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Kalispel Resident Fish Project

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KALISPEL RESIDENT FISH PROJECT

ANNUAL REPORT

2005

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PERPARED FOR:

U.S. DEPARTMENT OF ENERGY
BONNEVILLE POWER ADMINISTRATION,
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EXECUTIVE SUMMARY

In 2005 the Kalispel Natural Resource Department (KNRD) monitored its current enhancement projects for bull trout (*Salvelinus confluentus)* and westslope cutthroat trout (*Oncorhynchus clarki lewisi)*. Largemouth Bass (*Micropterus salmoides*) enhancement projects were also monitored. Additional baseline fish population and habitat assessments were conducted, in East River and several of its tributaries.

ACKNOWLEDGEMENTS

We would like to thank Glen Nenema (Chairman, Kalispel Tribal Council), the Kalispel Tribal Council and members of the Tribe for providing the support and the opportunity to conduct this project. A special thanks goes to Joe Maroney (KNRD Fisheries Program Manager) for technical and administrative support and assistance. The U.S. Department of Energy, Bonneville Power Administration, provided financial support for this project, contract number 97-BI-30242. Special thanks also to Virgil Watts (Contracting Officer Technical Representative). The Kalispel Natural Resource Department for providing field support and equipment.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Fire history, past timber harvest activities, and dams have influenced the landscape in the Priest River and lower Pend Oreille Subbasin. The subbasin was first logged in the late 1890s and much of the old-growth timber was removed. Logging railroad and log flumes were used on the mainstem Priest 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.

The Middle Fork East River is the only known tributary within the Priest River drainage downstream of Priest Lake that is known to support bull trout (*Salvelinus confluentus*) (DuPont and Horner, in press). In 2002 and 2003 a study that involved PIT and radio tagging subadults bull trout collected in the East River and Middle Fork East River was conducted by Geist et al. The purpose of the study was to try and determine out migration timing, size of out migrating juveniles, and what kind of interactions that these out migrates may encounter with Albeni Falls Dam. The study found that none of the radio tagged juveniles out migrated during the life of the radio tags and the questions were left unanswered.

In 2002, Idaho Fish and Game and Battelle radio tagged twenty pre-spawn bull trout in Middle Fork East River. Four radio receiving stations were placed on Albeni Falls Dam downstream of Priest River and two were placed on the Dover railroad bridge upstream of Priest River. Likely due to extreme environmental conditions in the fall of 2002 there was significant post-spawn mortality of the radio tagged bull trout (Geist et al. 2004). Consequently, at about the time the study was initiated there were 12 confirmed dead fish, 2 unconfirmed dead fish, and 6 alive fish (DuPont and Horner, in press). Four of the alive fish were found trapped behind a beaver dam. These fish were captured and released into Priest River. One of the fish released traveled 52 Km into Lake Pend Oreille in just two days (Geist et al. 2004). None of the bull trout radio tagged were detected downstream at Albeni Falls Dam.

In the East River watershed, a U. S. Forest Service Experimental Forest was established in 1911 and continues to be in existence today. The experimental forest encompasses 6,400 acres which includes the Canyon Creek watershed. Flow and snow pack data has been recorded within this watershed since 1937.

The fish assemblage existing today in the mainstem Priest River and Lower Pend Oreille subbasins are drastically different from pre-dam development. Due to the construction of Grand Coulee Dam, anadromous fish have been extirpated and 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. Outlet dam on the lower end of Priest Lake further fragmented the connectivity of native salmonid populations within the Priest River watershed.

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 Kalispel Tribe (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 (*S. confluentus*) were also captured.

Ashe et al. (1991) also found that largemouth bass (*Micropterus salmoides*) 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 was 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 changed the riverine habitat in this reach to habitat typical of a broad, shallow reservoir. The resulting high summer water temperatures exceeded 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. Tributary trapping data suggests that brown trout is the only trout species in Box Canyon Reservoir having an adfluvial population (KNRD et al. 2001). Temperature conditions limit the distribution of native trout in the reservoir. Bull trout have optimal rearing temperatures of 7-8^{0}C (Goetz, 1989) and temperatures exceeding 15^{0}C are thought to limit distribution (Fraley and Shepard, 1989, Goetz, 1991, Pratt, 1985). In Box Canyon reservoir, bull trout are limited to microhabitats in cold water springs, or metalimnion areas. Bull trout require spawning areas with clean gravel and temperatures ranging from 5-9^{0}C; these conditions do not exist in the reservoir. Conversely, largemouth bass have optimum temperatures of 13-26^{0}C and will select habitats in the littoral zone where temperatures exceed the optimum for bull trout. 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 Pend Oreille Subbasin. The 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. 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/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 Pend Oreille Subbasin. Of the streams surveyed by the Kalispel Natural Resource Department (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 dominate in a given length of stream (De Staso and Rahel 1994; Griffith 1988).

The habitat restoration portion of this project primarily addresses factors that limit native tributary populations. Our in-channel restoration increases habitat complexity, which provides refugia during extreme environmental events and, therefore, lowers the extinction risk for the targeted populations. The Tribe recognizes that instream habitat restoration is a temporary solution to habitat degradation and that recovery will only occur when future human impacts are minimized and watershed processes are restored. The Tribe has and will pursue opportunities for watershed restoration projects. However, watershed restoration will not yield significant improvements for years or decades. The Tribe also recognizes that some of the native fish populations in the Lower Pend Oreille subbasin will not persist for years or decades. In some watersheds, individual native fish sightings are rare or populations are isolated in small tributaries. Restoration implemented by the project increases the habitat attributes that are limiting native salmonids while the brook trout removal portion of this project will eliminate the threats associated with competition and hybridization with the native populations.

