mm). Resident and fluvial adults require large deep pools for cover in summer **and winter (Carl 1985).** Adfluvial bull trout in lakes utilize depth as cover. Hanzel (1 985) netted bull trout at depths of 284 meters (260 ft) and believed that they existed at 394 meters (360 ft); sampling was performed in spring, during isothermal conditions of lake.

B.1.7 Diet

Bull trout are voracious predators and have been noted to be opportunistic and adaptive in feeding habits (Boag 1987).

Bull trout larvae remain in gravel until yolk sac absorption is nearly complete (MacDonald and Fidler 1985). Bull trout begin feeding at emergence and select aquatic insects from the entire water column (McPhail and Murray 1979; Balon 1984).

Bull trout fry (<100 mm) feed exclusively on aquatic insects (Shepard *et. al.* 1984; Carl 1985; Pratt 1984, 1985), however, salmon eggs are important components of juvenile diets in the fall (Skeesick 1988). When juveniles reach 11 O-140 millimeters, they become increasingly piscivorous, however some overlap in size exists (Shepard *et. al.* 1984; Carl 1985; Hanzel 1985). Growth and condition improve after bull trout begin feeding on fish (Carl 1985), Jeppson and Platts (1959) observed that 100-300 millimeter trout consumed only insects. Hanzel (1985) reported that subadults (<300 mm) ate primarily sculpins, whitefish, kokanee, and incidentally consumed yellow perch, squawfish, peamouth chubs and suckers, and Mysis shrimp, if opportunely available (Fraley and Shepard 1988).

When bull trout reach 400 millimeters, consumption is primarily fish and insects. Adult resident bull trout fed almost exclusively on insects (Scott and Crossman 1979; Armstrong and Morrow 1980). Food preferences were Diptera (midges and flies), Trichoptera (caddisflies), Ephemeroptera (mayflies), and Plecoptera (stoneflies), in decreasing order of importance.

Adult fluvial populations tend toward increasing piscivory. Bull trout in McKenzie Rivers, Oregon consumed forage fish, insects and crayfish, while bull trout in Imnaha River, Oregon fed almost exclusively on salmon fingerlings (Skeesick 1988). To ensure winter survival, resident and fluvial bull trout require large deep pools to provide cover and an abundant prey source; whitefish, a preferred prey, cohabitate in pools with the bull trout (Carl 1985).

Adfluvial populations of bull trout are highly piscivorous and reach the largest size of all stocks. Preference for kokanee and whitefish have been documented by Bjornn (1961) and Shepard *et. al.* (1984). Hanzel (1985) documented diet preferences by availability and season; kokanee were most available and consumed in spring, whitefish in summer and fall, and yellow perch in winter. Overall, three whitefish species were the most important food items year-around; lake, mountain and pygmy. In addition to the above, sculpin, peamouth chub, suckers and squawfish were the next important prey items consumed (Hanzel 1985).

Spawning adults were observed to feed very little, if at all (Apperson *et. al.* 1988; Fraley and Shepard 1988).

During hatchery production of Dolly Varden and bull trout in British Columbia, Brown (1985) extensively explained the difficulties of providing a suitable diet for these bottom-dwellers. Palatability was a major concern with respect to these fish, as they demonstrated clear preferences for certain flavors and textures (Brown 1985). Since bull trout feed exclusively on the bottom, feeding and disease control (gill infections) were more difficult to control than in aquaculture of any other species of trout or charr (Hanzel 1985).

B.1.8 Species Interactions

Interactions between bull trout and northern squawfish, cutthroat, rainbow, and lake trout have been documented (Jeppson and Platts 1959; Thompson and Tufts 1967; Pratt 1984; Boag 1987; Marnell 1985). Jeppson and Platts (1959) found at 200-300 millimeters, northern squawfish were in competition with bull trout for food, since both species shifted to a piscivorous diet at that length. Thompson and Tufts (1967) agreed that bull trout and northern squawfish had similar preferences for food.

Although rainbow and bull trout do no compete for food resources or living space (Allan 1980; Boag 1987), it has been suggested that bull trout and juvenile rainbow trout partioned habitat and rainbow trout choose areas of higher water velocity (McPhail and Murray 1979).

In an intensive study, Pratt (1984) reported active habitat partitioning between juvenile bull and cutthroat trout. A second relationship was discovered between age 1+ cutthroat and larger bull trout. Bull trout were located in areas of high cutthroat densities, which suggested cutthroat fry served as prey for adult and subadult bull trout (Pratt 1984). Marnell (1985) studied- lakes of Glacier National Park and found well defined habitat partitioning; there was, however, an absence of the predator-prey relationship typically seen between these species. Shepard et. *al.* (1948) reported interspecific aggression between larger juvenile and subadult bull trout, and adult cutthroat trout.

Fluvial populations of bull trout and brook trout, that cohabitate in the same stream, have been observed to share the same habitat during at least one stage of their life histories (Peters 1985; Rode 1988). Hybridization of the two species has been common and extensive (Cavender 1978; Leary *et. al.* 1983). In Montana, Skeesick (1988) reported that fluvial bull trout populations in symapatry with brook trout are now declining. It was hypothesized by Rode (1988) that introduction of brook trout and competition with brown trout have led to the decline of bull trout populations.

A decline of adfluvial bull trout stocks, has been reported from Glacier National Park, Montana. Marnell (1985) attributed the decline to flood damage of spawning and rearing habitat and competition from introduced lake trout.

Cover & Woody Debris	Water Quality	Barriers
-·	good	waterfalls
	good	-
	·ed	gradient, flow, woody debris
		flow

...g aerial survey for lower, middle and upper reaches of the ninete... excluded).

	Substrate-Riffle:Pool	Soils & Bank Stability	Riparian	Channel	Cover & Woody Debris	Water Quality	Barrie...
	silted	highly erodible; wasted & unstable	none none none	unstable meander	good good good	marginal-poor heavy silt load	cement embu... culverts; cumulative imp...
le le	silted silted boulders	highly erodible	damaged to none	unstable meander	. . .	poor poor poor	cement embuttn... water quality; cumulative impac...
le le apids	silted substrate 50/50 r:p-high riffle high riffle	highly erodible; wasted and undercut	site-specific protected limited	unstable meander; unstable braided	. . .	silted; moderate-poor	none none none
	. . .	. . .	. . .	dry dry dry	. . .	none none none	concreet channel; no water
	gravel 50/50 riffle:pool	stable stable stable	undamaged undamaged none	unstable meander	good; logs and debris	good good good	none (potential for log jams and intermitte... flow in upper)
le-	50/50 riffle: pool	highly erodible; stable	damaged with residual snags	stable meander	good good good	muddy-poor	upper: Town of Plummer; culverts; sewage ponds + storm drain effluent; water quality
le-	gravel 50/50 riffle:pool	erodible; stable	undamaged; stable	stable stable stable	good good good	good good good	gravel pit; numerous culverts; possible log jams
	. . .	. . .	. . .	dry dry dry	. . .	none none none	frozen in winter; gradient
te te 'apids	50/50 riffle: pool	erodible; stable	site-specific:disturbed stable, protected, limited	stable stable stable	good good good	good good good	improperly graded culverts; headwaters: steep gradinet rapids
	. . .	. . .	. . .	dry dry dry	. . .	. . .	no water; gradient
te ·tly high	high riffle: low pool cascades	stable stable stable	stable; undamaged	stable stable stable	good good good	good	

FISHERIES HABITAT EVALUATION ON TRIBUTARIES OF THE COEUR d'ALENE INDIAN RESERVATION

ANNUAL REPORT

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Project Number 90-44
Contract Number DE-B179-90BP10544

FEBRUARY 1993

EXECUTIVE SUMMARY

The purpose of this study was to conduct physical and biological surveys of streams located on the Coeur d'Alene Indian Reservation. Surveys were designed to collect information on improving spawning habitat, rearing habitat, and access to spawning tributaries for bull trout and cutthroat trout and to evaluate the existing fish stocks.

The objectives of the second year of the study were to:

1. Develop a stream ranking system to select the five streams of primary fisheries potential.
2. Conduct physical field surveys.
3. Determine population dynamics.
4. Determine growth rates of existing trout species.
5. Determine macroinvertebrate densities and diversities, and,
6. Determine baseline angler utilization.

The Missouri method of evaluating stream reaches was modified and utilized to rank the ten tributaries (as determined by Graves et *al*.,1 990) associated with reservation lands. The method incorporated such data as stream bank and bed stability, condition of riparian vegetation, land use, degree of urbanization, passage barriers, water quality, flow and temperature regimes, as well as the overall habitat suitability for all life history stages of cutthroat and bull trout. This data was then combined with relative abundance data, growth rates and invertebrate densities to choose five streams, which offer the best potential habitat, for further study.

Relative abundance estimates resulted in the capture of 6,138 fish from June, August, and October, 1991. A total of 427 cutthroat trout were collected from all sampled tributaries. Relative abundance of cutthroat trout for all tributaries was 6.7%. Fighting Creek had the highest abundance of cutthroat trout at 93.1%, followed by Evans Creeks at 30.8%, Lake Creek at 12.1%, Hell's Gulch at 11 .l%, Alder Creek at 3.3%, Benewah Creek at 2.1% and Plummer/Little Plummer creeks at 5%.

Population estimates were conducted in Benewah, Alder, Evans and Lake creeks. Estimates were: 23.5 ± 2.3 fish/l ,922.6 m2 in Benewah Creek, 15.3 ± 2.1 fish/l ,039.6 m2 in Alder Creek, 69.1 ±

36.4 fish/857.1 m2 in Lake Creek, and 120.6 ± 20.5 fish/634.4 m2 in Evans Creek.

Growth rates and condition factors for cutthroat captured in each stream tended to be low in comparison to other streams in the region except for Benewah Creek. Eastern brook trout growth and condition factors were good in relation to other streams in the region.

Mean annual invertebrate densities in the tributaries ranged from 1205.3 organisms/m2 in Alder Creek to 2885.56 organisms/m2 in Evans Creek. Mean annual densities in the drift ranged from 21.3 organisms/m2 in Alder Creek to 265.7 organisms/m2 in Evans Creek. Invertebrate densities were comparable to other streams of the same size in the region.

Angler effort was determined to be minimal to nonexistent. Compliance with Idaho fish and game regulations regarding stream closures during spawning migrations limited the amount of angler utilization within the tributaries. Low to intermittent flow conditions in the tributaries during open fishing season also decreased angler pressure. Fishing pressure was heaviest by tribal members in late May during peak spawning runs. When runs began to diminish, fishing pressure declined. Fishing pressure was heaviest on those tributaries that were known to have existing runs of cutthroat trout such as Benewah and Lake creeks. Due to the lack of anglers, creel census were eliminated in early August.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the following individuals for their assistance in field data collection and laboratory analysis: George Aripa, Oswald George, Sam Sanchez, Ed Wolfe, Diana Richards, Mindy Sheer, John Raymond, Philip Lillengreen and Vance Lillengreen. Funding was provided by the U.S. Department of Energy, Bonneville Power Administration, Contract number 909-044-00. Additional financial support for this project was provided by a grant from the U.S. Department of the Interior, Bureau of Indian Affairs to the Upper Columbia United Tribes (UCUT) to fund the operation of the UCUT Fisheries Center at Eastern Washington University. All capital equipment for this project was supplied by the UCUT Fisheries Center. Special thanks go to Bob Austin (BPA Project Manager), Ernie Stensgar, (Chairman, Coeur d'Alene Tribal Council), Ernie Clark (former Planning and Natural Resource Director, Coeur d'Alene Tribe) and Diedre Allen, (former Coeur d'Alene Tribal Planner) for their assistance.

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1 .O INTRODUCTION

Bull and cutthroat trout were two species of salmonids native to the Lake Coeur d'Alene system. Historically these species were fished by the Coeur d'Alene Indians. Both species have been greatly reduced in occurrence in the last 100 years. Both species are currently of special concern (Johnson 1987) due to declining population numbers and continued reduction of habitat (Spahr 1991). A complete discussion of the fisheries management history of the Coeur d'Alene basin is contained in Graves et *a/* (1990).

In 1987 the Northwest Power Planning Council amended the Columbia River Basin Fish and Wildlife Program, directing the Boneville Power Administration (BPA) to fund, *"A baseline stream survey of tributaries located on the Coeur d' Alene Indian Reservation to compile information on improving spawning habitat, rearing habitat, and access to spawning tributaries for bull trout (Salvelinus confluentus), cutthroat trout (Qncorhynchus clarki) and to evaluate the existing fish stocks. If justified by the results of the survey, fund the design, construction and operation of a cutthroat and bull trout hatchery on the Coeur d'Alene Reservation; necessary habitat improvement projects; and a three-year monitoring program to evaluate the effectiveness of the hatchery and habitat improvement projects. If the baseline survey indicates a better alternative than construction of a fish hatchery, the Coeur d'Alene Tribe will submit an alternative plan for consideration in program amendment proceedings."* In 1990, BPA contracted the Coeur d'Alene Tribe to perform this study.

Twenty one creeks, flowing into Coeur d'Alene Lake, The St. Joe River and the St. Maries River, were initially identified within the study area as potentially useful for trout species. Data obtained from a helicopter survey further determined that only ten creeks which included; Fighting, Bellgrove, Lake, Squaw, Little Plummer, Plummer, Benewah, Hells Gulch, Evans and Alder creeks contained potential trout habitat.

The Three-phase study objectives are as follows:

1. Identify from twenty tributaries (as outlined in Graves *et a/*,1990), four tributaries best suited for habitat improvement by compiling information on spawning and rearing habitat and accessibility to spawning tributaries for cutthroat and bull trout.

2. Fund the design, construction and operation of a cutthroat and bull trout hatchery and necessary habitat improvement projects.

3. Conduct a three-year monitoring program to evaluate the effectiveness of the hatchery and habitat improvement projects.

The purpose of this phase of the study is to compile information on improving spawning habitat, rearing habitat, and access to spawning tributaries for bull and cutthroat troutand to evaluate the existing fish stocks. The objectives of this study were to collect information on:

1. Population dynamics (including relative abundance, population estimates, natural and fishing mortality.).

2. Growth rates

3. Behavior patterns (i.e., migratory tendencies): and

4. Factors limiting fish production (e.g., habitat availability, food availability).

At the end of the study, the information will be combined to develop recommendations for enhancement projects, cost estimates for each alternative and estimates for success (in terms of increasing fish production) of each alternative. Upon completion of these tasks recommendations for bull and cutthroat trout enhancement projects will be submitted to the Northwest Power Planning Council.

This report contains the findings of the second year of the project. Objectives of the second year were to:

1. Develop a stream ranking system that defines the top five streams most acceptable for rehabilitation for bull and cutthroat trout populations. Ranking was accomplished through modifications of the Missouri method of evaluating stream habitat.

2. Conduct ground surveys identifying:

    a. Length of suitable fish habitat.

b. General physical stream features, including flow. temperature, pH, dissolved oxygen, total dissolved solids, conductivity, nitrate, nitrite, alkalinity and phosphate.

c. Relative abundance of fish species in the study section.

3. Determine population levels of cutthroat and bull trout in each primary tributary

4. If possible, assess age, growth and condition of cutthroat and bull trout in each stream, if possible.

5. Determine macroinvertebrate densities and diversities in comparison to similar stream systems.

6. Determine baseline angler utilization and fish biomass harvested in priority streams.

7. Begin habitat surveys of selected primary tributaries.

2.0. MATERIALS AND METHODS

2.1. Description of the study area

The Coeur d'Alene drainage basin is located in the Idaho panhandle and drains approximately 9,583.O square kilometers. It is divided into two subbasins, which includes the Coeur d'Alene River and the St. Joe River Basin. The Coeur d'Alene River basin, located east and north of the lake, drains approximately 3,859 square kilometers, while the St. Joe River Basin, located east and south of Coeur d'Alene Lake drains approximately 4,891 .l square kilometers (Figure 2.1). The remaining 9% of the drainage basin consists of creeks flowing into Wolf Lodge Bay and Corbin Bay on the east side of the lake, and Windy, Rockford, Mica and Cougar bays on the west side of the lake.

The study area encompasses ten tributaries located within the Coeur d'Alene drainage basin, including: Bellgrove, Fighting, Hell's Gulch, Squaw, Plummer, Little Plummer, Benewah, Lake, Evans, and Alder creeks. A full description of these creeks can be found in Graves et *al* (1990). Hell's Gulch, Lake and Evans creeks are third order tributaries while all the rest are fourth order drainages.

Table 2.1 lists the locations of sample sites for relative abundance and population estimates for each creek, while figures 2.2-2.9 shows relative abundance, population estimates, macroinvertebrate densities and water quality sample sites for each creek.

2.2. PHYSICAL INVESTIGATIONS

2.2.1. Habitat quality index model to select primary tributaries.

A modified Missouri Habitat Quality Index (Fajen and Wehnes 1981) was used to rank the ten previously selected Coeur d'Alene tributaries in terms of their potential for cutthroat and bull trout habitat.

Fourteen components including seven habitat quality parameters and seven habitat alteration functions were used for stream rankings. The seven components habitat quality parameters were rated on a scale of zero to ten. The first six of the habitat

Table 2.1 Location of relative abundance, water quality and benthic macroinvertebrate sampling sites.

Stream name	Site	Location
Bellgrove/Fighting	1	R4W T48N Sec. 7 se1/4 sw1/4
Hell's Gulch	1	R2W T46N Sec. 6 nw1/4 se l/4
Plummer/L. Plummer	1	R4W T46n Sec. 2 sw1/4 ne1/4
	2	R4W T46 Sec. 10 sw1/4 swl/4
	3	R4W T46 Sec. 3 ne1/4 ne114
Benewah	1	
	2	
	3	
	4	R4W T45n Sec. 26 ne114 ne l/4
Lake	1	R5W T48n Sec. 21 nw1/4 sw1/4
	2	R6W T48n Sec. 12 sw l/4 nw1/4
Evans	1	R2W T47n Sec. 3 se1/4 se l/4
	2	R2W T47n Sec. 12 ne1/4 se1/4
Alder	1	R3W T45n Sec. 36 nw1/4nw1/4
	2	R3W T45n Sec. 33 sw1/4 nw1/4

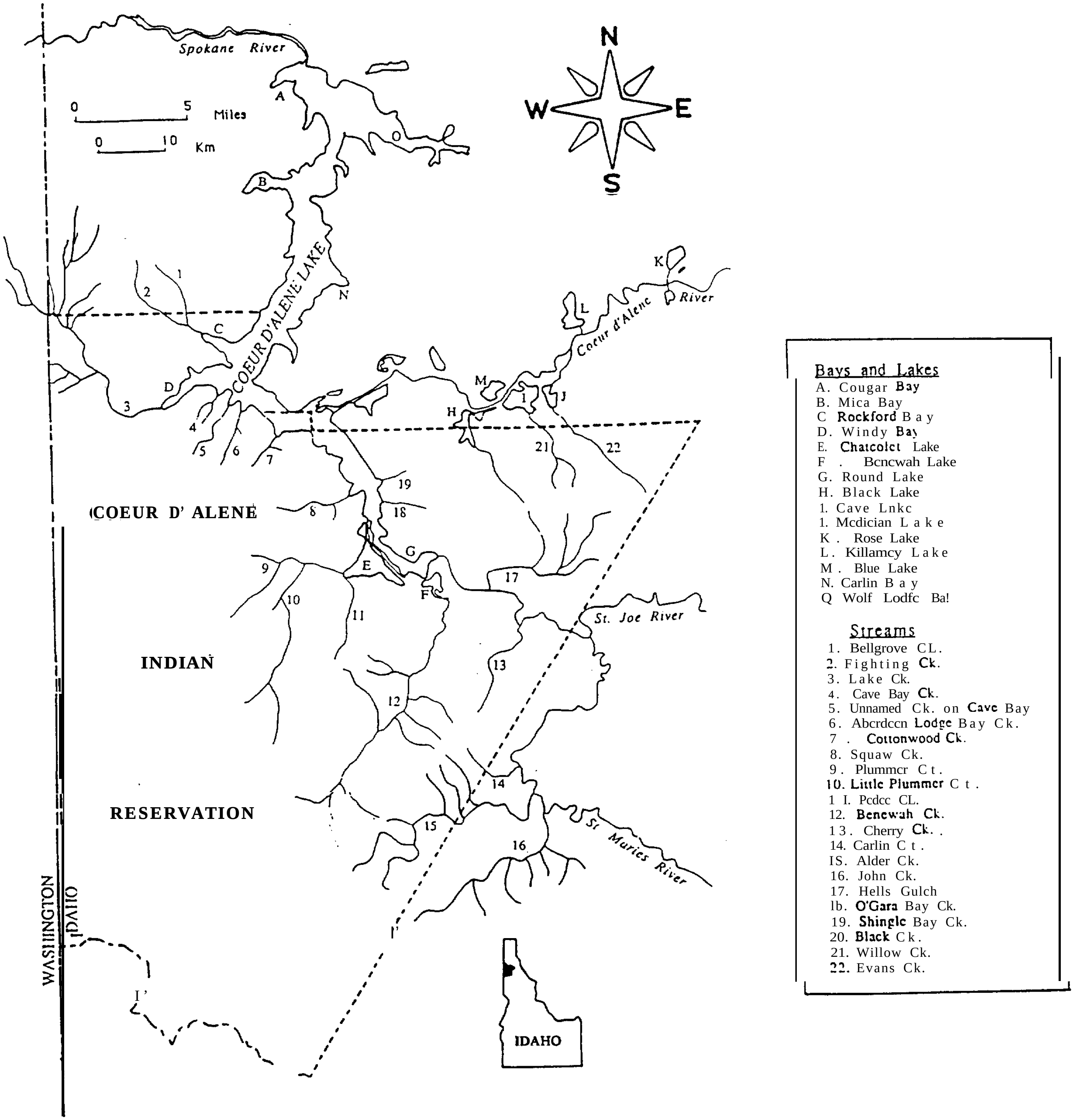

Figure 2.1. Map of the Coeur d'Alene drainage basin.

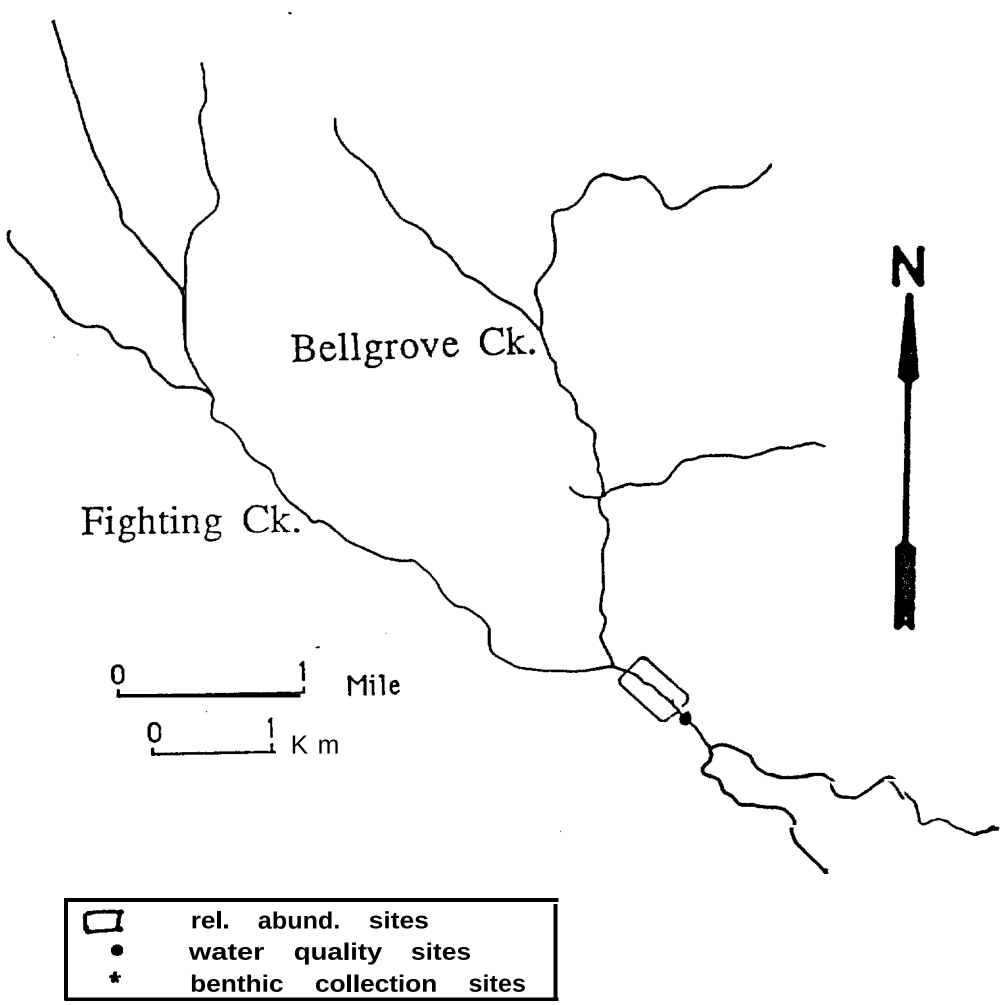

Figure 2.2. Map of Bellgrove and Fighting creeks showing the locations of the relative abundance, benthic macroinvertebrates and water quality stations.

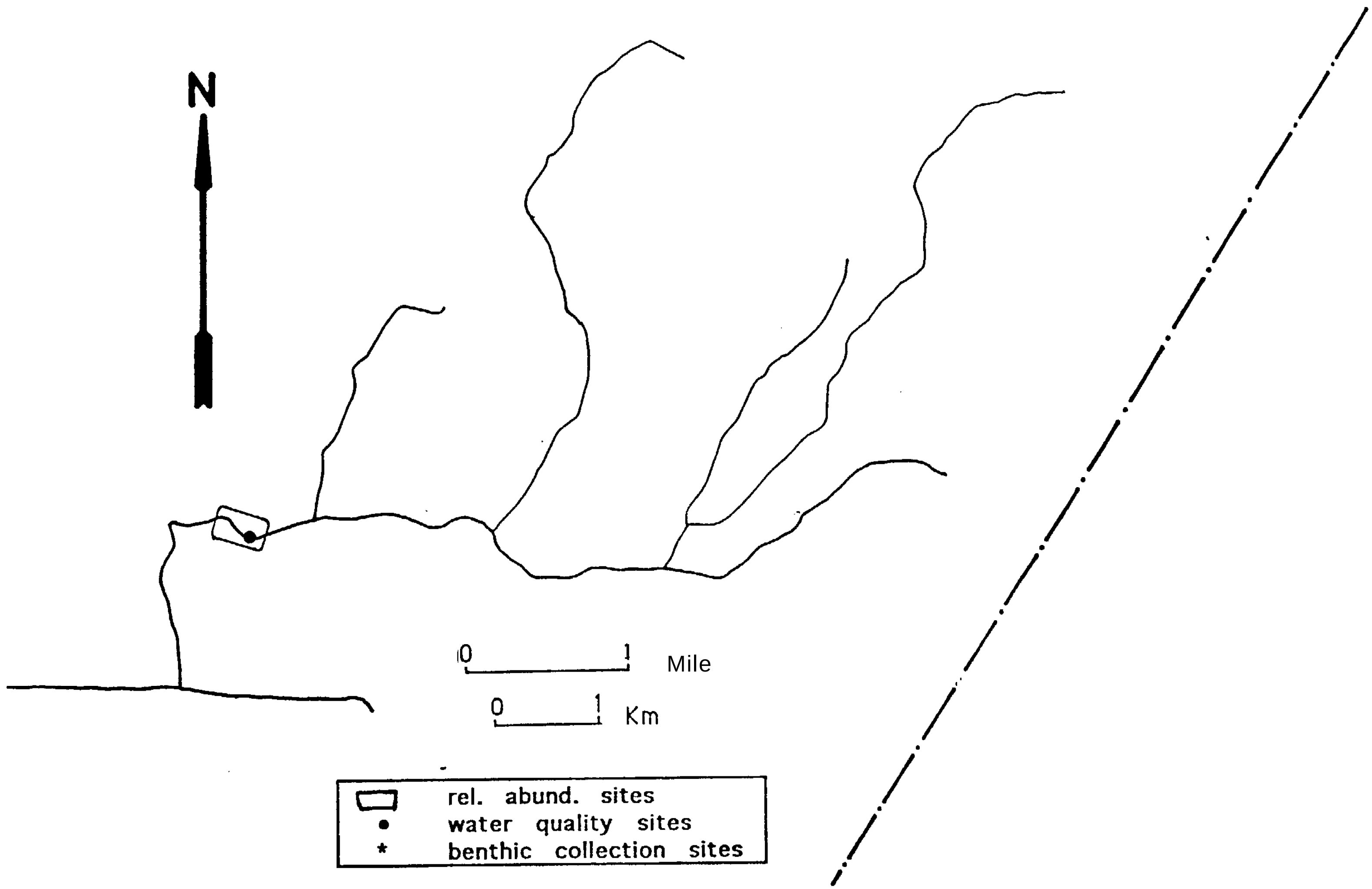

Figure 2.3. **Map** of Hell's Gulch showing the locations of the relative **abundance,** benthic macroinvertebrates and water quality stations.

Figure 2.4. Map of Squaw Creek showing the locations of the relative abundance benthic macroinvertebrates and water quality stations.

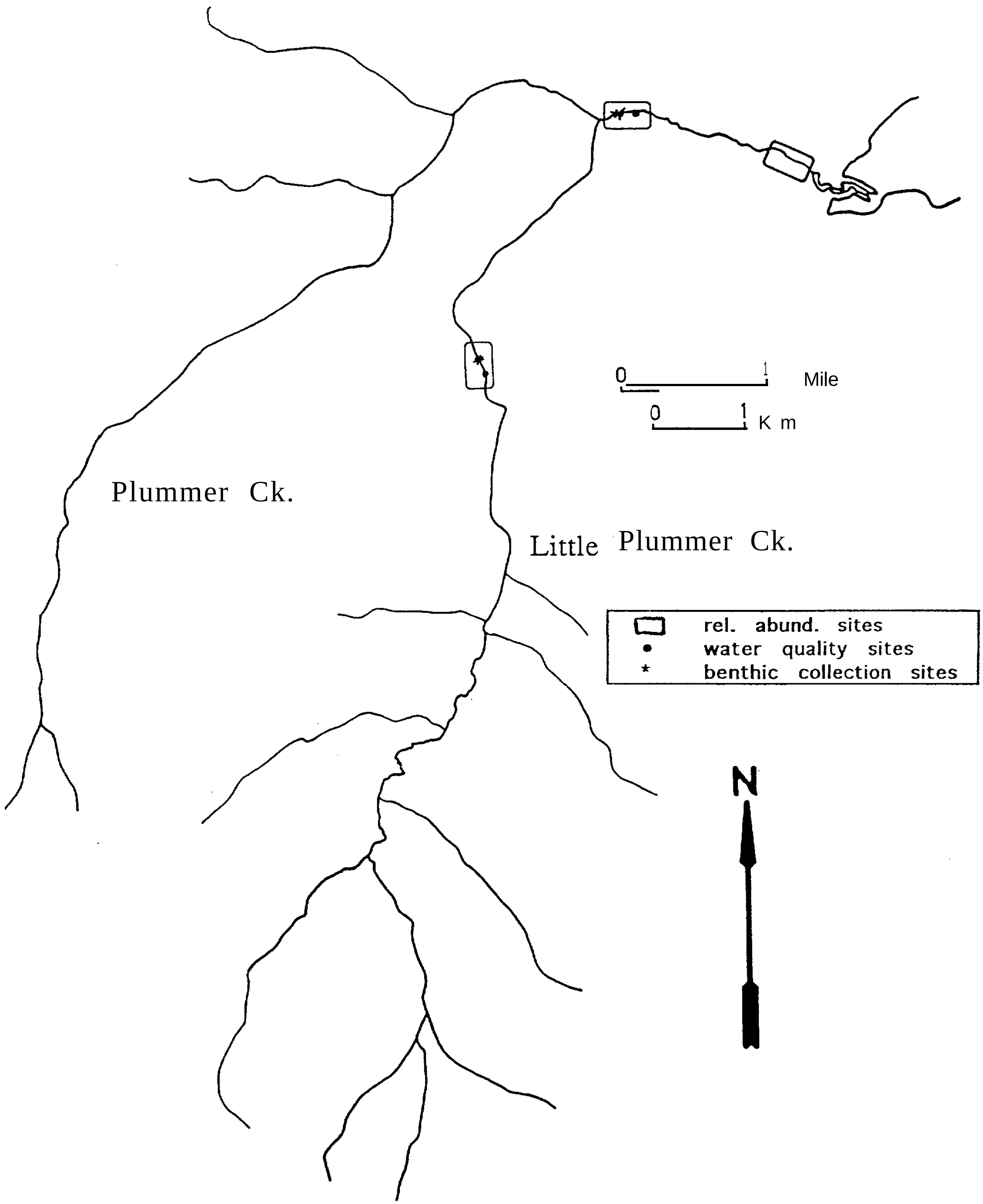

Figure 2.5. **Map of Plummer and Little Plummer creeks showing the locations of the relative abundance, benthic macroinvertebrate and water quality stations.**

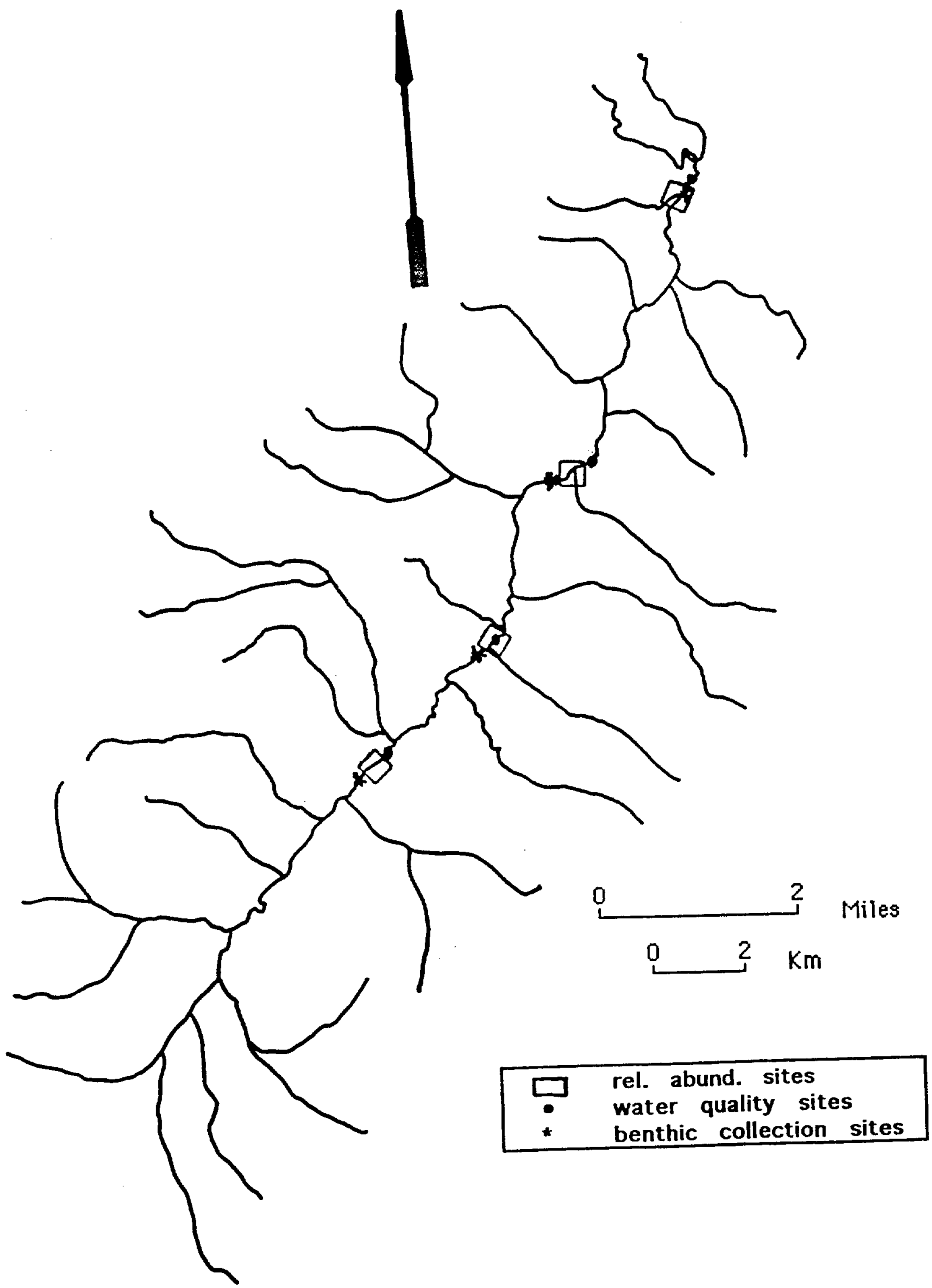

Figure 2.6. **Map of Benewah Creek showing the locations of the relative abudance, benthic macroinvertebrate and water quality stations.**

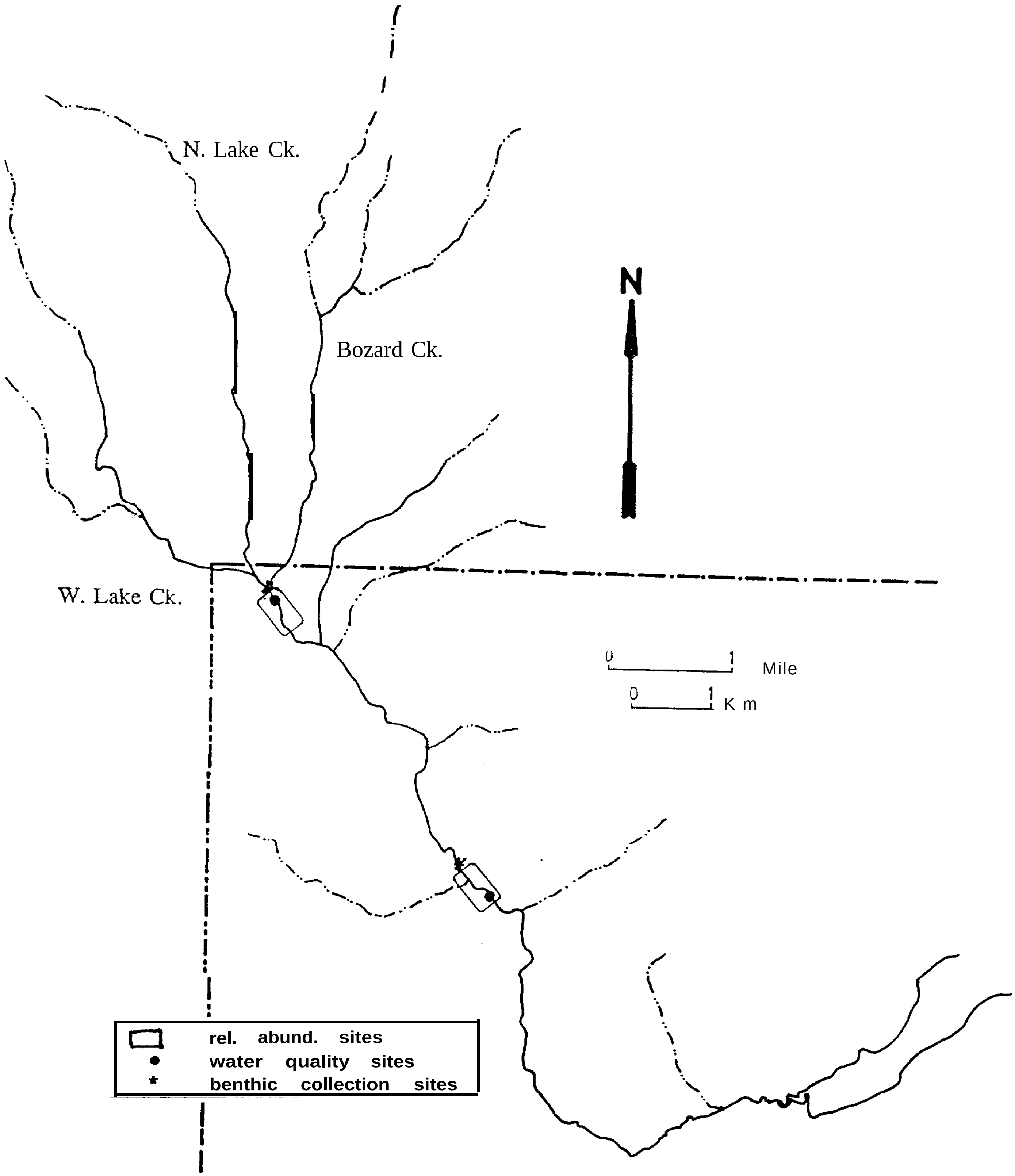

Figure 2.7. Map of Lake Creek showing the locations of the relative abundance, benthic macroinvertebrates and water quality stations.

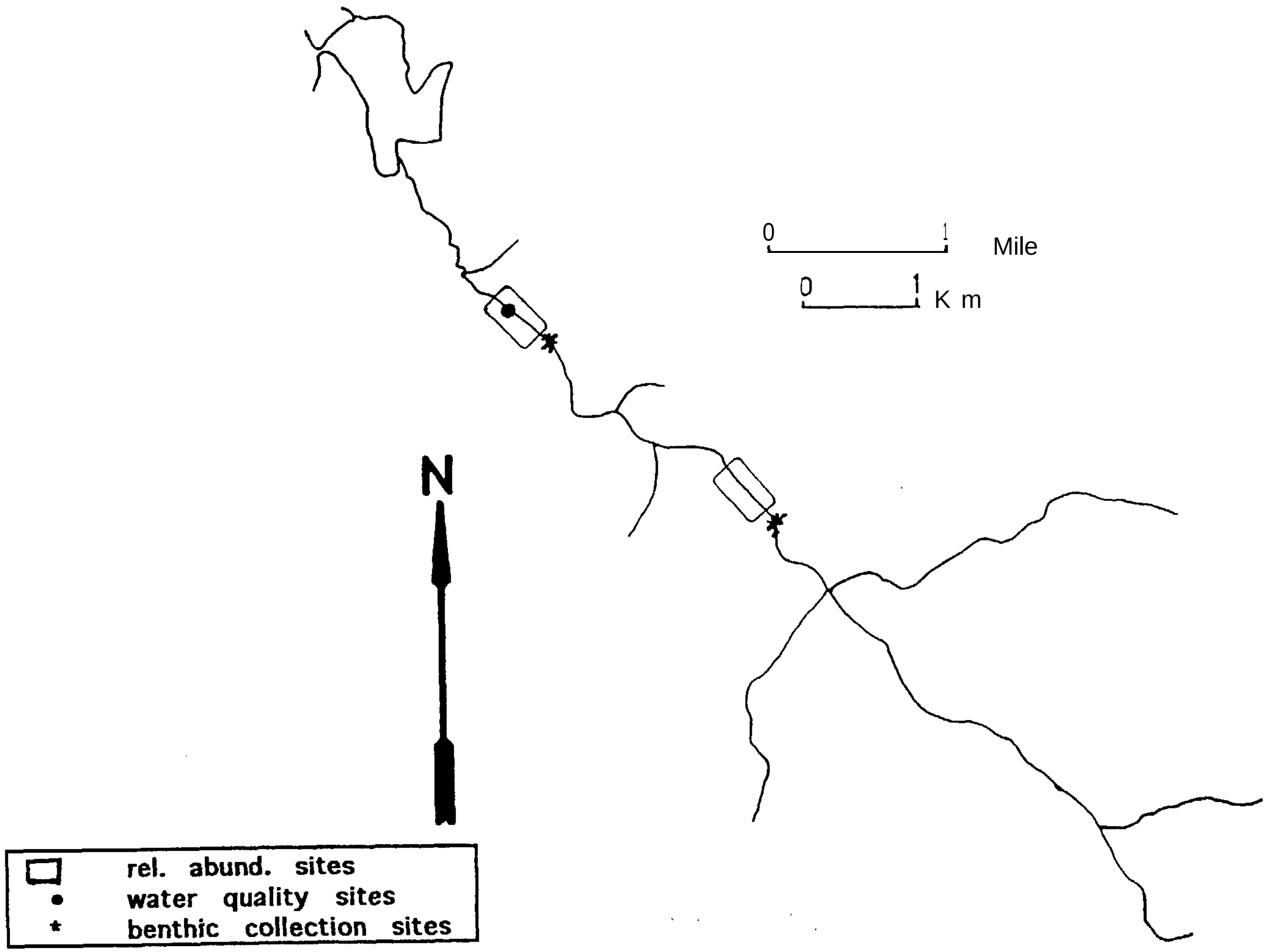

Figure 2.8. Map of Evans Creek showing the locations of the relative abundance, benthic macroinvertebrates and water quality stations.

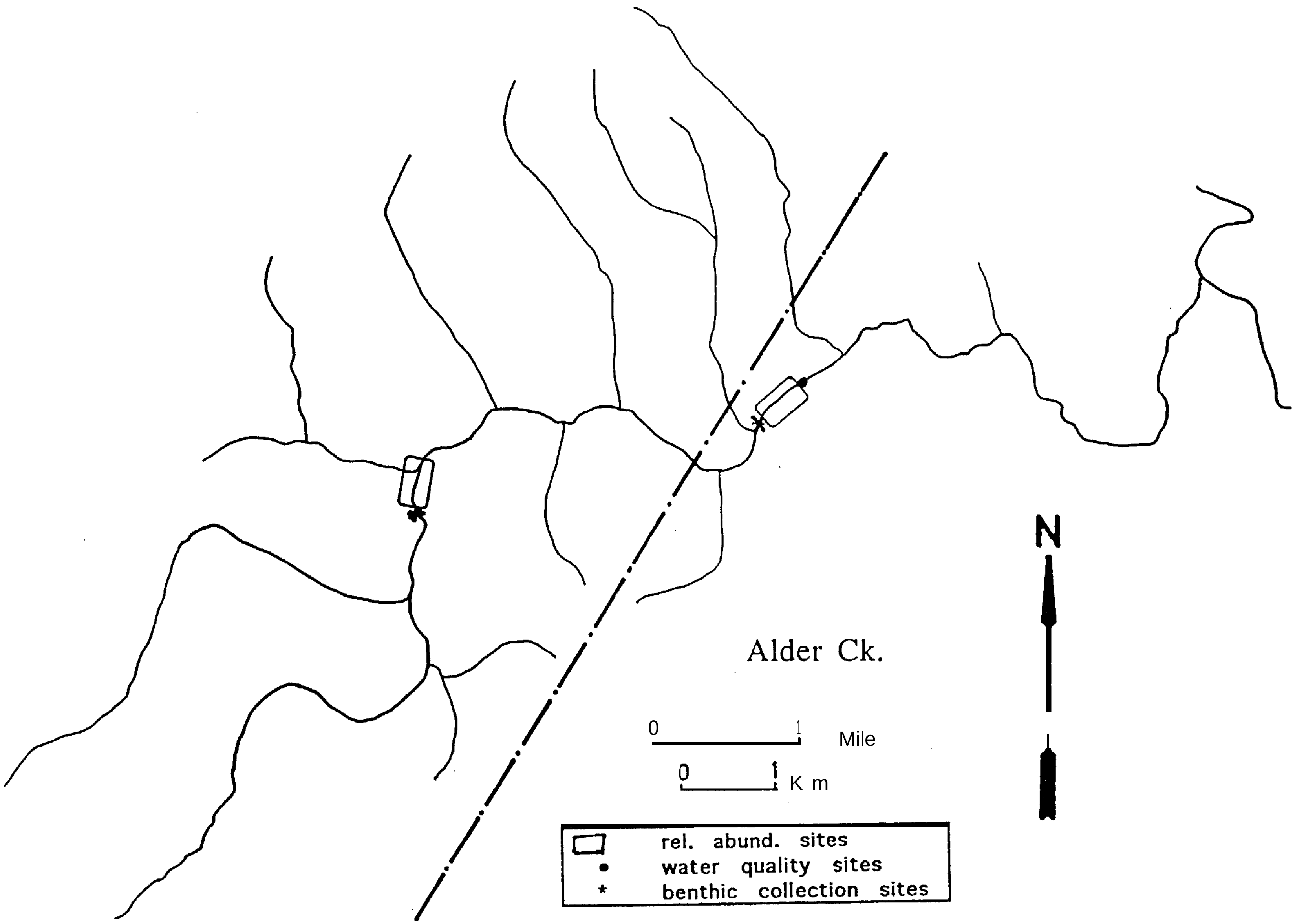

Figure 2.9. Map of Alder Creek showing the locations of the relative abundance, **benthic macroinvertebrates** and water quality stations.

quality parameters were used collectively to measure the variation from an ideal pristine state. Parameter seven was used to estimate a substrate size range that is acceptable for a fish species need.

Seven habitat alteration functions were rated on a scale of zero to one. Habitat alteration functions were intrinsic factors which directly and proportionately affect habitat quality. Each function had the power to reduce habitat quality ratings. These fourteen components (7 parameters and 7 functions) were combined to calculate a habitat quality index. Stream that had HI values between four and seven were considered ideal for enhancement studies, whereas stream reaches with high HI values (i. e. near pristine conditions) did not need enhancement. Streams with low HI values (i.e. severely degraded) were eliminated from further enhancement consideration because cost/benefits were considered prohibitive. The habitat quality index used was:

$$HI = \frac{\sum_{i=1}^{Np}(Pi)}{Np} \times f_1 \times f_2 \times f_3 \times f_4 \times f_5 \times f_6 \times f_7$$

where:	HI	=	Habitat quality index.
	Pi	=	Habitat parameters.
	Np	**=**	The number of parameters used.
	f	=	Habitat functions.

Those values closer to ten were considered more pristine and unaltered, and those closer to one, more altered and degraded.

To assure sampling continuity, habitat quality parameters one through six were estimated by the same field personnel. Parameter seven (substrate suitability) was calculated. Parameters used for this survey are as follows:

<u>Parameter one (Pl) evaluated man-made obstructions.</u> High values were given to those streams that had no manmade obstructions that caused a vertical drop of not more than one foot. Low ratings were given to streams that had one or more structures causing a drop of more than 10 feet during low flows. Rankings were:

P1	Barriers
10	No manmade obstructions to free passage of fish upstream.
8	No dams/structures causing a vertical drop of more than 1 foot during low flow.
5	No dams/structures causing a vertical drop of more than 3 feet during low flow.
3	No dams/structures causing a vertical drop of more than 10 feet during low flow.
0	One or more dams/structures each causing a drop of more than 10 feet during low flow.

Parameter two (P2) estimated the amount of the watershed in urban development. High values were given for a low percent of urban development where as low values were given for a high percentage of urban development. Rankings were:

P2	Urbanization
10	<5% of watershed in urban development.
8	510% of watershed in urban development.
5	1 l-40% of watershed in urban development.
3	4l-70% of watershed in urban development.
0	71-100% of watershed in urban development.

Parameter three (P3) examined the condition of riparian veaetation 50 to 100 feet from each stream bank. High values were assigned to streams that had banks protected by perennial vegetation and excellent canopy cover. Low values were assigned to streams with little perennial riparian vegetation with limited to no canopy cover. Rankings were:

P3	Condition of Riparian Veaetation: (50-100 ft each stream bank)
10	90-100% of banks protected by perennial vegetation with excellent canopy cover.
8	60-89% of banks protected by perennial vegetation with good canopy cover.
5	40-59% of banks protected by perennial vegetation with fair to good canopy cover.
3	10-39% of banks protected by perennial vegetation with limited to fair canopy cover.
0	O-9% of banks protected by perennial vegetation with limited to no canopy cover.

Parameter four (P4) evaluated the condition of the floodplain. High values were given to those streams where little or no evidence of recent active erosion of the floodplain occurred. Low values were assigned to those streams where the floodplain showed signs of severe erosion with a poorly defined stream channel. Rankings were:

P4	Condition of the Floodplain
10	Little or no evidence of active or recent erosion of the floodplain during floods.
7	Some segments show evidence of occasional erosion of the floodplain.
5	All segments show evidence of occasional erosion of the floodplain. Stream channel essentially intact
2	All segments show evidence of erosion of the floodplain. In places the stream channel is poorly defined.
0	Floodplain severely eroded and degraded, stream channel poorly defined with much lateral erosion and much reduced flow capacity.

Parameter five (P5) evaluated the percent of the watershed influenced bv timber or conservation practices. High values were assigned to those streams in which a large percent of the watershed was protected. Low values were assigned to those streams in which a low percentage of the watershed was protected. Rankings were:

P5	Land use of Watershed
10	100% of watershed protected by timber, improved pasture, terraces or other conservation practices.
8	80% protected.
5	50% protected.
3	30% protected.
1	10% protected.

Parameter six (P6) evaluated the percent of the watershed controlled bv irriaation and/or domestic withdrawals. High values were assigned to watersheds with little to no withdrawal, whereas, low values were assigned to watersheds with a high percent controlled by irrigation and/or domestic withdrawals. Rankings were:

P6	Flow Alteration
10	<1% of watershed controlled by irrigation and/or less than 50% of the watershed controlled by domestic withdrawals.
8	l-30% of watershed controlled by irrigations and/or 50-60% of the watershed controlled by domestic withdrawals.
5	30-60% of watershed controlled by irrigation and/or 60-75% of the watershed controlled by domestic withdrawals.
3	60-95% of watershed controlled by irrigation and/or 75-85% of the watershed controlled by domestic withdrawals
0	95-100% of watershed controlled by irrigation and/or greater than 85% of watershed controlled by domestic withdrawal.

Parameter seven (P7) evaluated substrate suitability. **High** values were assigned to those streams with suitable substrates and low values were assigned to those streams that had unsuitable substrate for targeted species of fish. The Wentworth Grade Scale (Table 2.2) was used in classifying sediment sizes. Rankings were:

P_7	Substrate suitability
10	Substrate suitability excellent
7	Substrate suitability acceptable
4	Substrate suitability poor
	Substrate suitability unacceptable

Habitat alteration functions one, two and four through seven were estimated by the same person for continuity. Function number three, water quality, was based on laboratory analysis. The functions evaluated as part of this survey included:

Function one (fl) related channel modification to percent fish reduction. Three types of modifications occurred: (1) Clearing and snagging, which removed instream and bank vegetation; (2) channel realignment, which cut a straight channel and eliminated the old meandering channel, decreasing the streams sinuosity; and (3) channel paving, in which the stream channel is lined with concrete, metal or some other material. Each modification will result in reductions of the fish population. High values were assigned when no channel modification occurred and low values were assigned for greatly modified channels. Rankings were:

f_1	Channel modification
Clearing, Snagging	25% fish reduction
Channel Realignment	80% fish reduction
Channel Paving	(i.e. culverts, 95% fish reduction)
Calculation:	1-(% stream modified X % fish reduction)
	(all %'s expressed as a decimal)

Function two (f2) was evaluated bv examinina stream impoundments. Stream channels that were not impounded had higher values then those streams that were impounded during normal runoff. Rankings were:

Table 2.2. Wentworth grade scale used in classifying sediment sizes (Pettijohn et al. 1973).

Particle name	Size (mm)
Boulder	256
Cobble	64
Pebble	4
Granule	2
Very Coarse Sand	1
Coarse Sand	1/2
Medium Sand	1/4
Fine Sand	1/8
Very Fine Sand	1116
Coarse Silt	1/32

f_2	Impoundment: % degradation 1-(% degradation expressed as a decimal) zero default = 0.01 *i.e* l-l = 0.01
0	Stream not impounded.
30	Stream reach impounded during a 1 in 75 year flood event.
50	Stream reach impounded during a 1 in 50 year flood event.
80	Stream reach impounded during a 1 in 25 year flood event.
100	Stream reach impounded at normal or conservation elevation of impoundment.

Function three (f3) was evaluated on water aualitv. Streams that were considered unpolluted (i. e. below EPA limits) were assigned a higher value than streams that were polluted above EPA standards for the protection of aquatic life (Table 5). Rankings were:

f_3	Water Quality based on EPA criteria
1.0	Stream water unpolluted. No pollutants detected by chemical analysis. Low or no turbidity.
0.8	Occasional above normal levels of one or two water quality constituents usually present, but detectable only by analysis.
0.5	Occasional visible signs of over supply of nutrients very noticeable turbidity.
0.1	Grossly polluted waters for majority of Parameters.

Function four (f4) was evaluated on the amount of unstable material (silt. sand and gravel) that was transported into and throuah an area. High values were given for low to no fine transported material. Low values were given to streams that had great amounts of unconsolidated transported material. Rankings were:

f_4	Streambed Condition
1.0	No apparent unstable material in channel with substrate of bedrock, boulders, rubble, gravel or firm alluvium.
0.9	Traces of unstable silt, sand, or gravel in quiet areas, pools large with firm substrate.
0.8	Quiet areas covered by unstable materials, deep pools restricted to areas with greatest scour.
0.7	Pools shallow, filled with silt, sand or gravel, riffles contain noticeable silt deposits.
0.5	Streambed completely covered by varying thicknesses of transported material such as silt, sand, and gravel.
0.1	Stream channel nearly or completely filled with unconsolidated, transported material; no surface flow except during floods.

Function five (f5) was evaluated on the stream's base flow. High values were given to perrianal streams with water velocities conducive to fish passage. Low values were given to intermittent streams or streams that had water velocities in excess of 6 ft per second and above, which prevented fish passage (Bell 1986). Rankings were:

f_5	Flows necessarv for passage
1.0	Flow Year around: No passage problems: Water velocity not to high to prevent passage below 6 ft/sec.
0.75	Flow year around: Minor passage problems due to low or high flows.
0.5	Channel drys up in late summer resulting in significant fish passage problems.
0.25	Channel drys up in late spring preventing fish passage; or water velocity too high for most fish passage.
0.01	Channel drys up in early spring; or water velocity to high for fish passage.

Function six (f6) was evaluated based on hiqh water temoeratures. Streams with water temperatures below 14^{o} C in summer were ranked higher then streams with water temperatures above 20^{o} C. Rankings were:

f_6	Water temperature
1.0	Average maximum water temperatures below 14^{o} C in summer.
0.75	Average maximum water temperatures of 15^{o} C in summer.
0.5	Average maximum water temperatures of 17^{o} C in summer.
0.25	Average maximum water temperatures of 19^{o} C in summer.
0.01	Average maximum water temperatures above 20^{o} C in summer.

Function seven (f7) was evaluated based on habitat suitability for all life staaes of cutthroat and bull trout. This was based on the estimated amount of habitat available for each life stage. Suitable cutthroat and bull trout habitat was based on literature review as described in Graves et al (1990). High values are given for good habitat for all life stages, while low values are given for poor habitat for one or more life stages. Rankings were:

f_7	Habitat suitabilitv for all life staaes
1	Good habitat for all life stages.
0.6	Poor habitat found for one life stage, limited for other stages, or limited for all life stages.
0.1	Poor habitat found for more than one life stage.

2.2.2. Cursory stream surveys

Ground surveys were initiated in April, 1991 to collect physical information that was used as input data for the above index model. Two field personnel began sampling from the mouth of a stream and continued to move in an upstream direction. Sampling stopped at a point upstream where the stream became too small to contain any trout habitat. Field personnel marked on USGS 7.5 minute topographic maps locations, amounts, and condition of the following physical information:

1.) Lenath of suitable fish habitat
2.) Passaae barriers
3.) Urban development of watershed
4.) Condition of rioarian veaetation
5.) Condition of the floodplain
6.) Land use of watershed
7.) Flow alteration
8.) Channel modification
9.) Imooundments
10.) Streambed condition
11.) Habitat suitability for all life Stages

2.2.3. Stream discharge measurements

Stream discharge was measured monthly using a Price pigmy current meter in conjunction with a top setting wading rod following the methods of Buchanan and Somers (1980). Stream widths were measured and divided into at least 10 equal segments. Velocities were then measured at each cell at two thirds of total depth. Discharge was calculated by the following formula:

$$Q = \sum_{i=1}^{n}\left(\frac{W_{i+1}-W_{i-1}}{2}\right)d_i\left(\frac{V_{i1}+V_{i2}}{2}\right)$$

where:

Q = Total discharge
n = Total number of individual sections
w_i = Horizontal distance from the initial point
di = Water depths for each section, and

v_i = Measured velocity for each section.

