

Kalispel Resident Fish Project

Annual Report
2000



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KALISPEL RESIDENT FISH PROJECT

ANNUAL REPORT

2000

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Executive Summary

In 2000 the Kalispel Natural Resource Department (KNRD) continued assessing habitat and population enhancement projects for bull trout (*Salvelinus confluentus*), westslope cutthroat (*Oncorhynchus clarki lewisi*) and largemouth bass (*Micropterus salmoides*). Habitat enhancement measures, as outlined in recommendations from the 1996, 1997, and 1998 annual reports, were monitored during field season 1999 and 2000. Post assessments were used to evaluate habitat quality, stream morphology and fish populations where enhancement projects were implemented.

Acknowledgments

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Bull Trout, Cutthroat Trout and Largemouth Bass

Habitat and Population

Assessment and Enhancement

Introduction

Fire history, past timber harvest activities, and dams have influenced the landscape in the Lower Pend Oreille Subbasin. The subbasin was first logged from 1915 to 1930 and much of the old-growth timber was removed. Logging railroad and log flumes were used on the mainstem Pend Oreille River and several of its tributaries. Log flumes were common, simplified the instream habitat, and decreased the recruitment source of large woody debris. In more recent years, road construction and maintenance, timber harvest, and cattle grazing have degraded stream habitat conditions. Numerous forest fires occurred between 1910 and 1929 and impacted many watersheds. From 1917 to 1929, an estimated 60 to 70% of the LeClerc Creek watershed burned. The largest fire in the LeClerc Creek watershed occurred in 1929.

The fish assemblage existing today in the subbasin is drastically different from pre-dam development. Anadromous fish have been extirpated due to the construction of Grand Coulee Dam; over 1,140 linear miles of spawning and rearing habitat in the Upper Columbia River System were eliminated (Scholz et al. 1985). The five dams on the lower Pend Oreille River are also believed to be a significant reason for the decline of native salmonid populations. These dams include Waneta (Canada), Seven Mile (Canada), Boundary (U.S.), Box Canyon (U.S.), and Albeni Falls (U.S.). None of these dams were built with fish passage facilities. Other dams and diversions such as Cedar Creek Dam, Sullivan Lake Dam, Mill Pond Dam, North Fork Sullivan Creek Dam, and Calispell Pumps were constructed in Pend Oreille River tributaries and further fragmented the connectivity of native salmonid populations.

In an attempt to partially mitigate for the resident and anadromous fish losses caused by hydropower development and operation, the Northwest Power Planning Council (Council) called for recommendations to develop a program that would provide measures to protect, mitigate and enhance fish and wildlife affected by the construction and operation of hydroelectric facilities located on the Columbia River and its tributaries. The Tribe, in conjunction with the Upper Columbia United Tribes (UCUT) Fisheries Center, undertook a three-year assessment of the fishery opportunities in the Pend Oreille River (Ashe et al. 1991) to provide the Council with recommendations. Assessment findings indicated that trout species were rare in the reservoir and compose less than 1% of the total abundance. Brown trout (*Salmo trutta*) were the most abundant trout species. Factors limiting trout production in the reservoir were identified as warm water temperatures, lack of habitat diversity and food availability. Trout were more abundant in the tributaries to the reservoir, which mostly supports brook trout (*Salvelinus fontinalis*) and brown trout, however westslope cutthroat (*Oncorhynchus clarki lewisi*), rainbow (*O. mykiss*), and bull trout (*Salvelinus confluentus*) were also captured.

Ashe et al. (1991) also found that largemouth bass comprised approximately 3-4 percent of the total fish population in the reservoir. Results indicate that growth rates of largemouth bass during the first four years in the Box Canyon Reservoir were lower than bass from other locations of the northern United States. The slower growth rates combined with a high rate of juvenile mortality associated with lack of overwintering habitat have reduced the potential for the bass population in the reservoir.

Bennett and Liter (1991) described the fish communities in Box Canyon Reservoir, the sloughs, and tributaries and examined factors that could limit game fish

production. Their findings determined that factors such as warm water temperatures and thermal barriers at the mouths of sloughs limited native trout. They estimated that overwinter survival of age 0⁺ largemouth bass in Box Canyon Reservoir ranged from 0.4-3.9%. It was suspected that poor overwinter survival is partially due to the lack of cover during the winter months.

Ashe et al. (1991) provided recommendations based upon these findings for enhancing fishery opportunities. Recommendations include: 1) construct an off-site rearing facility to supplement the number of juvenile largemouth bass within the Box Canyon Reservoir; 2) enhance tributary populations of native trout, and; 3) increase the amount of overwinter habitat in the reservoir. Bennett and Liter (1991) suggested similar management possibilities in the Box Canyon Reservoir such as supplementation of largemouth bass to enhance recruitment and introduction of a predator species to take advantage of the extensive forage base.

The recommendations from Ashe et al. (1991) were adopted and incorporated into the 1994 resident fish and wildlife section of the Council's Program and were further revised in the Council's 1995 Program. These recommendations called for:

- 1) Restoring tributary populations of native cutthroat and bull trout, and
- 2) Enhancing the largemouth bass population to provide a quality sport and subsistence fishery in the reservoir.

These goals may appear to conflict, but there is a dramatic difference in habitat between the tributaries and Box Canyon Reservoir. The Box Canyon reach of the Pend Oreille River was formed in 1955 by the construction of Box Canyon Dam. The dam forever changed the habitat in this reach to a broad, shallow reservoir. This resulted in higher summer water temperatures that exceed Washington Department of Ecology temperature standards on a regular basis. This change in habitat made favorable conditions for warmwater species. Ashe et al. (1991) and Bennett and Liter (1991) concluded that yellow perch is the most abundant species in Box Canyon Reservoir. The other species in descending order based on relative abundance are pumpkinseed, tench, and largemouth bass. Trout species are rare and of the trout species present, brown trout are the most abundant. Temperature conditions limit the distribution of native trout in the reservoir. In addition to the differences of habitat between tributaries and the reservoir, preliminary adfluvial trapping data suggests that adfluvial populations of cutthroat and bull trout are non-existent. Thus, habitat overlap between native trout and largemouth bass is unlikely and interaction very unlikely (NEPA Doc, 1996).

Cutthroat and bull trout populations residing in the tributaries need to be protected since these appear to be the remaining populations in the Lower Pend Oreille Subbasin. The three greatest impacts to these populations include: 1) habitat degradation from past land use activities; 2) habitat fragmentation and loss of connectivity due to man-made structures; and 3) hybridization and competition from introduced species. Genetic analysis conducted by the Washington Department of Fish and Wildlife (WDFW) showed that Pend Oreille River tributary populations of westslope cutthroat trout were genetically distinct from one another (Shaklee and Young 2000). Of the eight tributaries surveyed in the initial year of the project, none has been stocked with hatchery fish since 1978. Four of the eight have not been stocked since the 1940's. Although relative

abundance is low, genetic analysis and stocking records suggest these cutthroat trout populations are sustained without hatchery supplementation.

Isolation due to the fragmentation of native populations is likely to increase the risk of extinction through both environmental stochasticity and lack of genetic variation (Rieman and McIntyre 1993; Lacy 1987). Degraded habitat resulting in poor complexity further increases the risk of extinction for small, isolated populations because refugia from extreme environmental events are lacking (Pearsons et al. 1992, Saunders et al. 1990; Sedell et al. 1990). Hilderbrand and Kershner (2000) estimated that 8 km of stream length are required to sustain an isolated population of cutthroat trout with high abundance (0.3 fish/m).

Interactions with non-native species have also had an impact on resident populations of westslope cutthroat and bull trout. Brook trout X bull trout hybridization appears to be the most prevalent problem in isolated populations (Markle 1992). Competitive interactions with introduced species (mainly brook trout) have likely contributed to depressed cutthroat trout populations in the Lower Pend Oreille Subbasin. Of the 25 streams surveyed by the KNRD in the Lower Pend Oreille Subbasin, the highest cutthroat trout densities have been observed in streams and headwater reaches where brook trout were absent. Several studies indicate that abiotic factors (e.g. water temperature and velocity) may determine which trout species will be dominant in a given length of stream (De Staso and Rahel 1994; Griffith 1988).

Bull trout and cutthroat trout habitat assessment and population abundance.

The Kalispel Resident Fish Project began in 1995 with the selection of the study tributaries, habitat assessments, and assessment of fish populations in those tributaries. These baseline surveys showed that fish habitat is generally poor due to a lack of large woody debris, lack of pool type habitat, and high volumes of fine sediment. As a result of these conditions, rearing, spawning, and winter habitat were identified as limiting factors to fish populations in most reaches.

Based on the assessments taken during that initial field season, a process was developed to filter out the reaches of those tributaries that contained the most numerous limiting factors to fish habitat quality and quantity (KNRD & WDFW 1995). A set of recommended enhancement measures was subsequently developed for each of these reaches that are intended to address the specific habitat shortcomings. This list of recommendations was implemented during field season 1996 and became the core for additional recommendations for 1997 and 1998. Field season 1998 was the last year of implementation for recommended enhancement measures on the seven designated study tributaries. Post assessments of habitat and fish populations were conducted the year following implementation and on an annual basis thereafter.

2000 marked the fourth year of conducting monitoring and evaluation on structures that were implemented in 1996. Comparative analyses of changes in habitat attributes and changes in fish abundance using graphical displays were conducted following the 2000 field season. Also, the monitoring data has been examined for trends that may indicate which specific types of enhancement measures provide the greatest increase in habitat quality and quantity. However, at this point in the project no detailed analysis and interpretations have been performed and past annual reports have only

discussed trends. It is difficult to distinguish the effects of the restoration among many interacting factors and great natural variability within the physical and biological components of the ecosystem. Also, much of the restoration implemented may not yield results for several years or decades. More monitoring needs to be performed to minimize the variability in both habitat and fish abundance data.

Largemouth bass habitat enhancement.

The Upper Columbia United Tribes Fisheries Center conducted a three-year baseline study to assess the fishery improvement opportunities on the Pend Oreille River (Ashe 1992). Based on earlier estimates of aquatic macrophyte community composition (Falter et al. 1991) and limited overwinter survival of 0⁺ largemouth bass (Bennett et al. 1991), they suggested that the winter reduction in macrophyte communities created higher predation rates on 0⁺ bass. This led to their recommendation for the construction and placement of artificial cover structures to increase the amount of winter cover available in the reservoir. Baseline species abundance were determined by electrofishing the selected treatment and control sloughs prior to structure placement. In 1997 100 Berkley artificial structures and 100 Pradco artificial structures were constructed and placed in the study sloughs. Treatment and control sloughs have been sampled twice annually since implementation of the habitat structures. In 2000, data continued to be examined to determine: 1) if artificial structures may provide the missing winter cover component, and 2) if a difference exists between the efficacy of the Pradco and Berkley structures.

Description of Study Area

The Pend Oreille River begins at the outlet of Pend Oreille Lake, Idaho, and flows in a westerly direction to approximately Dalkena, Washington (Figure 1). From Dalkena the river turns and flows north into British Columbia where it joins the Columbia River. The approximate drainage area at the international border is 65,300 km² (Barber et al. 1990). The normal high flow month is June with a mean discharge of 61,858 cfs, the normal low flow month is August with a mean discharge of 11,897 cfs (Barber et al. 1990). The Box Canyon Reservoir has 47 tributaries and covers 90 river kilometers of the Pend Oreille River, from Albeni Falls Dam at the southern border to Box Canyon Dam at the northern border.

Cee Cee Ah Creek has a drainage basin area of 63.5 km², with 14.6 km of stream (Figure 2). Cee Cee Ah has a diverse morphology with varied gradient. Cee Cee Ah has an intermediate gradient on top, a flat gradient in the middle, a steep gradient in the lower section with a 25 m waterfall, and a low gradient for the last 2 km of stream. This creek has an extensive slough system for the last 1km before it's confluence with the Pend Oreille River. Cee Cee Ah Creek empties into the Pend Oreille River at river kilometer 130.

Browns Creek (Figure 2) is a major tributary of Cee Cee Ah Creek. Originating from springs fed by Browns Lake, the creek flows approximately 3.4 miles from the origin to the confluence with Cee Cee Ah Creek. Browns Creek begins in a series of beaver ponds in the headwaters and runs through relatively undisturbed forests to another series of beaver ponds in the middle reach. The lower portion runs through mature forests with fairly consistent gradient. The drainage basin area for Browns Creek is approximately 21.5 km².

LeClerc Creek is the largest drainage of the three priority tributaries. LeClerc Creek's drainage basin is 161 km² (Figure 3). The LeClerc system is split into three separate branches (East, West, and Middle). There is approximately 93 km of stream in the LeClerc system. This is one of the largest tributary systems in the Box Canyon Reservoir. Tributaries to the LeClerc system are, Mineral and Whiteman Creeks (tributaries to the West Branch of LeClerc), and Fourth of July Creek (tributary to East Branch of LeClerc Creek). The East and Middle branch flow together 5 km above the confluence with the Pend Oreille River. The main branch is formed by the merging of the East and West branches 2.5 km above the Pend Oreille River. LeClerc Creek flows into the Pend Oreille River at approximately river kilometer 90.

Indian Creek has the smallest drainage basin of all the tributaries surveyed at 20 km² and is one of the shortest tributaries with 3.84 km of stream (Figure 4). This stream has no secondary tributaries and is spring fed. This stream flows through relatively low gradients and is generally wide and shallow. A series of beaver dams are constructed at the mouth of this stream creating potential migration barriers. The stream flows into the Pend Oreille River on the East side at river kilometer 140.

Mill creek has a drainage basin area of 80.2 km², with 9.7 km of stream that empties into the Pend Oreille River at river kilometer 95 (Figure 5). The system is fed by water sources from North Baldy and the surrounding lower ridges. The stream in the upper reaches has a gentle gradient with beaver habitat and a slow meandering channel.

Due to erosion resistant geology, the lower portion of the stream changes to a high gradient system with cascading riffles and plunge pools until it reaches the confluence with the Pend Oreille River. Mill creek enters the Pend Oreille River at approximately river kilometer 108.

The bass habitat enhancement study was located in zero flow areas of the reservoir (i.e. adjacent to and within sloughs). Four sloughs were used for the study:

1) Campbell slough adjacent to the Pend Oreille Wetlands Wildlife Mitigation Project, located on the east side of the Box Canyon Reservoir, at river km 99, 2) No Name slough located directly across the reservoir from Campbell slough, on the west side of the reservoir, at river kilometer 99, 3) Cee Cee Ah slough, located within the Kalispel Reservation on the east side of the reservoir, at river km 109, and 4) Old Dike slough, contained within the Kalispel Reservation and located on the east side of the reservoir, at river km 107.

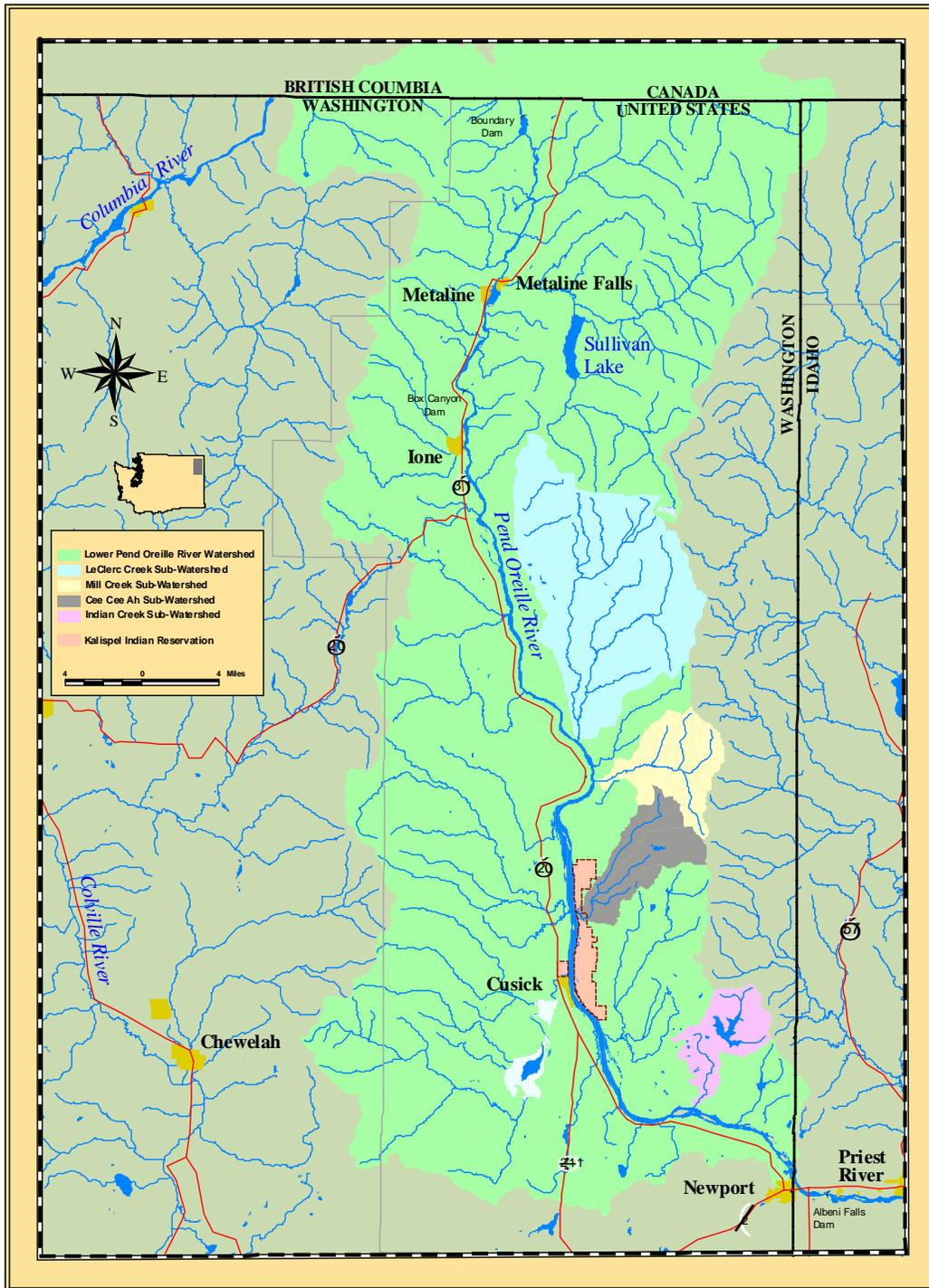


Figure1. Map of study area including Pend Oreille River watershed and sub-watersheds where enhancement activity has been implemented.