In summary, KNRD's plan for recovering native salmonid populations is:

1. Perform baseline stream habitat and fish population assessments to determine current distribution and abundance and identify core watersheds where recovery efforts will be focused.
2. Work to protect existing native populations and good habitat through participation in regional policy setting groups and consultation with area land, fish, and wildlife management agencies.
3. Pursue funding from various sources and participate jointly with other agencies in watershed restoration projects.
4. Implement instream and riparian restoration in identified recovery areas.
5. In recovery areas with non-native populations: 1) capture and relocate native fish, 2) treat streams to remove non-native species, and 3) translocate genetically identical or similar native fish from sister watersheds.
6. Monitor restoration and adapt management plans if needed.

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.

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 age 0^+ largemouth bass (Bennett and Liter 1991), they suggested that the winter reduction in macrophyte communities created higher predation rates on age 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 was 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.

2005 TRIBUTARY HABITAT AND FISH POPULATION ASSESSMENTS

DESCRIPTION OF STUDY AREA

Habitat and snorkel surveys were conducted in East River, Middle Fork East River, Tarlac, Uleda, Canyon, and Devil's Creek (Figure 1). East River is a tributary to Priest River located on the east bank approximately 12 miles north of the town of Priest River. The entire East River watershed drains approximately 21,033 acres. The dominant geology of the watershed is comprised of mixed granitic and metamorphic rock in the upper and mid portions and glacial and alluvial deposits in the lower portion. The East River starts at the confluence of the North and Middle Forks of the East River, and flows approximately 3 miles before emptying into Priest River.

The Middle Fork East River watershed drains 19,193 acres. The dominant geology of the watershed is comprised of mixed granitic and metamorphic rock except in the lower portion where the geology is composed of glacial and alluvial deposits. Management activities have influenced this watershed.

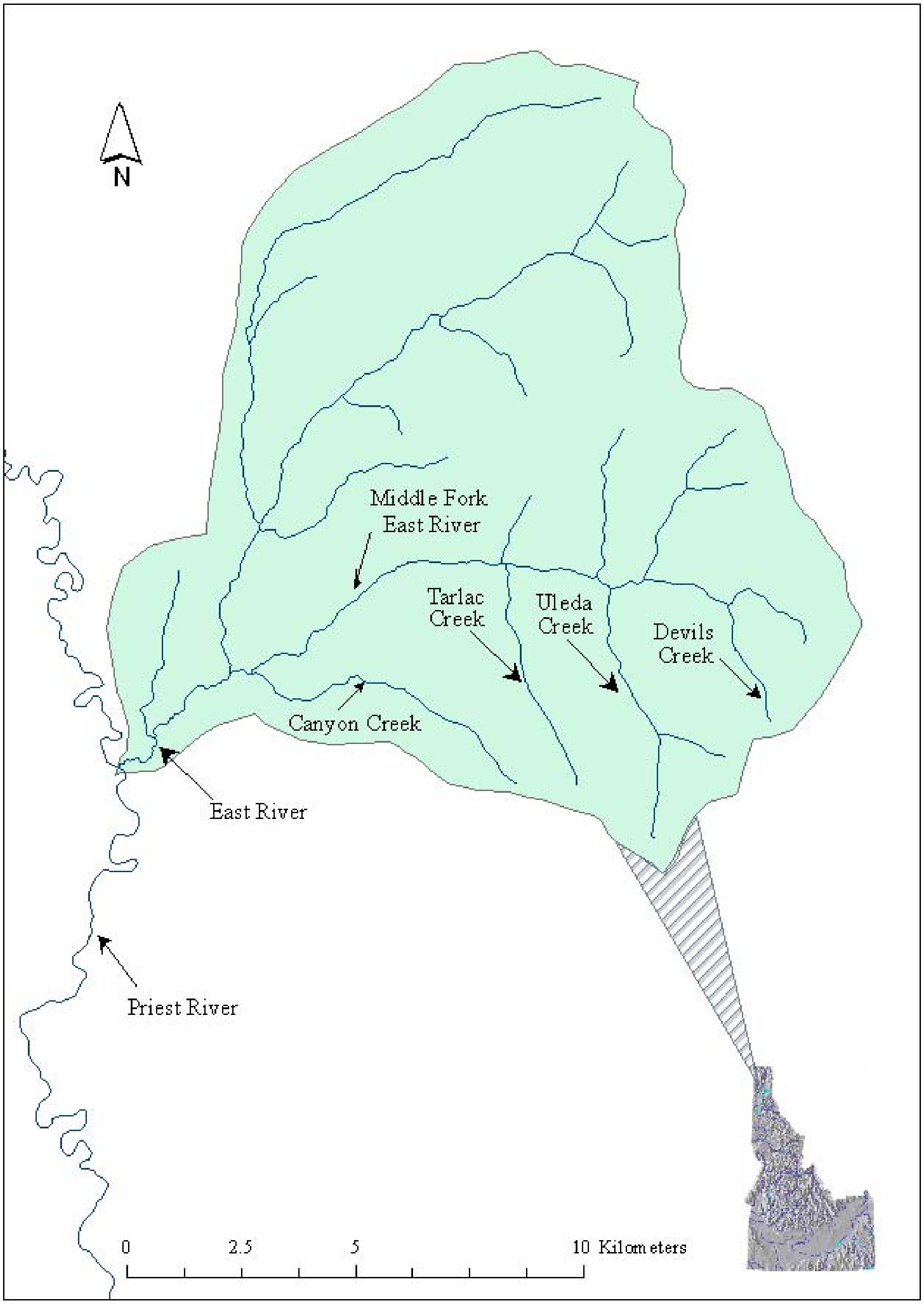

Figure 1. East River watershed.

