Exxon Valdez Oil Spill
Restoration Project Annual Report

Little Waterfall Creek Barrier Bypass Improvement: Pink (*Onchorynchus gorbuscha)* and Coho Salmon *(Onchorynchus kisutch)* Habitat Enhancement

Restoration Project 96139A1
Annual Report

This annual report has been prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report.

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Pink (*Onchorynchus gorbuscha)* and Coho Salmon *(Onchorynchus kisutch)* Habitat Enhancement

Restoration Project 96139A1
Annual Report

Study History: The project was initiated in 1994 (Restoration Project 94139A1) as a result of surveys (Restoration Project 93063) conducted on Kodiak Island which evaluated instream habitat and stock restoration techniques for wild salmon stocks. The emphasis of this evaluation was to improve or develop spawning habitat at systems with barriers to salmon passage which have historically prevented access. Surveys focused on systems which were directly impacted or were located in proximity to areas impacted by the *Exxon Valdez* oil spill (EVOS) with the intent of mitigating for injured spawning habitat. Data collected from these surveys were analyzed, including a cost-to-benefit analysis to determine the most effective mitigation techniques for Kodiak Island salmon systems. As result of these surveys, The *Exxon Valdez* Oil Spill Trustee Council selected Little Waterfall Creek as a site for spawning habitat mitigation. An annual report was submitted in 1996 summarizing Restoration Project 95139A1 activity. The project was continued under Restoration Project 96139A1 and is the subject of this annual report.

Abstract: Prior survey data indicated that Little Waterfall Creek contained a significant amount of spawning habitat that was underutilized by pink and coho salmon due to an ineffective barrier bypass structure. Deficiencies included steep gradients and excess water velocity. The primary objective of this restoration project was to improve salmon passage through this bypass, thus increasing escapement upstream of the barrier. Bypass renovation priorities were to reduce the gradients and design resting pools to minimize water velocity. Pink and coho salmon production data were assessed to determine pre-project status and for later comparison to post-project data. Bypass renovation was completed in fall 1995; gradients were reduced from 27% to 17-20% and two resting pools and an entrance pool were installed. The steeppass sections were staggered between pools to reduce velocity of stream flows. In 1996, Little Waterfall Creek pink salmon escapement was poor; however, 44% (2,400) passed through the improved bypass; in 1995, only 22% of the pink salmon escapement was observed upstream of the bypass. The 1996 bypass use represented the highest proportion of escapement ever observed in the system's upper reaches. Coho escapement surveys in 1996 were hampered by high water conditions that prevented initial assessment of bypass use.

Key Words: Afognak Island, barrier bypass, coho salmon, *Exxon Valdez* oil spill, Kodiak Island, *Onchorynchus gorbuscha*, *Onchorynchus kisutch,* pink salmon, spawning habitat.

Project Data: (will be addressed in the final report)

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

EXECUTIVE SUMMARY

Introduction

This report describes the progress of restoration activities on northern Afognak Island at Little Waterfall Creek which were intended to provide for replacement of lost salmon spawning habitat and harvest opportunities due to impacts from the *Exxon Valdez* oil spill. This project resulted from feasibility studies in the affected areas which identified Little Waterfall Creek to have spawning habitat not fully utilized by pink and coho salmon due to poor use of the largest of three existing barrier bypasses (fish ladders). Two of the bypasses were constructed and installed in Little Waterfall Creek in the mid-1970's; construction and installation of the largest and most upstream bypass was completed in the fall of 1980.

The primary focus of this project was to improve the design of the bypass, which had limited access to upstream spawning habitat. In addition, adult and juvenile pink and coho salmon production data, necessary to assess pre- and post- project affects were assessed, including summation of data previously collected as a result of ADF&G supplementation activity. At optimum colonization levels (24,000 pink salmon and 2,700 coho salmon), resultant production is estimated to provide a harvestable surplus of approximately 24,000 pink salmon and 4,000 coho salmon (Honnold 1994; Honnold *in press* a, b; Table 1).

The objectives of the project in FY 96 were: to supervise the completion of bypass modification and inspect final product to assure contract specifications are adhered to; to estimate pre-construction relative abundance of juvenile pink and coho salmon: preemergent fry (pink and coho salmon) and rearing fry (coho salmon); to evaluate the use of the improved bypass by pink and coho salmon and make field modifications if necessary; to estimate the escapement and distribution of pink and coho salmon upstream and downstream of the improved bypass; and to document project progress and results.

Methods

Engineering surveys determined that the deficiencies of the bypass included too steep of a grade (27%), insufficient number and placement of resting pools, and excessive water velocity. As a result, improvements were made to the bypass in 1995 (FY 96; Honnold *in press* a). In 1996, preemergent sampling and minnow trapping were conducted in sites upstream and downstream of the bypass to determine a relative index of abundance for pink salmon fry and coho salmon juveniles. The initial post-construction pink salmon escapement and distribution estimates in Little Waterfall Creek were completed in 1996; coho salmon escapements and system distribution were incomplete due to high water events. Observations of salmon use of the modified bypass were made in conjunction with these estimates.

Results and Discussion

The completed modifications to the bypass (in November 1995) provide slopes within the recommended specifications for pink and coho salmon bypass use, at 20% or less, for all sections, compared to 27% prior to the project. Bypass sections were also staggered to reduce water velocity; two resting pools were added; and the previous entrance tank was modified into an additional resting pool. The contract specifications were adhered to with the exception of the entrance tank, which was mounted on a concrete pad instead of flush with the streambed. This resulted in the entrance slot or opening being located higher than intended and was observed to hinder pink salmon entry into the entrance tank. The entrance tank was modified in 1996 to correct this problem.

Preemergent sampling occurred at Little Waterfall Creek in 1996 and preliminary analysis of the data indicate a substantial increase in the system's fry per m^2 index; however, distribution was almost entirely downstream of the bypass. The system's fry indices declined by five-fold, from 1982 to 1994, with the lowest estimate occurring in 1994 (77.9 fry/m^2). Downstream indices declined even more noticeably, by ~thirty-fold during this period. The decline of preemergent fry may be related to the high density of spawners in the lower habitat; the brood year escapements were > 100,000 for most of this period and most spawning was in downstream locations. The higher index in 1996 corresponds to an escapement of 37,000 in 1995 of which 29,000 were observed spawning in downstream habitat. The improvement of distribution to upstream habitat, as observed in the initial post-construction year (1996), may alleviate the declining fry index trend. However, Kodiak pink salmon systems are highly influenced by environmental conditions; thus seasonal fluctuations in stream hydrology at Little Waterfall Creek, such as frequent freshet events, likely affect egg-to-fry survivals. Thus, the decline of fry indices in the downstream habitat, may be influenced by both spawner density and environmental conditions. Egg-to-fry survival has been higher in downstream habitat (mean 6.6%) than upstream habitat (mean 1.8%) and also may be due to both spawner density and environmental parameters. Coho fry have not been captured in any years preemergent samples, however, were captured while minnow trapping in 1995 and 1996. The absence of preemergent coho salmon fry is likely a result of low escapements and sampling location and frequency.

Prior to completion of the three barrier bypasses (1968-1980), pink salmon escapement averaged 5,179 with none observed upstream of the third barrier. The post- bypass escapement (1981-1996) has averaged 57,200, with 10,800 (19%) distributed to upper spawning habitat. In 1996, the pink salmon escapement was estimated at 5,509 fish, of which 2,400 (44%) were observed in upstream spawning habitat. The distribution upstream of the largest (modified) bypass was the highest proportion of the overall escapement observed since the original bypass was installed. Odd year pink salmon escapements to the upper habitat have, generally, been larger than even years; thus, bypass use in 1996 is encouraging when considering perceived density influences. Density likely influences bypass use; however, does not appear to explain the variation in upper habitat use for all years. This variation was likely a result of design limitations that inhibited consistent migrations.

Pink and coho salmon returning to Little Waterfall Creek in 1996 and ensuing years are expected to have improved access to the primary spawning habitat upstream (~17,000 m^2) of the barrier bypass which is predicted to support 24,000 pink and 2,700 coho salmon. At this seeding level, a harvestable surplus of an additional 24,000 pink and 4,000 coho salmon is expected to be available to fishers. The Little Waterfall coho salmon runs have been small and harvest has been minimal; thus a new harvest opportunity may be afforded. The seeding of spawning habitat by coho salmon at current escapement levels (~100 in 1994) is expected to be slow, until optimum escapement levels are reached.

INTRODUCTION

Several beaches on Afognak Island were heavily oiled and remained oiled in 1990 following the *Exxon Valdez* oil spill (EVOS) in 1989 (Willette et al. 1994; Figure 1). Little Waterfall Bay (Little Waterfall Creek drainage - "local" stream designatorr 251-822; anadromous stream catalogue number 251-82-10020) was directly impacted by oil. Similar impacts in Prince William Sound (PWS) damaged salmon stocks (Willette et al. 1994).

This project began as result of surveys (Restoration Study 93063) conducted on Kodiak Island which evaluated instream habitat and stock restoration techniques for wild salmon stocks (Willette et al. 1994). The emphasis of this evaluation was to improve or develop spawning habitat at systems with barriers to salmon passage which have historically prevented access. Surveys focused on systems which were directly impacted or were located in proximity to areas impacted by the EVOS with the intent of mitigating for injured spawning habitat (Figure 1). Data collected from these surveys were analyzed, including a cost to benefit analysis (Hartman and Richardson 1993), to determine the most effective mitigation techniques for Kodiak Island salmon systems. As result of these surveys, the Exxon Valdez Oil Spill Trustee Council selected Little Waterfall Creek as a site for spawning habitat mitigation.

Barrier bypass (fish ladders) projects have been used extensively on Afognak Island (Figure 2) to restore and enhance sockeye (*Oncorynchus nerka*), coho (*O. kisutch*) and pink salmon (*O. gorbuscha*) runs (Honnold 1991; Honnold and Edmundson 1993 and Edmundson et al. 1994). For example, the Laura Lake sockeye and coho salmon runs were initially started, and currently sustained, by two bypasses which enable spawner access to underutilized habitat (Honnold and Edmundson 1993). Similarly, pink salmon production at Little Waterfall has been significantly improved through bypasses and increased spawning habitat use (Honnold 1991; Honnold *in press* a).