The estimated maximum spring runoff velocity was then calculated using the Manning Equation (Brooks et *al.* 1991) to determine the validity of function five (f5) in the above habitat quality index. The following formula was used:

$$V = \frac{1.49}{n} Rh^{2/3} S^{1/2}$$

where:

v = The average velocity in the stream cross section (ft/sec).

n = Roughness coefficient as read from Table 3 page Brooks *et al.* (1991).

s = Energy slope as approximated by the down gradient water suface slope (ft/ft).

Rh = Hydraulic radius based on the following formula:

$$Rh = \frac{A}{WP}$$

Where:

A = The cross-sectional area of flow (ft^2), and

WP = Wetted perimeter (ft).

2.2.4. Water quality analysis

Water samples were collected seasonally to determine water quality. Tests for conductivity, dissolved oxygen, pH and temperature were conducted in the field using a Surveyor model two Hydrolab. Water samples were also collected for laboratory analysis of nitrate, nitrite, phosphates, and alkalinity using a LaMotte Chemical calorimetric test kit. Total dissolved solids were determined using a HANNA model 0661-l 0 dissolved solids tester. Total suspended solids were determined using the methods reported in Standard Methods For the Examination of Water and Waste Water (APAH 1985).

2.2.5. Substrate analysis

Substrate samples were collected in segments of each creek that showed potential spawning sites for cutthroat and bull trout to determine the amount of sediment deposition and to evaluate fry production. A freeze core sample was used following procedures described by Walkotten (1976). Samples were placed in bags and transported to the laboratory for analysis. After drying, each sample was sorted into categories using a series of 13 sieves.

Material retained on each sieve was weighed and the percent dry weight in each size class was calculated (Driscoll, 1986). The data was then used to estimate the quality of the sampled substrate for trout reproduction. A spawning substrate quality index developed by Lotspeich and Everest (1981) which overcomes limitation of other indices have been used to assess substrate quality (Platts *et a/* 1979). The procedure uses a measure of the central tendency of the distribution of the sediment particle sizes in a sample and the dispersion of particles in relation to the central value to characterize the suitability of the substrate for salmonid spawning, incubation and emergence. These two parameters were combined to develop a “Fredle index” (f) of substrate quality according to Platts *et a/* (1983). The formula used was;

$$fe = \frac{d_g}{S_o}$$

where:

fe = Fredle index

S_o = Sorting coefficient,

d_g = Mean grain size based on the following formula:

$$dg = (d_1^{w1} \times d_2^{w2} \times \ldots dnwn)$$

where;

dg = mean grain size

dn = the diameter at selected weights

w = weight at a selected diameter

so = Sorting coefficient based on the following formula,

$$So = \frac{d_{75}}{d_{25}}$$

where:

d_{75}, d_{25} = particle size diameters at which either 75 or 25 percent of the sample is finer on a weight basis.

This index will give an indication of sediment permeability and pore size which are the two most influential factors governing salmonid embryo survival-to-emergence (Platts et a/,1 983). With this index, substrate quality can be compared before and after habitat improvements are made. Values for substrate suitability range from O-10. Values ranging from four or less are poor substrate suitability, while values between seven and ten are acceptable to excellent substrate values.

2.3. FISHERIES SURVEYS

2.3.1. Relative abundance

Fish relative abundance was determined by electrofishing using a Smith-Root Type VII pulsed-DC backpack electrofisher. Tributaries were sampled five days in June and August and six days in October. Tributaries were divided into lower, middle and upper sections to represent the longitudinal variation in habitat. In June, three concurrent three hundred foot sections were selected within each reach. In August and October two or three two hundred foot sections were electrofished within each reach depending on the length of the reach. Each section was electrofished using the standard guidelines and procedures described by Reynolds (1983). Fish captured were identified, enumerated, and measured to the nearest millimeter. A scale sample was removed from all salmonid species for age and growth determination.

2.3.2. Population estimates

Cutthroat and bull trout populations were estimated in tributaries streams in October, 1991 using the removal-depletion method (Seber and LeCren 1967, Zippen 1958).

The streams were divided into lower, middle and upper section. Four to six, two-hundred foot sections were randomly selected, depending on the length of the stream, to represent the longitudinal variation in habitat of each tributary. Blocknets were placed at the upstream and downstream boundaries to prevent immigration and emigration. Each section was electrofished using the standard guidelines and procedures described by Reynolds (1983). Fish were collected by using a Smith-Root Type VII pulsed-DC backpack electrofisher. A minimum of two electrofishing passes were made for each two hundrend foot section. Fish captured in the first pass were held in buckets until the second pass was made. Captured fish were identified, enumerated, measured to the nearest millimeter and some were tagged with a Floy FD-6B numbered anchor tag. Scales were removed and a weight measurement was taken from a representative group of each target species for age and growth determination.

For each reach in which two passes were made, the population was estimated using the following equation of Seber and LeCren (1967):

$$N = \frac{(U_1)}{(U_1 - U_2)},$$

Where: N = estimated population size;
U_1 = number of fish collected in the first pass; and,
U_2 = number of fish collected in the second pass

The standard error of the estimate was calculated by:

$$S.E.(N) = \sqrt{\frac{(U_1)^2 (U_2)^2 T}{(U_1 - U_2)}}$$

where: $S.E.(N)$ = standard error of the population estimates; and

T = total number of fish collected $(U_1 + U_2)$

When three or more passes were made in the section, the population was estimated using the methods of (Zippin 1958). The first number needed was calculated where:

$$T = \sum_{i=1}^{n}(U_i),$$

where: T = total number of fish collected
U_i = number of fish collected in the ith removal; and
n = the number of removals

The ratio (R) was then calculated using the equation:

$$R = \frac{\sum_{i=1}^{n}(i-1)U_i}{T}$$

The population estimate (N) was then calculated using the equation:

$$N = \frac{T}{Q}$$

where: Q = the proportion of fish captured during all passes. Q was located by using the ratio (R) on the curve found in Fig. 22 of Platts et al. (1983).

The standard error of the estimate was calculated by:

$$S.E.(N) = \sqrt{\frac{N(N-T)}{T^2 - N(N-T)\frac{(kP)^2}{(1-p)}}}$$

where: P = The estimated probability of capture during a single removal and is found using the ratio (R) on the curve found in Fig. 23 of Platts *et al.* (1983).

The 95 percent confidence intervals were placed around the estimate by multiplying the standard error by 1.96.

2.3.3. Age, growth and condition

Scale samples were collected by following methods of Jearld (1983). In the laboratory, several scales were mounted between two glass microscope slides and viewed using a Realist, Inc., Vantage 5 microfiche reader. The age was determined by counting the number of annulli (Lux 1971, Jearld 1983). Simultaneous to age determination, measurements were made from the center of the focus to the furthest edge of the scale. Along this line, measurements were made to each annulus. The measurements were made to the nearest millimeter under a constant magnification. Annual growth was then back-calculated using the Lee method as described by Carlander (1981). This method involved the use of the formula:

$$L_i = a + \left(\frac{(L_c - a)}{S_c}\right) S_i,$$

where: Li = Length of fish (in mm) at each annulus;
a = intercept of the body scale regression line;
Lc = length of fish (in mm) at time of capture;
SC = distance (in mm) from the focus to the edge of the scale; and
Si = scale measurement to each annulus.

The intercept (a) was obtained from the regression analysis of body length -v- scale length at time of capture. The number of fish in each age class were equalized before the regression analysis of the body length-scale length was conducted. This was accomplished by randomly selecting an equal number of fish from each age class. If an age class was represented by only a few fish then all were used. It was felt that this method yielded a more reliable intercept value since the regression line was not biased by strong year classes. The regression analysis was accomplished using StatView 512+ on a Macintosh SE computer.

The proportional method of back-calculation was used for some species when small sample sizes led to poor regressions. The following equation was used:

$$Li=\frac{Si}{Sc}Lc$$

This formula does not take into account the size of fish at scale formation as does the Lee method.

Condition factors were computed as an indicator of the fishes growth pattern and, therefor, an indication of its general condition (Everhart and Youngs 1981). The formula to calculate the condition factor is:

$$K_{tl}=\left(\frac{W}{L^3}\right)10^5$$

Where: K_{tl} = condition factor;
w = weight of fish in grams; and
L = total length of fish in millimeters.

Comparisons were made to condition factors in other streams in the Pacific Northwest.

2.3.4. Creel survey

The Coeur d'Alene creel survey was designed to:

1. Estimate total angler effort (pressure) in selected tributaries.
2. Determine catch-per-unit effort (CPUE) in selected tributaries.
3. Estimate the annual harvest (catch) for each species in selected tributaries.
4. Determine mean size, weight, and biomass of fish caught by anglers.

The study section was divided into three main areas. The sections included all those tributaries located in the northeast, southeast and northwest sections. The days in the month were divided into weekdays and weekend days (including holidays). The day was then divided into two time periods, AM and PM. The AM time period went from sunrise to 1 PM. The PM time period went from 1 PM to sunset.

During each AM and PM creel period, two randomly timed progressive angler pressure counts were conducted. These pressure counts were made by automobile with the direction of travel randomly selected. Creel clerks began at one of a section and worked either north or south until all tributaries had been surveyed. The number of anglers within the section was recorded. As the season progressed and tributaries went dry the four selected tributaries were targeted more heavily. Only occasionally progressive angler counts were conducted on all selected creel locations.

Angler interviews were conducted to obtain information about the number of anglers, the total number of hours fished, the species of preference, and the number of each species caught and kept or released.

Creel clerks examined all fish (if possible) caught by surveyed anglers, to obtain the species, length, weight, sex, and removed a scale sample for age determination.

Pressure was estimated monthly for each tributary, day type, and time period (stratum) by the formula:

$$PE_s = \left(\frac{N_s}{n}\right)(X_s)\ (H_a)$$

Where:

PE_s = pressure estimate for each stratum per month:

N_s = number of hours within each stratum per month;

$$N_s = (D_s)(H_d)$$

Where:

N_s = number of hours for each stratum per month:

D_s = number of days per month within the stratum; and

H_d = average number of hours per day for each stratum per month.*

n = number of hours sampled for each stratum per month;

X_s = mean number of anglers for each creek per month;

$$X_s=(X_d)(D_s)$$

Where:

X_s = mean number of anglers for each stratum per month;

X_d = mean number of anglers for each stratum per day; and

D_s = number of days per month within the time period.

and ,

Ha = mean number of angler hours per angler for each creek per month.

$$Ha = \left(\frac{T_h}{A_i}\right)$$

Where:

Ha = mean number of angler hours per angler for each stratum per month;

T_h = total hours spent fishing for each stratum per month; and

A_i = total number of anglers interviewed for each stratum per month.

The variance of the pressure estimate for each stratum per month was calculated by:

$$VPE_s = \left(\frac{N_s}{n}\right)S_s^2$$

where:

VPE_S = variance of pressure estimate for each stratum per month;

N_S = number of hours for each stratum per month;

n = number of hours sampled for each stratum per month; and

S_S = standard deviation of mean number of angler hours for each stratum per month.

Ninety-five percent confidence intervals for each stratum per month were calculated by:

$$C.I. = PE \pm \sqrt{VPE_S} \times 1.96$$

where: C.I. = 95% confidence intervals for each stratum per month;

PE = pressure estimate for each stratum per month; and

VPE_S = variance of the pressure estimate for each stratum per month.

Monthly angler pressure and 95% confidence intervals were calculated by summing the four stratum values for angler pressure and summing the 95% confidence intervals.

Catch per unit effort (CPUE) was calculated for each species of fish caught, whether the fish was kept or released, and for each species of fish caught and kept. CPUE was calculated for individual tributaries by dividing the number of fish caught by the number of hours spent fishing by interviewed anglers at that tributary.

Harvest of fish species was estimated by multiplying the CPUE times the pressure estimate.

2.4. MACROINVERTEBRATE SURVEYS

2.4.1. Benthic macroinvertebrates

Benthic macroinvertebrate densities were collected using the methods of Waters and Knapp (1961). A modified hess sampler, with an area of 0.1 m^2, and a net aperture of 390 µm, was pushed approximately 10 cm into the substrate at three sites across the width of the stream. Stones found in the area were removed and cleaned of all attached material. The substrate was then disturbed by stirring to obtain any remaining macroinvertebrates. The sample was then preserved in 10 percent formalin.and transferred to a 70% alcohol solution in the lab. Samples were collected in the same areas as the fish collections for feeding habits studies during all three sampling months.

2.4.2. Drift macroinvertebrates

Two drift samples were collected upstream from fish electroshocking areas in each tributary during each sampling month. Water depth was measured using a wading rod, while velocity measurements were measured directly in front of the sampler at 0.6 of the water depth, using a Price Pygmy current meter (Buchanan and Somers,1980). These measurements allowed for the calculation of densities of organisms per volume of water passing through the drift. All samples were preserved in the field using 10 percent formalin and transferred to a 70% alcohol solution in the lab.

2.4.3. Shannon-Weiner diversity index

To determine if a stream was healthy or unhealthy the Shannon-Weiner diversity index was used (Perkins 1982). With this method the number of species as well as the number of individuals within each species are taken into account (Krebs 1985). The lowest value would be obtained when only one species is represented in a stream. The highest value would be obtained when each species is represented by equal numbers of individuals.
This equation was:

$$H = -\sum_{i=1}^{s}(p_i)(\log_2 p_i),$$

where: H = Index of species diversity;
S = Number of species; and
p_i = Proportion of total sample belonging to the ith species.

Values above three represent high diversity and normally indicates a healthy unpolluted community. A low diversity of less than two usually indicates an unhealthy and possibly polluted community (Herricks and Cairns 1974). Densities and diversities were then compared to other area streams.

3.0 RESULTS

3.1. HABITAT EVALUATION

3.1.1. Habitat Quality Indices based on ground surveys

Habitat quality index values range from 0 to 10. Index values of O-3 are regarded as severely degraded tributaries, while values of 3-7 are regarded as moderately degraded but enhancable. Values of 7 and above are good to pristine and require little to no en hancement work.

Habitat quality index values ranged from 0.02 for Bellgrove Creek to 5.52 for Alder Creek (Table 3.1). Values for Bellgrove, Hells Gulch, Squaw, Fighting, Plummer and Little Plummer creeks were all below one. Benewah, Lake, Evans and Alder creeks had index values ranging from 3.04 for Benewah Creek to 5.52 for Alder Creek. For a complete explanation of individual parameter and function descriptions and values for each tributary see Appendix A.

The index value for Bellgrove Creek was the lowest of all habitat index values at (0.02). Factors that contributed to this HI value include one large obstruction, degraded riparian zones, erosion of the stream channel banks, poor land use practices, and unacceptable substrate suitability. Other factors include minor channel modifications, high turbidity, and a high percent of silt. Low base flow in the summer along with high water temperatures contribute to poor habitat for all life stages and a low index value.

A habitat index value of 0.19 was calculated for Fighting Creek. Reasons for this low HI value were; a large concrete bridge which resulted in a passage barrier; channel erosion; degraded riparian zones and poor land use in 40 percent of the watershed and unacceptable substrate suitability. Heavy silt loads, low base flow in the late summer, high water temperatures and limited habitat for all life stages also influenced the habitat index value.

An index value of 0.05 was calculated for Hell's Gulch. Factors that contributed to this value were passage barriers in the form of two culverts; one at the mouth and, another one mile upstream. Poor substrate suitability, channel realignments, midstream impoundments during a 1 in 50 year flood event, low base flow in

Table 3.1. Habitat quality index values for tributaries located within the Coeur d'Alene Indian Reservation.

Stream name	H.I. value	Reason
Bellgrove Creek	0.02	barrier, degraded riparian zones, channel erosion, land use practices, unsuitable substrate, water quality,high H20 temp., overall poor habitat for all life stages.
Fighting Creek	0.19	Barrier, degraded riparian area, channel erosion, land use, unsuitable substrate, heavy silt loads, low base flow, high H20 temp., limited habitat for all life stages.
Hell's Gulch Creek	0.05	culverts, unsuitable substrate, channel realignment, flow alterations, intermittent conditions, high H20 temp. and poor habitat for all life stages
Squaw Cree	0.08	erosion, land use, unsuitable substrate, ow base flow, poor habitat for ll life stages.
Plummer Creek	0.42	Channel erosion, land use, unsuitable substrate, heavy silt loads, low base flow, high H_20 temp poor adult habitat and limited habitat for other life stages.
L. Plummer Creek	0.71	Culverts, degraded riparian zones, channel erosion, land use, unsuitable substrate, high silt loads, passage problems, high h20 temp., no adult habitat and limited habitat for other life stages.
Benewah Creek	3.04	Degraded riparian zones, channel erosion, land use, minor passage problems and high H_20 temp.
Lake Creek	3.12	Land use, unsuitable substrate, water quality problems, high silt loads and high water temp.
Evans Creek	4.93	Degraded riparian zones, channel erosion, land use, high turbidity
Aider Creek	5.52	Bank stability, land use, high water temp.

late spring, and high water temperatures contribute to poor habitat for all life stages and a low index value.

Squaw Creek received an HI value of 0.08. Parameters that contributed to this value were; occasional erosion of the stream channel; poor land use in 30 percent of the watershed and poor to unacceptable substrate suitability . Low base flow in the early spring and poor habitat for all life stages resulted in a low habitat index value for Squaw Creek.

Plummer Creek received a habitat index value of 0.42. Contributing factors included channel erosion, poor land use in 50 percent of the watershed and unacceptable substrate suitability. Other factors included high siltation rates in the headwaters, low base flow in early summer, high water temperatures and poor habitat for adults and limited habitat for other life stages.

Little Plummer Creek had a habitat index value of 0.71. Parameters that contributed to this HI value were; one large obstruction, degraded riparian zones in 50 percent of the watershed, occasional stream channel erosion, poor land use in 30 percent of the watershed, and poor to unacceptable substrate suitability. Other factors for the habitat index value include high silt concentrations in quiet areas of the stream, low base flow causing passage problems, high water temperatures and poor habitat for adults and limited habitat for other life stages.

A habitat index value of 3.04 was calculated for Benewah Creek. Degraded riparian zones in 40 percent of the watershed, occasional channel erosion, poor land use in 40 percent of the watershed all contributed to the habitat index value. Other factors included minor passage problems due to low base flow and seasonally high water temperatures.

Lake Creek received an index value of 3.12. Parameters that contributed to this value were; poor land use in 40 percent of the watershed, and poor to unacceptable substrate. Other factors included high turbidity, low pH , high silt percentages in sections of the stream, and and high water temperatures.

A habitat quality index value for Evans Creek was calculated at 4.93. Parameters that contributed to this HI value were; degraded riparian zones along 50 percent of the stream, stream channel erosion in the lower segment, poor land use practices in 50 percent of the watershed, and site-specific substrate problems. Other factors included high turbidity during runoff events, and minor traces of silt in the stream bed.

Alder Creek had the highest habitat index value at 5.52. Minor problems in the upper stream drainage were encountered because of stream bank protection and land use practices. Higher than desirable water temperatures were also observed.

3.1.2. Stream discharge measurements

Discharge measurements were collected monthly from May, 1991 to October, 1991. Measurements were made the last week of the month for all months. Monthly discharge measurements for each creek are found in Table 3.2. May discharge measurements ranged from .36 cfs for Squaw Creek to 61.28 cfs for Benewah Creek. June discharge measurements ranged from 2.91 cfs for Hell's Gulch to 12.75 cfs for Alder Creek. Squaw Creek was intermittent by June and no discharge measurement could be made. Plummer Creek had the least discharge measurement for July at 1.72 cfs, while Evans Creek had the most discharge at 7.33 cfs. In August Fighting/Bellgrove Plummer, Little Plummer and Hell's Gulch were intermittent therefore, no discharge measurements were made. Evans Creek had the highest discharge measurement in August at 3.28 cfs, while Benewah Creek had the lowest measurable discharge at 1.88 cfs. In September, Benewah had the highest discharge measurement at 3.66 cfs, followed by Lake Creek at 3.38 cfs. In October, Benewah also had the highest discharge measurement at 4.30 cfs, followed by Evans at 3.50 cfs. Figure 3.1 and 3.2 shows the monthly discharge profiles for all tributaries.

3.1.3. Water quality analysis

Water quality data was collected seasonally in May, August and October. Temperature profiles were collected monthly from May to October. Spring water quality parameters (ppm) for alkalinity ranged from 10 ppm to 80 ppm for Alder and Plummer creeks respectively. Nitrite values ranged from 0.00 ppm for Hell's Gulch to .06 ppm for Squaw Creek. Nitrate values ranged from 0.00 ppm for Fighting/Bellgrove, Lake, Benewah and Alder creeks, to 0.13 ppm for Plummer and Evans creeks. Phosphate values ranged from 0.00 ppm

Table 3.2. Monthly discharge measurements in cubic feet per second (cfs) for selected Coeur d'Alene tributaries.

Stream	Discharge (cfs)					
	May	June	July	August	September	October
Fighting/Bellgrove	11.58	6.82	2.09	*	*	*
Hell's Gulch	51.27	2.91	3.06	*	*	*
Squaw	0.36	*	*	*	*	*
Mainstem Plummer	20.32	4.66	3.11	*	*	*
Little Plummer	16.09	4.50	1.72	*	*	*
Benewah	61.28	7.19	6.73	1.88	3.66	4.30
Lake	27.87	11.09	5.69	1.9	3.38	2.37
Evans	48.96	9.22	7.33	3.28	1.89	3.50
Alder	35.82	12.75	4.37	3.0	1.85	1.48

* intermittent conditions existed therefore, no samples were collected.

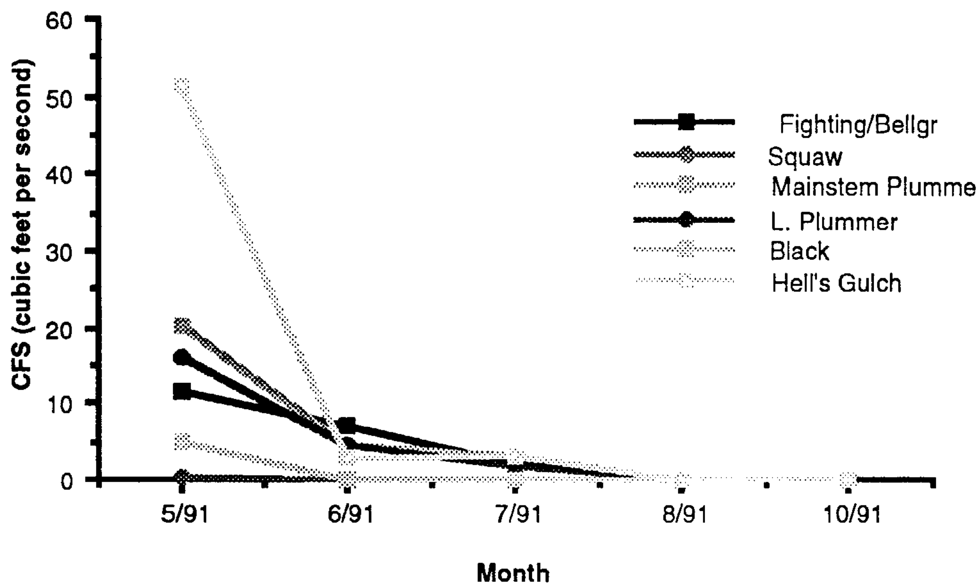

Figure 3.1 **Monthly discharge profiles for non-primary tribuataries located on the Coeur d'Alene Indian reservation during 1991.**

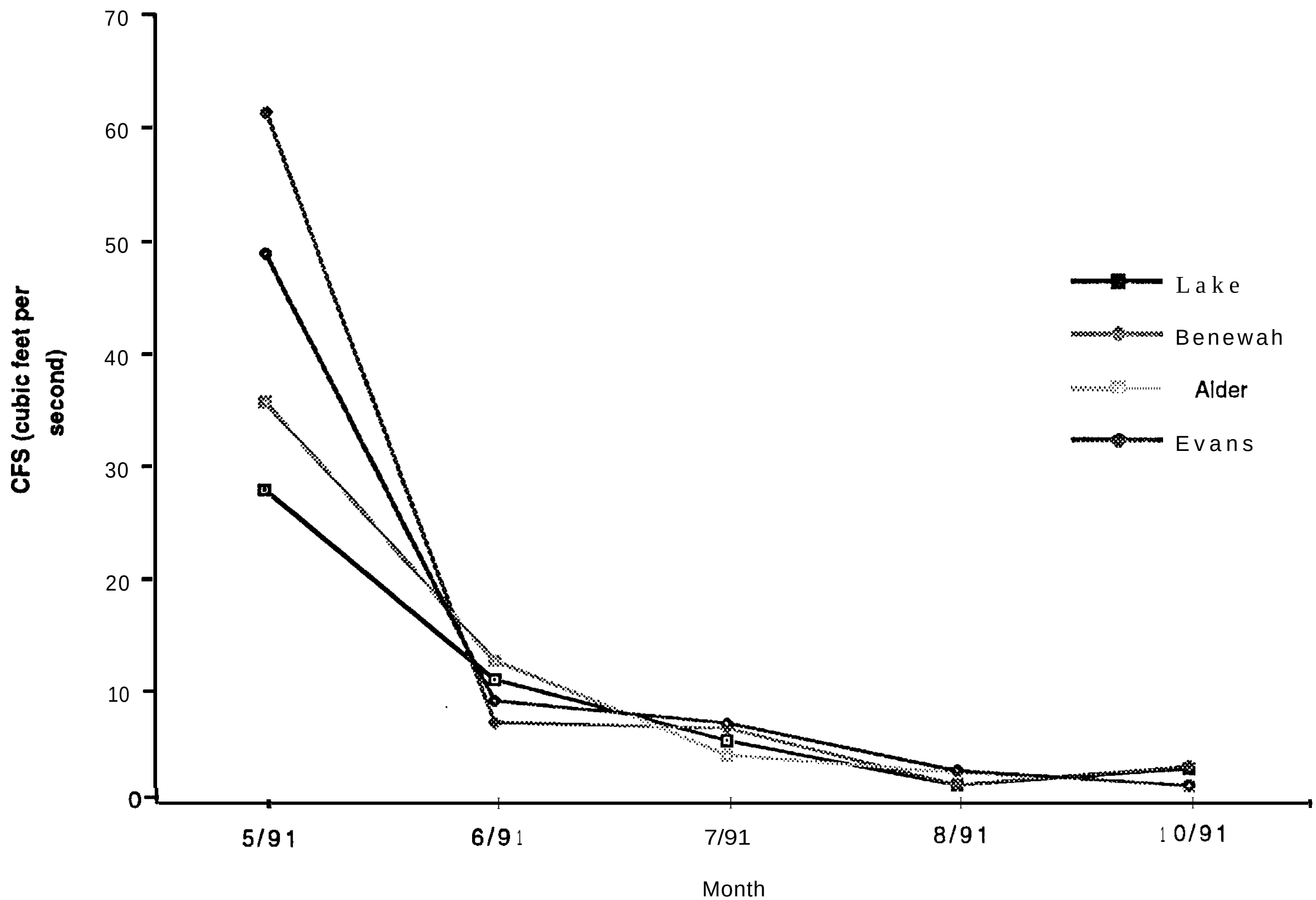

Figure 3.2 Monthly discharge profiles for primary tributaries located on the Coeur d'Alene Indian Reservation during 1992

for Lake Creek to 1.24 ppm for L. Plummer Creek. Total dissolved solids were below 10 ppm for all tributaries sampled (Table 3.3). Conductivity values ranged from .005 µmhos for Fighting/Bellgrove Creek to .058 µmhos for L. Plummer. PH values ranged from 4.8 for Lake Creek to 8.5 for Evans Creek. Dissolved oxygen values ranged from 6.5 mg/l for Lake Creek to 14.2 mg/l for Benewah Creek (Table 3.4).

Summer water quality values for alkalinity ranged from 20 ppm for Hell's Gulch to 60 ppm for Plummer and Alder creeks. Nitrite values ranged from .OO ppm for Plummer, Hell's Gulch and Evans creeks, to .10 for L. Plummer Creek. Nitrate values were 0.00 ppm for all tributaries sampled. Phosphate values ranged 0.00 for Evans Creek to 1.11 ppm. Total dissolved solids for all tributaries was below 10 ppm (Table 3.3). Conductivity values ranged from .004 µmhos for Plummer Creek to .032 µmhos for L. Plummer Creek. PH values ranged from 6.2 for Lake Creek to 7.4 for Evans Creek. Dissolved oxygen values ranged from 4.6 mg/l for Fighting/Bellgrove to 16.8 for L. Plummer Creek (Table 3.4).

Fall water quality values for alkalinity ranged from 30 ppm for Evans Creek to 50 ppm for Lake, Benewah and Alder creeks. Nitrite values ranged from 0.0 for Lake and Benewah creeks to 0.03 ppm for Alder Creek. Nitrate values ranged from 0.00 for Alder, Evans, and Benewah creeks to 0.09 ppm for Lake Creek. Phosphate values ranged from 0.00 ppm for Evans and Alder creeks to 0.07 ppm for Benewah Creek. Total dissolved solids for all sampled tributaries were below 10 ppm (Table 3.3). Conductivity values ranged from .034 µmhos for Evans Creek to .089 µmhos for Alder Creek. PH values ranged from 7.0 for Lake Creek to 8.0 for Benewah Creek. Dissolved oxygen values ranged from 11.8 mg/l for Lake Creek to 14.9 mg/l for Benewah and Evans creeks (Table 3.4).

Monthly temperature profiles are provided in Table 3.5. Temperatures in May ranged from 8° C for L. Plummer Creek to 12° C for Squaw Creek. June temperatures ranged from 7°C for Evans Creek to 21 .1°C for Lake Creek. July temperatures ranged from 12.2°C for Evans Creek to 18.8°C for Plummer Creek. Temperatures in August ranged from 13°C for Evans Creek to 20.9°C for Lake Creek. September temperature ranges were between 15°C for Evans Creek to 24°C for Benewah Creek. October temperature ranges were between 0.3°C for Lake Creek to 2.1°C for Evans Creek.

Table 3.3. Seasonal water quality parameters in parts per million (ppm) for selected Coeur d'Alene tributaries.

	SPRING					SUMMER					FALL				
	Alk.	NO_2	NO_3	PO_4	TDS	Alk.	NO_2	NO_3	PO_4	TDS	Alk.	NO_2	NO_3	PO_4	TDS
M. Fight/Bell.	35	.02	.oo	.95	<IO	40	.01	.oo	.18	<IO					
Hell's Gulch	40	.oo	.04	.23	<10	20	.oo	.oo	.la	<IO					
Squaw	45	.06	.04	.36	<IO	-					-	-	-	-	-
Plummer	80	.04	.13	.58	<IO	60	.oo	.oo	.la	<IO	-	-	-	-	-
L. Plumer	25	.04	.04	1.24	<IO	50	.IO	.oo	.07	<IO	-		-	-	
Benewah	40	.04	.oo	.70	<10	35	.OI	.00	.18	<IO	50	.00	.oo	.07	<10
Lake	40	.03	.oo	.oo	<IO	25	.01	.00	1.11	<IO	50	0.0	.09	.01	c l 0
Evans	40	.03	.13	.07	<IO	30	.oo	.oo	.oo	<IO	30	.01	.oo	.00	<10
Alder	10	.OI	.oo	.32	<IO	60	.01	.oo	.27	<10	50	.03	.oo	.oo	<IO

- no sample collected

Table 3.4. **Seasonal hydrolab water** quality parameters for selected Coeur d'Alene **tributaries.**

	SPRING			SUMMER			FALL		
	Cond.	pH	D.O.	Cond.	pH	D.O.	Cond.	pH	D.O.
M. Fight/Bell.	.005	5.2	8.6	.024	7.2	4.6	-	-	-
Hell's Gulch	.025	8.0	14.0	.006	6.7	15.2	-	-	-
Squaw	.038	7.5	11.6	-	-	-	-	-	-
Plummer	.005	7.4	10.6	.004	6.5	8.8	-	-	-
L. Plummer	.058	8.3	12.0	.032	6.6	16.8	-	-	-
Benwah	.046	8.2	14.2	.007	6.3	16.4	.071	8.0	14.9
Lake	.005	4.8	6.5	.016	6.2	a.5	.041	7.0	11.8
Evans	.025	8.5	13.9	.006	7.4	a.9	.034	7.9	14.9
Alder	.041	a.3	11.4	.006	6.4	10.8	.089	7.9	14.6

- no samples were collected

Table 3.5. **Monthly temperature** profiles in degrees Celsius for selected Coeur **d'Alene tributaries** from May,1 991 through October,1 991.

Stream name	May	June	July	August	September	October
Fighting/Bellgrove	8.5	20	15	*	*	*
Hell's Gulch	10	15.6	15.5	*	*	*
Squaw	12	*	*	*	*	*
Plummer	10	20.1	18.8	*	*	*
Little Plummer	8	20.1	13.8	*	*	*
Benewah	9	16.7	16.6	18	24	1.2
Lake	11	21.1	16	20.9	22.9	0.3
Alder	9	16.1	15	15.9	19	0.6
Evans			12.2			2.1

@ Water temperatures were collected the last week of the month.

• Intermittent conditions existed

3.1.4. Substrate analysis

A limited number of substrate samples were collected in segments of each creek in which potential spawning sites for cutthroat and bull trout were observed. The fredle index was calculated for each segment of creek sampled (Table) The fredle index is a measure of pore size and relative permeability both of which increase as the index number becomes larger. The larger the value of the number, the higher the expected emergence survival. Values for Fighting Creek ranged from 0.57 for Upper Fighting to 3.47 for Lower Fighting. Values for the Plummer system ranged from 0.44 for middle Little Plummer to 6.74 for upper Little Plummer. Index values for Evans ranged from 3.93 for Upper Evans to 5.52 for middle Evans. Fredle index values for Alder Creek were 7.25 for both upper and middle segments. Index values for Lake Creek ranged from 1.99 for Middle Lake to 4.83 for Upper Lake. Values for Benewah Creek ranged from 2.16 for Middle Benewah to 4.43 for Lower Benewah.

3.2. BIOLOGICAL EVALUATION

3.2.1. Relative Abundance

In June, August, and October, 1991, a total of 50.34 electroshocking hours were spent collecting relative abundance information. A total of 6,138 fish were collected from eight tributaries. For a complete breakdown of relative abundance data reference Appendix (B).

In June, 1991 a total of 21 hours were spent electroshocking for a total catch of 2,161 fish from eight selected tributaries (Table 3.7). A total of 254 fish were captured from Alder Creek in June. Of the 254 fish collected, 3 (1.2%) were cutthroat trout, 61 (24.0%) were eastern brook trout, 184 (72.4%) were sculpin *spp.* and 6 (2.4%) were longnose sucker (Table 3.8). Table 3.9 shows the breakdown of electrofishing relative abundance data for salmonid species by age class in Alder Creek. Fish were assigned an age based on their length using the back-calculated lengths at the end of each years growth (see section 3.2.3). Of the three cutthroat trout captured in Alder Creek during June, one (33.3%) was age 2+ and two (66.7%) were age 3+. Five (8.2%) of the eastern brook trout were 0+ of age, 38 (62.3%) were I+ of age, 14 (23.0%) were 2+ of age and four (6.6%) were 3+ of age.

Table 3.6. Fredle index values for selected Coeur d'Alene tributaries during 1991.

Creek	Mean grain size (mm)	Sorting coefficient	Fredle index
Lower Fighting	4.85	1.4	3.47
Upper Fighting	0.80	1.4	0.57
Middle Little Plummer	1.40	3.2	0.44
Main Stem Plummer	2.30	1.l	2.07
Little Plummer (Above Confluence)	8.90	1.3	6.74
Upper Benewah	4.21	1.3	3.16
Middle Benewah	3.01	1.4	2.16
Lower Benewah	4.43	1.0	4.43
Lake	6.87	1.4	4.83
Middle Lake	2.65	1.3	1.99
Upper Evans	4.91	1.3	3.93
Middle Evans	7.85	1.4	5.52
Upper Alder	10.30	1.4	7.25
Middle Alder	9.06	1.3	7.25

Table 3.7. Number of each species of fish caught by electrofishing at each Coeur **d'Alene** tributary in June,1 991.

Species	Alder	Benewah	Evans	Fighting	Hell's Gulch	Lake	Plummer/ L. Plummer
Shock time (min)	**154.9**	**326.3**	**137.9**	**56.9**	**58.6**	**154.9**	**366**
Cutthroat trout	3	15	30	27	1	3	4
Eastern brook trout	61	3			8		5
Sculpin *spp*	184	34	206			114	89
Longnose sucker	6	23		2			10
Pumpkinseed		6					
Redside shiner		183				21	44
Northern squawfish		4					4
Dace *spp.*		362				33	677
Yellow perch		1					
TOTAL	**254**	**631**	**236**	**27**	**9**	**171**	**833**

Table 3.8. Percent of each species of fish caught by electrofishing at each Coeur d'Alene tributary in June,1 991.

Species	Alder	Benewah	Evans	Fighting	Hell's Gulch	Lake	Plummer L. Plummer
Shock time (min)	**154.9**	**326.3**	**137.9**	**56.9**	**58.6**	**154.9**	**366**
Cutthroat trout	1.2	2.4	12.7	93.1	11.1	1.7	.5
Eastern brook trout	24.0	.5			88.8		.6
Sculpin *spp*	72.4	5.4	87.3			66.7	10.7
Longnose sucker	2.4	3.6		6.9			1.2
Pumpkinseed		1.0					
Redside shiner		29.0				12.3	5.3
Northern squawfish		.6					.5
Dace *spp.*		57.4				19.3	81.3
Yellow perch		.2					

Table 3.9. Breakdown of electrofishing relative abundance for salmonid species by age class in Alder Creek, 1991.

	Cutthroat trout			Eastern brook trout		
Age	6/91	8/91	10/91	6/91	8/91	10/91
o+				5 (8.2)	20 (20.6)	10 (8.5)
l+				38 (62.3)	32 (33.0)	52 (44.1)
2+	1 (33.3)	3 (33.3)	6 (33.3)	14 (23.0)	3 5)36.1	37 (31.4)
3+	2 (66.7)	6 (66.7)	12 (66.7)	4 (6.6)	10 (10.3)	19 (16.1)

Table 3.10. Breakdown of electrofishing relative abundance for salmonid species by age class in Benewah Creek, 1991.

	Cutthroat trout		
Age	6/91	8/91	10/91
o+		6 (46.2)	5 (14.7)
l+		1 (7.7)	16 (47.1)
2+	3 (20.0)	4 (30.8)	12 (35.3)
3+		2 (15.4)	
4+	10 (66.7)		1 (2.9)
5+	2 (i3.3)		

Table 3.11. Breakdown of electrofishing relative abundance for salmonid species by age class in Evans, 1991.

	Cutthroat trout		
Age	6/91	8/91	10/91
o+	6 (20.0)	25 (37.9)	35 (32.7)
l+	14 (46.7)	11 (16.7)	17 (15.9)
2+	6 (20.0)	13 (19.7)	31 (29.0)
3+	4 (13.3)	11 (16.7)	18 (16.8)
4+		6 (9.1)	6 (5.6)

Six hundrend and thirty-one fish were captured from Benewah Creek in June, 1991 (Table 3.7). Fifteen (2.4) of the 631 fish were cutthroat trout, 3 (0.5%) were eastern brook trout, 362 (57.4%) were date spp., 23 (3.6%) were longnose sucker, 4(0%.6%) were northern squawfish, 6 (1 .O%) were pumpkinseed, 183 (29.0%) were redside shiner, 34 (5.4%) were sculpin spp. and 1 (0.2%) was yellow perch (Table 3.8). Of the fifteen cutthroat trout captured in Benewah Creek during June, three (20.%) were 2+, ten (66.7%) were 4+, and two (13.3%) were 5+ of age (Table 3.10).

A total of 236 fish were captured in Evans Creek in June (Table 3.7). 30 (12.8%) of the 236 were cutthroat trout and 206 (87.3%) were sculpin *spp* (Table 3.8). Of the thirty cutthroat trout captured in Evans Creek during June, six (20.%) were 0+, 14 (46.7%) were I+, six (20.0%) were 2+, and four (13.3%) were 3+ of age (Table 3.1 I).

A total of 171 fish were collected from Lake Creek (Table 3.7). Three (1.7%) were cutthroat trout, 33 (19.3%) were dace *spp.,* 21 (12.3%) were redside shiners and1 14 (66.7%) were sculpin *spp* (Table 3.8). Of the three cutthroat trout collected during June, two (66.7%) were 2+ and one (33.3%) was 3+ of age (Table 3.12).

Fighting Creek produced a total of 29 fish (Table 3.7). Twenty-seven (93.1%) of the 29 were cutthroat trout and 2 (6.9%) were longnose suckers (Table 3.8). Of the twenty seven cutthroat trout captured in Fighting Creek during June, 22 (81.5%) were 2+ and 5 (18.5%) were 3+ of age (Table 3.13).

Hell's Gulch produced a total of nine fish (Table 3.7). One(11 .1 %) of the nine fish was a cutthroat trout and eight (88.8%) were eastern brook trout (Table 3.8).

A total of 833 fish were captured in the Plummer system (Table 3.7). Four (0.5%) cutthroat trout were captured as well as 5 (0.6%) eastern brook trout, 677 (81.3%) dace spp, 10 (1.2%) longnose suckers,4 (0.5%) northern squawfish,44 (5.3%) redside shiners, and 89 (10.7%) sculpin spp. (Table 3.8) Of the four cutthroat trout collected, three (75%) were 2+ and one (25.0%) was 5+ of age (Table 3.14).

Table 3.12. Breakdown of electrofishing relative abundance for salmonid species by age class in Lake Creek, 1991.

Age	Cutthroat trout 6/91	8/91	10/91
o+		10 (23.8)	9 (16.1)
1+		21 (50.0)	36 (64.3)
2+	2 (66.7)	5 (11.9)	1 (1.80
3+	1 (33.3)	6 (14.3)	10 (17.9)

Table 3.13. Breakdown of electrofishing relative abundance for salmonid species by age class in Fighting Creek, 1991.

Age	Cutthroat trout 6/91	8/91	10/91
o+			
l+			
2+	22 (81.5)		
3+	5 (18.5)		

Table 3.14. Breakdown of electrofishing relative abundance for salmonid species by age class in Plummer Creek, 1991.

Age	Cutthroat trout 6/91	8/91	10/91
o+			
l+			
2+	3 (75.0)		
3+			
4+			
5+	1 (25.0)		

In August, a total of 12.2 hours were spent collecting 1,824 fish from four tributaries. A total of 245 fish were collected from Alder Creek in August (Table 3.15). Nine (3.7%) were cutthroat trout, 97 (39.6%) were eastern brook trout and 139 (56.7%) were sculpin spp. (Table 3.16). Of the nine cutthroat trout collected during August three (33.3%) were 2+ and 6 (66.7%) were 3+. Of the 97 eastern brook trout collected, 20 (20.6%) were 0+, 32 (33.0%) were l+, 35 (36.1%) were 2+, and 10 (10.3%) were 3+ of age (Table 3.9).

A total of 1,108 fish were collected from Benewah Creek in August (Table 3.15). A total of 13 (1.2%) cutthroat trout were collected as well as 698 (62.9%) dace *spp,* 12 (1 .1%) longnose dace, 278 (25.1%) redside shiner, and 107 (9.7%) sculpin *spp.* (Table 3.16). Of the 13 cutthroat trout captured during August, six (46.2%) were 0+, one (7.7%) was l+, four (30.8%) were 2+ and two (15.4%) were 3+ of age (Table 3.10).

Two hundrend twenty six fish were collected from Evans Creek in August (Table 3.15). Sixty-six (29.2%) of the fish were cutthroat trout and 160 (70.8%) were sculpin spp.(Table 3.16). Of the 66 trout collected in Evans Creek during August, 25 (37.9%) were 0+, 11 (16.7%) were l+, 13 (19.7%) were 2+, 11 (16.7%) were 3+ and six (9.1%) were 4+ age (Table 3.11).

A total of 245 fish were collected from Lake Creek during August (Table 3.15). 42 (17.1%) cutthroat trout were collected as well as 90 (36.7%) dace *spp,* 1 (0.4%) longnose sucker, 29 (11.8%) redside shiner, and 83 (33.9%) sculpin *spp.* (Table 3.16). Of the 42 cutthroat trout captured, ten (23.8%) were 0+, 21 (50.0%) were l+, five (11.9%) were 2+ and six (14.3%) were 3+ of age (Table 3.12).

In October a total of 17.2 hours were spent collecting 2,153 fish (Table 3.17) in four tributaries. A total of 408 fish were captured from Aider Creek (Table 3.17). Of the 408 fish, 18 (4.4%) were cutthroat trout, 118 (28.7%) were eastern brook trout, 36 (8.8%) were longnose suckers, and 237 (58.1%) were sculpin spp.(Table 3.18). Of the 18 cutthroat trout collected from Alder Creek, six (33.3%) wee 2+ and 12 (66.7%) were 3+. Of the 118 eastern brook trout captured, ten (8.5%) were 0+, 52 (44.1%) were l+, 37 (31.4%) were 2+, and 19 (16.1%) were 3+ of age (Table 3.9).

Table 3.15. Number of each species of fish caught by electrofishing at each Coeur d'Alene tributary in August, 1991.

Species Shock time (min)	Alder 120.1	Benewah 360.5	Evans 170.4	Lake 79.3
Cutthroat trout	9	13	66	42
Eastern brook trout	97			
Sculpin *spp.*	139	107	160	83
Longnose sucker		12		1
Redside shiner		278		29
Dace *spp.*		698		90
TOTAL	**245**	**1,108**	**226**	**245**

Table 3.16. Percent of each species of fish caught by electrofishing at each Coeur d'Alene tributary in August, 1991.

Species	Alder	Benewah	Evans	Lake
Cutthroat trout	3.7	1.2	29.2	17.1
Eastern brook trout	39.6			
Sculpin *spp.*	56.7	9.7	70.8	33.9
Longnose sucker		1.1		0.4
Redside shiner		25.1		11.8
Dace *spp.*		62.9		36.7

Table 3.17. Number of each species of fish caught by electrofishing at each Coeur d'Alene tributary in October, 1991.

Species Shock time (min)	Alder 284.8	Benewah 361.6	Evans 116.8	Lake 271.4
Cutthroat trout	18	33	107	56
Eastern brook trout	117	6		
Rainbow trout		1		
Sculpin *spp.*	237	72	89	279
Longnose sucker	36	277		2
Redside shiner		258		4
dace *spp.*		480		80
Total	**408**	**1,127**	**197**	**421**

Table 3.18. Percent of each species of fish caught by electrofishing at each Coeur d'Alene tributary in October, 1991.

Species	Alder	Benewah	Evans	Lake
Cutthroat trout	4.4	2.9	54.3	13.3
Eastern brook trout	28.7	0.5		
Rainbow trout		0.09		
Sculpin *spp.*	58.1	6.4	45.2	66.3
Longnose sucker	8.8	24.6		0.5
Redside shiner		22.9		1.0
dace *spp.*		42.6		19.0

A total of 1,127 fish were collected from Benewah Creek in October (Table 3.17). Thirty-three (2.9%) cutthroat trout, 6 (0.5%) eastern brook trout, 1 (0.09%) rainbow trout, 480 (42.6%) dace spp., 277 (24.6%) longnose suckers, 258 (22.9%) redside shiners, 72 (6.4%) sculpin spp. were collected (Table 3.18). Of the 33 cutthroat trout collected in October, five (14.7%) were 0+, 16 (47.1%) were l+, 12 (35.3%) were 2+ and one (2.9%) was 4+ of age (Table 3.10).

Evans Creek produced a sample of 197 fish (Table 3.17). Of the 197 fish, 107 (54.3%) were cutthroat trout and 89 (45.2%) were sculpin *spp.* (Table 3.12). Of the 107 cutthroat trout, 35 (32.7%) were 0+, 17 (15.9%) were l+, 31 (29.0%) wee 2+, 18 (16.8%) were 3+ and 6 (5.6%) were 4+ of age (Table 3.18).

Four hundrend twenty-one fish were collected from Lake Creek in October (Table 3.17). 56 (13.3%) cutthroat trout were collected as well as, 80 (19.0%) dace *spp.,* 2 (0.5%) longnose suckers, 4 (1 .O%) redside shiners and 279 (66.3%) sculpin *spp.* (Table 3.18). Of the 56 cutthroat trout captured, nine (16.1%) were 0+, 36 (64.3%) were l+, one (1.8%) was 2+ and ten (17.9%) was 3+ of age (Table 3.12).

3.2.2. Population estimates

In October, population estimates were conducted in four selected tributaries. Population estimates, 95% confidence intervals and fish densities for each trout species captured in Benewah Creek can be found in Table 3.19. Only cutthroat trout populations could be estimated for Benewah Creek due to low sample size of other trout species. In reach 1, no cutthroat trout were captured. In reach 2 the estimated population of cutthroat trout is 5.0 + 0.0 with a density of 0.7 ± 0.0 per 100 m2. The estimated population of cutthroat trout for reach three was 18.5 ± 2.3 with a density of 3.6 ± 0.4 per 100 m2.

Cutthroat and eastern brook trout populations were estimated for Alder Creek (Table 3.20). In reach 1, cutthroat trout populations were estimated at 5.3 ± 1.9 fish for 231 m^2, with a density of 2.3 ± 0.8 per 100m2. Eastern brook trout populations were estimated at 9.8 ± 3.3 fish for 231 m^2, with a density of 4.2 ± 1.4 per 100 m^2. In Reach two, cutthroat trout populations were estimated at 4.0 ± 0.1 for 285.8 m^2, with a density of 1.4 ± 0.1 for 100 m2. Population estimates for eastern brook trout were 8.3 ± 0.1 for 285.8 m2 with a

Table 3.19 Estimated population, 95% confidence intervals, and fish density for each trout species captured in Benewah Creek at each reach in October, 1991.

SPECIES	EST. POP.	95% C.I.	#/100m² ±95% C.I.
Reach # 1 (691.0 m²)			
Cutthroat trout	0.0		
Reach # 2 (689.6 m²)			
Cutthroat trout	5.0	± 0.0	0.7 ± 0.0
Reach # 3 (518.5 m²)			
Cutthroat trout	18.5	± 2.3	3.6 ± 0.4

Table 3.20 Estimated population, 95% confidence intervals, and fish density for each trout species captured in Alder Creek at each reach in October, 1991.

SPECIES	EST. POP.	95% C.I.	#/100m² ±95% C.I.
Reach # 1 (231 m²)			
Cutthroat trout	5.3	± 1.9	2.3 ± 0.8
Eastern brook trout	9.8	± 3.3	4.2 ± 1.4
Reach # 2 (285.8 m²)			
Cutthroat trout	4.0	± 0.1	1.4± 0.1
Eastern brook trout	8.3	± 8.3	2.9 ± 1.4
Reach # 3 (291.8 m²)			
Cutthroat trout	4.0	± 0.1	1.4 ± 0.0
Eastern brook trout	57.9	± 5.3	19.8 ± 1.8
Reach # 4 (231.0 m²)			
Cutthroat trout	2	± 0.0	0.9 ± 0.0
Eastern brook trout	46.3	± 4.8	20.0 ± 2.1

density of 2.9 ± 1.4 per 100 m 2. In reach three estimated cutthroat trout populations were 4.0 ± 0.1 for 292 m2 with a density of 1.4 ± 0.0 per 100 m2. Eastern brook trout populations were estimated at 57.9 ± 5.3 for 292 m2 with a density of 19.8 ± 1.8 for 100 m2. Cutthroat trout populations were estimated at 2 ± 0.0 for 231 m2 with a density of 0.9 ± 0.0 for reach four. Eastern brook trout densities were estimated at 46.3 ± 4.8 for 231 m2 with a density of 20 ± 2.1 per 100 m2.

Cutthroat trout were the only trout population estimated for Lake Creek (Table 3.21). Reach one had an estimated cutthroat population of 32 ± 19.2 for 238 m2 with a density of 13.4 ± 8.1 per 100 m^2. In reach two cutthroat populations were estimated at 23.1 ± 5.4 for 214 m2 with a density of 10.8 ± 2.5 for 100 m2. In reach 3 cutthroat populations were estimated at 12.0 ± 11.8 for 177 m^2, with a density of 6.8 ± 6.7 for 100m^2. In reach 4, cutthroat populations were estimated at 2.0 ± 0.0 for 229 m2 with a density of 0.9 ± 0.0 for 100 m2.

Cutthroat trout populations were estimated for Evans Creek (Table 3.22). In reach 1, cutthroat populations were estimated at 44.3 ± 9.8 for 195 m2 with a density of 22.7 ± 5.0 per 100 m2. In reach 2, cutthroat trout populations were 17.6 ± 4.2 for 195 m2 with a density of 9.0 ± 2.2 for 100 m^2. In reach 3, cutthroat trout populations were estimated at 58.7 ± 6.5 for 244 m2 with a density of 24.1 ± 2.7 for 100 m2.

3.2.3. Age, Growth and Condition

Benewah Creek:

Back calculated lengths for cutthroat trout at the first annulus ranged from 56 to 99 mm with a grand mean of 68 mm (Table 3.23). At the formation of the second annulus lengths ranged from 106 to 136 mm with a mean of 118 mm. At the end of the third years growth mean sizes ranged from 139 to 218 mm with a grand mean of 176. At the end of the fourths years growth sizes ranged from 234 to 260 with a grand mean of 254 mm. The length at the fifth annulus was 289 mm.

Table 3.21 Estimated population, 95% confidence intervals, and fish density for each trout species captured in Lake Creek at each reach in October, 1991.

SPECIES	EST. POP.	95% C.I.	#/100 m^2 ±95% C.I.
Reach # 1 (237.9 m^2)			
Cutthroat trout	32.0	± 19.2	13.4 ± 8.1
Reach # 2 (213.5 m^2)			
Cutthroat trout	23.1	± 5.4	10.8 ± 2.5
Reach # 3 (176.9 m^2)			
Cutthroat trout	12.0	± 11.8	6.8 ± 6.7
Reach # 4 (228.8 m^2)			
Cutthroat trout	2.0	± 0.0	0.9 ± 0.0

Table 3.22. Estimated population, 95% confidence intervals, and fish density for each trout species captured in Evans Creek at each reach in October, 1991.

SPECIES	EST. POP.	95% C.I.	#/100 m^2 ±95% C.I.
Reach # 1 (195.2 m^2)			
Cutthroat trout	44.3	± 9.8	22.7 ± 5.0
Reach # 2 (195.2 m^2)			
Cutthroat trout	17.6	± 4.2	9.0 ± 2.2
Reach # 3 (244.0 m^2)			
Cutthroat trout	58.7	± 6.5	24.1 ± 2.7

Table 3.23. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Benewah Creek, 1991.

		MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS				
Cohort	N	1	2	3		
1990	24	56.3±7.7				
1989	21	75.6±11.3	115.3±14.5			
1988	9	66.1±10.1	105.7±20.5	139.2±29.0		
1987	1	98.6	140.1	192.6	213.5	
1986	8	84.9±12.2	135.9±18.3	214.7±20.4	259.6±18.3	289.4±20.5
GRAND MEAN	63	68.4±14.8	117.9±19.5	175.7±44.8	254.4±22.9	289.4±20.5
MEAN ANNUAL GROWTH INCREMENT		68	50	58	79	35

Table 3.24. Mean lengths, weights and condition factors for each age class of cutthroat trout in Benewah Creek, 1991.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
0+	3	1.3±0.6	59.3±6.7	0.65±0.26
1+	24	3.7±4.2	71.7±7.2	0.90±0.46
2+	21	28.2±17.8	139.0±16.4	0.98±0.48
3+	9	35.4±10.3	161.3±37.9	0.88±0.10
4+	1	155.0	245.0	1.05
5+	4	255.8±50.9	311.8±22.8	1.0±0.11
Total	62			0.92±0.39

Mean condition factors ranged from 0.65 for 0+ to 1 .O for 5+ cutthroat trout (Table 3.24), with an overall condition factor of 0.92.

Alder Creek

Back-calculated lengths for cutthroat trout at the first annulus ranged from 63 to 73 mm with a grand mean of 67 mm. At the formation of the second annulus lengths ranged from 102 to 104 mm with a grand mean of 103 mm. The length of the third annulus was 142 mm (Table 3.25).

Mean condition factors ranged from 0.83 for l+ to 0.88 for 2+ cutthroat trout, with an overall value of 0.87 (Table 3.26).

Back-calculated lengths for eastern brook trout at the first annulus ranged from 77mm to 95 mm with a grand mean of 79 mm. At the end of the second years growth lengths ranged from 120 mm to 157 mm with a grand mean of 132. The length at the third annulus was 182 mm.

Mean condition factors ranged from 0.8 for 0+ and 3+ to 0.9 for l+ and 3+ with an overall condition factor of 0.9.

Lake Creek

Back-calculated lengths for cutthroat trout at the first annulus ranged from 56 to 70 mm with a grand mean of 60 mm. At the end of the second years growth lengths ranged from 97 to 110 mm with a grand mean 107 mm. Length of the third annulus was 135 mm (Table 3.29).

Mean condition factors ranged from 0.82 for 2+ cutthroat trout to 1.05 for 0+, with an overall mean of 0.88 (Table 3.30).

Evans Creek

Back-calculated lengths for cutthroat trout at the first annulus ranged from 66 to 74 mm with a grand mean of 67 mm. at the end of the second years growth sizes ranged from 99 to 114 mm with a grand mean of 101 mm. Lengths at the third annulus ranged

Table 3.25. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Alder Creek, 1991.

		MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS		
Cohort	N	1	2	3
1990	6	72.6 ± 4.1		
1989	10	63.4 ± 5.6	104.5 ± 15.4	
1988	10	67.3 ± 8.3	102.1 ± 11.3	142.4 ± 34.20
GRAND MEAN	26	67.0 ± 7.2	103.3 ± 13.2	142.4 ± 34.2
MEAN ANNUAL GROWTH INCREMENT		67	36	39

Table 3.26. Mean lengths, weights and condition factors for each age class of cutthroat trout in Alder Creek, 1991.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
1+	4	123.7 ± 6.9	16.5 ± 3.1	0.83 ± 0.16
2+	10	159.7 ± 33.0	42.7 ± 38.3	0.88 ± 0.12
3+	14	220.6 ± 49.7	87.8 ± 54.3	0.87 ± 0.28
Total	28			0.87 ± 0.21

Table 3.27. Mean back-calculated lengths of each year's growth (annulus formation) for each age class of eastern brook trout in Alder Creek, 1991.

Cohort	N			
1990	55	76.6±8.6		
1989	36	73.7±11.9	120.3±18.8	
1988	17	95.2±6 1.2	156.8f68.4	181.5±44.2
Grand mean		78.7k26.4	132.1k44.4	181.5±44.2
Mean annual growth increment		79	53	50

Table 3.28. Mean lengths, weights, and condition factors for each age class of eastern brook trout in Alder Creek.

Age	N	Mean Weight (±SD)	Mean Length (±SD)	Mean K_{tl} (±SD)
0+	50	14.3±11.2	111.5±23.6	0.8±0.5
1+	55	21.1±28.3	113.9±43.6	0.9±0.1
2+	36	23.5±7.1	139.8±12.9	0.8±0.1
3+	18	89.6±42.0	211.4±26.9	0.9±0.2
TOTAL	159			0.9±0.4

Table 3.29. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Lake Creek, 1991.

		MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS		
Cohort	N	1	2	3
1990	61	56.2±7.1		
1989	18	70.0±11.3	110.0±25.5	
1988		66.0±4.9	97.3±9.9	135.4±6.8
GRAND MEAN		59.8±9.9	106.8±23.1	135.4±6.8
MEAN ANNUAL GROWTH INCREMENT		60	48	26

Table 3.30. Mean lengths, weights and condition factors for each age class of cutthroat trout in Lake Creek, 1991.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
0+	13	2.1±1.0	58.2±4.7	1.05f0.5
1+	58	3.91t1.8	76.4±10.1	0.85±0.3
2+	18	21.2±15.1	130.8±26.2	0.82±0.19
3+	6	36.5f8.3	160.7±4.5	0.88±0.19
Total	95			0.88±0.32

from 138 to 145 mm with a grand mean of 138 mm. Length at the fourth annulus was 185 mm (Table 3.31).

Mean condition factors ranged from 0.84 for 0+ to 1.22 for 4+ cutthroat trout. An overall condition factor of 0.88 was calculated for Evans Creek cutthroat (Table 3.32).

Fighting Creek

Back-calculations were made using the proportional method since a good regression could not be obtained for the body length-scale relationship. Back-calculated lengths at the end of the first years growth ranged from 49 to 55 mm with a grand mean of 53 mm. At the end of the second years growth lengths ranged from 93 to 97 mm with a grand mean of 97 mm. At the third annulus the length was 140 mm (Table 3.33).

Condition factors ranged from 0.9 for 2+ cutthroat trout to 1.07 for 3+ with an overall mean of 0.92 (Table 3.34).

Plummer Creek

Back-calculations were made using the proportional method since a good regression could not be obtained for the body length-scale relationship. Back-calculated lengths at the end of the first years growth ranged from 44 to 76 mm with a grand mean of 70 mm. At the end of the second years growth lengths ranged from 69 to 140 mm with a grand mean of 126 mm. At the end of the third years growth sizes ranged from 137 to 184 mm with a grand mean of 175 mm. Size at the fourth and fifth annulus was 211 and 253 mm, respectively (Table 3.35).

A condition factor of 1.01 was obtained for 3+ cutthroat trout in Plummer Creek (Table 3.36).

3.2.4. Creel Survey

Creel surveys were conducted monthly from May through August. Due to the low numbers or lack of anglers contacted not enough data was gathered to accurately calculate harvest or angler pressure estimates. Also, because of the lack of water present in the streams during summer, creel surveys were eliminated for the following year. The only month in which any fishing pressure existed was during May, coinciding with peek spawning runs of

Table 3.31. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Evans Creek, 1991.

		MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS			
Cohort	**N**	**1**	**2**	**3**	**4**
1990	67	65.9±12.6			
1989	39	67.4±10.3	99.1±13.5		
1988	17	66.5±9.4	104.8±12.6	138.0±22.7	
1987	1	73.8	114.4	144.8	185.4
GRAND MEAN		66.5±11.4	101.1±13.4	138.4±22.1	185.4
MEAN ANNUAL GROWTH INCREMENT		67	34	37	47

Table 3.32. Mean lengths, weights and condition factors for each age class of cutthroat trout in Evans Creek, 1991.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
0+	40	1.5±0.7	56.0±5.9	0.84±0.24
1+	63	8.5±5.7	95.2±23.4	0.88±0.37
2+	33	18.8±11.0	125.1±22.2	0.87±0.12
3+	13	46.2±30.4	160.8±26.2	0.94±0.12
4+	1	141	226	1.22
Total	150			0.88±0.28

Table 3.33. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Fighting Creek, 1991.

		MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS		
Cohort	N	1	2	3
1990				
1989		54.6±7.2	97.1±8.8	
1988		44.8±9.1	93.1±20.3	140.4±13.1
GRAND MEAN		53.0±8.0	96.6±10.3	140.4±13.1
MEAN ANNUAL GROWTH INCREMENT		53	44	44

Table 3.34. Mean lengths, weights and condition factors for each age class of cutthroat trout in Fighting Creek, 1991.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
2+	20	13.5k5.1	113.1±9.9	0.9±0.16
3+	3	44.7±2 1.4	158.3±14.3	1.07±0.23
Total	23			0.92±0.18

Table 3.35. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Plummer Creek, 1991.

		MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS				
Cohort	N	1	2	3	4	5
1989	1	44.1	69.4			
1988	4	75.7±13.9	140.4±32.8	184.3±55.7		
1986	1	73.8	115.9	137.0	210.8	252.9
GRAND MEAN		70.1±16.7	124.5±38.3	174.8±52.6	210.8	252.9
MEAN ANNUAL GROWTH INCREMENT		70	54	50	35	42

Table 3.36. Mean lengths, weights and condition factors for each age class of cutthroat trout in Plummer Creek, 1991.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
3+	3	34.3±1.2	150.7±5.5	1.01±0.12
Total	3			1.01±0.12

cutthroat trout. Fishing pressure existed only in those streams in which known runs of cutthroat trout existed, those being Benewah and Lake creeks

3.3. MACROINVERTEBRATE STUDIES

3.3.1. Benthic samples

A total of 75 hess samples were collected from tributaries during 1991. Mean densities of benthic macroinvertebrates in Hess samples ranged from a low of 1205.3 organisms/m2 in Alder Creek to a high of 2885.6 organisms/m 2 in Evans Creek. (Table 3.37). The density for Benewah Creek was 2,296.5 organisms/m2 and 1708.3 organisms/m2 in Lake Creek.

Chironomidae larvae was the most abundant macroinvertebrate in Alder, Benewah, Evans and Lake creeks at 32.21%, 40.2%, 22.83% and 37.50%, respectively. The second most abundant macroinvertebrate in Alder and Lake creeks were Elmidae larvae at 13.0% and 12.%% respectively (Table 3.39). The second most abundant macroinvertebrate in Benewah Creek was Leptophlebiidae at 10.3% and Baetidae at 11.7% in Evans Creek. Mean densities of benthic macroinvertebrates collected in hess samples by sample site and month can be found in Appendix C.

3.3.2. Drift samples

Fifty one drift samples were collected from the tributaries during 1991. Mean densities of invertebrates ranged from a low of 192.4 organisms/100m3 in Lake Creek to 265.7 organism/m3 in Evans Creek (Table 3.38). densities for Benewah and Alder creeks were 204.4 and 2.01.3 organisms/m3, respectively.

Chironomidae pupae were the most abundant macroinvertebrate collected in the drift on Benewah Creek at 18.6% followed by Chironomidae larvae and Helicopsychidae at 13.5% and 13.4%, respectively (Table 3.40). Baetidae was the most abundant organism found in Alder Creek at 33.6% followed by Ephemerellidae at 15.0% and Chrionomidae pupae at 11.7%. Elmidae larvae were the most abundant macroinvertebrate collected in drift samples from Lake Creek at 22.1% followed by Baetidae and Chironomidae larvae at 8.4% and 6.3%, respectively. Ephemerellidae was the most abundant organisms collected in Evans Creek at 27.6% followed by

Table 3.37. Mean densities of macroinvertebrates (#/m3) collected in Hess samples from selected tributaries during 1991. Sample sizes enclosed in parentheses.

	Benewah	Alder	Evans	Lake
June	2030 (6)	1206.7 (6)	2106.7 (6)	2695.0 (3)
August	2842.8 (9)	929.4 (6)	2640.0 (6)	1420.0 (6)
October	2686.7 (9)	1480.0 (6)	3911.7 (6)	1010.0 (6)
Annual X	2535.0 (24)	1205.4 (18)	2885.6 (18)	1708.3(15)

Table 3.38. Mean densities of macroinvertebrates (#/1 00 m3) collected in drift samples from selected tributaries during 1991. Sample sizes enclosed in parentheses.

	Benewah	Alder	Evans	Lake
June	87.7 (3)	81.9 (4)	49.4 (4)	307.5 (2)
August	53.1 (6)	234.8 (4)	255.1 (4)	225.6 (4)
October	472.3 (6)	286.2 (4)	492.5 (6)	44.1 (4)
Annual X	204.4 (15)	201.3 (12)	265.7 (14)	192.4 (10)

Table 3.39 Mean annual number of benthic macroinvertebrates per square meter (collected by hess sampler) in selected tributaries of the Coeur d'Alene Indian Reservatlon for the 1991 sampling period.

	ALDER		BENEWAH		EVANS		LAKE	
	annual x	% abund	annual x	% abund	annual x	% abund	annual x	% abund
QUATICS								
TRICHOPTERA								
Glossosomatidae	2.76	0.23	6.42	0.33	279.44	9.66	6.67	0.39
Brachycentridae	84.28	6.99			23.33	0.61	1.67	0.13
Hydropsychidae	8.94	0.74	75.26	2.97	113.33	3.93	1.67	0.10
Hydroptilidae	20.56	1.71	11.39	0.45	6.67	0.23	0.00	0.00
Helicopsychidae	0.10	<0.01	17.50	0.69				
Limnephilidae	15.56	1.29	63.98	2.52	3.33	0.12	1.11	0.09
Rhyacophilidae	0.67	0.06	0.56	0.02	28.89	1.00	0.00	0.00
Phryganeidae							0.56	0.03
T. pupae			1.11	0.04				
EPHEMEROPTERA								
Tricorythidae			8.61	0.34				
Heptageniidae	53.22	4.42	176.11	6.95	300.56	10.42	133.89	7.84
Ephemerellidae	98.78	8.20	163.43	6.45	116.11	4.02	97.78	65.72
Baetidae	55.11	4.57	248.80	9.81	337.76	11.71	61.11	4.75
Leptophlebiidae	21.39	1.78	261.02	10.30	37.76	1.31	43.89	2.57
PLECOPTERA								
Chloroperlidae	20.63	1.73	15.65	0.62	317.22	10.99	126.11	7.30
Perlidae	9.63	0.62	13.05	0.51	16.33	0.64	11.11	0.65
Perlodidae	37.61	3.12	53.15	2.10	120.56	4.18	177.22	10.37
Peltoperlidae					24.44	0.85		
Nemouridae	14.44	1.20	2.31	0.09	97.78	3.39	116.67	0.96
Capniidae					2.22	0.08	0.56	0.03
COLEOPTERA								
Elmidae larvae	157.00	13.03	60.63	2.40	118.89	4.12	196.11	i1.48
Elmidae adults	13.22	1.10	19.06	0.75	6.67	0.23	9.44	0.55
Dytiscidae	2.50	0.21	0.74	0.03	0.56	0.02	2.22	0.13
Hydrophilidae			37.76	1.49				
Psephenidae			13.33	0.53				
DIPTERA								
Chironomidae larvae	366.26	32.21	1020.00	40.24	658.89	22.63	638.69	37.50
Chironomidae pupae	20.72	1.72	16.56	0.65	19.44	0.67	0.56	0.03
Ceratopogonidae	0.06	0.01	1.46	0.06	7.78	0.27	0.56	0.03
Tipulidae	36.69	3.23	70.09	2.77	32.22	1.12	32.76	1.92
Tipulidae pupae			1.67	0.07	0.56	0.02		
Simuliidae	3.39	0.26	5.56	0.22	0.56	0.02	0.00	0.00
Simuliidae pupae					15.00	0.52	11.67	0.66
Tabanidae					0.56	0.02	0.00	0.00
Empididae			5.19	0.20	0.00	0.00	0.00	0.00
Psychodidae	11.33	0.94	3.05	0.12	41.67	1.44	4.44	0.26
Rhagionidae					0.56	0.02		
Athericidae	2.22	0.16	0.00	0.00				
Dixidae	0.00	0.00	0.37	0.01	0.00	0.00	0.00	0.00
LEPIDOPTERA								
Noctuidae			0.37	0.01				
HYDRACARINA	26.44	2.36	70.00	2.76	44.44	1.54	42.22	2.47
AMPHIPODA								
Taltiridae			6.30	0.25				0.06
CLADOCERA								
Chydoridae			30.00	1.18				
OSTRACODA					5.56	0.19		
OLIGOCHAETA								
Lumbriculidae	19.56	1.62	13.70	0.54	42.78	1.48	0.56	0.03
Naididae	1.67	0.14	1.11	0.04	2.22	0.		0.39

Table 3.39. (cont.)

	ALDER		BENEWAH		EVANS		LAKE	
	annual x	% abund	annual x	% abund	annual x	% abund	annual x	% abund
	22.70	1.89						
NEMATODA	4.56	0.38	12.50	0.49	5.00	0.17	3.89	0.23
MOLLUSCA								
Planorbidae	0.56	0.05	1.11	0.04				
Physidae			0.74	0.03			5.00	0.29
Lymanaktae			0.26	0.01			1.11	0.07
BIVALVIA								
Unbnktae	1.11	0.09						
Sphaeriidae	20.72	1.72	6.65	0.27	10.56	0.37	0.56	0.03
ERRESTRIALS								
DIPTERA								
Chlronomldae			1.11	0.04				
Drosophilldae	0.06	0.01					0.56	0.04
EPHEMEROPTERA								
Baetidae	0.06	0.01						
COLEOPTERA								
Lathridiidae	0.56	0.05						
Curculionidae	0.22	0.02	0.37	0.01	0.56	0.02	1.11	0.04
Carabidae			1.67	0.07				
HEMIPTERA								
Gerridae							2.22	0.07
Corixidae							2.78	0.16
Beloatomatldae					0.56	0.02		
HOMOPOTERA								
Aphididae	0.89	0.07					1.67	0.16
Cicadellidae	0.89	0.07						
HYMENOPTERA								
Bethyloidae					0.56	0.02		
Formicidae	0.22	0.02			2.22	0.08		
THYSANOPTERA								
Thrlpldae	1.22	0.10						
TRICHOPTERA								
Unk trich aduil	5.56	0.46			2.78	0.10	40.0	2.34
Limnephilidae			0.37	0.01				
ARANEIDA			0.74	0.03	1.67	0.06		
ARACHNID	0.56	0.05	0.74	0.03	1.67	0.06	0.56	0.03
ODONATA								
Aeshnidae			0.56	0.02				
Petaluridae			2.22	0.09				
Coenagrionidae			1.67	0.07				
DECAPODA								
Astacidae	1.11	0.09					2.22	0.13
Gastropoda	0.56	0.05						
Colembob					0.56	0.02		
OSTEICHTHYES	1.17	0.10	0.74	0.03	2.78	0.10		
UNKNOWN	11.11	0.92	5.74	0.23	30.56	1.06	0.56	0.03
TOTAL	1205.33	100.00	2534.99	100.00	2885.56		1706.3	100.00

Table 3.40. Mean annual number of benthic macroinvertebrates per square meter **(collected by drift sampler)** in selected tributaries of the Coeur **d'Alene Indian Reservation for the** 1991 sampling period.

	Benewah		Aider		Lake		Evans	
	annual mean	% abund	annual mean	% abund	annual mean	% abund	annual mean	% abund
QUATICS								
TRICHOPTERA								
Glossosomatidae	0.7	0.3	1.3	0.5	1.2	0.6	4.7	1.8
Brachycentridae	3.0	1.4	3.9	1.9	0.6	0.3	1.7	0.6
Hydropsychidae	2.7	1.3	0.7	0.4			4.6	1.7
Hydroptilldae	1.7	0.8						
Limnephilidae	1.3	0.6	0.4	0.2	0.5	0.3	1.0	3.6
Rhyacophilidae	0.7	0.3	0.2	0.8	0.7	0.4	4.3	1.6
Leptoceridee					0.2	0.1		
Phryganeidae					0.2	0.1		
Lepidostomatidae					0.2	0.1		
Helicopsychidae	27.7	13.4						
EPHEMEROPTERA							3.4	11.4
Heptageniidae	6.8	3.3	6.6	3.3	2.6	1.3	9.9	3.7
Ephemerellidae	6.0	3.4	3.1	15.0	1.8	5.3	73.4	27.6
Baetidae	11.2	5.4	67.7	33.6	16.9	8.4	2.2	0.8
Leptophlebiidae	9.4	4.5	3.9	1.0	9.7	5.7		
PLECOPTERA					1.2	0.6	14.8	5.6
Chloroperlidae	0.7	0.4	1.5	0.7	1.5	0.5	0.4	0.2
Perlidae			0.3	0.2	1.5	0.5	1.1	0.4
Perlodidae	0.6	0.3	1.6	0.8	0.6	0.3		
Peltoperlidae					0.6	0.3	7.3	2.8
Capniidae					0.2	0.1		
Nemouridae	0.8	0.4			0.2	0.1		
Leuctridae					1.2	0.7		
Capniidae					1.2	0.6		
COLEOPTERA			0.8	0.4	38.8	2.2		
Elmidae larvae	0.6	0.3	12.6	6.0	42.4	22.1	2.5	0.9
Elmidae adults	0.1	0.5	0.8	0.4	4.3	2.2	0.4	0.2
Dytiscidae					0.6	0.3		
Hydrophilidae	3.3	1.6			0.2	0.1		
Amphizoidae					0.2	0.1	0.2	0.6
Chrysomelidae					0.5	0.3		
Corcinellidae					0.5	0.3		
DIPTERA			0.4	0.2	0.0	5.2		
Chironomidae larvae	28.8	13.5	23.6	11.7	12.1	6.3		
Chlmnomldee pupae	38.6	18.6	2.9	1.5	2.3	1.2	5.4	19.0
Ceratopogonidae					1.1	0.6	19.2	7.2
Tipulidae	4.8	2.2 2	6.8	3.4			0.3	0.1
Tipulidae pupae					3.3	1.7	2.5	0.0
Simuliidae	0.9	0.5	6.8	3.4	2.5	1.3		
Simuliidae pupae					0.2	0.8	0.6	0.2
Psychodidae	1.8	0.0	2.4	1.2			1.9	0.4
Dixidae					0.5	0.3		
Blephariceridae	0.3	0.1	0.2	0.1	0.5	0.3	0.4	0.2
Blephariceridae					0.5	0.3		
Chaoboridae larvae					0.7	0.4		
Chaoboridae pupae					0.2	0.1		
LEPIDOPTERA					0.2	0.1		
Pyralidae					2.7	1.8	0.2	0.6
HYDRACARINA	0.8	0.5	5.8	2.9	17.9	10.0	9.5	3.6
CLADOCERA								
Chydoridae					0.7	0.4		

Table 3.40. (cont.)

	Benewah annual mean	Benewah % abund	Alder annual mean	Alder % abund	Lake annual mean	Lake % abund	Evans annual mean	Evans % abund
Cyclopoids	2.2	1.4	0.3	0.2	0.7	0.4		
OLIGOCHAETA	0.9	0.4					0.1	0.4
Lumbriculidae			0.6	0.4			1.2	0.4
Naididae			6.8	3.4				
MOLLUSCA								
Planorbidae	0.7	0.3	0.6	0.4				
Lunaeidae	0.2	0.7						
BIVALVIA								
Sphaeriidae	0.7	0.3	1.0	0.9				
ERRESTRIALS								
DIPTERA			1.4	0.7	0.3	0.2		
Chironomidae	3.6	1.0			0.3	0.2	6.5	2.4
Ceratopogonidae	0.3	0.1						
Simuliidae	0.4	0.2						
Mycetophilidae					0.3 0.3 0.1	0.2 0.2 0.6		
Drosophilidae								
Sciaridae	5.5	2.6			0.4 0.3	0.2 0.2	0.7	0.3
Dolichopodidae	0.9	0.4						
Bibionidae	1.3	0.6						
Trixoscelidae	2.7	1.3						
EPHEMEROPTERA								
Baetidae	0.0	0.4						
Duns					0.7	0.4		
Amphizoidae					1.4	0.5		
COLEOPTERA					0.4	0.2		
Lathridiidae					0.6	0.3		
Hydrophilidae	0.3	0.1						
Curculionidae	0.3	0.1			0.6	0.3	0.2	0.8
Carabidae	0.3	0.1						
Buprestidae	1.2	0.6						
HEMIPTERA			0.3	0.2				
Reduviidae			0.8	0.4				
Corixidae	0.2	0.7	0.3	0.1			1.7	0.4
Veliidae	0.3	0.2						
Gerridae	0.8	0.3	0.3	0.2				
Hydrophilidae			0.8	0.4				
HOMOPTERA					2.4	1.3		
Lepidosaphes							0.8	0.3
Aphididae	14.2	6.9	3.5	1.7	2.4	1.3	2.6	1.4
Cicadellidae	0.2	0.7	1.1	0.5				
HYMENOPTERA					1.3	0.7		
Apidae								
Formicidae	0.2 1.6	0.8 0.7	2.4	1.2	0.5 1.8	0.9 0.2	0.3	0.1
Maseridae								
Spheidae			0.1	0.7				
Mymaridae	0.9	0.4						
Dupridae	0.1	0.6						
Platygasteridae	0.2	0.8						
THYSANOPTERA								
Thripidae	0.1	0.7	0.3	0.2	0.2 0.2	0.8 0.8	0.3	0.1
TRICHOPTER								
Unk trich adult	0.7	0.3					0.6	0.2
UNKNOWN	0.8	4.7			0.2	0.1	0.9	0.3
ARACHNID	1.9	0.9	1.1	0.5	0.3	0.1	0.4	0.1
OSTEICHTHYES	0.5	0.2	0.9	0.5	0.4	0.2	0.8	0.3
Cottidae					0.5	0.2	0.2	0.8
Coenagridae	0.3	0.1						
Collembola	0.9	0.4			1.4	0.8	0.2	0.7
Aeshnidae	3.7	1.8						
Pentatomidae							0.5	0.2
	27.4	1.0	21.3	1.o	191.a	1.0	265.7	100.0

Chironomidae pupae at 19.0% and Heptageniidae at 11.4%. Mean densities of benthic macroinvertebrates collected in drift samples by sample site and month can be found in Appendix C.

Shannon-Weiner diversity for benthic macroinvertebrates was highest in Alder Creek with a value of 3.85 (Table 3.41). The next highest value was 3.72 for Evans Creek. Hell's Gulch had the lowest diversity index at 2.74.

Diversity values calculated for the drift ranged from 4.14 for Benewah Creek (Table 3.42) to 1.27 for Fighting Creek.

Table 3.41. **Shannon-Weiner diversity** indices for benthic macroinvertebrates **collected in each tributary.**

	Benewah	Lake	Alder	Evans	Plummer	Fighting	Hells'Gulch
# of Taxa	52	38	44	42	33	28	18
# of indiv.	6553	1084	2380	5082	2015	619	434
Shannon-div.	3.26	3.35	3.85	3.72	3.25	3.07	2.74

Table 3.42. Shannon-Weiner diversity indices for organisms collected in the drift **for each tributary.**

	Benewah	Lake	Alder	Evans	Plummer	Fighting	Hells'Gulch
# of Taxa	61	43	38	39	42	45	18
# of indiv.	959	699	830	1963	807	3465	195
Shannon-div.	**4.14**	3.53	3.67	3.40	3.06	**1.27**	2.63

4.0. DISCUSSION

Land use practices within each selected watershed has contributed to the degradation of the fishery resources on the Coeur d'Alene Indian Reservation. Major habitat problems associated with the area include high sediment input from non-point sources, including agricultural (grazing and farming) and, silvacultural practices. Some stream systems are located in low elevation drainages in which snow melt run-off and rain events are the primary sources of water. These drainages, due to flow constraints (zero flow in summer) and adverse land use practices within the basins, have limited resident fish production potential. However, some drainages offer more extensive and renewable water sources, in which land-use practices can be controlled or modified to enhance the habitat quality and quantity for cutthroat trout. A combination of hatchery production and natural habitat enhancement should be utilized to restore these populations. A limited number of bull trout were collected on reservation waters, suggesting that enhancement efforts should be principally directed towards the restoration of current resident species populations (i.e., cutthroat trout). However, since bull trout populations appear to be in precipitous decline, efforts should also be made to enhance bull trout via hatchery production.

Relative abundance and population data showed that cutthroat trout densities, compared to other Idaho streams, are low for all surveyed tributaries except for Evans Creek. Densities in Evans Creek were comparable to other similar tributaries within the state of Idaho (Table 4.1). For those tributaries which contained brook trout, densities were also comparable to other similar tributaries within the area (Table 4.2).

Cutthroat trout growth rates were low compared to other Idaho streams except those growth rates of fish in Benewah Creek (Table 4.3). Benthic densities were high compared to other Idaho streams suggesting that food production is not a fish population limiting factor (Table 4.4). Specific problems, with a detailed discussion on each individual creek follows

Table 4.1 Comparison of cutthroat trout densities (#/100m^2).

Location	Density	Reference
Coeur d'Alene River Tributaries.		
Brown Creek, ID.	9.3	Apperson et al., (1988)
Copper Creek, ID.	1.6	Apperson et al., (1988)
Cougar Gulch, ID	18.3	Apperson et al., (1988)
Evans Creek, ID (1984)		
Site 1	27.5	Apperson et *al.,* (1988)
st. Joe Tributaries.		
Benewah Creek (1984)		
Site 1	1.4	Apperson et al., (1988)
Site 2	3.2	
Site 3	1.7	
Bond Creek		
Site 1	1.6	Apperson et *al.*, (1988)
Site 2	4.0	
Trout Creek		
Site 1	14.5	Apperson et *al.*, (1988)
Site 2	58.6	
St. Maries River Tributaries		
Alder Creek (1984)		
Site 1	3.8	Apperson et al., (1988)
Site 2	14.2	
Merry Creek		
Site 1	7.6	Apperson et *al.,* (1988)
Site 2	26.0	
Tributaries in current study		
Benewah Creek, ID		
Site 1	0.0	Present study
Site 2	0.7	Present study
Site 3	3.6	Present study
Alder Creek, ID		
Site 1	2.3	Present study
Site 2	1.4	Present study
Site 3	1.4	Present study
Site 4	0.9	Present study
Lake Creek, ID		
Site 1	13.4	Present study
Site 2	10.8	Present study
Site 3	6.8	Present study
Site 4	0.9	Present study
Evans Creek, ID		
Site 1	22.7	Present study
Site 2	9.0	Present study
Site 3	24.1	Present study

Table 4.2 Comparison of eastern brook trout densities (#/100m^2).

Location	Density	Reference
Copper Creek		
Site 1	2.6	Apperson et *al.,* (1988)
Site 2	4.6	
Aider Creek (1984)		
Site 1	0.0	Apperson et *al.,* (1988)
Site 2	3.6	
Fortier Creek	4.2	Apperson et *al.,* (1988)
Benewah Creek (1984)	1.4	Apperson et *al.,* (1988)
Reeds Gulch	132.5	Apperson et *al.,* (1988)
Homor Creek, ID	31.3	Corsi & Elle (1989)
Leiberg Creek, ID	0.1	Gamblin (1987)
Alder Creek		
Site 1	4.2	Present study
Site 2	2.9	Present study
Site 3	19.8	Present study
Site 4	20.0	Present study

Table 4.3. Comparison of mean back-calculated lengths at annulus formation for cutthroat trout.

	(Length at annulus formation)					
	1	2	3	4	5	6
Tributaries to Priest Lake (Carlander, 1969)	86	127	170	201	254	-
N.Idaho Tributaries (Carlander, 1969)						
Upper	53	102	152	224		
Lower	71	135	226	292		
Adfluvial	71	140	216			
East River, Priest River drainage, N. Idaho (Horner 1987)	95	136	171			
Big Creek, Priest River drainage, N. Idaho (Horner 1987)	81	121	154	177		
Skookum Creek, WA (Barber et *al.* 1989)	101	136				
Cee Cee Ah Creek, WA (Barber et *al.* 1989)	94	134				
Tacoma Creek, WA (Barber et *al.* 1989)	101	140	182			
LeClerc Creek, WA (Barber et *al.* 1989)	93	137	178			
Benewah Creek, N. Idaho (Present study)	68	118	176	252	289	-
Alder Creek, N. Idaho (Present study)	67	103	142			
Lake Creek, N. Idaho (Present study)	60	107	135			
Evans Creek, N. Idaho (Present study)	67	101	138	185		
Fighting Creek, N. Idaho (Present study)	53	97	140			
Plummer Creek, N. Idaho (Present study)	70	124	175	211	253	-

Table 4.4. Comparison of benthic macroinvertebrate densities and diversity indices from Coeur d'Alene tributaries with other streams of similar stream order.

Location	Stream order	Density #/m^2	Diversity	Sampling device	Reference
Firehole River,WY		940		Hess	(Armitage, 1958)
Chamokane Creek, WA.	3	53,569	3.27	Hess	(O'Laughlin et *al.* 1988)
Mink Creek, ID. (1968)	3	6,900		Hess	(Minshall, 1988)
Mink Creek, ID (1969)	3	21,000	3.7	Hess	(Minshall, 1981)
Gold Creek, ID.	3	549		Surber	(Oien, 1957)
N. Fork Coeur d'Alene River, ID		4359.5	2.9	Surber	(Savage, 1970)
Crystal Creek, ID	3	602.5		Surber	(Oien, 1957)
Silver Creek, ID	3	688.7		Surber	(Oien, 1957)
Benewah Creek, ID		2535	3.26	Hess	(Present study)
Alder Creek, ID		1205	3.85	Hess	(Present study)
Evans Creek, ID		2885.6	3.72	Hess	(Present study)
Lake Creek, ID		1708.3	3.35	Hess	(Present study)
Plummer		*	3.06	Hess	(Present study)
Fighting		*	3.07	Hess	(Present study)
Hell's Gulch		*	2.74	Hess	(Present study)

4.1. TARGET TRIBUTARIES

Target tributaries were chosen based on their relative high quality fisheries habitat and potential habitat enhancement opportunities. These tributaries included Lake, Benewah, Evans and Alder creeks.

4.1.2. Lake Creek

The major potential limiting factor restricting the fisheries resources in Lake Creek is the excessive Amount of fine sediment accumulated in the spawning substrate. Inadequate rearing habitat also potentially limits cutthroat trout production. No information was available to determine if over-wintering habitat was a limiting factor (Table 4.5).

Elevated substrate embeddeness directly affects spawning and rearing success. Spawning substrate covered with fine silt creates insufficient interstitial space necessary for gas exchange. This condition reduces egg to alevin survival (Bjornn 1969). Pools also have become filled by fine sediment. This, in turn, has reduced pool depths and smothered invertebrate populations thus contributing to reduced rearing success. Inadequate riparian overhanging vegetation further exacerbates this habitat condition. In a study conducted by the Kootenai-Shoshone Soil Conservation District in 1991, suspended sediment loads as high as 50 tons and turbidity levels as high as 140 NTU's during peak spring runoff were recorded. Without a reduction in sediment, recruitment below optimal habitat conditions will remain.

Cutthroat trout densities in Lake Creek suggest that a depressed but viable population of cutthroat trout exists. Relative abundance estimates indicated that 0+ through 3+ fish were common in Lake Creek suggesting some success in spawning and emergence. The percent of success could not be determined since no data was collected on spawners. This will be addressed in next years work. Population estimates ranged from 0.9 fish/l 00 m^2 to 13.4 fish/l00 m^2. This indicated that Lake creek is potentially underseeded (Bjorn 1978).

Table 4.5. Factors that are potentially limiting trout production (based on ground **surveys and biological** data collection) in selected Coeur d'Alene **tributaries, ID.**

Stream name	Spawning habitat Qual.	Spawning habitat Quant.	Rearing habitat Qual.	Rearing habitat Quant.	over-wint. habitat Qual.	over-wint. habitat Quant.	Sediments	H20 quantity	Temp.	Comments
Fighting/B&grove	*	*	*	*	*	*		*	*	Low base flow and high temp.
Squaw	*	*	*	*	t	*		*	*	Interm. cond.
Hell's Gulch	*	*	*	•	⊠	⊠		⊠	⊠	Interm. cond.
Plummer/L. Plummer	*	*	*	*	•	⊠		•	⊠	Low base flow and high temp.
Lake Creek	•		*		◊	◊				high % embedd exists.
Evans					0	0				
Alder					0	0				Falls may create a high water barrier
Benewah					0	0				

• determined to be a potential limiting factor.
could be a potential limiting factor.
0 not enough information to determine if a potential limiting factor.

Growth rates of cutthroat trout were low compared to other Idaho trout streams. This may be due to excessive sediment input which causes high turbidity levels. Negative effects of growth on trout have been recorded at an exposure of 25 NTU for several days. (Carlander, 1969). It has been documented that levels of 25 NTU's or more affect the trouts ability to visually recognize and capture food prey items. NTU levels of 50 can also cause displacement of salmonids who avoid such turbid waters to rear and feed.

Food availability in Lake Creek was lower than in other study sites, however in general these densities were higher than in other Idaho streams. As demonstrated in section 3.2, embeddeness rates were most elevated in Lake Creek, which potentially reduces invertebrate colonization.

4.1.3. Benewah Creek

Benewah Creek was also picked as a target tributary. Potential limiting factors associated with the Benewah Creek drainage range from quantity and quality of spawning habitat, quality of rearing habitat associated with low flows and high water temperatures during summer. No data on over-wintering habitat is available and will be collected next year Table 4.5).

Factors affecting spawning habitat include sediment input from non-point sources, including silvacultural and livestock grazing practices. Low flows in early summer limit the amount of "washing" the gravels receive, therefore, redds become filled with fine particles. This has the potential to lower emergence success. Bank sloughing is a common occurrence in the middle and upper reaches of Benewah. Little riparian vegetation remains to stabilize and protect the banks.

Rearing habitat is limited to scour holes and beaver ponds in the upper reaches where heavy livestock grazing occurs. Pools are filled with siltly materials and contain very little instream and overhang cover. Temperatures in these pools are in excess of 20°C in summer. These pools are utilized more by red-side shiners and dace *spp.* found in the system.

Cutthroat trout densities were low in Benewah Creek. Most fish captured were between 0-3+ years. This suggests that a limited amount of emergence does take place in Benewah yearly. The percent survival could not be determined since data was not collected on spawners. Population estimates conducted in October suggest that the stream is underseeded for cutthroat trout.

Growth rates for cutthroat trout in Benewah were comparable to other Idaho trout streams. The food base was thought not to be limiting in Benewah since densities were above those of other Idaho trout streams.

The major problem with Benewah Creek is the severe degradation of riparian habitat associated with cattle grazing, and the input of sediment from bank sloughing and silvacultural practices. Restoration of the fisheries habitat associated with Benewah Creek may be achieved using land-owner eduction, fencing and revegetation of the riparian area.

4.1.4. Evans Creek

Evans Creek was also chosen as a primary tributary. No factors were directly designated as potentially limiting factors for Evans Creek (Table 4.5). However, cumulative land use practices in the drainage will eventually result in severe habitat degradation. No information on over-wintering habitat is available for Evans Creek and will be addressed in next years work. The major areas of concern in Evans Creek are silvacultural practices and limited widespread livestock grazing.

In the lower reaches of Evans Creek grazing practices have eroded stream banks. Sediment deposition is elevated in this area. This area can serve only as a migration corridor for adfluvial/fluvial cutthroat trout. No spawning and limited rearing habitat exists in the lower reach.

Spawning gravels are abundant in the middle reach of Evans Creek. Some sediment deposition occurs in low gradient areas due to non-point sediment recruitment as a result of silvacultural practices and grazing activities in this area.

Cutthroat trout densities in Evans Creek were the highest of all streams in this survey. Electrofishing surveys resulted in the capture of only cutthroat trout and sculpin spp. in Evans creek. Ages of cutthroat trout ranged from O-4+ fish. Population estimates for Evans Creek ranged from 9.0 fish/l00 m2 to 24.1 fish/l00 m2. These are the highest cutthroat trout densities obtained in surveyed streams but is still low compared to other Idaho streams. This suggests that cutthroat trout may be underseeded in this drainage. There seems to be a resident as well as adfluvial stock of cutthroat present in Evans Creek. However, the extent of each is undetermined at this time and will be addressed further next year.

Cutthroat trout growth and condition was also lower in comparison to other streams of the area. Benthic densities and diversities were determined to be good in comparison with other streams of similar size. Growth may be lower due to the limited amount of rearing habitat as well as intraspecific competition within selected areas.

Restoration alternatives for Evans Creek includes limiting livestock access along stream banks, preventing vehicular traffic within the stream channel and controlling erosional processes connected with silvacultural practices. Promoting bank stability in the lower section via riparian revegetation and fencing is also needed.

4.1.5. Alder Creek

No conclusive potential limiting factors could be established for Alder Creek (Table 4.5). However, cumulative land use practices including silvacultural and livestock grazing practices are the major activities that have contributed to non-point source sediment input. Over-wintering habitat was not assessed during the study period and will be addressed next year. A potential migration barrier exists on Alder Creek. Approximately one and half miles from the mouth a ten-to-fifteen foot cascade-like waterfall prevents passage of cutthroat to numerous stretches of spawning gravels.

Spawning habitat below the falls is somewhat limited, however, if access above the falls is provided, quantity of spawning habitat would not be a problem. Grazing and silvacultural practices have impacted the amount of siltation located within the stream channel, Rearing habitat is abundant above the falls, with adequate instream as well as overhanging cover.

A major problem associated with cutthroat trout survival in Alder Creek, excluding the waterfall, is the number and density of eastern brook trout located in the upper areas. Cutthroat trout densities were very low with no young of year fish being captured. Age classes captured included 3 and 4 year old fish above the falls. No data was collected below the falls due to an access problem.

However, data will be collected next year to determine species densities below the falls. Eastern brook trout densities in Alder Creek were high with all age classes O-3+ being captured. This indicates a healthy viable population of eastern brook trout exists in Alder Creek. Population estimates conducted in October indicated that cutthroat trout were present but in very low numbers, whereas, eastern brook trout were very abundant. This suggests a possible reason for the low numbers of cutthroat trout. According to (cite reference)when cutthroat and brook trout exist in the same reach of stream, brook trout will actively displace cutthroat trout.

Management considerations for Alder Creek include the possibility of modifying the falls to provide adequate up and downstream passage, actively removing brook trout, while restocking cutthroat trout, as well as, limiting cattle access to stream banks and controlling erosion from silvacultural actives.

4.2. NON-TARGET TRIBUTARIES

Non-targeted tributaries are those streams that were eliminated from intensive physical and biological evaluation. Those non-targeted tributaries are; Bellgrove, Fighting, Sqauw, Plummer, Little Plummer creeks and Hell's Gulch. These streams were eliminated from further studies based on the results of the Missouri habitat evaluation method (see section 3.1.).

Factors that were considered to be potentially limiting trout production in these non-targeted streams include; lack of spawning, rearing, and overwintering habitat as well as temperature, water quantity and passage (Table 4.5).

Spawning gravels in all Coeur d'Alene tributaries are covered by large quantities of silt. The quantity and quality of this spawning habitat has been affected by land use practices within the basins. These practices include, but are not limited to; grazing, agriculture, silvaculture and other land-use activities.

Rearing habitat is affected by high water temperatures during summer and insufficient flow regimes. Maximum water temperatures associated with juvenile cutthroat trout is 15°C (Pratt, 1984, Baltz et *al* 1987). Elevated water temperatures observed in these systems during the summer months exceeded this maximum preference limit. Summer cover for cutthroat trout is normally associated with deep lateral scour and plunge pools with abundant cover (Peters, 1988). In stream habitat showed little diversity with deep pools lacking. The predominate habitat type observed for all non-target streams was shallow riffles and runs with depths averaging 3-6 inches. Overhanging bank vegetation was predominantly sparse. These habitat characteristics in addition to elevated substrate embeddeness levels all contribute to the degraded quality of spawning, rearing and overwintering fish habitat.

Relative abundance estimates conducted on these streams indicated that low populations of resident trout species exists. These low abundances were predicted given the lack of quality habitat.

4.3. CONCLUSION AND RECOMMENDATIONS

The economy of the Coeur d'Alene basin is centered around agriculture and timber production. However, tourism in northern Idaho is also on the rise, and is the fastest growing business in the area. With new restrictions being imposed on the timber industry and the shift towards tourism in northern Idaho, the basins focus must be shifted towards enhancement of the resources, including, clean water and the fisheries potential of the area.

In order to have an increase in the trout fishery in all selected targeted tributaries erosion control practices must be implemented and maintained. Sediment loads in all targeted streams must be reduced in order to maintain a viable cutthroat trout population. Also, access by livestock must be limited to allow revegetation of stream banks. This may include land owner education as well as fencing of certain sections of the stream channels. lnstream enhancement techniques will also be important to establish cover, and alter pool-riffle ratios.

Due to the low numbers of cutthroat trout found in all surveyed stream sections, hatchery supplementation, along with habitat enhancement efforts, will be the only viable way of increasing stock size. This is also true for the bull trout stocks present within these tributaries.

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APPENDIX A

Table A.1. Parameter and function description and values for Bellgrove Creek.

Parameter Function	Description	Value
P_1	1 Concrete bridge abutment, 3/4 miles from the mouth, causing a drop of a foot.	5
P_2	5-10% of watershed in urban development.	8
P_3	App. 45% of banks protected by perennial vegetation with fair canopy cover.	5
P_4	All segments show evidence of occasional erosion.	5
P_5	50% protected.	5
P_7	Substrate suitability poor to unacceptable	2
f_1	Minor, in lower part.	0.96
f_2	No impoundments	1.0
f_3	High turbidity causing water quality problems.	0.5
f_4	Upper stream has high silt percentages.	0.7
f_5	Channel becomes intermittent in summer	0.5
f_6	Average maximum water temperatures above 19°C.	0.25
f_7	Poor habitat for all life history stages.	0.1
HI value		0.024

Table A.2. Parameter and function description and values for Squaw Creek.

Parameter/ Function	Description	Value
P_1	Minor manmade obstructions to free fish passage.	9
P_2	5-10% of watershed in urban development	8
P_3	App. 90% of banks protected by perennial vegetation with fair canopy cover.	9
P_4	Some segments show evidence of occasional erosion.	7
P_5	70% of watershed protected by land use practices.	7
P_7	<1% of watershed controlled by irrigation. <5% controlled by domestic withdrawals	10
f_1	5% of channel modified due to channel realignment.	0.96
f_2	No impoundments	1.0
f_3	No pollutants detected	1.0
f_4	No apparent unstable material in channel	1.0
f_5	Channel becomes intermittent in early spring.	0.1
f_6	Water temp. below 14°C.	1.0
f_7	Poor habitat for all life stages.	0.1
HI value		0.08

Table A.3. Parameter and function description and values for Fighting Creek.

Parameter Function	Description	Value
P_1	1 concrete bridge abutment, 3/4 miles from the mouth, causing a drop of a foot	5
P_2	5-10% of watershed in urban development.	8
P_3	App. 60% of banks protected by perennial vegetation with fair canopy cover.	6
P_4	All segments show evidence of occasional erosion.	5
P_5	60% of watershed protected by land use practices.	6
P_6	<1% of watershed controlled by irrigation. <5% controlled by domestic withdrawals.	10
P_7	Substrate suitability unacceptable for spawning and emergence.	1
f_1	5% of channel modified due to channel realignment	0.96
f_2	No impoundments.	1.0
f_3	Water quality influenced by turbidity.	0.8
f_4	High silt percentages throughout the stream.	0.4
f_5	Channel becomes intermittent in late summer.	0.7
f_6	Average maximum water temperatures above 19°C.	0.25
f_7	Habitat limited for all life stages.	0.6
HI value		0.19

Table A.4. Parameter and function description and values for Hells' Gulch.

Parameter Function	Description	Value
Pl	Culvert at mouth and one mile upstream causing passage problems.	7
P2	510% of watershed in urban development.	8
P3	Approximately 90% of banks protected by perennial vegetation with fair canopy cover.	9
P4	Some segments show evidence of occasional erosion.	9
P5	80% of watershed protected by land use practices.	8
P6	<1% of watershed controlled by irrigation. <5% controlled by domestic withdrawals.	10
P7	Substrate suitability for spawning and emergence poor.	4
f l	App. one mile from mouth, 30% of stream has been realigned.	0.76
f2	Midstream reach impounded during a 1 in 50 year flood event.	0.5
f3	No pollutants detected.	1 .0
f4	Traces of fine material in quiet areas.	0.9
f5	Channel becomes intermittent in late spring.	0.25
f6	Average maximum water temperatures above 15°C.	0.75
f7	Poor habitat for all life stages.	0.1
HI value		0.05

Table AS. Parameter and function description and values for Plummer Creek.

Parameter/ Function	Description	Value
P_1	No manmade obstructions to free fish passage.	10
P2	<5% of watershed in urban development.	10
P3	App.90% of banks protected by perennial vegetation with fair canopy cover.	9
P_4	All segments show evidence of occasional erosion.	5
P_5	50% of watershed protected by land use practices.	5
P_6	<1% of watershed controlled by irrigation. <5% controlled by domestic withdrawals.	10
P7	Substrate suitability for spawners and emerging fry poor to unacceptable	3
fl	No significant channel modifications encountered.	1 .0
f_2	No impoundments.	1 .0
f_3	Water quality influenced by turbidity	0.8
f_4	Upper stream has high silt percentages.	0.7
f_5	Channel becomes intermittent in late summer.	0.5
f_6	Average maximum water temperatures above 18°C.	0.4
f_7	Poor habitat for adults and limited habital for other life history stages.	0.5
HI value		0.42

Table A.6. Parameter and function description and values for Little Plummer Creek.

Parameter/ Function	Description	Value
P_1	Large culvert two mile from confluence with Plummer Creek which caused a passage barrier.	8
P2	5-10% of watershed in urban development	8
P_3	50% of banks protected by perennial vegetation with fair canopy cover.	5
P_4	All segments show evidence of occasional erosion.	5
P_5	70% of watershed protected by land use practices.	7
P_6	<1% of watershed controlled by irrigation. <5% controlled by domestic withdrawals.	10
P7	Substrate suitability for spawning and emergence acceptable to poor.	5
f l	Approximately 0.5% channel realignment	0.996
f_2	No impoundments.	1 .0
f_3	No pollutants detected.	1 .0
f_4	Quiet areas covered by fine material, deep pools restricted to areas of greatest scour	0.8
f_5	Flow perennial, but passage problems due to low base flow.	0.65
f_6	Average maximum water temperatures 18°C and above.	0.4
f_7	Poor habitat for adults and limited habitat for other life stages.	0.5
HI value		0.71

Table A.7. Parameter and function description and values for Lake Creek.

Parameter/ Function	Description	Value
P_1	No manmade obstructions.	10
P_2	<5% of watershed in urban development.	10
P_3	App. 90% of banks protected by perennial vegetation with fair canopy cover.	9
P_4	Some segments show evidence of occasional erosion.	8
P_5	60% of watershed protected by land use practices.	6
P_6	5% of watershed controlled by irrigation <5% controlled by domestic withdrawals.	8
P_7	Substrate suitability acceptable to poor.	6
f_1	No significant channel modifications encountered.	1.0
f_2	No significant impoundments.	1.0
f_3	Low pH and high turbidity in west fork of Lake Creek caused water quality problems in mainstem.	0.85
f_4	Silt present in stream bed with areas of heavy deposition.	0.95
f_5	Perennial flow with no passage problems	1.0
f_6	Average maximum water temperatures 17°C and above.	0.5
f_7	Adequate habitat for all life stages.	0.95
HI value		3.12

Table A.8. Parameter and function description and values for Benewah Creek.

Parameter/ Function	Description	Value
P_1	No manmade obstructions.	10
P2	<5% of watershed in urban development.	10
P3	60% of banks protected by perennial vegetation with fair to limited canopy cover.	6
P_4	Some segments show evidence of occasional erosion.	7
P_5	60% of watershed protected by land use practices.	6
P_6	<1% of watershed controlled by irrigation. <5% controlled by domestic withdrawals.	10
P7	Substrate suitability acceptable.	7
f l	No significant channel modifications.	1 .0
f_2	No impoundments.	1.0
f_3	No pollutants detected.	1 .0
f_4	Traces of unstable material in stream channel.	0.95
f_5	Perrianeal flow, but passage problems due to low base flow.	0.80
f_6	Average water temperatures higher then 17°C in places during summer.	0.5
f_7	Good habitat for all life stages.	1 .0
HI value		3.04

Table A.9. Parameter and function description and values for Evans Creek.

Parameter Function	Description	Value
P_1	No manmade obstructions.	10
P2	5-10% of watershed in urban development.	8
P3	50% of banks protected by perennial vegetation with fair to limited canopy cover.	4
P_4	All segments show evidence of occasional erosion, with continuous erosion in lower section of stream.	4
P_5	50% of watershed protected by land use practices.	5
P_6	<1% of watershed controlled by irrigation. <5% controlled by domestic withdrawals.	10
P7	Substrate suitability acceptable to good	8
f l	Some channel realignment in the lower stream channel.	0.96
f_2	No impoundments	1.0
f3	High turbidity during runoff	0.9
f_4	Traces to minor amounts of silt in stream channel.	0.85
f_5	Perennial flow, no passage problems.	1 .0
f_6	Water temperatures below 14°C.	1 .0
f_7	Good habitat for all life stages.	1 .0
HI value		4.93

Table A.IO. Parameter and function description and values for Alder Creek.

Parameter Function	Description	Value
P1	No manmade obstructions.	10
P2	<5% of watershed in urban development.	10
P3	90-100% of banks protected by perennial vegetation.	9
P4	Minor erosion of the floodplain.	10
P5	90% of watershed protected by land use practices.	9
P6	<1% of watershed controlled by irrigation. <5% controlled by domestic withdrawals.	10
P7	Substrate suitability acceptable to good.	8
fl	No significant channel modifications.	1 .0
f2	No impoundments.	1.0
f3	No pollutants detected.	1 .0
f4	Traces of unstable material in quiet areas in the upper section of stream.	0.9
f5	Perrianel flow with no passage problems.	1.0
f6	Average maximum water temperatures of 16°C.	0.65
f7	Good habitat for all life stages.	1 .0
HI value		5.52

APPENDIX B

Table B.l. **Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Lake Creek during June, 1991.**

Site Shock time (min) Shock Area (ft²)	Lower *	Middle 88.1 15,450	Upper 66.8 8820
Cutthroat trout		3 (2.2%)	-
Redside shiner		21 (15.2%)	-
Sculpin spp.		81 (58.7%)	33 (100%)
Western speckled dace		33 (23.9%)	
Total		**138**	**33**

Table B.2. **Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Plummer and Little Plummer creeks during June, 1991.**

Site Shock time (min) Shock Area (ft²)	Lower mainstem 125.4 17,130	Middle mainstem 92.7 16,080	Upper Little Plummer 147.9 12180
Cutthroat trout	4 (3.3%)	0	0
Eastern brook trout	2 (1.7%)	2 (1.0%)	1 (0.2%)
Redside shiner	0	31 (14.8%)	13 (2.6%)
Sculpin spp.	89 (73.6%)	0	0
Northern squawfish	4 (3.3%)	0	0
Western speckled dace	12 (9.9%)	176 (84.2%)	489 (97.2%)
Longnose sucker	10 (8.3%)	0	0
Total	**121**	**209**	503

Table B.3. **Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Fighting Creek during June, 1991.**

Site Shock time (min) Shock Area (ft²)	Lower 56.9 13,112	Middle*	Upper*
Cutthroat trout	25 (92.6%)		
Longnose sucker	2 (7.4%)		
Total	27		

Table 8.4. **Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Hell's Gulch Creek during June 1991.**

Site Shock time (min) Shock Area (ft²)	Lower 58.6 11,390.6	Middle*	Upper*
Cutthroat trout	1 (11.1%))		
Eastern brook trout	8 (88.8%)		
Total	9		

Table B.5. **Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Alder Creek during June 1991.**

Site Shock time (min) Shock Area (ft²)	Lower *	Middle 87.1 14,419	Upper 100.7 11,291.7
Cutthroat trout		1 (4.5%)	2 (.9%)
Eastern brook trout		3 (13.6%)	58 (25%)
Longnose sucker		6 (27.3%)	0
Sculpin spp.		12 (54.5%)	172 (74.1%)
Total		22	232

Table 8.6. **Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Evans Creek during June 1991.**

Site	Lower	Middle *	Upper
Shock time (min)	97.9		40
Shock Area (ft²)	8498		13,770
Cutthroat trout	17 (11.1%)		13 (15.7%)
Sculpin spp.	136 (88.9%)		70 (84.3%)
Total	**153**		83

Table 8.7. **Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Benewah Creek during June 1991.**

Site	Lower	Middle	Upper
Shock time (min)	152.1	114.9	59.3
Shock Area (ft²)	18,660	20,100	22,380
Cutthroat trout	6 (4.5%)	9 (5.2%)	0
Eastern brook trout	0	2 (1.2%)	1 (0.3%)
Longnose sucker	6 (4.5%)	4 (2.3%)	13 (4.0%)
Pumpkinseed	5 (3.7%)	1 (0.6%)	0
Redside shiner	17 (12.7%)	43 (24.9%)	123 (38%)
Sculpin spp.	27 (20.1%)	6 (3.5%)	1 (0.3%)
Northern squawfish	3 (2.2%)	1 (0.6%)	0
Western speckled dace	69 (51.5%)	107 (61.8%)	186 (57.4%)
Yellow perch	1 (0.7%)	0	0
Total	**134**	**173**	324

• represent areas that were inaccessible or otherwise posted.

APPENDIX C

Table C.I. Mean densities of benthic macroinverbrates (#/m2) collected in Hess samples from Benewah Creek during 1991, (samples sizes enclosed in parenthesis).

Month	Lower (X)	Middle (X)	Upper (X)	Total (X)
June	*	1986.7 (3)	550.0 (3)	1268.4 (6)
August	843.3 (3)	2753.3 (3)	3836.7 (3)	2477.8 (9)
October	3216.7 (3)	4950.0 (3)	3673.3 (3)	3946.7 (9)
Annual mean	2038.3 (6)	3230.0 (9)	2686.7 (9)	2564.3 (24)

Table C.2. Mean densities of benthic macroinvertebrates (#/m2) collected in Hess samples from Alder Creek during 1991, (sample sizes enclosed in parenthesis).

Month	Lower (X)	Middle (X)	Upper (X)	Total (X)
June		1640.0 (3)	773.3 (3)	1206.7 (6)
August		1730.1 (3)	128.7 (3)	929.4 (6)
October		896.7 (3)	2063.3 (3)	1480.0 (6)
Annual mean		1422.2 (9)	988.4 (9)	1205.4 (18)

Table C.3 Mean densities of benthic macroinvertebrates (#/m2) collected in Hess samples from Evans Creek during 1991, (sample sizes enclosed in paranthesis).

Month	Lower (X)	Middle (X)	Upper (X)	Total (X)
June		1523.3 (3)	2686.7 (3)	2105.0 (6)
August		2590.0 (3)	2686.7 (3)	2638.4 (6)
October		6026.7 (3)	1796.7 (3)	3911.7 (6)
Annual mean		3380.0 (9)	2388.9 (9)	2885.0 (18)

Table C.4. Mean densities of benthic macroinvertebrates (#/m2) collected in Hess samples from Lake Creek during 1991, (sample sizes enclosed in paranthesis).

Month	Lower (X)	Middle (X)	Upper (X)	Total (X)
June		*	**269.5 (3)**	**269.5 (3)**
August		**153.3 (3)**	**2686.7 (3)**	**1420.0 (6)**
October		333.3 (3)	1686.7 (3)	1010.0 (6)
Annual mean		243.3 (6)	2356.1 (9)	899.8 (15)

Table C.5. **Mean densities of benthic macroinverbrates (#/m3) collected in drift samples from Benewah Creek during 1991, (samples sizes enclosed in parenthesis).**

Month	Lower (X)	Middle (X)	Upper (X)	Total (X)
June	*	73.4 (2)	101.9 (1)	87.7 (3)
August	14.0 (2)	127.3 (2)	17.3 (2)	53.1 (6)
October	234.8 (2)	558.9 (2)	623.2(2)	472.3 (6)
Annual mean	124.4 (4)	253.2 (6)	247.5 (5)	1204.4 (15)

Table C.6. **Mean densities of benthic macroinvertebrates (#/m3) collected in drift samples from Alder Creek during 1991, (sample sizes enclosed in parenthesis).**

Month	Lower (X)	Middle (X)	Upper (X)	Total (X)
June		160.3 (2)	3.6 (2)	81.9 (4)
August		220.1 (2)	247.5 (2)	234.8 (4)
October		247.0 (2)	325.5 (2)	286.2 (4)
Annual mean		209.8 (6)	192.2 (6)	200.9 (12)

Table C.7. **Mean densities of benthic macroinvertebrates (#/m3) collected in drift samples from Evans Creek during 1991, (sample sizes enclosed in paranthesis).**

Month	Lower (X)	Middle (X)	Upper (X)	Total (X)
June		41.7 (2)	57.1 (2)	49.4 (4)
August		456.5 (2)	53.7 (2)	255.1 (4)
October	86.7 (2)	344.4 (2)	1046.4 (2)	492.5 (6)
Annual mean	28.9 (2)	280.9 (6)	385.7 (6)	249.2 (14)

Table C.8. **Mean densities of benthic macroinvertebrates (#/m3) collected in drift samples from Lake Creek during 1991, (sample sizes enclosed in paranthesis).**

Month	Lower (X)	Middle (X)	Upper (X)	Total (X)
June		•	307.5 (2)	307.5 (2)
August		5.1 (2)	446.1 (2)	225.6 (4)
October		84.0 (2)	4.2 (2)	44.1 (4)
Annual mean		44.6 (4)	252.6 (6)	192.4 (10)

FISHERIES HABITAT EVALUATION IN TRIBUTARIES OF THE COEUR d'ALENE INDIAN RESERVATION

ANNUAL REPORT 1992

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Project Number 90-044
Contract Number DE-BI79-90BP10544

OCTOBER 1993

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EXECUTIVE SUMMARY

Bull trout and cutthroat trout are two species of salmonids native to the Lake Coeur d'Alene system. Historically, these species were fished by the Coeur d'Alene Indians. Cutthroat trout were once the most abundant trout species in the Coeur d'Alene system. However, since 1932, cutthroat trout have declined significantly. In addition, bull trout numbers have been greatly reduced in the last 100 years, and are currently of special concern. The population decline of both fish species has been attributed to heavy metal pollution, habitat degradation caused by grazing, agriculture and silvaculture practices, overharvest, and lake elevation changes that occurred during construction and subsequent operation of Post Falls Dam. By 1967 cutthroat trout comprised only 4% of the total catch in Lake Coeur d'Alene according to Rankel (1968).

The objective of this study was to conduct a baseline stream survey of tributaries located within reservation boundaries. In this survey habitat information related to improving spawning and rearing habitat was compiled. Accessibility to spawning tributaries for cutthroat and bull trout and existing fish stocks were evaluated. Two years were spent collecting baseline data to assess population dynamics, growth rates, behavior patterns and factors potentially limiting the fishery. Preliminary fishery improvement opportunities were identified based on the results of these data.

Relative abundance data resulted in the capture of 1,881 fish from May, July and September, 1992. A total of 349 cutthroat trout were collected from all sampled tributaries. Evans Creek had the highest relative abundance of cutthroat trout at 98.8%. No bull trout were captured in any of the surveyed tributaries

Population estimates were conducted in September, 1992. Density estimates for cutthroat trout were 1.4 fish/l00 m^2 in Benewah Creek, 11.8 fish/l00 m^2 in Alder Creek, 1.5 fish/l00 m^2 in Lake Creek and 33.0 fish/l00 m^2 in Evans Creek. Density estimates were also determined for eastern brook trout in Aider Creek (6.1 fish/l 00m^2). No bull trout were captured in any surveyed section and are assumed to be absent from the study areas.

Growth rates and condition factors for cutthroat trout captured in each stream tended to be comparable to other streams in

North Idaho. Eastern brook trout growth and condition factors were also comparable to those found in other streams in the region. Bull trout growth rates and condition factors could not be assessed because no bull trout were captured during the study.