Tarlac, Uleda, and Devil's Creeks are all small to mid-sized tributaries to the upper reaches of Middle Fork East River. Each of these tributaries enters Middle Fork East River from the south and each has a relatively small, steep watershed. Tarlac and Uleda Creek are both historical bull trout spawning streams, although no bull trout have been observed in Tarlac Creek in several years.

Canyon Creek is a tributary to lower Middle Fork East River and also enters the river on the southern side of the watershed. The Canyon Creek watershed drains approximately 2,900 acres. The dominant geology of the watershed consists of mixed granitic and metamorphic rock in the upper portion and glacial and alluvial deposits in the lower portion. Most of the Canyon Creek watershed is within the U.S. Forest Service Experimental Forest.

METHODS

Stream and fish population survey methodologies used within the Priest River subbasin were similar to those developed by Espinosa (1988) and further revised by Murphy and Huntington (1995). Habitat survey data were collected in two ways: 1) at a transect directly perpendicular to the stream thalweg, and 2) in the 30 m interval that separated adjacent transects. Primary pools, spawning habitat, unstable banks, and acting woody debris were identified and enumerated in the entire length of each 30 m stream segment between two transects. Data for the remainder of the habitat attributes (Table 1) were collected at the end of each 30 m segment: the actual transect site. Reaches were defined by lengths of stream channel with common confinement, gradient, and substrate (Rosgen, 1994). Breaks between two homogeneous areas defined a new reach. Reach overviews were completed at the end of each reach; these contained written descriptions of prominent features and/or potential impacts to habitat quality. Each reach was permanently marked, flagged, and geo-referenced using a Trimble Geo-explorer III receiver.

In May, thermographs were placed in the lower portion of each stream and recorded temperature at hourly intervals. Thermographs were also placed in the middle and/or upper sections of some of the larger streams. Thermographs were collected in October.

Fish density estimates for baseline surveys were collected using standard snorkel survey techniques (Espinosa 1988). The surveys were conducted during the period of July 15 through September 30. Snorkeling data included the number of each species observed in age classes 0^+ to 5^+. Total density of each species was reported as the number of fish per 100 m^2. The standard size/age classes for salmonid species were determined according to Espinosa (1988). Lengths of baseline snorkel stations were 100 m and selected so that the area snorkeled was representative of the reach. Fish stations were permanently marked and flagged using aluminum tags and flagging and then geo-referenced using a Trimble Geo-explorer III receiver.

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	Estimate potential square meters of spawning gravels between transects and rate 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 between transects.
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).

Table 1 Continued

Cobble Embeddedness	Visual estimate of the percentage fine or coarse sediment surrounding substrate at transect. 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.
Bank Stability	Visual estimate of the length of unstable bank between transects 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 within the wetted channel.
Potential Debris Recruitment	Number of trees within the transect that could potentially fall into the stream > 10 cm and a length > 1m.
Measurements for Residual Pool Depth	Measure average pool depth at the deepest portion of the pool and at the pool tailout. Measure to the nearest cm.