Three barriers in Little Waterfall Creek have been bypassed with structures allowing increased pink and coho salmon passage to previously unused spawning habitat (Edmundson et al. 1994; Figure 3). Two bypasses were constructed and installed in Little Waterfall Creek in the mid-1970's; construction and installation of a third bypass (the largest and most upstream) was completed in the fall of 1980. Pink salmon escapements at Little Waterfall have averaged 38,300 from 1968-1996, with a pre-bypass (1968-1980) average of 5,200 compared to a post-bypass (1981-1996) average of 57,200 (Honnold *in press* b). Although the system has benefited from the installation of the barrier bypasses, as indicated by the increased pink salmon escapement, the largest barrier bypass structure has not operated efficiently and has impeded salmon passage into the largest portion of spawning habitat (Willette et al. 1994). Since the installation of this bypass, pink salmon escapement to upstream habitat has averaged 10,800. Coho salmon escapement data is incomplete due to enumeration deficiencies (Honnold *in press* a); however, foot survey counts have ranged from no salmon (several years from 1980 -1993) to 95 (1994). Juvenile production data parallel the adult escapement data; with pink fry abundance indices less upstream of the bypass compared to downstream (Honnold *in press* a). Coho fry have not been identified during any preemergent sampling efforts; however, coho fry were observed rearing above and below the barrier as indicated by minnow trapping (Honnold *in press* a,b).

Barrier height, the quality and quantity of spawning habitat above barriers, and the degree of utilization of available spawning habitat significantly affects the efficiency and cost effectiveness of barrier bypasses (Willette et al. 1994). Habitat utilization rates are often considerably less than estimated capacity (McDaniel 1981). A evaluation was conducted in 1992 to characterize the useable salmon spawning habitat in Little Waterfall Creek (Willette et al. 1994). Habitat assessment (using field methods described by methods Olsen and Wenger (1991) and criteria established by Chambers et al. (1955) determined that the area above the largest bypass comprised approximately 80% (~17,000 m^2) of the total stream habitat. The habitat was estimated to support 24,000 pink and 2,700 coho salmon based upon a 1:1 sex ratio (ADF&G unpublished data), and an optimum female density for pink and coho salmon of 0.7 (Heard 1978) and 0.08 (Sheng et al. 1990), respectively. At optimum colonization levels, resultant production is estimated to provide a harvestable surplus of approximately 24,000 pink salmon (Willette et al. 1994; Table 1). Originally, coho salmon production at full seeding of the upstream habitat was estimated to provide~15,000 fish for harvest (Willette et al. 1994); however, egg-to-smolt survival assumptions (7.4%) were derived from sockeye salmon survival data (Honnold and Edmundson 1993). Survival of stream-rearing juvenile coho salmon (1-2%) is much less than that of lake-rearing sockeye (Bradford 1994; Table 1). This lower survival may be related to their aggressive territorial behavior and may result in exclusion of rearing opportunities. Thus, coho production as a result of improved access to upper spawning habitat was revised to ~5,400, of which ~4,000 would be harvested (Honnold *in press* a,b). The original cost to benefit data indicated that this project would have long term benefits greater than costs of production (Hartman and Richardson 1993). Lower coho salmon survival, however, would decrease the cost to benefit ratio but would still, likely, provide future benefits in excess of project costs.

The evaluation of the design and operation of the largest bypass structure determined several deficiencies, impacting salmon passage (Willette et al. 1994). The grade of the bypass (27%) was considered too steep. A slope of 22% or less is recommended for sockeye salmon when resting pools (similar to those at Little Waterfall) are employed (Blackett 1987). Pink salmon, a less vigorous fish, may require even less slope (Honnold 1991). Thus, the existing data indicated that the gradient of this bypass should be reduced by modifying the existing concrete resting tanks and extending the lower portion of the bypass, as well as adding two new tanks for improved resting opportunity (Honnold 1995; Honnold 1996; Honnold *in press* a,b; Figure 4).

In 1994 , pre-construction production parameters were assessed, including pink and coho salmon escapements and egg-to-fry abundance indices, engineering surveys were completed, and the initial design for bypass improvements developed (Honnold 1995; Honnold 1996; Honnold *in press* a,b). Similarly, in 1995, additional escapement and juvenile production data were collected, including initial coho stream rearing information, final engineering documents were completed for the contract bidding process, and a contract was awarded to SeaCoast Construction (Honnold 1996; Honnold *in press* a). Construction , however, scheduled to begin in July 1995, and be completed by September, was delayed due to poor work conditions as result of high water events. Thus, construction did not begin until October 1995, and was completed in November 1995. The delay in construction prevented evaluation of the bypass since annual Little Waterfall Creek salmon runs were complete by mid-October. The post-construction evaluation began in February 1996 with an intial inspection of over-wintering condition of the bypass, followed by escapement estimation and observations of bypass use in August and September (Honnold *in press* b). Juvenile indexing of pink and coho salmon fry continued in 1996 as part of the pre-bypass use evaluation. Initial post-bypass use production of juveniles will occur in 1997.

OBJECTIVES

Bypass modification (construction) was scheduled to occur in July 1995; however was delayed until November 1995. As result, the objectives listed in the Fiscal Year (FY) 96 (October 1, 1995 - September 30, 1996) Detailed Project Proposal (Honnold 1995) were modified to read as follows:

1) Supervise the completion of bypass modification and inspect final product to assure contract specifications are adhered to.

2) Estimate pre-construction relative abundance of juvenile pink and coho salmon: preemergent fry (pink and coho salmon) and rearing fry (coho salmon).

3) Evaluate the use of the improved bypass by pink and coho salmon and make field modifications if necessary.

4) Estimate the escapement and distribution of pink and coho salmon upstream and downstream of the improved bypass.

5) Document project progress and results.

METHODS

1) Supervise the completion of bypass modification and inspect final product to assure contract specifications are adhered to.

The improvements to the bypass were completed in FY 96 and methodology was described in the FY 95 annual report (Honnold *in press* a); funds for the construction were allocated in FY 95. Supervision and inspections were conducted by the project leader during construction (October-November 1995) and post construction (February and May 1996). An inspection by the project engineer was scheduled for August 1996; however, weather prevented an on site assessment.

Photographs of the project, as well as written documentation of field observations (design and fish passage) were utilized by the project engineer for evaluation of the modified bypass.

2) Estimate pre-construction relative abundance of juvenile pink and coho salmon: preemergent fry (pink and coho salmon) and rearing fry (coho salmon).

Spawning redds downstream and upstream of the barrier were sampled in March 1996 prior to fry emergence for a relative index of fry abundance (Donnelly 1983; Swanton et al. 1993) and egg-to-fry survival (Figure 3). Ten redds, in both locations, were sampled as described by White (1980; 1986) to capture eggs and fry and enumerate by species (Swanton et al. 1993; White 1988; McNeil 1964). Downstream and upstream indices of fry abundance were calculated by: # fry enumerated per site divided by the # digs conducted per site times the diameter of the fry net (two feet); and multiplying the sum by 10.76 to convert to square meters (K. Brennan, ADF&G, personal communication). These data were intended to assess baseline parameters prior to use by salmon of the improved bypass. Analysis-of-variance (ANOVA) or analysis-of-covariance (ANOCOVA) will be used once sufficient data are available to test for pre- and post- bypass improvement differences in emergent fry indices and/or egg-to-fry survivals, depending on which statistical method is appropriate (Ivan Vining, ADF&G, Kodiak, personal communication).

Juvenile coho salmon relative abundance (catch per unit effort) data were collected downstream and upstream of the barrier in 1996. Two sampling locations (Figure 3) were established in 1995 and unbaited minnow traps (Gray et al. 1984; Kyle 1990) were set for ~ 24 hours once a month from June through August at each site. Trapping was modified in 1996 to increase effort by the addition of four sampling sites; two upstream of the barrier and two downstream of the barrier (Figure 3). In addition, baited and unbaited traps were fished at each site in 1996. The use of baited traps was intended to increase catches; unbaited traps were included to provide consistency at the original sampling sites established in 1995. All juvenile fish captured (for both years) were enumerated by species and released. Juvenile coho salmon catch per unit effort (CPUE) was calculated for each trapping period for upstream of bypass and downstream of bypass comparison. ANOVA or ANOCOVA will be used to test for pre- and post- bypass improvement differences in coho fry CPUE once sufficient data are collected. The specific test applied to this data will depending on which statistical method is appropriate (Ivan Vining, ADF&G, Kodiak, personal communication).

3) Evaluate the use of the improved bypass by pink and coho salmon and make field modifications if necessary.

Observations were made several times daily in 1996 to determine the efficiency of fish passage through the improved bypass. This occurred when sufficient salmon were present in the creek downstream of the bypass and were attempting to enter the entrance tank. Further observations were made as salmon progressed from each bypass section to resting tanks and on to the exit of the bypass. Quantitative data were not collected; however, general trends were noted

4) Estimate the escapement and distribution of pink and coho salmon upstream and downstream of the improved bypass.

Pre-construction escapement and distribution of pink and coho salmon upstream and downstream were assessed in 1994 by conducting weekly foot surveys of Little Waterfall Creek from 08 August through 19 September (Honnold 1995). In 1995, salmon surveys were conducted in August; however, high water events prevented September surveys (Honnold *in press* a,b). The first post-construction surveys of pink and coho salmon escapement and distribution upstream and downstream of the bypass were completed in 1996. Surveys were conducted 16 and 30 August but were discontinued in September due to high water events. Peak live counts were used to estimate salmon escapement in the system. The estimates were differentiated by habitat upstream and downstream of the barrier bypass. The documentation of annual habitat use by salmon spawners was completed prior to this project (before 1994) as part of ADF&G and KRAA annual enhancement monitoring (Honnold 1996; Honnold *in press* a). These activities focused on pink salmon; however, for some years coho salmon escapement and distribution were documented. Historical trends of pink and coho salmon escapement in the Little Waterfall system will be summarized in this report. Analysis of variance (ANOVA) or covariance (ANOCOVA) will be used once sufficient data are available to test for pre and post bypass improvement differences in indexed escapements, depending on which statistical method is appropriate (Ivan Vining, ADF&G, Kodiak, personal communication). In addition, pink salmon escapement variability (odd/even year run strength differences) will be accounted for by comparing proportions of spawners upstream and downstream of the bypass before and after the improvements. Statistical analysis of this comparison will be defined once data are available.

5) Document project progress and results.

The necessary documentation of project progress and results as outlined by the Trustee Council included: providing quarterly project status updates and work plans, preparing an abstract for inclusion in the annual Restoration Workshop proceedings, writing an annual report for FY 95 activities, and providing requested information in response to the EVOS Trustee comments on the FY 97 DPD.

RESULTS

1) Supervise the completion of bypass modification and inspect final product to assure contract specifications are adhered to.

The improvements to the bypass were completed in FY 96 and results were described in the FY 95 annual report (Honnold *in press* a). In February and later in May, 1996, the bypass was inspected to ascertain whether contract specifications were followed during construction. Several modifications were made to the specifications and approved by the project engineer. None of these modifications changed the overall objective of reducing the gradient and flows of the bypass as described in the engineering plan (Honnold *in press* a). However, the entrance tank was set on top of a four inch concrete pad instead of flush with the streambed as shown on the contract drawings (Figure 5; Appendix A; see Honnold *in press* a for specifications). Thus, the entrance slot was located higher than designed; possibly too high for salmon to easily enter.