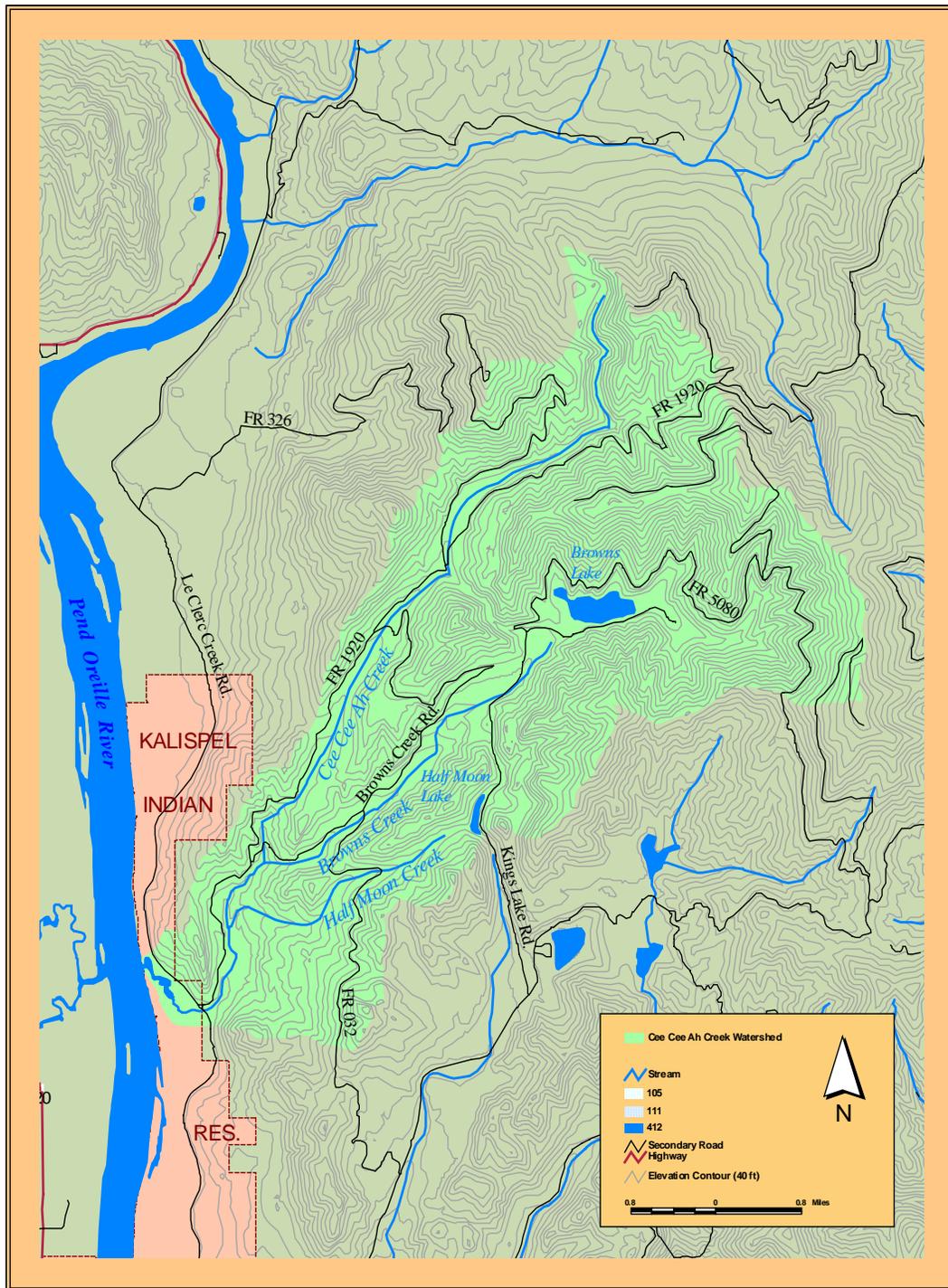


Figure 2. Map of Cee Cee Ah Creek watershed and Browns Creek sub-watershed where habitat enhancement was implemented in 1996, 1997 and 1998.

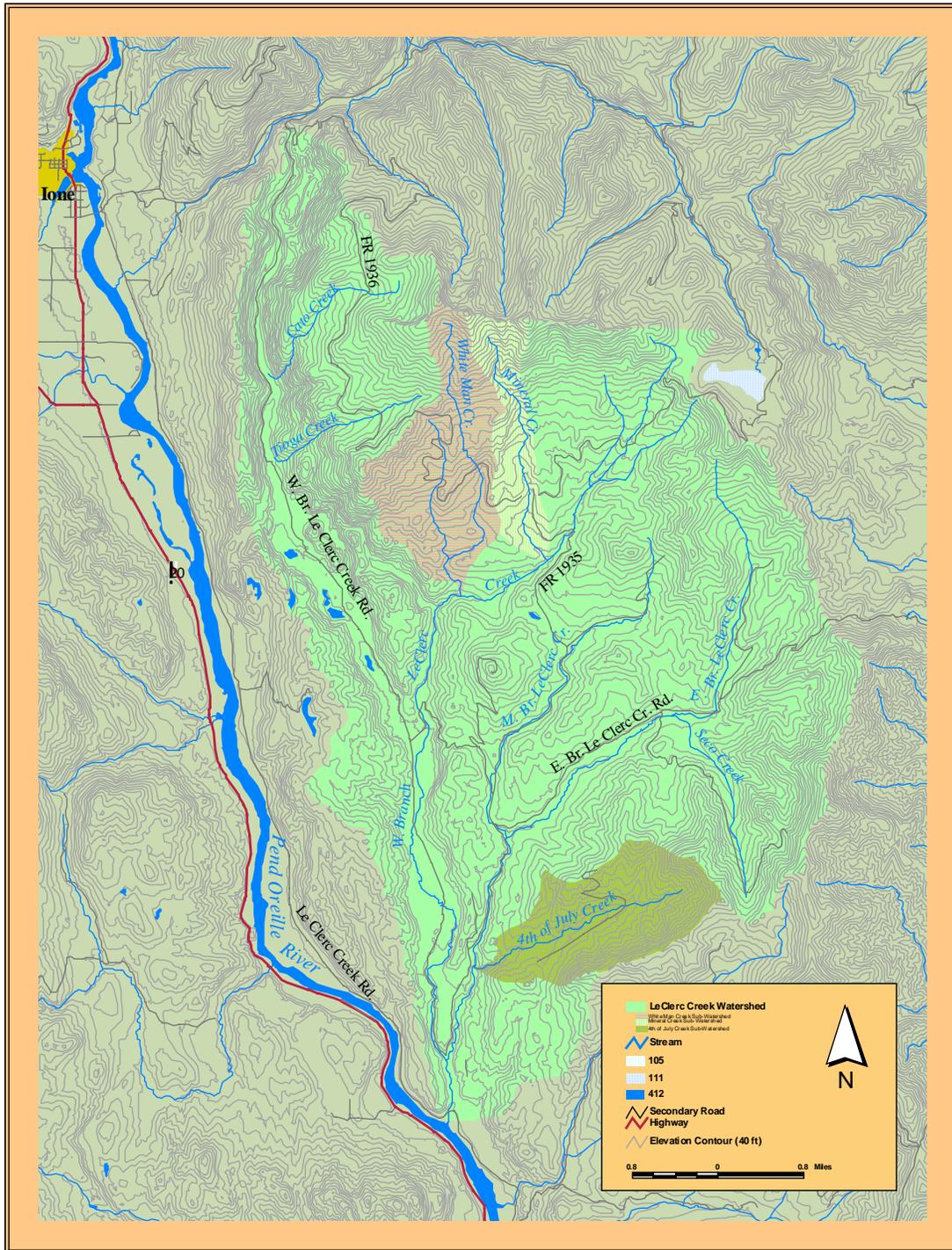


Figure 3. Map of LeClerc Creek watershed and highlighted sub-watersheds where habitat enhancement was implemented in 1996, 1997 and 1998.

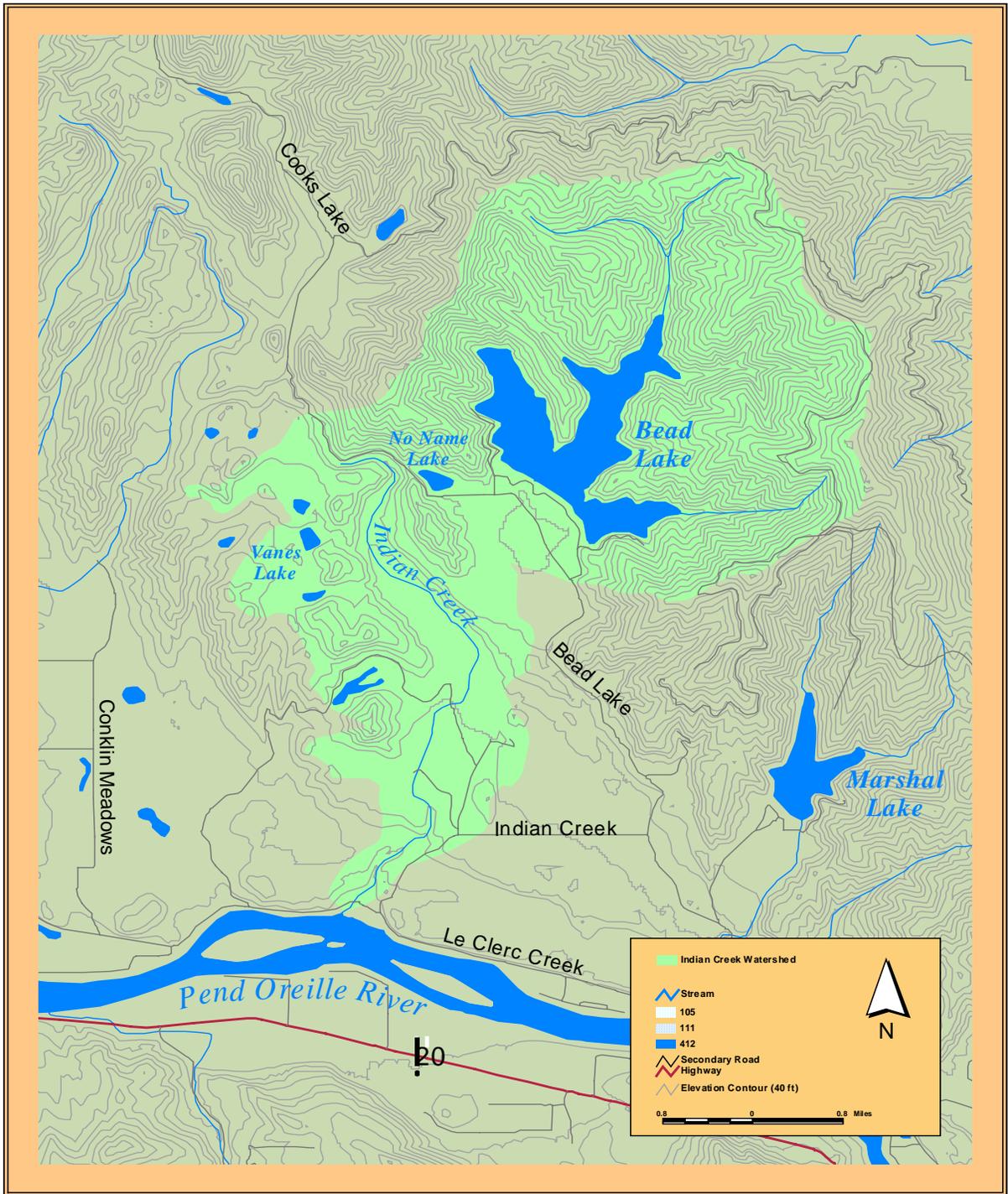


Figure 4. Map of Indian Creek watershed where habitat enhancement was implemented in 1996, 1997 and 1998.

Methods

Bull trout and cutthroat trout habitat assessment and population abundance

Stream and fish population survey methodologies used within the Box Canyon Reach were similar to those developed by Espinosa (1988) and further revised by Huntington and Murphy (1995). The KNRD stream habitat survey methodology contained four facets: transect surveys, reach overviews, interreach comparisons and fish surveys. Habitat surveys were broken into two components: transect surveys and reach overview surveys. Transect surveys were the division of the stream into 30-meter (m) segments. Primary pools, spawning habitat and acting woody debris counts were collected for the entire length of each 30-m segment. The remainder of the habitat quality parameters (Table 1) such as habitat type, substrate, habitat function, bank stability, cover, and embeddedness were collected at the end of each 30-m segment (the actual transect site). This method allowed for a number value to be assigned to each habitat quality parameter. Reaches were defined by stretches of stream with common gradient, substrate and vegetation. Breaks between two homogeneous areas defined a new reach. Reach overview surveys were the visual observation and description of variables occurring within each reach (Table 2). Each reach was permanently marked and flagged using aluminum tags and flagging as a reference point for long-term monitoring.

Fish density estimates for baseline surveys were collected using standard snorkel survey techniques (Espinosa 1988). Sampling was conducted during the period from July 15 through September 15. Population density was addressed by number, size (age class) and species of fish per 100 m². The standard size/age classes for salmonid species (Table 3) were determined according to Espinosa (1988). Lengths of baseline snorkel stations were 30 m and selected so that the area snorkeled is representative of the reach. Fish stations were permanently marked and flagged using aluminum tags and flagging.

Following the compilation of transect data, an interreach comparison was conducted using the mean values for each reach. This was the fundamental unit of comparison to determine specific reaches for enhancement projects. Threshold values were established for embeddedness, bank stability, bank cover, instream cover, pool-riffle ratio, spawning gravel and primary pools (Table 4). All threshold values were obtained from Hunter (1991) and/or MacDonald et al. (1991). The mean data for each reach was analyzed by using these threshold criteria. Each habitat value that did not fall within the threshold was counted as habitat that is unsatisfactory for quality or quantity. The reaches with the most numerous unsatisfactory habitat values were identified as potential enhancement sites for that particular stream. Snorkel surveys were used to determine fish population densities and age class distribution for all salmonid populations within each stream. Information from the snorkel surveys and the interreach comparisons was used to draw conclusions on the effects of degraded habitat quality and non-native salmonids on native salmonid species. Conclusions were used to aid in more informed restoration recommendations.

The data from the specific reaches identified in the interreach comparison was evaluated in a flowchart to provide a list of possible options for the types of structures or

measures used in enhancement (Figure 6). The flow chart took into account gradient, embeddedness, and pool to riffle ratio. Each structure was designed to perform specific functions and required specific habitat placement (Table 5). Structure selection was made by reviewing the list of options for enhancement and choosing the structure that addresses the limiting factors for each particular reach of enhancement. Reach accessibility was also considered when choosing between structures with similar function but varying levels of effort in their construction. Specific placement was determined by the transects within each reach that were in the habitat type for which each structure was designed.

Prior to implementation, all sites selected as areas for enhancement were pre-assessed using an intense version of the standard transect methodology. The same methodology was used for both pre and post assessments. The only modification to the transect methodology was shortening the length between transects. Riparian project areas were assessed with 10-m transects for each kilometer where fencing and planting occurred. Instream structures were assessed using 5-m transects from 30 m above (upstream) the structure site to 30 m below (downstream).

Fish monitoring stations for riparian restoration were calculated to be one 30-m snorkel station per 250 m of stream. A minimum sample size of three snorkel stations for each restoration area was conducted, unless the area was less than or equal to 90 m long, in which case the entire area was snorkeled. Assuming the lowest known bull trout population density (0.075 bull trout/30 m) in the state of Washington (Hillman and Platts 1993), we were 95% confident that if bull trout were in the stretch of the stream we would observe them at this rate of sampling. Bull trout were used to determine the sample size because they are the least abundant native salmonid species in the area. Each monitoring station was benchmarked at the upper and lower boundary with labeled aluminum tags attached to rebar stakes. Data from snorkel stations will be used to determine densities of all fish species present.

Fish monitoring for instream structures was conducted annually to determine the fish numbers and species within the enhancement area. The stream length snorkeled, from 30 m below to 30 m above the stream section where structures were placed, was identical to where habitat monitoring occurs.

All in-stream structure enhancement areas were monitored annually. Riparian planting and cattle exclusion fence sites are intended to provide longer term rehabilitation over an extended time schedule. The rate of post-assessment sampling for these sites will be every third year.

Post assessment data in 14 reaches were compared to pre-assessment data for structures implemented from 1996 to 1998. Comparisons were limited to the following stream survey attributes: 1) substrate embeddedness, 2) spring spawning gravel, 3) fall spawning gravel, 4) percent pool habitat, 5) average depth, 6) average width, and 7) number of primary pools. These survey attributes were chosen for comparison because they have the best potential to reflect short term changes in habitat that may result from the restoration structures. Also, these were the attributes identified in the baseline surveys as limiting fish populations. Since no control reaches were sampled, changes to habitat attributes were assumed to be the result of the restoration structures.

Largemouth bass habitat enhancement

Selection of the sloughs used in the bass habitat study was based on the two types of sloughs available within the reservoir. The sloughs are either backwater stream mouths or dead end river backwater. Four sloughs were selected: one stream fed treatment slough, one stream fed control slough, one backwater treatment slough and one backwater control slough.

Two types of artificial structures were used in the treatment sloughs. The Berkley structures are 4-ft. cubes of plastic slats that provide cover in the interstitial spaces. The Pradco structures resemble palm trees and provide cover under the palms. The placement of each type was alternated between the two treatment sloughs (Berkley in the mouth transect in one slough and in the inland transect of the second slough).

Each slough was sampled prior to artificial habitat installation. Two 75-m sampling transects were established for each slough. Between the transects, a 75-m buffer was established to avoid data collection overlap. Each transect was then electrofished for a period of 300 seconds and all fish were collected. Bass total lengths and abundance were recorded; all other fish were recorded as total numbers by species.

In the spring and fall, each transect is electrofished annually. Relative abundance (CPUE) and species composition are calculated for each transect. Analysis will include whether the structures increase the abundance of juvenile largemouth bass and whether utilization is higher for either the Berkely or Pradco structures.

Table 1. Transect variables and method of collection.

Variable	Method of collection
Habitat Type	Visually determine habitat types (i.e., pool, riffle, glide, pocketwater, run, alcove).
Dominant Substrate Size	Visually determine largest percentage of substrate for that habitat type (i.e., silt, sand, gravel, cobble, boulder, bedrock).
Habitat Function	Visually determine habitat functions (i.e., winter, summer, spawning or unusable).
Spawning Gravel Amount and Quality	Measure potential square meters of spawning gravels within each transect and quality (i.e. gravel size, location and current velocity Kalispel internal doc.1-95) Good = All criteria met. Fair = 2 criteria met. Poor = 1 criteria met.
Stream Depths	Measure depth at 1/4, 1/2, 3/4 across channel to the nearest cm.
Habitat Widths	Measure each specific habitat type in a transect to the nearest 0.1m.
Primary Pools	Number of pools with length or width greater than the avg. width of stream channel within each transect.
Pool Quality	Rating based upon collection of length, width, depth, and cover.
Pool Creator	Identify item creating the pool (e.g., large woody debris, boulders, beaver, enhancement, other).
Cobble Embeddedness	Visual estimate of the percentage fine or coarse sediment surrounding substrate / Actual measurement was recorded with an embed meter approximately every 20 transects. Regression of the estimated numbers with the actual measurements calculated a correction factor for all estimated values.