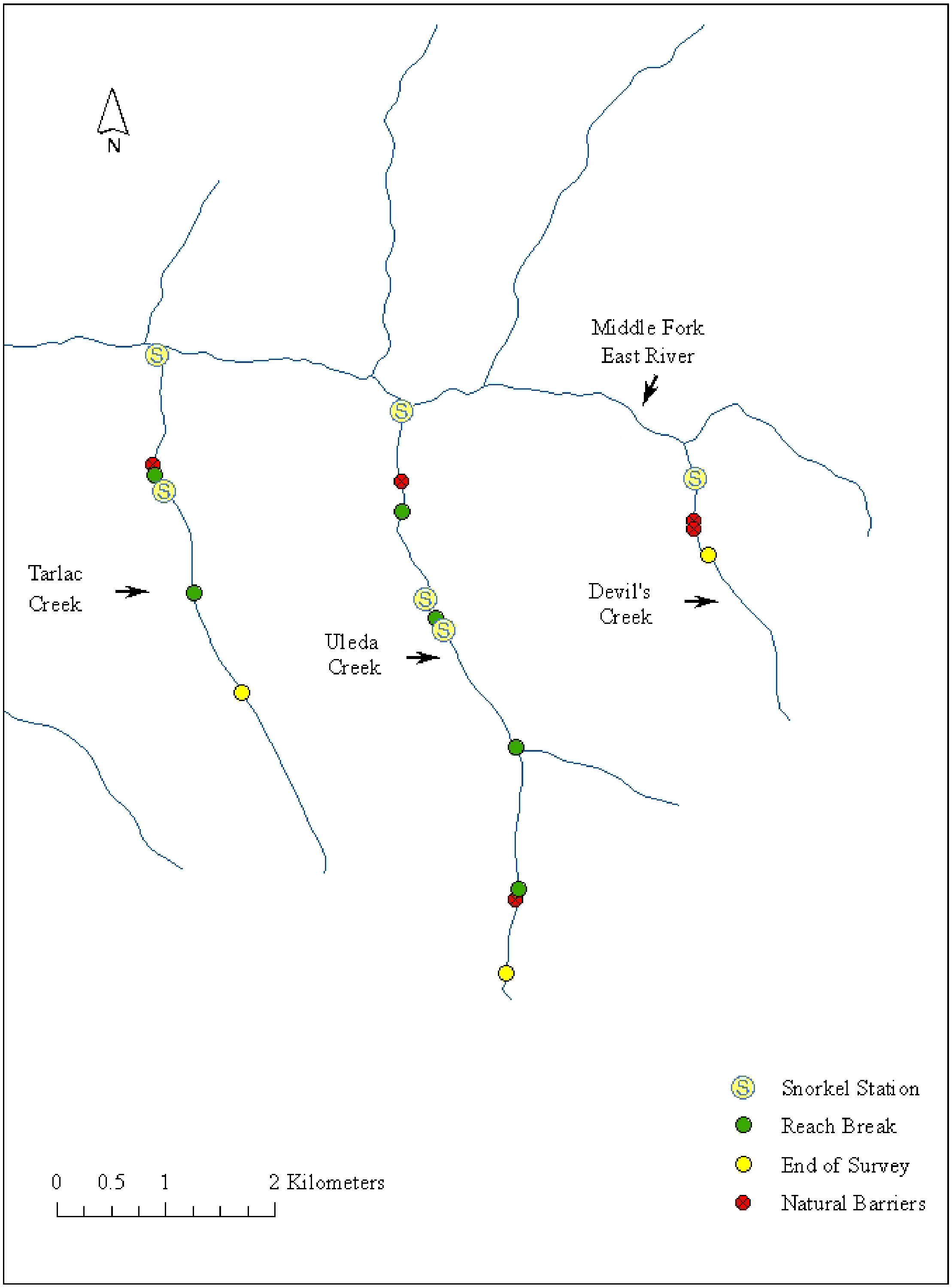

Figure 2. Reach breaks and snorkel stations in Uleda, Tarlac, and Devil's Creek.

RESULTS

Uleda Creek

Five reaches totaling 5.6 Km (3.5 miles) were surveyed in Uleda Creek (Figure 2). The survey began at the confluence of Uleda Creek and Middle Fork East River and was terminated in the headwaters. The Uleda Creek watershed contained evidence of historic and recent logging operations; abandoned and maintain roads were commonly observed. The Uleda Creek stream channel was fairly straight with low sinuosity. Large Woody Debris (LWD) Jams were common throughout much of the survey. One jam in reach 2 was estimated to be 32 m in length and 10 m in height (Figure 3).

Figure 3. Reach 2 logjam that was 32 m in length and 10 m in height.

In Uleda Creek cutthroat trout and bull trout were the only species observed in five snorkel stations (Figure 4). Bull trout were only observed in reach 1 (3.6 fish/100 m^2), while westslope cutthroat trout were noted in every reach except reach 5, where no fish were observed. Reach 3 contain the highest density of westslope cutthroat trout (7.9 fish/100 m^2).

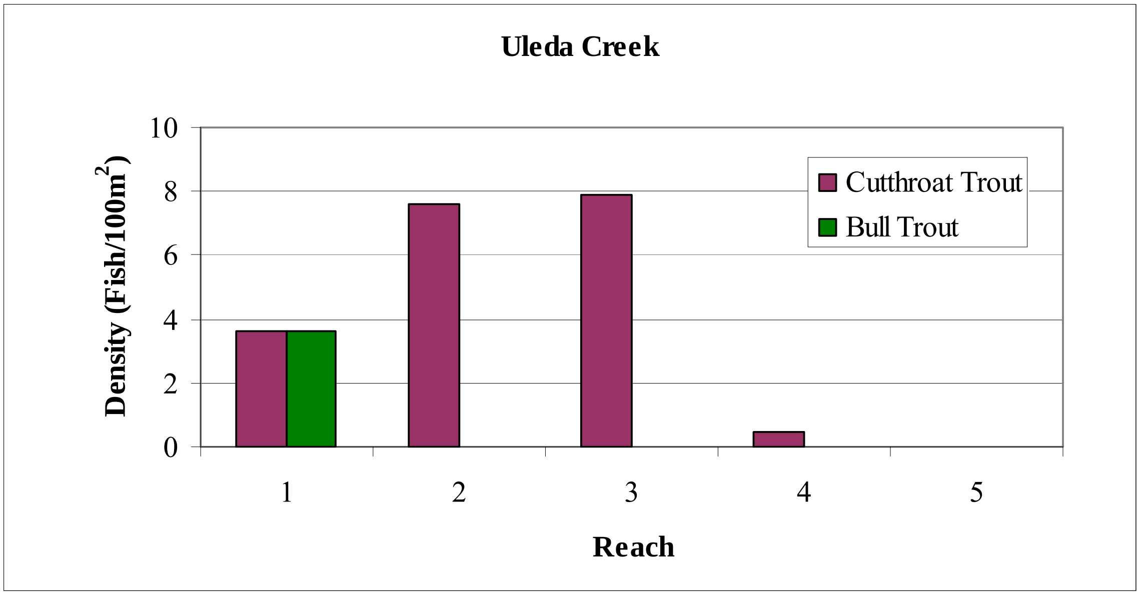

Figure 4. Fish densities for stations snorkeled in Uleda Creek.

Throughout the five surveyed reaches in Uleda Creek riffle was the dominant habitat type. Boulder was the dominant substrate class except for reach 3 where rubble was dominant (Table 2). Average embeddedness was 48% with a high of 53% in reach 4 and a low of 43% in reach 5 (Table 3). LWD was observed throughout the survey with a high of 57.1 pieces/100 m in reach 1 to a low of 37.5 pieces/100 m in reach 2 (Table 4). Bank stability was high in all the reaches. Primary pools were observed in Uleda Creek with a high of 23.5/Km in reach 1 to a low of 9.7/Km in reach 5. Spawning gravels were lacking throughout all 5 reaches with only a total of 13.5 m^2 observed. Split channels were common, due to abundant LWD jams.

Table 2. Channel characteristics for reaches surveyed in Uleda Creek.

Uleda Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B2a	8.7	Boulders	22
2	B2a	7.1	Boulders	20
3	B3a	7.4	Rubble	25
4	A2a+	11.0	Boulders	19
5	A2a+	22.0	Boulders	-

Table 3. Uleda Creek limiting factors attributes.