Migration trap data indicated that Lake and Benewah creeks had a remnant population of adfluvial cutthroat trout as well as a resident population of cutthroat trout. Stocks on Alder Creek could not be determined from the data collected and Evans Creek retained only a resident population of cutthroat trout.

Habitat surveys were conducted on each of the four streams. Surveys showed that habitat was a limiting factor for cutthroat and bull trout survival in most of the watersheds . Land use practices within each selected watershed has contributed to the degradation of the fishery resources on the Coeur d'Alene Indian Reservation. Major habitat problems associated with the area included insufficient overwintering and rearing habitat as well as high sediment input from non-point sources which included agricultural (grazing and farming) and silvacultural (timber) practices. Stream systems located in low elevation drainages received their primary sources of water from snow melt run-off and rain events. Due to flow constraints (zero flow in summer) and adverse land use practices within the basins, these drainages, had limited resident fish production potential. However, perennial drainages could have existing land-use practices modified to enhance the habitat quality and quantity for cutthroat and bull trout.

The Coeur d'Alene Tribe identified two biological objectives for their fishery: 1) Restore tributary populations of native cutthroat and bull trout, which were historically prominent in the Lake Coeur d'Alene system; and, 2) Increase subsistence harvest. In order to successfully accomplish the above objectives three major goals were identified:

1) Protect existing stocks of native trout species located within the Coeur d'Alene Indian Reservation's jurisdiction.

2) Expand populations of native cutthroat and bull trout to levels above endangerment of extinction; and

3) Reestablish self-sustaining populations of cutthroat and bull trout in the Couer d'Alene system.

The first recommendation is for complete closure of the cutthroat trout and bull trout fishing in reservation tributaries. These closures will help protect declining stocks from mortality due to angler harvest during spawning migrations and those juveniles rearing in the system.

The Idaho Department of Fish and Game (IDFG) has imposed special fishing regulations on cutthroat trout in the Couer d'Alene System. Closure of cutthroat fishing has already been established during spawning periods. IDFG has also closed all bull trout fishing in the Lake Coeur d'Alene system. The tribe fully supports all of these decisions. However, the Coeur d'Alene Tribe has reviewed their hunting/fishing regulations and has closed cutthroat and bull trout harvest by both tribal members and non-Indians on waters of the reservation.

The Coeur d'Alene Indian Tribes' long term goal is for the tributaries to support self-sustaining populations of cutthroat and bull trout. In order to accomplish this it will be necessary to conduct habitat enhancement measures and additional fisheries investigations. Our second recommendation is that habitat enhancement be conducted on four tributaries (Lake, Benewah, Evans and Alder creeks) at necessary locations to increase recruitment to the population.

Tributaries were surveyed extensively and were considered severely damaged and degraded due to land use practices which included agriculture, grazing and silvaculture. Problems encountered included eroding stream banks, massive sediment loading resulting in high embeddeness, insufficient canopy, instream and overhanging cover. Waterfalls and debris jams in some streams posed migration barriers for cutthroat and bull trout. Animal keeping practices within the system were also major problems associated with almost all drainages. Vehicular traffic within and crossing the stream channel were also common problems. Numerous unauthorized dump sites were observed along the stream corridor.

This recommendation was approved by the Council in their 1987 Columbia Basin Fish and Wildlife plan upon completion of a baseline survey of reservation tributaries, unless the Coeur d'Alene tribe recommended another alternative. The Coeur d'Alene Tribe recommends that BPA fund the advanced design, construction, operation and maintenance for habitat improvements mentioned.

Technical design, labor, construction, operation and maintenance of habitat improvements will be administered by the Couer d'Alene Tribe using funding provided by BPA.

Since overharvest has been a major problem in the Coeur d'Alene System for a long period of time even with protection measures previously mentioned, the current population of cutthroat and bull trout will probably not be sufficient for rapid repopulation of the tributaries to carrying capacity. Most likely it will take several decades to rebuild these populations solely by natural reproduction. Consequently it will be necessary to supplement native populations to accomplish the goal of population expansion.

For the reasons mentioned above the third recommendation the Coeur d'Alene tribe has is that Bonneville Power Administration (BPA) fund design, construction, operation and maintenance of a low capital hatchery for cutthroat and bull trout on the Couer d'Alene Indian Reservation.

This recommendation was approved by the Council in their 1987 Columbia Basin Fish and Wildlife plan upon completion of a baseline survey of reservation tributaries, unless the Coeur d'Alene tribe recommended another alternative. Results of the baseline survey recommend that BPA fund the design, construction, operation and maintenance of a low capital hatchery facility on the Coeur d'Alene Indian Reservation. Hatchery design, land acquisition and environmental assessment should commence in 1994. The Coeur d'Alene Tribe should operate and manage hatchery via funding from BPA. This will partially mitigate the Coeur d'Alene Tribe for anadromous fish losses. .

The above measure should be monitored to determine effectiveness as outlined in the Power Council's Adaptive Management Policy. Therefore, it is recommended that all fishery enhancement projects (habitat improvements and supplementation efforts) be monitored for a three-year period after implementation to determine their effectiveness. The monitoring program should include:

1.) Creel survey to determine the number of angler hours, catch per unit effort by anglers, and catch and harvest rates for each species.

2.1 Population estimates of both hatchery raised and wild cutthroat and bull trout to determine if populations increase owing to habitat enhancement and stocking

3.) Growth rates of hatchery and wild fish stocks.

4.) Abundance of preferred prey organisms to determine the effect of stocking different numbers of fish on the ecosystem.

5.) A mark recapture study with various ages of hatchery released cutthroat and bull trout to determine if they remain in the tributaries or migrate into Lake Coeur d'Alene. Assess effectiveness of different locations, age or size at release and time of release for outplanting.

6.) Periodic assessments and quantification of habitat to ensure continuance of habitat improvement benefits.

Monitoring of hatchery outplanting and habitat improvements will provide important knowledge upon which future management decisions can be based.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the following individuals for their assistance in field data collection and laboratory analysis: George Aripa, Oswald George, Sam Sanchez, Ed Wolfe, Diana Richards, Mindy Sheer, John Raymond, Philip Lillengreen and Vance Lillengreen. Philip Cernera and Chuck Finan for thier assistance in editing the final report. Funding was provided by the U.S. Department of Energy, Bonneville Power Administration, Contract number 909-044-00. Additional financial support for this project was provided by a grant from the U.S. Department of the Interior, Bureau of Indian Affairs to the Upper Columbia United Tribes (UCUT) to fund the operation of the UCUT Fisheries Center at Eastern Washington University. All capital equipment for this project was supplied by the UCUT Fisheries Center. Special thanks go to Bob Austin (BPA Project Manager), Dr. Allen Scholz (UCUT Director), and Ernie Stensgar, (Chairman, Coeur d'Alene Tribal Council), for their assistance.

1 .O. INTRODUCTION

In 1987 the Northwest Power Planning Council amended the Columbia River Basin Fish and Wildlife Program, directing the Bonneville Power Administration (BPA) to fund, *"A baseline stream survey of tributaries located on the Coeur d'Aiene Indian Reservation to compile information on improving spawning habitat, rearing habitat, and* access *to spawning tributaries for bull trout (Salvelinus confluentus), cutthroat trout (Oncorhynchus clarki), and to evaluate the existing fish stocks. If justified by the results of the survey, fund the design, construction and operation of a cutthroat and bull trout hatchery on the Coeur d'Alene Indian Reservation; necessary habitat improvement projects; and a three year monitoring program to evaluate the effectiveness of the hatchery and habitat improvement projects. If the baseline survey indicates a better alternative than construction of a fish hatchery, the Coeur d'Alene Tribe will submit an alternative plan for consideration in program amendment proceeding."* In 1990, BPA contracted the Coeur d'Alene Tribe to perform this study. This report contains the results of the third year of the study and the Coeur d'Alene Indian Tribes' preliminary recommendations for enhancing the cutthroat and bull trout fishery on the Coeur d'Alene Indian Reservation. These recommendations are based on study results from year three data and information obtained in the first two years of the study.

1.1. Fisheries Management History of the Coeur d'Alene Basin.

See Graves *et al.* (1991) for a discussion of the past history of the study area.

1.2. Summary of 1990 and 1991 Findings

Twenty-one creeks, flowing into Lake Coeur d'Alene, and the St. Joe and St. Maries rivers, were initially identified within the study area as having habitat potentially suitable for trout species. **Data obtained from an aerial survey further determined that only ten** of the original twenty one creeks located within the Coeur d'Alene Indian Reservation contained potential trout habitat (Graves *et a/.* 1991). These tributaries included:

Fighting	Plummer
Bellgrove	Benewah
Lake	Hell's Gulch
Squaw	Evans
Little Plummer	Alder

The Missouri method of evaluating stream reaches was modified and used to rank the ten tributaries (Fajen and Wehnes 1981). This ranking, in combination with biological information collected, were used to determine the four streams with the best potential cutthroat and bull trout habitat. This work was accomplished by D. Chad Johnson for his masters thesis.

Biological data collected on the ten streams included; relative abundance data, trout population estimates, growth rates and benthic macroinvertebrate densities (Lillengreen et al 1993). Relative abundance data resulted in the capture of 6,138 fish from June, August and October, 1991. A total of 427 cutthroat trout were collected from all sampled tributaries. Relative abundance of cutthroat trout for all tributaries was 6.7%. Fighting Creek had the highest relative abundance of cutthroat trout (93.1%). Evans Creek, Lake Creek, Hells Gulch, Alder Creek, Benewah Creek, and Plummet-/Little Plummer creeks had relative abundances of 30.8%, 12.1%, II.I%, 3.3%, 2.1% and 0.5%, respectively. No bull trout were captured in any of the surveyed tributaries (Lillengreen *et al.* 1992).

Population estimates were conducted in only four of the ten tributaries due to intermittent stream conditions found during the summer on the other six selected streams. The four streams in which population estimates were conducted included Benewah, Alder, Evans and Lake creeks. Density estimates for cutthroat trout were 1.2 fish/l 00 m2 in Benewah Creek, 1.5 fish/l00 m2 in Alder Creek, 8.1 fish/l00 m2 in Lake Creek and 18.9 fish/l 00 m2 in Evans Creek. Density estimates were also determined for eastern brook trout in Alder Creek (11.8 fish/100m^2). No bull trout were captured in any surveyed section and are assumed to be absent from the study areas.

Growth rates and condition factors for cutthroat trout captured in each stream tended to be low in comparison to other streams in the region except for Benewah Creek (Lillengreen *et al.* 1992). Growth rates for cutthroat trout existing in Benewah Creek were comparable to other streams in the region. Eastern brook trout growth and condition factors were also comparable to those found in other streams in the region. Bull trout growth rates and condition factors could not be assessed because no bull trout were captured during the study.

Mean annual invertebrate densities in the tributaries ranged from 1,206 organisms/m2 in Alder Creek to 2,886 organisms/m2 in Evans Creek. Mean annual densities in the drift ranged from 21. organisms/m2 in Alder Creek to 266 organism/m2 in Evans Creek. Invertebrate densities were similar to other streams of the same size in the region. For a more detailed breakdown of invertebrate densities reference Lillengreen *et al.* (1992).

Land use practices within each selected watershed have contributed to the degradation of the fishery resources on the Coeur d'Alene Indian Reservation. Major habitat problems associated with the area included high sediment input from non-point sources which included agricultural (grazing and farming) and silvacultural (timber) practices. Stream systems located in low elevation drainages received their primary sources of water from snow melt run-off and rain events. Due to flow constraints (zero flow in summer) and adverse land use practices within the basins, these drainages, had limited resident fish production potential. However, perennial drainages could have existing land-use practices modified to enhance the habitat quality and quantity for cutthroat and **bull** trout.

Four out of the ten tributaries, Lake, Benewah, Evans and Alder creeks were chosen for further study based on their relatively high quality fisheries habitat and potential habitat enhancement opportunities.

1.3. Study Objectives

The objectives of this study were to:

* Conduct in-depth habitat evaluations of the four primary tributaries which included; estimates of amount of habitat (ie pools, riffle, cascades and side channels), estimate of instream and overhang cover; mass wasting (slope failure); bank cutting; vegetative type; and seral stage along stream corridor.

* Determine the population dynamics of trout species present in each tributary.

* Determine migratory behavior patterns of trout in each stream in order to assess stocks present (adfluvial, fluvial, or resident).

* Assess age, growth and condition of cutthroat and bull trout.

* Determine extent and effectiveness of cutthroat and bull trout spawning.

* Identify alternatives for restoring cutthroat and bull trout; Identify biological habitat restoration alternatives

* establish biological objectives based on restoration alternatives.

2.0. METHODS AND MATERIALS

2.1. Description of the Study Area.

The Coeur d'Alene drainage basin is located in the Idaho panhandle and extends approximately 9,583 square kilometers. It is divided into two subbasins, including the Coeur d'Alene River basin and the St. Joe River basin. The remainder of the drainage basin consists of streams flowing into Wolf Lodge, Corbin, Windy, Rockford, Mica and Cougar bays of Lake Coeur d'Alene (Figure 2.1).

The study area included four tributaries located within the Coeur d'Alene drainage basin; Lake, Benewah, Evans and Alder creeks.

The Lake Creek watershed (Figure 2.2) is located in southwest Kootenai County, Id. and southeast Spokane County, WA. Lake Creek discharges into Lake Coeur d'Alene at Windy Bay. Lake Creek is a third order stream and is approximately 21 kilometers long. Over half of the watershed is forested land while the remainder is agricultural land. Lake Creek is used as a domestic, as well as a limited livestock, water source.

The Benewah Creek watershed (Figure 2.3) is located in Benewah County, Id. and is a fourth order stream. Benewah Creek discharges in the southern portion of Benewah Lake, which since the raising of the water levels associated with the Post Falls Dam, is part of Lake Coeur d'Alene. Benewah Creek is approximately 24 kilometers long. Predominate land use practices within the watershed are grazing, timber and residential uses.

The Evans Creek watershed (Figure 2.4) is located in Kootenai County, Id. and is a second order stream. Evans Creek discharges into Medicine Lake, a lateral lake associated with the Coeur d'Alene River. Evans Creek is approximately ten kilometers long. Land uses associated with Evans Creek include silvaculture, grazing and residential uses. Evans Creek is used as a domestic and livestock water source.

The Alder Creek watershed (Figure 2.5) is located in Benewah County, Id. and is a fourth order stream. Alder Creek discharges into the St. Maries River and is approximately 20 kilometers long. The major land use practices within the watershed are

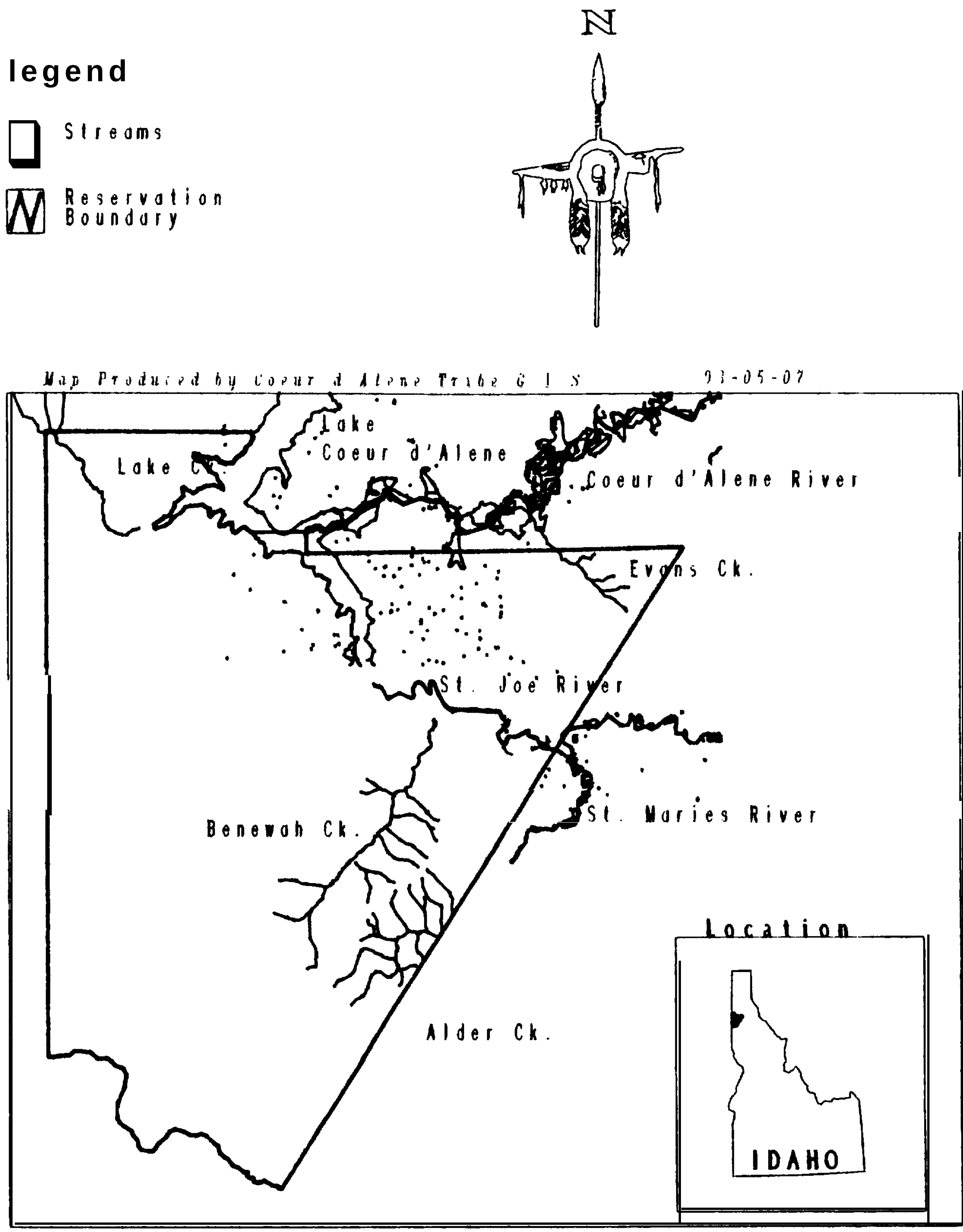

figure 2.1 Map Of the Coeurd'Alenelake Drainage

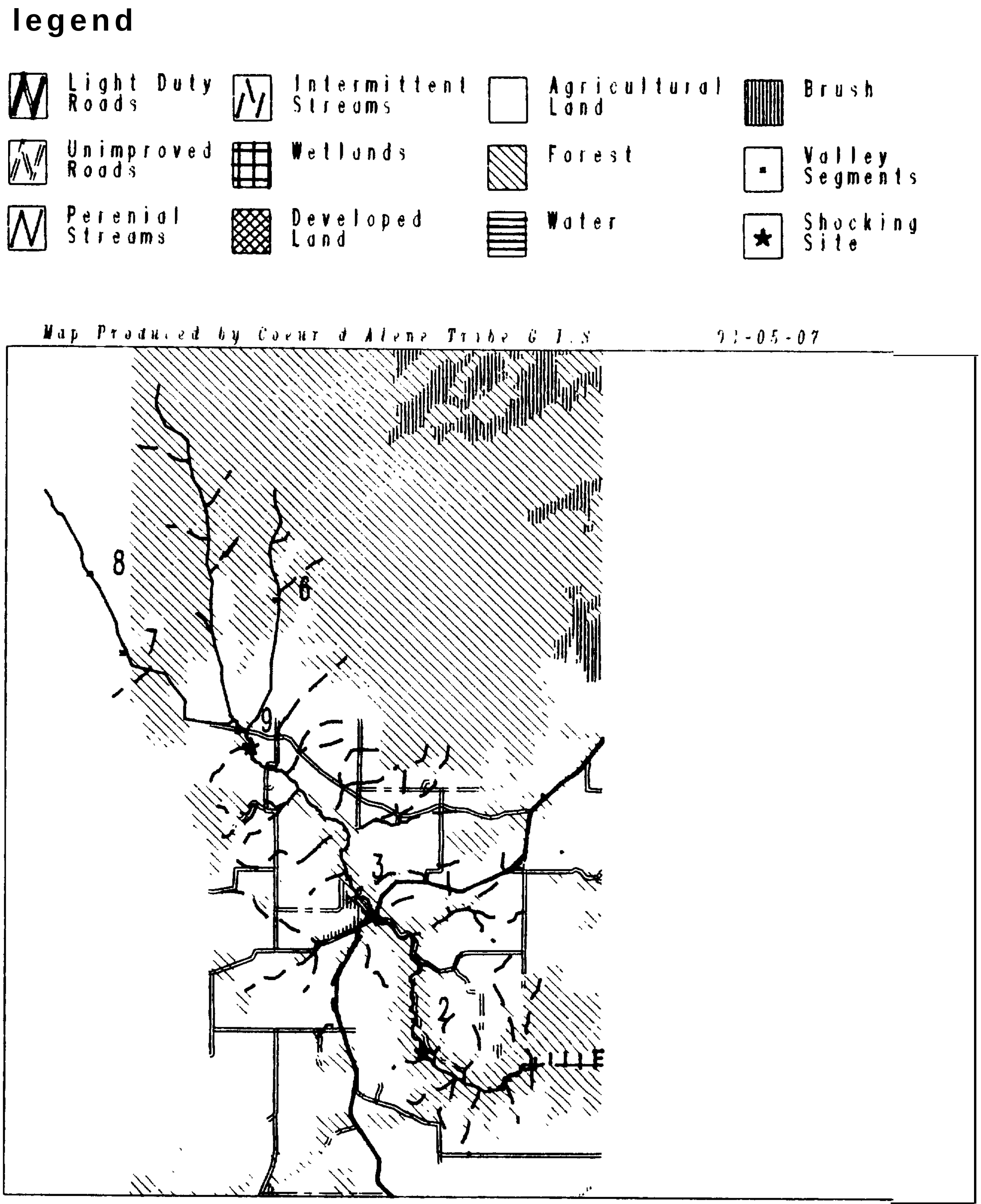

Figure 2.2 lake Creek Drainage

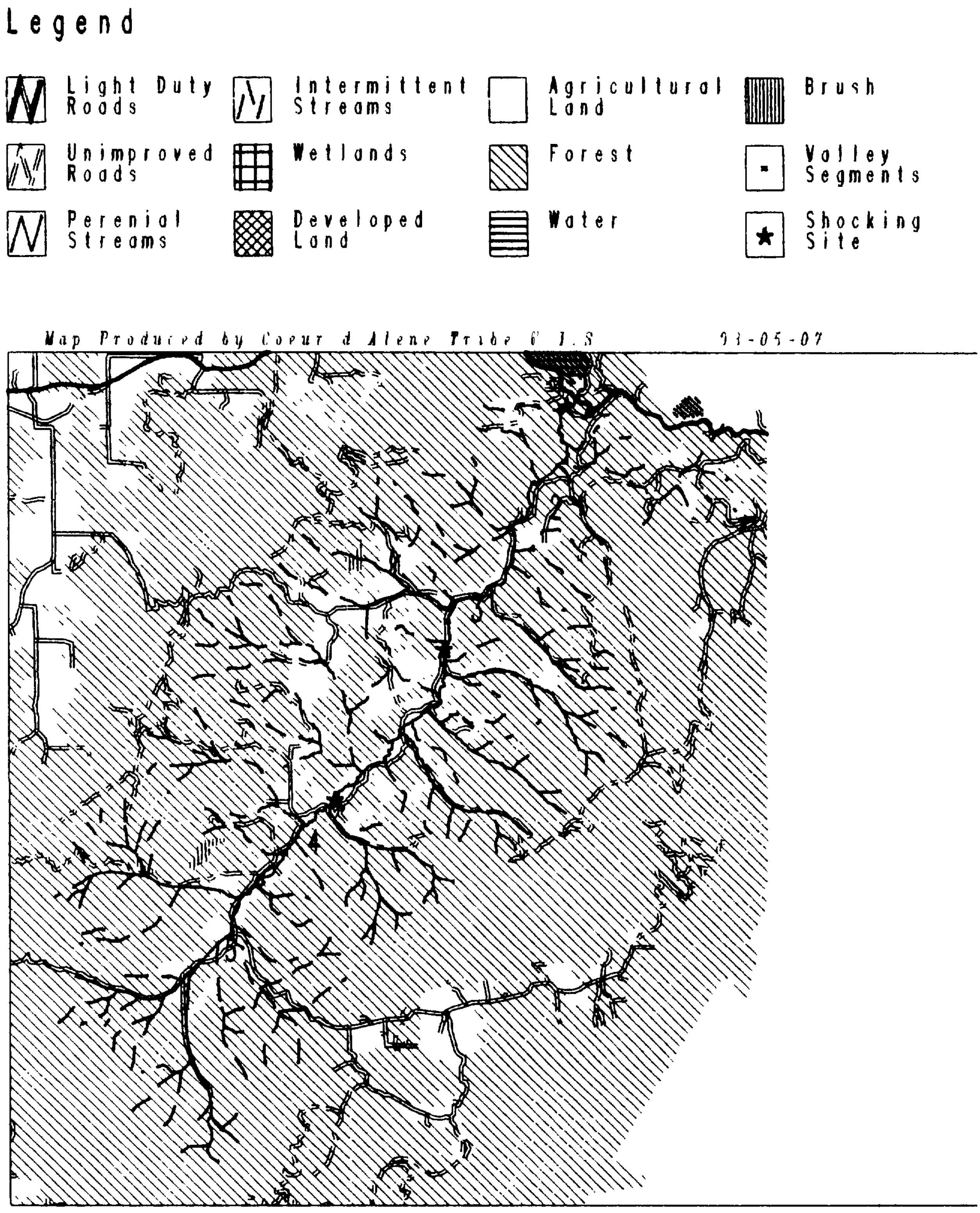

Figure 2.3 Benewah Creek Drainage

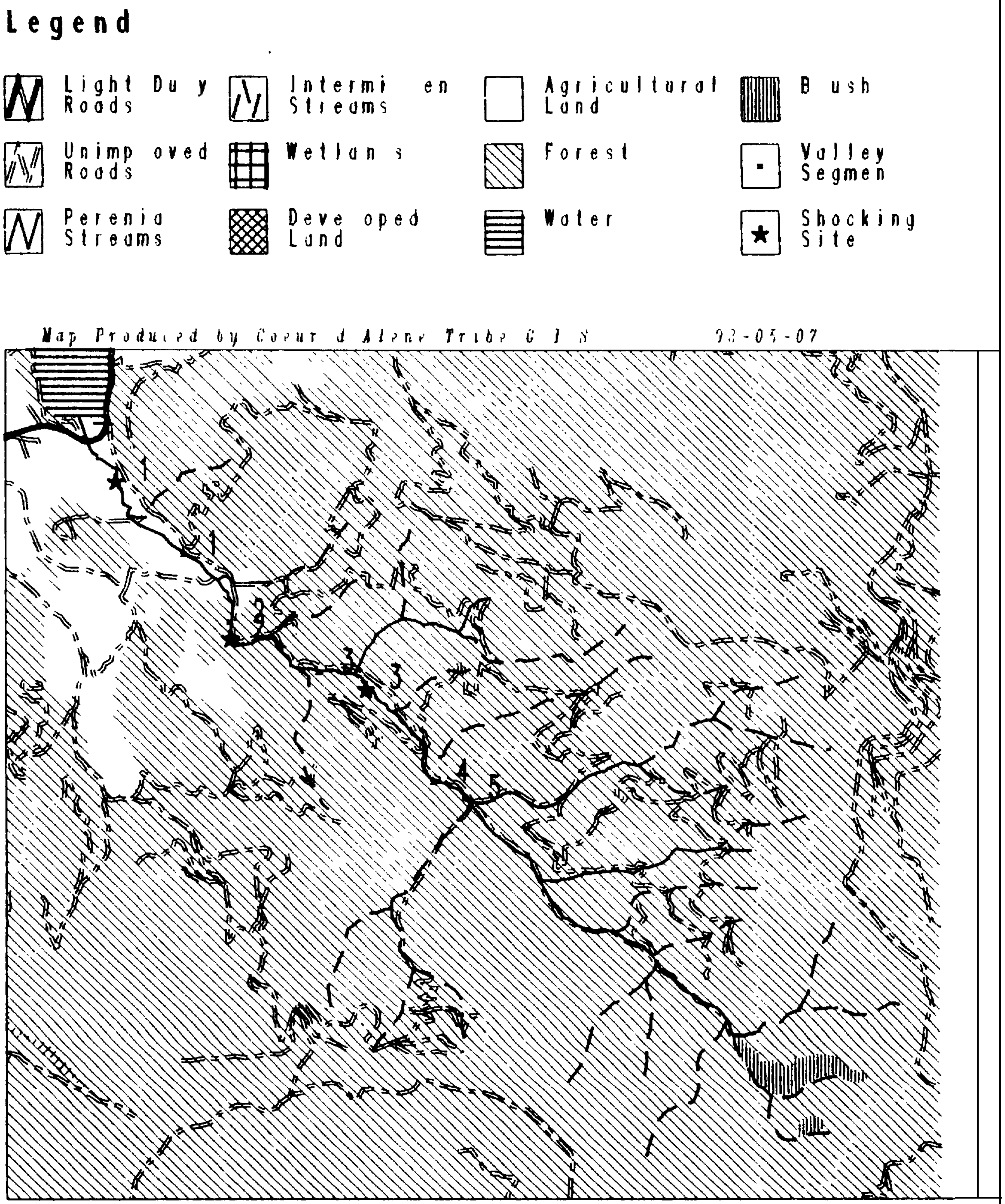

Figure 2.4 Evans Creek Drainage

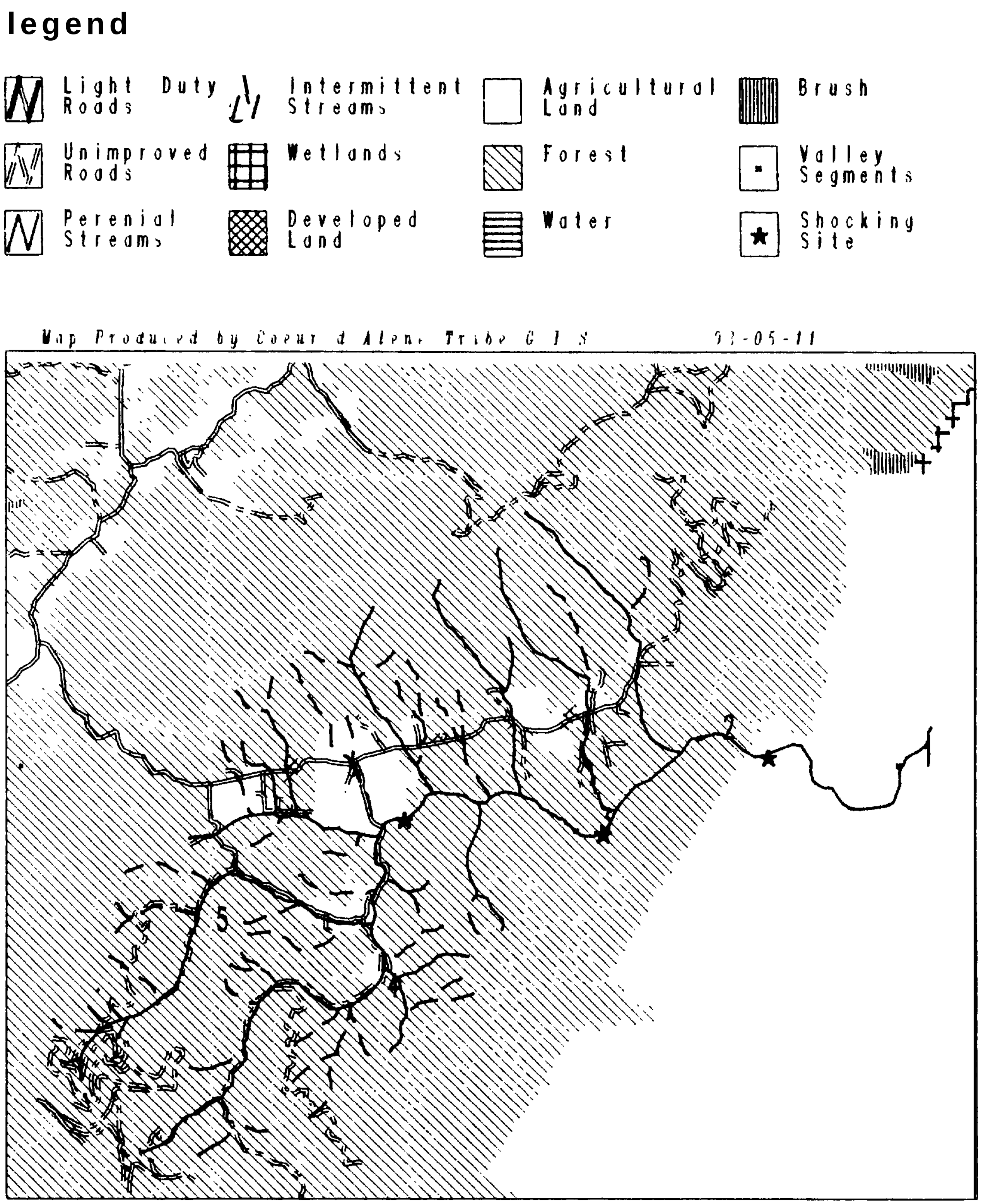

Figure 2.5 Alder Creek Drainage

private/industrial timber production and livestock grazing, Alder Creek is also used as a livestock and limited domestic water source.

2.2. Physical Investigations

Physical investigations were conducted on the four tributaries and included; habitat evaluations, stream reach channel stability profiles, discharge profiles, water quality analysis, and substrate analysis.

2.2.1. Habitat Evaluation of Primary Tributaries.

Habitat surveys were conducted on primary tributaries using modified methods of Timber/Fish/Wildlife Ambient Stream Monitoring Program (1991) (TFW) and Platts et al. (1983) during May-October, 1992. A crew of two walked the entire length of each stream channel from the confluence to the upstream limit of suitable trout habitat. Horizontal control surveys were conducted the first pass and habitat surveys were conducted during the second pass.

Horizontal Control Surveys

Streams were delineated into segments as outlined by Cupp (1989). Valley segment types (Frissell 1986) were defined by five general groups of characteristic features: 1) valley bottom longitudinal slope; 2) side-slope gradient; 3) ratio of valley bottom width to active channel width; 4) channel pattern and 5) adjacent geomorphic surfaces. These segments were identified on topographic maps and aerial photographs, and were easily verified in the field.

A field crew of two people walked the stream channel and established fixed reference points (horizontal control points) within each valley segment. These points were located along the stream channel above the high water mark so they could be easily identified in future field seasons. Each point was marked with aluminum tags and flagging. Distances between the fixed points were measured using a hip chain, as crew members followed the stream channel as closely as possible to account for channel turns. Distances were recorded on standardized data sheets. Compass bearings at each control point were recorded on standardized data sheets. Discharge measurements were made or estimated at the beginning of each valley segment. Stream gradient was measured every five horizontal control points using a Suunto Type 20 Clinometer. The presence of mass wasting and bank cutting was also noted and the length and area visually estimated for the entire length of stream and recorded on standardized data forms.

Habitat Surveys

A field crew of two **people** systematically surveyed the habitat of valley segments delineated in the horizontal surveys. Habitat sampling methods followed the procedures in the TFW ambient stream monitoring handbook (1991) with few modifications. One modification was that all habitat units were measured instead of using the visual estimation procedure. Fish habitat was classified into three broad categories; riffles, pools, and side channels. The first category riffle, was further defined into six riffle habitat types; glides or runs, pocket water, low gradient riffles, step pool cascades,slip face cascades, and rapids. The next category, pools, was divided into five habitat types; dammed pools, eddy pools, plunge pools, scour pools, and scour holes. The third category was classified as being side channels. Habitat units were categorized by the definitions found in Bisson et al. (1988) and can be found in Appendix A. Each habitat unit was then measured for length and width. Mean depth for riffle units and a minimum and maximum depth for pool units was measured. At every habitat unit, woody debris was counted, and categorized as logs or root wads. Diameter of the woody debris was estimated, location determined and function derived. The riparian condition was estimated by determining the canopy closure every five habitat units. This measurement provided an indirect measure of shading the stream received by adjacent riparian vegetation. One person stood in the middle of the channel unit and took four readings using a convex spherical densiometer. The measurements were taken facing upstream and downstream, and facing the right and left banks. The sectors of the densiometer that had vegetation in them were counted. The densiometer was divided into 24 sectors. Each sector was subdivided into four quarters. Each quarter had a possible score of 1, and each section had a possible score of four. All scores, for each direction, were summed and then divided by four to get an average score. This value was then subtracted from 96 and multiplied by 1.04 to give the percent canopy closure (Platts et *a/.* 1987). All canopy closure measurements within each stream reach were then averaged to determine the overall stream canopy closure percentage. The vegetation along the streambank was categorized as follows; visual estimates of the seral or successional stage of plant communities was made at every habitat unit. Type of dominant vegetation whether deciduous, coniferous or mixed, and land use, were documented.

Data Analysis

Data was recorded on standardized TFW forms and entered into R-BASE, a computerized data base located at the Northwest Indian Fisheries Commission in Olympia, Washington. A summary report of the data was then generated.

2.2.2. Stream Reach Index and Channel Stability Evaluation

The Stream Reach Inventory and Channel Stability Evaluation Procedure (Pfankuch 1975) was used to assess stream stability conditions. The stream reach index specifically targets and provides information about the capacity of streams to adjust and recover from potential changes in flow and/or increases in sediment production.

The stream reach inventory and channel stability evaluation was conducted on only those sections of streams where fishery surveys had taken place. Stream reaches were walked by a two member team and standardized data forms (Appendix C) were completed for each stream reach. Each reach was evaluated following the methods found in The Stream Reach Inventory and Channel Stability Evaluation Procedure (Pfankuch, 1975) and assigned a rating. Ratings were considered excellent when values were below 38, good when values were between 39-76, fair when values were between 77-l 14 and poor when values were above 115. Overall stream ratings were determined by multiplying the length of each reach by its numeric rating, summing the products and dividing by the total length of the stream sampled.

This inventory in conjunction with habitat surveys was used to assess habitat conditions and define impacts in stream reaches due to land use practices.

2.2.3. Stream Discharge Measurements

Stream discharge was measured monthly from February 1992 to November 1992, using a Price pigmy current meter in conjunction with a top setting wading rod following the methods of Buchanan and Somers (1980). Stream widths were measured and divided into at least 10 equal cells. Velocities were then measured at each cell at two thirds of total depth. Discharge was calculated with the formula:

$$Q = \sum_{i=1}^{n} \left(\frac{W_{i+1} - W_{i-1}}{2}\right) d_i \left(\frac{V_{i1} + V_{i2}}{2}\right)$$

where:

- Q = Total discharge
- n = Total number of individual sections
- w_i = Horizontal distance from the initial point
- d_i = Water depths for each section, and
- v_i = Measured velocity for each section.

2.2.4. Water Quality Analysis

Water samples were collected seasonally. Tests for conductivity, dissolved oxygen, pH and temperature were conducted in the field using a Hydrolab Surveyor II. Water samples were also collected for laboratory analysis of nitrate, nitrite, phosphates, turbidity and alkalinity using a LaMotte Chemical colorimetric test kit. Total dissolved solids were determined using a HANNA model 0661-l 0 dissolved solids tester.

2.2.5. Substrate Analysis

Substrate samples were collected in each section of the stream to determine the amount of sediment deposition and to evaluate fry production. Each stream was divided into a lower, middle and upper reach. Within each reach, five sites were marked and two duplicate samples were collected at each site. A manual sampling method was used in which a garbage can with a diameter of 42 cm was inserted into the stream bed to a depth of eight inches.

The particles were then extracted by hand or shovel. The samples were wet-sieved in the field due to the remoteness of some of the sample sites. The sample was put in a bucket and the excess water was poured off. The sample was placed onto a series of sieves ranging from 64 mm to .18 mm. The excess water was allowed to drain off and then the sample retained on each sieve was poured into a graduated cylinder filled with water. The amount of water displaced was recorded. The error introduced by wet sieving, because of water present, was corrected using data on Table 2.1 found in Shirazi and Seim (1979). The percent weight in each size class was then calculated.

The Fredle Index provided an indicator of sediment permeability and pore size. The index was used to estimate the quality of the sampled substrate for trout reproduction (Platts et *al.* 1983). The Fredle Index combined the measure of the central tendency of the distribution of the sediment particle sizes in a sample and the dispersion of particles in relation to the central value (Lotspeich and Everest 1981). This procedure characterized the suitability of the substrate for salmonid spawning, incubation and emergence. The formula used was;

$$fe = \frac{d_g}{S_o}$$

where:

fe = Fredle index

S_o = Sorting coefficient,

dg = Mean grain size based on the following formula:

$$d_g = (d_1^{w1} \times d_2^{w2} \times \ldots dnwn)$$

where;

dg = mean grain size

dn = the diameter at selected weights

w = weight at a selected diameter

So = Sorting coefficient based on the following formula,

$$So = \frac{d_{75}}{d_{25}}$$

This index indicates sediment permeability and pore size which are the two most influential factors governing salmonid embryo survival-to-emergence (Platts et *a/* 1983). With this index, substrate quality can be compared before and after habitat improvements are made.

Average survival to emergence for cutthroat trout was calculated for each substrate core site using the predictive equation for cutthroat trout developed by Irving and Bjornn (1984). This equation relates survival to gravel size. The equation used was:

$$\% \text{Surv} = 102.83 - 0.838(S_{9.5}) - 9.29\ (S_{0.85}) + 0.386\ (S_{0.85})^2$$

Where:

%S = Percent Survival

$S_{9.5}$ = % of substrate $\leq$ 9.5 mm

$S_{.85}$ = % of substrate $\leq$ .85 mm

Using this equation embryo survival was predicted at each core site based on the amount of fines present in the sample. The data was then combined to predict average emergence success of cutthroat trout for each reach of each tributary.

2.3. Fisheries Surveys

2.3.1. Relative Abundance

Fish relative abundance was determined by electrofishing using a Smith-Root Type VII pulsed-DC backpack electrofisher. Tributaries were sampled in May, July and September. Tributaries were divided into lower, middle and upper sections. Within each section, two random concurrent two-hundred foot segments were selected. Each section was electrofished using the standard guidelines and procedures described by Reynolds (1983). Fish captured were identified, counted, and measured to the nearest millimeter. A scale sample was removed below the dorsal fin from all salmonid species for age and growth analysis.

2.3.2. Population Estimates

Cutthroat and bull trout populations were estimated in the four streams in October 1992, using the removal-depletion method (Seber and LeCren 1967, Zippen 1958).

Six, two-hundred foot sections were randomly selected, to represent the longitudinal variation in habitat of each tributary. Blocknets were placed at the upstream and downstream boundaries to prevent immigration and emigration. Each section was electrofished using the standard guidelines and procedures described by Reynolds (1983). Fish were collected by spot shocking using a Smith-Root Type VII pulsed-DC backpack electrofisher. A minimum of two electrofishing passes were made for each two hundred foot section. Fish captured in the first pass were held in buckets until the second pass was made. Captured fish were identified, counted, and measured to the nearest millimeter. Cutthroat trout of 200 mm in length and larger were tagged with a Floy FD-6B numbered anchor tag. Scales were removed and weights taken from a representative group of each target species for age and growth and condition determination.

For each reach in which two passes were made, the population was estimated using the following equation of Seber and LeCren (1967):

$$N = \frac{(U_1)}{(U_1 - U_2)},$$

Where:

N = estimated population size;

U_1 = number of fish collected in the first pass;

and,

U_2 = number of fish collected in the second pass

The standard error of the estimate was calculated by:

$$S.E.(N)=\sqrt{\frac{(U_1)^2(U_2)^2T}{(UI-U2)}}$$

where:

SE.(N) = standard error of the population estimates; and

T = total number of fish collected (U_1+U_2)

When three or more passes were made in the section, the population was estimated using the methods of Zippin (1958). The first number needed was calculated by:

$$T = \sum_{i=1}^{n}(U_i),$$

where:

T = total number of fish collected

Ui = number of fish collected in the ith removal; and

n = the number of removals

The ratio (R) was then calculated using the equation:

$$R = \frac{\sum_{i=1}^{n} (i-1) U_i}{T}$$

The population estimate (N) was then calculated using the equation:

$$N = \frac{T}{Q}$$

where:

Q = the proportion of fish captured during all passes. Q was located by using the ratio (R) on the curve found in Fig. 22 of Platts et al. (1983).

The standard error of the estimate was calculated by:

$$S.E.(N) = \sqrt{\frac{N(N-T)}{T^2 - N(N-T)\frac{(kP)^2}{(1-p)}}}$$

where:

P = The estimated probability of capture during a single removal and is found using the ratio (R) on the curve found in Fig. 23 of Platts et al. (1983).

The 95 percent confidence intervals were placed around the estimate by multiplying the standard error by 1.96.

2.3.3. Spawning Surveys

Spawning surveys were conducted in late April and early May during 1992 to assess cutthroat trout spawning success. A two member field crew walked from the mouth of the stream to the upper limit of fish habitat. Redds were located, counted, classified and marked on topographic maps as described by Shepard and Graham (1983).

2.3.4. Migration Data

In March, 1992 upstream and downstream migration traps were installed in Lake, Evans and Benewah creeks. The upstream trap was placed approximately 200 yards from the downstream trap. Traps were not installed on Alder Creek due to inaccessibility. Traps remained in the streams until late June at which time they were removed. The trap design consisted of a weir, runway and a holding box (Figure 2.6). The design was a modification of the juvenile downstream trap found in Conlin and Ttuty (1979) (See Figure 2.7).

The traps were checked twice daily during peak spawning periods from March through the middle of May and once daily afterwards until late June. Fished captured in the traps were identified, counted, measured, weighed, and a scale sample was taken to assess the growth, condition and stock (fluvial/adfluvial/resident) of the fish.

2.3.5. Age, Growth, and Condition

Scales were used for age determination and calculating growth rates (Everhart and Youngs, 1981). Scales from the trout were taken below the dorsal fin. The area for scale removal is chosen based on size, large and consistent annuli, and shape (regular symmetry of the scale) (Carlander 1982; Bagenal and Tesch 1978). Scale samples were collected following methods of Jearld (1983). In the laboratory, several scales were mounted between two glass microscope slides and viewed using a Realist, Inc., Vantage 5 microfiche reader. The age was determined by counting the number of annulli (Lux 1971, Jearld 1983). Simultaneous to age determination, measurements were made from the center of the focus to the furthest edge of the scale. Along this line, the measurements were made to the nearest millimeter to each annulus

Figure 2.6. Picture of the Lake Creek migration trap-

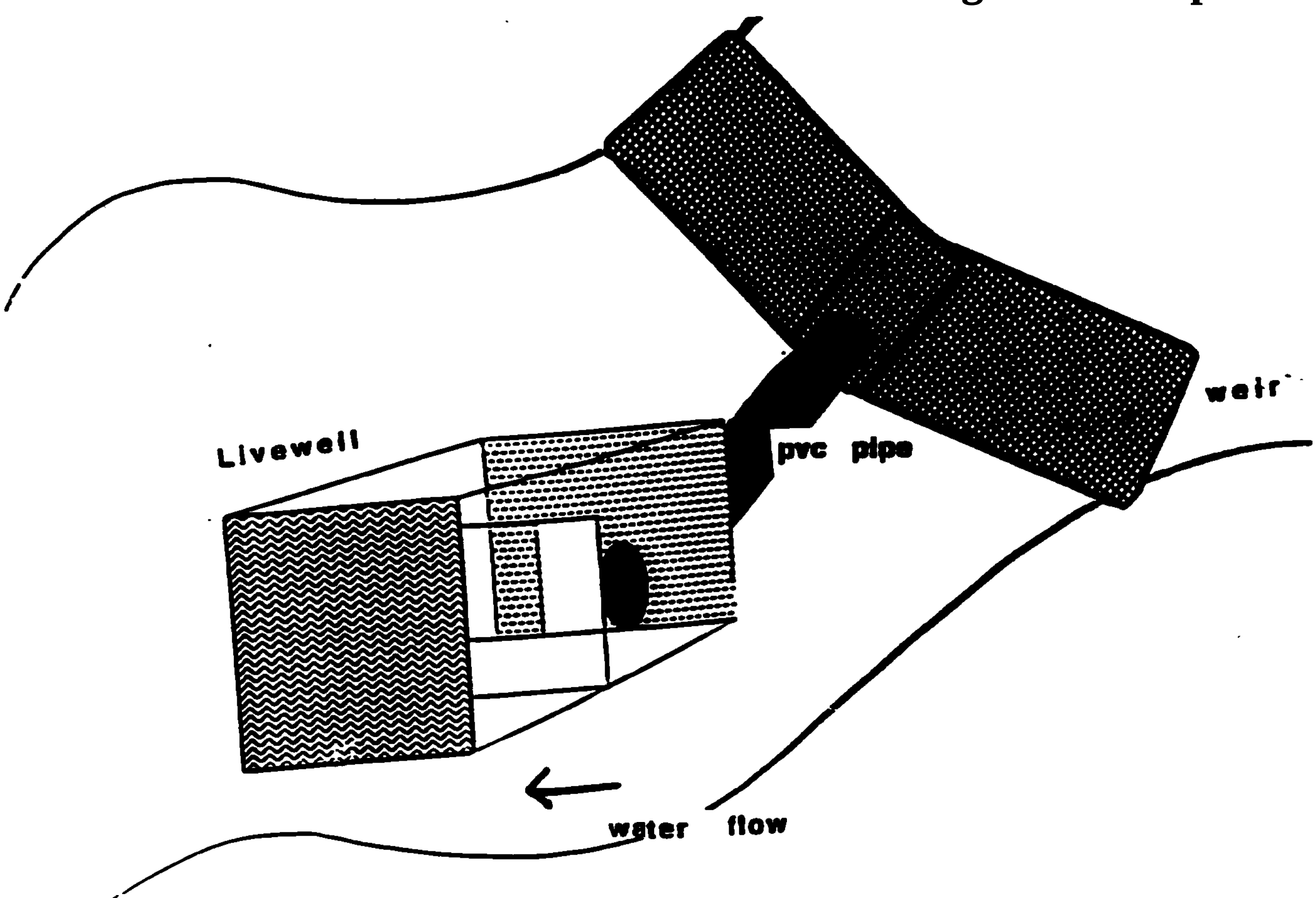

Figure 2.7. Diagram of migration trap installed in tributaries.

under a constant magnification. Annual growth was then back-calculated using the Lee method as described by Carlander (1981). The formula used:

$$L_i = a + \left(\frac{(L_c - a)}{S_c}\right) S_i,$$

where:

where:	Li	=	Length of fish (in mm) at each annulus;
	a	=	intercept of the body scale regression line:
	Lc	=	length of fish (in mm) at time of capture;
	SC	=	distance (in mm) from the focus to the edge of the scale; and
	Si	=	scale measurement to each annulus.

The intercept (a) was obtained from the regression anafysis of body length -v- scale length at time of capture. The regression analysis was accomplished using StatView 512+ on a Macintosh SE computer. .

The proportional method of back-calculation was used for species with small sample sizes due to poor regression results. The following equation was used:

$$L_i = \frac{S_i}{S_c} L_c$$

This formula does not take into account the size of fish at scale formation as does the Lee method.

Condition factors were computed as an indicator of the fishes growth pattern and, therefore, an indication of its general condition (Everhart and Youngs 1981). The formula used to calculate the condition factor was:

$$K_{tl} = \left(\frac{W}{L^3}\right)10^5$$

Where: K_{tl} = condition factor:

W = weight of fish in grams; and

L = total length of fish in millimeters.

Calculated condition factors were compared to other streams in the Pacific Northwest.

3.0 RESULTS

3.1. Physical **Investigations**

3.1.1. **Habitat Evaluation of Primary Tributaries**

Habitat summary reports were generated for all valley segments of each tributary. Valley segments were based on the channel typing of Cupp (1985). Habitat typing was completed after other data collection sites had been established, therefore, habitat segments were divided into more reaches. These were then combined, when appropriate, to determine the overall habitat conditions within each stream reach. Those segments that were not included in the reach designation have been included in Appendix B and may be referenced to determine the habitat conditions present.

3.1.1.2. **Lake Creek**

The Lake Creek drainage was divided into seven valley segments. Approximately 20 kilometers of the Lake Creek watershed were surveyed during 1992. Four valley segments comprised the mainstem of Lake Creek and three valley segments surveyed were tributaries to Lake Creek. These included Bozard and West Lake Creeks.

Surveyed sections of Lake Creek ranged in elevation from 652 to 841 meters. Stream order ranged from one to three and had an average stream gradient of 1.4. Primary land uses practices in the watershed included; forest (70.2%), agriculture (22.2%), livestock grazing (6.2%), mining (2%), and other (1 .O%) which included residential, urban and right of way access. (Table 3.1). For the entire watershed 437 habitat units were classified (Table 3.2) comprising a total area of 64,631 square meters. Of the 437 habitat units, six (1.4%) were identified as cascades, 318 (72.6%) as riffles, as 107(24.6%) as pools (Table 3.2).

For the lower reach of Lake Creek, valley segments one and two were combined. Elevation in the lower reach of Lake Creek began at 652 meters and rose to 732 meters in 4,187 meters. Mean stream gradient was 1.4%. Primary land use practices were forest (97.1%), mining (0.8%) and other (2.0%). The riparian area was dominated by a mixed vegetative stand that was 50.6% mature forest, 22.0% shrub, 17.9% grass/forb, and 8.6% pole. Canopy cover

Table 3.1. Summary report for Lake Creek (including Bozard and West Lake Creeks), May-August, 1992.

Elevation	652-841 m
Total length	20,875.1 m
Stream order	1 - 3
Mean stream gradient	1.4% (0.8%-2.0%)
Pool/riffle/cascade ratio	1/7.8/0.1
Land use	
Timber	70.2%
Agriculture	22.2%
Livestock grazing	6.2%
Mining	0.2%
Other (includes residential etc.)	1.0%
Vegetative type	
Deciduous	0.3%
Coniferous	0.3%
Mixed	99.4%
Seral Stage	
Grass/forb	22.5%
Shrub	31.5%
Pole	3.7%
Young	14.9%
Mature	27.1%
Old growth	0.4%
Other	
x Canopy cover	5.2% (0.0-l 9.7)
# Woody debris	
Logs	344
Root wads	20
Mass Wasting	

Table 3.2 **Frequency of occurrence, total percent occurrence, total area and percent area for habitat types on surveyed areas of the Lake Creek drainage, including Bozard and West Lake Creeks, May-August, 1992.**

Habitat Type	Frequency	% Frequency	Total Area (sq. meters)	% total
Rapid (RPD)	2	0.5	10	co.1
Step-pool cascade (SPC)	1	0.2	38	co.1
Slip-face cascade (SFC)	3	0.7	38	<0.1
Total Cascades	6	**1.4**	86	**0.1**
Pocketwater (PKW)	30	6.9	9,507	14.7
Glide (GLD)	128	29.3	26,208	40.6
Run (RUN)	0	0.0	0	0.0
Low gradient riffle (LGR)	160	36.6	21,525	33 3
Total Riffles	**31 8**	72.6	57,240	88.6
Damned pool (DMP)	6	1.4	657	1.0
Eddy pool (EDP)	3	0.7	58	0.1
Plunge pool (PLP)	14	3.2	535	0.8
Scour pool (SCP)	78	17.9	5,290	8.2
Scour hole (SCH)	6	1.4	282	0.4
Beaverpond (BVP)	0	0.0	0	0.0
Total Pools	**107**	24.6	6,822	**10.5**
Secondary channel (SDC)	6	1.4	483	0.8
Grand Totals	437		64,631	

ranged from 0-99% with a average of 18.1%. Two hundred forty-four logs and 18 root wads were counted in this reach. No mass wasting or bank cutting was observed in this reach (Table 3.3).

In the lower reach, 178 habitat units were categorized for a total area of 18,947 m? Six (3.4%) of the units were classified as cascades , 133 (74.7%) were riffles, 36 (20.3%) were pools and three (1.7%) were side channels (Table 3.4). Within the cascade category, three (1.7%) were slip face cascades for a total area of 37 m^2, two (1 .l%) were rapids for a total area of 10 m^2 and one (0.7%) was a step pool cascade for a total area of 38 m^2. Within the riffle category, 58 (32.6%) were low gradient riffles for a total area of 5,472 m^2, 46 (25.8%) were glides for a total area of 2,333 m^2 and 29 (16.3%) were pocketwater for a total area of 9,302 m^2. In the pool category, 21 (11.8%) were scour pools for a total area of 1,071 m^2, and eight (4.5%) were plunge pools for a total area of 195 m? Three (1.7%) scour holes, eddy pools and one (0.6%) dammed pool were also identified for total areas of 73m^2, 58m^2, and 28m^2, respectively. Calculated mean residual pool depths were 0.13 m for dammed pools, 0.24 m for eddy pools, 0.34 m for plunge pools, 0.47 m for scour pools and 0.60 m for scour holes (Table 3.4).

For the middle reach of Lake Creek only valley segment three was included. Elevation in this section ranged from 732 to 765 meters (Table 3.5). Total segment length was 4,172 meters and the average stream gradient was 1.4%. A pool/riffle/cascade ratio of 0.19/1/0 was calculated. Land use practices in the middle reach included forest (89.6%), agriculture (9.2%), livestock grazing (9.2%) and other (1.2%) which includes residential and right away. The riparian area is dominated with a deciduous stand of mature timber (89.6%) and grass/forb (9.2%).

In the middle reach, 163 habitat units were counted and identified. One-hundred-twenty-two (74.9%) were in the riffle category, 38 (23.3%) were in the pool category and 3 (1.8%) were identified as secondary channels for a total of 19,144 m2. Within the riffle category, 51(31.3%) were glides for a total area of 8,101 m^2, and 71 (43.6%) were low gradient riffles for a total area of 16,054 m2. In the pool category, 36 (22.1%) were scour pools for a total area of 2,585 m^2, and scour holes and dammed pools each one (0.6%) for total areas of 132 m^2 and 211 m^2, respectively (Table

Table 3.3. Summary report for lower Lake Creek*, May-August, 1992.

Elevation	652-732 m
Total length	4,167 m
Stream order	3
Mean stream gradient	1.4%
Pool/riffle/cascade ratio	1/12.6/.06
Land use	
Timber	97.4%
Agriculture	
Livestock grazing	
Mining	0.8%
Other (includes residential etc.)	20%
Vegetative type	
Deciduous	0.9%
Coniferous	
Mixed	99.1%
Seral Stage	
Grass/forb	17.9%
Shrub	22.0%
Pole	8.6%
Young	50.6%
Mature	0.7%
Old growth	
Other	
x Canopy cover	18.1%
# Woody debris	
Logs	244
Root wads	18
Mass Wasting	0

*(includes valley segment #1 and #2).

Table 3.4. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth values for the lower reach* of Lake Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	2	1.1	10	<0.1	
Step pool cascade	1	0.6	38	0.2	
Slip face cascade	3	1.7	37	0.2	
Total Cascades	**6**	3.4	85	0.4	
Pocketwater	29	16.3	9,302	49.1	
Glide	46	25.8	2,333	12.3	
Run	0	0.0	0	0.0	
Low gradient riffle	58	32 6	5.472	28 9	
Total Riffles	**133**	74.7	17,107	90.3	
Dammed pool	1	0.6	38	0.2	0.13
Eddy pool	3	1.7	58	0.3	0.24
Plunge pool	8	4.5	195	1.o	0.34
Scour pool	21	11.8	1,071	5.7	0.47
Scour hole	3	1.7	73	0.4	0.60
Beaver pond	0	0.0	0	0.0	0.00
Total Pools	36	20.3	**1,435**	7.6	
Secondary channel	3	1.7	320	1.7	0.10
Grand Totals	**178**		**18,947**		

*(includes valley segment #1 and #2).