Table 1. *continued*

Variable	Method of collection
Bank Stability	Visual estimate of the percentage of unstable bank per transect for possible sediment source.
Instream Cover Rating	Percent of the stream surface covered by large woody debris, aquatic vegetation, bank vegetation in or near the surface of the water / Amount of cover provided by undercuts, root wads, boulders or turbulence.
Dominant/Subdominant Riparian Vegetation	Visual estimate of dominant vegetation and of subdominant vegetation species.
Stream Channel Gradient	Using a clinometer measure percent slope.
Acting Woody Debris	Number of woody debris with a diameter >10cm and a length >1m in the stream.
Potential Debris Recruitment	Number of trees within the transect that could potentially fall into the stream > 10 cm and a length > 1m.
Residual Pool Depth	The average pool depth by averaging the deepest portion of the pool and the pool tailout. Measure to the nearest cm.

Table 2. Reach variables and method of collection.

Variables	Method of Collection
Air and Water Temperature	Thermometer reading in centigrade.
Channel Type	A general classification of channel type based on channel morphology (see Rosgen 1994).
Average Embeddedness	Estimate of the average embeddedness for the entire reach Actual measurement was recorded with an embed meter approximately every 20 transects, Regression of the estimated numbers with the actual measurements calculated a correction factor for all estimated values.
Dominant Habitat Type	Dominant habitat type for the reach (i.e., pool, riffle, glide, pocketwater, run, alcove).
Disturbance	Estimation of the effects of land use practices (i.e. logging, roads, cattle, mining).
Aquatic Vegetation	Estimation of the occurrence of aquatic vegetation for the reach (i.e., abundant, fairly common, scarce, none).
Shading	Visual estimation of the amount of stream shaded by canopy along the stream reach
Habitat Quality	Estimation of the habitat quality for the entire reach (i.e., good, fair, poor).
Other	Any notable attribute not required for recording that can be recorded for reference to impact, or in interest to habitat quality.

Table 3. Fish species age/length class distributions (Espinosa 1988).

Species	Age	Length
Cutthroat Trout	0+	< 65 mm FL
Rainbow Trout	1+	65-110 mm FL
	2+	111-150 mm FL
	3+	151-200 mm FL
	4+	201-305 mm FL
	BIG	> 305 mm FL
Bull Trout	0+	< 65 mm FL
Brook Trout	1+	65-115 mm FL
Brown Trout	2+	116-165 mm FL
	3+	166-210 mm FL
	4+	211-305 mm FL
	BIG	>305 mm FL
Mountain Whitefish	N/A	< 100 mm
	N/A	100 - 305 mm
	N/A	> 305 mm
Sculpin	Total Number	Record Species If Possible
Sucker	Total Number	Record Species If Possible

Table 4. Interreach comparison threshold values (after Hunter 1991; MacDonald 1991).

Limiting Factors	Threshold Value
Embeddedness	Any value $\geq .30$ or $\leq .70$
Bank Stability	Any value $\leq 75\%$
Bank Cover	Any value ≤ 2.5
Instream Cover	Any value ≤ 2.0
Pool - Riffle Ratio	Any value $\leq .5:1$ or $\geq 1.5:1$
Spawning Gravel	Three lowest cumulative values
Primary Pools	Three lowest values

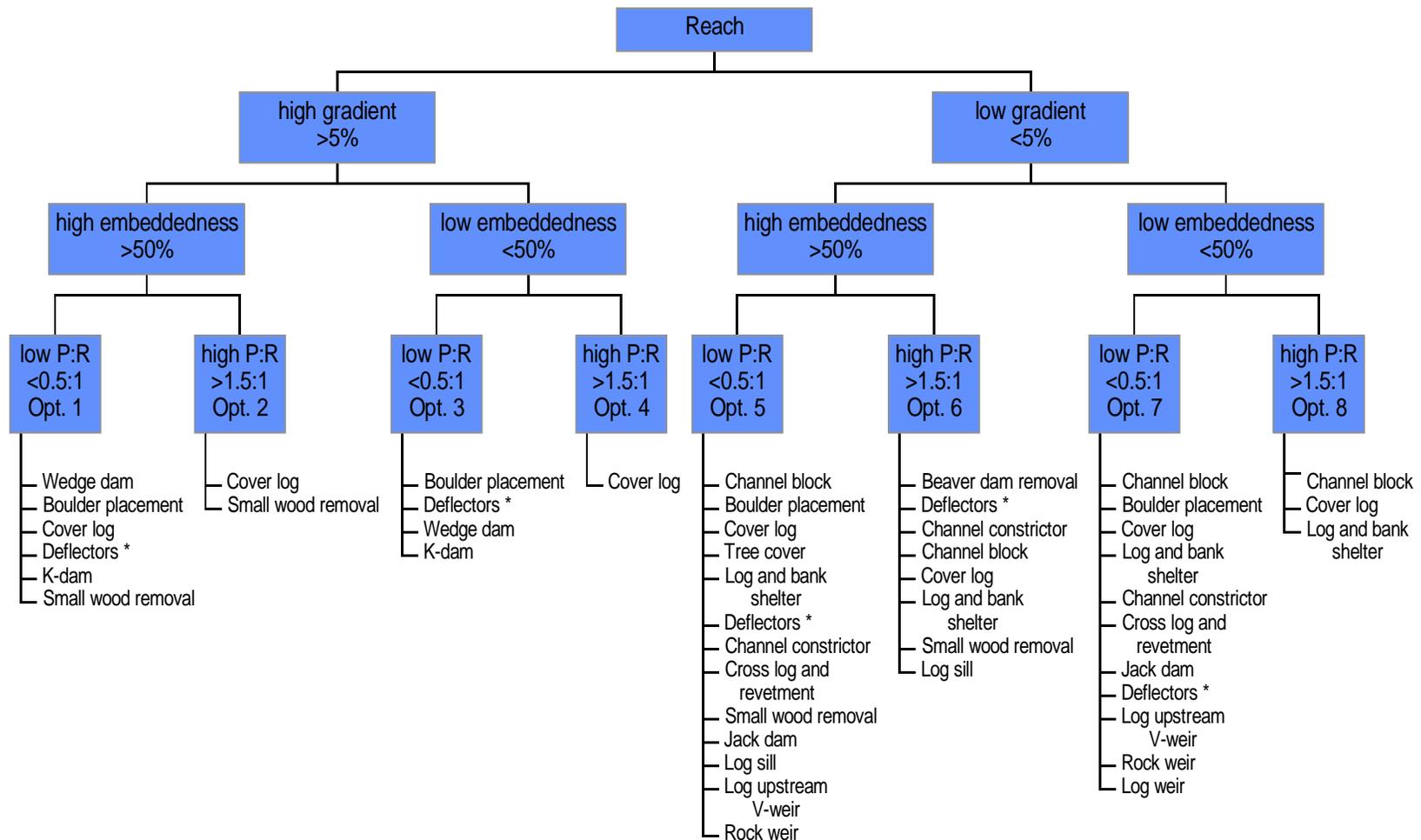


Figure 5. Flowchart for identified reaches of enhancement and the possible structures available for enhancement. Values derived after Harrelson et al. 1994, Macdonald 1991 and Hunter 1991. Table 4. Instream structures and the descriptions for placement requirements, function and impacts.

Table 5. Instream structures and the descriptions for placement requirements, functions and impacts.

<u>Structure</u>	<u>Habitat</u>	<u>Stream Requirements</u>	<u>Purpose</u>	<u>Impacts</u>
Wedge dam	Riffles Runs	Well defined stream banks. Stream < 30 ft. wide. Gradient >5%. Substrate consisting of: Rubble, cobble and gravel Ideal locations are at a break In gradient with a steeper section Immediately upstream.	Creates a fair to excellent scour pool. Creates spawning gravel at tail-out of pool	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Boulder placement	Riffles Runs	Greatest benefits in currents Exceeding 2 feet per	Provides overhead cover and resting areas.	+ Creates pocketwater behind boulder. + Added depth is also created by the scouring resulting from reduced channel capacity and increased current velocity.
	Glides	Second.		
	Open Pools	Suitable for any size stream.	Creates natural appearance.	
Cover log	Open Pools Runs	Works best in meanders or in conjunction with deflectors. Requires adequate water depth (at least 8" deep.) Suitable for any size stream.	Provides optimum cover.	+ Creates overhead cover. + Directs current away from meander. - May cause unwanted bank cutting.
Single-Wing Deflector	Riffles	When possible, divert water into a	Constricts and diverts	+ Constricts and diverts water flow.
	Glides	Relatively stable section of stream	water flow so that	+/- May cause deposition of sediment just below
	Runs	Bank	Pools are formed by Structure towards bank	

Table 5. *continued*

<u>Structure</u>	<u>Habitat</u>	<u>Stream Requirements</u>	<u>Purpose</u>	<u>Impacts</u>
Double-Wing Deflector	Riffles	Especially suitable for shallow	Creates mid-channel	+ Narrows channel.
	Runs Glides	sections of stream where the gradient is too steep for effective deflector and cover log.	pools through scouring. Creates spawning gravel at tail-out of pool.	+ Scours a pool below structure. +/- May cause deposition of sediment just below structure towards bank. - May cause unwanted bank cutting.
Channel Constrictor	Riffles	Provides best results when placed	Provides overhead	+ Scours the streambed.
	Runs Glides	in long, straight, low-gradient stretches of stream.	cover. Narrows channel. Scour and deepen streambed.	+ Increases velocity. + Helps transport sediment. - May concentrate sediment below structure. +/- Incises the channel.
Log Deflector	Riffles	When possible, divert water into a	Constricts and diverts	+ Constricts and diverts water flow.
	Glides	relatively stable section of stream	water flow so that	+/- May cause deposition of sediment just below
	Runs	bank. Suitable for a variety of sites. Most suitable in wide shallow riffles.	pools are formed by scouring. Creates spawning gravel	structure towards bank. + Directs meander.

Table 5. *continued*

<u>Structure</u>	<u>Habitat</u>	<u>Stream Requirements</u>	<u>Purpose</u>	<u>Impacts</u>
Log Paired Deflector	Riffles	Especially suitable for shallow	Creates mid-channel	+ Narrows channel
	Runs Glides	sections of stream where the gradient is too steep for effective deflector and cover log.	pools through scouring. Creates spawning gravel at tail-out of pool.	+ Scours a pool below structure. +/- May cause deposition of sediment just below structure towards bank.
Rock Deflector	Riffles	When possible, divert water into a	Directs flow from	+ Constricts and diverts water flow.
	Runs	relatively stable section of stream	cut bank.	+/- May cause deposition of sediment just below
	Glides	bank. Suitable for a variety of sites. Most suitable in wide shallow riffles.	Directs meander. Scours pool.	structure towards bank. + Directs meander.
Boulder Paired Deflector	Riffle	Especially suitable for shallow	Creates mid-channel	+ Narrows channel.
	Runs Glides	sections of stream where the gradient is too steep for effective deflector and cover log.	pools through scouring. Creates spawning gravel at tail-out of pool.	+ Scours a pool below structure. +/- May cause deposition of sediment just below structure towards bank.

Table 5. *continued*

<u>Structure</u>	<u>Habitat</u>	<u>Stream Requirements</u>	<u>Purpose</u>	<u>Impacts</u>
K – Dam	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient >5%. Substrate consisting of: rubble, cobble and gravel. Ideal locations are at a break in gradient with a steeper section immediately upstream.	Creates a fair to excellent scour pool. Creates spawning gravel at tail-out of pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment. - Prone to undercutting of structure.
Small Wood Removal	Riffles Glides Runs	Small wood must be acting as a silt trap or inhibiting fish migration in order to be removed. Typically used to increase velocity and transport sediment.	Typically used to increase velocity and transport sediment. Helps expose substrate.	+ Increases velocity. + Transports sediment. + Exposes substrate. + Narrows channel.
<u>Structure</u> Channel Block	<u>Habitat</u> Braided Channel	<u>Stream Requirements</u> Braided channel that is virtually unusable.	<u>Purpose</u> Consolidates flow . into a single, deeper channel.	<u>Impacts</u> + Concentrates flow into a single deeper channel. + May increase velocity. - May concentrate sediment deposition downstream.

Table 5. *continued*

<u>Structure</u>	<u>Habitat</u>	<u>Stream Requirements</u>	<u>Purpose</u>	<u>Impacts</u>
Tree Cover	Riffles Runs Glides	Suitable for a variety of sites. Greatest benefits probably occur in wide shallow streams with sand or gravel substrate.	Provides excellent overhead cover. Increases stream velocity. Transports sediment.	+ Constricts wide shallow channels. + Increases stream velocity. + Transports sediment.
Log & Bank Shelter	Open Pools	Suitable for use in low gradient. Stream bends or meanders. Can be used with a deflector.	Provides overhead cover. Provides some streambank protection.	+ Creates overhead cover. + Directs current away from meander.
Cross Log & Revetment	Riffles Runs	Structure works best in low gradient sections of the stream. Works even better at the beginning of wide, shallow bends with marginal pools or cover.	Creates scour pool. Creates overhead cover. Protects the bank.	+ Creates a scour pool. + Protects bank.
Jack Dam	Riffles Runs	High banks. Moderate to steep gradient.	Produces deep scour pools.	+/- Creates calmer water above the structure. + Creates scour pool.

Table 5. *continued*

<u>Structure</u>	<u>Habitat</u>	<u>Stream Requirements</u>	<u>Purpose</u>	<u>Impacts</u>
Log Sill	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%.	Creates scour pool. May create spawning gravel.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Log Upstream V-Weir	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%. Works well in sand and gravel substrate.	Creates deep plunge pool. Creates spawning gravel at tail-out of pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Rock Weir	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%.	Creates scour pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Log Weir	Riffles Runs	Well defined stream banks. Stream < 15 ft. wide. Gradient <5%.	Creates scour pool.	+/- Creates calmer water above the structure. + Creates a scour pool below the structure. +/- May act as a trap for sediment.
Beaver dam removal	Long Pools	A beaver dam in the in the lower 2/3 of the stream . A beaver dam that may inhibit fish passage.	Narrows channel. Exposes substrate.	- Releases a large volume of sediment downstream. +/- Incises the channel . + Decreases sediment upstream. + May expose substrate such as cobble, gravel and boulders.

Results

Bull trout and cutthroat trout densities and habitat attributes in restoration sites.

Cee Cee Ah Creek

Reach 4

In 1996, three K-dams were constructed in reach 4 following the pre-assessment. Inter-annual trends have been variable; however, substrate embeddedness decreased from 48% in the pre-assessment to 32% in 2000 (Table 6). Combined spawning gravel was highest in the pre-assessment (24 m²) and declined to 0.5 m² in 2000. The percent of pool habitat increased from 7.3% in the 1996 pre-assessment to 24% in 2000. Average depths have increased from 12.1 cm in the pre-assessment to 19.5 cm in 2000. Increased average width was also observed; average width increased from 3.1 in 1996 to 3.8 in 2000. Primary pools increased from 2 in the 1996 pre-assessment to 5 in 1999; however, despite the increase in pool habitat percent, primary pool number decreased in 2000 to 2.

In the 1997 implementation site, four K-dams were constructed following the pre-assessment. Embeddedness decreased from 48% in 1997 to 34% in 2000 (Table 7). Spawning gravels increased from 0.5 m² in the 1997 pre-assessment to 2.5 m² in 1999, and then no spawning gravels were observed in 2000. Percent pool habitat also increased; pools comprised 17% in 1997 and 42% in 2000. Average depth decreased from 31.9 cm in 1997 to 21.2 cm in 2000. Average width has varied annually; and was unchanged in 2000 relative to the pre-assessed width of 3.7 m. Primary pool numbers increased; no primary pools were observed in the pre-assessment and 2 primary pools were identified in 2000.

Five structures were implemented in 1998. Embeddedness has been variable; pre-assessed embeddedness was 45% and 2000 embeddedness was 43% (Table 8). No spawning gravel was observed in the pre-assessment and in 1999, 1.0 m² of combined spawning gravel was counted in 2000. Percent pool habitat has increased dramatically. No habitat was classified as pool in the 1998 pre-assessment and 51% of the habitat was classified as pool in 2000. Average depth decreased from 31.6 cm in 1998 to 21.2 cm in 2000. Average width remained relatively unchanged; width was 4.5 m in 1998 and 4.4 m in 2000. The number of primary pools has increased from 1 in the pre-assessment to 3 in 2000.

Brook trout were the only fish species observed in the structures implemented in reach 4. Densities decreased in the 1996 and 1997 implementation sites and increased in the 1998 site (Figure 7). In the section of reach 4 where structures were implemented in 1996, pre-assessment brook trout densities were 8.6 fish/100 m² and declined to 4.0 fish/100 m² in 2000. For the reach 4 site implemented in 1997, brook trout densities decreased from 4.7 fish/100 m² to 4.0 fish/100 m² in 2000. In the 1998 implementation site, brook trout density has increased from the 3.9 brook trout/100 m² in the pre-assessment to 4.6 brook trout/100 m² in 2000. No snorkel data were collected in reach 4 during the 1999 field season because of a U.S. Forest Service area closure due to safety concerns with a helicopter logging operation and heavy log truck traffic.

Table 6. Annual Cee Cee Ah Creek reach 4 habitat attributes from the 1996 implementation site.

Attribute	96 Structures				
	Pre '96	Post '97	Post '98	Post '99	Post '00
Embeddedness (%)	48	52	38	60	32
Pool/Riffle	0.4	0.4	0.7	0.3	0.3
Spring Spawn Gravel (m ²)	15.8	0.0	5.5	0.5	0.5
Fall Spawn Gravel (m ²)	8.1	0.0	4.5	0.0	0.0
% Pool	7	5	5	19	24
% Riffle	65	61	50	48	69
% Run	11	20	26	33	5
% Pocketwater	15	14	19	0	0
% Glide	1	0	0	0	2
Avg Depth (cm)	12.1	24.6	30.2	21.6	19.5
Avg Width (m)	3.1	3.3	3.8	3.6	3.8
# Primary Pools	2	1	2	5	2

Table 7. Annual Cee Cee Ah Creek reach 4 habitat attributes from the 1997 implementation site.