Uleda Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	48	99	2.4	4.4	0.3	1.0	23.5
2	48	100	2.5	4.3	0.2	2.5	13.3
3	48	100	2.4	3.7	0.3	3.5	16.3
4	53	100	3.0	3.9	0.3	4.5	20.0
5	44	100	3.5	3.5	0.4	2.0	9.7

Table 4. Habitat attributes for reaches surveyed in Uleda Creek.

Uleda Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	19.3	6.1	47.8	20	73	1	57.1
2	18.3	5.8	46.1	8	79	3	37.5
3	18.7	6.5	48.3	18	67	4	49.1
4	14.8	5.0	33.5	17	73	2	55.3
5	12.2	2.4	30.6	27	67	1	44.6

A thermograph placed in the lower part of reach 1 of Uleda Creek recorded water temperature hourly. The thermograph began recording data on May 25th and was removed from the stream on October 10th. The highest seven day average daily maximum temperature recorded was 11.2 °C on August 12th (Figure 5). The lowest seven day average daily maximum temperature recorded was 5.2 °C on October 10th. In Uleda Creek the seven day average daily maximum temperature only exceeded 10 °C from July 21st to August 24th.

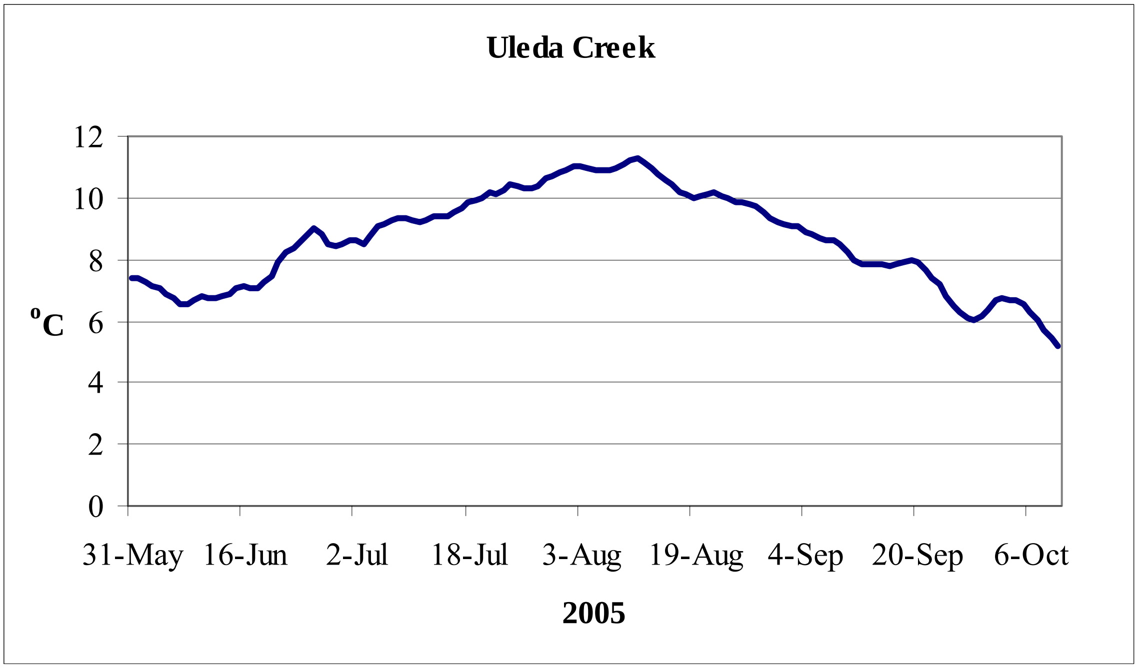

Figure 5. Seven day average daily maximum temperatures for Uleda Creek.

Tarlac Creek

Three reaches totaling 3 Km (1.9 miles) were surveyed in Tarlac Creek. The survey began at the confluence of Tarlac Creek and Middle Fork East River and was terminated in the headwaters. An abandoned road with multiple crossings was observed along the creek throughout the survey. Stumps were also observed along both banks and in some cases in the creek throughout most of the survey (Figure 6). In reach 2, where most of the stumps were observed, the channel was unstable and braiding was common. In reach 1, several possible fish passage barriers were noted and photographed (Figures 7 and 8). Westslope cutthroat trout and brook trout were the only two species observed in the 3 snorkel stations (Figure 9). Reach 2 had the highest density of westslope cutthroat trout (4.4 fish/100 m^2). No fish were observed in the reach 3 snorkel station.

Figure 6. Tarlac Creek reach 2 stumps in and along creek.

Figure 7. Tarlac Creek reach 1 possible fish passage barrier.

Figure 8. Tarlac Creek reach 1 possible fish passage barrier.