2) Estimate pre-construction relative abundance of juvenile pink and coho salmon: preemergent fry (pink and coho salmon) and rearing fry (coho salmon).

Little Waterfall Creek was sampled on 07 April and 21 March in 1994 and 1996, respectively, to estimate preemergent salmon fry relative abundance (Table 2). Ten samples each were collected at sites upstream and downstream of the third most upstream barrier falls (Figure 3). In 1995, high flows and poor weather prevented sampling. Prior to this project, samples were collected at both upstream and downstream locations when time permitted (1982, 1986, 1987, and 1992). Sampling was conducted in 28 March, 1997; however, data are considered preliminary; thus, will not be discussed in this report (Table 2). In 1996, 1695 (100%) pink salmon fry were captured at downstream sample sites, compared to 0 (0%) upstream of the barrier falls. In 1994, , 316 (68%) pink salmon fry were captured at downstream sample sites compared to 147 (32%) at upstream sites. The distribution of pink salmon fry captured downstream (71%) and upstream (29%) of the barrier was similar in 1992. In 1982 (0), 1986 (2) and 1987 (0), few fry were captured above the barrier. Indexed estimates of fry per square meter have shown similar trends, except in 1994 at upstream sites when 39.5 fry/m^2 were estimated compared to 37.4 fry/m^2 at downstream sampling sites. The total indexed abundance estimates (both locations combined) in 1987 and 1994 (123.2 and 124.6 fry/m^2) were the lowest for all years. Coho salmon have not been captured at any sample locations.

Pink salmon egg-to-fry survival estimates downstream (of the bypass) have ranged from a high of 19.5% (1996 escapement) to a low of 0.3 % (1993 escapement), averaging 6.6% (Table 3). Upstream egg-to fry survivals ranged from a high of 10.9% (1991 escapement) to a low of 0% (for four years), averaging 1.8%.

Minnow trapping was conducted 25 June, 17 July, and 15 August 1996 to assess the relative abundance of juvenile coho salmon rearing in Little Waterfall Creek. Twenty-one coho (0.29 CPUE) salmon fry were caught upstream (sites A-C) of the barrier compared to 43 captured (0.60 CPUE) at the downstream trapping location (sites A-C) during 72.0 hours of sampling (Table 4; Figure 3).

Minnow trapping effort was increased in 1996 with the addition of two sampling sites (A and C) in both upstream and downstream habitat (Figure 3). In addition, baited and unbaited traps (1 each) were fished at each site in 1996. The addition of these variables make comparisons of overall 1996 trapping data to 1995 data inappropriate. Unbaited trapping data from Site B in 1996, however, may be comparable to 1995 trapping data (unbaited; Table 4). Four coho fry were caught (0.06 CPUE) in upstream habitat (unbaited-site B) in 1996 compared to 12 coho fry captured (0.18 CPUE) in 1995 at the same unbaited site (B). Similar numbers of coho fry were captured at site B (unbaited) in downstream habitat for both 1995 (10) and 1996 (12). The CPUE for both years was also similar in downstream habitat; 0.15 in 1995 and 0.17 in 1996.

In 1996, unbaited trapping resulted in lower catches and CPUE at both upstream and downstream sites (A-C) when compared to baited trapping (Table 5). Nine coho fry were caught (0.13 CPUE) in unbaited traps and 12 coho fry were caught (0.17 CPUE) in baited traps in upstream habitat; 13 (0.18 CPUE) and 30 (0.42 CPUE) coho fry were caught in unbaited and baited traps, respectively, in downstream habitat.

3) Evaluate the use of the improved bypass by pink and coho salmon and make field modifications if necessary.

The improved bypass was observed during the month of August when pink salmon were present downstream and were attempting their migration to upstream habitat. An earlier inspection of the bypass revealed that contract specifications were not adhered to when the entrance tank was positioned. The tank was placed on a cement pad instead of flush on the streambed (Figure 5). Initial observations of fish passage indicated that the entrance to the tank was too high for pink salmon to easily enter. This was remedied in the field by cutting out a portion of the tank to lower the entrance. In addition, a pool was created in front of the tank with sandbags which provided additional stream depth and more space for salmon to enter the bypass. These modifications were sufficient to attract pink salmon into the entrance tank. Once pink salmon were in the entrance tank, a proportion (~44% of the total escapement) proceeded up the bypass runs and resting tanks and eventually exited the bypass. The improper design, however, may need further modification in the future (Appendix A). In addition, another problem with fish passage was identified. That is, as the pink salmon exited the bypass upstream, they were sometimes washed back over the falls. This was remedied in the field by placement of aluminum picket panels adjacent to the existing concrete wall (Figure 6). This effectively increased the height of the wall and prevented fish from washing over the falls. A more permanent solution may be needed in the future to solve this problem (Appendix A). The permanent extension of the height of the existing concrete wall may be a more long-term solution.

4) Estimate the escapement and distribution of pink and coho salmon upstream and downstream of the improved bypass.

A total of 5,509 live pink salmon were observed in Little Waterfall Creek on 16 August 1996 (Table 6). Of these, 2,400 (44%) were observed in habitat upstream of the improved bypass. Approximately 1,752 (49%) of 3,569 pink salmon were observed in upstream habitat on 30 August 1996. Pink salmon escapement has been documented from 1968 through 1996 at Little Waterfall Creek. Prior to completion of the three barrier bypasses (1968-1980), pink salmon escapement averaged 5,179 with no fish observed upstream of the third barrier. The post bypass escapement (1981-1996) averaged 57,218, of which on average, 10,746 (19%) were distributed to habitat upstream of the largest bypass. In recent years (1990's) pink salmon distribution to the upper reaches has varied considerably, with an escapement of 45,000 (41% of total) in 1993 compared to 6,500 (28% of total) and 8,300 (22% of total) in 1994 and 1995, respectively. Thus, the 1996 distribution upstream of the largest (modified) bypass represents the highest proportion (44%) of total escapement for all years. Odd year pink salmon escapements to the upper habitat have, generally, been larger than even years and correspond to the entire system escapement trends.

When including 1996 data, pink salmon escapements at Little Waterfall have averaged 38,300 from 1968-1996 (65,600 odd-year; 25,500 even-year), with a pre-bypass (1968-1980) average of 5,200 (7,000 odd-year; 3,900 even-year) compared to a post-bypass (1981-1996) average of 57,200 (76,400 odd-year; 38,000 even-year) fish. Escapement to upstream habitat has averaged 6,350 (12,400 odd-year; 2,185 even-year); post-bypass escapement has averaged 10,800 (15,900 odd year; 4,700 even-year). The average even-year escapement to upstream habitat (4,700) is 12% of the average total even-year escapement compared to 44% reaching the upper habitat in 1996.

Coho salmon escapement data are incomplete in 1996 due to enumeration deficiencies as result of high water events; however, foot survey counts on 30 August resulted in a peak live count of 90 fish. These coho salmon were all observed downstream of the modified bypass. Upstream distribution was not documented in 1996.

A total of 90 live coho salmon were observed in Little Waterfall Creek in 1994 (prior to bypass improvements). Of these, 47 (49%) were distributed upstream of the third barrier falls (Table 6). High water events prevented coho escapement surveys in 1993 and 1995. ADF&G has previously documented coho usage, associated with pink salmon enhancement activities in the system. Counts, however, have been sporadic and often incomplete due to insufficient funding and weather constraints. Escapements have ranged from 0 (several years from 1980 -1993) to 95 (1994). The largest recorded coho salmon count prior to this project was 65 (1984), with a mean count from 1981-1995 of 26 fish. Stream distribution was recorded in 1990, 1991, and 1994 when 11 (61%), 22 (71%), and 47 (49%) coho were observed upstream of the barrier, respectively. Coho were also observed in the upstream areas in 1989 (22) and 1992 (34), however, overall system escapement is unavailable for those years.

5) Document project progress and results.

Quarterly reports and work schedules were submitted on schedule in FY 96. In addition, the FY 95 annual project report was submitted for peer review in June 1996. Lastly, an abstract describing FY 96 project progress was submitted in December 1996 for inclusion in the 1997 annual Restoration Workshop proceedings.

DISCUSSION

The primary factor that has limited full utilization of spawning habitat upstream of the largest barrier falls at Little Waterfall Creek is inadequate passage through the bypass. The original design of the bypass did not provide proper slope or water velocity conducive to salmon use. Smaller bypasses located downstream of the bypass in question are readily used by pink salmon and have slopes of 20% (Honnold 1991). Similarly, the Portage Creek fishpass (Figure 2) has a 13% slope and is used without difficulty by pink salmon (Honnold 1991). Other fishway evaluations indicate that sockeye, coho and chinook salmon pass readily through bypasses with 13%-28.7% slopes (Gauley 1960; Gauley and Thomson 1963; Slatick 1973). Steeppasses with gradients of 22-25% assure water discharge sufficient to attract fish to enter a bypass (Antonnikov 1964) and ascend easily as observed for sockeye and chinook salmon at the Frazer Lake fishpass (22% slope) on Kodiak Island (Blackett 1987). Pink salmon, a physically less vigorous fish, appear to need slopes in the 13-20% range, for optimum passage through bypasses, as observed at Little Waterfall Creek (Honnold *in press* a).

A fishway (bypass) must be designed so that water velocities do not exceed the swimming capabilities of the target species (Ziemer 1965). Larger sockeye, coho and chinook salmon, can withstand high water velocity (13.4-15.8 fps); however, smaller fish of these species may not successfully negotiate similar flows rates (Weaver 1962). Most salmonids are capable of negotiating a water velocity of approximately eight feet per second (fps) (Antonnikov 1964); but for short duration's, velocities slightly greater than 8 fps are not excessive (Ziemer 1965). Flows should also be sufficient to provide a minimum discharge from the bypass entrance of 3 fps to attract fish and resting areas with velocity not greater than 1 fps for every 10 feet of vertical rise, depending on shape and length (Ziemer 1965). Insufficient number and poor location of resting pools also reduces salmon passage (Bruce A. McCurtain, ADF&G, personal communication). Coho salmon are highly susceptible to fatigue and adequate resting facilities are necessary in fishways with water velocities exceeding 1.1 meters per second (3.61 fps) for any considerable distance (Paulik et al 1957). Resting tanks at Frazer Lake fishpass are beneficial for holding slower or descending salmon without blocking passage of other salmon (Blackett 1987). It is also necessary to provide consistent flow patterns in bypasses to allow for head increases, and stable water velocity. The design of the Alaska -type fishpass accounts for these head changes with baffles reducing water velocity (Ziemer 1965). Pink salmon swimming ability has been observed to be poor in the most upstream bypass at Little Waterfall Creek during high flow events (Honnold *in press* a). The original design of this bypass did not appear to provide proper water velocities for consistent pink salmon passage. Water velocity appeared to exceed the optimum for larger salmonid species during most conditions, and baffles may not have been effective because of the excessive slope. Resting pool water velocity likely exceeded the recommended level (1 fps) due to the long steeppass section runs and pools not being staggered to impede the water velocity. The literature does not adequately address the limitations of pink salmon swimming ability with regards to bypass use, instead focusing on other salmonid species. The affected bypass was designed and constructed in the late 1970's when most performance parameters were gleaned from successful chinook, coho, and steelhead projects.