Table 3.5. Summary report for middle Lake Creek*, May-August, 1992.

Elevation	732-765 m
Total length	4,172 m
Stream order	3
Mean stream gradient	1.4%
Pool/riffle/cascade ratio	.19/1.0/0
Land use	
Timber	89.6%
Agriculture	9.2%
Livestock grazing	9.2%
Mining	
Other (includes residential etc.)	1.2%
Vegetative type	
Deciduous	98.9%
Coniferous	
Mixed	1.1%
Serai Stage	
Grass/forb	
Shrub	9.2%
Pole	
Young	89.6%
Mature	
Old growth	
Other	
x Canopy cover	0.0%
# Woody debris	
Logs	19
Root wads	1
Mass Wasting	0

3.6). Average residual pool depths were calculated at 0.91 meters for dammed pools, 0.55 meters for scour pools and 0.82 meters for scour holes.

The upper reach of Lake Creek consisted of valley segment #4. Elevation ranged from 765 to 780 meters and measured 5,075 meters in length. Average stream gradient was 1.3% and a pool/riffle/cascade ratio of 0.15/1/0 was calculated. Land use practices in this reach consisted mainly of agriculture (77.9%) forest (7.0%) and residential (1.2%) (Table 3.7). A 100% mixed stand existed in this area with a predominate seral stage of grass/forb (51.2%) followed by mature timber at 48.8%. No 'canopy cover existed in this reach of Lake Creek. Fifty three logs and one root wad were counted in this section. No mass wasting or bank cutting were observed.

In the upper reach 43 habitat units were counted for a total area of 16,160 m^2. Thirty one (72.1%) were in the riffle category and 12 (27.7%) were in the pool category (Table 3.8). Within the riffle category 19 (44.2%) were identified as glides (44.2%) for a total area of 12,359 m^2 and 12 (27.9%) were low gradient riffles for a total area of 430 m? Dammed pools, scour pools, and scour holes were identified within the pool category at 4 (9.3%), 6 (14.0%) and 2 (4.7%) respectively (Table 3.8) for total areas of 409 m^2, 1585 m^2, and 77 m^2, respectively. Residual pool depths were calculated at 0.53 m, 0.27 m, 0.68 m, and 0.59 m for dammed, plunge, scour pools and scour holes, respectively.

Habitat typing was conducted on more valley segments within Lake Creek, however data collection did not occur in these areas. Correlation of habitat and fisheries data can not be conducted for these valley segments, but the habitat surveys can be found in Appendix B.

3.1.1.3. Benewah Creek

Benewah Creek was divided into five valley segments. Approximately 19 kilometers of the Benewah Creek watershed were surveyed during 1992.

Surveyed sections of the Benewah Creek drainage ranged in elevation from 683 to 853 meters. Stream order ranged from one to four and had an average stream gradient of 2.1. Primary land uses practices in the watershed included livestock grazing (54.%), timber

Table 3.6. **Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth values for the middle reach* of Lake Creek May-August, 1992.**

Habitat Type	Frequency	% Frequency	Total Area (Sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0.0	0	0.0	
Step pool cascade	0	0.0	0	0.0	
Slip face cascade	0	0.0	0	0.0	
Total cascades	**0**	**0.0**	**0**	**0.0**	
Pocketwater	0	0.0	0	0.0	
Glide	51	31.3	8,101	42.3	
Run	0	0.0	0	0.0	
Low gradient riffle	71	43.6	7,953	41.5	
Total riffles	**122**	**74.9**	**16,054**	**83.8**	
dammed pool	1	0.6	211	1.1	0.91
eddy pool	0	0.0	0	0.0	0.00
plunge pool	0	0.0	0	0.0	0.27
scour pool	36	22.1	2,585	13.5	0.55
scour hole	1	0.6	132	0.7	0.82
Beaver pond	0	0.0	0	0.0	
Total pools	**38**	**23.3**	**2,928**	**15.3**	
Secondary channel	3	1.8	162	0.9	0.38
Grand totals	**163**		**19,144**		

* (includes valley segment # 3)

Table 3.7. Summary report for upper Lake Creek*, May-August, 1992.

Elevation	**765-780 m**
Total length	**5,074 m**
Stream order	**3**
Mean stream gradient	**1.3%**
Pool/riffle/cascade ratio	**.15/1.0/0**
Land use	
Timber	**7.0%**
Agriculture	77.9%
Livestock grazing	13.9%
Mining	
Other (includes residential etc.)	1.2%
Vegetative type	
Deciduous	
Coniferous	
Mixed	100%
Seral Stage	
Grass/forb	51.2%
Shrub	
Pole	
Young	**48.8%**
Mature	
Old growth	
Other	
x Canopy cover	0.0%
# Woody debris	
Logs	**53**
Root wads	1
Mass Wasting	**0**

* (includes valley segment # 4)

Table 3.8. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth values for the upper reach* of Lake Creek May-August, 1992.

Habitat type	Frequency	% Frequency	Total Area (sq. m)	% Area	Residual pool depth (m)
Rapid	0	0.0	0	0.0	
Step pool cascade	0	0.0	0	0.0	
Slip face cascade	0	0.0	0	0.0	
Total Cascades	**0**	**0.0**	**0**	**0.0**	
Pocketwater	0	0.0	0	0.0	
Glide	19	44.2	12,358	76.5	
Run	0	0.0	0	0.0	
Low gradient riffle	12	27 9	1.729	10 7	
Total Riffles	**31**	**72.1**	**14,089**	87.2	
dammed pool	4	9.3	409	2.5	0.53
eddy pool	0	0.0	0	0.0	0.00
plunge pool	0	0.0	0	0.0	0.27
scour pool	6	13.9	1,585	9.8	0.68
scour hole	2	4.6	77	0.5	0.59
Beaver pond	0	0.0	0	0.0	
Total Pools	**12**	27.7	2,071	**12.8**	
Secondary channel	0	0.0	0	0	0.00
Grand Totals	**43**		**16,160**		

* (includes valley segment # 4)

(23.8%), residential, right of way (20.8%), agriculture (1 .1%) and wetland (0.9%). A mixed vegetative stand dominates the riparian area while the predominate seral stage is grass/forb (46.9%) followed by shrub (39.2%), mature (8.3%), young trees (1.8%) and pole (1.1 %). A mean canopy cover of 3.2% was calculated with a range of 0-99%. Six bank cutting sites were identified for a total length of 3,337 meters (Table 3.9). For the entire watershed 916 habitat units were classified comprising a total area of 10,4751 square meters (Table 3.10). Of the 916 habitat units, 77 (8.5%) were identified as cascades, 405 (44.2%) as riffles, and 430 (47.1 %) as pools.

For the lower reach of Benewah Creek, valley segments #1 and #2 were combined. Elevation began at 683 meters and rose to 732 meters in 3,776 meters. Mean stream gradient was 3.3% and a pool/riffle/cascade ratio of 1/14.5/2.8 was calculated (Table 3.11). Land use practices within the reach included forested (35.3%), residential and right of way (39.5%), livestock grazing (12.5%), mining (.06%) and wetland designation (0.8%). The vegetative type was comprised of deciduous, coniferous and mixed stands at 37.6%, 12.0% and 49.7%, respectively. The dominant seral stage was shrub (55.4%) followed by mature trees (21.5%), grass/forb (17.8%), pole (2.3%), young trees (2.0%), old growth forest (0.4%) and other (7.5%). Mean canopy cover was calculated at 4.9% with a range of 0 to 76%, Forty three logs and four root wads were counted in this section as woody debris.

A total of 169 habitat units for a total of 23,665 m^2 were enumerated and identified in the lower reach of Benewah Creek (Table 3.12). Twenty three (13.6%) were in the cascade category, 93 (55.1%) were in the riffle category, 52 (30.8%) were in the pool category and 1 (0.6) was identified as a secondary channel. In the cascade category, 10 (5.9%) were step pool cascades for a total area of 3,290 m^2, and 13 (7.7%) were slip face cascades for a total of 310 m^2. In the riffle category, 47 (27.8%) were identified as pocketwater for a total area of 2,045 m^2, 30 (17.8%) low gradient riffles for a total of 2,706 m^2, and 16 (9.5%) as glides for a total of 2,045 m^2. In the pool category 19 (11.2%) were identified as dammed pools for a total area of 553 m^2, 15 (8.9%) were scour holes for a total of 252 m^2, 12 (7.1%) were scour pools for a total of 377 m^2, 5 (3.0%) were plunge pools for a total area of 107 m^2, and one

Table 3.9. Summary report for the Benewah Creek Watershed, May-August, 1992.

Elevation	**683-853 m**
Total length	**19,605.8 m**
Stream order	**4**
Mean stream gradient	**2.1%**
Pool/riffle/cascade ratio	**1/14.5/2.8**
Land use	
Timber	23.8%
Agriculture	0.4%
Livestock grazing	54.0%
Mining	co.01 %
Wetland	0.9%
Other (includes residential,right of way, etc.)	20.a%
Vegetative type	
Deciduous	34.5%
Coniferous	4.5%
Mixed	61 .O%
Seral Stage	
Grass/forb	46.9%
Shrub	39.2%
Pole	1.1%
Young	1.8%
Mature	8.3%
Old growth	0.1 %
Other	2.5%
x Canopy cover	3.2 (O-99)
# Woody debris	
Logs	657
Root wads	33
Mass Wasting	**0.0**
Bank cutting	613337 **m**
Side Channels	**271975.2 m**

Table 3.10. **Frequency of occurrence, total percent occurrence, total area and percent area for habitat types on surveyed areas of the Benewah Creek drainage, May-August, 1992.**

Habitat Type	Frequency	% frequency	Total Area (sq. m)	% Area
Rapid	0	0.0	0	0
Step pool cascade	[illegible]	[illegible]	[illegible]	3.4
Slip face cascade	61	[illegible]	[illegible]	2.4
Total Cascades	77	8.5	6,006	5.8
Pocketwater	85	9.3	26,979	25.8
Glide	89	9.7	13,441	12.8
Run	0	0.0	0	0.0
Low gradient riffle	231	25.2	25,019	23.9
Total Riffles	405	44.2	65,439	62.5
Dammed pool	50	5.5	5,236	5.0
Eddy pool	6	0.7	38	co.1
Plunge pool	8	0.9	175	0.2
Scour pool	287	31.3	16,977	16.2
Scour hole	62	6.8	852	0.8
Beaver pond	17	1.9	9,827	9.4
Total Pools	430	47.1	33,105	31.7
Secondary channel	4	0.4	201	0.2
Grand totals	**916**		**104751**	

Table 3.11. Summary report for the lower reach* of Benewah Creek, May-August, 1992.

Elevation	**683-732 m**
Total length	**3775.7 m**
Stream order	**4**
Mean stream gradient	**3.3%**
Pool/riffle/cascade ratio	**1/14.5/2.8**
Land use	
Timber	**35.3%**
Agriculture	
Livestock grazing	12.5%
Mining	0.6%
Wetland	0.8%
Other (includes residential,right of way, etc.)	39.5%
Vegetative type	
Deciduous	37.6%
Coniferous	12.8%
Mixed	49.7%
Seral Stage	
Grass/forb	17.a%
Shrub	55.4%
Pole	2.3%
Young	2.0%
Mature	21.5%
Old growth	0.4%
Other	7.5%
x Canopy cover	4.9 (O-76)
# Woody debris	
Logs	43
Root wads	4
Mass Wasting	0
Bank cutting	0
Side Channels	0

(*includes valley segments #1,#2)

Table 3.12. Frequency of occurrence, total percent occurrence, total area, percent area and residual pool depth values for the lower reach* of Benewah Creek, May-August, 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. m)	% Area	Residual pool depth (m)
Rapid	0	0.0	0	0.0	0
Step pool cascade	10	5.9	3,290	13.9	
Slip face cascade	13	7.7	310	1.3	
Totals Cascades	**23**	**13.6**	3,600	**15.2**	
Pocketwater	47	27.8	13,909	58.7	
Glide	16	9.5	2,045	8.6	
Run	0	0.0	0	0.0	
Low gradient riffle	30	17 8	2.706	11.4	
Total Riffles	**93**	55.1	18,660	78.7	
Dammed pool	19	11.2	553	2.3	0.55
Eddy pool	1	0.6	1.2	<0.1	0.08
Plunge pool	5	3.0	107	0.5	0.50
Scour pool	12	7.1	377	1.6	0.54
Scour hole	15	8.9	252	1.1	0.39
Beaver pond	0	0.0	0	0.0	
Total Pools	52	30.8	**1,290**	5.6	
Secondary channel	1	0.6	115	0.5	0.03
Grand Totals	**169**		23,665		

(*includes valley segments #1,#2)

(0.6%) was an eddy pool for a total of 1 m^2. Mean residual pool depths were calculated at 0.55 meters for the dammed pools, 0.08 meters for eddy pools, 0.5 meters for the plunge pools, 0.54 meters for the scour pools and 0.39 meters for the scour holes.

Valley segments #3 and # 4 were combined for the middle section of Benewah Creek. Elevation began at 732 meters and rose to 838 meters in 11,461 meters (Table 3.13). Mean stream gradient was calculated at 1.6 and a pool/riffle/cascade ratio of 1/1.4/0.08 was calculated. Land use practices within the section included forested (20.1%), livestock grazing (61.5%), wetland designation (1.8%) and residential (16.7%). Vegetative type was primarily deciduous (65.3%) followed by mixed vegetation (32.3%) and coniferous (0.7%). Predominate seral stages included shrub (50.9%), and grass/forb (40.9%). The remaining 8.5% included some pole, young and mature stands. Mean canopy cover in this reach was 4.7% with a range of 0-99%. Four hundred fifty-seven logs and 17 root wads were enumerated within this section. Bank cutting occurred in six areas for a total length of 3,337 meters. Twenty seven side channels were enumerated within this reach for a total of 975 meters.

A total of 658 habitat units were enumerated and identified within the middle reach of Benewah Creek for a total of 73,286 m^2 (Table 3.14). Of the 658 units, 355 (54.1%) were in the pool category, 252 (38.3%) were in the riffle category and, 51 (7.8%) were in the cascade category. Of the fifty one in the cascade category, 48 (7.3%) were slip face cascades for a total area of 2,186 m^2, and three (0.5%) were step pool cascades for a total area of 207 m? In the riffle category, 165 (25.2%) were low gradient riffles for a total area of 17,877 m^2, 49 (7.4%) were glides for a total area of 8,234 m^2, and 38 (5.8%) were pocketwater for a total area of 15,691 m^2. In the Pool category, 257 (39.1%) were scour pools for a total area of 15 601 m^2, 47 (7.1%) were scour holes for a total area of 600 m^2, 26 (4.0%) were dammed pools for a total area of 2,959 m^2, 17 (2.6%) were beaver ponds for a total area of 9,827 m^2, five (0.8%) were eddy pools for a total area of 37 m^2, and three (0.5%) were plunge pools for a total area of 67 m? Calculated mean residual pool depths were 0.51 meters for dammed pools, 0.14 meters for eddy pools, 0.51 meters for plunge pools, 0.45 meters for scour pools, 0.27 meters for scour holes and 0.56 meters for beaver ponds.

The upper reach of Benewah Creek consisted of valley segment

Table 3.13. Summary report for the middle reach* of Benewah Creek, May-August, 1992.

Elevation	**732-838 m**
Total length	**11,461.1 m**
Stream order	**4**
Mean stream gradient	**1.6%**
Pool/riffle/cascade ratio	**1/1.4/0.08**
Land use	
Timber	20.1%
Agriculture	
Livestock grazing	61.5%
Mining	
Wetland	1.8%
Other (includes residential,right of way, etc.)	16.7%
Vegetative type	
Deciduous	65.3%
Coniferous	0.7%
Mixed	32.3%
Seral Stage	
Grass/forb	40.9%
Shrub	50.9%
Pole	1.0%
Young	3.5%
Mature	3.7%
Old growth	
Other	
x Canopy cover	4.7% (O-99)
# Woody debris	
Logs	457
Root wads	17
Mass Wasting	
Bank cutting	613337 m
Side Channels	271975.2 m

(“includes valley segments #3,#4)

Table 3.14. Frequency of occurrence, total percent occurrence, total area, percent area and residual pool depth values for the middle reach* of Benewah Creek, May-August, 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. m)	% Area	Residual pool depth (m)
Rapid	0	0.0	0	0.0	
Step pool cascade	3	0.5	207	0.3	
Slip face cascade	48	7.3	2,186	3.0	
Totals Cascades	**51**	7.8	2,393	3.3	
Pocketwater	38	5.8	15,691	21.4	
Glide	49	7.4	8,234	11.2	
Run	0	0.0	0	0.0	
Low gradient riffle	165	25 1	17,877	24 4	
Total Riffles	252	38.3	41,802	57.0	
Dammed pool	26	4.0	2,959	4.0	0.51
Eddy pool	5	0.8	37	0.1	0.14
Plunge pool	3	0.5	67	0.1	0.51
Scour pool	257	39.1	15,601	21.3	0.45
Scour hole	47	7.1	600	0.8	0.27
Beaver pond	17	2.6	9,827	13 4	0.56
Total Pools	355	54.1	**29,091**	39.7	
Secondary channel	0	0.0	0	0.0	0
Grand Totals	658	**100.2**	73,286		

(*includes valley segments #3,#4)

#5. Elevation began at 838 meters and rose to 853 meters in 4,369 meters. A mean stream gradient of 1.5 was calculated. A pool/riffle/cascade ratio of .002/.006/1 was calculated. Land use within this reach consisted of livestock grazing (76.7%), forest (15.9%), residential (6.6%), and agriculture (1.1 %).

One hundred percent of the surveyed area was a mixed stand in which 83.5% was grass/forb with the remaining 12.5% shrub. No canopy cover existed in this reach. One hundred fifty seven logs and 12 root wads were enumerated (Table 3.15).

A total of 88 habitat units were identified for the upper reach of Benewah Creek. Of those 88, three (5.4%) were in the cascade category, 60 (68.2%) were in the riffle category, and 22 (25.1%) were in the pool category. In the cascade category all three units were identified as step pool cascades for a total area of 12 m? In the riffle category 36 (40.9%) were low gradient riffles for a total area of 4,437 m^2, and 24 (27.3%) were glides for a total area of **3,162** m^2. In the pool category 18 (20.5%) were scour pools for a total area of 1,001 m^2, and four (4.6%) were dammed pools for a total area of 1,723 m^2. Calculated residual pool depths were 1.3 meters for the dammed pools and 0.7 for the scour pools (Table 3.16).

3.1.1.4. **Evans Creek**

Five valley segments were surveyed for Evans Creek totaling 5,843 meters. Surveyed sections of the Evans Creek drainage ranged in elevation from 646 to 759 meters. Stream order ranged from one to four and had an average stream gradient of 2.2 Primary land uses practices in the watershed included forested (77.7%) and livestock grazing (22.3%) (Table 3.17). A mixed vegetative type was most abundant at 81 .O% and a strictly deciduous stand made up the remaining vegetation at 19%. The seral stage included mature stands at 77.3%, followed by grass/forb (18.9%), old growth (2.7%) and shrub (0.9%).

For the entire watershed 294 habitat units were classified (Table 3.18) comprising a total area of 25,521 square meters. Of the 294 habitat units, 72 (24.5%) were identified as cascades, 85 (28.9%) as riffles, as 137 (46.7%) as pools.

Table 3.15. Summary report for the upper reach of Benewah Creek, May-August, 1992.

Elevation	838-853 m
Total length	4369 m
Stream order	4
Mean stream gradient	1.5%
Pool/riffle/cascade ratio	.002/.006/l
Land use	
Timber	15.9%
Agriculture	1.1%
Livestock grazing	76.7%
Mining	
Wetland	
Other (includes residential,right of way, etc.)	6.3%
Vegetative type	
Deciduous	
Coniferous	
Mixed	100.0%
Seral Stage	
Grass/forb	83.5%
Shrub	12.5%
Pole	
Young	
Mature	
Old growth	
Other	
x Canopy cover	0.0 (O-0.00)
# Woody debris	
Logs	157
Root wads	12
Mass Wasting	0
Bank cutting	0
Side Channels	0

* (includes valley segment #5)

Table 3.16. Frequency of occurrence, total percent occurrence, total area, percent area and residual pool depth values for the upper reach* of Benewah Creek, May-August, 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. m)	% Area	Residual pool depth (m)
Rapid	0	0.0	0	0.0	
Step pool cascade	3	3.4	12	0.1	
Slip face cascade	0	0.0	0	00.	
Totals Cascades	**3**	5.4	12	**0.1**	
Pocketwater	0	0.0	0	0.0	
Glide	24	27.3	3,162	30.3	
Run	0	0.0	0	0.0	
Low gradient riffle	36	40 9	4,437	42 6	
Total Riffles	**60**	68.2	7,599	72.9	
Dammed pool	4	4.5	1,724	16.5	1.28
Eddy pool	0	0.0	0	0.0	0.00
Plunge pool	0	0.0	0	0.0	0.00
Scour pool	18	20.4	1,001	9.6	0.66
Scour hole	0	0.0	0	0.0	0.00
Beaver pond	0	0.0	0	0.0	0.00
Total Pools	22	25.1	2,725	26.1	
Secondary channel	3	3.4	86	0.8	0.13
Grand Totals	**88**		**10,421**		

* (includes valley segment #5)

Table 3.17. Summary report for the Evans Creek Watershed, May-August, 1992.

Elevation	**646-759 m**
Total length	5,843 **m**
Stream order	**4**
Mean stream gradient	2.2% **(1.5%-3.0%)**
Pool/riffle/cascade ratio	**1/3.4/2.29**
Land use	
Timber	77.7%
Agriculture	
Livestock grazing	22.3
Mining	
Other (includes residential etc.)	
Vegetative type	
Deciduous	19.0
Coniferous	
Mixed	81 .o
Seral Stage	
Grass/forb	18.9
Shrub	0.9
Pole	
Young	77.3
Mature	
Old growth	2.7
Other	
x Canopy cover	**59.2 (O-93)**
# Woody debris	
Logs	**136**
Root wads	13
Mass Wasting	**1800 m**

Table 3.18. **Frequency of occurrence, total percent occurrence, total area and percent area for habitat types on surveyed areas Evans Creek, May-August,1992.**

Habitat type	Frequency	% Frequency	Total Area (sq. m)	% Area
Rapid (RPD)	58	19.7	8,051	31.6
Step-pool cascade (SPC)	10	3.4	525	2.1
Slip-face cascade (SFC)	4	1.4	161	0.6
Total Cascades	72	24.5	8,737	34.3
Pocketwater (PKW)	0	0.0	0	0.0
Glide (GLD)	2	0.7	142	0.5
Run (RUN)	0	0.0		0.0
Low gradient riffle (LGR)	83	28.2	12.0837	50.3
Total Riffles	85	28.9	**12,979**	50.8
Dammed Pool (DMP)	9	3.1	262	1.0
Eddy pool (EDP)	9	3.1	166	0.6
Plunge pool (PLP)	25	8.5	481	1.9
Scour pool (SCP)	87	29.6	2,791	10.9
Scour hole (SCH)	7	2.4	104	0.4
Beaver pond (BVP)	0	0.0	0	0.0
Total Pools	137	46.7	3,805	14.8
Secondary channel (SDC)	0	0.0	0	0.0
Grand Totals	**294**		**25,521**	

In the lower reach of Evans Creek, only valley segment #1 was used. Elevation began at 646 meters and rose to 658 meters in 1,808.3 meters (Table 3.19). Mean stream gradient was 2.0% and a pool/riffle/cascade ratio of 13/77/1 was calculated. Land use practices within this section were 100% livestock grazing. The predominate vegetation was grass/forb at 94.8% and shrub at 4.3%. Mean canopy cover was 32.9% with a range of 0-72%. Sixteen logs and 8 root wads were identified in this reach. One thousand eight hundred meters of bank cutting were identified within this reach.

Fifty-eight habitat units were identified and counted within this section for a total of 8,931 m^2. Of the 58 units, two (3.5%) were in the cascade category, 27 (46.6%) were in the riffle category, and 29 (50.1%) were in the pool category. Both units in the cascade category were slip-face cascades for a total of 97 m? Twenty-five (46.6%) of the 27 units in the riffle category were low gradient riffles for a total, area of 7,364 m^2, and two (3.5%) were glides for a total area of 142 m^2. In the pool category, 19 (32.8%) were scour pools for a total area of 1,083 m^2, 5 (8.6%) were eddy pools for a total area of 144 m^2, three (5.2%) were scour holes for a total area of 52 m^2 and two (3.5%) were dammed pools for a total area of 42.3 m^2 (Table 3.20). Mean residual pool depths were calculated at 0.26 m, 0.68 m, 0.59 m and 0.43 meters for dammed, eddy, scour pools and scour holes, respectively.

Valley segment #2 comprised the middle reach of Evans Creek. Elevation began at 658 meters and rose to 695 meters in 832.1 meters (Table 3.21). Average stream gradient was 1.5% and a pool/riffle/cascade ratio of 4/17/1 was calculated. Land use was 100% forested. Vegetation consisted of 98.4% mature growth and 1.6% old growth. Mean canopy cover was 61% with a range of 0-93%. Fifty-eight logs and three root wads were counted within the reach

Sixty-four habitat units were counted and identified within the middle reach of Evans Creek for a total of 3,299 m^2 (Table 3.22). Seven (11 .0%) were in the cascade category, 31 (48.4%) were in the riffle category and 26 (40.6%) were in the pool category. Of the seven units in the cascade category, four (6.3%) were rapids for a total area of 72 m^2, two (3.1 %) were slip-face cascades for a total area of 64 m^2 and one (1.6%) was a step-pool cascade for an area of 8 m^2. All units (31/48.4%) in the riffle category were low gradient

Table 3.19. Summary report for lower reach of Evans Creek, May-August, 1992.

Elevation	**646-658 m**
Total length	**1808.3 m**
Stream order	**4**
Mean stream gradient	**2.0%**
Pool/riffle/cascade ratio	**13/77/1**
Land use	
Timber	
Agriculture	
Livestock grazing	100.0%
Mining	
Other (includes residential etc.)	
Vegetative type	
Deciduous	94.8%
Coniferous	
Mixed	5.2%
Seral Stage	
Grass/forb	95.7%
Shrub	4.3%
Pole	
Young	
Mature	
Old growth	
Other	
x Canopy cover	32.9 (O-72)
# Woody debris	
Logs	16
Root wads	8
Bank cutting	**1800 m**

* (includes only valley segment #1)

Table 3.20. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth values for the lower reach* of Evans Creek during 1992.

Habitat Type	Frequency	% Frequency	Total area (sq. m)	% total	Residual pool depth (m)
Rapid (RPD)	0	0.0	0	0.0	
Step-pool cascade	0	0.0	0	0.0	
Slip-face cascade	2	3.5	97	1.1	
Total Cascades	**2**	3.5	97	**1.1**	
Pocketwater	0	0.0	0	0.0	
Glide (GLD)	2	3.5	141	1.6	
Run (RUN)	0	0.0	0	0.0	
Low gradient riffle	25	43 1	7,365	82 5	
Total Riffles	**27**	46.6	7,506	84.1	
Dammed Pool (DMP)	2	3.5	42	0.5	0.26
Eddy pool (EDP)	5	8.6	144	1.6	0.68
Plunge pool (PLP)	0	0.0	0	0.0	0.00
Scour pool (SCP)	19	32.8	1,089	12.2	0.59
Scour hole (SCH)	3	5.2	52	0.6	0.43
Beaver pond (BVP)	0	0.0	0	0.0	0.00
Total Pools	**29**	**50.1**	**1,328**	**14.9**	

* (includes only valley segment #1)

Table 3.21. Summary report for the middle reach of Evans Creek, May-August, 1992.

Elevation	**658-695 m**
Total length	**832 m**
Stream order	**4**
Mean stream gradient	**1.5%**
Pool/riffle/cascade ratio	**4/17/1**
Land use	
Timber	100.0%
Agriculture	
Livestock grazing	
Mining	
Other (includes residential etc.)	
Vegetative type	
Deciduous	
Coniferous	
Mixed	100.0%
Seral Stage	
Grass/forb	
Shrub	
Pole	
Young	
Mature	98.4
Old growth	1.6
Other	
x Canopy cover	**61 (O-93)**
# Woody debris	
Logs	**58**
Root wads	**3**
Mass Wasting	**0**

Table 3.22. **Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth values for the middle reach* of Evans Creek, May-August, 1992.**

Habitat Type	Frequency	% Frequency	Total area (sq. m)	% total	Residual pool depth (m)
Rapid (RPD)	4	6.3	72	2.2	
Step-pool cascade	1	1.6	8	0.2	
Slip-face cascade	2	3.1	64	1.9	
Total Cascades	**7**	**11.0**	**144**	4.3	
Pocketwater (PKW)	0	0.0	0	0.0	
Glide (GLD)	0	0.0	0	0.0	
Run (RUN)	0	0.0	0	0.0	
Low gradient riffle	31	**48 4**	2 533	**76.8**	
Total Riffles	**3 1**	48.4	2,533	76.8	
Dammed Pool (DMP)	2	3.1	26	0.8	0.20
Eddy pool (EDP)	0	0.0	0	0.0	0.68
Plunge pool (PLP)	3	4.7	42	1.3	0.34
Scour pool (SCP)	18	28.1	510	15.5	0.39
Scour hole (SCH)	3	4.7	43	1.3	0.22
Beaver pond (BVP)	0	0.0	0	0.0	0.00
Total Pools	26	40.6	621	**18.9**	
Sec. channel (SDC)	0	0.0	0	0	0.00
Grand Totals	**6 4**		**3,299**		

riffles for a total area of 2,533 m^2. Eighteen (28.1%) of the pools were classified as scour pools for a total of 510 m^2, while plunge pools and scour holes both accounted for three each units (4.7%) for total areas of 42m^2 and 43 m^2, respectively. The remaining two (3.1%) units were classified as dammed pools for a total area of **26.5** m^2. Calculated mean residual pool depths were 0.26, 0.68, 0.59, and 0.43 meters for dammed, eddy, scour pools and scour holes, respectively.

In the upper reach of Evans Creek, valley segments #3 and #4 were combined. Elevation began at 695 meters and rose to 756 meters in 2,859.1 meters (Table 3.23). Mean stream gradient was 2.7% and a calculated pool/riffle/cascade ratio of l/303/3.9 was calculated. Major land use practices within the watershed were forest (97.4%) and livestock grazing (2.6%) . The majority of the riparian area was mature forest stands (97.1%) and old growth (2.7%). Mean canopy cover was 65.6% with a range of 38-88%. Forty-eight logs for large organic debris were counted within this section.

One hundred fifty-six habitat units were identified within the upper reach for a total area of 11,460 m^2 (Table 3.24). Of the 158 units, 52 (33.3%) were cascades, 26 (16.7%) were riffles and 78 **(50.0%)** were pools. Within the cascade category, 46 (29.5%) were rapids for a total of 6,450 m^2. Six (3.8%) were step-pool cascades for a total area of 372 m^2. In the riffle category, all twenty-six (16.7%) were low gradient riffles for a total area of 2,877 m? Of the 78 pools, 48 (30.8%) were scour pools for a total area of 1,134 m ^{2}, 20 (12.8%) were plunge pools for a total area of 405 m^2, five (3.2%) were dammed pools for a total area of 193 m^2, four (2.6%) were eddy pools for a total area of 21 m2 and one (0.6%) was a scour hole for a total area of 9 m^2. Calculated mean residual pool depths were 0.45, 0.19, 0.43, 0.40, and 0.18 meters for dammed pools, eddy pools, plunge pools, scour pools and scour holes, respectively.

3.1.1.5. **Alder Creek**

Four valley segments were surveyed for the Alder Creek drainage totaling 5,843 meters. Average stream gradient was 2.2% (Table 3.25). Major land uses within the riparian area was 81.5% forested, 10.3% livestock grazing, and 8.2% residential. A mixed vegetative type was most abundant at 57.6% followed by a deciduous

Table 3.23. Summary report for the upper reach of Evans Creek, May-August, 1992.

Elevation	**695-756 m**
Total length	**2859 m**
Stream order	**4**
Mean stream gradient	**2.7%**
Pool/riffle/cascade ratio	**1/3.3/3.9**
Land use	
Timber	97.4%
Agriculture	
Livestock grazing	2.6%
Mining	
Other (includes residential etc.)	
Vegetative type	
Deciduous	
Coniferous	0.7
Mixed	99.3%
Seral Stage	
Grass/forb	
Shrub	
Pole	
Young	
Mature	97.1
Old growth	2.7
Other	
x Canopy cover	65.6 (38-88)
# Woody debris	
Logs	48
Root wads	0
Mass Wasting	**0**

. (includes valley segment #3 and #4)

Table 3.24. Frequency of occurrence, total percent occurrence, total area, percent area,and residual pool depth values for the upper reach* of Evans Creek, May-August, 1992.

Habitat Type	Frequency	% Frequency	Total area (sq. m)	% total	Residual pool depth (m)
Rapid (RPD)	46	29.5	6450	56.3	
Step-pool cascade	6	3.8	371	3.2	
Slip-face cascade	Q	0.0	Q	0.0	
Total Cascade	**52**	33.3	6,821	59.5	
Pocketwater (PKW)	0	0.0	0	0.0	
Glide (GLD)	0	0.0	0	0.0	
Run (RUN)		0.0	0	0.0	
Low gradient riffle	26	16.7	2,877	25.1	
Total Riffles	**26**	**16.7**	2,877	25.1	
Dammed Pool (DMP)	5	3.2	193	1.7	0.45
Eddy pool (EDP)	4	2.6	21	0.2	0.19
Plunge pool (PLP)	20	12.8	405	3.5	0.43
Scour pool (SCP)	48	30.8	1,134	9.9	0.40
Scour hole (SCH)	1	0.6	9	0.1	0.18
Beaver pond (BVP)	Q	0.0	0	0.0	0.00
Total **Pools**	78	50.0	**1.762**	**15.4**	
Sec channel (SDC)	0	0.0	0	0.0	0.00
Grand Totals	**156**		**11,461**		

* (includes vailey segment #3 and #4)

Table 3.25. Summary report for the Alder Creek Watershed, May-August, 1992.

Elevation	**740-902 m**
Total length	**'11,810 m**
Stream order	**3**
Mean stream gradient	2.7% **(2.3%-3.0%)**
Pool/riffle/cascade ratio	
Land use	
Timber	81.5%
Agriculture	
Livestock grazing	10.3%
Mining	
Wetland	
Other (includes residential,right of way, etc.)	8.2%
Vegetative type	
Deciduous	29.8%
Coniferous	12.6%
Mixed	57.6%
Serai Stage	
Grass/forb	**15.3%**
Shrub	52.0%
Pole	0.8%
Young	**19.9%**
Mature	12.1%
Old growth	
Other	
x Canopy cover	34.4% (O-99)
# Woody debris	
Logs	297
Root wads	48
Mass Wasting	

stand at 29.8% and a coniferous stand at 12.6%. Predominate seral stage was 52% shrub, 19.9% young forest, 15.3% grass/forb, 12.1% mature forest and 0.8% pole trees. Mean canopy cover was 34.4% with a range of 0-99%. Two hundred ninety-seven logs and forty eight root wads were identified within the stream channel.

A total of 606 habitat units for a total of 125,325 m^2 were identified and counted in Alder Creek. Of the 606 units, 35 (5.8%) were cascades, 424 (69.9%) were riffles,- 142 (23.5%) were pools and 5 (0.8%) were side channels (Table 3.26).

Valley segments #1 and #2 were combined and comprised the lower reach of Alder Creek. Elevation of the lower reach began at 704 meters and rose to 817 meters in 3,313.8 meters. Mean stream gradient was 2.8% and a pool/riffle/cascade ratio of 4.8/1/.03 was calculated. Primary land use within the riparian area was 99.6% forest and .04% other. A mixed deciduous and coniferous vegetative type was the most abundant (59.9%), followed by a strictly coniferous stand (34.6%), and a deciduous stand (5.6%). Primary seral stage was young trees (40.7%) followed by shrub (35.1%), mature forest (14.6%), grass/forb (8.4%) and pole (1.2%). Mean canopy cover was 30.0% with a range of 0-99%. One hundred forty-eight logs, and 17 root wads were identified within this reach for large organic debris (Table 3.27).

Two hundred twenty two units were identified in the lower reach of Alder Creek for a total area of 85,018 m^2 (Table 3.28). Of the 222 units, 11 (5.1%) were cascades, 150 (67.6%) were riffles, 58 (23.5%) were pools and three (1.4%) were side channels. Of the eleven units in the cascade category, seven (3.2%) were step-pool cascades for a total area of 408 m^2, three (1.4%) were slip face cascades for a total area of 31 m^2, and one (0.5%) was a rapid for a total area of 29 m^2. Of the 150 riffle units, 74 (33.3%) were classified as low gradient riffles for a total area of 23,062 m^2, 47 (21.2%) were glides for a total area of 4,878 m^2, and 29 (13.1%) were pocketwater for a total area of 42,278 m? Thirty-three (14.9%) units in the pool category were identified as scour pools for a total area of 5,282 m^2. Eighteen (8.1%) were identified as plunge pools for a total area of 2,102 m^2, six (2.7%) were identified as dammed pools for a total area of 6,893 m^2 and one (0.5%) was identified as a scour hole for a total area of 55 m^2. Three (1.4%) side channels were identified in this reach for a total area of 366 m^2. Average residual pool depths were 0.42 meters for dammed

Table 3.26. Frequency of occurrence, total percent occurrence, total area and percent area for the Alder Creek drainage, May-August, 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. m)	% Area
Rapid	1	0.2	29	<0.1
Step pool cascade	9	1.5	417	0.3
Slip face cascade	25	4.1	352	0.3
Total Cascades	35	5.8	798	0.7
Pocketwater	39	6.4	42,948	34.3
Glide	165	27.2	15,471	12.3
Run	0	0.0	0	0.0
Low gradient riffle	220	36.3	42.059	33 6
Total Riffles	424	**69.9**	100,478	80.2
Dammed pool	29	4.8	12,020	9.6
Eddy pool	0	0.0	0	0.0
Plunge pool	21	3.5	2,279	1.8
Scour pool	91	15.0	9,044	7.2
Scour hole	1	0.2	55	co.1
Beaver pond	0	0.0	0	0.0
Total Pools	**142**	23.5	23,398	**18.7**
Secondary channel	5	0.8	653	0.52
Grand totals	606		**12,5327**	

Table 3.27 Summary report for the lower reach* of Alder Creek, May-August, 1992.

Elevation	**704-817 m**
Total length	**3313.8m**
Stream order	3
Mean stream gradient	2.8%
Pool/riffle/cascade ratio	**4.8/1/.03**
Land use	
Timber	**99.6%**
Agriculture	
Livestock grazing	
Mining	
Wetland	
Other (includes residential,right of way, etc.)	0.4%
Vegetative type	
Deciduous	5.6%
Coniferous	34.6%
Mixed	**59.9%**
Seral Stage	
Grass/forb	8.4%
Shrub	35.1%
Pole	1.2%
Young	40.7%
Mature	14.6%
Old growth	
Other	
x Canopy cover	30.0 **(O-99)**
# Woody debris	
Logs	148
Root wads	17
Mass Wasting	

* (includes valley segments #1 and #2)

Table 3.28. Frequency of occurrence, total percent occurrence, total area, percents area, and residual pool depth for the lower reach* of Alder Creek, May-August, 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. m)	% Area	Residual pool depth (m)
Rapid	1	0.5	29	<0.1	
Step pool cascade	7	3.2	408	0.5	
Slip face cascade	3	1.4	31	<0.1	
Total Cascades	**11**	**51**	**469**	0.7	
Pocketwater	29	13.1	42,278	52.5	
Glide	47	21.2	4,878	6.1	
Run	0	0.0	0	0.0	
Low gradient riffle	74	33 3	23,062	28.6	
Total Riffles	**150**	67.6	**70,218**	87.2	
Dammed pool	6	2.7	6,893	8.6	0.42
Eddy pool	0	0.0	0	0.0	
Plunge pool	18	8.1	2,102	2.6	0.69
Scour pool	33	14.9	5,282	6.6	0.47
Scour hole	1	0.5	55	0.7	0.08
Beaver pond	0	0.0	0	0.0	0.00
Total Pools	58	26.2	14,332	**18.5**	
Secondary channel	3	1.4	366	0.5	
Grand Totals	**222**		**85,018**		

• (includes valley segments #1 and #2)

pools, 0.69 meters for plunge pools, 0.47 meters for scour pools, and 0.08 meters for scour holes.

The middle reach of Alder Creek was comprised of valley segment #3. Elevation stayed constant at 817 meters in 961 meters. Mean stream gradient was 3.0% and a pool/riffle/cascade ratio of 2.7/71.2/1 was calculated (Table 3.29). Primary land use within the riparian area was 78.9% forest, 8.9% livestock grazing and 12.2% residential. A deciduous vegetative type was the most predominate (77.8%) while a mixed deciduous/coniferous mix made up the remaining 22.2%. Primary seral stage was 68.9% shrub followed by 26.7% grass/forb, 3.3% young trees and 1.1% pole trees. Mean canopy cover was 26.8% with a range of 0-95%. Two logs and one root wad were identified within this reach.

Forty-five habitat units were identified within this reach for a total area of 3,954 m^2. Of these units, three (6.6%) were in the cascade category, 40 (88.9%) were in the riffle category, and two (4.4%) were in the pool category (Table 3.30). Of the three cascade units, two (4.4%) were slip-face cascades for a total area of 49 m^2 and one (2.2%) was a step-pool cascade for a total area of 4 m? Of the forty riffle units, 21 (46.7%) were identified as glides for a total area of 1,361 m^2, and 19 (42.2%) were low gradient riffles for a total area of 2396 m? One plunge pool and scour pool were identified within the pool category for a total area of 126 m^2 and 19 m^2, respectively. Residual pool depths were calculated at 0.55 meters and 0.18 meters for plunge pools and scour pools, respectively.

Valley segment #4 comprised the upper section of Alder Creek. Elevation began at 817 meters and rose to 902 meters in 7,535 meters. Mean stream gradient was 2.3% with a pool/riffle/cascade ratio of 33/84/l (Table 3.31). Primary land use within the riparian area was 65.8% forested, 22.0% livestock grazing and 12.2% residential. A mixed coniferous/deciduous vegetative type existed in 90.9% of the area, while a deciduous stand existed in 6.0% and a coniferous stand existed in 3.1%. Primary seral stage was 51.9% shrub, followed by 15.6% young trees, 21.7% mature trees and 10.8% grass/forb. Mean canopy cover was 46.3%, with a range of 0-94%. One-hundred-forty-eight logs and thirty root wads were identified in the upper reach of Alder Creek.

Three-hundred-eighteen habitat units were identified with the upper reach of Alder Creek for a total area of 32,732 m^2. Of the 318

Table 3.29. Summary report for the middle reach* of Alder Creek, May-August, 1992.

Elevation	817-817 m
Total length	961 m
Stream order	3
Mean stream gradient	3.0%
Pool/riffle/cascade ratio	2.7171 .2/l
Land use	
Timber	78.9%
Agriculture	
Livestock grazing	8.9%
Mining	
Wetland	
Other (includes residential,right of way, etc.)	12.2%
Vegetative type	
Deciduous	77.8%
Coniferous	
Mixed	22.2%
Seral Stage	
Grass/forb	26.7%
Shrub	68.9%
Pole	1.1%
Young	3.3%
Mature	
Old growth	
Other	
x Canopy cover	26.8 (O-95)
# Woody debris	
Logs	2
Root wads	1
Mass Wasting	

. (includes valley segment #3)

Table 3.30. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth for the middle reach of Alder Creek, May-August, 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. m)	% Area	Residual pool depth (m)
Rapid	0	0.0	0	0.0	
Step pool cascade	1	2.2	4	0.0	
Slip face cascade	2	4.4	49	1.2	
Total Cascades	**3**	6.6	53	**1.2**	
Pocketwater	0	0.0	0	**0.0**	
Glide	21	46.7	1,361	34.4	
Run	0	0.0	0	0.0	
Low gradient riffle	19	42.2	2,396	60.6	
Total Riffles	**40**	88.9	3,757	95.0	
Dammed pool	0	0.0	0	0.0	0.00
Eddy pool	0	0.0	0	0.0	0.00
Plunge pool	1	2.2	126	3.2	0.55
Scour pool	1	2.2	19	0.5	0.18
Scour hole	0	0.0	0	0.0	0.00
Beaver pond	0	0.0	0	0.0	0.00
Total Pools	2	4.4	145	3.7	
Secondary channel	0	0.0	0	0.0	
Grand Totals	**45**		**3,954**		

Table 3.31. Summary report for the upper reach of Alder Creek, May-August, 1992.

Elevation	817-902 m
Total length	7,535 m
Stream order	3
Mean stream gradient	2.3
Pool/riffle/cascade ratio	33/84/1
Land use	
Timber	65.8%
Agriculture	
Livestock grazing	22.0%
Mining	
Wetland	
Other (includes residential,right of way, etc.)	12.2%
Vegetative type	
Deciduous	6.0%
Coniferous	3.1%
Mixed	90.9%
Seral Stage	
Grass/forb	10.8%
Shrub	51.9%
Pole	
Young	15.6%
Mature	21.7
Old growth	
Other	
x Canopy cover	46.3 (O-94)
# Woody debris	
Logs	147
Root wads	30
Mass Wasting	

units, 21 (6.6%) were in the cascade category, 214 (67.2%) were in the riffle category, 81 (25.4%) were in the pool category and two (0.6%) were side channels. Twenty (6.3%) of the units in the cascade category were classified as slip face cascades for a total area of 271 m^2 and one (0.3%) was a step-pool cascades for a total area of 6 m^2. Of the 214 riffle units, 118 (37.1%) were low gradient riffles for a total area of 14,100 m^2, 86 (27.0%) were glides for a total area of 8,510 m^2 and ten (3.1%) were pocketwater for a total area of 671 m^2. Out of 81 pool units, 57 (17.9%) were scour pools for a total area of 3,744 m^2, 23 (7.2%) were dammed pools for a total area of 5,126 m^2 and one (0.3%) was a plunge pool for a total area of 21 m? Two (0.6%) side channels were identified for a total area of **287** m? Mean residual pool depths were calculated at 0.57 meters for dammed pools, 0.30 meters for plunge pools and 0.50 meters for scour pools (Table 3.32).

Habitat was identified and counted for the headwaters of Alder Creek and the north fork of Alder Creek and can be found in Appendix B.

3.1.2. Stream Reach Index and Channel Stability Evaluation.

Stream reach index and channel stability evaluations were conducted on each stream reach during 1992. Streams were divided into reaches based on fish relative abundance and population data sites. An overall stream rating was determined as well as individual reach ratings. Raw numbers for each category for each stream reach can be found in Appendix C.

Fifty three percent of Lake Creek was surveyed (Table 3.33). An overall fair stream rating was determined from a stream value of 90. The lower reach of Lake Creek had a good value at 59 and the middle reach had a fair rating at 78. The upper reach of Lake Creek rated poor with a value of 128.

Sixty seven percent of Benewah Creek was surveyed for an overall fair stream rating of (89). The lower and upper sections received a fair stream rating with values of 80 and 106, respectively, while the middle section received a good stream rating at 74.

Table 3.32. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth for the upper reach of Aider Creek, May-August, 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. m)	% Area	Residual pool depth (m)
Rapid	0	0	0	0.0	
Step pool cascade	1	0.3	6	0.1	
Slip face cascade	20	6.3	271	0.8	
Total Cascades	**21**	6.6	271	0.9	
Pocketwater	10	3.1	671	2.1	
Glide	86	27.0	8,510	26.0	
Run	0	0.0	0	0.0	
Low gradient riffle	118	37 1	14.100	43 1	
Total Riffles	214	67.2	23,281	71.2	
Dammed pool	23	7.2	5,126	15.7	0.57
Eddy pool	0	0.0	0	0.0	0.00
Plunge pool	1	0.3	21	0.1	0.30
Scour pool	57	17.9	3,744	11.4	0.50
Scour hole	0	0.0	0	0.0	0.00
Beaver pond	0	0.0	0	0.0	0.00
Total Pools	**81**	25.4	**32,1**73	27.2	
Secondary channel	2	0.6	287	0.9	0.08
Grand Totals	**31 8**		**32,731**		

Table 3.33. Calculated stream reach and channel stability index (SRCSI) values for each stream segment sampled and the overall stream rating May - June, 1992.

Stream reach	SRCSI value (rating)	Reach length (km)	Overall stream rating
Benewah			
Lower	80 (fair)	4.4	
Middle	74 (good)	5.0	89
Upper	106 (fair)	6.8	**FAIR**
Area sampled (% of entire stream)		16.2 (67%)	
Evans			
Lower	138 (poor)	1.7	
Middle	77 (fair)	1.9	98
Upper	68 (good)	0.9	**FAIR**
Area sampled (% of entire stream)		4.5 (56%)	
Alder			
Lower	41 (good)	5.0	
Middle	46 (good)	3.1	48
Upper	59 (good)	3.9	**GOOD**
Area sampled (% of entire stream)		12.0 (60%)	
lake			
Lower	59 (good)	3.1	
Middle	78 (fair)	3.4	90
Upper	121 (poor)	4.3	**FAIR**
Area sampled (% of entire stream)		10.8 (53%)	

Fifty six percent of the Evans Creek Watershed was surveyed for an overall fair stream rating of 98. The lower section received a poor rating with a value of 138, the middle section received a fair rating (77) and the upper section received a good rating (68).

Sixty percent of the Alder Creek Watershed was surveyed for an overall good stream rating (48). All three sections of Alder received a good rating with values of 41, 46, and 59 for the lower, middle and upper segments, respectively.

3.1.3. Stream Discharge

Stream discharge measurements were collected monthly from February 6, 1992 through November 10, 1992. During the months of spring run off, March and April, discharge measurements were collected three and two times, respectively. Table 3.34. lists the monthly discharge measurements for all four creeks. Benewah Creek had a discharge of 30 cubic feet per second (cfs) in February followed by the yearly high flow of 39 cfs in the second week of March (Figure 3.1). The discharge declined each month following high flow from 32 cfs in March (20th) to the years lowest discharge of 1.0 cfs in August. September, October and November measurements increased to 3, 2 and 10 cfs, respectively.

Evans Creek discharges for the year were 21 cfs for February, 29, 19 and 17 cfs for March, 12 and 13 cfs for April, 5 cfs for May, 4 for June, 2 for July, 2 for August, 3 for September, 5 for October and 5 cfs for November (Figure 3.2). Early March was the highest discharge recorded and the lowest discharge was found in August.

Figure 3.3 shows the yearly discharge profile for Lake Creek. The highest recorded discharge was 32 cfs on March 13th, after this point the discharge declined to 22 cfs in late March and steadily decreased to 0.4 cfs through the month of August. Beginning in September discharge increased to 0.5 cfs followed by October, November and February with discharges of 3, 5 and 24 cfs, respectively.

Alder Creek discharges for the 1992 year were 21, 14 and 7 cfs for March, 5 and 6 cfs for April, 3 cfs for May, 3 for June, 1 for July and August, 4 for September, 8 for October and 13 cfs for November (Figure 3.4). The highest discharge was recorded in March and the lowest discharge was found in July and August

Table 3.34. Monthly discharge measurements in cubic feet per second (cfs) for selected Coeur d'Alene tributaries during 1992.

Month	Benewah	Alder	Lake	Evans
2/6/92	30.1	*	23.7	20.6
3/13/92	38.9	21.3	32.2	28.7
3/20/92	31.8	13.7	21.8	19.2
3/30/92	16.9	7.3	16.8	17.1
4/9/92	10.5	5.2	10.9	11.5
4/27/92	5.2	5.5	4.5	12.8
5/27/92	5.5	3.2	3.8	4.7
6/30/92	2.6	3.3	1.0	4.4
7/30/92	0.8	0.6	0.4	1.8
8/10/92	0.6	0.6	0.4	1.6
9/8/92	2.7	3.9	0.5	2.8
10/8/92	2.3	7.9	2.5	4.9
11/10/92	9.8	12.5	5.2	4.6

*site could not be accessed.

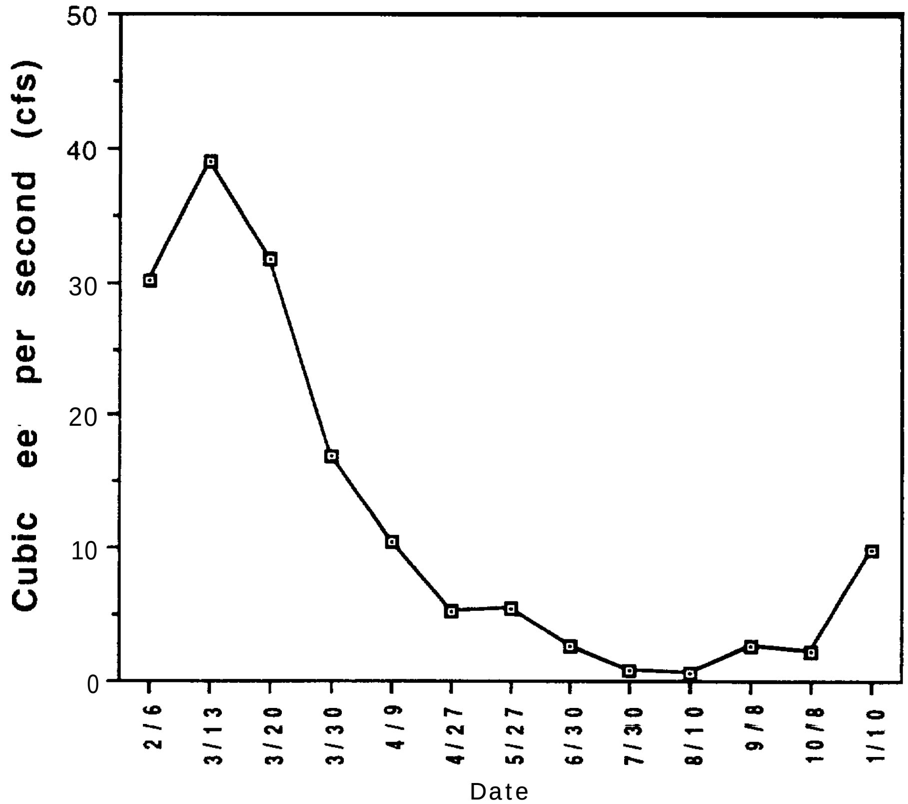

Figure 3.1. Monthly discharge measurements for Benewah Creek, February-November, 1992.

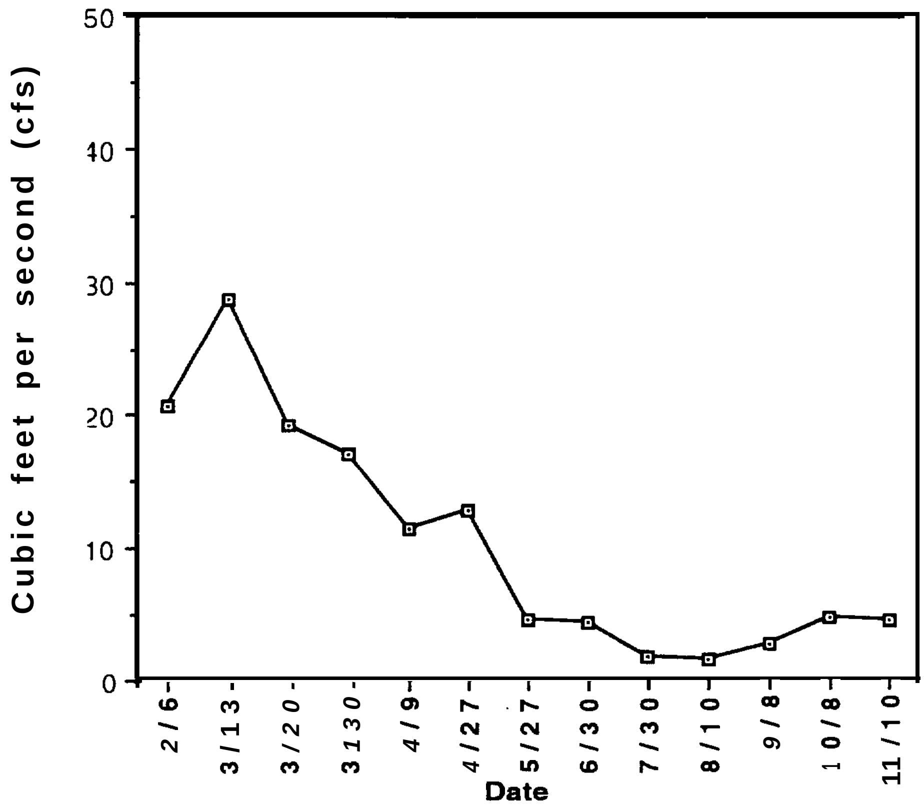

Figure 3.2. Monthly discarge profiles for Evans Creek, February-November, 1992.

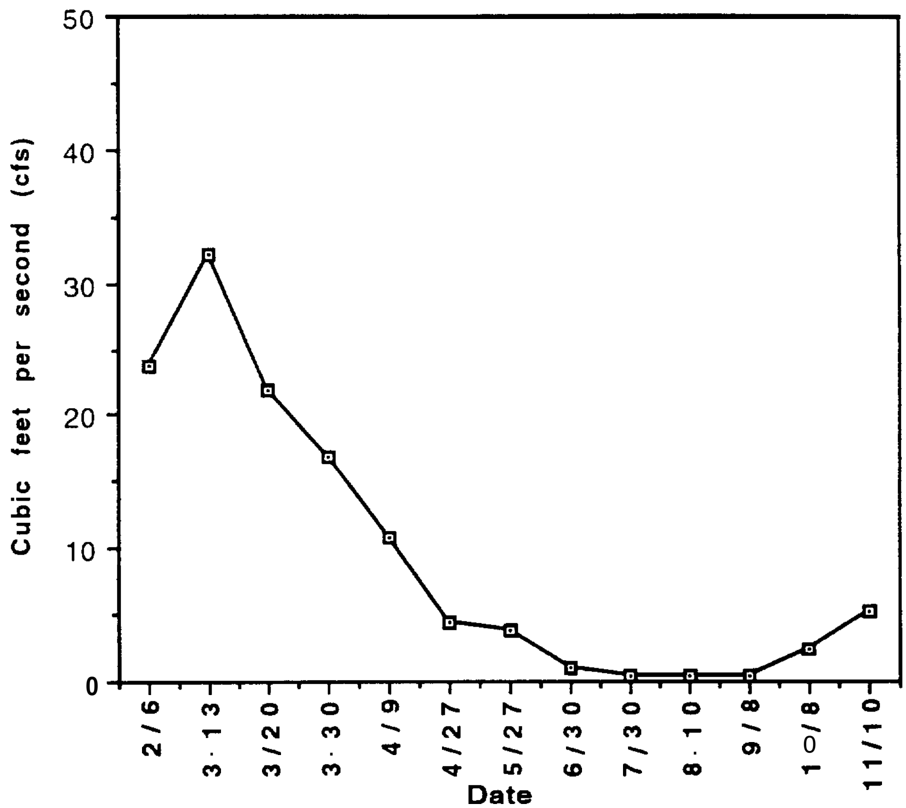

Figure 3.3. Monthly discharge profiles for Lake Creek, February-November, 1992.