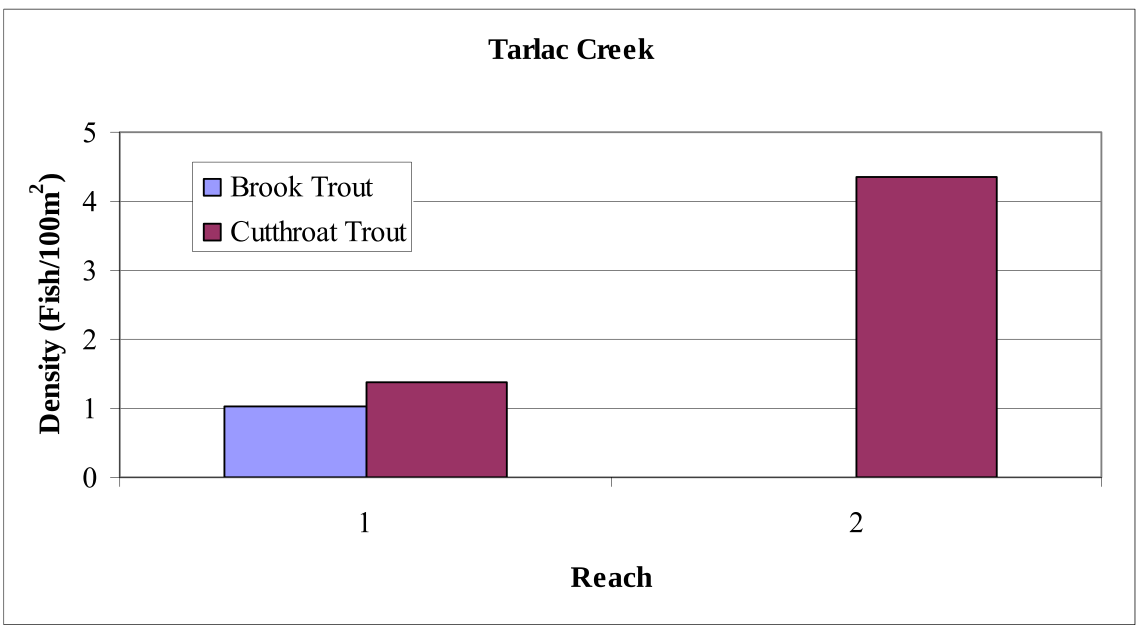

Figure 9. Fish densities for stations snorkeled in Tarlac Creek.

All reaches in Tarlac Creek were classified as A type channels and had gradients greater than 10% (Table 5). The dominant substrate in all three reaches was composed of large rubble to boulders. Embeddedness was the lowest in reach 1 (50%) and the highest in reach 2 (55%) with and average of 52% (Table 6). Riffle habitat was the dominant type throughout the survey. Spawning gravels were rare, with only 31 m^2 recorded throughout the survey. LWD was abundant in all reaches surveyed with an average of 58.5 pieces/ 100 m (Table 7). Primary pools were also fairly common with an average of 25.7 pools/Km.

A thermograph placed in the lower portion of reach 1 recorded water temperature data hourly. The thermograph began recording data on May 25th and was collected on October 10th (Figure 10). The highest seven day average daily maximum temperature recorded was 11 ^{o}C on August 15th. The lowest seven day average daily maximum temperature recorded was 6.4 ^{o}C on October 10th. In Tarlac Creek the seven day average daily maximum temperature only exceeded 10 ^{o}C from July 24th to August 31st.

Table 5. Channel characteristics for reaches surveyed in Tarlac Creek.

Tarlac Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	A3a+	10.4	Rubble	18
2	A3a+	12.0	Rubble	17
3	A2a+	15.9	Boulders	13

Table 6. Tarlac Creek limiting factors attributes.

Tarlac Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	50	100	1.6	3.4	0.4	10.5	27.2
2	55	100	2.4	3.1	0.3	3.5	28.0
3	51	100	2.2	2.9	0.2	17.0	21.9

Table 7. Habitat attributes for reaches surveyed in Tarlac Creek.

Tarlac Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	15.3	4.3	35.5	19	69	1	53.5
2	13.8	4.6	31.7	14	70	2	74.3
3	12.7	4.1	36.4	16	74	0	47.9

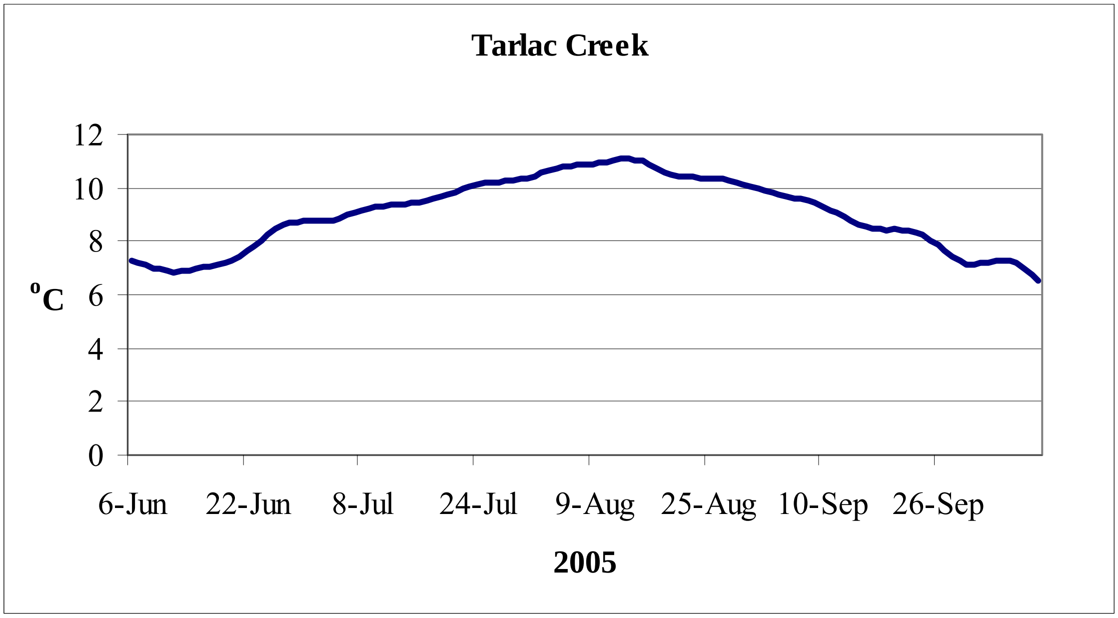

Figure 10. Seven day average daily maximum temperatures for Tarlac Creek.

Canyon Creek

Two reaches totaling 2.6 Km (1.6 miles) were surveyed in Canyon Creek (Figure 11). The survey began at the confluence of Canyon Creek and Middle Fork East River and was terminated at the base of a large fish passage barrier (Figure 12). The confluence area of Canyon Creek is composed of a complex braided channel network. Brook trout was the only species observed in two snorkel stations (Figure 13). Reach 1 contained the highest density of brook trout (9.3 fish/100 m^2).