This project provided for modifications to the bypass to correct deficiencies in slope, water velocity, and number and location of resting pools. Slopes for all sections are now at 20% (Figure 7) or less, compared to 27% prior to the project (Figure 8). Observations in 1996 indicate a constant water velocity in the steeppass runs and greatly reduced velocity in resting pools, as a result of staggering of steeppass runs. The addition of two resting pools and the modification of the previous entrance tank into an additional resting pool also may have increased fish endurance and improved passage through the bypass. The outflow at the new entrance pool also provided the required attraction for salmon; however, the entrance tank was placed too high, making entry difficult. The field modifications to the entrance tank allowed fish entry in 1996. The substrate in front of the entrance tank did not initially provide a pool for pink salmon to stage prior to entering the bypass. A pool constructed with sandbags temporarily alleviated the problem in 1996. It would be advisable in 1997 to create a permanent 2-3 foot deep pool by excavating the substrate.

Pre-construction preemergent fry data indicate the habitat downstream of the bypass has historically produced more juvenile pink salmon compared to upstream habitat as result of a larger proportion of escapement to the area. Little Waterfall Creek often has one of the highest annual indices of pink salmon fry/m^2 on Afognak Island (Kevin Brennan, ADF&G, personal communication); however, the system index declined by ~five- fold from 1982 to 1994. Furthermore, fry indices declined by ~thirty -fold in downstream spawning habitat during this period. In 1996, the total fry index, as well as the downstream index increased substantially to the highest level since 1982. The brood year escapements were over 100,000 for most years that the fry index declined and the majority of spawning occurred in downstream habitat. In 1995, however, the escapement was 37,000 of which 29,000 spawned in downstream habitat; this may explain the higher fry index in 1996. Aside from brood year 1995 (1996 preemergent fry index), the trend may indicate habitat degradation due to the uneven distribution of pink salmon that spawn in the system. Approximately 80% of the systems spawning habitat is located upstream of the largest barrier bypass (Honnold 1995); however, average pink salmon distribution to this area has been only 19% of the total escapement. This indicates that 81% of the escapement utilizes only 20% of the spawning habitat and may, in part, explain the declining index of preemergent fry. Although the overall index of fry/m^2 in 1994 was the lowest recorded for all years, the upstream habitat (above the largest bypass) index was greater than the downstream index. This change corresponds to the only brood year (1993) that the upper habitat was fully utilized by pink salmon spawners. Previous Kodiak Island studies suggested significant density dependent relationships for pink salmon populations for both egg retention and preemergent fry response (Donnelly 1983; Eggers et al 1991). Swanton et al (1993), however, reported no conclusive evidence that the depression of pink salmon indices (fry/m^2) for Kodiak Island systems, overall, was directly caused by high spawner densities as a result of the 1989 overescapements; Little Waterfall Creek exhibited the most negative #Sd_{fry}/m^2 (Standardized Residuals=(1990 fry/m^2 - historical mean fry/ m^2)/standard deviation of historical mean fry/m^2) of 23 Kodiak streams examined. The relationship between spawner density and resultant fry produced may be highly influenced by environmental conditions for Kodiak pink salmon systems (Charles O. Swanton, ADF&G, personal communication). Frequent freshet events occur at Little Waterfall Creek and may influence egg-to-fry survival and a portion of the variability in the fry indices at Little Waterfall Creek. Thus, the decline of fry/m^2 indices in the downstream habitat, may be influenced by both spawner density and environmental conditions.

The absence of coho salmon fry in preemergent samples is not unexpected with the low spawner numbers observed in the system. Additional samples in different locations may be necessary to document emergent coho salmon fry abundance indices.

Coho salmon fry CPUE in Little Waterfall Creek was slightly higher in the upstream habitat compared to downstream habitat in 1995. The CPUE in 1996 in upstream habitat declined three-fold compared to 1995 but downstream CPUE was similar for both years.

The coho salmon escapement distribution to upper habitat indicates a larger proportion (60%) have migrated by way of the bypass (prior to modification) compared to pink salmon (19%). The limitations of the bypass, previously discussed, appear to affect pink salmon migrations to a greater extent than coho migration. Coho salmon generally spend more time in fresh water during spawning migration (Donald "Tony" Chatto U.S. Fish and Wildlife Service, Kodiak, personal communication), thus more would be expected to eventually be observed in the upper habitat over time. In 1994 less than half (49%) of the coho observed were upstream of the bypass, which may indicate bypass performance limitations for this species as well. Additional escapement distribution information is required to further assess these trends. The small coho escapement at

Little Waterfall Creek, compared to pink salmon, poses difficulty in assessment of bypass limitations; however, bypass modifications would be predicted to assist the migration to upper habitat, since slope and water velocity criteria of the pre-project bypass were at upper limitations for coho salmon.

Pink salmon utilization of spawning habitat upstream of the original bypasses at Little Waterfall Creek has been greatly improved, as indicated by a twelve-fold increase (5,000 to 60,000) in the mean escapement post-bypass completion. The spawning habitat upstream of the largest bypass and has been fully utilized only once (1993) in 15 years. Generally, data indicates variable use of the upper habitat, however, larger escapements (odd year) have frequently resulted in greater utilization of the habitat upstream of the barrier. Thus, use of the original bypass may have been influenced by density. Density, however, does not appear to explain the variation in upper habitat use for all years. In 1993, when 45,000 (41%) pink salmon were observed upstream, overall escapement was estimated at 111,000, however, in 1984 and 1994, when 26% and 28% of the escapement, respectively, migrated to upstream habitat, the escapement levels were only 40,000 and 23,000, respectively. This indicates that density may contribute to bypass use, but does not solely determine migration variability. The modified bypass may have altered the influence of density as initial use in 1996 at low density was proportionally higher than other years.

Bypass use also appears to have been influenced by run timing. The earliest portion of the pink salmon run in some years have been observed to use the bypass in larger proportions. In 1991, pink salmon were tagged at a weir located near salt water at Little Waterfall Creek. Approximately 45.3% of tag recoveries were found upstream of the bypass from samples tagged 25 July- 02 August compared to 21% recovered in upstream habitat from fish tagged 09-16 August. In 1992, when tagging was replicated, only 28% of fish tagged during the early period were recovered upstream of the bypass compared to 19% for later tagging. The escapement in 1991 was 115,000 of which 16,000 were observed upstream of the bypass while in 1992 the escapement was 43,000 and 6,000 pink salmon were observed upstream of the bypass. This indicates that density as well as escapement timing may have influenced the tagging results.

The factor discussed above have likely influenced bypass use; however, much of the variation in escapement distribution to upper and lower habitat is probably a result of design limitations that inhibit consistent migrations through the bypass. The problems identified with the design of the barrier bypass were corrected in 1995 and appear to have increased pink salmon passage to upstream habitat. Coho salmon are also expected to benefit from the modified bypass and consistently utilize in the upper habitat in the future.

The upstream habitat (~17,000 m^2) is predicted to support 24,000 pink and 2,700 coho salmon (Willette et al 1994). At this seeding level, an additional harvestable surplus of 24,000 pink and 4,000 coho salmon is projected. Pink salmon harvest of Little Waterfall pink salmon has averaged (1982-1995) approximately 50,000 annually (Honnold *in press* a). Thus, the full utilization of habitat may result in almost 50% more pink salmon for harvest. Coho salmon harvest at Little Waterfall has been minimal, thus new harvest opportunity may be afforded. The seeding of spawning habitat by coho salmon at current escapement levels (~100 in 1994) is expected to be slow. For example, if 100 additional fish reach the upper spawning area, only 800 coho salmon would be predicted to be produced (Table 1). Assuming a 75% exploitation rate, leaves 200 for escapement. This increase would, then be expected to continue slowly until optimum levels are reached in approximately ten years. The intent of this project is provide coho salmon spawners opportunities for natural seeding in upstream habitat. In ensuing years, it may be prudent to evaluate the utility of further supplementation techniques to increase coho salmon escapements. Several coho supplementation projects undertaken on Afognak Island, have successfully produced returns by way of juvenile lake stocking (Honnold and Clevenger 1995). Little Waterfall Lake, located upstream of the barrier falls, may provide similar opportunity to increase coho escapements. Rearing habitat, indigenous species interactions, and other supplementation criteria will need to be addressed if this option is considered. Coho salmon escapement estimates should be improved and expanded prior to further application of this or other supplementation options. EVOS Trustee Council funding will not be requested for such options and this project will continue as designed. Thus, other funding sources will need to be pursued if other supplementation options are considered in the future.

SUMMARY AND CONCLUSIONS

Little Waterfall Creek pink salmon have had limited access to upstream spawning habitat, which has resulted in an excess number of spawners distributed in downstream habitat. The steep slope, limited number of resting pools, and resultant high water velocity of the largest barrier bypass were identified as the primary explanations for poor utilization of upper habitat. Bypasses with slopes of 13-20% and evenly spaced (one/10 foot rise) resting pools, providing flows of 8 fps or less, enable consistent pink salmon passage. Coho salmon have similar requirements, however, can negotiate bypasses with steeper slopes. The original bypass design was insufficient due to slopes of 27%, irregular spaced resting pools and resultant high water velocity, especially during freshet events. This project provided for modifications to correct the original bypass design, including reducing slopes to 20% or less, and adding three properly spaced staggered resting pools. Juvenile and adult production assessment prior to bypass modification reflects the poor passage to upper habitat, as indicated by low preemergent fry abundance, rearing coho abundance, and spawner distribution. The high incidence of over utilization of spawning habitat downstream of the bypass may have decreased pink salmon fry production, however environmental factors most likely also influenced declining fry numbers. The variation in bypass passage by pink salmon indicates that density alone does not explain the years of increased escapement to upstream habitat and is most likely a result of steeppass limitations and water velocity fluctuations in response to season hydrological changes in Little Waterfall Creek. Coho salmon adult and juvenile data are limited, and additional data are necessary to determine production trends. Pink salmon proportional use of the bypass and distribution to upstream habitat improved substantially in 1996 as result of bypass improvements. Full seeding of upstream habitat can potentially provide ~50% more pink salmon for harvest. Coho salmon will also be available to harvest when escapement levels reach optimum levels; however, is not expected to occur in the near-term. Major unanswered questions include: post bypass improvement juvenile pink and coho salmon abundance trends, odd-year pink salmon use of the bypass, coho salmon use of the bypass (escapement and distributions), and how to permanently alleviate entrance tank and exit channel design deficiencies.