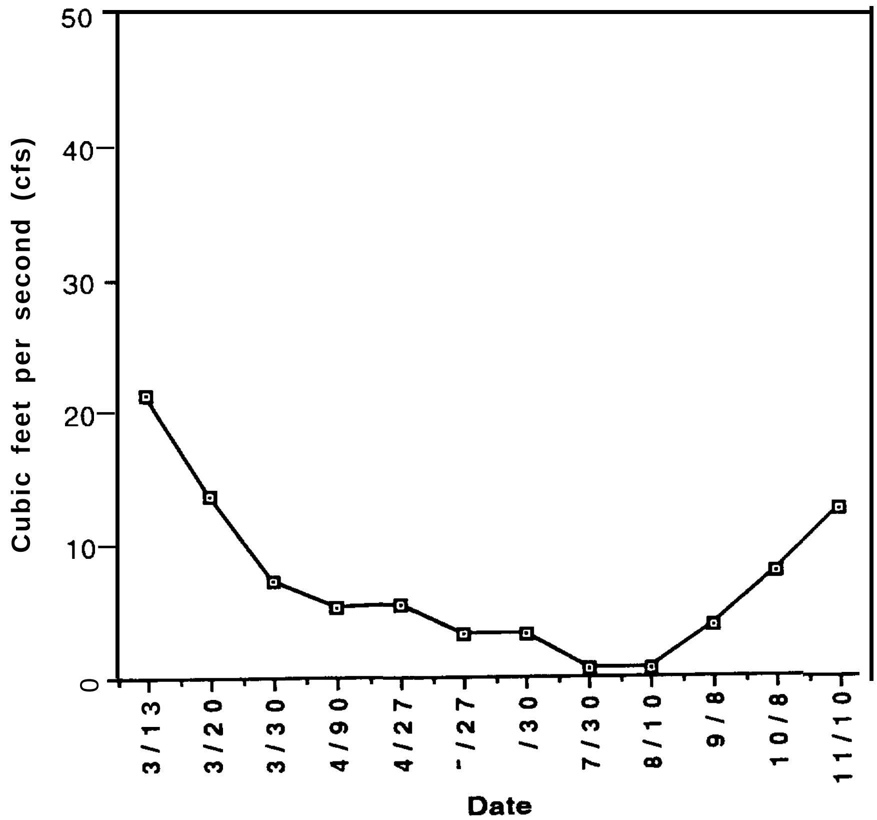

Figure 3.4. Monthly discharge profi es for Alder Creek, March-November, 1992.

3.1.4. Stream Temperatures

Monthly temperatures were collected at the four streams from February 6, 1992 to November 10, 1992. During the months of spring run off, March and April, temperatures were collected three and two times, respectively. Table 3.35 lists the monthly temperatures for all four creeks.

Benewah Creeks lowest temperature was 0° Celsius for the month of February. The temperatures steadily increased through the year to 4 °C, 7 °C, 4 °C, 5 °C, 13 °C, 12 °C, and 17 °C for March 13th, March 20th, March 30th, April 9th, April 27th, May, and July , respectively. The highest temperature was recorded in July at 17 °C, followed by a sharp decrease of 7 °C in October, and a gradual decrease to 4° C in November (Figure 3.5).

Evans Creeks temperatures for the year were 4 °C for February, 4 and 6 °C for March, 4 and 10 °C for April, 15 °C for May, 17 °C for July, 4 °C for September, 8 °C for October and 3 °C for November (Figure 3.6). The highest temperature was recorded in July and the lowest temperature was recorded in November.

The temperature profile for Lake Creek is shown in Figure 3.7 The lowest temperature of 1 °C was recorded in February. March temperatures were 6 and 4 °C, followed by April at 5, 12, and 10 °C, June at 25 °C, September at 4 °C, October at 11 °C and November at 3 °C. July had the highest monthly temperature of the year for Lake Creek.

Alder Creeks temperatures for the year were 3, 6 and 4 °C for March, 3 and 12 °C for April, 12 °C for May, 17 °C for July, 4 °C for September, 3 °C for October and 3 °C for November (Figure 3.8). The highest temperature was recorded in July and the lowest temperature was recorded in March.

3.1.5. Water Quality Analysis

Water quality data was analyzed seasonally for spring, summer and fall in April, August, and September, respectively for the four creeks. Spring alkalinity values ranged from 30 ppm in Evans Creek to 50 ppm in Benewah and Alder Creeks. Nitrite values ranged from .Ol ppm in Benewah, Evans, and Lake Creeks to .03 ppm in Alder

Table 3.35. Monthly temperature profiles (centigrade) for selected Coeur d'Alene tributaries during 1992.

Month	Benewah	Alder	Lake	Evans
2/6/92	0	*	1.0	4.0
3/13/92	4.4	2.8	5.6	4.4
3/20/92	6.7	5.6	3.9	3.9
3/30/92	4.4	4.4	4.4	6.1
4/9/92	5.0	3.0	5.0	4.0
4/27/92	13.0	12.0	12.0	10.0
5/27/92	12.0	12.0	10.0	15.0
6/30/92	•	*	*	*
7/30/92	17	17	25.0	17.0
8/10/92	*	*	*	•
9/8/92	6.6	4.4	4.4	4.4
10/8/92	5.6	3.3	11.0	a
11/10/92	4.4	3.3	2.8	2.8

*values were not collected.

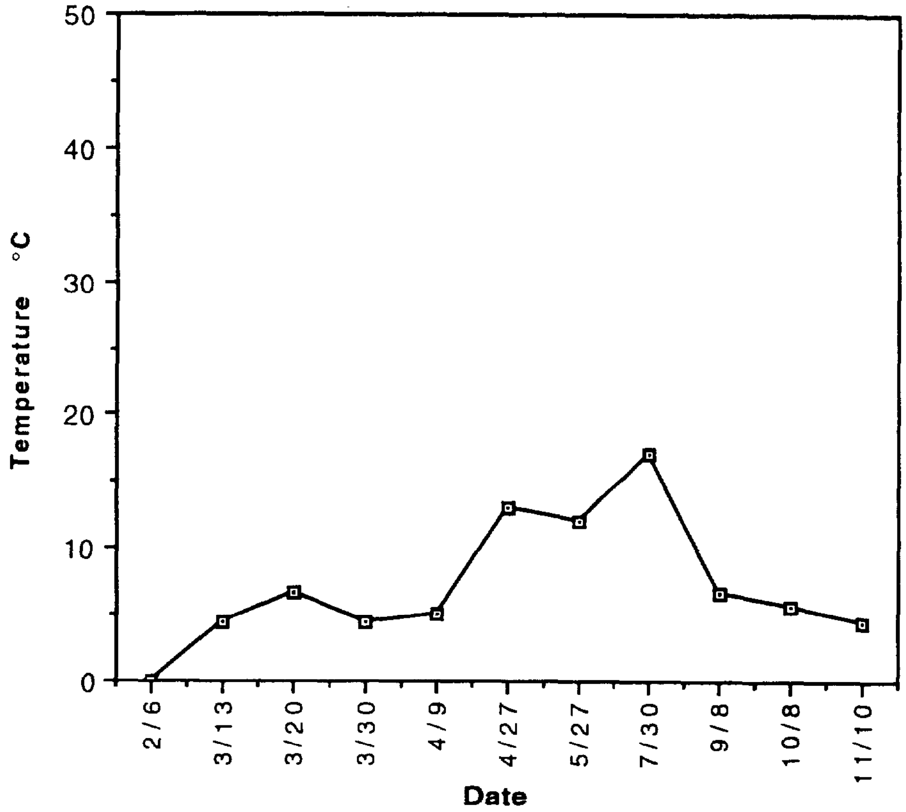

Figure 3.5. Temperature profiles for Benewah Creek, February-November, 1992.

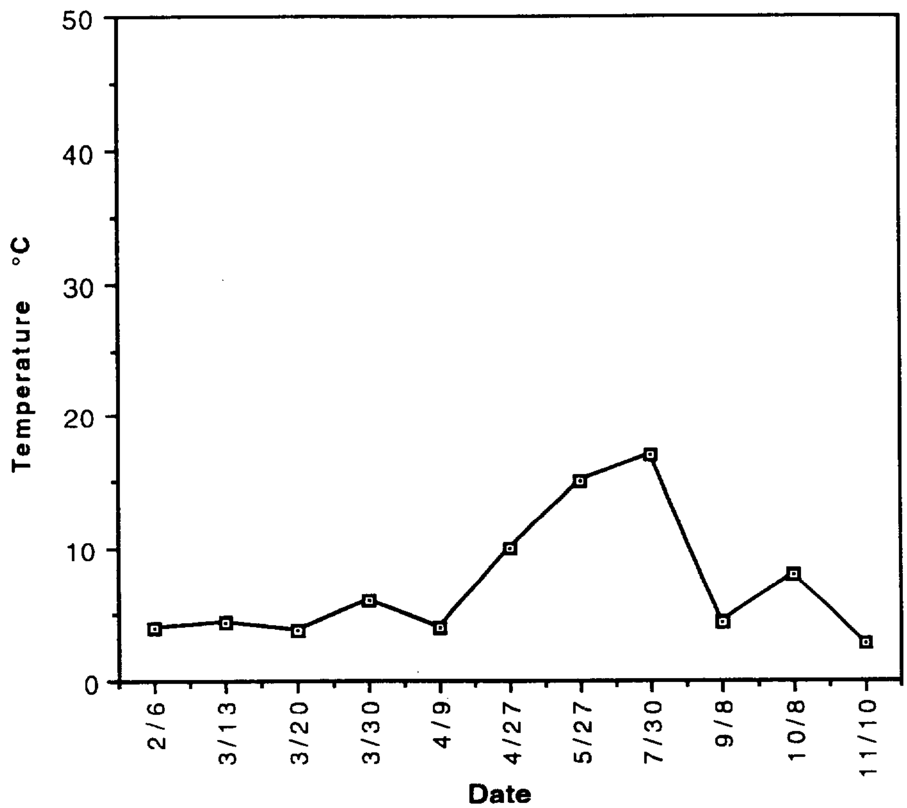

Figure 3.6. Temperature profiles for Evans Creek, February-November, 1992.

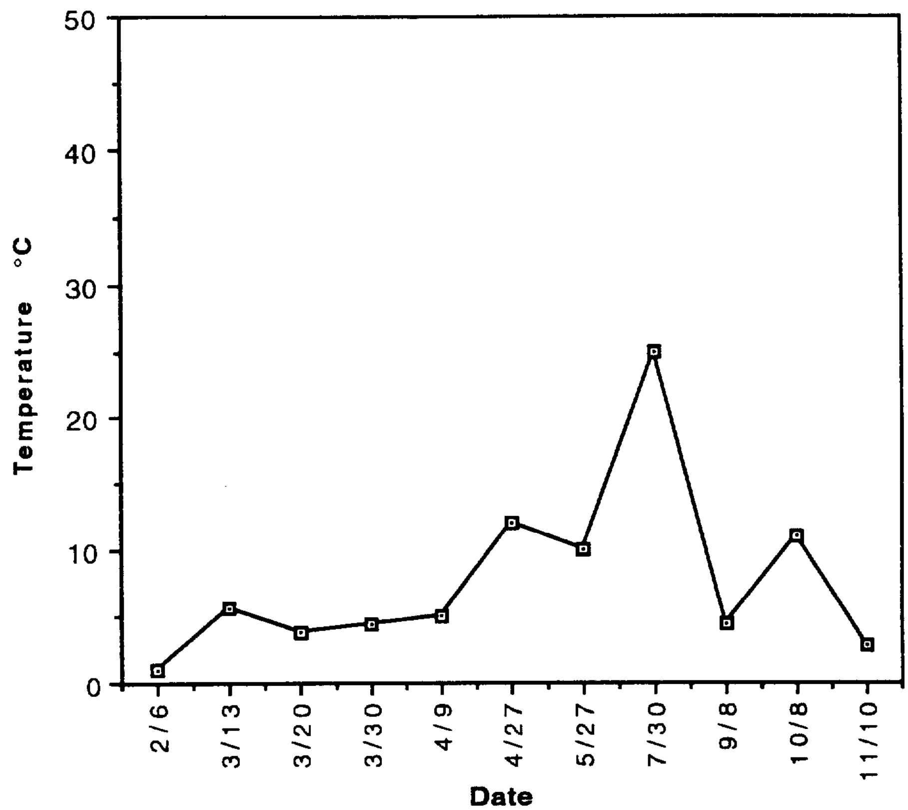

Figure 3.7. Temperature profiles for Lake Creek, February-November, 1992.

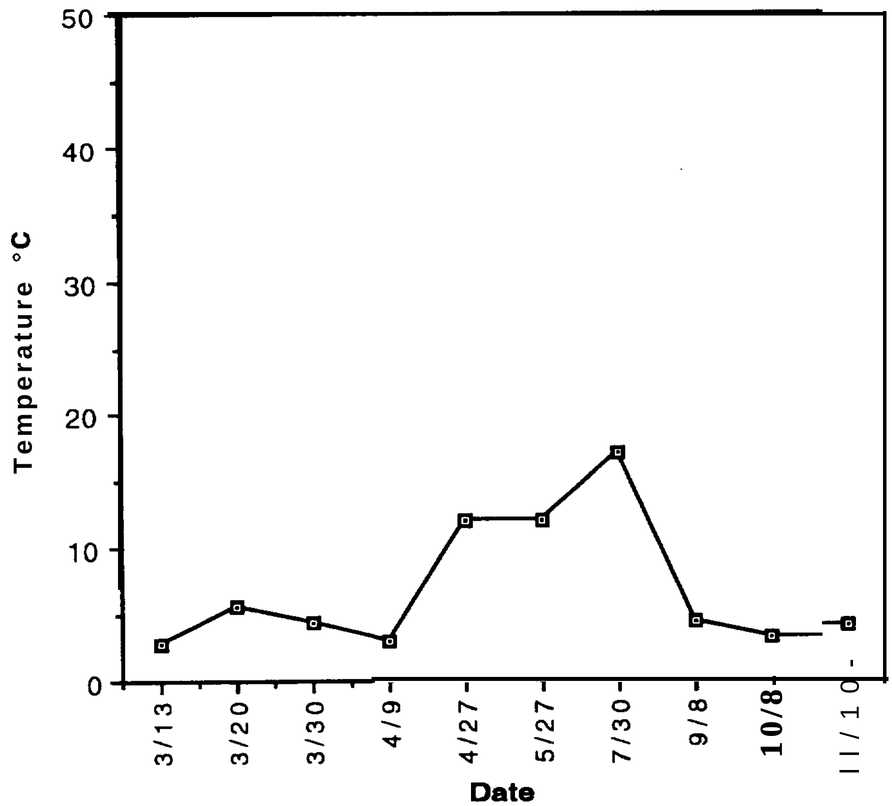

Figure 3.8. Temperature profiles for Alder Creek, March-November, 992.

Creek. Nitrate values ranged from 0 in Benewah, Evans and Alder Creeks to .09 in Lake Creek. Phosphate values ranged from .07 ppm in Lake Creek to 1.39 ppm in Alder Creek. Total dissolved solids (ppm) ranged from 10 in Evans Creek to 20 in the remaining three creeks. Turbidity values ranged from 12 Formazin Turbidity Units (FTU) in Evans Creek to 18 FTU in Lake and Alder Creeks (Table 3.36). PH values ranged from 6.0 in Evans to 7.3 in Alder Creek (Table 3.37).

Summer alkalinity values ranged from 40 ppm in Evans Creek to 65 ppm in Lake Creek. Nitrite values ranged from 0 in Alder Creek to .06 ppm in Benewah and Lake Creeks. Nitrate (ppm) values ranged from 0 in Evans Creek to .08 in Alder Creek. Phosphate values ranged from .18 ppm in Alder Creek to 1.06 ppm in Evans Creek (Table 3.36). PH values ranged from 5.0 in Lake Creek to 7.6 in Alder Creek. Dissolved oxygen (ppm) values ranged from 10.8 in Evans Creek to 12.2 in Lake Creek (Table 3.37).

Fall alkalinity values ranged from 40 ppm in Evans and Lake Creek to 80 ppm in Alder Creek. Nitrite values ranged from .Ol ppm in Alder Creek to .06 ppm in Benewah Creek. Nitrate values were 0 for all four creeks in the fall. Phosphate values ranged from .76 ppm in Benewah Creek to 1.06 ppm in Evans Creek (Table 3.36). PH values ranged from 7.1 in Evans and Lake Creeks to 7.4 in Benewah Creek (Table 3.37).

3.1.6. Fredle Index Values and Percent Cutthroat Trout Survival

A total of one hundred and fifty substrate samples were collected from four streams during 1992. Geometric means, sorting coefficients, fredle index values, and predicted % survival rates of cutthroat trout were calculated for each sample and can be found in Appendix D.

Mean fredle index values and percent survival can be found in Table 3.38. Mean fredle index values for Benewah Creek were 17.9, 18.9 and 4.5 for the lower, middle, and upper reaches, respectively. Mean fredle index values for Alder Creek were 7.9, 21.6, and 10.0 for the lower, middle and upper reaches, respectively. Evans Creek had fredle index values of 3.7, 6.8, and 7.4 for the lower, middle, and upper reaches respectively. Lake Creek had index values of 8.3, 8.7,

Table 3.36 Seasonal water quality parameters for selected Coeur d'Alene tributaries.

	SPRING						SUMMER				FALL			
	Alk. (ppm)	NO_2 (ppm)	NO_3 (ppm)	PO_4 (ppm)	TDS (ppm)	Turbidity (NTU)	Alk. (ppm)	NO_2 (ppm)	NO_3 (ppm)	PO_4 (ppm)	Alk. (ppm)	NO_2 (ppm)	NO_3 (ppm)	PO_4 (ppm)
Benewah	50	.01	0	1.09	20	15	60	.06	.04	.58	50	.06	0	.76
Evans	30	.01	0	.36	10	12	40	.05	0	1.06	40	.04	0	1.06
Lake	45	.01	.09	.07	20	18	65	.06	.04	.44	40	.03	0	.91
Alder	50	.03	0	1.39	20	18	60	0	.08	.18	80	.01	0	.91

*Total dissolved solids and turbidity not determined.

Table 3.37 Seasonal hydrolab water quality parameters for selected Coeur d'Alene tributaries.

	SPRING		SUMMER		FALL*	
	pH	D.O. (ppm)	pH	D.O. (ppm)	pH	D.O. (ppm)
Benewah	6.3-7.3		5.0-7.3	11.9	7.4	-
Evans	6.0-6.3		6.5-7.3	10.8	7.1	
Lake	6.7		5.0-7.2	12.2	7.1	
Alder	7.0-7.3		6.4-7.6	11.6	7.2	

-data not collected

Table 3.38 Mean fredle index values and mean calculated percent survival values for cutthroat trout in selected stream reaches during 1992.

Stream	Fredle Index	% Survival
Bene wah		
Lower	17.9	**87.9**
Middle	18.9	**96.7**
Upper	4.5	67.4
Alder		
Lower	7.9	**90.6**
Middle	21.6	**97.5**
Upper	10.0	86.1
Evans		
Lower	3.7	**59.3**
Middle	***6.8***	78.6
Upper	***7.4***	83.1
Lake		
Lower	8.3	74.2
Middle	8.7	69.5
Upper	10.7	54.0
Bozard	1.1	19.3
West Lake Creek	0.4	5.4
Upper Lake Creek'	***0.1***	0.0

'upstream of where forks of Lake Creek merge and 10.7 for the lower, middle and upper reaches. Bozard Creek had a fredle index value of 1 .1, while West Lake Creek had a value of 0.4 and Upper Lake Creek had a Fredle index value of 0.1.

Average predicted cutthroat trout survival was 87.9% for lower reach, 96.7% for the middle reach and 67.4% for the upper reach of Benewah Creek (Table 3.38). Cutthroat survival rates for Alder Creek were calculated at 90.6% for the lower reach, 97.5% for the middle reach and 86.1% for the upper reach. Evans Creek had predicted survival rates of 59.3%, 78.6% and 83.1% for the lower, middle and upper reaches, respectively. Lake Creek had predicted survival rates of 74.2, 69.5, and 54.0% for the lower, middle and upper reaches respectively. Bozard Creek had a predicted survival rate of 19.3%, while West Lake Creek had a survival rate of 5.4% and Upper Lake Creek had a survival rate of 0.0%.

3.2. BIOLOGICAL EVALUATION

3.2.1. Relative Abundance

In May, July and September, 1992, a total of 23.3 electroshocking hours were spent collecting relative abundance information. A total of 1,881 fish were collected from the four tributaries (Table 3.39). In May and July, shocking effort was lower then in September, therefore the sample reflected the lower effort by the lowere number of fish captured. In Lake Creek, a total of 521 fish were captured with sculpin species being the most abundant species at 53.4%. In Benewah Creek, 367 total fish were captured with redside shiners comprising 40.1%. A total of 275 fish were captured in Alder Creek, with eastern brook trout being the most abundant at 44.4%. In Evans Creek, a total of 241 fish were captured and the most abundant was cutthroat trout at 98.8%. Cutthroat trout densities were highest in Evans Creek, followed by Alder (22.9%), Benewah (4.5%) and Lake Creeks (1.9%) (Table 3.40). Relative abundance data for each month, reach and stream can be found in Appendix E.

3.2.1.1. Lake Creek

In May, July and September a total of 3, 0 and 518 fish were collected in Lake Creek, respectively (Table 3.41). Of the three fish collected in May, two (66.6%) were cutthroat trout and one (33.3%) was a rainbow x cutthroat hybrid (Table 3.42). Both cutthroat trout

Table 3.39. Number of each species of fish caught by electrofishing at each Coeur d'Alene tributary during 1992.

Species Shock time (min)	Alder 504	Benewah 367	Evans 414	Lake 309
Cutthroat trout	63	38	238	10
Eastern brook trout	122	2	1	
Rainbow x cutthroat	1			1
Rainbow	1			
sculpin spp.	84	2		278
Longnose sucker	2	22		
Northern squawfish		2		
Largemouth bass		113	1	
Pumpkinseed			1	
Redside shiner		338		
Dace *spp.*	2	326		232
TOTAL	***275***	***843***	***241***	***521***

Table 3.40. Percent of each species of fish caught by electrofishing at each Coeur d'Alene tributary during 1992.

Species	Alder	Benewah	Evans	Lake
Cutthroat trout	22.9	4.5	98.8	1.9
Eastern brook trout	44.4	0.2	0.4	
Rainbow x cutthroat	0.4			0.2
Rainbow	0.4			
Sculpin *spp.*	30.5	0.2		53.4
Longnose sucker	0.7	2.6		
Northern squawfish		0.2		
Largemouth bass		13.4	0.4	
Pumpkinseed			0.4	
Redside shiner		40.1		
Dace *spp.*	0.7	38.7		44.5

Table 3.41. Number of each species of fish caught by electrofishing in Lake Creek during May - September, 1992.

Species Shock time (min)	May 96	July 95	September 118
Cutthroat trout	2		8
Rainbow x cutthroat	1		
Sculpin *spp.*			278
Dace *spp.*			232
TOTAL	***3***	***0***	***518***

Table 3.42. Percent of each species of fish caught by electrofishing in Lake Creek during May - September, 1992.

Species	May	July	September
Cutthroat trout	66.6		1.5
Rainbow x cutthroat	33.3		
Sculpin *spp.*			53.7
Dace *spp.*			44.8

Table 3.43. Electrofishing relative abundance for salmonid species by age class in Lake Creek, 1992.

Age	Cutthroat trout 5/92	7/92	9/92
0 +			5 (62.5)
1 +	2 (100.0)		3 (37.5)
2 +			
3 +			

were a year old (Table 3.43). No fish were captured in Lake Creek in July. For the month of September, 278 of the fish captured were sculpin species.(53.7%), 232 were dace species (44.8%), and 8 were cutthroat trout (1.5%). Of the eight cutthroat trout collected five were 0+ years of age and three were 1+ years of age.

3.2.1.2. Benewah Creek

In May, July and September a total of 45, 4 and 794 fish were collected from Benewah Creek (Table 3.44). Of the 45 collected in May, twenty-four (53.3%) were cutthroat trout, 2 (4.4%) were eastern brook trout, twelve (26.7%) were longnose sucker, two (4.4%) were northern squawfish and 5 (11 .1%) were redside shiner (Table 3.45). Of the 24 cutthroat captured, eight (33.3%) were 1 years of age, 14 (58.3%) were 2 years of age and two (8.3%) were 5 years of age (Table 3.46). All four fish collected in July in Benewah Creek were cutthroat trout with three (75.0%) being 2 years of age and one (25.0%) being 3 years of age. Of the 794 fish collected from Benewah Creek in September, 333 (41.9%) were redside shiner, 326 (41 .1%) were dace species, 113 (14.2%) were largemouth bass, ten (1.3%) were cutthroat trout, ten (1.3%) were longnose sucker and 2 (0.3%) were sculpin species. Of the ten cutthroattrout captured, one (10.0%) was 0 years of age and nine (90.0%) were 2 years of age.

3.2.1.3 Alder Creek

A total of 148, 11 and 117 fish were captured in Alder Creek in May, July and September, respectively (Table 3.47). Of the 148 fish collected in May, 84 (56.8%) were sculpin species, 44 (29.7%) were eastern brook trout, 13 (8.8%) were cutthroat trout, 2 (1.4%) were longnose sucker, 2 (1.4%) were dace species 1 (0.7%) was a rainbow x cutthroat hybrid and 1 (0.7%) was a rainbow (Table 3.48). Of the thirteen cutthroat trout captured in Alder Creek during May, ten (76.9%) were age l+,one (7.7%) was age 2+ and two (15.4%) were age 3+. Of the 44 eastern brook trout captured, twelve (27.3%) were 1+ years of age, 15 (34.1%) were 2+ years of age, 12 (27.3%) were 3+ years of age, 2 (4.5%) were 4+ years of age and 3 (6.8%) were age 5+ (Table 3.49). Of the eleven fish captured from Alder Creek in July, nine (81.8%) of the fish collected were eastern brook trout and two (22.2%) were cutthroat trout. Three (33.3%) of the nine brook trout collected were age 1+, 4 (44.4%) were age 2+, and the remaining 2 **(22.2%)** were age 3+. Of the two cutthroat trout captured, one

Table 3.44. Number of each species of fish caught by electrofishing in Benewah Creek during May - September, 1992.

Species Shock time (min)	May 98	July 107	September 162
Cutthroat trout	24	4	10
Eastern brook trout	2		
Largemouth bass			113
Sculpin spp.			2
Longnose sucker	12		10
Northern squawfish	2		
Redside shiner	5		333
Dace *spp.*			326
TOTAL	***45***	***4***	***794***

Table 3.45. Percent of each species of fish caught by electrofishing in Benewah Creek during May - September, 1992.

Species	May	July	September
Cutthroat trout	53.3	100	1.3
Eastern brook trout	4.4		
Largemouth bass			14.2
Sculpin *spp.*			0.3
Longnose sucker	26.7		1.3
Northern squawfish	4.4		
Redside shiner	11.1		41.9
Dace *spp.*			41.1

Table 3.46. Electrofishing relative abundance for salmonicl species by age class in Benewah Creek, 1992.

Age	Cutthroat trout 5/92	7/92	9/92
o+			1 (10.0)
1+	8 (33.3)		
2+	14 (58.3)	3 (75.0)	9 (90.0)
3+		1 (25.0)	
4+			
5+	2 (8.3)		

Table 3.47. Number of each species of fish caught by electrofishing in Alder Creek during May - September, 1992.

Species Shock time (min)	May 168	July 100	September 236
Cutthroat trout	13	2	48
Eastern brook trout	44	9	69
Rainbow x cutthroat	1		
Rainbow	1		
Sculpin spp.	84		
Longnose sucker	2		
Dace *spp.*	2		
TOTAL	***148***	***11***	***117***

Table 3.48. Percent of each species of fish caught by electrofishing in Alder Creek during May - September, 1992.

Species	May	July	September
Cutthroat trout	8.8	22.2	41 .o
Eastern brook trout	29.7	81.8	58.9
Rainbow x Cutthroat	0.7		
Rainbow	0.7		
Sculpin *spp.*	56.8		
Longnose sucker	1.4		
Dace *spp.*	2.0		

Table 3.49. Breakdown of electrofishing relative abundance for salmonid species by age class in Alder Creek, 1992.

	Cutthroat trout			Eastern brook trout		
Age	5/92	7/92	9/92	5/92	7/92	9/92
0+			28 (58.3)			
1+	10 (76.9)	1 (50.0)	3 (6.3)	12 (27.3)	3 (33.3)	3 (4.3
2+	1 (7.7)	1 (50.0)	12 (25.0)	15 (34.1)	4 (44.4)	24 (34.8)
3+	2 (15.4)		5 (10.4)	12 (27.3)	2(22.2)	20 (29.0)
4+				2 (4.5)		11 (15.9)
5+				3 (6.8)		11 (15.9

(50.0%) was 1+ years of age and one (50.0%) was 2+ years of age. In September, one hundred seventeen fish were collected in Alder Creek. Of those 117 fish, 69 (58.9%) were eastern brook trout and 48 (41.0%) were cutthroat trout. Of the 69 eastern brook trout, 3 (4.3%) were 1+ years of age, 24 (34.8%) were 2+ years of age, 20 (29.0%) were 3+ years of age, 11 (15.9%) were 4+ years of age and 11 (15.9%) were 5+ years of age. Of those 48 cutthroat trout, 28 (58.3%) were 0+ years of age, 3 (6.3%) were 1+ years of age, 12 (25.0%) were 2+ years of age and five (10.4%) were 3+ years of age.

3.2.1.4. Evans Creek

A total of 23, 62 and 156 fish were captured in Evans Creek during May, July and September, respectively (Table 3.50). All 23 (100%) fish captured in May were cutthroat trout (Table 3.51). Of the 23 cutthroat captured, 12 (52.2%) were 1+ of age, 7 (30.4%) were 2+ of age, 1 (4.3%) was 3+ of age, and 3 (13.0%) were 4+ of age (Table 3.52). In July, all 62 fish collected were also cutthroat trout. Of the 62 cutthroat, 1 (1.6%) was 0+, 26 (41.9%) were 1+ years of age, 18 (29.0%) were 2+ years of age, 8 (12.9%) were 3+ years of age, and 9 (14.5%) were 4+ years of age. Of the 156 fish collected from Evans Creek in September, 153 (98.1%) were cutthroat trout, 1 (0.6%) was an eastern brook trout, 1 (0.6%) was a largemouth bass, and 1 (0.6%) was a pumpkinseed. Of the 153 cutthroat trout collected, 42 (27.5%) were 0+ years of age, 56 (36.6%) were 1+ years of age, 34 (22.2%) were 2+ years of age, 13 (8.5%) were 3+ years of age and eight (5.2%) were 4+ years of age 1.

3.2.2. Population estimates

In September, population estimates were conducted in four selected tributaries. Population estimates, 95% confidence intervals and fish densities for each trout species capture in Lake Creek can be found in Table 3.53. Cutthroat trout were the only trout population estimated for Lake Creek (Table 3.53). Reach one had an estimated cutthroat population of 4.0 ± 0.0 for 253 m^2 with a density of 1.6 ± 0.0 per 100 m? In reach two cutthroat populations were estimated at 0.0. In reach 3 cutthroat populations were estimated at 4.0 ± 0.0 for 142 m^2, with a density of 2.8 ± 0.0 for 100m^2.

Population estimates, 95% confidence intervals and fish densities for each trout species captured in Benewah Creek can be found in Table 3.54. Only cutthroat trout populations could be

Table 3.50. Number of each species of fish caught by electrofishing in Evans Creek during May - September, 1992.

Species Shock time (min)	May 103	July 133	September 178
Cutthroat trout	23	62	153
Eastern brook trout			1
Largemouth bass			1
Pumpkinseed			
TOTAL	23	62	156

Table 3.51. Percent of each species of fish caught by electrofishing in Evans Creek during May - September, 1992.

Species	May	July	September
Cutthroat trout	100	100	98.1
Eastern brook trout			0.6
Largemouth bass			0.6
Pumpkinseed			0.6

Table 3.52. Breakdown of electrofishing relative abundance for salmonid species by age class in Evans Creek, 1992.

Age	Cutthroat trout 5/92	7/92	9/92
0+		1 (1.6)	42 (27.5)
1+	12 (52.2)	26 (41.9)	56 (36.6)
2+	7 (30.4)	18 (29.0)	34 (22.2)
3+	1 (4.3)	8 (12.9)	13 (8.5)
4+	3 (13.0)	9 (14.5)	8 (5.2)

Table 3.53. Estimated population, 95% confidence intervals, and fish density for each trout species captured in Lake Creek at each reach in September, 1992.

Species	Est. Pop.	95% C.I.	#/100m2 ± 95% C.I.
Reach #1 (253 m^2)			
CTT	4.0	±0.0	1.6 ± 0.0
Reach #2 (240 m^2)			
CTT	0.0	±0.0	0.0 ± 0.0
Reach #3 (142 m^2)			
CTT	4.0	±0.0	2.8 ± 0.0

Table 3.54. Estimated population, 95% confidence intervals, and fish density for each trout species captured in Benewah Creek at each reach in September, 1992.

Species	Est. Pop.	95% C.I.	#/100m2 ± 95% C.I.
Reach #1 (244 m^2)			
CTT	3.0	±0.0	1.2 ± 0.0
Reach #2 (230 m^2)			
CTT	5.0	±0.0	2.2 ± 0.0
Reach #3 (237 m^2)			
CTT	2.0	±0.0	0.8 ± 0.0

estimated for Benewah Creek due to low sample size of other trout species. In reach one, the estimated population of cutthroat trout was 3.0 ± 0.0 for 243.6 m^2 with a density of 1.2 ± 0.0 per 100 m? The estimated population of cutthroat trout for reach two was 5.0 ± 0.0 for 230 m^2, with a density of 2.2 ± 0.0 per 100 m? In reach three, the estimated cutthroat trout population in 2.0 ± 0.0 for 237 m^2 **with a density of 0.8 ± 0.0 per 100** m^2

Cutthroat and eastern brook trout populations were estimated for Alder Creek (Table 3.55). In reach one, cutthroat trout populations were estimated at 4.0 ± 0.0 fish for 274 m^2 , with a density of 1.5 ± 0.0 per 100m^2. Eastern brook trout populations were estimated at 3.0 ± 0.0 fish for 274 m^2, with a density of 1 .1 ± 0.0 per 100 m? In Reach two, cutthroat trout populations were estimated at 59.3 ± 10.2 for 177.1 m^2, with a density of 33.5 ± 5.8 for 100 m^2. Population estimates for eastern brook trout were 6.0± 0.0 for 177.1 m^2 with a density of 3.4 ± 0.0 per 100 m^2. In reach three estimated cutthroat trout populations were 1 .O ± 0.0 for 303 m^2 with a density of 0.3 ± 0.0 per 100 m^2. Eastern brook trout populations were estimated at 41.7 ± 12.9 for 303 m^2 with a density of 13.8 ± 4.3 for 100 m^2.

Cutthroat trout populations were estimated for Evans Creek (Table 3.56). In reach 1, cutthroat populations were estimated at 0. In reach 2, cutthroat trout populations were 99.6 ± 8.8 for 177 m^2 with a density of 56.2 ± 4.97 for 100 m? In reach 3, cutthroat trout populations were estimated at 76.2 ± 15.9 for 178 m^2 with a density of 42.9 ± 8.9 for 100 m^2.

3.2.3. Spawning surveys

Spawning surveys were conducted on Lake, Benewah, Alder and Evans, creeks during early May. The entire stream length was surveyed to locate and identify redds. Because spawning surveys were conducted during spring runoff the ability to see the bottom of the stream channel, especially in mainstem areas, was difficult. Only one confirmed redd was located on lower Lake Creek, other redd **sites were suspected but the ability to confirm that they were** actually redds was difficult. No redds or potential redds were identifyed on any other streams.

Table 3.55. Estimated population, 95% confidence intervals, and fish density for each trout species captured in Alder Creek at each reach in September, 1992.

Species	Est. Pop.	95% C.I.	#/100m2 ± 95% C.I.
Reach #1 (274 m^2)			
CTT	4.0	±0.0	1.5 ± 0.0
EBT	3.0	0.0	1.1 ± 0.0
Reach #2 (177 m^2)			
CTT	59.3	±10.2	33.5 ± 5.8
EBT	6.0	± 0.0	3.4 ± 0.0
Reach #3 (303 m^2)			
CTT	1.0	±0.0	0.3 ± 0.0
EBT	41.7	±12.9	13.8 ± 4.26

Table 3.56. Estimated population, 95% confidence intervals, and fish density for each trout species captured in Evans Creek at each reach in September, 1992.

Species	Est. Pop.	95% C.I.	#/100m2 ± 95% C.I.
Reach #1 (150 m^2)			
CTT	0.0	±0.0	0.0 ± 0.0
Reach #2 (177 m^2)			
CTT	99.6	±8.8	56.2± 5.0
EBT	1.0	± 0.0	0.6 ± 0.0
Reach #3 (178 m^2)			
CTT	76.2	±15.9	42.9 ± 9.0

3.2.4. Migration Trap Data Analysis

Migration traps were installed in three tributaries on March 19-24, 1992. On March 19th, one upstream and one downstream migration trap were installed in Lake Creek . On March 23rd traps were installed in Benewah Creek and on March 24th traps were installed in Evans Creek. Traps were operated daily until June 1st at which time they were removed. A total of 196 longnose suckers, 31 cutthroat trout, one rainbow trout, one longnose dace, and one largemouth bass were collected in all tributaries during the sampling period.

Table 3.57 shows the number and species of each fish captured in the upstream and downstream migration traps in Lake Creek for each Month. During March, six cutthroat trout spawners were collected in the upstream trap. Sizes ranged from 318 to 368 mm. Of the six cutthroat, two were males, one was female and the others were undetermined. Based on back-calculated lengths, ages ranged from four to six years. In April, 20 cutthroat trout were captured in the upstream migration trap. Sizes ranged from 236 to 396 mm. Four of these fish were identified as males, while seven were identified as females and the remaining undetermined. Ages ranged from two to six years. One fish was two years of age, two were 3 years of age, five were 4 years of age, nine were 5 years of age and three were 6 years of age. No fish were captured in either trap in May and June (Table 3.58).

Table 3.59 shows the number and species of fish captured in the migration traps in Benewah Creek. In March, one cutthroat was captured in the upstream trap and one longnose dace was captured in the downstream trap. The cutthroat trout captured was 99 mm and was a one year old fish. In April no cutthroat were captured in either trap, however six longnose suckers ranging from 305 to 432 mm were captured in the upstream trap (Table 3.60). In May approximately 190 longnose suckers were captured in between the upstream and downstream traps. A rain event caused the water levels in Benewah to raise, causing a portion of the weir to wash out. No holes were found in the downstream trap, therefore, passage above the traps was impossible. The area was electrofished and no cutthroat were found, however 190 longnose suckers were captured. No fish were captured in June.

Table 3.61 shows the number and species of fish captured in

Table 3.57. Number of each species of fish caught in migration traps in Lake Creek during 1992

Species Trap location	March upstrm.	March dnstrm	April upstrm	April dnstrm	May upstrm	May dnstrm
Cutthroat trout	6		20	1		
Rainbow trout			1			
Total	*6*		*21*	*1*		

Table 3.58. Size ranges, year class and sex of each species of fish caught in migration traps in Lake Creek during 1992.

Trap location	Date	Species	Age	Sex	Length (mm)	Weight (g)
Upstream	3/92	CTT	4+	M	318	250
		CTT	5+	F	330	420
		CTT	5+	U	334	200
		CTT	5+	U	337	300
		CTT	5+	U	339	298
		CTT	6+	M	368	430
Upstream	4/92	CTT	2+	M	236	250
		CTT	3+	U	280	175
		CTT	3+	U	282	180
		CTT	4+	U	304	400
		CTT	4+	U	310	150
		CTT	4+	M	315	450
		CTT	4+	F	316	200
		CTT	4+	F	316	205
		CTT	5+	M	320	255
		CTT	5+	M	320	250
		CTT	5+	U	330	150
		CTT	5+	U	333	200
		CTT	5+	F	334	300
		CTT	5+	U	334	289
		CTT	5+	U	335	250
		CTT	5+	F	336	310
		CTT	5+	F	336	300
		CTT	6+	F	349	300
		CTT	6+	F	350	401
		Cl-T	6+	U	362	400
		RBT	6+	U	396	235
Downstream	4/92	CTT	1+	U	118	12

Table 3.59. Number of each species of fish caught in migration traps in Benewah Creek during 1992

Species Trap location	March upstrm.	 dnstrm	April upstrm	 dnstrm	May upstrm	 dnstrm
Cutthroat trout	1					1
dace *spp.*		1				
Longnose sucker			6		190	
Total	***1***	***1***	***6***		***190***	***1***

Table 3.60. Size ranges, year class and sex of each species of fish caught in migration traps in Benewah Creek during 1992.

Trap	Date	Species	Age *	Sex	Length (mm)	Weight (g)
Upstream	3/92	CTT	1+	U	99	2
Downstream	3/92	LND		U	70	2
Upstream	4/92	LNS			305	
		LNS			305	
		LNS			406	
		LNS			330	
		LNS			432	1132
		LNS			432	1359
	5/92	Approximately 190 LNS were captured between the upstream and downstream trap.				

Table 3.61. Number of each species of fish caught in migration traps in Evans Creek during 1992

Species Trap location	March upstrm.	dnstrm	April upstrm	dnstrm	May upstrm	dnstrm
Cutthroat trout	1		1			
Largemouth bass				1		
Total	*1*		*1*	*1*	*0*	*0*

Table 3.62 Size ranges, year class and sex of each species of fish caught in migration traps in Evans Creek during 1992.

Trap	Date	Species	Age *	Sex	Length (mm)	Weight (g)
Upstream	3/92	CTT	4+	U	205	195
Upstream	4/92	CTT	1+	U	114	29
Downstream	4/92	LMB			120	

* ***Ages are*** based ***on back calculation data***

Evans Creek. In March, one cutthroat trout 205 mm long was collected in the upstream trap. Based on back-calculated lengths this was a 4 year old fish. In April, one cutthroat trout was collected in the upstream trap. Length of the fish was 114 mm. Based on back calculated lengths this was a one year old fish (Table 3.62). One largemouth bass was collected in the downstream trap in April. No fish were collected in either trap during May and June.

3.2.5. Age, Growth and Condition

Lake Creek

A total of 32 scales were collected from cutthroat trout in Lake Creek for age determination. Back-calculated lengths for cutthroat trout at the first annulus ranged from 91 to 122 mm with a grand mean of 1 IO mm (Table 3.63). At the end of the second years growth, lengths ranged from 127 to 205 mm with a grand mean 177 mm. At the end of three years of growth, lengths ranged from 243 to 270 mm with a grand mean of 257 mm. Lengths ranged from 284 to 315 mm at the end of four years of growth, with a grand mean of 299 mm. At age 5, lengths ranged from 313 to 340 mm with a grand mean of 319 mm. At age 6, back calculated lengths for cutthroat trout averaged 348 mm.

Mean lengths, weights and condition factors for each age class of cutthroat trout in Lake Creek are listed in Table 3.64. Mean condition factors ranged from 0.6 for 4+ cutthroat trout to 1 .1 for 1+ cutthroat trout, with an overall mean of 0.8.

Benewah Creek:

A total of 26 scales were collected from cutthroat trout in Benewah Creek for age determination and back calculated growth. Mean back calculated lengths for cutthroat trout at the first annulus ranged from 72 to 88 mm with a grand mean of 82 mm (Table 3.65). At the formation of the second annulus lengths ranged from 108 to 123 mm with a grand mean of 109 mm. At the end of the third years growth mean sizes ranged from 141 to 211 mm with a grand mean of 164. The length at the fourth annulus was 262 mm and the length of the fifth annulus was 298 mm.

Mean lengths, weights and condition factors for cutthroat trout are listed in Table 3.66. Mean condition factors ranged from

Table 3.63. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Lake Creek, 1992.

		MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS					
Cohort	N	1	2	3	4	5	6
1991	3	101 ± 4					
1990	3	91 ± 7	127 ± 12				
1989	2	122 ± 11	205 ± 43	267 ± 73			
1988	9	118 ± 10	197 ± 25	269 ± 32	315 ± 31		
1987	12	108 ± 13	164 ± 27	243 ± 25	284 ± 28	313 ± 28	
1986	3	116 ± 5.3	201 ± 27	270 ± 30	312 ± 10	340 ± 11	348 ± 25
GRAND MEAN	32	110 ± 13	177 ± 34	257 ± 33	299 ± 31	319 ± 28	348 ± 25
MEAN ANNUAL GROWTH INCREMENT		110	67	80	42	20	29

Table 3.64. Mean lengths, weights and condition factors for each age class of cutthroat trout in Lake Creek, 1992.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
0+	5	3.0 ± 0.7	72.6 ± 4.0	0.8 ± 0.1
1+	3	19.7 ± 6.7	119.7 ± 7.5	1.1 ± 0.2
2+	3	26.7 ± 12.9	142.7 ± 21.5	0.9 ± 0.1
3+	2	153.5 ± 47.4	285.0 ± 69.30	0.9 ± 0.8
4+	9	230.6 ± 57.0	332.2 ± 26.3	0.6 ± 0.2
5+	12	256.7 ± 86.4	319.7 ± 27.9	0.8 ± 0.2
6+	3	395.7 ± 86.1	355.7 ± 25.5	0.9 ± 0.3
Total				0.8 ± 0.3

Table 3.65. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Benewah Creek, 1992.

		MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS				
Cohort	N	1	2	3	4	5
1991	8	88 ±10				
1990	15	79 ± 5	108 ±7			
1989	2	76 ±2	110 ±6	141 ± 20		
1988	0					
1987	1	72	123	211	262	298
GRAND MEAN	26	82 ± 8	109 ± 8	164 ± 43	262	298
MEAN ANNUAL GROWTH INCREMENT		82	27	55	98	36

Table 3.66. Mean lengths, weights and condition factors for each age class of cutthroat trout in Benewah Creek, 1992.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
0+	1	3	72	0.8
1+	8	12.4 ± 5.5	111.6 ± 18.2	0.8 ± 0.2
2+	14	14.2 ± 5.6	122.3 ± 10.1	0.8 ± 0.2
3+	2	22.5 ± 9.2	167 ± 16.9	0.5 ± 0.4
4+	0			
5+	1	250	313	0.8
Total				0.8 ± 0.2

0.5 for 3+ fish to 0.8 for all other age classes of cutthroat trout. An overall mean condition factor of 0.8 was calculated.

Alder Creek

A total of 24 scales were collected from cutthroat trout in Alder Creek. Back-calculated lengths for cutthroat trout at the first annulus ranged from 73 to 91 mm with a grand mean of 79 mm. At the formation of the second annulus lengths ranged from 128 to 138 mm with a grand mean of 124 mm. The length at the third annulus was 183 mm (Table 3.67).

Mean lengths, weights and condition factors for each age class of cutthroat trout are listed in Table 3.68. Mean condition factors ranged from 0.7 for 0+ to 1 .1 for 3+ cutthroat trout, with an overall mean condition factor of 0.8.

A total of 79 scales were collected from brook trout in Alder Creek. Mean lengths for first years growth ranged from 53 to 81 mm. with a grand mean of 66 mm. (Table 3.69). After second annulus formation lengths ranged from 107 to 122 mm. with a grand mean of 118 mm. At age 3, brook trout lengths ranged from 147 to 163 mm. with a grand mean of 160 mm. The range of lengths after four years of growth was 173 to 189 mm. with an overall mean of 187 mm. The back calculated length of the only five year old brook trout collected was 213 mm.

Mean lengths, weights and condition factors for each age class of brook trout in Alder Creek are listed in Table 3.70. The lowest mean condition factor was 0.94 for 1+ and 5+ fish. The highest condition factor was 1.20 for 2+ fish. The overall mean condition factor was 1 .1 1.

Evans Creek

A total of 87 scales were collected from cutthroat trout in Evans Creek for age determination. Back-calculated lengths for cutthroat trout at the first annulus ranged from 73 to 77 mm with a grand mean of 74 mm. At the end of the second years growth, sizes ranged from 114 to 124 mm with a grand mean of 118 mm. Lengths at the third annulus ranged from 150 to 171 mm with a grand mean of 154 mm. At the end of the fourth year of growth a grand mean of 204 mm was obtained (Table 3.71).

Table 3.67. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Alder Creek, 1992.

	MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS			
Cohort	N	1	2	3
1991	16	83 ± 13		
1990	4	84 ± 10	138 ± 3910	
1989	4	91 ± 19	128 ±23	183 ± 24
GRAND MEAN	24	79 ± 23	124 ± 40	183 ±24
MEAN ANNUAL GROWTH INCREMENT		79	45	59

Table 3.68. Mean lengths, weights and condition factors for each age class of cutthroat trout in Alder Creek, 1992.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
o+	20	2.7 ± 0.9	71.4 ± 6.1	0.7 ± 0.1
1+	14	15.7 ± 7.9	119.6 ± 21.9	0.9 ± 0.1
2+	5	60.6 ± 40.9	179.4 ± 46.6	0.9 ± 0.1
3+	3	150.0 ± 86.6	234.7 ± 9.0	1.1 ± 0.5
Total				0.8 ± 0.2

Table 3.69. Mean back calculated lengths at the end of each years growth (annulus formation) for each age class of brook trout in Alder Creek, 1992.

	MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS					
Cohort	N	1	2	3	4	5
1991	8	78.7±15.5				
1990	38	80.6±91.1	122.5±17.3			
1989	26	64.6±16.5	115.3±19.5	163.3±26.3		
1988	6	63.5±18.1	109.3±16.4	150.9±17.0	189.1±16.9	
1987	1	53.9±0.0	107.0±0.0	146.9±0.0	173.5±0.0	213.4±0.0
GRAND MEAN	79	66.4±16.7	118.3±18.3	160.5±24.8	186.8±16.5	213.4±0.0
MEAN ANNUAL GROWTH INCREMENT		66	52	42	29	26

Table 3.70. Mean lengths, weights and condition factors for each age class of brook trout in Alder Creek, 1992.

Age	N	Mean weight (g) ± SD	Mean length (mm) ± SD	Mean K_{tl} ± SD
1+	8	21.7±10.4	128.6±22.1	0.94±0.12
2+	38	40.8±29.2	153.4±21.6	1.20±1.47
3+	26	79.6±37.2	195.3±26.9	1.02±0.22
4+	6	121.7±50.0	215.0±18.6	1.17±0.26
5+	1	130.0±0.0	240.0±0.0	0.94±0.0
Total	79			1.11±1.03

Table 3.71. Mean back-calculated lengths at the end of each years growth (annulus formation) for each age class of cutthroat trout in Evans Creek, 1992.

	MEAN ± S.D. BACK CALCULATED LENGTH AT ANNULUS				
Cohort	**N**	**1**	**2**	**3**	**4**
1991	47	74 ± 12			
1990	22	73 ± 10	114 ± 15		
1989	15	77 ± 10	124 ± 19	150 ± 44	
1988	3	75 ± 5	120 ± 4	171 ± 10	204 ± 12
GRAND MEAN	87	74 ± 11	118 ± 17	154 ± 40	204 ± 12
MEAN ANNUAL GROWTH INCREMENT		74	44	36	50

Table 3.72. Mean lengths, weights and condition factors for each age class of cutthroat trout in Evans Creek, 1992.

Age	N	Mean weight (g) ±SD	Mean length (mm) ±SD	Mean K_{tl} ±SD
0+	15	2.1 ± 1.3	58.7 ± 7.0	1.0 ± 0.3
1+	46	11.3 ± 5.7	105.0 ± 17.2	0.9 ± 0.2
2+	21	28.7 ± 13.3	145.2 ± 17.6	0.9 ± 0.1
3+	15	63.8 ± 32.8	190.1 ± 29.5	0.9 ± 0.2
4+	3	73.3 ± 2.9	239.0 ± 5.3	0.5 ± 0.1
Total				10.9 ± 0.2

Mean lengths, weights and condition factors for each age class of cutthroat trout in Evans Creek are listed in Table 3.72. Mean condition factors ranged from 0.5 for 4+ cutthroat trout to 1 .O for 0+ fish with an overall mean of 0.9.

4.0. DISCUSSION

A literature review determined optimal habitat conditions for cutthroat and bull trout (Graves *et al.* 1991). These optimal habitat conditions for cutthroat and bull trout were then compared to the habitat which existed in surveyed streams. Habitat parameters assessed for the entire stream were; base stream flow, temperature, and dissolved oxygen. Each stream was divided into reaches and for each reach the available habitat was determined. Available habitat was identified through habitat typing, which identified pools, riffles and secondary channels. In conjunction with habitat typing, large organic (woody) debris, riparian vegetation, and land use were assessed to determine instream and overhanging cover. Substrate and percentage of fine sediment were also used to determine instream cover, as well as, predicted cutthroat emergence success. Biological data collected included trout population estimates, trout densities, trout stock assessment, and benthic macroivertebrate densities. All data was combined to determine potential limiting factors affecting cutthroat and bull trout in the surveyed streams.

Conclusions and recommendations on ways to increase the cutthroat and bull trout fisheries were determined.

4.1. Cutthroat trout

Optimal conditions for cutthroat trout can be characterized by clear cold water, silt free rocky substrate in riffle-run areas, an approximate 1 :1 pool-riffle ratio with areas of slow, deep water, well vegetated stream banks, abundant instream cover, and relatively stable water flow, temperatures, and stream banks (Graves *et al* 1991; Raleigh and Duff 1981).

The most critical period for maintaining quality trout habitat exists during summer in which base flow and high water temperatures exist. Base flow greater then 50% of the average annual flow is considered excellent, while a base flow of 25-50% is fair, and a base flow of <25% is poor for maintaining quality trout habitat (Hickman and Raleigh 1982; Wesche 1980). Optimal temperature ranges for juvenile and adult cutthroat trout are between 11 - 15.5 °C and avoidance occurs when temperatures exceed 21 °C (Hickman and Raleigh 1982). For embyro survival, optimal temperature ranges are between 7 - 11.5 °C, while acceptable ranges are between 3 - 16 °C.

Dissolved oxygen concentrations are also important in maintaining quality trout habitat. High water temperatures lessen the amount of dissolved oxygen present in the stream. Optimal dissolved oxygen concentrations range between 4.5-7.3 mg/l in water with temperatures lower than 15 °C, and 6.0 - 9.0 mg/l in water with temperatures above 15 °C (Hickman and Raleigh 1982).

Cutthroat trout use pools throughout their life cycle for rearing, overwintering, and resting. Preferred pool habitat can be characterized as large, deep, low velocity areas with adequate cover. Pools used for rearing must include 3-16% cover in the form of depth, turbulence or instream structures (Boussu 1954, Lewis 1969) Lateral habitat or side channels may replace pool habitat for rearing cutthroat trout. In winter, adult and subadult cutthroat trout will aggregate in deep wide pools with low to negative velocities with adequate escape cover (Wilson et al 1987, Peters 1988).

Large organic debris is a major component in the development of cover and pools for westslope cutthroat trout habitat (Pratt 1984; Lider 1985; Gamblin 1988). It also plays an important role in stream stability, habitat complexity, bedload storage, rearing habitat protection and macroinvertebrete densities.

Substrate size and the amount of fine sediments are important to cutthroat trout habitat for spawning, food production, overwintering and rearing habitat. For successful spawning and reproduction, cutthroat trout require an adequate amount of gravels between 2.0 and 6.0 cm in diameter with less then 10% fine sediments.

Substrate is also important for over-wintering habitat of cutthroat trout. For optimal winter and escape cover of fry and juveniles, 10% of the substrate ranges between 10-40 centimeters in diameter (Hickman and Raleigh 1982). When temperatures drop below 8 °C small fish utilize the substrate for hiding and under extreme environmental conditions, such as high velocities and ice formation, fry and subadults burrow into the substrate (Everest, 1969, Bjorn et al 1982). It has been documented that fine sediments reduce carrying capacity of essential pool habitat, and eventually eliminate pools (Bjornn et all 1977; Rhodes and Jones 1991).

Cutthroat trout cover can be classified as instream and overhanging cover. Useable instream cover is associated with water at least 1.5 feet deep and less than 15 cm/sec velocity (Hickman and Raleigh 1982). For overhanging cover, it is estimated that 50-100% shade is acceptable habitat for cutthroat trout in streams less than 50 feet wide (Idyll 1942; Hunt 1975; Martin et al 1981). Canopy cover is also important in providing temperature control, contributing to the energy budget, allochthonous input to the stream, controlling watershed erosion and maintaining streambank integrity. A stream-side buffer of approximately 33 meters, of which 80% is either well-rooted and vegetated or has stable rocky streambanks, will maintain adequate erosion control (Raleigh and Duff 1981).

For a complete literature review of cutthroat trout reference Graves *et al.* (1991).

4.1.1. Lake Creek

Parameters determined for the entire Lake Creek drainage were base flow, temperature, and dissolved oxygen.

During 1991 and 1992 low flow conditions existed in Lake Creek. In 1991 base flow was 1.9 cfs (cubic feet per second) and in 1992 was 0.4 cfs (Table 4.1). The most critical period for quality trout habitat exists during base flow conditions. In 1991 and 1992 base flow was 13.4% and 25.2% of the average annual flow, respectively. This is far below the recommended 50% average annual flow for adequate trout habitat. For the last six years, including 1991 and 1992, this region has been experiencing a drought which has greatly impacted water yield in the streams, as well as, the quantity and quality of cutthroat trout habitat.

Maximum summer water temperatures in Lake Creek were 23" C and 17°C for 1991 and 1992, respectively (Table 4.1). Temperatures exceeded the optimal range for cutthroat (1 l-1 5.5°c) during 1991 and 1992, and avoidance temperatures (21°C) for cutthroat trout were exceeded during 1991. During the spawning season (April-June), when there were potential embryos existing in the stream, temperatures were in the acceptable range for cutthroat

Table 4.1. Stream characteristics of Lake Creek collected in 1991 and 1992.

Stream reach	LAKE CREEK Lower	Middle	Upper
Fish densitv (m^2)			
Cutthroat			
1991		.12	.04
1992	.02	0	.03
Eastern brook trout			
1991	0	0	0
1992	0	0	0
Bull trout			
1991	0	0	0
1992	0	0	0
Geometric means (%fines)			
1992	19.2 (6.0)	20.1 (5.2)	20.0 (24.6)
% survival			
1992	74	69	54
% canopv (mean)			
1992	18	0	0
Maximum water temperature (°C)			
1991	23	23	23
1992	25	25	25
Q (base flow in CFS)			
1991	1.9	1.9	1.9
1992	0.4	0.4	0.4
Dissolved oxvaen			
1991	6.5	8.5	11.8
1992	*	12.2	*
Residual pool mean depth (M)			
1992	0.4	0.6	0.5
%pools/%riffle			
1992	8/92	15/85	.1/99.9
Larae Organic Debris			
1992 logs	244	19	53
1992 root wads	18	1	1
Maior Land Use			
1992	97% forested	89% forested	78% agriculture

-data not collected

trout in 1991 and optimal in 1992.

Dissolved oxygen concentrations in Lake Creek for 1991 and 1992 (Table 4.1) were well within acceptable ranges.

Lower Lake Creek

In lower Lake Creek pools accounted for only 8% of the total habitat, while secondary channels or side channels were non existent. During base flow an average residual pool depth (the amount of water that would be present during zero flow) of 0.36 meters was calculated (Table 4.1). Taking into account the amount of pools and the residual depths, water/habitat that would remain during base flows is extremely minimal. Based on the lack of pool habitat it is questionable if this reach can sustain trout populations during periods of low flow and during winter.

Since pool habitat was lacking, cover became a critical component within this reach. The riparian zone was 97% forested, however, the trees were young and grasses dominated within 50 feet of the stream channel. Large organic debris (LOD) was present in the stream channel, however the young seral stage of the standing trees indicated a lack of present LOD recruitment. Mean canopy cover was 18% which indicated that the riparian area provided very little shading to the stream channel.