Attribute	97 Structures			
	Pre '97	Post '98	Post '99	Post '00
Embeddedness (%)	48	32	45	34
Pool/Riffle	0.7	0.6	0.4	1.0
Spring Spawn Gravel (m ²)	0.5	0.0	2.5	0.0
Fall Spawn Gravel (m ²)	0.0	0.0	0.0	0.0
% Pool	17	10	22	42
% Riffle	56	30	60	49
% Run	8	44	18	8
% Pocketwater	18	16	0	0
% Glide	0	0	0	0
Avg Depth (cm)	31.9	29.8	16.8	21.2
Avg Width (m)	3.7	4.2	3.3	3.7
# Primary Pools	0	3	1	2

Table 8. Annual Cee Cee Ah Creek reach 4 habitat attributes from the 1998 implementation site.

Attribute	98 Structures		
	Pre '98	Post '99	Post '00
Embeddedness (%)	45	59	43
Pool/Riffle	0.4	0.8	1.5
Spring Spawn Gravel (m ²)	0.0	0.0	0.5
Fall Spawn Gravel (m ²)	0.0	0.0	0.5
% Pool	0	33	51
% Riffle	67	35	45
% Run	16	32	3
% Pocketwater	13	0	0
% Glide	0	0	0
Avg Depth (cm)	31.6	23.8	21.2
Avg Width (m)	4.5	3.6	4.4
# Primary Pools	1	4	3

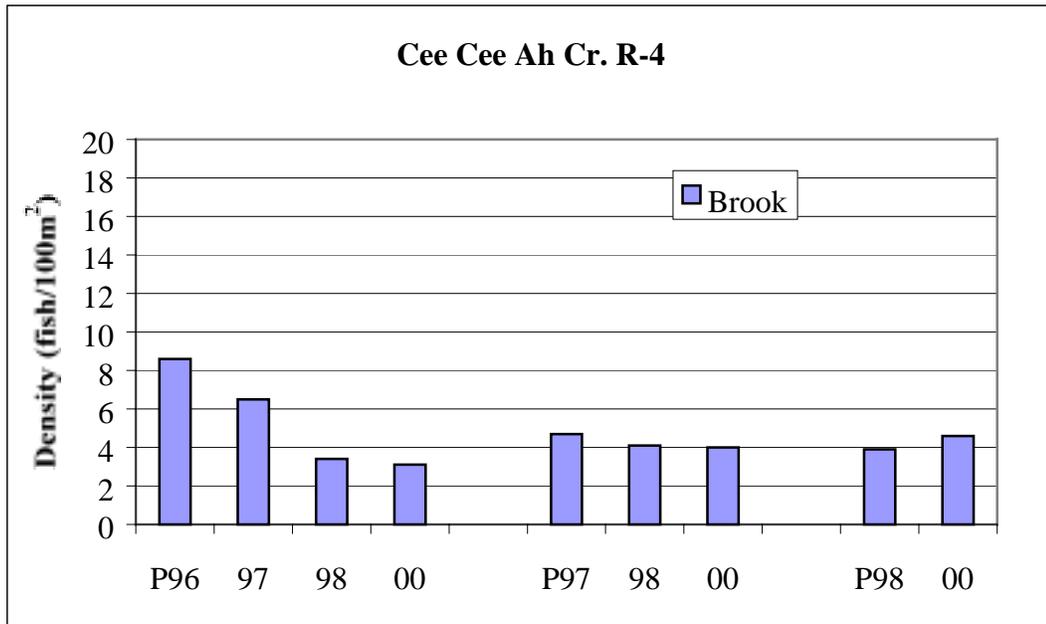


Figure 6. Annual Cee Cee Ah Creek reach 4 fish densities from the 1996, 1997, and 1998 implementation sites.

Reach 5

In reach 5, three cross log revetments were constructed in 1996 to create scour pools. Substrate embeddedness in the 1996 implementation site decreased from 77% to 43% in 2000 (Table 9). No spawning gravel was identified in the pre-assessment and 3.0 m² was observed in 2000. Pool habitat was not observed in the 1996 pre-assessment; however, 43% of the habitat was classified as pool in 2000. Average depth was greater in all post assessment years. The average depth increased from 16.2 cm in 1996 to 18.1 cm in 2000 with a high of 25.7 cm in 1998. Average width decreased from 3.1 m in 1996 to 2.6 m in 2000.

In the 1997 implementation site of reach 5, four cross log revetments were constructed to create scour pools. Substrate embeddedness was variable but decreased from 1997 to 2000 from 61% to 46%, respectively (Table 10). Combined spawning gravel increased and was only observed in 1999 (1.5 m²) and 2000 (2.0 m²). Pool habitat increased from 8% in 1997 to 80% in 2000. Average depth increased from the 1997 pre-assessment (26.7 cm) to 1998 (32.4 cm). However, the 2000 average depth was less than the pre-assessed depth. Average width increased initially from 3.6 m in the pre-assessment. However, average width decreased to 2.6 m in 2000. Primary pool number increased from 1 during the pre-assessment to 3 in 2000.

Four structures were implemented in reach 5 in 1998. Embeddedness decreased from 62% in the pre-assessment to 52% in 2000 (Table 11). No spawning gravels were observed in 1998 or 1999 and 2.0 m² were observed in 2000. Percent pool habitat increased from 20% in 1998 to 56% in 2000. Average depth and width decreased. The number of primary pools increased substantially. No primary pools were classified in the 1998 pre-assessment and 5 were observed in 2000.

In reach 5, post implementation brook trout densities were higher in the 1996 site (Figure 8). Brook trout density increased from 6.2 fish/100 m² to 11.7 fish/100 m² in 2000. Cutthroat trout were only observed at this site in 1996. For the reach 5 site implemented in 1997, brook trout density increased from 8.5 fish/100 m² to 14.5 fish/100 m² in 1999 and then decreased to 3.8 fish/100 m² in 2000. Annual decreases in brook trout were observed in the 1998 implementation site. Density declined from 14.6 fish/100 m² in 1998 to 7.4 fish/100 m² in 2000.

Table 9. Cee Cee Ah Creek reach 5 habitat attribute values from the 1996 implementation site.

Attribute	96 Structures				
	Pre '96	Post '97	Post '98	Post '99	Post '00
Embeddedness (%)	77	56	47	58	43
Pool/Riffle	0.2	0.2	0.2	0.2	0.8
Spring Spawn Gravel (m ²)	0.0	1.5	0.0	3.5	2.0
Fall Spawn Gravel (m ²)	0.0	0.0	0.0	0.5	1.0
% Pool	0	7	0	19	43
% Riffle	66	53	57	67	41
% Run	21	34	32	13	11
% Pocketwater	13	6	11	0	0
% Glide	0	0	0	0	4
Avg Depth (cm)	16.2	21.5	25.7	18.1	18.1
Avg Width (m)	3.1	3.2	4.0	3.2	2.6
# Primary Pools	2	3	5	2	7

Table 10. Cee Cee Ah Creek reach 5 habitat attribute values from the 1997 implementation site.

Attribute	97 Structures			
	Pre '97	Post '98	Post '99	Post '00
Embeddedness (%)	61	44	62	46
Pool/Riffle	0.6	0.7	0.5	5.0
Spring Spawn Gravel (m ²)	0.0	0.0	1.5	1.0
Fall Spawn Gravel (m ²)	0.0	0.0	0.0	1.0
% Pool	8	7	26	80
% Riffle	49	18	54	11
% Run	30	64	19	9
% Pocketwater	13	8	0	0
% Glide	0	2	0	0
Avg Depth (cm)	26.7	32.4	19.2	23.0
Avg Width (m)	3.6	4.7	4.1	2.6
# Primary Pools	1	2	4	3

Table 11. Cee Cee Ah Creek reach 5 habitat attribute values from the 1998 implementation site.

Attribute	98 Structures		
	Pre '98	Post '99	Post '00
Embeddedness (%)	62	68	52
Pool/Riffle	0.3	0.7	1.5
Spring Spawn Gravel (m ²)	0.0	0.0	1.0
Fall Spawn Gravel (m ²)	0.0	0.0	1.0
% Pool	20	25	56
% Riffle	52	50	44
% Run	21	26	0
% Pocketwater	7	0	0
% Glide	0	0	0
Avg Depth (cm)	31.9	22.7	21.0
Avg Width (m)	4.0	4.7	3.0
# Primary Pools	1	2	5

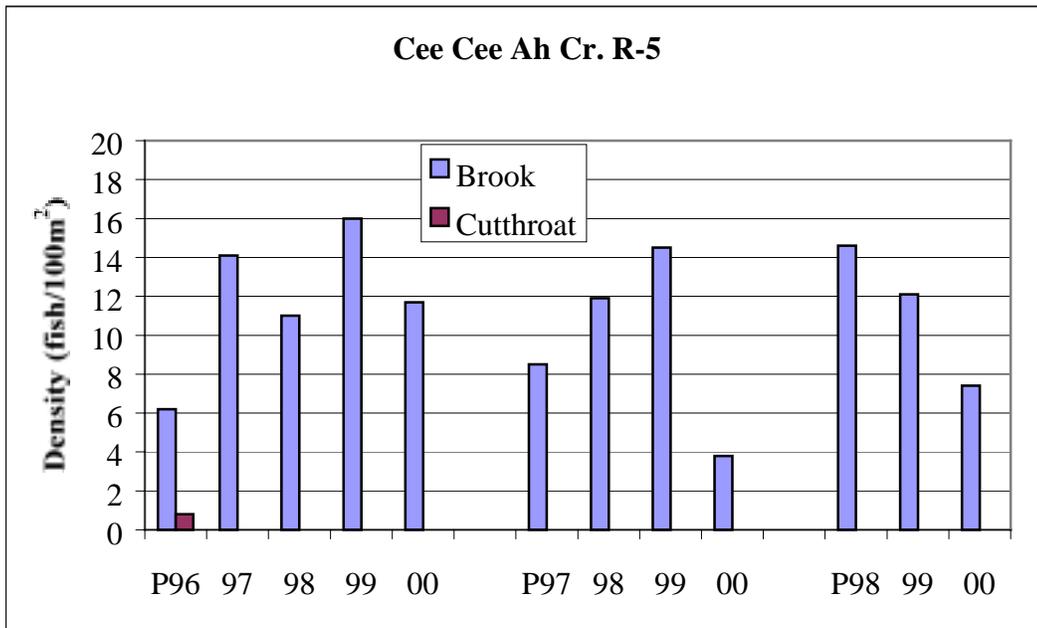


Figure 7. Annual Cee Cee Ah Creek reach 5 fish densities from the 1996, 1997, and 1998 implementation sites.

Reach 6

In 1996, three upstream v-weirs were constructed to create pool habitat and recruit spawning gravel. Substrate embeddedness in this implementation site generally decreased. Pre-assessed embeddedness was 59% and 2000 embeddedness was 49% (Table 12). A decrease in spawning gravel was observed. 14 m² was identified in the 1996 pre-assessment while post assessment spawning gravel ranged from 6 m² in 1998 to 1.5 m² in 1997. Pool habitat increased annually in the 1996 implementation site. Pre-assessed pool habitat composition was 9% and increased to 51% in 2000. All post assessment average depths were greater than the pre-assessed average depth (18.7 cm). Average widths increased from 2.5 m in 1996 to 2.6 m in 2000 with a high of 3.2 m in 1998 and 1999. The number of primary pools appeared to remain relatively unchanged. 5 primary pools were identified in 1996, 4 pools were classified as primary in 1997 and 1999, no primary pools were identified in 1998, and 5 were classified in 2000.

Four upstream v-weirs were constructed in reach 6 in 1997. Substrate embeddedness was 67% in 1997 (pre-assessment) and decreased to 45% in 2000 (Table 13). Spawning gravel appeared to increase initially; 1 m² was identified in the pre-assessment, 4.5 m² in 98, and 3 m² in 1999; however, no spawning gravel was observed in 2000. Pool habitat increased substantially from 5% in 1997 to 61% in 2000. The pre-assessed depth was 34.3 cm in 1997 and decreased to 21.9 cm in 2000. Average widths were relatively unchanged (3.3 m to 3.5 m) from 1997 to 1999 and decreased to 2.5 m in 2000. Primary pool number increased from 2 in 1997 to 4 in 2000.

In 1998, three structures were implemented to increase pool habitat and recruit spawning gravel. Substrate embeddedness decreased from 63% in 1998 to 45% in 2000 (Table 14). A decrease in spawning gravel occurred from the pre-assessment (4.5 m²) to 2000 (1.0 m²). No pool habitat was classified in the pre-assessment and 48% of the habitat was classified as pool in 2000. Average depth decreased annually from 31.1 cm in 1998 to 20.6 cm in 2000. Average width also decreased. The pre-assessed average width was 3.6 m and decreased to 2.5 m in 2000. Primary pools increased substantially from 1 to 5.

In reach 6, brook trout densities were relatively stable in the site where structures were implemented in 1996 up to 2000 (Figure 9). Pre-implementation density was 16.6 fish/100 m², increased in 1997 to a high of 18.9 fish/100 m², and then decreased to 5.6 fish/100 m² in 2000. Brook trout density in the 1997 implementation site was 11.5 fish/100 m², increased to 17.2 fish/100 m² in 1999, and decreased to 7.8 fish/100 m² in 2000. In the 1998 restoration site, brook trout density increased nearly 400% from 4.3 fish/100 m² to 15.8 fish/100 m² in 1999. However, density in this site decreased to 5.7 fish/100 m² in 2000. In reach 6, cutthroat trout (n=1) were only observed in the 1997 pre-implementation site.

Table 12. Cee Cee Ah Creek reach 6 habitat attribute values from the 1996 implementation site.

96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00
Embeddedness (%)	59	61	41	57	49
Pool/Riffle	0.2	0.5	0.7	0.7	1.0
Spring Spawn Gravel (m ²)	7.7	1.5	6.0	2.5	1.0
Fall Spawn Gravel (m ²)	6.4	0.0	0.0	1.0	1.0
% Pool	9	12	17	38	51
% Riffle	45	35	51	49	35
% Run	39	49	24	3	7
% Pocketwater	2	4	8	1	0
% Glide	4	0	0	8	4
Avg Depth (cm)	18.7	23.9	31.7	19.9	21.6
Avg Width (m)	2.5	2.9	3.2	3.2	2.6
# Primary Pools	5	4	0	4	5

Table 13. Cee Cee Ah Creek reach 6 habitat attribute values from the 1997 implementation site.

97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00
Embeddedness (%)	67	47	67	45
Pool/Riffle	0.6	0.7	0.7	1.6
Spring Spawn Gravel (m ²)	1.0	3.5	1.5	0.0
Fall Spawn Gravel (m ²)	0.0	1.0	1.5	0.0
% Pool	5	7	39	61
% Riffle	53	60	43	32
% Run	21	19	9	7
% Pocketwater	21	14	0	0
% Glide	0	0	8	0
Avg Depth (cm)	34.3	29.9	19.6	21.9
Avg Width (m)	3.3	3.5	3.3	2.5
# Primary Pools	2	2	3	4

Table 14. Cee Cee Ah Creek reach 6 habitat attribute values from the 1998 implementation site.

Attribute	98 Structures		
	Pre '98	Post '99	Post '00
Embeddedness (%)	63	46	45
Pool/Riffle	0.3	0.4	0.8
Spring Spawn Gravel (m ²)	4.0	0.0	0.5
Fall Spawn Gravel (m ²)	0.5	0.0	0.5
% Pool	0	25	48
% Riffle	65	58	44
% Run	20	5	8
% Pocketwater	13	0	0
% Glide	0	12	0
Avg Depth (cm)	31.1	18.4	20.6
Avg Width (m)	3.6	3.2	2.5
# Primary Pools	1	2	5

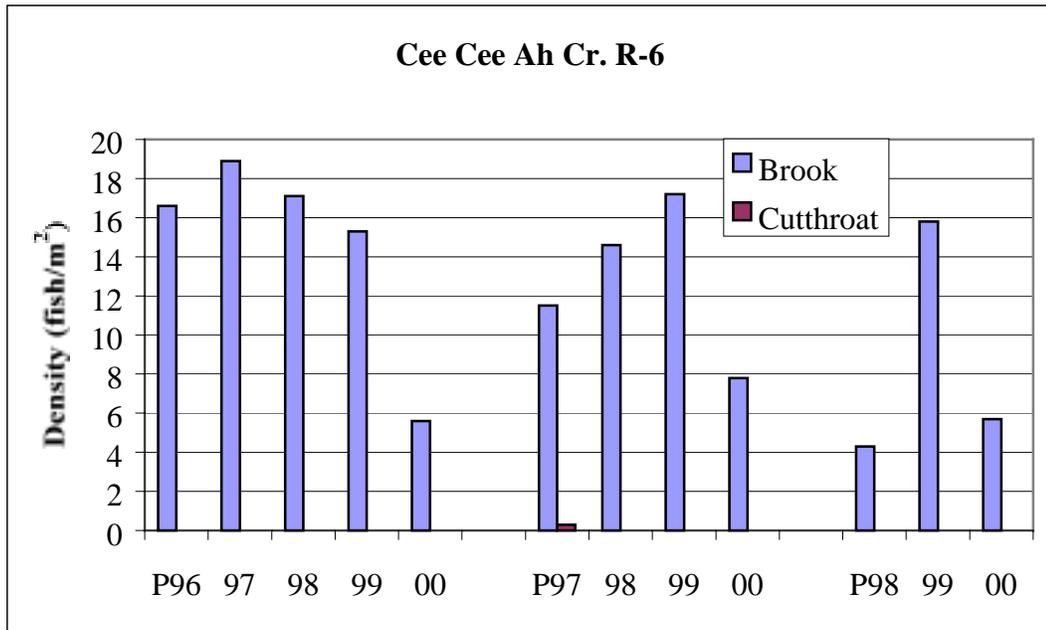


Figure 8. Annual Cee Cee Ah Creek reach 6 fish densities from the 1996, 1997, and 1998 implementation sites.

Indian Creek

Reach 3

In 1996, three double-wing deflectors were constructed in reach three following the pre-assessment. Post implementation substrate embeddedness in reach 3 was lower in all three years of monitoring (Table 15). Pre-implementation embeddedness was 80 percent and monitoring values ranged from 56% to 75%. Total spring and fall spawning gravel progressively declined from the pre-assessed estimate of 46 m² to the 2000 estimate of 0.5 m². Pool type habitat in reach 3 increased from 0% in 1996 to 51% in 2000. Average depths in monitoring years were all greater than the 1996 pre-assessment value. In 1996, the average depth was 17.9 cm and post assessments depths ranged from 26.7 cm in 2000 to 41.7 cm in 1997. Average widths increased over the pre-assessed value but were relatively unchanged in monitoring years. Primary pools were only identified in post assessments. Two primary pools were observed in 1997 and five pools were observed in 2000.