In conclusion, the improvements made to the largest most upstream bypass at Little Waterfall were successful thus far as reflected by the increased proportion of the pink salmon escapement observed upstream the barrier in 1996.

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Table 1. Spawner density, fecundity, survivals and exploitation rates used as planning assumptions to forecast pink and coho salmon production benefits for Little Waterfall Restoration project.

Parameter	Mean	Source (Area)
Pink Salmon		
Optimum female density (#/sq.m)	0.7	Heard (1978)
Average fecundity	1858	PWS(PWS aquaculture assoc. 1991)
Egg-fry survival (%)	6.4	SE Alaska (unpublished ADFG data)
Marine survival rate (%)	3.1	Alaska (Sharr et al. 1993)
Exploitation rate (%)	54	Barrett et al. (1990) and Kodiak (unpublished ADFG data)
Coho Salmon		
Optimum female density (#/sq.m)	0.08	Sheng et al (1990)
Average fecundity	4835	Alaska (ADFG unpublished data)
Egg-smolt survival (%)	2.0	Bradford (1994)
Marine survival rate (%)	4.1	Washington, California (Willette et al 1994)
Exploitation rate (%)	75	Chapman (1986)

Table 2. Little Waterfall Creek preemergent salmon fry sampling results, 1982 - 1997.

Year	Date	# Digs	% Digs w/fry	Number of Pink Fry [a] U.stream	%	D. stream	%	Indexed # of Pink Fry [b] U.stream	D. stream	Total Indexed # Pink Fry
1982	6-Apr	20	50	0	0.0	2177	100.0	0	1171.23	585.61
1986	25-Mar	20	55	2	0.2	1259	99.8	0.54	338.10	339.21
1987	1-Apr	20	80	0	0.0	458	100.0	0	246.40	123.20
1992	28-Mar	20	100	353	29.2	856	70.8	95.5	224.90	325.22
1994	7-Apr	20	55	147	31.7	316	68.3	39.5	37.40	124.55
1996	21-Mar	20	50	0	0.0	1695	100.0	0.00	911.91	455.96
1997	28-Mar	20	15	0	0.0	244	100.0	0	131.27	65.64

[a] Actual number of pink fry enumerated from all digs.
[b] Estimated number of pink fry per square meters (#fry/(#digs x 2)) x 10.76).

Table 3. Little Waterfall Creek pink salmon escapement, potential egg deposition, indexed fry/sq.meter, indexed fry and egg-to-fry survival estimates, 1981-1996.

	Escapement			Potential Egg Deposition [a]			Indexed Fry/ meter sq. [b]			Indexed fry [c]			Egg to fry survival		
YEAR	Total	Upstream	Downstream	Total	Upstream	Downstream	Total	Upstream	Downstream	Total	Upstream	Downstream	Total	Upstream	Downstream
1981	61,193	1,100	60,093	56,848,297	1,021,900	55,826,397	585.61	0.00	1171.23	12,473,493	0	5,036,289	21.9	0.0	9.0
1982	47,500	0	47,500	44,127,500	0	44,127,500									
1983	21,700	1,600	20,100	20,159,300	1,486,400	18,672,900									
1984	40,000	10,400	29,600	37,160,000	9,661,600	27,498,400									
1985	119,200	19,800	99,400	110,736,800	18,394,200	92,342,600	339.21	0.54	338.10	7,225,173	9,180	1,453,830	6.5	0.0	1.6
1986	48,400	nd	nd	44,963,600	nd	nd	123.20	0.00	246.40	2,624,160	0	1,059,520	5.8	nd	nd
1987	29,100	nd	nd	27,033,900	nd	nd									
1988	49,680	nd	nd	46,152,720	nd	nd									
1989	117,200	19,500	97,700	108,878,800	18,115,500	90,763,300									
1990	47,000	3,100	43,900	43,663,000	2,879,900	40,783,100									
1991	115,000	16,000	99,000	106,835,000	14,864,000	91,971,000	325.22	95.50	224.90	6,927,186	1,623,500	967,070	6.5	10.9	1.1
1992	43,000	6,000	37,000	39,947,000	5,574,000	34,373,000									
1993	111,000	45,000	66,000	103,119,000	41,805,000	61,314,000	124.55	39.50	37.40	2,652,915	671,500	160,820	2.6	1.6	0.3
1994	23,000	6,500	16,500	21,367,000	6,038,500	15,328,500									
1995	37,000	8,300	28,700	34,373,000	7,710,700	26,662,300	455.96	0.00	911.91	9,711,948	0	3,921,213	28.3	0.0	14.7
1996	5,509	2,400	3,109	5,117,861	2,229,600	2,888,261	65.54	0.00	131.27	1,396,002	0	564,461	27.3	0.0	19.5
Mean:	57,218	10,746	40,538	53,155,174	9,983,177	46,350,097	288.47	19.36	437.32	6,144,411	329,169	1,880,458	14.1	1.8	6.6

[a] 50:50 sex ratio; fecundity of 1858 (Willette et al. 1994).

[b] (Number of fry/(number of digs x 2)) x 10.76 (K.Brennan,ADF&G,personal communication); 1996 data (1997 samples) are preliminary.

[c] Index of fry/sq.meter x useable spawning habitat (1996 data are preliminary).

Table 4. Little Waterfall Creek minnow trapping species compostion and coho fry catch-per-unit-effort (CPUE) at sites upstream and downstream (A, B, and C) of the largest barrier falls, 1995 and 1996.

		1995 Site B, Unbaited							1996 Site B, Unbaited							1996 Sites A-C, Unbaited, Baited Combined					
			Hours	Catch						Hours	Catch						Hours	Catch			
Date	Location [a]	# Traps	Fished	Coho Fry	CPUE [b]	Stickleback	DV char	Date	# Traps [c]	Fished	Coho Fry	CPUE [b]	Stickleback	DV char	Date	# Traps	Fished	Coho Fry	CPUE [b]	Stickleback	DV char
30-Jun	Upstream	2	20.5	4	0.20	0	0	25-Jun	2	24	0	0.00	0	0	25-Jun	6	24	10	0.42	1	1
	Downstream	2	20.5	9	0.44	2	0		2	24	4	0.17	1	4		6	24	14	0.58	2	7
7-Jul	Upstream	2	24	5	0.21	0	2	17-Jul	2	24	4	0.17	0	1	17-Jul	6	24	8	0.33	0	5
	Downstream	2	24	1	0.04	1	0		2	24	4	0.17	0	2		6	24	21	0.88	0	2
23-Aug	Upstream	2	24	3	0.13	0	0	15-Aug	2	24	0	0.00	9	1	15-Aug	6	24	3	0.13	9	1
	Downstream	2	24	0	0.00	0	0		2	24	4	0.17	0	0		6	24	8	0.33	4	0
Totals:	Upstream	6	68.5	12	0.18	0	2	Totals:	6	72	4	0.06	9	2	Totals:	18	72	21	0.29	10	7
	Downstream	6	68.5	10	0.15	3	0		6	72	12	0.17	1	6		18	72	43	0.60	6	9
Mean:	Upstream	2	22.8	4.0	0.18	0	0.7	Mean:	2	24.0	1.3	0.06	3.0	0.7	Mean:	6	24.0	7.0	0.29	3.3	2.3
	Downstream	2	22.8	3.3	0.15	1	0		2	24.0	4.0	0.17	0.3	2.0		6	24.0	14.3	0.60	2.0	3.0

[a] Upstream and downstream of third most upstream barrier falls.

[b] Catch-per-unit-effort

[c] One trap actually fished; assuming equivalent catches if using two traps for comparison to 1995 data.

Table 5. Little Waterfall Creek minnow trapping catch and coho fry catch-per-unit-effort (CPUE) - baited versus unbaited traps, 1996.

		# Traps		Hours	Catch - baited				Catch - unbaited			
Date	Location [a]	Baited	Unbaited	Fished	Coho Fry	CPUE [b]	Stickleback	DV char	Coho Fry	CPUE [b]	Stickleback	DV char
25-Jun	Upstream	3	3	24	7	0.29	1	1	3	0.13	0	0
	Downstream	3	3	24	11	0.46	1	6	3	0.13	1	1
17-Jul	Upstream	3	3	24	5	0.21	0	5	3	0.13	0	0
	Downstream	3	3	24	14	0.58	0	1	7	0.29	0	1
15-Aug	Upstream	3	3	24	0	0.00	0	0	3	0.13	9	1
	Downstream	3	3	24	5	0.21	2	0	3	0.13	2	0
Totals:	Upstream	9	9	72	12	0.17	1	6	9	0.13	9	1
	Downstream	9	9	72	30	0.42	3	7	13	0.18	3	2
Mean:	Upstream	3	3	24.0	4.0	0.17	0.3	2.0	3.0	0.13	3.0	0.3
	Downstream	3	3	24.0	10.0	0.42	1.0	2.3	4.3	0.18	1.0	0.7

[a] Upstream and downstream of third most upstream barrier falls.

[b] Catch-per-unit-effort

Table 6. Pink and coho salmon escapement estimates for Little Waterfall Creek, 1968-1996.[a]

Year	Pink Salmon			Coho Salmon		
	Total [b]	Upstream [c]	%	Total [b]	Upstream [c]	%
1968	500	0	0	nd	nd	nd
1969	nd	nd	nd	nd	nd	nd
1970	2,000	0	0	nd	nd	nd
1971	nd	nd	nd	nd	nd	nd
1972	499	0	0	nd	nd	nd
1973	nd	nd	nd	nd	nd	nd
1974	6	0	0	nd	nd	nd
1975	7,000	0	0	nd	nd	nd
1976	5,000	0	0	nd	nd	nd
1977	nd	nd	nd	nd	nd	nd
1978	3,580	0	0	nd	nd	nd
1979	7,150	0	0	nd	nd	nd
1980	15,700	0	0	nd	nd	nd
1981	61,193	1,100	2	3	nd	nd
1982	47,500	0	0	15	nd	nd
1983	21,700	1,600	7	5	nd	nd
1984	40,000	10,400	26	65	nd	nd
1985	119,200	19,800	17	0	nd	nd
1986	48,400	nd	nd	nd	nd	nd
1987	29,100	nd	nd	1	nd	nd
1988	49,680	nd	nd	nd	nd	nd
1989	117,200	19,500	17	nd	22	nd
1990	47,000	3,100	7	18	11	61
1991	115,000	16,000	14	31	22	71
1992	43,000	6,000	14	nd	34	nd
1993	111,000	45,000	41	nd	nd	nd
1994	23,000	6,500	28	95	47	49
1995	37,000	8,300	22	nd	nd	nd
1996	5,509	2,400	44	90	nd	nd
Mean:	38,277	6,350	17	32	27	61
Mean (OY):	62,554	12,367	20			
Mean (EY):	25,490	2,185	9			
Mean 68-80:	5,179	0	0	nd	nd	nd
Mean 68-80 (OY):	7,075	0	0			
Mean 68-80 (EY):	3,898	0	0			
Mean 81-96:	57,218	10,746	19	32	27	61
Mean 81-96 (OY):	76,424	15,900	21			
Mean 81-96 (EY):	38,011	4,733	12			

OY - Odd Year; EY - Even Year

[a] First two barriers bypassed with fish passes in 1979; third bypassed in 1980.