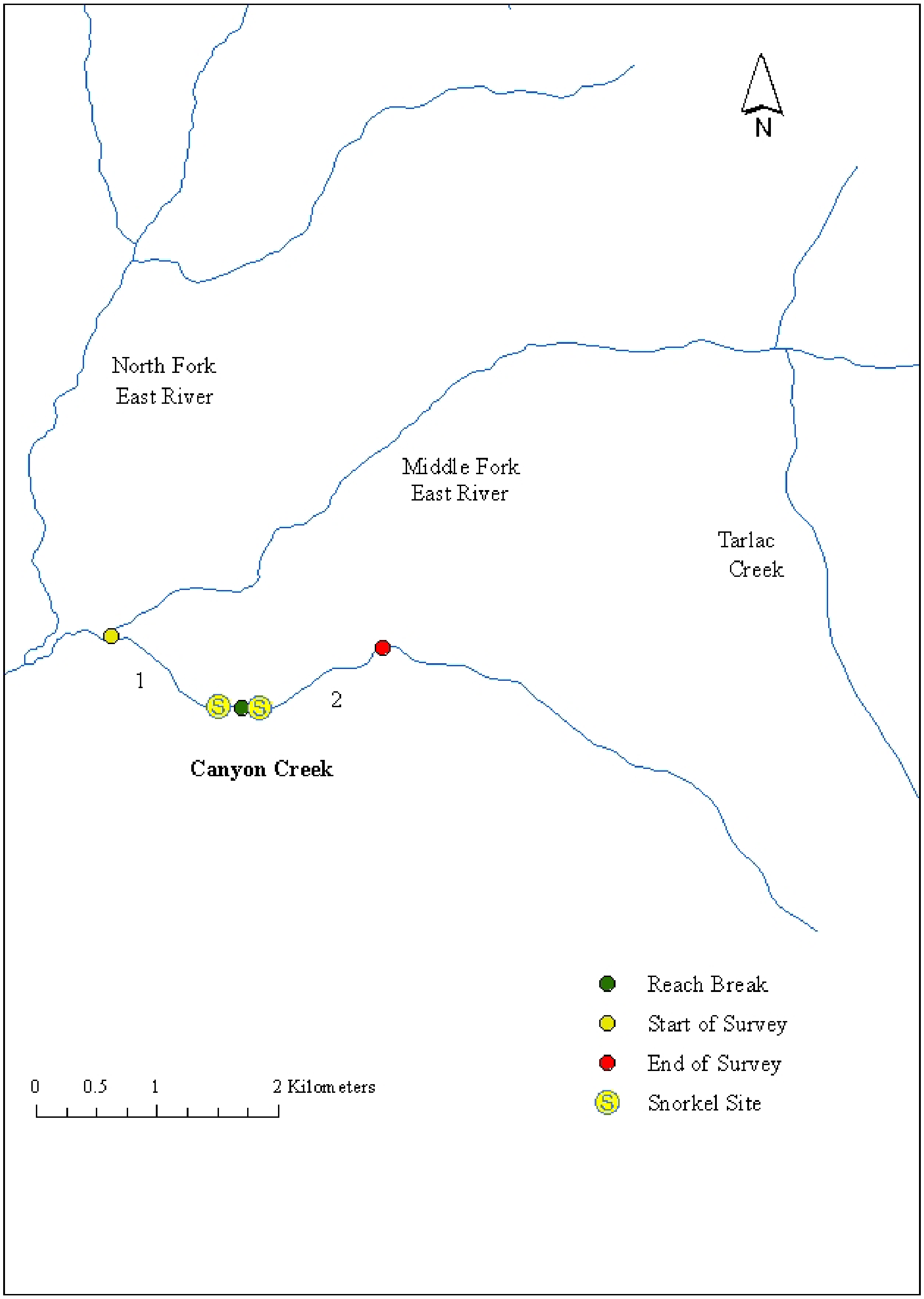

Figure 11. Reach breaks and snorkel stations in Canyon Creek.

Figure 12. Canyon Creek fish passage barrier located at the end of reach 2.

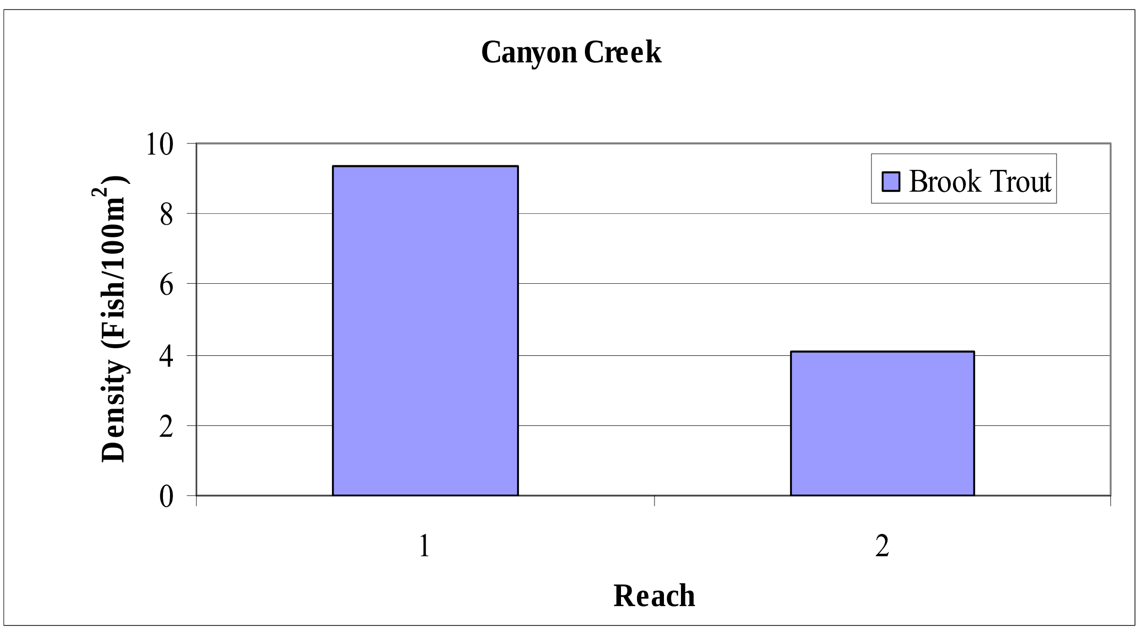

Figure 13. Fish densities for stations snorkeled in Canyon Creek.