Fish densities in reach 3 appeared to decline from pre-assessment in 1996 to 2000 (Figure 10). Cutthroat trout were not observed in the pre-assessment or in 2000; they were initially observed in 1997 and densities decreased annually in 1998 and 1999. The brook trout density varied annually; density was 6.0 fish/100 m², the high was 7.0 fish/100 m² in 1998, and the low of 2.0 fish/100 m² was observed in 2000. Brown trout density was highest during the pre-assessment (5.0 fish/100 m²) and 1997 was the low (0.8 fish/100 m²).

Table 15. Indian Creek reach 3 habitat attribute values from the 1996 implementation site.

Attribute	96 Structures				
	Pre '96	Post '97	Post '98	Post '99	Post '00
Embeddedness (%)	80	56	75	67	68
Pool/Riffle	0.2	0.8	0.6	0.5	2.0
Spring Spawn Gravel (m ²)	23.0	20.0	9.0	0.5	0.0
Fall Spawn Gravel (m ²)	23.0	14.0	9.0	1.5	0.5
% Pool	0	0	0	5	51
% Riffle	64	33	35	25	27
% Run	26	47	56	66	19
% Pocketwater	7	19	9	3	0
% Glide	2	0	0	0	2
Avg Depth (cm)	17.9	41.7	29.1	38.3	26.7
Avg Width (m)	2.9	4.8	5.0	4.7	4.3
# Primary Pools	0	2	0	1	5

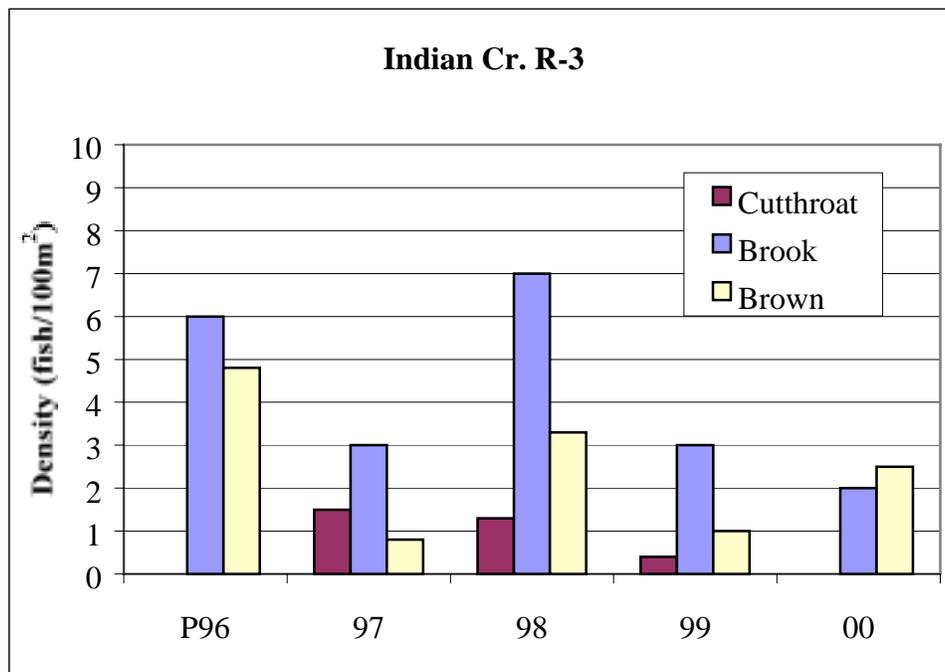


Figure 9. Annual Indian Creek reach 3 fish densities from the 1996 implementation site.

Reach 4

In reach 4, three log weirs were constructed to provide to scour pools and recruit spawning gravel. Substrate embeddedness decreased from a 1996 pre-assessed value of 82% to 38% in 2000 (Table 16). A distinct decrease in combined fall and spring spawning gravel was observed in 1999 and 2000. In 1996, pre-assessed spawning gravel was estimated at 18 m², monitoring estimates in 1997 and 1998 were 14 m² and 20 m², respectively. Spawning gravel declined to 4.6 m² in 1999 and 3.0 m² in 2000. No pool type habitat was classified in the pre-assessment survey in 1996. Pool habitat has increased to 15% in 2000. Average widths and depths increased in years following the pre-assessment. The pre-assessed average depth was 10.9 cm; in subsequent monitoring years, average depths ranged from 19.8 cm in 2000 to 28.7 cm in 1997. The pre-assessed average width was 2.1 m and increased to 3.8 m by 2000. 1997 and 2000 were the only years where surveyors identified primary pools; 3 pools were observed each year.

Changes to fish densities in reach 4 were variable (Figure 11). Cutthroat density increased over 300% from 1996 to 2000. Cutthroat densities were near pre-assessment levels in 1998 and 1999. Brown trout density increased to 4.8 fish/100 m² in 1998; however, density in 2000 (1.5 fish/100 m²) was less than the pre-assessed density (2.3 fish/100 m²). Brook trout densities were low and relatively unchanged throughout the monitoring period. The only bull trout observed (in 1997) was believed to be an adfluvial fish from Lake Pend Oreille since it was fin clipped. This fish was previously captured and passed in the downstream trap.

Table 16. Indian Creek reach 4 habitat attribute values from the 1996 implementation site.

Attribute	96 Structures				
	Pre '96	Post '97	Post '98	Post '99	Post '00
Embeddedness (%)	82	16	33	50	38
Pool/Riffle	0.1	0.2	0.1	0.0	0.3
Spring Spawn Gravel (m ²)	9.0	8.5	10.0	2.1	1.5
Fall Spawn Gravel (m ²)	9.0	5.5	10.0	2.5	1.5
% Pool	0	4	2	1	15
% Riffle	85	82	90	94	80
% Run	8	4	1	5	0
% Pocketwater	6	10	7	0	4
% Glide	0	0	0	0	1
Avg Depth (cm)	10.9	28.7	22.1	26.5	19.8
Avg Width (m)	2.1	4.3	4.2	4.2	3.8
# Primary Pools	0	3	0	0	3

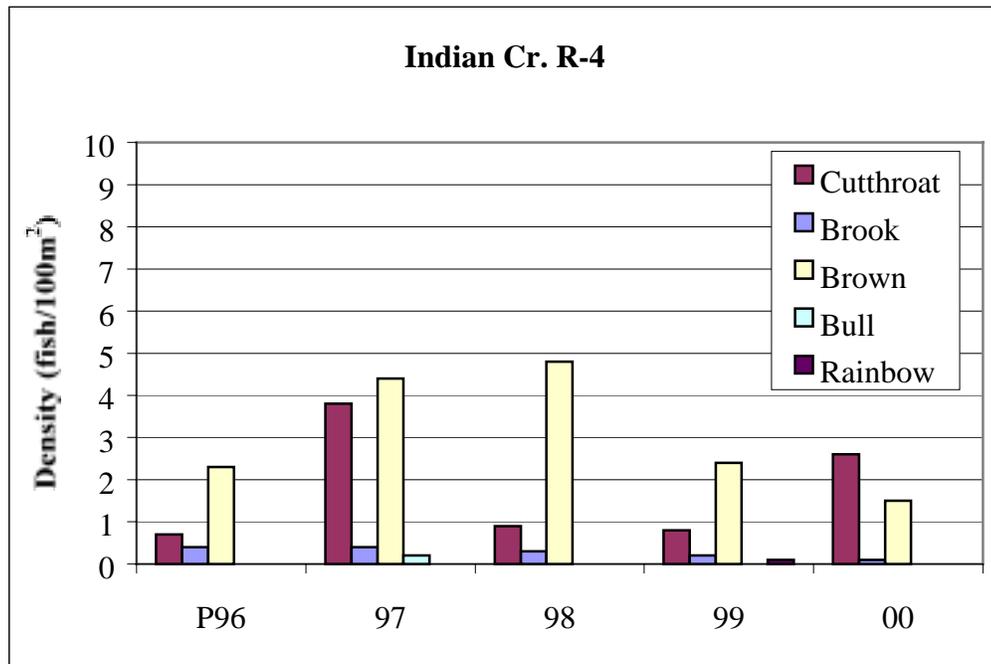


Figure 10. Annual Indian Creek reach 4 fish densities from the 1996 implementation site.

Browns Creek

Reach 4

Three K-dams were constructed in reach 4 in 1997. Substrate embeddedness has increased from the 1997 pre-assessment to post assessment in 2000 (Table 17). 1997 embeddedness was 31% and increased in subsequent years to 41% in 1998, 49% in 1999, then decreased to 39% in 2000. Combined spring and summer spawning gravels in monitoring years appeared to decrease markedly over pre-assessed estimates. 1997 pre-assessed spawning gravel was estimated at 47.5 m²; post assessed spawning gravels decreased to 3.0m² in 2000. The percent of pre-assessed habitat classified as pool was 3% and increased to 19% in 2000. Average depth decreased from 25.7 cm in 1997 to 19.7 cm in 2000. Wetted width decreased from a pre-assessed average of 4.9 m to a post assessed average of 4.1 in 2000. In the 1998 post assessment, surveyors classified three pools as primary pools. No primary pools were observed in 1997, 1999, or 2000.

Three additional structures were built in reach 4 in 1998. Embeddedness in this site increased from 28% in the pre-assessment to 41% in 2000 (Table 18). Combined spawning gravel decreased markedly. Pre-assessed spawning gravel was 18.5 m²; no spawning gravel was observed in 1999 and 6.0 m² were observed in 2000. Pool type habitat increased in 2000. No habitat was classified as pool in the 1998 pre-assessment and the 1999 post assessment. However, 33% of the habitat was classified as pool during the 2000 assessment. Average depth showed a decrease in 2000. Average depth was 26.5 cm in 1998, 26.2 in 1999, and decreased to 19.8 in 2000. Average width has been highly variable. The pre-assessed width was 4.0 m, increased to 7.2 m in 1999, and decreased to 3.9 m in 2000. The only primary pools (n=2) were observed in the 2000 post assessment.

Post implementation fish densities increased nearly 200% over pre-implementation densities in reach 4 (Figure 12). In the 1997 implementation site, brook trout densities increased from 0.1 fish/100 m² in 1997 to 0.6 fish/100 m² and 0.7 fish/100 m² in 1998 and 1999, respectively. Pre-assessment brown trout density was 2 fish/100 m²; densities increased to 11 fish/100 m² in 1998 and 8 fish/100 m² in 1999. Brown and brook trout densities also increased in the 1998 implementation site. Brook trout density increased from 0.2 fish/100 m² in 1998 (pre-assessment) to 0.7 fish/100 m². Brown trout increased from 4.1 fish/100 m² in 1998 to 7.8 fish/100 m². Only one cutthroat trout was observed in reach 4 and that fish was seen during the 1998 pre-assessment.

Table 17. Browns Creek reach 4 habitat attribute values from the 1997 implementation site.

Attribute	97 Structures			
	Pre '97	Post '98	Post '99	Post '00
Embeddedness (%)	31	41	47	39
Pool/Riffle	0.1	0.3	0.1	0.3
Spring Spawn Gravel (m ²)	35.0	4.5	0.0	1.5
Fall Spawn Gravel (m ²)	12.5	4.5	0.0	1.5
% Pool	3	6	3	19
% Riffle	88	76	84	79
% Run	2	9	13	3
% Pocketwater	6	9	0	0
% Glide	0	0	0	0
Avg Depth (cm)	25.7	22.4	24.2	19.7
Avg Width (m)	4.9	5.2	4.7	4.1
# Primary Pools	0	3	0	0

Table 18. Browns Creek reach 4 habitat attribute values from the 1998 implementation site.

Attribute	98 Structures		
	Pre '98	Post '99	Post '00
Embeddedness (%)	28	52	41
Pool/Riffle	0.0	0.0	0.5
Spring Spawn Gravel (m ²)	14.0	0.0	3.0
Fall Spawn Gravel (m ²)	4.5	0.0	3.0
% Pool	0	0	33
% Riffle	92	87	67
% Run	2	12	0
% Pocketwater	5	1	0
% Glide	0	0	0
Avg Depth (cm)	26.5	26.2	19.8
Avg Width (m)	4.0	7.2	3.9
# Primary Pools	0	0	2

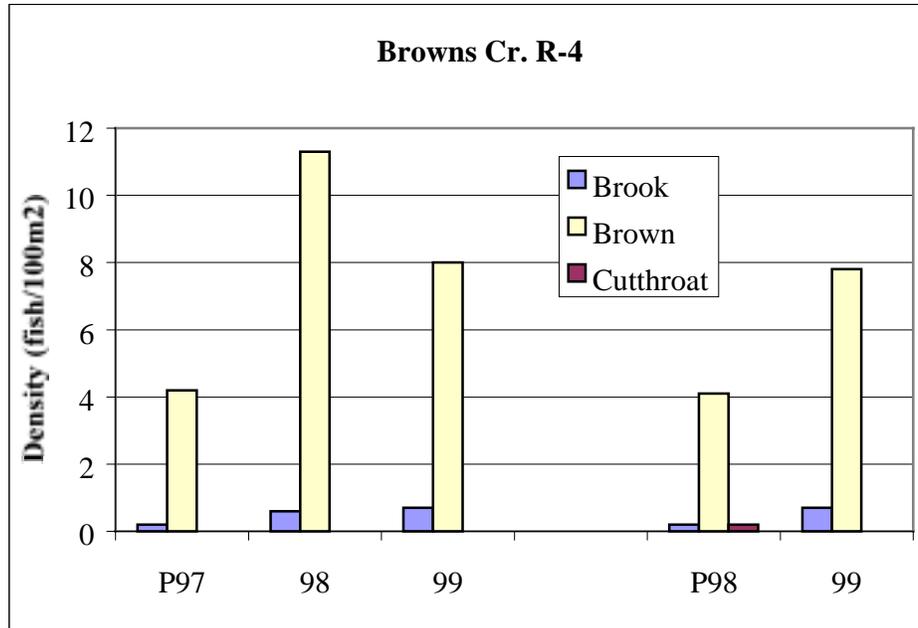


Figure 11. Annual Browns Creek reach 4 fish densities from the 1997 and 1998 implementation site.

Reach 9

In reach 9, three single wing deflectors were implemented in 1997. Substrate embeddedness was 42% in 1997 and decreased to 23% in 2000 (Table 19). Spawning substrate and pool type habitat were not present in pre or post assessments. Average depths were relatively unchanged from 1997 to 1999; but, depth decreased to 22.9 cm in 2000. Average width also decreased. The pre-assessed average width was 4.1 m and decreased to 3.2 m in 2000. Observers classified two primary pools during the pre-assessment. In 1998, 1999, and 2000 post assessments, no pools were given the primary classification.

Three additional structures were implemented in reach 9 in 1998. Embeddedness in this site increased from 21% in 1998 to 31% in 2000 (Table 20). No spawning gravels have been detected in any of the assessments. No pool type habitat was observed in 1998 and 1999; but 22% of the habitat was pool in 2000. Average depth decreased from 38.6 cm in 1998 to 23.2 cm in 2000. Average width in 2000 was the same as the pre-assessed width (3.5 m). Two primary pools were identified in 2000. No primary pools were observed in previous assessments.

Fish densities in reach 9 have been variable. Brown trout decreased dramatically from a pre-assessed density of 20.6 fish/100 m² to 4.0 fish/100 m² in 2000 (Figure 13). Cutthroat were not present during the 1997 pre-assessment and density was 1.3 fish/100 m² in 2000. Densities in the 1998 implementation site have increased. Brown trout was the only species observed during the pre-assessment and had a density of 2.2 fish/100 m². Brook trout and cutthroat trout were observed in the 2000 post assessment and brown trout density increased to 6.6 fish/100 m². In 1999, lower Browns Creek was under a U.S. Forest Service area closure that prevented access to the reach 9 implementation site.

Table 19. Browns Creek reach 9 habitat attribute values from the 1997 implementation site.

Attribute	97 Structures			
	Pre '97	Post '98	Post '99	Post '00
Embeddedness (%)	42	32	35	23
Pool/Riffle	0.1	0.2	0	0
Spring Spawn Gravel (m ²)	0.0	0.0	0.0	0.0
Fall Spawn Gravel (m ²)	0.0	0.0	0.0	0.0
% Pool	0	0	0	0
% Riffle	79	84	100	100
% Run	6	0	0	0
% Pocketwater	15	16	0	0
% Glide	0	0	0	0
Avg Depth (cm)	34.8	36.0	32.8	22.9
Avg Width (m)	4.1	3.6	3.6	3.2
# Primary Pools	2	0	0	0

Table 20. Browns Creek reach 9 habitat attribute values from the 1998 implementation site.

Attribute	98 Structures		
	Pre '98	Post '99	Post '00
Embeddedness (%)	21	45	31
Pool/Riffle	0.2	0.0	0.4
Spring Spawn Gravel (m ²)	0.0	0.0	0.0
Fall Spawn Gravel (m ²)	0.0	0.0	0.0
% Pool	0	0	22
% Riffle	84	95	73
% Run	0	0	0
% Pocketwater	16	5	5
% Glide	0	0	0
Avg Depth (cm)	38.6	33.8	23.2
Avg Width (m)	3.5	4.1	3.5
# Primary Pools	0	0	2

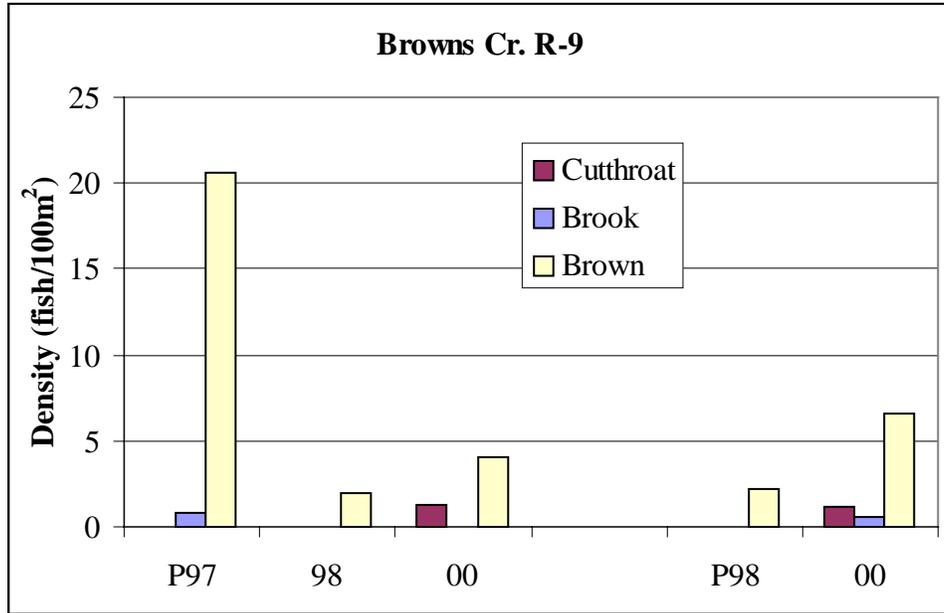


Figure 12. Annual Browns Creek reach 9 fish densities from the 1997 and 1998 implementation site.