[b] Foot or aerial survey estimates - 1968-76, 1981, 1988-89, 1993-1996; weir counts - 1982-87, 1990-92. 1990-92.

[c] Foot survey estimates upstream of third barrier bypass.

nd = no data.

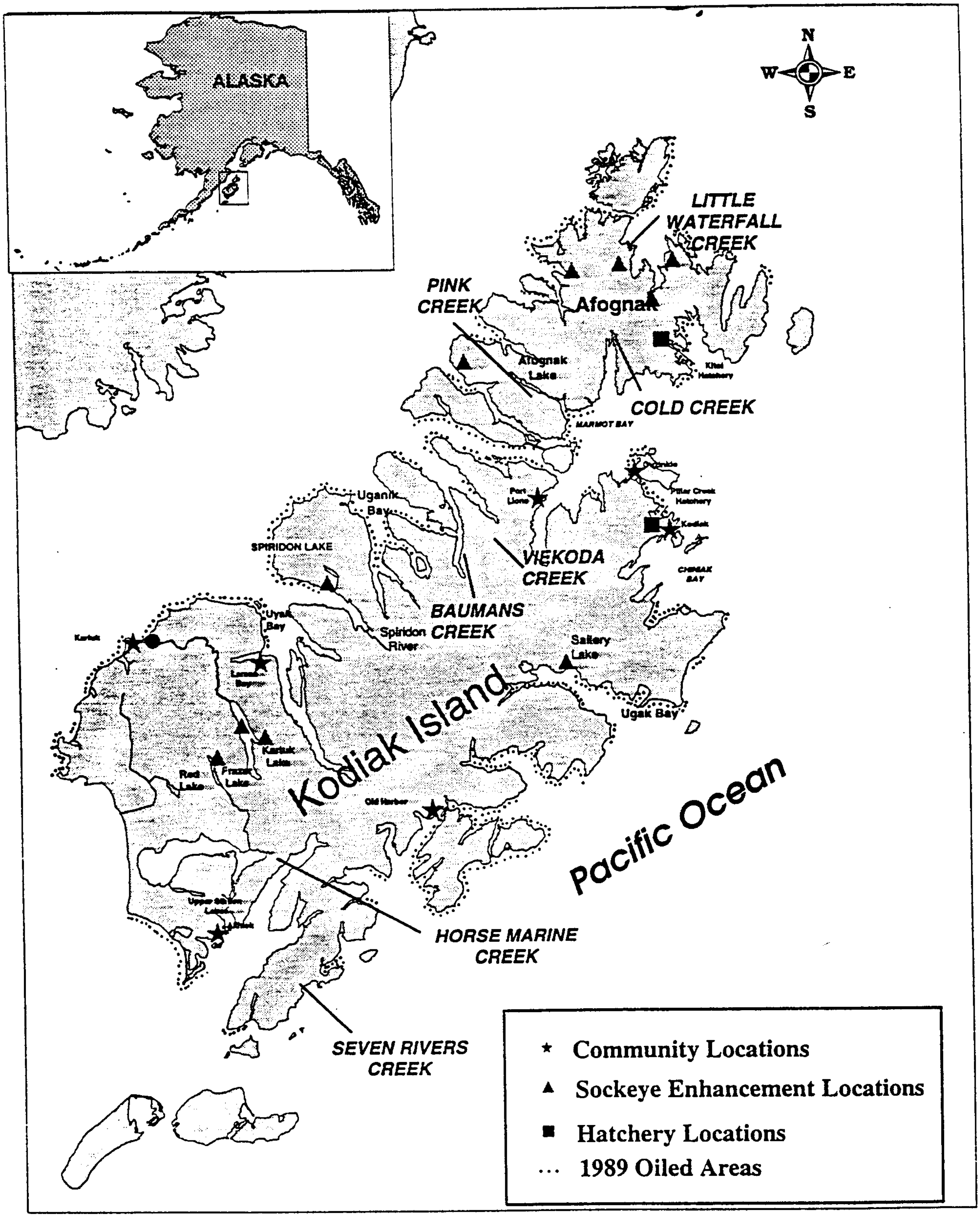

Figure 1. Location of 1989 oiled areas and salmon restoration/mitigation systems.

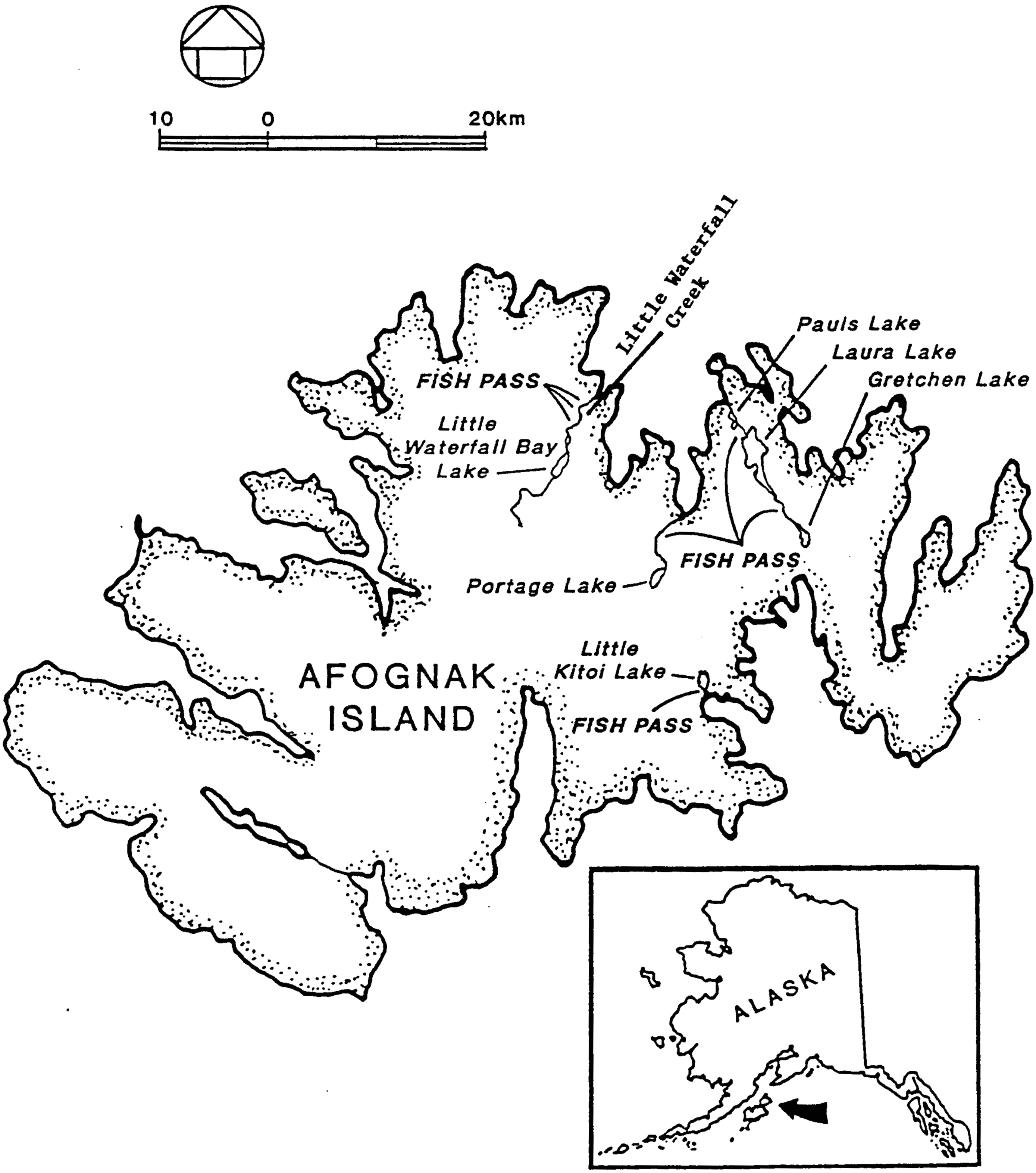

Figure 2. Location of fishpasses on Little Waterfall Creek, and other salmon systems on Afognak Island.

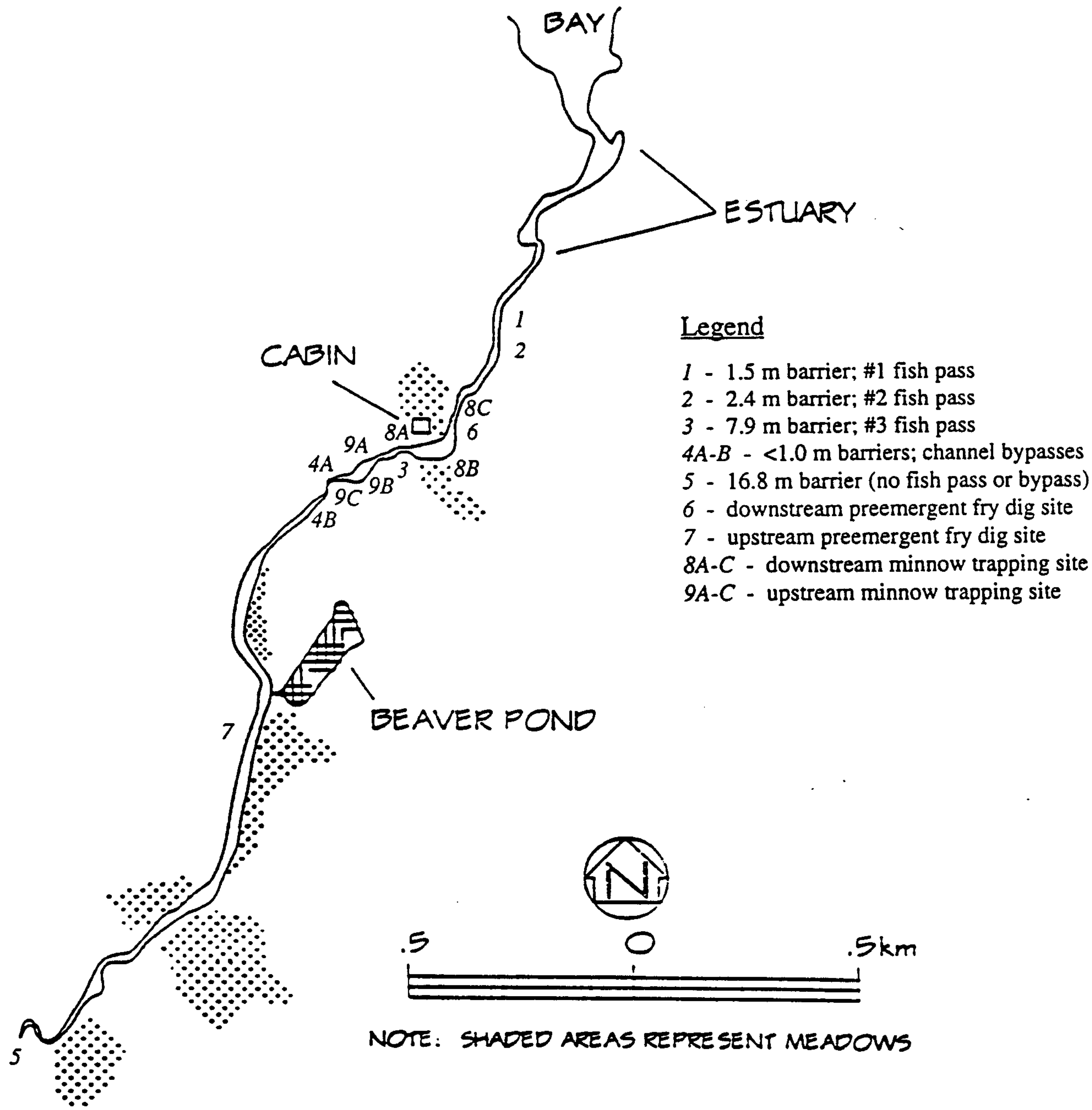

Figure 3. Location of barriers, fish passes, preemergent fry dig sites, and minnow trapping sites on Little Waterfall Bay Creek, Afognak Island.