Instream cover for escape and winter cover, was provided by the large organic debris present in the system instead of substrate related cover. An average geometric mean (mean substrate size) of 19.2 mm was calculated. For optimal escape and winter cover substrate between IO-40 cm is optimal indicating that little instream cover existed from substrate. However, LOD located within the channel may provide escape and winter cover for cutthroat trout.

Substrate and percent fines were also important in determining the average percent survival from egg to swim up fry. Six percent fine substrate was calculated for this reach for a 74% egg to swim up fry survival rate, indicating silt was not a major problem.

Low habitat availability,namely pools, was directly correlated to cutthroat trout densities. In 1992 cutthroat trout densities were 1.6 fish/100m^2 for this reach. These densities are low compared to

Table 4.2 Comparison of cutthroat trout densities in Northern Idaho tributaries (#/100m^2).

Location	Density		Reference
Coeur d'Alene River Tributaries.			
Brown Creek, ID.	9.3		Apperson et *al.*, (1988)
Copper Creek, ID.	1.6		Apperson et *al.*, (1988)
Cougar Gulch, ID	18.3		Apperson et *al.*, (1988)
Evans Creek, ID (1984)			
Site 1	27.5		Apperson *et* al., (1988)
St. Joe Tributaries.			
Benewah Creek (1984)			
Site 1	1.4		Apperson et *al.*, (1988)
Site 2	3.2		
Site 3	1.7		
Bond Creek			
Site 1	1.6		Apperson et *al.,* (1988)
Site 2	4.0		
Trout Creek			
Site 1	14.5		Apperson et *al.,* (1988)
Site 2	58.6		
St. Maries River Tributaries			
Alder Creek (1984)			
Site 1	3.8		Apperson et al., (1988)
Site 2	14.2		
Merry Creek			
Site 1	7.6		Apperson *et al.*, (1988)
Site 2	26.0		
Tributaries in current study			
	'91	'92	
Benewah Creek, ID			
Lower	0.0	1.2	Lillengreen et *al.* (1992) &
Middle	0.7	2.2	Present study
Upper	3.6	0.8	
Aider Creek, ID			
Lower		1.5	Lillengreen et *al.* (1992) &
Middle	1.8	33.5	Present study
Upper	1.1	0.3	
Lake Creek, ID			
Lower		1.6	Lillengreen et *al.* (1992) &
Middle	12.1	0.0	Present study
Upper	3.8	2.8	
Evans Creek, ID			
Middle	15.8	56.2	Lillengreen et *al.* (1992) &
Upper	24.1	42.9	Present study

other North Idaho cutthroat trout streams (Table 4.2).

Middle Lake Creek

In the middle reach of Lake Creek, pools comprised 15% of the available habitat. No side channels or lateral habitat was found. An average residual pool depth of 0.64 meters was calculated. Pool habitat was well below optimal for cutthroat trout (Table 4.1).

With pool habitat lacking, cover became a critical component for cutthroat trout survival in this reach. The riparian zone was 89% forested and 9% livestock grazing. Average canopy

cover was 0% indicating that very little shading of the stream channel occurred from the riparian zone. Most of the forested area consisted of young trees, grass and forb with low numbers of large organic debris located within the stream channel.

A geometric mean of 20.1 mm was calculated for substrate within this reach, which falls into the optimal size for cutthroat trout spawning gravels. Percent fine sediment in this reach was calculated at 5.2%, and calculated emergence success was 695% indicating that silt loading was not a major problem.

Low habitat availability was correlated to trout densities. In 1991, the middle reach had densities of 12.1 cutthroat/100m^2 and in 1992 had densities of 0.0 cutthroat /100m^2 for the middle reach These densities are low compared to other North Idaho streams (Table 4.2).

Upper Lake Creek

In the upper reach of Lake Creek pools comprised 0.1% of the habitat. A residual pool depth of .52 meters was calculated. Habitat in this reach consisted mainly of glides formed from old beaver dams.

Since pool habitat was lacking in the upper reach of Lake Creek, cover was again a critical component for cutthroat trout habitat. In the upper reach of Lake Creek the riparian area was 78% agriculture (barren fields) and 7% forested. Mean canopy cover was 0%. Large woody debris growing adjacent to the stream channel for shading and future recruitment of large organic debris to the stream channel was nonexistent.

Limited cover existed from LOD present in the system and no cover existed from substrate.

Twenty-four percent fines were calculated for this reach. Calculated emergence success values was 54.0% survival from egg to swim up fry. This reach was the only reach in which spawning gravels were abundant (gravels between 2-6 cm). However, this was also the site in which high percent fines were calculated.

Low habitat availability and high percentages of fine sediment correlated to low densities of cutthroat trout. Densities of 3.9 cutthroat/100m^2 and 2.8 cutthroat/100m^2 for 1991 and 1992 were calculated. These densities are low compared to other North Idaho streams (Table 4.2).

Conclusion and Recommendations for Lake Creek

Overall, the lack of pools in Lake Creek may be an indication of cumulative silt loading. Habitat surveys showed that 90% of the pools identified in Lake Creek were over 1.5 feet deep but only accounted for 9.4% of the total habitat surveyed. All three reaches lacked pool habitat therefore it is questionable if trout populations could be supported during periods of low flow and during winter.

Lake Creek has a limited riparian area for stream temperature control, erosion control or future recruitment of large organic debris.

Macroinvertebrate density data collected in 1991 (Lillengreen *et al* 1992) indicated that productivity in Lake Creek was comparable to other streams **which support healthy cutthroat trout populations. Therefore, food production was not a major limiting factor.**

Habitat conditions in Lake Creek which could have contributed to the low numbers of cutthroat trout and recommendations on ways to **improve cutthroat trout habitat are:**

Habitat condition	
*	Optimal maximum water temperatures for embyro, juvenile and adult life history stages were exceeded both years, and in 1992 the accepted temperature range was exceeded.

Recommendation:

- * Increase the amount of stream shading through riparian vegetation management. These management techniques could include the following; fences, buffer strips, planting.

Habitat condition

- * Base flow of 13.4% and 25% of average annual flow for 1991 and 1992.

Recommendation

- * Partially caused by low snow pack, but also water retention time decreased due to the lack of riparian and upland vegetation. Increase riparian and upland vegetation as stated above.

Habitat condition

- * Cumulative effects of silt loading has decreased the amount of pool habitat present, which in turn affects overwintering as well as rearing habitat.

Recommendation

Decrease sediment from a watershed approach "treat headwater areas" Instate BMP's (Best management practices) for timber, agriculture and grazing land uses. BMP's could include but are not limited to riparian leave zones for both timber and agriculture and rest-rotation schedules for livestock grazing. Instream structures may be built to create more pool habitat Also substrate cleaning is a viable option but should only be considered after instream and upland sediment recruitment has beer abated. Restoring stable channel geomorphology is also recommended.

Habitat condition

- * Rioarian area is lackinq for LOD recruitment.

Recommendation

Plant hardwoods for future recruitment of large organic debris as well as shrubs

Habitat condition

Channel Instability

Recommendation

All these conditions have, in part, been factors creating a disequilibrium in the stability of the channel. To a large extent land uses have predisposed the system to this instability. By following the above recommendations channel stability will, over time, improve. Also channel stabilization measures will be conducted for short term protection.

4.1.2. Benewah Creek

Parameters determined for the entire Benewah Creek drainage were base flow, temperature and dissolved oxygen.

Low flow conditions existed in Benewah Creek during 1991 and 1992. In 1991 base flow was 1.9 cfs and in 1992 was 0.6 cfs. Base flow in 1991 was 13.2% and in 1992 was 4.9% of the average annual flow (Table 4.3). Both base flows are below the average annual flow that is needed to maintain quality trout habitat. Low snow-pack and low water retention time from land-use practices were major contributors to the low base flow.

Maximum stream temperature in Benewah Creek were 24°C and 17°C for 1991 and 1992, respectively (Table 4.3). The maximum stream temperature for cutthroat trout (21 °C) was exceeded in 1991 indicating that cutthroat trout may have shown avoidance. Temperatures were collected once monthly, therefore, if these high temperatures existed for 7 days or more is unknown. High temperatures existing in a stream for seven days or more cause cutthroat trout to abandon these areas (Hickman and Raliegh 1982))

Dissolved oxygen concentrations were optimal for cutthroat trout (Table 4.3).

Lower Benewah Creek

In the lower reach of Benewah Creek 6% of the available habitat was pools. No side channels or lateral habitat existed. A mean residual pool depth of .4 meters was calculated (Table 4.3). Sufficient pool habitat associated with instream cover was not available in this reach, therefore it is questionable if cutthroat would utilize this area.

Cover within this reach was limited to a few pieces of large organic debris present in the stream channel. The riparian zone was dominated by shrubs and grasses which in turn resulted in an average canopy cover of 4.9%.

Various substrate sizes found in the lower reach of Benewah Creek may be used as over-wintering cover for cutthroat trout. Another area of concern in Benewah Creek was the possibility of severe bedload movement. The amount of cleared uplands, lack of canopy and riparian vegetation and compaction from grazing has increased bedload movement (Rhodes and Jones 1991). Bedload movement occurs during rain, rain on snow, or spring runoff. During spring spawning season, bedload movement scours the streambed, destroying redds. During winter events bedload movement may kill fish using the substrate as overwintering habitat.

A percent fine value of 3.1 was calculated for this reach with a geometric mean of 30 mm. An 87.9% survival from egg to swim up fry existed (Table 4.3). Optimal gravel sizes with low silt percentages existed in this reach which indicated that spawning gravels and silt were not a limiting factor for cutthroat trout.

Trout densities were once again correlated to available habitat as well as high water temperatures. Trout densities for the lower reach of Benewah Creek were 0 trout/100m^2 and 1.2 trout/l 00m^2 for 1991 and 1992, respectively (Table 4.3).

Middle Benewah Creek

In the middle reach of Benewah Creek 41% of the area was pool habitat. A residual pool depth of .41 meters was calculated and few pools had deep spots essential for rearing and escape cover. Most of the pools were formed by beavers and bedform scouring. Scouring

Table 4.3. Stream characteristics of Benewah Creek collected in 1991 and 1992.

	BENEWAH CREEK		
Stream reach	Lower	Middle	Upper
Fish densitv (m^2)			
Cutthroat			
1991	0	.01	.04
1992	.01	.02	.01
Eastern brook trout			
1991	0	0	0
1992	0	0	0
Bull trout			
1991	0	0	0
1992	0	0	0
Geometric mean(%fines)			
1992	29 (3.1)	27.4 (4.4)	13.3 (10.3)
% survival			
1992	88	97	67
% canopv (mean)			
1992	5	5	0
Maximum water temperature (°C)			
1991	24	24	24
1992	17	17	17
Q (base flow in CFS)			
1991	1.9	1.9	1.9
1992	0.6	0.6	0.6
Dissolved oxygen			
1991	14.2	16.4	14.9
1992	*	11.9	*
Residual pool mean depth (M)			
1992	0.4	0.4	1.o
° pools/%riffle			
1992	6/94	41/59	26/74
Larae Orqanic Debris (#)			
1992 logs	43	457	157
1992 root wads	4	17	12
Maior Land Use			
1992	39% residential	62% livestock	77% livestock

-data not collected

occurred due to unstable stream banks. Cattle grazed 62% of the riparian area, leaving unstable stream banks, little riparian vegetation and a mean canopy closure of 4.9%. Future recruitment of LOD did not exist, because of the high livestock grazing pressure (Table 4.3).

A percent fine value of 4.4 was calculated for the middle reach with a geometric mean of 27.4 mm (Table 4.3). Average cutthroat emergence success was estimated at 96.7%, which indicated that percent fines was not a limiting factor and that ample spawning size gravels existed in this reach.

The lack of adequate pool habitat with associated cover was thought to be the reason for the low numbers of cutthroat trout in this reach. Cutthroat trout densities of only 0.7 fish/l00 m^2 and 2.2 fish/l 00 m^2 were calculated for 1991 and 1992, respectively (Table 4.3).

Upper Benewah Creek

In the upper reach of Benewah Creek pools accounted for 26% of the available habitat. Three side channels for a total of 85.6 m^2 were also identified providing rearing habitat for young of the year and juvenile cutthroat trout. A mean residual pool depth of .97 meters was calculated for the reach in which dammed pools had a residual pool depth of 1.28 meters. In this reach there were 157 logs and 12 root wads and a mean canopy cover of 0.0%. Seventy-seven percent of the riparian area was grazed by livestock which contributed to the lack of LOD presently located in the stream channel. Future recruitment of LOD into this reach is limited due to the lack of large timber adjacent to the stream channel (Table 4.3).

Percent fines for upper reach was 10.3 with a geometric mean of 13.3 mm, respectively (Table 4.3). Average cutthroat emergence success was estimated at 67.4% which indicated that as percent fines increased survival from egg to swim up fry decreased (Irving and Bjornn 1977). Also, gravel sizes for cutthroat trout spawning were on the small side for this reach.

Highest cutthroat trout densities for Benewah Creek were found in the upper reach. Cutthroat trout densities of 3.6

trout/100m^2 and 0.8 trout1100 m^2 were calculated during 1991 and 1992, respectively. However, these densities are low in comparison to other North Idaho Streams (Table 4.2).

Conclusions and Recommendations for Benewah Creek

Overall, high water temperatures, low base flow and lack of available habitat in the form of deep pools associated with cover are major factors limiting cutthroat trout densities in Benewah Creek.

Macroinvertebrate densities collected in 1991 (Lillengreen et *al* 1992) indicated that macroinvertebrate densities were comparable to other low productivity high quality cutthroat trout streams in the area. Food production in Benewah Creek was not a limiting factor for cutthroat trout.

Habitat conditions in Benewah Creek which could contribute to the low numbers of cutthroat trout and recommendations on ways to improve cutthroat trout habitat are:

lYabitat Condition

* High water temperatures exceeded optimal cutthroat trout range during 1991 and 1992.

Recommendation

* Increase amount of stream shading through riparian vegetation management. These management techniques can include the following; fences, buffer strips, planting

lHabitat Condition

* Base flow below 50% annual stream flow for optimal trout habitat.

lRecommendation

* Partially caused by low snow pack, but also water retention time decreased due to the lack of riparian and upland vegetation. Increase riparian and upland vegetation as stated above.

Habitat Condition

* Excessive bedload movement.

Recommendation

* Reduce bedload movement through channel stabilization. Methods used could include restoring riparian vegetation establishing plants with large root masses and reconstruction of bank areas to level off and stabilize high cut bank areas.

Habitat Condition

* Lack of quality rearing and overwintering habitat

Recommendation

* Create deep pools. Beaver activity may assist in this task.

4.1.3. **Alder Creek**

Parameters determined for the entire Alder Creek drainage were base flow, temperature and dissolved oxygen.

Low flow conditions existed in Alder Creek during 1991 and 1992. In 1991 base flow was 18.8% of the average annual flow at 1.9 cfs and in 1992 was 8.5% of the average annual flow at 0.6 cfs (Table 4.4). Both are well below the average annual flow that is considered to maintain quality trout habitat. Low snow-pack and increased water yield from land-use practices are major contributing factors to the low base flow.

Temperature ranges in Alder Creek were within the acceptable range for cutthroat trout survival with maximum water temperatures of 19°C and 17°C for 1991 and 1992, respectively. Drought conditions and fairly open canopy are the main reasons for higher water temperatures outside of the optimal range of 11°C - 15.5°C (Table 4.4).

Dissolved oxygen concentrations were optimal for cutthroat trout.

Table 4.4. Stream characteristics of Alder Creek collected in 1991 and 1992.

Stream reach	Lower	ALDER CREEK Middle	Upper
Fish density (m^2)			
Cutthroat			
1991		.02	.01
1992	.02	.34	0
Eastern brook trout			
1991		.04	.20
1992	.01	.03	.14
Bull trout			
1991	0	0	0
1992	0	0	0
Geometric mean (%fines)			
1992	24.7 (3.3)	33.8 (10.8)	21.7 (27.0)
% survival			
1992	91	97	86
% canopy (mean)			
1992	30	27	46
Maximum water temperature (°C)			
1991	19	19	19
1992	17	17	17
Q (base flow in CFS)			
1991	1.5	1.5	1.5
1992	0.6	0.6	0.6
Dissolved oxygen			
1991	11.4	10.8	14.6
1992	•	11.6	*
Residual pool mean depth (M)			
1992	0.4	0.4	0.5
%pools/%riffle			
1992	17/83	4/96	58/42
Larae Organic Debris (#)			
1992 logs	148	2	147
1992 root wads	17	1	30
Major I and Use			
1992	99% timber	79% timber	66% timber

-data not collected

Lower Alder Creek

In Lower Alder Creek pools accounted for 17% of the total available habitat. During base flow a residual pool depth of 0.41 meters was calculated indicating that during summer flows few if any of the pools had water 1.5 feet deep or deeper which is essential for winter and escape cover. Three side channels for a total of 366 meters were identified within this reach. Mean canopy cover in this section averaged 30% with a range of 0-99%. This percentage canopy is a critical component for stream temperature regulation and provides optimum conditions for invertebrate production. This reach also had 149 logs and 17 root wads indicating that LOD is relatively abundant for instream cover which is essential when low water depth exists. Ninety nine percent of the riparian zone was forested securing future recruitment of large organic debris.

In the lower reach of Alder Creek an average of 3.3% fines was calculated with a geometric mean of 24.7 mm. Cutthroat survival from egg to swim up fry was estimated at 90.6%, which indicated that silt was not a major limiting factor.

No trout densities were calculated for the lower section of Alder Creek during 1991. In 1992, densities were 1.5 cutthroat/l $00m^2$ and 1 .1 eastern brook trout/l $00m^2$. Cutthroat trout densities were low compared to other cutthroat trout streams in North Idaho (Table 4.2) while eastern brook trout densities were comparable to other North Idaho streams (Table 4.5).

Middle Alder Creek

In the middle reach of Alder Creek pool habitat accounted for only 4% of the available habitat. No lateral habitat (side channels) was identified within this reach. A residual pool depth of 0.37 meters was calculated with a mean canopy of 26.8% (Table 4.4). Large organic debris was limited to two logs and one root wad. A combination of these factors indicated that this reach would not be utilized by cutthroat trout. Cutthroat trout densities were 1.9 cutthroat trout/$100m^2$ and 3.6 eastern brook trout/$100m^2$ in 1991. In 1992, densities of 33.5 cutthroat trout/$100m^2$ and 3.4 eastern brook trout/$100m^2$ were calculated. A serious change in the available habitat was recorded during September when population estimates were conducted. This change was attributed to the

Table 4.5 Comparison of eastern brook trout densities in Northern Idaho tributaries (#/100m^2).

Location	Density	Reference
Alder Creek (1984)		
Site 1	0.0	Apperson et **al.,** (1988)
Site 2	3.6	
Alder Creek (1991)		
Middle	3.5	Lillengreen et al., (1992)
Upper	19.9	
Alder Creek (1992)		
Lower	1.1	Present study
Middle	3.4	
Upper	13.8	
Benewah Creek (1984)	1.4	Apperson *et al.*, (1988)
Copper Creek		
Site 1	2.6	Apperson *et* a/., (1988)
Site 2	4.6	
Fortier Creek	4.2	Apperson et al., (1988)
Homor Creek	31.3	Corsi & Elle (1989)
Leiberg Creek	0.1	Gamblin (1987)
Reeds Gulch	132.5	Apperson et *al.*, (1988)

migration of beaver into the area. Beaver dams had created pool habitat and a corresponding increase in trout numbers was observed (see Appendix F). Habitat

typing in this reach should be repeated to assess the beaver activity before any recommendation be made.

The middle reach had a calculated percent fine sediment of 10.8% and a substrate geometric mean of 33.8 mm. Survival from egg to swim up fry was estimated at 97.5% indicating that silt was not a problem and that ample amount of spawning gravels existed (Table 4.4).

Upper Alder Creek

In the upper reach of Alder Creek pool habitat accounted for 58% of the available habitat. Two side channels, for a total of 287 meters, were identified which provided lateral habitat for young of the year fish and juvenile rearing habitat. A residual pool depth of 0.46 m was calculated. Mean canopy cover was 46.3% with 147 logs and 30 root wads within this section. Future recruitment of LOD was limited in some areas because of past forest practices, such as removing timber from the riparian zone. However, most of the reach had high recruitment of LOD (Table 4.4).

The upper reach had 27.0% fines with a geometric mean of 21.7 mm. An egg to swim up fry survival rate of 86.1% was calculated. This indicated that spawning gravels were adequate, however, silt may limit the amount of fry survival.

Trout densities of 1.2 cutthroat $/100m^2$ and 19.9 eastern brook trout $/100m^2$ were calculated for 1991. Densities of 0.3 cutthroat trout/l $00m^2$ and 13.8 eastern brook trout/l $00m^2$ were calculated for 1992 (Table 4.4). One factor that may be limiting the densities of cutthroat trout in this reach is interspecific competition with eastern brook trout. It has been documented that eastern brook trout will actively displace cutthroat trout (Griffith, 1972).

Conclusions and Recommendations for Alder Creek

All stream reaches for both years, with the exception of the middle reach in 1992, had lower cutthroat trout densities when compared to other North Idaho Streams (Table 4.2). Brook trout densities were comparable (Table 4.5).

Macroinvertebrate densities collected in 1991 (Lillengreen et ***al*** 1992) showed similar production to other North Idaho streams supporting healthy westslope cutthroat trout populations. Food production was not a limiting factor.

Habitat conditions in Alder Creek which could contribute to the low numbers of cutthroat trout and recommendations on ways to improve cutthroat trout habitat are:

Habitat Condition

- Low base flows of 18.8% and 8.5% of annual flow for 1991 and 1992, respectively.

Recommendation

- Increase water retention time by increasing riparian vegetation. Monitor beaver activity documenting habitat changes.

Habitat Condition

- The presence of eastern brook trout in the system.

Recommendation

- Designate the upper reach of Alder Creek above the falls, impassable to adfluvial cutthroat trout and an area limited in resident cutthroat. Manage the upper reach of Alder Creek for resident cutthroat trout and discourage private eastern brook trout plantings.

Habitat Condition

- Lack of deep pool habitat for rearing and overwintering cutthroat trout.

Recommendation

- Create deep pools by using log wiers. Management of ` beaver activity may assist in this task by creating large dammed pools.

4.1.4. Evans Creek

Low flow conditions existed in Evans Creek during 1991 and 1992. In 1991, base flow was 1.9 cfs, 15.4% of the average annual flow, and in 1992 was 1.6 cfs, 15.4% of the average annual flow. Both years were below the average annual flow required to maintain quality trout habitat, but of all four streams surveyed, Evans has the best water retention (Table 4.6). Base flow would improve in Evans with an adequate snow-pack and termination of the local drought.

Maximum stream temperatures in Evans Creek were 15°C and 17°C for 1991 and 1992, respectively. The maximum stream temperature for cutthroat trout (21°C) was never exceeded. In 1992, during low water flow, the temperature did not rise above the optimal temperature range for cutthroat trout.

Dissolved oxygen concentrations were optimal for cutthroat trout (Table 4.6).

Lower Evans Creek

In the lower reach of Evans Creek pools comprised 15% of the available habitat. Mean canopy in this reach was 32.9% with 16 logs and 8 root wads as large organic debris. One hundred percent of the riparian area had been grazed by cattle which explained the 1800 meters of bank cutting in this reach (Table 4.6). The presence of cattle year round has destroyed the integrity of the stream bank and increased instream sedimentation.

A percent fine value of 40.7%, and a geometric mean of 12.1 mm was calculated for the lower reach (Table 4.6). Percent emergence success was calculated at 59.3% which indicated that as percent fines increased, and the average survival from egg to swim up fry decreased.

Cutthroat trout densities for the lower reach of Evans Creek were not estimated for 1991 and were $0.0/100m^2$ during 1992 (Table 4.6). This area served only as a migratory corridor for cutthroat trout and was completely avoided by the resident

Table 4.6. Stream characteristics of Evans Creek collected in 1991 and 1992.

Stream reach	Lower	EVANS CREEK Middle	Upper
Fish density (m²)			
Cutthroat			
1991		.16	.24
1992		.56	.43
Eastern brook trout			
1991	0	0	0
1992	0	0	0
Bull trout			
1991	0	0	0
1992	0	0	0
Geometric means (%fines)			
1992	12.1 (40.7)	19.5 (11.0)	21.7 (9.7)
% survival			
1992	59	79	83
% canopy (mean)			
1992	33	61	66
Maximum water temperature (°C)			
1991	15	15	15
1992	17	17	17
Q (base flow in CFS)			
1991	1.9	1.9	1.9
1992	1.6	1.6	1.6
Dissolved oxygen			
1991	13.9	8.9	14.9
1992	•	10.8	•
Residual pool mean depth (M)			
1992	0.5	0.4	
%pools/%riffle			
1992	15/85	20/80	38/62
Large Organic Debris (#)			
1992 logs	16	58	48
1992 root wads	8	3	0
Major Land Use			
1992	100% livestock	100% timber	97% timber

-data not collected

cutthroat trout population.

Middle Evans Creek

In the middle reach of Evans Creek, pools comprised 20% of the available habitat. This area had average residual pool depths of .37 meters (Table 3.6). This depth is not optimal habitat, but association with heavy overhanging cover and large organic debris provided sufficient habitat. Average canopy cover in this reach was 61% and a total of 58 logs and 3 root wads were counted. The numerous log jams were not included in the total woody debris count. Future recruitment of large organic debris is unlimited because of the large amount of standing trees adjacent to the stream channel. Areas of concern in this reach include future timber sales and the number of instream road crossings present.

A percent fine value of 11 .O% and a geometric mean of 19.5 mm . was calculated (Table 4.6). Survival from egg to swim up fry was calculated at 78.6%. This suggested that cumulative effects of silt loading in this reach could eventually limit trout densities. Ample spawning gravels were present, however, silt may be a factor in cutthroat trout survival. Whether trout use this area for spawning is unknown.

The middle reach of Evans Creek had cutthroat trout densities of 15.8 trout/100m^2 during 1991 and 56.2/1 00m^2 for 1992. These densities are similar to other cutthroat trout streams in North Idaho (Table 4.2).

Upper Evans Creek

In the upper reach of Evans Creek, 38% of the available habitat was in the form of pools. A residual pool depth of .31 meters was calculated for this reach. These lower pool depths were associated with large amounts of overhanging canopy (mean canopy cover of 66%) and numerous debris jams and logs (Table 4.6). Road crossings and future timber sales in the upper reach were a problem. Limited cattle grazing does exist in the upper reach of Evans Creek and is beginning to show degradation of the riparian area. Proper BMP's for grazing will reduce the cumulative effects.

A percent fine value of 9.7% and a geometric mean of 21.7 mm were calculated for this reach. Percent survival from egg to swim up fry was calculated at 83.1%. Spawning gravels were abundant in this reach and silt was not a major factor.

In the upper reach of Evans Creek cutthroat trout densities were 24 fish/100m^2 for 1991 and 42.9 fish/100m^2 for 1992. These densities are similar to other cutthroat trout streams in North Idaho (Table 4.2).

Conclusions and Recommendations for Evans Creek

Overall, Evans Creek is relatively undamaged. However, there are problem areas, mainly the lower reach. Proper best management practices will partially mitigate for present damages. Future land use activities in the drainage basin have serious connotations to the stability of Evans Creek and should be monitored to insure that BMP's are implemented.

Macroinvertebrate production for Evans Creek as reported in Lillengreen *et al.* (1992) showed that food production was similar to other North Idaho streams producing viable cutthroat populations.

Habitat conditions in Evans Creek which could contribute to the decline of cutthroat trout and recommendations on ways to maintain cutthroat trout habitat are:

Habitat condition

* Stream protection zone and the water retention capability is optimal in most areas of Evans Creek.

Recommendation

* Monitor timber sales in the area to prevent disastrous effects on the drainage including enhancement of road or possible construction of new roads away from stream.

Habitat condition

* Lower reach has severe bank stability problems.

Recommendation

* Proper grazing strategies as well as re-establishment of riparian vegetation/ and root mass for bank stability.

4.2. Cutthroat trout stock assessment for surveyed streams.

In 1992, migration traps were installed to determine if adfluvial, fluvial or resident cutthroat were using the tributary. Stock determination was achieved through age and growth analysis as well as migratory tendencies.

4.2.1. Lake Creek

Data collected from Lake Creek showed that a remnant population of adfluvial and a resident population of cutthroat trout existed. This conclusion was based on age and growth analysis, migration trap data, and the outlet of Lake Creek is Lake Coeur d'Alene..

When comparing back calculated lengths to other tributaries known to contain adfluvial stocks of cutthroat trout, (Table 4.7) growth rates and ages obtained from cutthroat trout captured in the migration traps were comparable. In comparison, those tributaries in which resident stocks were found showed similar sizes to those cutthroat found during 1991 in the upper sections of Lake Creek. This indicated that a small population of resident cutthroat utilize the upper areas of Lake Creek.

The viability of the adfluvial stock is questioned since only 29 fish were captured in the traps. Sampling error may account for these low numbers of cutthroat since the migration traps were rendered inoperable at times during the spawning run. Of the 29 fish captured, eight were females with an average length of 333 mm. Based on average length and fecudity reported in literature, each female should produce approximately 6,127 eggs. Irving and Bjornn (1984) showed that survival from egg to swim-up fry may range from 0.4% to 95% in the laboratory depending upon the levels of fine sediment.

Based on the fact that spawning gravels were identified in the upper reach of Lake Creek, the percent fine value and percent emergence success calculated for the upper reach, was used to calculate the number of eggs that would survive to swim up fry. This value would calculate to approximately 3,308 cutthroat trout fry per female.

Table 4.7. **Comparison of mean back-calculated lengths at annulus formation for cutthroat trout.**

	Length at annulus formation					
	1	2	3	4	5	6
Tributaries to Priest Lake (Carlander, 1969)	86	127	170	201	254	
N. Idaho Tributaries (Carlander, 1969)						
Upper	53	102	152	224		
Lower	71	135	226	292		
Adfluvial		140	216			
East River, Priest River drainage, N. Idaho (Horner 1987)	95	136	171			
Big Creek, Priest River drainage, N. Idaho (Horner 1987)	81	121	154	177		
Cee Cee Ah Creek, WA (Barber et *al*. 1989)	94	134				
Tacoma Creek, WA (Barber et *al*. 1989)	101	140	182			
LeClerc Creek, WA (Barber et *al*. 1989)	93	137	178			
Benewah Creek, N. Idaho						
(Lillengreen et *al*. 1992) N=63	68	118	176	252	289	
(Present study) N=26	82	109	164	262	298	
Alder Creek, N. Idaho						
(Lillengreen et *al*. 1992) N=26	67	103	142			
(Present study) N=24	79	124	183			
Lake Creek, N. Idaho						
(Lillengreen et *al*. 1992) N=79	60	107	135			
(Present study) N=32	110	177	157	199	319	348
Evans Creek, N. Idaho						
(Lillengreen et a/. 1992) N=124	67	101	138	185		
(Present study) N=87	74	118	154	204		
Fighting Creek, N. Idaho (Lillengreen *et* a/. 1992)	53	97	140			
Plummer Creek, N. Idaho (Lillengreen et a/. 1992)	70	124	175	211	253	

This figure multiplied by eight females equals 26,464 cutthroat trout fry for Lake Creek. The estimated seeding levels and the actual densities collected for the three reaches of Lake Creek do not correlate. One explanation can be that spawning is taking place in the headwater areas of the stream, which have higher embeddeness rates and therefore lower survival rates (See Appendix D). A second explanation could be due to habitat sampling methods in Lake Creek. Due to the failure of the traps, survey intensity levels and lack of definite data, further investigation is needed to determine accurate seeding levels for Lake Creek.

4.2.2. Benewah Creek

Benewah Creek is a tributary to Benewah Lake, which is part of Lake Coeur d'Alene. Therefore, migratory stocks would be adfluvial. Migration trap data for Benewah Creek did not show proof of an adfluvial population of cutthroat trout. Age class data showed most of the cutthroat trout captured in Benewah Creek to be between O-3 years of age. Whether these are resident fish or adfluvial fish that are emigrating is undetermined. Presence of an adfluvial population of cutthroat trout in Benewah Creek was indicated by back calculated lengths and age class structures of the older fish captured. Growth rates of cutthroat trout were similar until age 3+ (Table 4.7). Those older age classes captured had growth rates indicative of adfluvial cutthroat trout.

4.2.3. Alder Creek

Alder Creek discharges into the St. Maries River, therefore any migratory stocks present would be fluvial. However, stocks were not determined as fluvial or resident since no migration traps were installed. The possibility of an fluvial stock may exist in the lower section based on historical personal testimonies of tribal elders. Above the falls it is highly questionable whether a fluvial stock exists because of the barrier that exists in the form of a waterfall. Therefore, fish captured in the middle and upper reaches, both located above the falls, are thought to be resident fish. Back calculated lengths were calculated for Alder Creek in 1991 and 1992. In 1991 no cutthroat trout were collected below the falls. 1992 growth rates, when compared to growth rates of documented fluvial stocks, were smaller, indicative of resident stocks (Table 4.7). In 1992, cutthroat trout were captured below the falls and growth rates were larger after year two indicative of a fluvial population.

4.2.4. Evans Creek

Back calculated lengths, age class structure (see section 3.2.1, Table 3.45), and migration trap data indicated Evans Creek contains a healthy population of resident west-slope cutthroat trout. Fluvial or adfluvial stocks could not be determined from the data collected.

4.3. Bull trout

Habitat conditions for bull trout were difficult to summarize since no bull trout were captured during the study. Bull trout have become functionally extinct in the lower St. Joe and Coeur d'Alene basins where the study tributaries were located. Bull trout still exist in the upper St. Joe River in unentered watersheds. Bull trout require more pristine conditions than cutthroat trout. Therefore, any improvement in cutthroat trout habitat would be beneficial to both trout species.

4.4. Conclusions

Habitat degradation and low survival rates of cutthroat trout to maturity have contributed to depressed populations of cutthroat trout within the Coeur d'Alene System. It would likely take several decades to rebuild these populations solely by natural reproduction once habitat improvement has been completed. Trout production levels in all tributaries, except Evans Creek, are well below optimal seeding levels. In conjunction with habitat restoration, seeding the tributaries is the best suited approach to increase population levels of cutthroat trout. The Coeur d'Alene Tribe identified two biological objectives for their fishery 1). Restore native populations of cutthroat and bull trout, while maintaining genetic integrity, and 2.) Increase subsistence harvest. In order to accomplish these goals four objectives were determined 1.) protect existing stocks, 2.) restore degraded habitat, 3.) expand current populations and, 4.) re-establish self-sustaining populations of cutthroat and bull trout.

In order to protect existing stocks of cutthroat and bull trout, the Coeur d'Alene Indian Tribe's first recommendation was to close fishing during spawning migration periods. The Idaho Department of Fish and Game (IDFG) has imposed special fishing regulations on cutthroat trout in the Couer d'Alene System. Closure of cutthroat fishing has already been established during spawning periods. IDFG has also closed all bull trout fishing in the Lake Coeur d'Alene system. The tribe fully supports all of these decisions. However, the Coeur d'Alene Tribe upon reviewing their hunting/fishing regulations has closed cutthroat and bull trout harvest by both tribal members and non-Indians in waters of the reservation. These closures will protect declining stocks from mortality due to angler harvest during spawning migrations as well as rearing cutthroat and bull trout.

Our long term goal is for the tributaries to support self-sustaining populations of cutthroat and bull trout. In order to accomplish this the Coeur d'Alene Tribe recommends that necessary habitat enhancement measures take place before any other work is completed. Tributaries surveyed showed extensive damage due to land use practices which included agriculture, grazing and silvaculture. Problems encountered included eroding stream banks, massive sediment loading resulting in high embeddeness, insufficient canopy, instream and overhanging cover. Animal keeping practices within the system were also major problems associated with almost all drainages. Vehicular traffic within and crossing the stream channel were also common problems.

Since overharvest and habitat degradation have been major problems in the Coeur d'Alene System for a long period of time even with the protection measures previously mentioned, the current population of cutthroat and bull trout will probably not be sufficient for rapid repopulation of the tributaries to carrying capacity. Habitat degradation and low survival rates of cutthroat and bull trout fry have also contributed to depressed populations of these species. Most likely it will take several decades to rebuild these populations solely by natural reproduction. Consequently it will be necessary to supplement native populations to accomplish the goal of population expansion.

For the reasons mentioned above the third recommendation is for a low capital hatchery for cutthroat and bull trout on the Couer d'Alene Indian Reservation. The cutthroat and bull trout hatchery is only a short term plan to aid in re-establishing these populations and increasing substenence fishing.

The Coeur d'Alenes final recommendation is that all fishery enhancement projects (habitat improvements and supplementation efforts) be monitored for a five-year period after implementation to determine their effectiveness. The monitoring program should include:

1.) Creel survey to determine the number of angler hours, catch per unit effort by anglers, and catch and harvest rates for each species.

2.) Population estimates of both hatchery raised and wild cutthroat and bull trout to determine if populations increase owing to habitat enhancement and stocking

3.) Growth rates of hatchery and wild fish stocks.

4.) Abundance of preferred prey organisms to determine the effect of stocking different numbers of fish on the ecosystem.

5.) A mark recapture study with various ages of hatchery released cutthroat and bull trout to determine if they remain in the tributaries or migrate into Lake Coeur d'Alene. Assess effectiveness of different locations, age or size at release and time of release for outplanting.

6.) Periodic assessments and quantification of habitat to ensure continuance of habitat improvement benefits.

Monitoring of hatchery outplanting and habitat improvements will provide important knowledge upon which future management decisions can be based.

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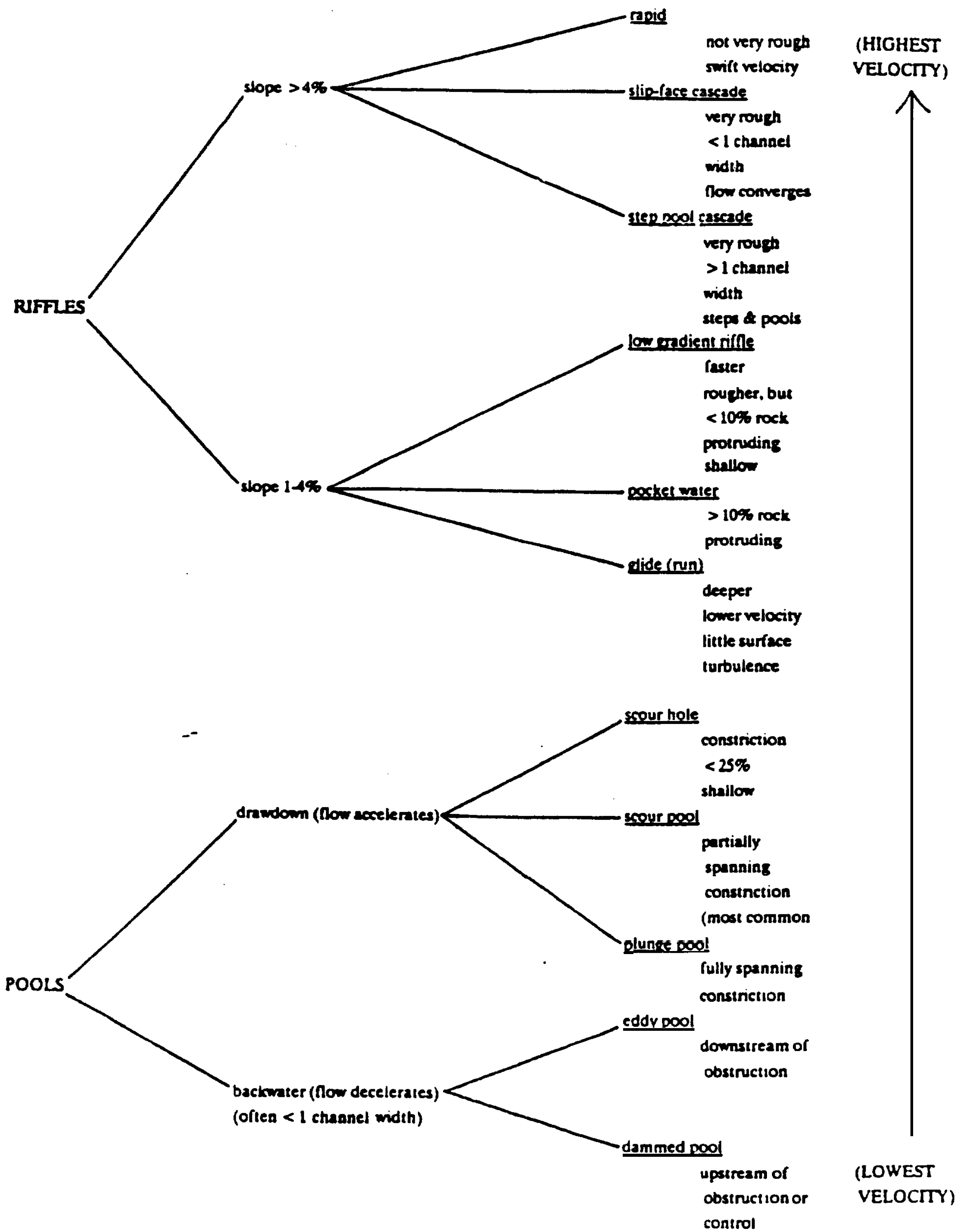
APPENDIX A

KEY TO CHANNEL UNITS (from Sullivan)



I n

SYNOPTICAL KEY To CHANNEL UNITS

This key is designed to assist in the identification of channel units in third sod fourth order stream as they appear during baseflow conditions. Although most of the units have similar chrractetistics as those described at the more extreme high or low flows, the depth and water surface characteristics, in particular, may vary. The relationship between units is illustrated in Pigure 5.12, pg 97.

Is Water flowing or standing in smaller channels (braids) thet are connected to the main chsnoel vithia the active floodplain. These smaller reaches may have both pools rod riffler (described below) although they are usually of smaller proportioo then main channel units. The cheooels that are inundated during higher flows are often discoaoected from the flow at lower flows lerviog pools of standing water along the channel margins.

SECONDARY CHANNEL

(SIDE CHANNEL)

Lb Water flowing in a well-defined permanent channel

2a Water is shallower and faster than the reach ● ver8ge; steep water surface slope

RIFFLE UNITS

(macro-units), lead 3a

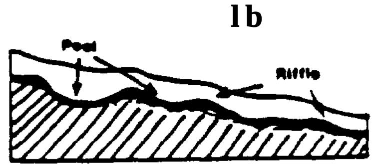
2b Water is deeper and ● louer than the reach average; gentle water surface slope

POOL UNITS

(macro-units) , lead 8a

I a

lb



RIFFLE UNITS
(Macro-units)

Riffle units are relatively shallow and fast with steep channel gradients; flow is swift and the water surface is rough or wavy; substrate is generally gravel to cobble in rite; water surface may be broken by rocks protruding through the surface

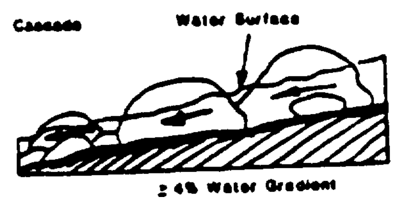
3a Channel and water surface slopes greater than or approximately equal to 0.04; flow uneven or turbulent with whitewater caused by local standing wave •

CASCADE UNITS
(woo-units), lead 4a

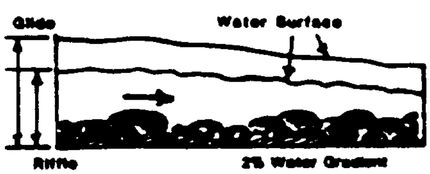
3b Channel gradient less than 4% but greater than 1%; flow is cveo but turbulent with little white water

RIPPLE UNITS
(meso-units), lead 7a

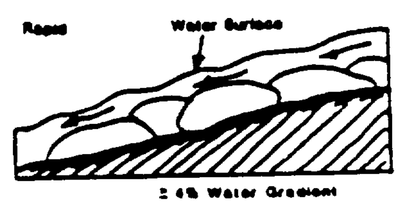
3a



3 b



3a



CASCADE UNITS

A meso-unit class of channel units with channel slopes greater than or approximately equal to 4%. Cascade units tend to be associated with obstructions that constrict stream flow, although in smaller, steeper streams they can occur in unconstricted channels.

4a Few rocks protrude through the flow although flow is swift and very turbulent; often found upstream of channel constrictions where gravel bars slope diagonally across the channel funneling streamflow into narrow troughs along one bank; water surface streams and is opaque but whitewater is not common; may have standing waves present at the downstream end of the unit at the junction of the unit and the head of the pool where flow passes channel obstructions.

RAPIDS

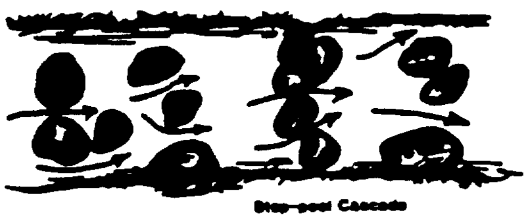
4b Rocks protrude through the flow on 10% of more or the surface area of the unit giving these units high relative roughness and causing considerable pooling of water behind the rocks; whitewater scattered throughout the unit at most flows

5a Relatively long channel units (length greater than 1 channel width); tend to occur where valley slopes are greater than 3.5% but usually not steeper than 6%; generally in smaller streams (third order or smaller) but are also found in larger streams at valley constrictions (bedrock outcrops, earthflows, debris jams etc.); characterized by a series of boulder bars, composed of strings of boulders wedged together across all or part of the channel, or logs, that form small falls and create a series of steps spaced at 1 channel width or less and separated by short, shallow pools

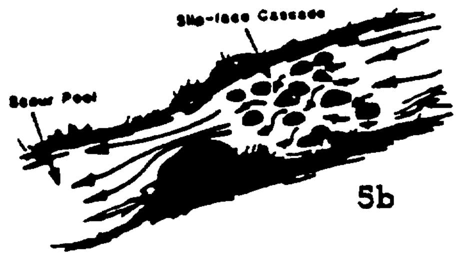
STEP-POOL CASCADES

5b Shorter units, less than or equal to 1 channel width, that form upstream of local constrictions such as logs, debris jams, bedrock outcrops, etc.; often the downstream end of the unit cuts across the channel at a 45° angle; occur on the steep, downstream face of gravel bars positioned at the channel obstructions; flow converges through the unit and channel width decreases approximately 25% from the upstream to downstream end of the unit

SLIP-FACE CASCADES



5a



5b

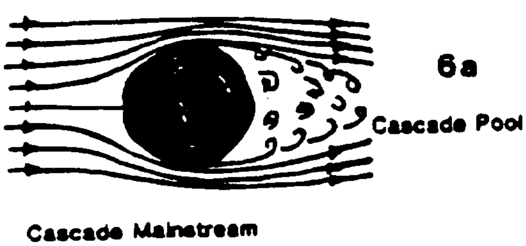
6a Small pools on the downstream side of the protruding rocks surrounded by swiftly flowing water

Cascade pools

(also referred to as pocket water)

6b Swiftly flowing water between the protruding rocks

Cascade-mainstream



6a

6b

RIFFLES (MESO-UNITS)

Channel gradient between 1 and 4%; generally composed of gravel to cobble substrate with little of the surface area of the unit made up of large rocks protruding through the flow (although these units often appear rough at very low flows); uniform flow (banks parallel through the length of the unit); standing waves generally absent; moderate to swift velocity; moderate to shallow depth

7a Slower, smoothly flowing water with moderate depth; usually on the lower end of the range of channel gradient (between 1 and 2%); these units can occur anywhere in the stream where riffles may occur, but they most often occur at the transition between particularly elongated pools and the downstream riffle in the zone referred to as the tailout of the pool, but they are usually only identified at particularly elongated pools and therefore these units are not a common feature in small streams.

<u>GLIDE</u>

A unit with similar characteristics is common in larger streams (fourth order or larger).

Run

7b Swiftly flowing with depth shallow enough that submerged particles of the bed disturb the water surface (often producing a diamond-shaped pattern of surface waves) but generally do not protrude through the flow (0 to 10% of the surface area); channel gradient greater than 2% but less than 4%.

<u>LOW-GRADIENT RIFFLES</u>

Low-gradient riffles resemble cascades at the very low flows of the year since many boulders normally submerged become exposed. The 10% surface area cutoff point appears to be a reasonably good separating criteria, even at low flows, but unit slope can always be used to distinguish the two units.

POOL UNITS
(Macro-units)

Flow in pools is relatively deep and slow with gentle energy gradients; water surface is tranquil or slightly disturbed although not to the extent that the surface becomes opaque (some turbulence may occur at the head of the pool as flow passes through the constriction with which the pool is associated); substrate may vary in size from fines to boulders

8a Flow decelerates within the unit and the flow path is often lateral or vortical relative to the main stream

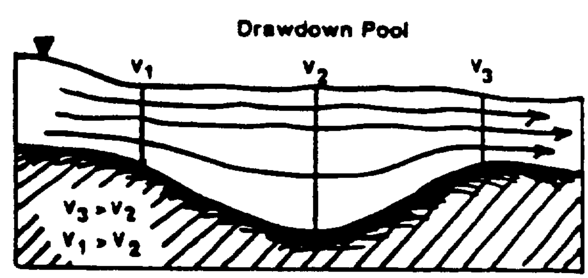
BACKWATER POOLS, LEAD 9A

8b Flow accelerates within the pool, speeding up at the downstream end where the depth decreases, and flow path follows the main stream

DRAWDOWN POOLS, LEAD 10A

8a

8b



BACKWATER POOLS (meso-unit)

Backwater pools are always associated with obstructions. Flow lines diverge from the downstream path and flow decelerates within the unit, moving perpendicular or lateral to the main flow; flow is characterized by decreasing velocity and decreasing water surface slope within the unit; units are often without distinct three-dimensional shapes and units are determined relative to the obstructions (not to the streambed); water surface slope less than 0.5%

9a Unit lies upstream of obstruction such as log, debris jam, etc.; unit is often found proximal to slip-face cascades where obstructions partially span the channel (at high flow water often backs up through the unit and drowns out the cascades); can be large (full channel width, several channel widths in length) or small (on the order of one square meter) depending on the degree to which the obstruction blocks the channel

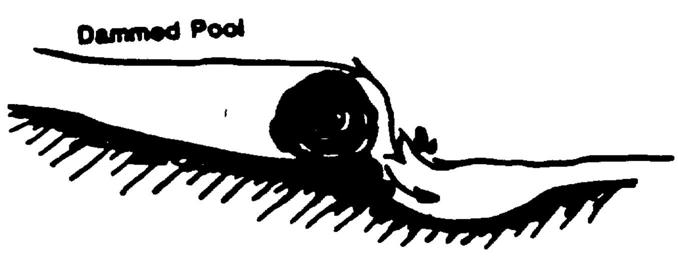
DAMMED POOL

9b Unit lies downstream of an obstruction; eddies formed by the obstruction are relatively large and generally border the thalweg on one side and the downstream edge of the channel on the other

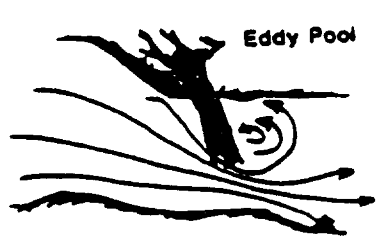
EDDY POOL

This pool type has been described as backwater pools by Bisson et al. (1982), but herein the term backwater pool will be applied only to the general category of pools in which flow decelerates.

9a



9b



DRAWDOWN POOLS

Pools associated with the thalweg of the channel. Flow is usually rapid where flow enters the upstream end of the pool, decelerates where it meets the slower body of water in the pool, but accelerates again at the shallowing downstream end of the pool; submerged jets of flow form at the head of the pool which radiates outward causing diverging flow and channel width from the upstream to downstream end of the pool; water surface slope greater than 0.5 % but less than 1.0%

10a Pool found downstream of an obstruction that spans at least three fourths of entire active channel but which lies within the top one half of the channel depth at bankfull discharge (indicated by the permanent vegetation line) but not above the bank; unit shape is shorter and deeper than other drawdown pools; often found downstream of a free overfall (water fall) where flow leaves the stream bed and plunges into the downstream pool

<u>PLUNGE POOL</u>

(Smaller plunge pools can occur along the sides of of the channel where obstructions block secondary channels.)

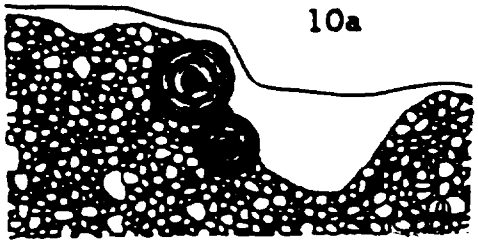
10a

10b

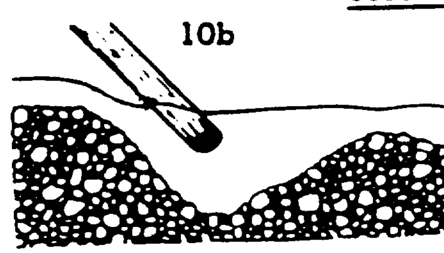
10b Pool found downstream of a partially-spanning channel obstruction that constricts the channel more than 25% but less than 100% of the bankfull width marked by the vegetation line (the maximum constriction that forms these units may be closer to 3/4 bankfull channel width); constrictions cause lateral scour as flow is directed sideways against the banks or vertical scour of the bed

<u>SCOUR POOL</u>

10a



10b



APPENDIX B

Table B.l. Frequency of occurence, total percent occurence, total area, percent area, and residual pool depth values for Valley Segment #1 for Lake Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	2	1.77	9.7	0.16	
Step pool cascade	0	0	0	0	
Slip face cascade	2	1.77	17.4	0.29	
Total Cascades	**4**	**3.54**	**27.1**	**0.45**	
Pocketwater	2	1.77	223.9	3.7	
Glide	34	30.09	1664.2	27.51	
Run	0	0	0	0	
Low gradient riffle	43	38.05	3285.8	54.32	
Total Riffles	79	**69.91**	5173.9	**85.53**	
Dammed pool	1	0.88	37.7	0.62	0.27
Eddy pool	3	2.65	57.7	0.95	0.48
Plunge pool	7	6.19	165.8	2.74	0.42
Scour pool	15	13.27	461.8	7.63	0.5
Scour hole	3	2.65	72.8	1.2	0.6
Beaver pond	0	0	0	0	0
Total Pools	**29**	**25.64**	**795.8**	**13.14**	**2.27**
Secondary channel	1	0.88	52.4	0.87	0.09
Grand Totals	**113**	**99.97**	**6049.2**	**99.99**	**2.36**

Table B.2. Summary report for Valley Segment # 1 of Lake Creek Watershed data collected during 1992.

Elevation	**652-681 m**
Total length	**1450.8 m**
Stream order	3
Mean stream gradient	0.8
Pool/riffle/cascade ratio	**31.4/1.91e-2/1**
Land use	
Forest	99.6%
Agriculture	
Livestock grazing	
Mining	
Wetland	
Other (includes residential,right of way, etc.)	0.4%
Vegetative type	
Decidious	1.8%
Coniferous	
Mixed	**98.2%**
Seral stage	
Grass/forb	35.0%
Shrub	42.9%
Pole	16.8%
Young	
Mature	
Old growth	
Other	
x Canopy cover	**19.7 (O-99)**
# Woody debris	
Logs	234
Root wads	18

Table B.3. Frequency of occurrence, total percent occurence, total area, percent area, and residual pool depth values for Valley Segment #2 for Lake Creek during 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	1	1.33	37.7	0.29	
Slip face cascade	1	1.33	20.1	0.16	
Total Cascades	**2**	2.66	57.8	0.45	
Pocketwater	27	36	9077.9	70.39	
Glide	12	16	669.3	5.19	
Run	0	0	0	0	
Low gradient riffle	15	20	2185.6	16.95	
Total Riffles	**54**	72	**11932.8**	**92.53**	
Dammed pool	0	0	0	0	0
Eddy pool	0	0	0	0	0
Plunge pool	1	1.33	28.9	0.22	0.27
Scour pool	16	21.33	609.3	4.72	0.44
Scour hole	0	0	0	0	0.6
Beaver pond	0	0	0	0	0
Total Pools	**17**	22.66	638.2	4.94	0.77
Secondary channel	2	2.67	268.1	2.08	0.12
Grand Totals	**75**	**99.99**	**12896.9**	**100**	**0.89**

Table 8.4. Summary report for Valley Segment # 2 of Lake Creek Watershed data collected during 1992.

Elevation	**681-731 m**
Total length	**2735.9 m**
Stream order	3
Mean stream gradient	2.0
Pool/riffle/cascade ratio	**15.6/2.07e-2/1**
Land use	
Forest	94.7%
Agriculture	
Livestock grazing	
Mining	1.3%
Wetland	
Other (includes residential,right of way, etc.)	4.0%
Vegetative type	
Decidious	
Coniferous	
Mixed	**98.7%**
Serai stage	
Grass/forb	
Shrub	
Pole	
Young	
Mature	98.7%
Old growth	
Other	1.3%
x Canopy cover	**16.5** (O-33)
# Woody debris	
Logs	10
Root wads	0

Table B.5. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth values for Valley Segment #3 for Lake Creek during 1992.

Habitat Type	Frequency	% Frequency	Total Area (Sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	0	0	0	0	
Slip face cascade	0	0	0	0	
Total Cascades	**0**	**0**	**0**	**0**	
Pocketwater	0	0	0	0	
Glide	51	31.29	8101.1	42.32	
Run	0	0	0	0	
Low gradient riffle	71	43.56	7952.6	41.54	
Total Riffles	122	74.85	16053.7	83.86	
Dammed pool	1	0.61	211.1	1.1	0.91
Eddy pool	0	0	0	0	0
Plunge pool	0	0	0	0	0.27
Scour pool	36	22.09	2585.2	13.5	0.55
Scour hole	1	0.61	132.4	0.69	0.82
Beaver pond	0	0	0	0	0
Total Pools	38	23.31	2928.7	**15.29**	2.55
Secondary channel	3	1.84	162.1	0.85	0.38
Grand Totals	**163**	**100**	**19144.5**	**100**	**2.93**

Table B.6. Summary report for Valley Segment # 3 of Lake Creek Watershed data collected during 1992.

Elevation	**731-765 m**	
Total length	**4171.8 m**	
Stream order	3	
Mean stream gradient	1.4	
Pool/riffle/cascade ratio	**0.19/1/0**	
Land use		
Forest	**89.6%**	
Agriculture	**9.2%**	
Livestock grazing	**9.2%**	
Mining		
Wetland		
Other (includes residential,right of way, etc.)	1.2%	
Vegetative type		
Decidious		
Coniferous		
Mixed	**98.9%**	
Serai stage		
Grass/forb	**9.2%**	
Shrub		
Pole		
Young		
Mature	**89.6%**	
Old growth		
Other	1.2%	
x Canopy cover	0	**(0-0)**
# Woody debris		
Logs	19	
Root wads	1	
Valley type	**M I**	

Table 8.7. Frequency of occurrence, total percent occurence, total area, percent area, and residual pool depth values for Valley Segment #4 for Lake Creek during 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	0	0	0	0	
Slip face cascade	0	0	0	0	
Total Cascades	**0**	**0**	**0**	**0**	
Pocketwater	0	0	0	0	
Glide	19	44.19	12358.5	76.48	
Run	0	0	0	0	
Low gradient riffle	12	27.91	1729.5	10.7	
Total Riffles	**31**	**72.1**	**14088**	**87.1 8**	
Dammed pool	4	9.3	408.6	2.53	0.53
Eddy pool	0	0	0	0	0
Plunge pool	0	0	0	0	0.27
Scour pool	6	13.95	1585	9.81	0.68
Scour hole	2	4.65	76.8	0.48	0.59
Beaver pond	0	0	0	0	0
Total Pools	**12**	**27.9**	**2070.4**	**12.82**	**2.07**
Secondary channel	0	0	0	0	0
Grand Totals	**4 3**	**100**	**16158.4**	**100**	**2.07**

Table 8.8. Summary report for Valley Segment # 4 of Lake Creek Watershed data collected during 1992.