Fourth of July Creek

Reach 8

In 1997, three wedge dams and three log weirs were constructed in reach 8 of Fourth of July Creek. 1997 pre-assessment substrate embeddedness in reach 8 was 82% (Table 21). Decreased embeddedness was observed in subsequent years of monitoring (60% in 1998, 71% in 1999, and 20% in 2000). Combined spawning gravels increased from 18 m² in 1997 to 20 m² in 1998. However, no spawning gravel was identified during the 1999 monitoring survey and only 0.5 m² was observed in 2000. No habitat was classified as pool in 1997 and 1998. Pools comprised 12.4% of the habitat in the 1999 and increased to 32% in 2000. Average depth increased from 12.5 cm in 1997 to 14.2 cm in 1999, but decreased to 11.8 in 2000. Average width also decreased; the 1997 pre-assessed width was 2.4 m and the 2000 average width was 1.9 m. No primary pools were identified in the 1997 pre-assessment or the 1998 post assessment. Surveyors counted one primary pool in 1999 and 6 in the 2000 post assessment.

Cutthroat trout (density of 8 fish/100 m²) and brook trout (density of 3 fish/100 m²) were observed in the 1997 pre-implementation snorkel survey (Figure 14). In 1998, cutthroat trout density declined to 5 fish/100 m², brook trout density increased to 5 fish/100 m², and bull trout and brown trout were also observed (densities of 1 fish/100 m²). Cutthroat trout densities increased 700% in 1999 to 35 fish/100 m². Bull trout and brown trout were also observed in 1999 (densities of 1 fish/100 m²); however, no brook trout were present. In 2000, the cutthroat density declined to 9.3 fish/100 m² while the brook trout density increased to 22.2 fish /100 m².

Table 21. Fourth of July Creek reach 8 habitat attribute values from the 1997 implementation site.

Attribute	97 Structures			
	Pre '97	Post '98	Post '99	Post '00
Embeddedness (%)	82	60	71	20
Pool/Riffle	0.1	0.4	0.3	0.5
Spring Spawn Gravel (m ²)	9.0	10.0	0.0	0.0
Fall Spawn Gravel (m ²)	9.0	10.0	0.0	0.5
% Pool	0	0	12	32
% Riffle	85	59	51	61
% Run	8	19	37	3
% Pocketwater	6	21	0	1
% Glide	0	0	0	0
Avg Depth (cm)	12.5	16.0	14.2	11.8
Avg Width (m)	2.4	3.0	2.3	1.9
# Primary Pools	0	0	1	6

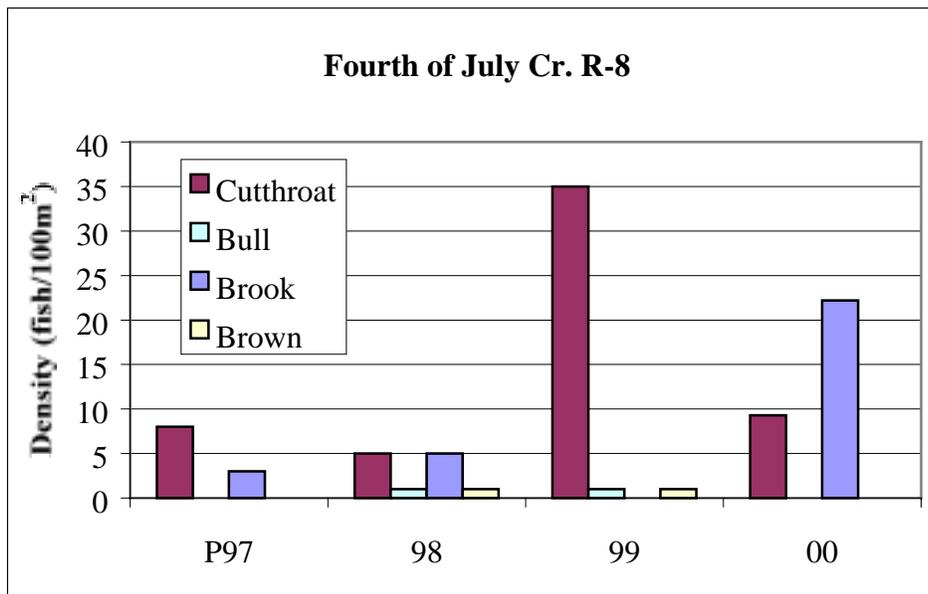


Figure 13. Annual Fourth of July Creek reach 8 fish densities from the 1997 implementation site.

Mineral Creek

A total of ten double wing deflectors were implemented in reach 1 of Mineral Creek from 1996 to 1998. Pre-assessment substrate embeddedness was 53% in the 1996 site, initially decreased in 1997 to 35%, and increased to 61% in 2000 (Table 22). 1996 pre-assessed combined spring and fall spawning gravel was 40.9 m². Spawning gravel appeared to decrease significantly in the post assessment surveys; in 1998, 1.8 m² of gravel was identified, no spawning gravel was observed in 1997 and 1999, and only 1.0 m² was identified in 2000. Percent pool type habitat increased from 4% in 1996 to 32% in 2000. Average depths in the 1996 implementation area increased annually through 1999. However, a marked decrease in depth was observed in 2000. The 1996 pre-assessed average depth was 16.4 cm, the 1999 post assessment average depth was 25.3 cm, and the 2000 average depth decreased to 14.4 cm. Average widths also increased annually up to 2000. The average pre-assessment width was 2.6 m and the 2000 width was 2.5 m. Four pools were classified as primary during the 1996 pre-assessment. The only post assessment surveys where primary pools were observed was in 1998 (n=2) and 2000 (n=3).

In reach 1 where structures were implemented in 1997, pre-assessed substrate embeddedness was 71%, declined to 52% in 1999, and then increased to 69% in 2000 (Table 23). Combined spawning gravel showed a similar trend with decreases in 1998 and 1999 over the pre-assessed amount (4.5 m²). However, 9.0 m² of spawning gravel were tallied in 2000. Percent pool habitat increased from 19% in the 1997 pre-assessment to 43% in 2000. Depths decreased from the pre-assessed average of 43.6 cm in 1997 to 15.0 in 2000. Average width also decreased in 2000. The pre-assessed width averaged 3.5 m and width was 2.6 m in the 2000 post assessment. Although annually variable, the number of pools classified as primary increased from 2 in 1997 to 3 in 2000.

Embeddedness in the 1998 restoration site increased from 54% in 1998 to 64% in 2000 (Table 24). Combined spawning gravel decreased from 5.5 m² identified in the pre-assessment to 2.0 m² in 2000. Percent pool type habitat increased from 15% in 1998 to 33% in 2000. Average depth and width decreased in 2000 after exhibiting little change from 1998 to 1999. The only primary pool recorded in this restoration site was during the 2000 post assessment.

For the 1996 implemented structures, similar trends were observed in cutthroat trout and brook trout densities over the monitoring period (Figure 15). Densities increased in 1997 from pre-assessed densities. However, both brook trout and cutthroat trout densities declined in 1998 and then again in 1999. In 2000, brook trout were not observed in the restoration site and the cutthroat trout density increased. The cutthroat density in 2000 is still about half of the pre-assessed densities. Fish densities in the 1997 implementation site showed a declining trend. The 1997 pre-assessed cutthroat trout density was 20.0 fish/100 m² and declined to 7.7 fish/100 m² in 2000. Cutthroat density in the 1998 restoration site have been increasing. The pre-assessed density was 5.0 fish/100 m² and the 2000 density was 6.4 fish/100 m².

Table 22. Mineral Creek reach 1 habitat attribute values from the 1996 implementation site.

96 Structures					
Attribute	Pre '96	Post '97	Post '98	Post '99	Post '00
Embeddedness (%)	53	35	45	43	61
Pool/Riffle	0.5	0.3	0.6	0.1	0.8
Spring Spawn Gravel (m ²)	25.6	0.0	1.7	0.0	0.5
Fall Spawn Gravel (m ²)	15.3	0.0	0.0	0.0	0.5
% Pool	4	0	21	4	32
% Riffle	61	67	57	92	52
% Run	16	21	3	3	0
% Pocketwater	19	12	19	1	12
% Glide	1	0	0	0	4
Avg Depth (cm)	16.4	19.0	23.7	24.7	14.4
Avg Width (m)	2.6	2.9	3.4	3.7	2.5
# Primary Pools	4	0	2	0	3

Table 23. Mineral Creek reach 1 habitat attribute values from the 1997 implementation site.

97 Structures				
Attribute	Pre '97	Post '98	Post '99	Post '00
Embeddedness (%)	71	62	52	69
Pool/Riffle	0.3	0.8	0.1	0.6
Spring Spawn Gravel (m ²)	3.5	2.0	0.0	4.5
Fall Spawn Gravel (m ²)	1.0	0.0	0.0	4.5
% Pool	19	24	10	43
% Riffle	62	50	48	40
% Run	13	16	42	0
% Pocketwater	5	9	0	0
% Glide	0	0	0	17
Avg Depth (cm)	43.6	25.6	31.1	15.0
Avg Width (m)	3.5	2.9	3.4	2.6
# Primary Pools	2	1	2	3

Table 24. Mineral Creek reach 1 habitat attribute values from the 1998 implementation site.

Attribute	98 Structures		
	Pre '98	Post '99	Post '00
Embeddedness (%)	54	57	64
Pool/Riffle	0.3	0.6	0.8
Spring Spawn Gravel (m ²)	4.5	0.0	1.0
Fall Spawn Gravel (m ²)	1.0	0.0	1.0
% Pool	15	17	33
% Riffle	71	57	52
% Run	5	23	0
% Pocketwater	6	3	14
% Glide	0	0	0
Avg Depth (cm)	34.0	34.4	15.2
Avg Width (m)	3.6	3.6	2.1
# Primary Pools	0	0	1

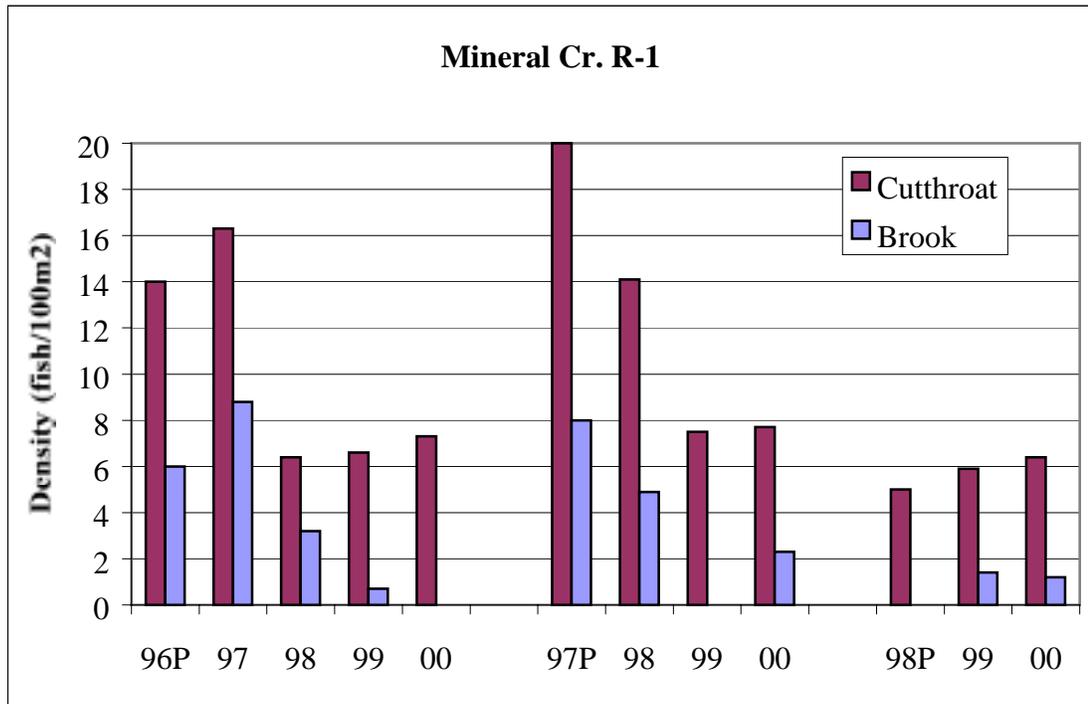


Figure 14. Reach 1 fish densities from 1996 to 2000 for the three implementation sites in Mineral Creek.

Whiteman Creek

Reach 4

In 1997, channel blocks were constructed in three sections where the channel was braided. Also, six log structures were created to provide cover and direct flow from unstable banks. This entire restoration site is enclosed by the fencing project completed in 1996. Following implementation, substrate embeddedness was relatively high and unchanged in reach 4. 1997 pre-assessed substrate embeddedness was 95% and post assessment in 1998, 1999, and 2000 were 84%, 94%, and 88%, respectively (Table 25). 12.5 m² of spawning gravel were noted in 1997 and increased in 2000 to 36.0 m². No spawning gravel was identified in 1999. Pool composition decreased from 7.5% in 1997 to 0% in 1998; percent pool habitat then increased to 14% in 1999 and 66% in 2000. Average depth and width increased annually from 1997 to 1999. The 1997 pre-assessed average depth was 34 cm; post assessment depths were 42 cm in 1998 and 46 cm in 1999. Average width increased from 3.1 m in 1997 to 4 m and 4.1 m in 1998 and 1999, respectively. However, depth and width decreased to 25.5 cm and 2.4 m in 2000. One pool was classified as primary in 1997 and 1998, two primary pools were observed in 1999, and 21 pools were primary in 2000.

Brook trout was the only species observed in reach 4. Post implementation brook trout densities were higher than the pre-implementation density (Figure 16). Brook trout densities in 1998 (45 fish/100 m²) and 2000 (44.5 fish/100 m²) were over double the 1997 pre-assessed density (20 fish/ 100 m²).

Table 25. Whiteman Creek reach 4 habitat attribute values from the 1997 implementation site.

Attribute	97 Structures			
	Pre '97	Post '98	Post '99	Post '00
Embeddedness (%)	95	84	94	88
Pool/Riffle	0.0	0.0	0.0	2.8
Spring Spawn Gravel (m ²)	8.5	14.0	0.0	18.5
Fall Spawn Gravel (m ²)	4.0	10.5	0.0	17.5
% Pool	7	0	14	66
% Riffle	0	13	0	20
% Run	92	84	86	9
% Pocketwater	0	0	0	1
% Glide	0	0	0	4
Avg Depth (cm)	34.0	41.9	45.5	25.5
Avg Width (m)	3.1	4.0	4.1	2.4
# Primary Pools	1	1	2	21

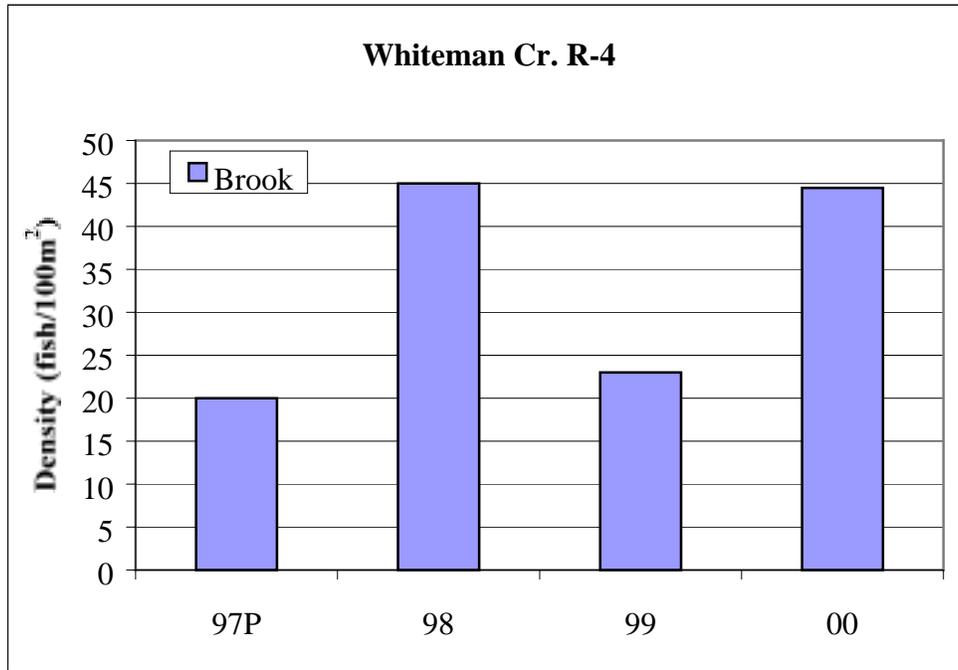


Figure 15. Annual Whiteman Creek reach 4 fish densities from the 1997 implementation site.

Reach 5

In 1996, boulder structures were placed in reach 5 to create pool habitat. Percent embeddedness had relatively little change from pre-assessment in 1996 (54%) to post assessment in 2000 (48%, Table 26). Spawning gravel was absent from the assessment area for all years. Pool habitat increased from 7% in 1996 to 39% in 2000. Post assessed average depths increased from the pre-assessed average depth of 13.3 cm. Post assessed average depths ranged from 15.5 cm in 2000 to 21.5 cm in 1997. Average widths also increased from the pre-assessed width of 2.6 m. Average width ranged from 4.7 m in 1998 to 3.3 m in 2000. The number of primary pools increased from 0 in 1996 to 8 in 1999. However, primary pool number decreased in 2000 to two.

In reach 5, cutthroat densities were relatively low and unchanged through 1999 (Figure 17). Cutthroat density in the pre-assessment was 0.5 fish/100 m². However, the cutthroat density increased to 1.2 fish/100 m² in 2000. Brook trout densities in reach 5 increased annually from a pre-implementation density of 6 fish/100 m² in 1996 to 15 fish/100 m² in 1999. In 2000, brook trout density declined to 7.6 fish/100 m².

Table 26. Whiteman Creek reach 5 habitat attribute values from the 1996 implementation site.