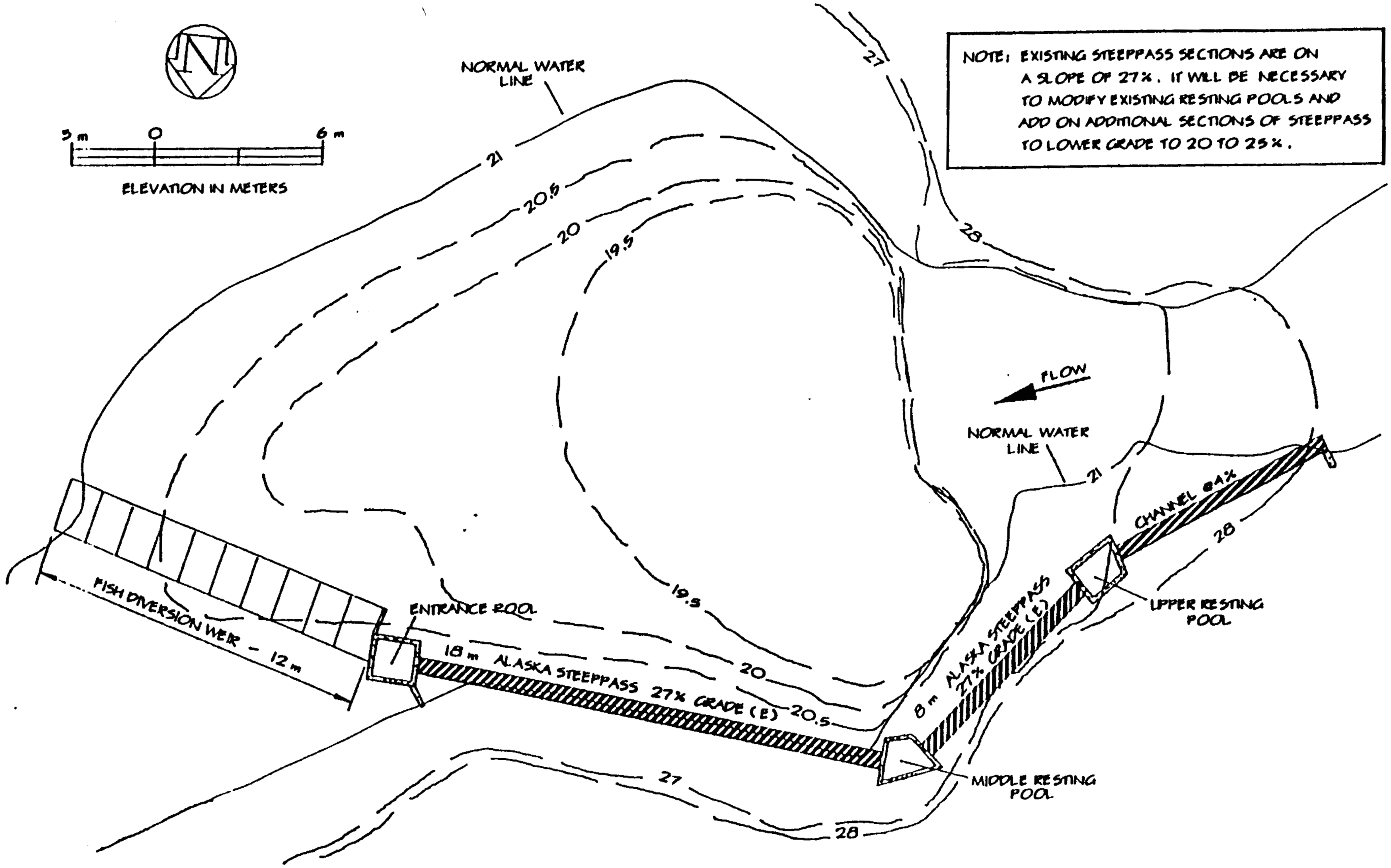

Figure 4. Design of original barrier bypass at 7.9 meter falls and recommended modifications to improve salmon passage.

Figure 5. Photographs of entrance tank before and after field modifications, 1996.

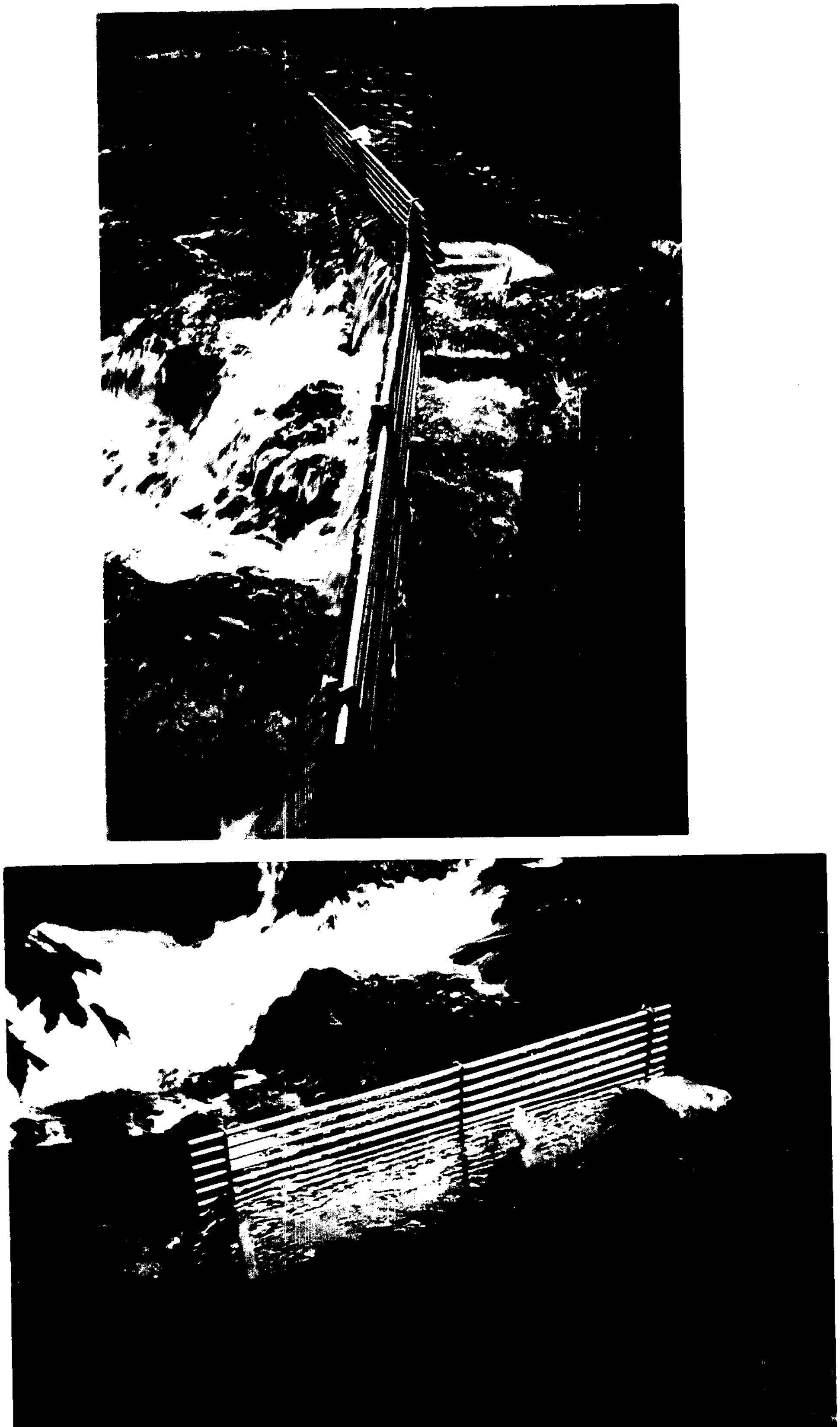

Figure 6. Photographs showing the use of aluminum picket panels to prevent "backwash" of salmon over the waterfall at Little Waterfall Creek, 1996.