Elevation	765-780 m	
Total length	5074.6 m	
Stream order	3	
Mean stream gradient	1.3	
Pool/riffle/cascade ratio	0.15/1/0	
Land use		
Forest	7.0%	
Agriculture	77.9%	
Livestock grazing		
Mining		
Wetland		
Other (includes residential,right of way, etc.)	1.2%	
Vegetative type		
Decidious		
Coniferous		
Mixed	100.0%	
Serai stage		
Grass/forb		
Shrub	51.2%	
Pole		
Young	48.8%	
Mature		
Old growth		
Other		
x Canopy cover	0	(0-0)
# Woody debris		
Logs	53	
Root wads	1	
Valley type	M2	

Table B.9. Frequency of occurrence, total percent occurence, total area, percent area, and residual pool depth values for Bozard Creek during 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	0	0	0	0	
Slip face cascade	0	0	0	0	
Total Cascades	**0**	**0**	**0**	**0**	
Pocketwater	0	0	0	0	
Glide	3	33.33	2077.2	32.44	
Run	0	0	0	0	
Low gradient riffle	5	55.56	4319.5	67.46	
Total Riffles	**8**	**88.89**	**6396.7**	**99.9**	
Dammed pool	0	0	0	0	0
Eddy pool	0	0	0	0	0
Plunge pool	1	11.11	6.7	0.1	0.27
Scour pool	0	0	0	0	0
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	**1**	**11.11**	**6.7**	**0.1**	**0.27**
Secondary channel	0	0	0	0	0
Grand Totals	**9**	**100**	**6403.4**	**100**	**0.27**

Table B.IO. Summary report for Bozard Creek Watershed data collected during 1992.

Elevation	**780-787 m**
Total length	**3041.6 m**
Stream order	2
Mean stream gradient	2.0
Pool/riffle/cascade ratio	**1.05e-3/1/0**
Land use	
Forest	66.7%
Agriculture	33.3%
Livestock grazing	33.3%
Mining	
Wetland	
Other (includes residential,right of way, etc.)	
Vegetative type	
Decidious	
Coniferous	
Mixed	100.0%
Serai stage	
Grass/forb	
Shrub	100.0%
Pole	
Young	
Mature	
Old growth	
Other	
x Canopy cover	**0 (0-0)**
# Woody debris	
Logs	**0**
Root wads	0
Valley type	M 2

Table B.11. Frequency of occurrence, total percent occurence, total area, percent area, and residual pool depth values for Valley Segment #1 for West Lake Creek during 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	0	0	0	0	
Slip face cascade	0	0	0	0	
Total Cascades	**0**	**0**	**0**	**0**	
Pocketwater	0	0	0	0	
Glide	9	39.13	1337.8	37.4	
Run	0	0	0	0	
Low gradient riffle	9	39.13	2182.5	61.01	
Total Riffles	**18**	78.26	3520.3	**98.41**	
Dammed pool	0	0	0	0	0
Eddy pool	0	0	0	0	0
Plunge pool	1	4.35	24.7	0.69	0.3
Scour pool	4	17.39	32.1	0.9	0.46
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	**5**	**21.74**	56.8	0.78	0.49
Secondary channel	0	0	0	0	0
Grand Totals	**23**	**100**	**3577.1**	**99.19**	**0.49**

Table 8.12. Summary report for Valley Segment #1 of West Fork Lake Creek Watershed data collected during 1992.

Elevation	780-793 m
Total length	2975.5 m
Stream order	2
Mean stream gradient	1 .o
Pool/riffle/cascade ratio	1.62e-2/1/0
Land use	
Forest	30.4%
Agriculture	
Livestock grazing	69.6%
Mining	
Wetland	
Other (includes residential,right of way, etc.)	
Vegetative type	
Decidious	
Coniferous	
Mixed	100.0%
Seral stage	
Grass/forb	60.9%
Shrub	30.4%
Pole	8.7%
Young	
Mature	
Old growth	
Other	
x Canopy cover	0 (0-0)
# Woody debris	
Logs	25
Root wads	0
Valley type	M2

Table B.13. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth values for Valley Segment #2 for West Lake Creek during 1992.

Habitat Type	Frequency	% Frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	0	0	0	0	
Slip face cascade	0	0	0	0	
Total Cascades	**0**	**0**	**0**	**0**	
Pocketwater	1	9.09	205.5	8.9	
Glide	0	0	0	0	
Run	0	0	0	0	
Low gradient riffle	5	45.45	2055.5	89.03	
Total Riffles	**6**	54.54	2261	97.93	
Dammed pool	0	0	0	0	0
Eddy pool	0	0	0	0	0
Plunge pool	4	36.36	30.9	1.34	0.2
Scour pool	1	9.09	16.7	0.72	0.49
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	5	45.45	47.6	2.06	0.51
Secondary channel	0	0	0	0	0
Grand Totals	11	**99.99**	2308.6	99.99	**0.51**

Table B.14. Summary report for Valley Segment # 2 of West Fork Lake Creek Watershed data collected during 1992.

Elevation	793-841 m	
Total length	1424.9 m	
Stream order	2	
Mean stream gradient	1 .o	
Pool/riffle/cascade ratio	2.11e-2/1	
Land use		
Forest	100.0%	
Agriculture		
Livestock grazing		
Mining		
Wetland		
Other (includes residential,right of way, etc.)		
Vegetative type		
Decidious		
Coniferous		
Mixed	100.0%	
Seral stage		
Grass/forb		
Shrub	45.5%	
Pole		
Young	54.5%	
Mature		
Old growth		
Other		
x Canopy cover	0.0	(0-0)
# Woody debris		
Logs	3	
Root wads	0	

Table B.15. Frequency of occurrence, total percent occurrence, total area, percent area and residual pool depth values for Valley Segment #1 for Benewah Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	2	5.71	2727.9	30.65	
Slip face cascade	0	0	0	0	
Total Cascades	2	5.71	2727.9	30.65	
Pocketwater	5	14.29	2619.7	29.44	
Glide	8	22.86	1635.2	18.38	
Run	0	0	0	0	
Low graident riffle	10	28.57	1280.1	14.38	
Total Riffles	23	65.72	5535	62.2	
Dammed pool	2	5.71	137	1.54	0.67
Eddy pool	0	0	0	0	0
Plunge pool	1	2.86	42.3	0.47	0.61
Scour pool	3	8.57	205.7	2.31	0.61
Scour hole	3	8.57	136.1	1.53	0.46
Beaver pond	0	0	0	0	0
Total Pools	9	25.71	521.1	5.85	2.35
Secondary channel	1	2.86	115.1	1.29	0.06
Grand Totals	35	100	8899.1	99.99	2.41

Table 8.16. Summary report for Valley Segment # 1 of Benewah Creek Watershed data collected during 1992.

Elevation	683-713 m
Total length	1904.2 m
Stream order	4
Mean stream gradient	3.0
Pool/riffle/cascade ratio	.233/2.029/1
Land use	
Forest	5.6%
Agriculture	
Livestock grazing	25.0%
Mining	
Other (includes residential,right of way, etc.)	69.4%
Vegetative type	
Decidious	69.4%
Coniferous	16.7%
Mixed	13.9%
Serai stage	
Grass/forb	27.8%
Shrub	52.8%
Pole	2.8%
Young	
Mature	16.7%
Old growth	
Other	
x Canopy cover	3.11 (O-28)
# Woody debris	
Logs	17
Root wads	1

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Table B.17. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth values for Valley Segment #2 for Benewah Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	8	5.93	562.4	3.81	
Slip face cascade	13	9.63	310	2.1	
Total Cascades	21	15.56	872.4	5.91	
Pocketwater	42	31.11	11288.6	76.45	
Glide	8	5.93	409.9	2.78	
Run	0	0	0	0	
Low graident riffle	20	14.81	1425.7	9.66	
Total Riffles	70	51.85	13124.2	88.89	
Dammed pool	18	13.33	415.9	2.82	0.42
Eddy pool	1	0.74	1.2	>.01	0.15
Plunge pool	4	2.96	65.4	0.44	0.39
Scour pool	9	6.67	170.5	1.15	0.46
Scour hole	12	8.89	116.3	0.79	0.31
Beaver pond	0	0	0	0	0
Total Pools	44	32.59	769.3	5.2	1.73
Secondary channel	0	0	0	0	0
Grand Totals	135	100	14765.9	100	1.73

Table 8.18. Summary report for Valley Segment #2 of Benewah Creek Watershed data collected during 1992.

Elevation	713-732 m
Total length	1871.5 m
Stream order	4
Mean stream gradient	3.6
Pool/riffle/cascade ratio	.8/15.0/1
Land use	
Forest	65.0%
Agriculture	
Livestock grazing	
Mining	1.1%
Wetland	1.5%
Other (includes residential,right of way, etc.)	9.5%
Vegetative type	
Decidious	5.8%
Coniferous	8.8%
Mixed	85.4%
Seral stage	
Grass/forb	7.7%
Shrub	58.0%
Pole	1.8%
Young	4.0%
Mature	26.3%
Old growth	0.7%
Other	1.5%
x Canopy cover	6.64 (O-76)
# Woody debrls	
Logs	26
Root wads	3

Table B.19. Frequency of occurrence, total percent occurrence, total area, percent area and residual pool depth values for Valley Segment # 3 for Benewah Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	3	2.01	207.2	0.85	
Slip face cascade	28	18.79	1659.4	6.84	
Total Cascades	31	20.8	1866.6	7.69	
Pocketwater	35	23.49	14606.6	60.18	
Glide	14	9.4	2244.3	9.25	
Run	0	0	0	0	
Low graident riffle	25	16.78	4089.2	16.85	
Total Riffles	74	49.67	20940.1	86.28	
Dammed pool	10	6.71	425.4	1.75	0.42
Eddy pool	1	0.67	5.9	0.02	0
Plunge pool	0	0	0	0	0.39
Scour pool	16	10.74	787.2	3.24	0.37
Scour hole	17	11.41	245.7	1.01	0.27
Beaver pond	0	0	0	0	0
Total Pools	44	29.53	1464.2	6.02	1.45
Secondary channel	0	0	0	0	0
Grand Totals	149	100	24270.9	99.99	1.45

Table 8.20. Summary report for Valley Segment #3 of Benewah Creek Watershed data collected during 1992.

Elevation	732-793 m
Total length	3546.4 m
Stream order	4
Mean stream gradient	2.4
Pool/riffle/cascade ratio	.8/11.2/1
Land use	
Forest	38.7%
Agriculture	25.6%
Livestock grazing	
Mining	
Wetland	3.6%
Other (includes residential,right of way, etc.)	32.1%
Vegetative type	
Decidious	37.7%
Coniferous	1.4%
Mixed	60.9%
Serai stage	
Grass/forb	26.5%
Shrub	57.3%
Pole	2.0%
Young	7.0%
Mature	7.3%
Old growth	
Other	
x Canopy cover	4.33 (O-70)
# Woody debris	
Logs	4
Root wads	5
Bank cutting	3/659 m
Side channels	2168.3 m

Table 8.21. Frequency of ocurrence, total percent occurrence, total area, percent area and residual pool depth values for Valley Segemtn #4 for Benewah Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	0	0	0	0	
Slip face cascade	20	3.93	527.3	1.08	
Total Cascades	20	3.93	527.3	1.08	
Pocketwater	3	0.59	1083.6	2.21	
Glide	35	6.88	5990.2	12.22	
Run	0	0	0	0	
Low graident riffle	140	27.5	13787.5	28.13	
Total Riffles	178	34.97	20861.3	42.56	
Dammed pool	16	3.14	2534.3	5.17	0.6
Eddy pool	4	0.79	30.5	0.06	0.27
Plunge pool	3	0.59	67.1	0.14	0.64
Scour pool	241	47.35	14812.4	30.22	0.52
Scour hole	30	5.89	354.2	0.72	0.27
Beaver pond	17	3.34	9827.2	20.05	1.11
Total Pools	311	61.1	27625.7	56.36	3.41
Secondary channel	0	0	0	0	0
Grand Totals	509	100	49014.3	100	3.41

Table 8.22. Summary report for Valley Segment #4 of Benewah Creek Watershed data collected during 1992.

Elevation	793-838 m
Total length	7914.7 m
Stream order	4
Mean stream gradient	0.8
Pool/riffle/cascade ratio	52.4/39.6/1
Land use	
Forest	1.4%
Agriculture	
Livestock grazing	97.4
Mining	
Wetland	
Other (includes residential,right of way, etc.)	1.2%
Vegetative type	
Decidious	92.9%
Coniferous	
Mixed	3.7%
Serai stage	
Grass/forb	54.9%
Shrub	44.0%
Pole	
Young	
Mature	
Old growth	
Other	
x Canopy cover	5.05 (O-99)
# Woody debris	
Logs	453
Root wads	12
Bank cutting	3/2678 m
Side Channels	251906.9 m

Table 8.23. Frequency of occurrence, total percent occurrence, total area, percent area and residual pool depth values for Valley Segment #5 for Benewah Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	3	3.41	11.7	0.11	
Slip face cascade	0	0	0	0	
Totals Cascades	3	3.41	11.7	0.11	
Pocketwater	0	0	0	0	
Glide	24	27.27	3161.5	30.34	
Run	0	0	0	0	
Low graident riffle	36	40.91	4436.7	42.58	
Total Riffles	60	68.18	7598.2	72.92	
Dammed pool	4	4.55	1723.5	16.54	1.28
Eddy pool	0	0	0	0	0
Plunge pool	0	0	0	0	0
Scour pool	18	20.45	1001.4	9.61	0.66
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	22	25	2724.9	26.15	1.94
Secondary channel	3	3.41	85.6	0.82	0.13
Grand Totals	88	100	10420.4	100	2.07

Table 8.24. Summary report for Valley Segment #5 of Benewah Creek Watershed data collected during 1992.

Elevation	838-854 m
Total length	4369 m
Stream order	4
Mean stream gradient	1.5
Pool/riffle/cascade ratio	.002/.006/l
Land use	
Forest	15.9%
Agriculture	1.1%
Livestock grazing	76.7%
Mining	
Wetland	
Other (includes residential,right of way, etc.)	6.3%
Vegetative type	
Decidious	
Coniferous	
Mixed	100.0%
Seral stage	
Grass/forb	83.5%
Shrub	12.5%
Pole	
Young	
Mature	
Old growth	
Other	
x Canopy cover	0.0 (0-0)
# Woody debris	
Logs	157
Root wads	12

Table 8.25. Frequency of occurrence, total percent **occurence,** total area, percent area, and residual pool depth values for Valley Segment **#1** for Evans Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step-pool cascade	0	0	0	0	
Slip-face cascade	2	3.45	96.9	1.09	
Total Cascades	2	3.45	96.9	1.09	
Pocketwater	0	0	0	0	
Glide	2	3.45	141.5	1.56	
Run	0	0	0	0	
Low gradient riffle	25	43.1	7364.6	62.46	
Total Riffles	27	46.55	7506.1	64.04	
Dammed Pool	2	3.45	42.3	0.47	0.26
Eddy pool	5	8.62	144.3	1.62	0.68
Plunge pool	0	0	0	0	0
Scour pool	19	32.76	1089.5	12.2	0.59
Scour hole	3	5.17	52.1	0.58	0.43
Beaver pond	0	0	0	0	0
Total Pools	29	50	1326.2	14.67	1.96
Sec. channel	0	0	0	0	0
Grand Totals	58	100	8931.2	100	1.96

Table 8.26. Summary report for Valley Segment # 1 of Evans Creek Watershed data collected during 1992.

Elevation	646-659 m
Total length	1808.3 m
Stream order	4
Mean stream gradient	2.0
Pool/riffle/cascade ratio	13/77/1
Land use	
Forest	
Agriculture	
Livestock grazing	100.0%
Mining	
Other (includes residential etc.)	
Vegetatlve type	
Decidious	94.8%
Coniferous	
Mixed	5.2%
Seral stage	
Grass/forb	95.7%
Shrub	4.3%
Pole	
Young	
Mature	
Old growth	
Other	
x Canopy cover	32.9 (O-72)
# Woody debris	
Logs	16
Root wads	8

Table 8.27. Frequency of occurrence, total percent **occurence,** total area,percent area, and residualpool depth values for Valley Segment **#2** for Evans Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	4	6.25	71.7	2.17	
Step-pool cascade	1	1.56	7.8	0.24	
Slip-face cascade	2	3.13	63.8	1.93	
Total Cascades	7	10.94	143.3	4.34	
Poc ketwater	0	0	0	0	
Glide	0	0	0	0	
Run	0	0	0	0	
Low gradient riffle	31	48.44	2533.4	76.8	
Total Riffles	31	48.44	2533.4	76.8	
Dammed Pool	2	3.13	26.5	0.8	0.2
Eddy pool	0	0	0	0	0.68
Plunge pool	3	4.69	42.1	1.28	0.34
Scour pool	18	28.13	509.9	15.46	0.39
Scour hole	3	4.69	43.5	1.32	0.22
Beaver pond	0	0	0	0	0
Total Pools	26	40.64	622	18.86	1.65
Sec. channel	0	0	0	0	0
Grand Totals	64	100.02	3298.7	100	1.65

Table 8.28. Summary report for Valley Segment # 2 of Evans Creek Watershed data collected during 1992.

Elevation	658-695 m	
Total length	832.1 m	
Stream order	4	
Mean stream gradient	1.5	
Pool/riffle/cascade ratio	4/17/1	
Land use		
Forest	100.0%	
Agriculture		
Livestock grazing		
Mining		
Other (includes residential etc.)		
Vegetative type		
Decidious		
Coniferous		
Mixed	100.0%	
Seral stage		
Grass/forb		
Shrub		
Pole		
Young		
Mature	98.4	
Old growth	1.6	
Other		
x Canopy cover	61	(O-93)
# Woody debris		
Logs	58	
Root wads	3	

Table 8.29. Frequency of occurence, toal percent occurence, total area, percent area, and residual pool depth values for Valley Segment #3 for Evans Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Resldual pool depth (m)
Rapid	14	17.95	967.3	20.85	
Step-pool cascade	1	1.28	14.4	0.31	
Slip-face cascade	0	0	0	0	
Total Cascades	15	19.23	981.7	21.16	
Pocketwater	0	0	0	0	
Glide	0	0	0	0	
Run	0	0	0	0	
Low gradient riffle	23	29.49	2653.7	57.21	
Total Riffles	23	29.49	2653.7	57.21	
Dammed Pool	3	3.85	116.7	2.52	0.53
Eddy pool	0	0	0	0	0
Plunge pool	11	14.1	217.6	4.69	0.53
Scour pool	25	32.05	660.1	14.23	0.47
Scour hole	1	1.28	8.8	0.19	0.37
Beaver pond	0	0	0	0	0
Total Pools	40	51.28	1003.2	21.63	1.9
Sec. channel (SDC)	0	0	0	0	0
Grand Totals	78	100	4638.6	100	1.9

Table 8.30. Summary report for Valley Segment # 3 of Evans Creek Watershed data collected during 1992.

Elevation	695-732 m	
Total length	1182.4 m	
Stream order	4	
Mean stream gradient	2.3	
Pool/riffle/cascade ratio	1/2.7/1	
Land use		
Forest	97.4%	
Agriculture		
Livestock grazing	2.6%	
Mining		
Other (includes residential etc.)		
Vegetative type		
Decidious		
Coniferous		
Mixed	100.0%	
Seral stage		
Grass/forb		
Shrub		
Pole		
Young		
Mature	96.8	
Old growth	3.2	
Other		
x Canopy cover	66.0	(38-88)
# Woody debris		
Logs	30	
Root wads	0	

Table 8.31. Frequency of occurence, toal percent occurence, total area, percent area,and residualpool depth values for Valley Segment #4 for Evans Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	32	41.03	5482.8	80.37	
Step-pool cascade	5	6.41	357.1	5.23	
Slip-face cascade	0	0	0	0	
Total Cascades	37	47.44	5839.9	85.6	
Pocketwater	0	0	0	0	
Glide	0	0	0	0	
Run	0	0	0	0	
Low gradient riffle	3	3.85	223.7	3.28	
Total Riffles	3	3.85	223.7	3.28	
Dammed Pool	2	2.56	76.1	1.12	0.37
Eddy pool	4	5.13	21.4	0.31	0.38
Plunge pool	9	11.54	187.3	2.75	0.32
Scour pool	23	29.49	473.5	6.94	0.33
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	38	48.72	758.3	11.12	1.4
Sec channel	0	0	0	0	0
Grand Totals	78	100.01	6821.9	100	1.4

Table 8.32. Summary report for Valley Segment # 3 of Evans Creek Watershed data collected during 1992.

Elevation	732-756 m	
Total length	1676.7 m	
Stream order	4	
Mean stream gradient	3.0	
Pool/riffle/cascade ratio	.1/.03/1	
Land use		
Forest	97.4%	
Agriculture		
Livestock grazing	2.6%	
Mining		
Other (includes residential etc.)		
Vegetative type		
Decidious		
Coniferous		
Mixed	98.7%	
Seral stage		
Grass/forb		
Shrub		
Pole		
Young		
Mature	97.4	
Old growth	2.6	
Other		
x Canopy cover	65.2	(42-87)
# Woody debris		
Logs	18	
Root wads	0	

Table 8.33. Frequency of occurence, total percent occurence, toal area, percent area, and residual pool depth values for Valley Segment #5 for Evans Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	8	50	1529.2	83.55	
Step-pool cascade	3	18.75	146.1	7.98	
Slip-face cascade	0	0	0	0	
Total Cascades	11	68.75	1675.3	91.53	
Pocketwater	0	0	0	0	
Glide	0	0	0	0	
Run	0	0	0	0	
Low gradient riffle	1	6.25	62	3.39	
Total Riffles	1	6.25	62	3.39	
Dammed Pool	0	0	0	0	0
Eddy pool	0	0	0	0	0
Plunge pool	2	12.5	34.5	1.89	0.21
Scour pool	2	12.5	58.4	3.19	0.3
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	4	25	92.9	5.08	0.51
Sec channel	0	0	0	0	0
Grand Totals	16	100	1830.2	100	0.51

Table 8.34. Summary report for Valley Segment # 5 of Evans Creek Watershed data collected during 1992.

Elevation	756-759 m
Total length	343.8 m
Stream order	4
Mean stream gradient	2.8
Pool/riffle/cascade ratio	.05/.04/l
Land use	
Forest	93.8%
Agriculture	
Livestock grazing	6.3%
Mining	
Other (includes residential etc.)	
Vegetatlve type	
Decidious	
Coniferous	
Mixed	100.0%
Seral stage	
Grass/forb	
Shrub	
Pole	
Young	
Mature	93.8
Old growth	6.3
Other	
x Canopy cover	70.8 (62-81)
# Woody debris	
Logs	14
Root wads	0

Table 8.35. Frequency of occurrence, total percent occurrence, total area, percents area, and residual pool depth for Valley Segment #1 for Alder Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	1	1	28.8	0.0	
Step pool cascade	2	2.1	95.6	0.1	
Slip face cascade	0	0	0	0.0	
Total Cascades	3	3.1	124.4	0.1	
Pocketwater	18	18.6	41092.5	55.5	
Glide	9	9.3	2355	3.2	
Run	0	0	0	0.0	
Low graident riffle	26	26.8	16783.1	22.7	
Total Riffles	53	54.7	60230.6	81.4	
Dammed pool	6	6.2	6893.1	9.3	0
Eddy pool	0	0	0	0.0	0
Plunge pool	5	5.1	1343.6	1.8	0.85
Scour pool	27	27.8	5060.8	6.8	0.48
Scour hole	1	1	54.6	0.1	0.15
Beaver pond	0	0	0	0	0
Total Pools	39	40.1	13352.1	18	1.48
Secondary channel	3	3.1	365.7	0.5	0
Grand Totals	98	97.9	74072.8	100	1.48

Table 8.36. Summary report for Valley Segment #1 Alder Creek Watershed data collected during 1992.

Elevation	704-768 m
Total length	396.4 m
Stream order	3
Mean stream gradient	2.8
Pool/riffle/cascade ratio	2.8/29.1/1
Land use	
Forest	100.0%
Agriculture	
Livestock grazing	
Mining	
Wetland	
Other (includes residential,right of way, etc.)	
Vegetative type	
Decidious	3.1%
Coniferous	69.1%
Mixed	27.8%%
Seral stage	
Grass/forb	
Shrub	13.8%
Pole	
Young	57.1%
Mature	29.1%
Old growth	
Other	
x Canopy cover	40.8 (5-90)
# Woody debris	
Logs	115
Root wads	13

Table 8.37. Frequency of occurence, total percent occurence, total area, percent area, and residualpool depth values for Valley Segment #2 for Alder Creek, during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	5	4.03	311.7	2.76	
Slip face cascade	3	2.42	31	0.27	
Total Cascades	8	6.45	342.7	3.03	
Pocketwater	11	8.87	1185	10.48	
Glide	38	30.65	2523.1	22.31	
Run	0	0	0	0	
Low graident riffle	48	38.71	6278.5	55.52	
Total Riffles	97	78.23	9986.6	88.31	
Dammed pool	0	0	0	0	0
Eddy pool	0	0	0	0	0
Plunge pool	13	10.48	758.3	6.71	0.53
Scour pool	6	4.84	220.7	1.95	0.45
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	19	15.32	979	8.66	0.98
Secondary channel	0	0	0	0	0
Grand Totals	124	100	11308.3	100	0.98

Table 8.38. Summary report for Valley Segment #2 Alder Creek Watershed data collected during 1992.

Elevatlon	768-817 m
Total length	2917.8 m
Stream order	3
Mean stream gradient	2.8
Pool/riffle/cascade ratio	2.8/29.1/1
Land use	
Forest	99.2%
Agriculture	
Livestock grazing	
Mining	
Wetland	
Other (includes residential,right of way, etc.)	0.8%
Vegetative type	
Decidious	8.1%
Coniferous	
Mixed	91.9%
Seral stage	
Grass/forb	16.9%
Shrub	56.5%
Pole	2.4%
Young	24.2%
Mature	
Old growth	
Other	
x Canopy cover	19.18 (O-99)
# Woody debris	
Logs	33
Root wads	4

Table B.39. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth for Valley Segment #3 for Alder Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	1	2.22	3.7	0	
Slip face cascade	2	4.44	49.1	1.24	
Total Cascades	3	6.66	52.8	1.24	
Pocketwater	0	0	0	0	
Glide	21	46.67	1361	34.42	
Run	0	0	0	0	
Low gradient riffle	19	42.22	2395.7	60.58	
Total Riffles	40	88.89	3756.7	95	
Dammed pool	0	0	0	0	0
Eddy pool	0	0	0	0	0
Plunge pool	1	2.22	126.3	3.2	0.55
Scour pool	1	2.22	18.6	0.47	0.18
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	2	4.44	144.9	3.67	0.73
Secondary channel	0	0	0	0	0
Grand Totals	45	99.99	3954.4	99.91	0.73

Table 8.40. Summary report for Valley Segment # 3 of Alder Creek Watershed data collected during 1992.

Elevation	817 m
Total length	961.3 m
Stream order	3
Mean stream gradient	3.0
Pool/riffle/cascade ratio	2.7171 .2/1
Land use	
Forest	78.9%
Agriculture	
Livestock grazing	8.9%
Mining	
Wetland	
Other (includes residential,right of way, etc.)	12.2%
Vegetative type	
Decidious	77.8%
Coniferous	
Mixed	22.2%
Seral stage	
Grass/forb	26.7%
Shrub	68.9%
Pole	1.1%
Young	3.3%
Mature	
Old growth	
Other	
x Canopy cover	26.8 (O-95)
# Woody debris	
Logs	2
Root wads	1

Table 8.41. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth for Valley Segment #4 for Alder Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	1	0.31	6	0.02	
Slip face cascade	20	6.29	271.4	0.83	
Total Cascades	21	6.6	277.4	0.65	
Pocketwater	10	3.14	670.9	2.05	
Glide	86	27.04	8510.2	26	
Run	0	0	0	0	
Low graident riffle	118	37.11	14100.1	43.07	
Total Riffles	214	67.29	23281.2	71.12	
Dammed pool	23	7.23	5126.5	15.66	0.57
Eddy pool	0	0	0	0	0
Plunge pool	1	0.31	21.4	0.07	0.3
Scour pool	57	17.92	3743.8	11.44	0.5
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	81	25.46	8891.7	27.17	1.37
Secondary channel	2	0.63	287.2	0.88	0.08
Grand Totals	318	99.98	32737.5	94.02	1.45

Table 8.42. Summary report for Valley Segment # 4 of Alder Creek Watershed data collected during 1992.

Elevation	817-902 m
Total length	7534.5 m
Stream order	3
Mean stream gradient	2.3
Pool/riffle/cascade ratio	33/84/1
Land use	
Forest	65.8%
Agriculture	
Livestock grazing	22.0%
Mining	
Wetland	
Other (includes residential,right of way, etc.)	12.2%
Vegetative type	
Decidious	6.0%
Coniferous	3.1%
Mixed	90.9%
Seral stage	
Grass/forb	10.8%
Shrub	51.9%
Pole	
Young	15.6%
Mature	21.7
Old growth	
Other	
x Canopy cover	46.3 (O-94)
# Woody debris	
Logs	147
Root wads	30

Table 8.43. Frequency of occurrence, total percent occurrence, total area, percent area, and residual pool depth for Valley Segment #1 for North Fork Alder Creek during 1992.

Habitat Type	Frequency	% frequency	Total Area (sq. meters)	% Area	Residual pool depth (m)
Rapid	0	0	0	0	
Step pool cascade	0	0	0	0	
Slip face cascade	0	0	0	0	
Total Cascades	0	0	0	0	
Pocketwater	0	0	0	0	
Glide	11	52.38	721.3	22.18	
Run	0	0	0	0	
Low graident riffle	9	42.86	250 1.4	76.91	
Total Riffles	20	95.24	3222.7	99.09	
Dammed pool	0	0	0	0	0
Eddy pool	0	0	0	0	0
Plunge pool	1	4.76	29.5	0.91	0.85
Scour pool	0	0	0	0	0
Scour hole	0	0	0	0	0
Beaver pond	0	0	0	0	0
Total Pools	1	4.76	29.5	0.91	0.85
Secondary channel	0	0	0	0	0
Grand Totals	21	100	3252.2	100	0.85

Table B.44. Summary report for Valley Segment # 1 of North Fork Alder Creek Watershed data collected during 1992.

Elevation	817-962 m	
Total length	?	
Stream order	2	
Mean stream gradient	2.0	
Pool/riffle/cascade ratio	9.15e-3/1	
Land use		
Forest		
Agriculture		
Livestock grazing	100.0%	
Mining		
Wetland		
Other (includes residential,right of way, etc.)		
Vegetative type		
Decidious	85.7%	
Coniferous		
Mixed	9.5%	
Seral stage		
Grass/forb	100.0%	
Shrub		
Pole		
Young		
Mature		
Old growth		
Other		
x Canopy cover	0.0	(0-0)
# Woody debrls		
Logs	0	
Root wads	0	

APPENDIX C

Table C.1. Stream reach inventory and channel stability evaluation for the lower reach of Lake Creek, May 13, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%	2	Bank slope gradient 30-40%		Bank slope gradient 40-60%		Bank slope gradient 60%	
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.	3	Infrequent and/or very small. Mostly healed over. Low future potential.		Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.		Present, volume and size are both increasing.	6	Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.		70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	9	<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.		Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	2	Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.		40-65%, mostly small boulders to cobbles 6-12".	4	20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	2	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.		Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.		Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.		Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.	4	Some new increase in bar formation, mostly from coarse gravels.		Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.	2	Corners and edges well rounded in two dimensions.		Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".		Mostly dull, but may have up to 35% bright surfaces.	2	Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.	2	Moderately packed with some overlapping.		Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.	4	Distribution shift slight. Stable materials 50-80%.		Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.	6	5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.		30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	23	Good column total	16	Fair column total	18	Poor column total	0

Table C.2. Stream reach inventory and channel stability evaluation for the middle reach of Lake Creek, May 13, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%		Bank slope gradient 30-40%	4	Bank slope gradient 40-60%		Bank slope gradient 60%	
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.		Infrequent and/or very small. Mostly healed over. Low future potential.	6	Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.		Present, volume and size are both increasing.	6	Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.		70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	6	50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.		Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.		Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.	3	Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.		40-65%, mostly small boulders to cobbles 6-12".	4	20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.		Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.		Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.		Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	8	Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.	4	Some new increase in bar formation, mostly from coarse gravels.		Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.	2	Corners and edges well rounded in two dimensions.		Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".		Mostly dull, but may have up to 35% bright surfaces.	2	Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.		Moderately packed with some overlapping.	4	Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.		Distribution shift slight. Stable materials 50-80%.	8	Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.		5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.	12	30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	4	Good column total	56	Fair column total	18	Poor column total	0

Table C.3. Stream reach inventory and channel stability evaluation for the upper reach of Lake Creek, May 13, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%	2	Bank slope gradient 30-40%		Bank slope gradient 40-60%		Bank slope gradient 60%	
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.		Infrequent and/or very small. Mostly healed over. Low future potential.		Moderate frequency and size, with some raw spots eroded by water during high flows.	10	Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.		Present, volume and size are both increasing.		Moderate to heavy amounts, predominantly larger sizes.	8
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.		70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	9	<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.		Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.		Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	4
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.	2	40-65%, mostly small boulders to cobbles 6-12".		20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.		Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	4	Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.		Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.		Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".		Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	15
9 Deposition	Little or no enlargement of channel or point bars.		Some new increase in bar formation, mostly from coarse gravels.		Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	16
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.		Corners and edges well rounded in two dimensions.		Well rounded in all dimensions, surfaces smooth.	4
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".	1	Mostly dull, but may have up to 35% bright surfaces.		Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.		Moderately packed with some overlapping.		Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	8
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.		Distribution shift slight. Stable materials 50-80%.		Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	16
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.		5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.		30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	20
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.	1	Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.		Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	6	Good column total	4	Fair column total	19	Poor column total	91

Table C.4. Stream reach inventory and channel stability evaluation for the lower reach of Benewah Creek, May 11, 1992.

# Item rated	Stability Indicators by Classes Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%	2	Bank slope gradient 30-40%		Bank slope gradient 40-60%		Bank slope gradient 60%	
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.		Infrequent and/or very small. Mostly healed over. Low future potential.	4	Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.	4	Present, volume and size are both increasing.		Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.		Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	2	Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.		40-65%, mostly small boulders to cobbles 6-12".		20-40%, with most in the 3-6" diameter class.	6	<20% rock fragments of gravel sizes, 1-3" or less.	
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.		Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	4	Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.		Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.		Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".		Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.		Some new increase in bar formation, mostly from coarse gravels.	8	Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.		Corners and edges well rounded in two dimensions.	3	Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".		Mostly dull, but may have up to 35% bright surfaces.		Mixture, 50-50% dull and bright, ±15% ie. 35-65%.	3	Predominantly bright, 65%+ exposed or scoured surfaces.	
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.		Moderately packed with some overlapping.		Mostly a loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.		Distribution shift slight. Stable materials 50-80%.		Moderate change in sizes. Stable materials 20-50%.	10	Marked distribution change. Stable materials 0-20%.	
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.		5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.	10	30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	5	Good column total	32	Fair column total	43	Poor column total	0

Table C.5. Stream reach inventory and channel stability evaluation for the middle reach of Benewah Creek, May 11, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%	2	Bank slope gradient 30-40%		Bank slope gradient 40-60%		Bank slope gradient 60%	
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.		Infrequent and/or very small. Mostly healed over. Low future potential.		Moderate frequency and size, with some raw spots eroded by water during high flows.	9	Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.	4	Present, volume and size are both increasing.		Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.		70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	6	50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.		Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	2	Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.		40-65%, mostly small boulders to cobbles 6-12".	4	20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.		Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.		Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.		Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	5	Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.		Some new increase in bar formation, mostly from coarse gravels.	8	Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.		Corners and edges well rounded in two dimensions.	3	Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".	1	Mostly dull, but may have up to 35% bright surfaces.		Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.	2	Moderately packed with some overlapping.		Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.	4	Distribution shift slight. Stable materials 50-80%.		Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.		5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.	1 2	30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	9	Good column total	4 4	Fair column total	2 1	Poor column total	0

Table C.6. Stream reach inventory and channel stability evaluation for the upper reach of Benewah Creek, May 11, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%	2	Bank slope gradient 30-40%		Bank slope gradient 40-60%		Bank slope gradient 60%	
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.	3	Infrequent and/or very small. Mostly healed over. Low future potential.		Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.	4	Present, volume and size are both increasing.		Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.		Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	2	Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.		40-65%, mostly small boulders to cobbles 6-12".		20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	8
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.		Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	4	Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.		Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.		Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".		Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
9 Deposition	Little or no enlargement of channel or point bars.		Some new increase in bar formation, mostly from coarse gravels.		Moderate deposition of new gravel and coarse sand on old and some new bars.	12	Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.		Corners and edges well rounded in two dimensions.	3	Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".		Mostly dull, but may have up to 35% bright surfaces.		Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	4
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.		Moderately packed with some overlapping.		Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	8
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.		Distribution shift slight. Stable materials 50-80%.		Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	16
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.		5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.		30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	8	Good column total	10	Fair column total	36	Poor column total	52

Table C.7. Stream reach inventory and channel stability evaluation for the lower reach of Evans Creek, July 21, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%		Bank slope gradient 30-40%		Bank slope gradient 40-60%		Bank slope gradient 60%	8
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.		Infrequent and/or very small. Mostly healed over. Low future potential.		Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	12
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.	4	Present, volume and size are both increasing.		Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.		70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	12
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.		Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.		Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.	3	Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.		40-65%, mostly small boulders to cobbles 6-12".		20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	8
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.		Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.		Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.	7	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.		Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".		Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.		Some new increase in bar formation, mostly from coarse gravels.		Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	16
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.		Corners and edges well rounded in two dimensions.		Well rounded in all dimensions, surfaces smooth.	4
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".	1	Mostly dull, but may have up to 35% bright surfaces.		Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.		Moderately packed with some overlapping.		Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	8
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.		Distribution shift slight. Stable materials 50-80%.		Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	16
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.		5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.		30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	24
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.		Perennial types scarce or absent. Yellow-green, short term bloom may be present.	4
	Excellent column total	1	Good column total	4	Fair column total	22	Poor column total	112

Table C.8. Stream reach inventory and channel stability evaluation for the middle reach of Evans Creek, July 21, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%		Bank slope gradient 30-40%		Bank slope gradient 40-60%		Bank slope gradient 60%	8
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.		Infrequent and/or very small. Mostly healed over. Low future potential.	6	Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.	4	Present, volume and size are both increasing.		Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.		Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	2	Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.		40-65%, mostly small boulders to cobbles 6-12".	4	20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	2	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.		Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.		Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".		Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.		Some new increase in bar formation, mostly from coarse gravels.	6	Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.		Corners and edges well rounded in two dimensions.	3	Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".		Mostly dull, but may have up to 35% bright surfaces.		Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	4
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.		Moderately packed with some overlapping.	4	Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.		Distribution shift slight. Stable materials 50-80%.	8	Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.		5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.	12	30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	9	Good column total	46	Fair column total	6	Poor column total	12

Table C.9. Stream reach inventory and channel stability evaluation for the upper reach of Evans Creek, July 21, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%		Bank slope gradient 30-40%		Bank slope gradient 40-60%		Bank slope gradient 60%	8
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.	3	Infrequent and/or very small. Mostly healed over. Low future potential.		Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.		Present, volume and size are both increasing.	6	Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.	1	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.		Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.	2	40-65%, mostly small boulders to cobbles 6-12".		20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	2	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.		Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.		Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".		Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.		Some new increase in bar formation, mostly from coarse gravels.	8	Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.	2	Corners and edges well rounded in two dimensions.		Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".		Mostly dull, but may have up to 35% bright surfaces.		Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	4
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.	2	Moderately packed with some overlapping.		Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.		Distribution shift slight. Stable materials 50-80%.	8	Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.		5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.	12	30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	17	Good column total	30	Fair column total	9	Poor column total	12

Table C.10. Stream reach inventory and channel stability evaluation for the lower reach of Alder Creek, May 4, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%		Bank slope gradient 30-40%	4	Bank slope gradient 40-60%		Bank slope gradient 60%	
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.		Infrequent and/or very small. Mostly healed over. Low future potential.	6	Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.		Present but mostly small twigs and limbs.	5	Present, volume and size are both increasing.		Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.	1	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.		Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.	2	40-65%, mostly small boulders to cobbles 6-12".		20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	2	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.		Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.		Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".		Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.	4	Some new increase in bar formation, mostly from coarse gravels.		Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.	2	Corners and edges well rounded in two dimensions.		Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".		Mostly dull, but may have up to 35% bright surfaces.	2	Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.	2	Moderately packed with some overlapping.		Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.	4	Distribution shift slight. Stable materials 50-80%.		Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.	6	5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.		30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.	2	Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.		Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	28	Good column total	21	Fair column total	0	Poor column total	0

Table C.11. Stream reach inventory and channel stability evaluation for the middle reach of Alder Creek, May 7, 1992.

	Stability Indicators by Classes							
# Item rated	Excellent		Good		Poor		Fair	
1 Land form slope	Bank slope gradient <30%		Bank slope gradient 30-40%	4	Bank slope gradient 40-60%		Bank slope gradient 60%	
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.	3	Infrequent and/or very small. Mostly healed over. Low future potential.		Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.	2	Present but mostly small twigs and limbs.		Present, volume and size are both increasing.		Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.	1	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.		Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.		40-65%, mostly small boulders to cobbles 6-12".		20-40%, with most in the 3-6" diameter class.	6	<20% rock fragments of gravel sizes, 1-3" or less.	
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.		Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	3	Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.		Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.	2	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".		Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.	2	Some new increase in bar formation, mostly from coarse gravels.		Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.	2	Corners and edges well rounded in two dimensions.		Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".	1	Mostly dull, but may have up to 35% bright surfaces.		Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.		Moderately packed with some overlapping.	4	Mostly a loose assortment with no apparent overlap.		No packing evident. Loose assortment, easily moved.	
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.	4	Distribution shift slight. Stable materials 50-80%.		Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.	6	5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.		30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocity and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	24	Good column total	13	Fair column total	9	Poor column total	0

Table C.12. Stream reach inventory and channel stability evaluation for the upper reach of Alder Creek, May 4, 1992.

# Item rated	Excellent		Good		Poor		Fair	
			Stability Indicators by Classes					
1 Land form slope	Bank slope gradient <30%	2	Bank slope gradient 30-40%		Bank slope gradient 40-60%		Bank slope gradient 60%	
2 Mass Wasting or Failure or potential)	No evidence of past or any potential for future mass wasting into channel.	3	Infrequent and/or very small. Mostly healed over. Low future potential.		Moderate frequency and size, with some raw spots eroded by water during high flows.		Frequent or large, causing sediment nearly yearlong or imminent danger of same.	
3 Debris Jam Potential	Essentially absent from immediate channel area.	2	Present but mostly small twigs and limbs.		Present, volume and size are both increasing.		Moderate to heavy amounts, predominantly larger sizes.	
4 Vegetative Bank Protection	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	3	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.		50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.		<50% density plus fewer species and less vigor indicate poor, discontinuous, and shallow root mass.	
5 Channel Capacity	Ample for present plus some increases. Peak flows contained W/D ratio <7.	1	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.		Barely contains present peaks. Occasional overbank floods. W/D ratio 15 to 25.		Inadequate. Overbank flows common. W/D ratio >25.	
6 Bank Rock Content	65%+ with large, angular, boulders 12"+ numerous.		40-65%, mostly small boulders to cobbles 6-12".		20-40%, with most in the 3-6" diameter class.		<20% rock fragments of gravel sizes, 1-3" or less.	6
7 Obstructions Flow Deflectors Sediment Traps	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.		Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.		Moderately frequent, moderately unstable obstructions and deflectors move with high water causing bank cutting and filling of pools.	5	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	
8 Cutting	Little or none evident. Infrequent raw banks less than 6" high generally.		Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	8	Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.		Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	
9 Deposition	Little or no enlargement of channel or point bars.	4	Some new increase in bar formation, mostly from coarse gravels.		Moderate deposition of new gravel and coarse sand on old and some new bars.		Extensive deposits of predominantly fine particles. Accelerated bar development.	
10 Rock Angularity	Sharp edges and corners, plane surfaces roughened.		Rounded corners and edges, surfaces smooth and flat.	2	Corners and edges well rounded in two dimensions.		Well rounded in all dimensions, surfaces smooth.	
11 Brightness	Surfaces dull, darkened, or stained, Generally not "bright".		Mostly dull, but may have up to 35% bright surfaces.	2	Mixture, 50-50% dull and bright, ±15% ie. 35-65%.		Predominantly bright, 65%+ exposed or scoured surfaces.	
12 Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.		Moderately packed with some overlapping.		Mostly a loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	
13 Bottom Size Distribution and Percent Stable Materials	No change in sizes evident. Stable materials 80-100%.	4	Distribution shift slight. Stable materials 50-80%.		Moderate change in sizes. Stable materials 20-50%.		Marked distribution change. Stable materials 0-20%.	
14 Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.	6	5-30% affected. Scour at constrictions and steepened grades. Some deposition in pools.		30-50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.		More than 50% of the bottom in a state of flux or change nearly yearlong.	
15 Clinging Aquatic Vegetation (Moss and Algae)	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.		Common. Algal forms in low velocitiy and pool areas. Moss here too and swifter waters.		Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	3	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	
	Excellent column total	25	Good column total	12	Fair column total	14	Poor column total	6

APPENDIX D

Table D.1. Calculated geometric mean, sorting coefficient, fredle index value and percent survival for each substrate sample collected In Lake Creek during 1992.

STREAM Lower Lake	LEFT				RIGHT				MEAN % SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	32.1	1.4	23.1	80.5	42.4	1.2	34.5	>100.0	90.3
site 2	18.7	3.8	4.9	90.2	14.7	5.1	2.9	72.6	81.4
site 3	18.2	4.5	4.1	78.7	17.7	4.6	3.9	77.5	78.1
site 4	18.1	3.3	5.4	81.9	11.9	6.5	1.8	59.2	70.6
site 5	8.6	7.7	1.1	55.7	10.4	12.7	0.8	45.4	50.6
Average	*19.1*	4.7	7.7	*77.4*	*19.4*	6.0	8.8	70.9	
Middle Lake	LEFT				RIGHT				% SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	32.4	1.4	22.9	73.6	30.2	2.2	14.0	82.9	78.3
site site 3 2	20.9 17.6	5.3 2.5	3.3 8.4	66.2 82.5	38.9 14.8	8.3 1.3	31 1.8	87.4 69.9	76.8 76.2
site 4	10.0	7.7	1.3	60.8	13.1	9.1	1.4	69.9	65.4
site 5	12.1	13.6	0.9	51.2	11.6	10.8	1.1	50.8	51.0
Average	*18.6*	*6.1*	7.4	*66.0*	*21.7*	*6.3*	*9.9*	*72.2*	
Upper Lake	LEFT				RIGHT				% SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	51.9	1.0	51.9	>100.0	18.0	3.7	4.9	76.5	88.3
site 2	18.4	4.0	4.6	52.7	1.2	1.4	0.8	co.0	26.4
site 3	27.9	2.0	13.9	69.9	27.4	2.0	13.7	73.6	71.8
site 4	24.0	2.8	8.7	81.4	11.0	21.4	0.5	30.5	56.0
site 5	0.6	1.9	0.3	co.0	20.6	3.0	6.9	55.0	27.5
Average	24.6	2.3	15.9	60.8	15.6	6.3	5.4	47.1	

Table D.l. continued...

Bozard	LEFT				RIGHT				% SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	0.7	3.0	0.2	<0.0	4.3	12.0	0.4	co.0	<0.0
site 2	0.6	2.7	0.2	co.0	0.6	2.4	0.2	co.0	<o.o
site 3	3.3	13.2	0.2	<0.0	6.4	9.1	0.7	23.1	11.6
site 4	0.9	4.6	0.2	<o.o	0.9	4.8	0.2	co.0	<0.0
site 5	11.6	2.6	4.4	83.5	12.1	2.8	4.3	86.1	84.8
A verage	3.4	5.2	1.0	16.7	4.9	6.2	1.2	21.8	19.3

West Fork Lake	LEFT				RIGHT				% SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	0.9	2.3	0.4	<o.o	0.8	2.6	0.3	co.0	<o.o
site 2	0.7	2.4	0.3	<o.o	0.7	2.5	0.3	co.0	<o.o
site 3	0.9	3.1	0.3	co.0	0.8	3.8	0.2	<0.0	co.0
site 4	1.1	2.5	0.4	co.0	1.1	1.7	0.7	co.0	co.0
site 5	2.1	4.1	0.5	<o.o	2.0	4.6	0.4	54.3	27.2
Average	1.1	2.9	0.4	<0.0	1.7	3.0	0.4	10.9	5.4

Upper Upper Lake	LOWER (Left)				UPPER (Right)				% SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	0.6	8.0	0.1	<o.o	0.5	8.3	0.1	co.0	<o.o
site 2	0.5	7.2	0.1	co.0	1.5	106.7	0.0	co.0	<o.o
site 3	0.3	3.1	0.1	<o.o	0.6	5.1	0.1	<0.0	<0.0
site 4	1.1	17.3	0.1	co.0	0.5	6.0	0.1	co.0	<0.0
site 5	0.5	3.3	0.2	co.0					<o.o
A verage	0.6	7.8	0.7	<o. 0	0.8	31.5	0.7	<0.0	<o.o

Table D.2. Calculated geometric mean, sorting coefficient, frdle index value and percent survival for each substrate sample collected In Benewah Creek during 1992.

STREAM	LEFT				RIGHT				MEAN % SURVIVAL
Lower Benewah	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	32.1	3.0	7.3	89.2	23.2	3.5	6.6	78.8	84.0
site 2	20.6	3.7	5.6	81.4	20.6	3.9	5.3	81.4	81.4
site 3	7.8	5.0	1.6	58.0	31.4	2.0	15.7	90.2	74.1
site 4	40.5	1.1	36.7	>100.0	34.5	1.8	18.7	>100.0	>100.0
site 5	40.7	1.1	36.9	>100.0	49.3	1.1	44.7	>100.0	>100.0
Mean	26.3	2.8	17.6	85.7	31.8	2.5	18.2	90.1	87.9
STREAM Middle Benewah	LEFT				RIGHT				MEAN % SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	45.0	1.1	40.8	>100.0	54.2	1.0	54.2	>100.0	>100.0
site 2	40.2	1.5	30.0	>100.0	15.2	2.6	5.8	>100.0	>100.0
site 3	14.9	2.7	5.5	>1 00.0	22.0	2.5	8.7	>100.0	>100.0
site 4	26.3	2..3	11.6	>100.0	35.6	1.5	24.4	>100.0	>100.0
site 5	15.2	2.1	7.1	>100.0	5.7	6.3	0.9	83.8	83.8
Mean	28.3	1.9	19.0	>100.0	26.5	2.8	18.8	96.7	96.7
STREAM Upper Benewah	LEFT				RIGHT				MEAN % SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	30.8	2.0	15.0	>100.0	8.3	4.8	1.7	77.2	88.6
site 2	6.2	4.0	1.6	63.5	12.5	2.5	5.1	83.1	73.3
site 3	5.0	7.5	0.7	16.4	5.4	6.1	0.9	28.2	22.3
site 4	28.1	2.9	9.6	85.7	13.3	2.3	5.9	88.6	87.2
site 5	6.8	5.4	1.3	63.3	16.8	5.3	3.2	67.7	65.5
Average	15.4	4.4	5.6	57.2	11.3	4.2	3.4	69.0	67.4

Table D.3. Calculated geometric mean, sorting coefficient, fredle index value and % survival for- each substrate sample collected from Alder Creek during 1992.

STREAM Lower Alder	LEFT				RIGHT				MEAN % SURVIVAL
	Dg	So	F	%S	Dg	So	F	%S	X
site 1	25.4	3.6	7.1	90.8	25.0	2.8	8.9	91.2	91 .o
site 2	25.3	3.3	7.8	89.8	25.0	3.0	8.4	87.1	88.4
site 3	20.4	4.4	4.7	77.9	25.3	2.8	9.0	88.0	82.9
site 4	27.4	2.7	10.2	90.9	25.5	2.8	9.1	>100	95.4
site 5	22.3	3.3	6.9	90.6	23.3	3.3	7.2	>100	95.3
Average	24.2	3.5	7.3	88.0	25.2	2.9	8.5	93.3	
STREAM Middle Alder	LEFT				RIGHT				MEAN % SURVIVAL
	Dg	So	F	%S	Dg	So	F	%S	X
site 1	37.8	1.3	28.2	91.9	39.9	1.2	33.6	>100	96.0
site 2	28.4	2.2	13.0	91.2	33.7	1.6	21.1	91.8	91.5
site 3	40.3	1.1	35.2	>100	38.4	1.3	30.5	>100	>100
site 4	28.1	1.7	14.1	>100	28.0	3.0	9.3	>100	>100
site 5	28.8	2.3	12.5	>100	35.0	1.9	18.5	>100	>100
Average	32.7	1.7	20.6	96.6	35.0	1.8	22.6	98.4	
STREAM Upper Alder	LEFT				RIGHT				MEAN % SURVIVAL
	Dg	2.6	F	%S	Dg	1.9	F	%S	X
site 1	27.7	4.0	10.8	82.1	35.5	4.7	18.8	89.5	85.8
site 2	18.1		4.5	89.2	16.0		3.4	80.7	85.0
site 3	8.1	6.2	1.3	63.7	11.7	2.4	4.8	87.2	75.5
site 4	38.1	1.1	33.4	86.7	31 .1	2.0	15.6	91.5	89.1
site 5	13.9	4.0	3.5	>100	16.8	4.7	3.6	90.2	95.1
Average	21.2	3.6	10.7	84.3	22.2	3.1	9.2	87.8	

Table D.4. Calculated geometric mean, sorting coefficient, fredle index value and percent survival for each substrate sample collected in Evans Creek during 1992.

STREAM	LEFT				RIGHT				MEAN % SURVIVAL
Lower Evans	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	0.3	1.5	0.2	co.0	0.3	1.2	0.2	<0.0	co.0
site 2	1.4	4.2	0.3	26.7	1.2	4.4	0.3	56.8	41.8
site 3	14.9	7.0	2.1	76.9	14.3	5.8	2.5	87.5	82.2
site 4	15.3	7.9	1.9	77.9	14.5	7.1	2.1	77.2	77.6
site 5	29.8	2.2	13.6	90.1	29.9	2.1	14.1	99.8	94.9
Average	12.3	4.6	3.6	54.4	12.0	4.1	3.8	64.3	59.3
STREAM Middle Evans	LEFT				RIGHT				MEAN % SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	34.4	1.7	20.6	91.6	37.1	1.8	20.4	93.5	92.6
site 2	17.7	5.3	3.3	68.2	18.4	4.7	3.9	75.1	71.7
site 3	18.8	4.0	4.7	52.5	18.2	2.8	6.6	88.8	70.7
site 4	14.8	3.5	4.2	79.8	14.0	8.8	1.6	86.1	82.9
site 5	11.2	8.3	1.3	71.8	10.8	10.8	1.0	78.3	75.1
Average	19.4	4.6	6.8	72.8	19.7	5.8	6.7	84.4	78.6
STREAM Upper Evans	LEFT				RIGHT				MEAN % SURVIVAL
	D_g	S_o	F	%S	D_g	S_o	F	%S	X
site 1	9.8	12.7	0.7	67.9	10.3	11.0	0.93	40.8	54.4
site 2	21.2	4.4	4.8	90.2	22.1	2.5	8.7	90.4	90.3
site 3	22.4	2.6	8.5	86.5	21.8	3.9	5.6	88.5	87.5
site 4	27.8	2.3	11.9	99.9	30.8	2.3	13.6	99.8	99.8
site 5	25.6	2.8	9.2	80.4	25.5	2.5	10.0	86.9	83.7
Average	21.4	5.0	7.0	85.0	22.1	4.4	7.8	81.3	83.1

APPENDIX E

Table E.l. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Lake Creek during May, 1992.

Site Shock time (min)	Lower 20	Middle 34	Upper 42
Cutthroat trout		2	
Rainbow x cutthroat	1		
TOTAL	1	2	0

Table E.2. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Lake Creek during September, 1992.

Site Shock time (min)	Lower 51	Middle 25	Upper 42
Cutthroat trout	4 (2.1)		4 (100.0)
Sculpin spp.	28 (14.7)	250 (77.2)	
Dace spp.	158 (83.2)	74 (22.8)	
TOTAL	190	324	4

Table E.3. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Benewah Creek during May, 1992.

Site Shock time (min)	Lower 38	Middle 32	Upper -2'8
Cutthroat trout	8 (29.6)	6	10 (83.3)
Eastern brook trout			2 (16.7)
Longnose sucker	12 (44.4)		
Norther squawfish	2 (7.4)		
Redside shiner	5 (18.5)		
TOTAL	27	6	12

Table E.4. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Benewah Creek during July, 1992.

Site Shock time (min)	Lower 28	Middle 40	Upper 39
Cutthroat trout		4	
TOTAL	0	4	0

Table ES. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Benewah Creek during September, 1992.

Site Shock time (min)	Lower 63	Middle 62	Upper 37
Cutthroat trou	3 (1.8)	5 (1.9)	2 (0.6)
Largemouth bass	113 (66.1)		
Longnose sucker	4 (2.3)	2 (0.7)	4 (1.1)
Redside shiner	31 (18.1)	134 (49.8	168 (47.5)
Sculpin spp.		1 (0.4)	1 (0.3)
Dace spp.	20 (11.7)	127 (47.2)	179 (50.6)
TOTAL	171	269	354

Table E.6. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Evans Creek during **May**, 1992.

Site Shock time (min)	Lower 30	Middle 33	Upper 40
Cutthroat trout	2	8	13
TOTAL	2	8	13

Table E.7. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Evans Creek during July, 1992.

Site Shock time (min)	Lower 42	Middle 49	Upper 42
Cutthroat trout		44	18
TOTAL	0	44	18

Table E.8. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Evans Creek during September, 1992.

Site Shock time (min)	Lower 30	Middle 82	Upper 66
Cutthroat trout		93 (98.9)	60 (100.0)
Eastern brook trout		1 (1.1)	
Largemouth bass	1 (50.0)		
Pumpkinseed	1 (50.0)		
TOTAL	2	94	60

Table E.9. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Alder Creek during May, 1992.

Site Shock time (min)	Lower 65	Middle 29	Upper 74
Cutthroat trout	6 (11.8)	4 (20.0)	3 (3.9)
Eastern brook trout	5 (9.8)	8 (40.0)	31 (40.3)
Rainbow x cutthroat	1 (2.0)		
Rainbow trout			1 (1.3)
Longnose sucker	2 (3.9)		
Scuipin spp.	34 (66.7)	8 (40.0)	42 (54.5)
Dace spp.	3 (5.9)		
TOTAL	51	20	77

Table E.lO. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Alder Creek during July, 1992.

Site Shock time (min)	Lower	Middle	Upper
Cutthroat trout		2	
Eastern Brook trout			9
Sculpin spp.			
Dace spp.			
TOTAL		2	9

Table E.ll. Total number and relative abundance (%) of each species caught during relative abundance electrofishing surveys on Alder Creek during September, 1992.

Site Shock time (min)	Lower 64	Middle 78	Upper 94
Cutthroat trout	4 (57.1)	43 (87.8)	1 (1.6)
Eastern brook trout	3 (42.9)	6 (12.2)	60 (98.4)
TOTAL	7	49	61

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