Attribute	96 Structures				
	Pre '96	Post '97	Post '98	Post '99	Post '00
Embeddedness (%)	54	67	47	49	48
Pool/Riffle	0.2	0.4	0.5	0.6	1.1
Spring Spawn Gravel (m ²)	0.0	0.0	0.0	0.0	0.0
Fall Spawn Gravel (m ²)	0.0	0.0	0.0	0.0	0.0
% Pool	7	0	24	21	39
% Riffle	82	61	57	57	43
% Run	6	10	15	11	2
% Pocketwater	6	29	4	11	15
% Glide	0	0	0	0	0
Avg Depth (cm)	13.3	21.5	19.9	17.5	15.5
Avg Width (m)	2.6	4.1	4.7	3.5	3.3
# Primary Pools	0	1	1	8	2

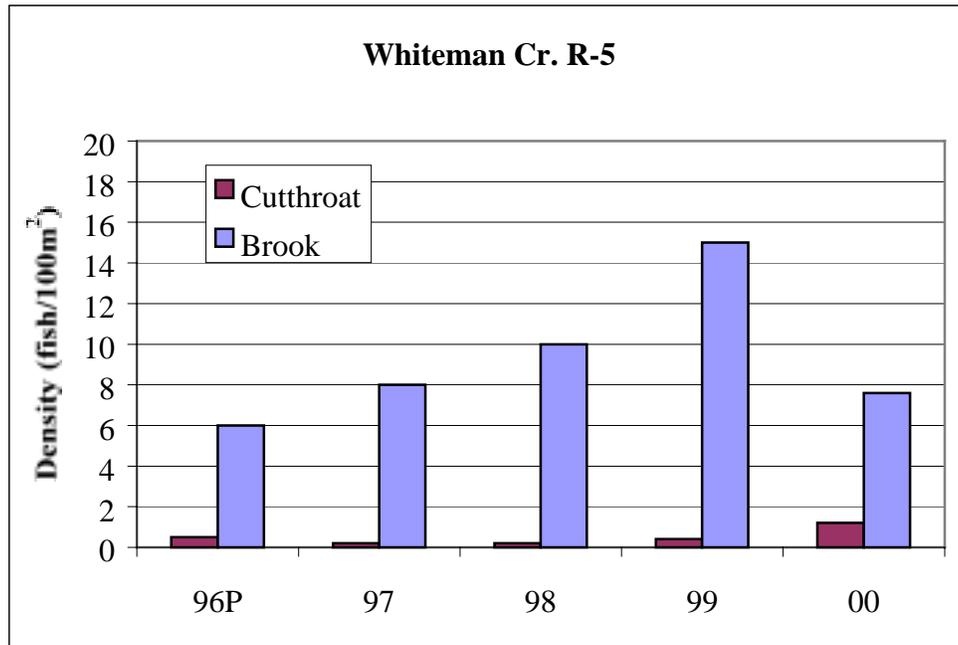


Figure 16. Annual Whiteman Creek reach 5 fish densities from the 1996 implementation site.

Reach 6

Boulder structures were also placed in reach 6 to create pool habitat. Post assessment substrate embeddedness decreased from the pre-assessed embeddedness of 73% (Table 27). Post assessed embeddedness ranged from a low of 38% in 1998 to a high of 60% in 1999. An increase in spawning substrate was observed until 1999. 4 m² of spawning habitat was observed in the pre-assessment. Spawning substrate increased to 10 m² in 1997 and 1998. However, no spawning gravel was identified in 1999 and in 2000. Pool habitat increased annually from 0% in the 1996 pre-assessment to 38% in the 2000 post assessment. Pre-assessed (1996) average depth was 23.4 cm and increased to 27.5 cm in 1997. Average depths decreased in subsequent years to 18.5 cm in 1998, 14.3 cm in 1999, and 15.6 cm in 2000. Average widths increased in the first two years of post assessment. The pre-assessed width was 3.8 m; width increased to 4.6 m in 1997 and 6.4 m in 1998. In 1999 and 2000, average widths decreased to 3.2 m and 2.7 m, respectively. No primary pools were observed in the 1996 pre-assessment and the 1997 and 1998 post assessments. Primary pool number increased to 2 in 1999 and 3 in 2000.

2000 cutthroat densities in reach 6 (3.0 fish/100 m²) were 6 times higher than the pre-assessed density of 0.5 fish/100 m² (Figure 18). Post assessed brook trout densities were variable. The 1996 pre-assessed brook trout density was 14 fish/100 m²; density decreased to 10 fish/100 m² in 1997 and then increased to 16 fish/100 m² and 17 fish/100 m² in 1998 and 1999, respectively. Brook trout density then decreased in 2000 to 7.7 fish/100 m².

Table 27. Whiteman Creek reach 6 habitat attribute values from the 1996 implementation site.

Attribute	96 Structures				
	Pre '96	Post '97	Post '98	Post '99	Post '00
Embeddedness (%)	73	55	38	60	55
Pool/Riffle	0.3	0.4	0.1	0.8	0.9
Spring Spawn Gravel (m ²)	2.0	5.5	7.5	0.0	0.0
Fall Spawn Gravel (m ²)	2.0	4.5	2.5	0.0	0.0
% Pool	0	4	4	32	38
% Riffle	73	51	83	51	54
% Run	12	30	10	3	0
% Pocketwater	14	15	3	14	7
% Glide	0	0	0	0	0
Avg Depth (cm)	23.4	27.5	18.5	14.3	15.6
Avg Width (m)	3.8	4.6	6.4	3.2	2.7
# Primary Pools	0	0	0	2	3

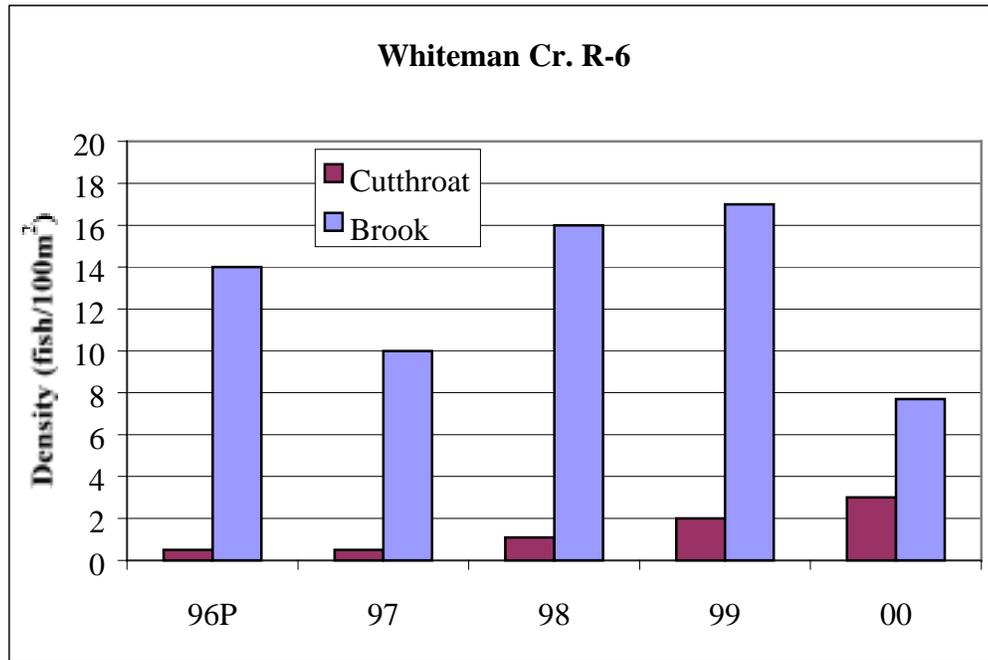


Figure 17. Annual Whiteman Creek reach 6 fish densities from the 1996 implementation site.

Largemouth bass habitat enhancement

Sampling of the largemouth bass enhancement sites did not occur in the fall of 2000. Early sub-freezing temperatures iced the sloughs over in early November and the ice remained throughout the month. From 1997 (pre-assessment) to spring 2000, largemouth bass relative abundance varied at each sampling site. However, 1999 fall abundance had increased over 1997 fall abundance (pre-treatment) in five of the eight sites; abundance was unchanged in two of the remaining three sites. In Cee Cee Ah Slough #1, largemouth bass relative abundance was 2 in the fall of 1997 and 1999 and 0 in the springs of 1998, 1999, and 2000 (Figure 19). In Cee Cee Ah Slough #2, largemouth bass were not present in the catch until the fall of 1999 (n=2, Figure 20). No fish were captured in the spring of 2000.

In No Name Slough #1, largemouth bass relative abundance appeared to increase significantly in the fall of 1999 when 14 were collected (Figure 21). No largemouth bass were collected in the 1997 pre-assessment or the 1999 and 2000 spring post assessment. Two largemouth bass were collected in the spring of 1998. No bass were present in the 1997 pre-assessment sample in No Name Slough #2 (Figure 22). Two bass were collected in the spring of 1998 and four bass were collected in the fall 1999 sample. No fish were collected in the 1999 or 2000 spring sampling period.

In Old Dyke #1, Two bass were captured in the 1997 pre-assessment and one bass was sampled in the fall 1999 sampling (Figure 23). No largemouth bass were present in the catch in the spring sampling period in 1998, 1999, or 2000. In Old Dyke #2, largemouth bass were present in the catch in all sample periods from 1997 to 2000 (Figure 24). One bass was captured in the 1997 pre-assessment, three were captured in spring 1998, one was collected in spring 1999, 6 were caught in fall 1999 and one was captured in the spring of 2000. Relative abundance of all other species declined in Old Dyke #2. 1997 pre-assessment and spring 1998 abundance were at or near 40; abundance declined to 2 in spring 2000.

In Campbell Slough #1, largemouth bass relative abundance increased dramatically from pre-assessment (n=1) to spring 1998 (n=19)(Figure 25). However, abundance declined to 1 in fall 1999 and 2 in spring 2000. Relative abundance in spring 2000 was relatively unchanged from the 1997 pre-assessment. Largemouth bass relative abundance initially increased in Campbell Slough #2 (Figure 26). The 1997 pre-assessed abundance was 1. Large increases were observed in spring 1998 (n=19) and spring 1999 (n=18). Five largemouth bass were captured in fall 1999. However, in 2000 both largemouth bass (n=1) and other species (n=15) relative abundance were equal to the 1997 pre-assessment.

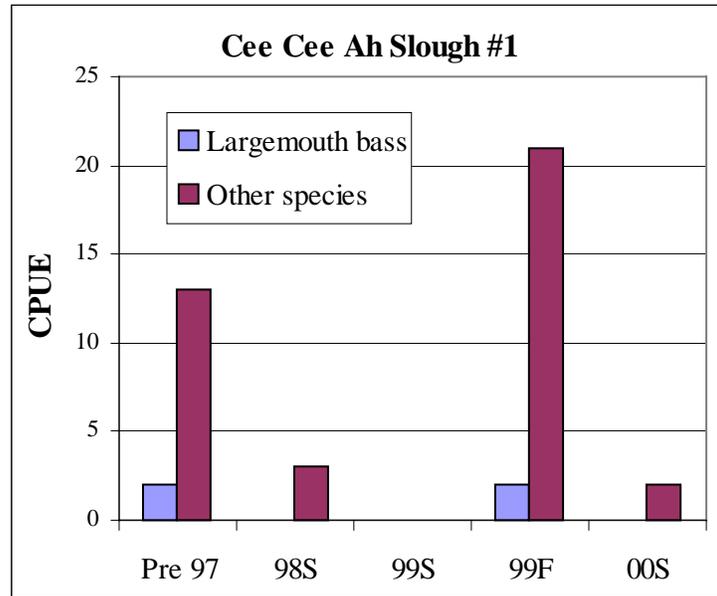


Figure 18. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #1.

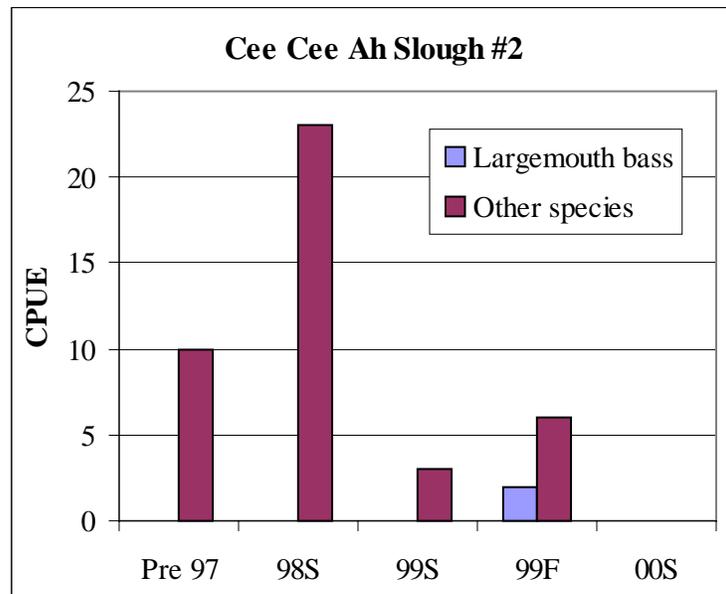


Figure 19. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #2.

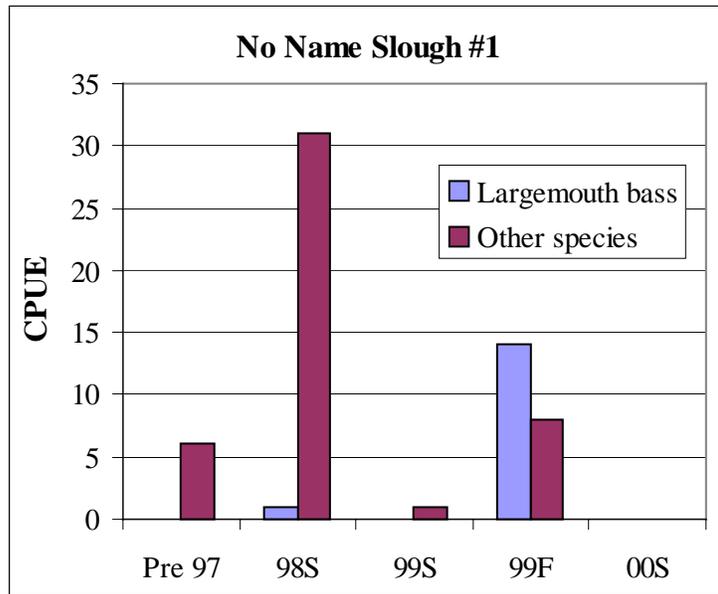


Figure 20. Largemouth bass and combined fish relative abundance for transects in No Name Slough #1.

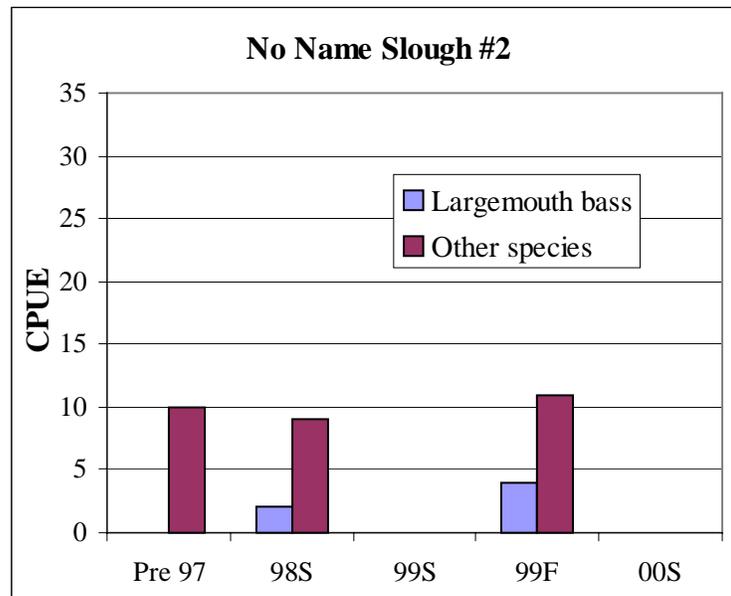


Figure 21. Largemouth bass and combined fish relative abundance for transects in No Name Slough #2.

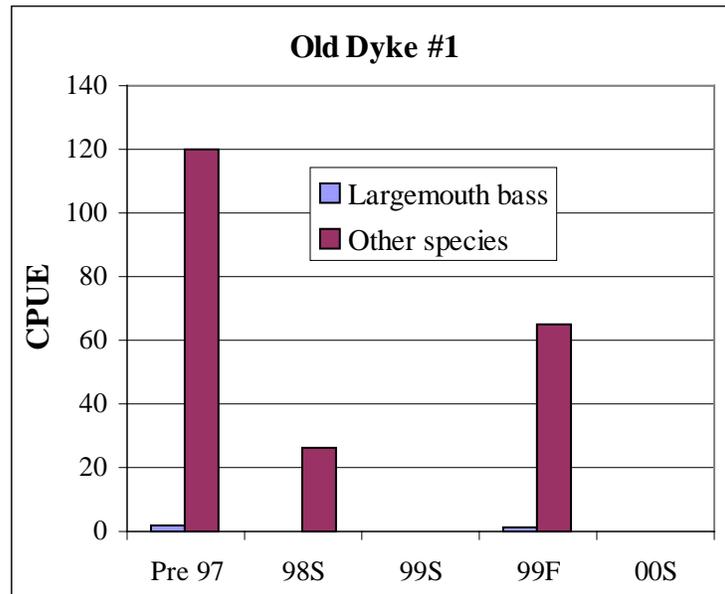


Figure 22. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #1.

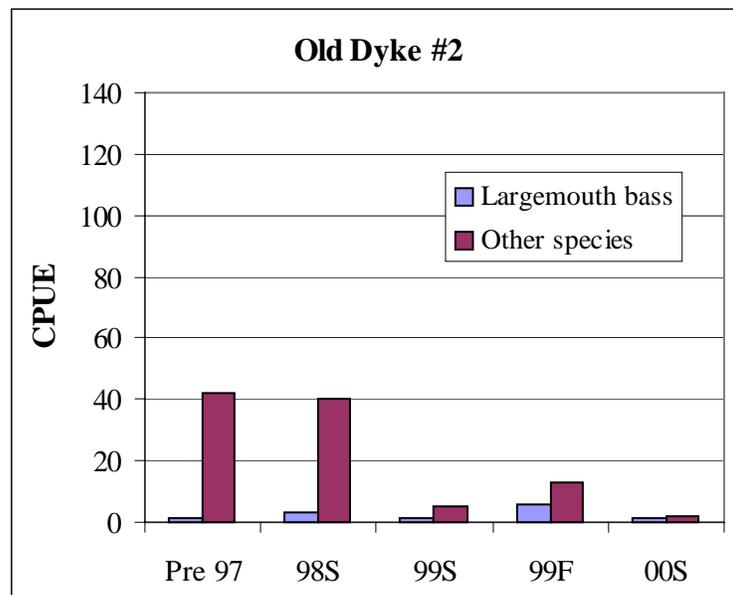


Figure 23. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #2.