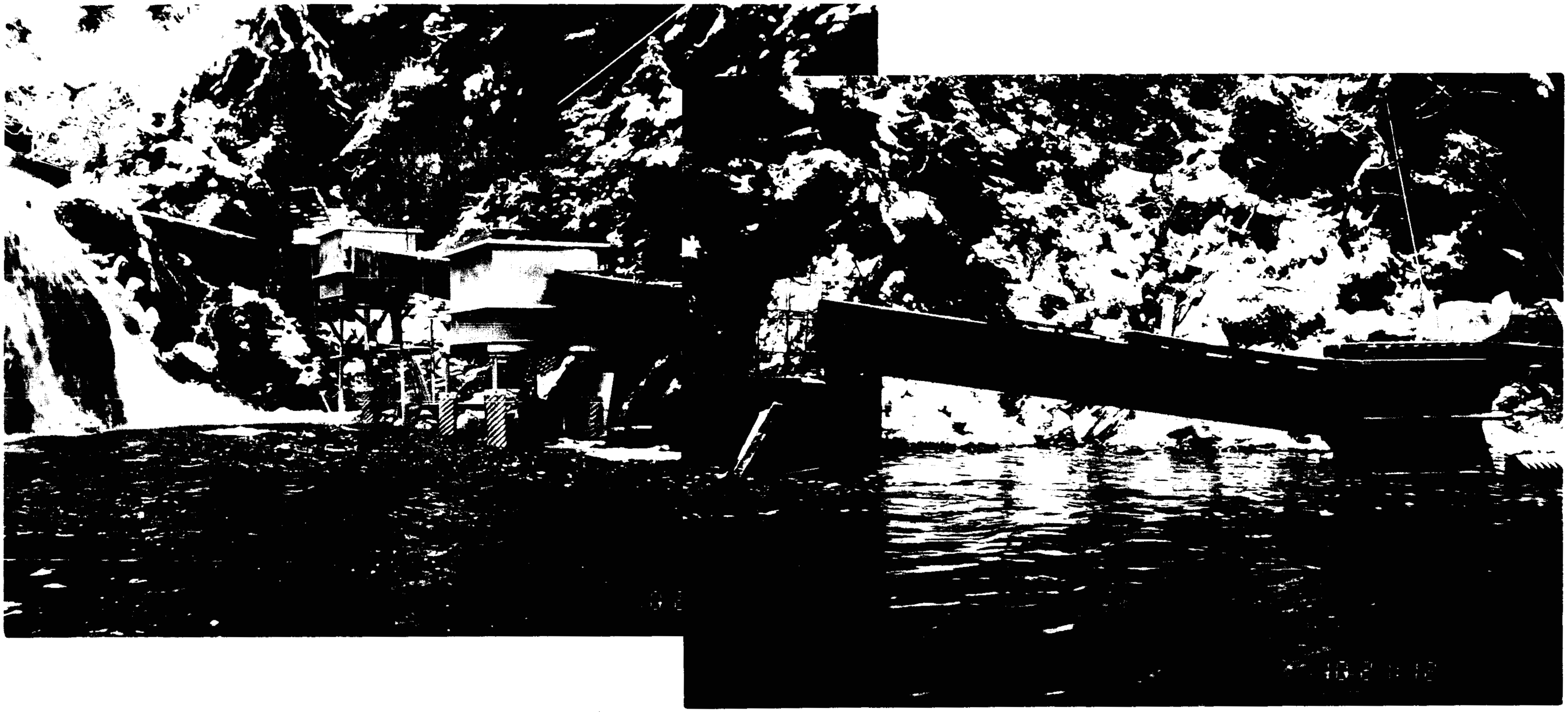

Figure 7. Photographs of completed Little Waterfall Creek barrier bypass modifications to reduce gradient and improve resting areas.

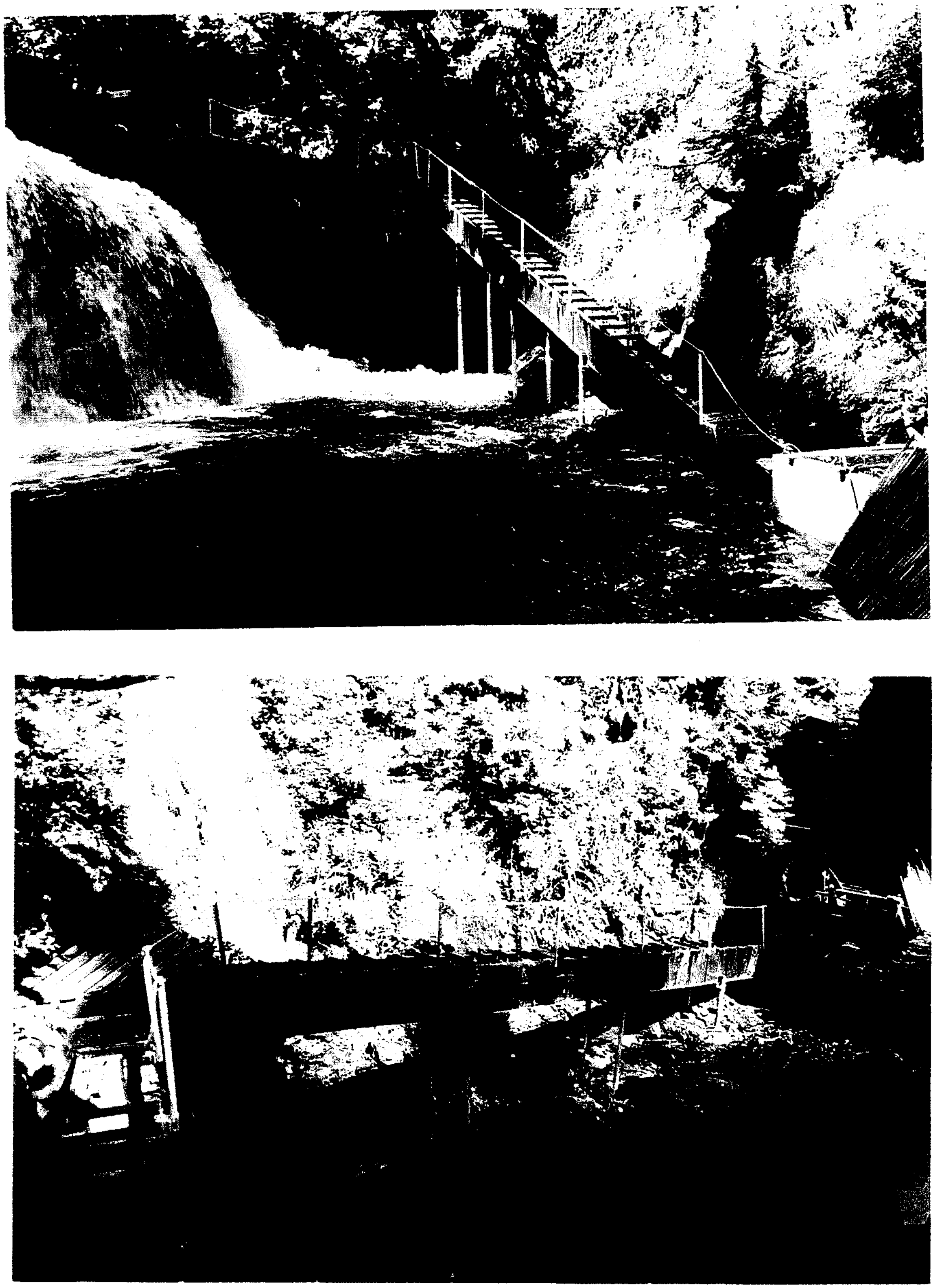

Figure 8. Photographs of Little Waterfall Creek barrier bypass prior to modifications to reduce gradient and improve resting areas.

APPENDIX

Memorandum

DATE: September 23, 1996

TO: L. Coggins & S. Honnold – Fish Biologists

FROM: Bruce A. McCurtain – Engineering

RE: Frazer Lake & Little Waterfall Steeppass Inspection Report

Background:

This report summarizes the Frazer Lake Steeppass conditions found during a site visitation by L. Coggins and Bruce McCurtain. Weather prevented a site visitation to the Little Waterfall Steeppass. Photographs were used to evaluate the condition of this newly constructed steeppass. This report includes options to assist CFMD in maintaining the two steeppasses.

Introduction:

FRAZER LAKE STEEPPASS

There are two steeppasses located at a fall 1.6 km downstream from Frazer Lake. Frazer lake is located on the southwestern end of Kodiak Island in the Kodiak National Wildlife Refuge. The steeppass inspected is the original steeppass constructed in 1962. Improvements were made on the original steeppass in 1971 through 1976. An adjoining steeppass was constructed in 1977 and was completed in 1979. Presently this steeppass is not used for passing salmon over the falls. This inspection report only covers the older steeppass. However, the entrance and exit pools are common for both steeppasses. The existing condition of both steeppasses is good and with minor maintenance will last several more years. The following are the items that I recommend for repair for the older steeppass:

1. Exit Pool - There are two areas on the exit pool that require repair: the crack on the north side wall and the deteriorated concrete and the space between the two walls on the south side. See Figure 1 for proposed fix for the north wall and Figure 2 for the south wall. The two areas are not affecting the structural integrity of the exit box but if not repaired will continue to deteriorate.

The main item that requires attention on the exit pool is a safety item. The exit pool requires a railing around the exterior or grating placed over the opening. This requirement is a mandate under the OSHA Safety Code. This requirement would be the same for the resting pools and entrance pool if the drop is more than 4 feet. Figure 3 shows proposed grating over the exit pool. A railing, if used, will have to meet OSHA requirements. The existing walkway on the exit pool will also have to meet OSHA requirements.

2. Resting Pools - Over the years different methods have been tried to plug the openings where the steeppasses enter the resting pools. Water spraying from these areas is not harmful but could cause slippery surfaces on the steeppass and is not aesthetically pleasing. The resting pools are not consistent with the size of the holes cut for the steeppasses. Figure 4 shows a proposed method of stopping the flow of water around the steeppasses. Each resting pool would have to be a specific fix..

3. Miscellaneous items - The plywood coverings on the steeppass near the entrance box needs repair. Replacing the plywood covers with aluminum will prevent the bears from destroying the covers and possibly prevent an injury to employees working on the steeppass.. Downstream weir appears to be stable in its existing condition. Several of the bolts connecting the weir to the piling were disconnected or missing.. Any work to rebolt the weir to the piling would require restabilization of the streambed. The weir platform also does not meet OSHA requirements. The platform walkway should be checked for deterioration and planks cleated together and fastened to the weir supports. The weir also requires a handrail. Entrance pool wood requires repair.

Frazer Lake (Cont.)

4. Cost - The total cost of the recommended repair is $10000.00, Rough Order of Magnitude (ROM). This cost is for materials only and does not include labor and transportation. ROM estimate may vary +/-35% depending on method and the concept design.

LITTLE WATERFALL STEEPPASS

1. Little Waterfall Steeppass, located on Afognak Island, was reconstructed in the fall of 1995. Work included lowering the grades of the existing steepppass adding two resting pools and a new entrance box for passage of pink salmon. Field modifications had to be made to the entrance box this year to get fish to enter the steeppass. The contractor had set the entrance box on top of a 4" concrete pad instead of flush with the streambed as shown on the contract drawings. Modification of the entrance required lowering the entrance slot in the box so fish would enter. Because the entrance location is the most important phase of the steeppass the concrete pad should be removed and the box set on the stream bed. A grout mixture should be placed under the flanges and the box bolted down using the existing bolting if possible. If the existing bolting is not used it will be necessary to set new bolts. After the box is set a pool should be cut in the rock streambed at the entrance to the box. Repair of the box where it was modified may be necessary to pass fish. Another problem is where the fish exit the steeppass. Depending on the flow in the stream the fish are sometimes washed backed over the falls. This can be remedied by extending the wall up about 1' to protect the fish as they exit the existing channel. The total cost for this modification would be $6000.00 ROM if completed by force account.

This inspection report provides a concept design development for maintenance repairs for the two steeppasses. The cost estimates are quite general in nature. A more realistic and thorough analysis of the cost and design can be made when the capital maintenance plan is prepared.

Please let me know if you need anything further on this report.

Attachments