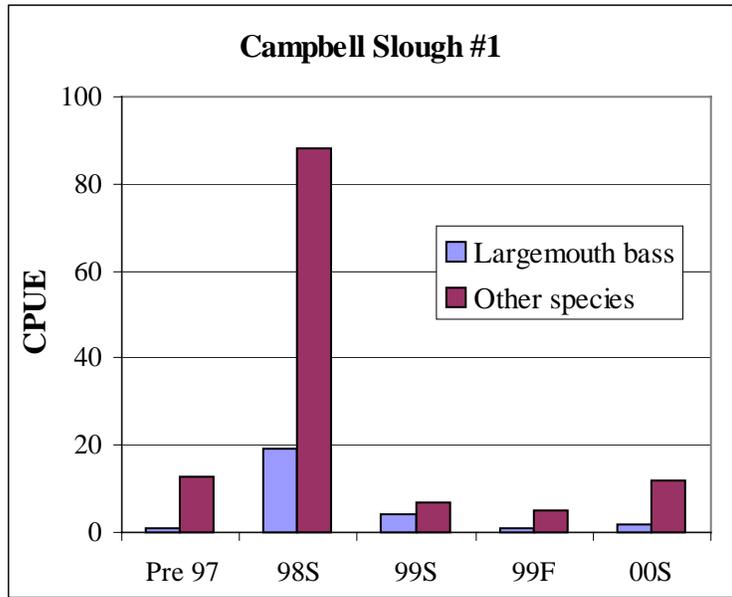


Figure 24. Largemouth bass and combined fish relative abundance for transects in Campbell slough #1.

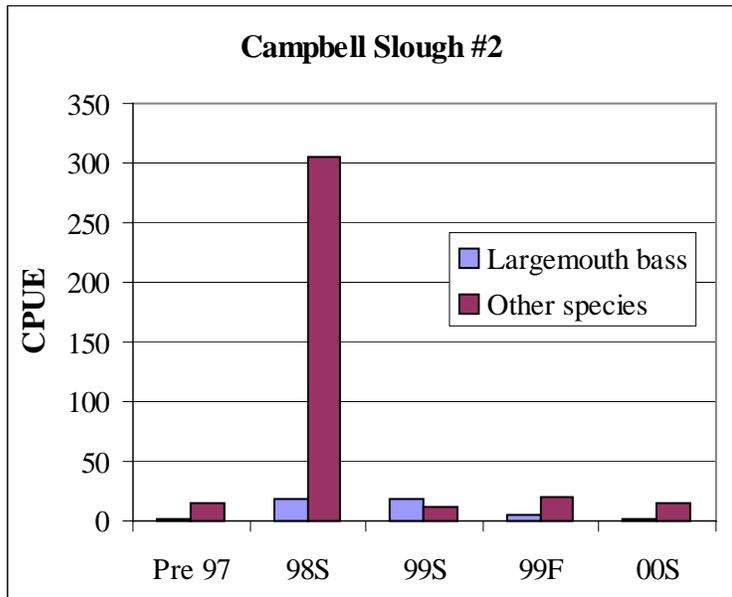


Figure 25. Largemouth bass and combined fish relative abundance for transects in Campbell Slough #2.

Discussion

Bull trout and cutthroat trout habitat assessment

It is difficult to distinguish the effects of the restoration among many interacting factors and great natural variability within the physical and biological components of the ecosystem. Also, much of the restoration implemented may not yield results for several years or decades. Observer classification of habitat types also introduces variability (Roper and Scarnecchia 1995). Among KNRD surveyors, a distinct difference in the way habitats with certain characteristics (e.g. velocity, channel shape, and surface turbulence) were consistently classified by different observers was noted. The tendencies were for some observers to classify a habitat as a run while other observers classified the same habitat as a pool. Differences in classification were particularly evident in Whiteman Creek reach 4. Primary pool number in reach 4 increased from one during the pre-assessment to 21 in 2000. Also, pool habitat increased from 7% to 66% while run habitat decreased from 92% to 9%. In 2000, pool habitat increased in all restoration sites relative to the pre-assessment. While differences in habitat classification (observer variability) likely occurred to a lesser degree in all assessments, we have observed a decrease in riffle habitat suggesting that pool habitat is, in fact, increasing. More monitoring needs be performed to minimize the variability in both habitat and fish abundance data.

One trend we have observed is the apparent loss of spawning gravel, particularly in reaches where structures were implemented in 1996. In the spring of 1997, a rain on snow event created flooding that caused significant damage throughout the Lower Pend Oreille Subbasin. Most of the spawning gravel appeared to be lost from 1996 to 1997. High flows likely flushed gravels from these reaches and recruitment from upstream reaches was minimal and/or gravels were deposited out of the bankfull channel. In 2001, we will examine restoration reaches in Indian, Cee Cee Ah, and Mineral creeks and evaluate whether natural gravel recruitment is occurring and whether further implementation to recruit gravels is warranted.

In 2000, we observed the lowest summer flows since implementation and monitoring began in 1996. As a result, over half (54%, n=12) of the lowest average depths at each site were measured in 2000. However, only 6 of the 12 sites with the lowest average depths had the highest wetted width to depth ratio compared to previous assessments (Table 28). Of those 6 restoration sites, 5 are located in 2 reaches: Browns Creek reach 9 and Mineral Creek reach 1. Browns Creek reach 9 is an A type channel with steep high banks and a characteristically low entrenchment ratio (flood-prone width/bankfull width). Therefore, a decrease in flow affects depth to a much larger degree than width.

Table 28. Wetted width to depth ratios in sites where restoration was implemented from 1996 to 1998.

Restoration Site	Wetted Width to Depth Ratio				
	Pre	1997	1998	1999	2000
CCA-4	25.6	13.4	12.6	16.7	19.5
CCA-4	11.6	----	14.1	19.6	17.5
CCA-4	14.2	----	----	15.1	20.8
CCA-5	19.1	14.9	15.6	17.7	14.4
CCA-5	13.5	----	14.5	21.4	11.3
CCA-5	12.5	----	----	20.7	14.3
CCA-6	13.4	12.1	10.1	16.1	12.0
CCA-6	9.6	----	11.7	16.8	11.4
CCA-6	11.6	----	----	17.4	12.1
IND-3	16.2	11.5	17.2	12.3	16.1
IND-4	19.3	15.0	19.0	15.8	19.2
BRN-4	19.1	----	23.2	19.4	20.8
BRN-4	15.1	----	----	27.5	19.7
BRN-9	11.8	----	10.0	11.0	14.0
BRN-9	9.1	----	----	12.1	15.1
FFJ-8	19.2	----	18.8	16.2	16.1
MIN-1	15.9	15.3	14.3	15.0	17.4
MIN-1	8.0	----	11.3	10.9	17.3
MIN-1	10.6	----	----	10.5	13.8
WMN-4	9.1	----	9.5	9.0	9.4
WMN-5	19.5	19.1	23.6	20.0	21.3
WMN-6	16.2	16.7	34.6	22.4	17.3

In Cee Cee Ah Creek, limiting factors were identified as overwintering habitat (pools) and spawning habitat (KNRD 1996). Log structures were implemented to create pools and recruit spawning gravel in the tail-outs. Pool habitat appears to be increasing in all of the restoration sites in Cee Cee Ah Creek. In reaches 4, 5, and 6, nine restoration sites were implemented from 1996 to 1998. Seven sites had increases in the number of primary pools and two sites were unchanged. The percent of pool type habitat increased in every implementation site. In reach 4, riffle habitat slightly increased in one site (1996 implementation site) and the decreases in the other two sites were relatively small. Combined spring and fall spawning gravel area increased in four of the nine sites and decreased in the remaining five. Large decreases in spawning gravels from 1996 to 1997 occurred in reaches 4 (from 24.0 m² to 0.5 m²) and 6 (from 14.0 m² to 2.0 m²). Spawning gravels have been recruited in reach 5. No spawning gravel was present in the restoration site pre-assessments from 1996 to 1998. In 2000, each of the reach 5 restoration sites had spawning gravel. However, the areas of spawning gravel were relatively small, ranging from 2.0 m² to 3.0 m².

The trend in fish densities in Cee Cee Ah Creek varied from site to site. Cutthroat trout were only observed on two occasions in Cee Cee Ah Creek. Competition from brook trout is likely limiting cutthroat trout production. When comparing pre-assessment to 2000 densities, brook trout increased in three sites and decreased in six sites. Two of the three sites with an increase in fish density also had the biggest increases in primary pool number. The 1996 reach 5 restoration site had an increase of 5 primary pools and the 1998 reach 6 implementation site increased 4 primary pools.

Pool habitat and substrate embeddedness were identified as limiting factors in reaches 3 and 4 in Indian Creek. Percent pool habitat, substrate embeddedness, and primary pool number all improved. In 2000, total fish densities decreased in reach 3 and were relatively unchanged in reach 4 compared to pre-assessed densities. However, westslope cutthroat trout density increased over 300% in reach 4 while non-native trout densities have decreased. Improved habitat conditions in reach 4 may be providing an advantage to cutthroat trout. Substrate embeddedness decreased dramatically in Reach 4. The 1996 pre-assessed embeddedness was 82% and decreased to 38% in 2000 with an annual range of 16% to 50%. Spawning gravel has decreased substantially from 1996 to 2000. In reach 3, combined spring and fall spawning habitat decreased from 46 m² in 1996 to 0.5 m² in 2000. Reach 4 spawning gravel decreased from 18 m² in 1996 to 3.0 m² in 2000. Due to the decrease, spawning gravel may be limiting fish populations at this time. Assessments of spawning gravel will be made in reaches 3 and 4 in 2001 to determine how much spawning gravel is available within the channel in each reach. Other factors not identified in the stream survey may also be limiting fish populations in Indian Creek. The KNRD operates adfluvial fish traps on 11 tributaries in the Box Canyon reach of the Pend Orielle River. Of those 11 traps, the Indian Creek trap had the most fish captured in 1998. Adfluvial fish likely represent a portion of the sampled population. Therefore, if a portion of the population is adfluvial, there may be other factors outside of the project watershed influencing the population (e.g. limiting factors for salmonids in Box Canyon Reservoir).

A lack of pool habitat was identified as limiting fish populations in reach 4 of Browns Creek (KNRD 1996). In the 1997 implementation site, pool habitat has increased

from 3% to 19%; however, no primary pools were present in 2000. An increase in pool habitat and primary pool number has been observed in the 1998 restoration site. Snorkeling of the reach 4 restoration sites did not occur in 2000. A significant loss of spawning gravel has occurred at both sites. The pre-assessment for the 1997 implementation site identified 47.5 m² of combined spawning gravel. Only 3.0 m² was present in 2000 at this site. The 1998 site had 18.5 m² of spawning gravel during the pre-assessment and 6.0 m² in 2000. Despite these losses, an increase in spawning gravel was observed from 1999 to 2000. In the future, we will evaluate the loss of spawning habitat if the increasing trend does not continue.

In 1997 and 1998, restoration was implemented in reach 9 of Browns Creek to increase pool habitat. None of the habitat in the 1997 site has been classified as pool in the 4 years of assessments that have been conducted. Two primary pools were identified in the 1997 pre-assessment site and none have been classified since that time. In the 1998 implementation site, no primary pools were present in the pre-assessment and 2 were identified in the 2000 monitoring survey. The two pools identified in the 1997 pre-assessment and in the 2000 post assessment (for the 1998 implementation) are likely the same pools. The 1998 site was located downstream and relatively close to the 1997 site. The methodology calls for surveying 30 m beyond the last structure on the upstream and downstream ends of the site. Since the restoration sites were so close, there was an overlap between the area surveyed in the 1997 and 1998 sites. The two primary pools counted in the 1997 pre-assessment were located at the downstream end of the site in an area that is now associated with the 1998 implementation site. In the 1997 implementation site, total fish density has decreased from 21.4 fish per 100 m² in 1997 to 5.3 fish per 100 m² in 2000. Fish density has increased in the 1998 implementation site from 2.2 fish per 100 m² in 1998 to 8.0 fish per 100 m² in 2000. Cutthroat trout density has increased in both restoration sites. No cutthroat were observed in either pre-assessment; in 2000, the 1997 site had 1.3 cutthroat per 100 m² and the 1998 site had 1.2 cutthroat per 100 m².

High embeddedness and a lack of pool habitat were identified as limiting factors in reach 8 of Fourth of July Creek (KNRD 1996). Log structures were implemented in 1997 to address the limiting attributes. Since 1997, substrate embeddedness decreased to 20%, the percent of habitat classified as pool increased from 0% to 32%, and the number of primary pools increased from 0 to 6. The response of the fish population has also been favorable. Total fish densities have increased from 11.0 fish per 100 m² in 1997 to 31.5 fish per 100 m² in 2000. At this site, one bull trout was observed in 1998 and one in 1999. It appears that the structures implemented in Fourth of July Creek have resulted in better habitat and increased fish densities.

Single wing deflectors were constructed in reach 1 of Mineral Creek in 1996 and 1997. High substrate embeddedness and low pool habitat were the limiting factors identified from the baseline survey. Fish densities have decreased over 50% in the sites implemented in 1996 and 1997 while the 1998 site has had a slight increase. Overall, primary pools have changed little in the three restoration areas. Increased wetted width to depth ratio, recent bank instability, and a significant loss of spawning gravel from 1996 to 1997 have occurred in Mineral Creek restoration sites in reach 1. Several of the implemented structures are displaced and appear unstable. These indicators suggest that

the channel in reach 1 may be laterally unstable. The 2001 work plan includes stabilizing the displaced structures and implementing bank stabilization measures.

A lack of overwinter habitat (pools) and low depths due to channel braiding were identified as the limiting factors in reach 4 of Whiteman Creek. Structures were implemented in 1997 to concentrate flows in mid-channel. Reach 4 is also enclosed in a riparian fence that was constructed in 1996. Improved habitat appears to have resulted in increased fish density. Primary pools increased from 1 to 21 and pool habitat from 7% to 66%. Brook trout was the only species observed in reach 4 from 1995 to 1999. From 1997 to 2000, brook trout density increased over 200%.

Pool habitat was identified as the limiting factor in reach 5 of Whiteman Creek. Boulder structures were implemented to create pool habitat. From 1996 to 2000, percent pool habitat increased from 7% to 39% and the number of primary pools increased from 0 to 2. Pocketwater habitat also increased while riffle habitat decreased from 82% in 1996 to 43% in 2000. Brook trout density increased from 6.0 fish per m² in the pre-assessment to 7.6 fish per 100 m² in 2000. In the same period, cutthroat density increased from 0.5 fish per 100 m² to 1.2 fish per 100 m². As the habitat in reach 5 improves, conditions may tend to favor cutthroat trout over brook trout.

Boulder structures were placed in Whiteman Creek reach 6 as pool habitat was also identified as the limiting factor. From 1996 to 2000 pool habitat increased from 0% to 38% and primary pools increased from 0 to 3. Brook trout density declined from 14.0 fish per 100 m² in 1996 to 7.7 fish per 100 m² in 2000. However, cutthroat trout density continued to increase; the pre-assessed density was 0.5 fish per 100 m² and the 2000 density was 3.0 fish per 100 m². The implemented structures in Whiteman Creek appear to be improving limiting habitat attributes resulting in a corresponding increase in fish populations.

Largemouth bass habitat enhancement

From 1997 to the fall of 1999, largemouth bass relative abundance increased in five of the eight enhancement sites. Overall, few fish were captured in the 2000 spring sampling period and no fish were captured in 4 of the 8 sampling transects. In 1999, no fish were captured in 3 of the 8 sites during the spring sampling period. The sloughs were inaccessible during the fall 2000 sampling period due to ice cover. The goal for this study is to provide overwinter cover to juvenile largemouth bass. However, mean size of captured bass has increased from 94 mm (n=7, range 42 mm to 157 mm) to 131 mm (n=35, range 53 mm to 470 mm). Temperature may be causing fish to move out of the sloughs during the spring sampling period in April. At the time the spring sampling occurred in 1999 (April 14 and 15), water temperature was approximately 7°C in Cee Cee Ah Slough and 9°C in the main river. Turbidity was high due to runoff from Cee Cee Ah Creek. The high turbidity inhibited the ability to sight stunned fish. Also, fish may be avoiding sloughs where high turbidity exists.

Biological objectives

The overall biological objectives were established to provide production goals for all of the Box Canyon Reach tributaries, as adopted by the NWPPC. Monitoring and evaluation of each individual project tributary will determine the need for modification of these objectives. Through these adaptive management strategies biological objectives that are more suitable for these tributaries may be established at a later date.

Biological objective 1

Attain densities (all age classes) of 9.8 bull trout/100m² (or 390 fish /linear mile) age class in the upper one third of each major tributary system. This equates to 97,410 bull trout (all age classes) in approximately 250 miles of suitable tributary habitat in the system. Total numbers of adult bull trout recruited to the fishery will be 4,410 fish, composed of an escapement of 2,205 and harvest of 2,205 fish, by the year 2016.

Biological objective 2

Interim bull trout targets are established at 48,855 total fish (all age classes), including a total of 2,205 fish recruited to the fishery, composed of an escapement of 1,102 fish and a harvest of 1,103 fish, by the year 2006.

Biological objective 3

Attain population of 242,212 adult cutthroat in 500 miles of suitable cutthroat habitat in the system, including an escapement of 156,800 fish and harvest of 85,412 fish by the year 2016.

Biological objective 4

Interim cutthroat targets are established at 121,106 total adults recruited to the fishery, composed of an escapement of 78,400 fish and harvest of 42,706 fish by the year 2006.

Biological objective 5

Increase the biomass of harvestable largemouth bass in the Box Canyon Reservoir from current 6 pounds/acre (44,400 pounds for the entire reservoir) to an interim target of 8 pounds/acre (59,200 pounds for the entire reservoir) by 2003 and final target of 12 pounds/acre (88,800 for the entire reservoir) by 2008. The interim net gain will be 14,800 pounds of harvestable largemouth bass. The final net gain will be 44,400 pounds of harvestable bass.

Biological objective 6

Increase 0+ largemouth bass overwinter survival from current levels of 0.4 – 3.9 percent to approximately 15 – 20 percent. This increase in overwinter survival will contribute to the goal of 12 pounds/acre of harvestable bass.

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