The dominant substrate throughout Canyon Creek was gravel (Table 8). Reach 1 was classified as a B4a channel type with an average gradient of 4.7%. Reach 2 was classified as an A4 channel type with an average gradient of 9.5%. The overall embeddedness of Canyon Creek was relatively low (33% in reach 1 and 37% in reach 2) (Table 9). Riffle was the dominant habitat type in both reaches. A total of 56 m^2 of spawning gravels were recorded. LWD was abundant with an average of 45.6 pieces/100 m (Table 10). Primary pools were fairly common with 18.6 pools/Km in reach 1 and 12.9 pools/Km in reach 2.

A thermograph was placed in reach 1 of Canyon Creek and recorded temperature data hourly. The thermograph began recording data on June 28th and was collected on October 10th. The highest seven day average daily maximum temperature recorded was 13.2 ^{o}C on August 5th (Figure 14). The lowest seven day average daily maximum temperature recorded was 5.8 ^{o}C on October 10th. Seven day average daily maximum temperatures remained above 10 ^{o}C from the time the thermograph was deployed on June 28th until September 4th.

Table 8. Channel characteristics for reaches surveyed in Canyon Creek.

Canyon Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B4a	4.7	Gravel	14
2	A4	9.5	Gravel	9

Table 9. Canyon Creek limiting factors attributes.

Canyon Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	33	100	3.2	2.7	0.2	42.0	18.6
2	37	100	2.8	2.9	0.2	14.0	12.9

Table 10. Habitat attributes for reaches surveyed in Canyon Creek.

Canyon Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	11.2	3.4	27.9	10	67	0	50.4
2	12.4	3.4	28.5	17	65	0	40.8

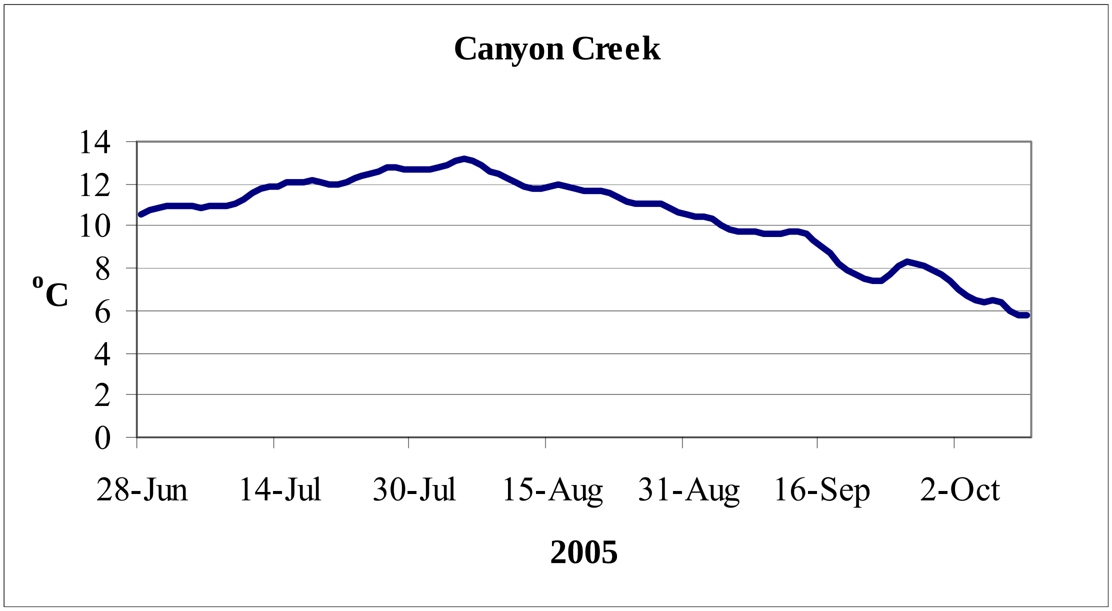

Figure 14. Seven day average daily maximum temperatures for Canyon Creek.

East River

Three reaches totaling 4.3 Km (2.7 miles) were surveyed in East River (Figure 15). The survey began at the confluence of East River and Priest River and was terminated at the confluence of North Fork East River and Middle Fork East River. East River is a low gradient, highly sinuous stream. Reach 3 runs through pasture land that appears to have moderate to heavy grazing pressure. Throughout much of the East River uplands the riparian area is composed of grasses and dense shrubs leaving little possibility for future LWD recruitment. Reach 1 contained a large area of unstable bank that is likely contributing large amounts of sediment into the system (Figure 16).

Numerous fish species were observed in the East River snorkel stations (Table 11). The most abundant species observed was mountain whitefish (*Prosopium williamsoni*) (5.6 fish/100 m^2), followed by sculpin (*Cottus Ssp*) (5.4 fish/100 m^2). The most abundant salmonid species observed were brook trout (2.5 fish/100 m^2) and brown trout (1.8 fish/100 m^2). Bull trout, westslope cutthroat trout, and rainbow trout were also observed at low densities.

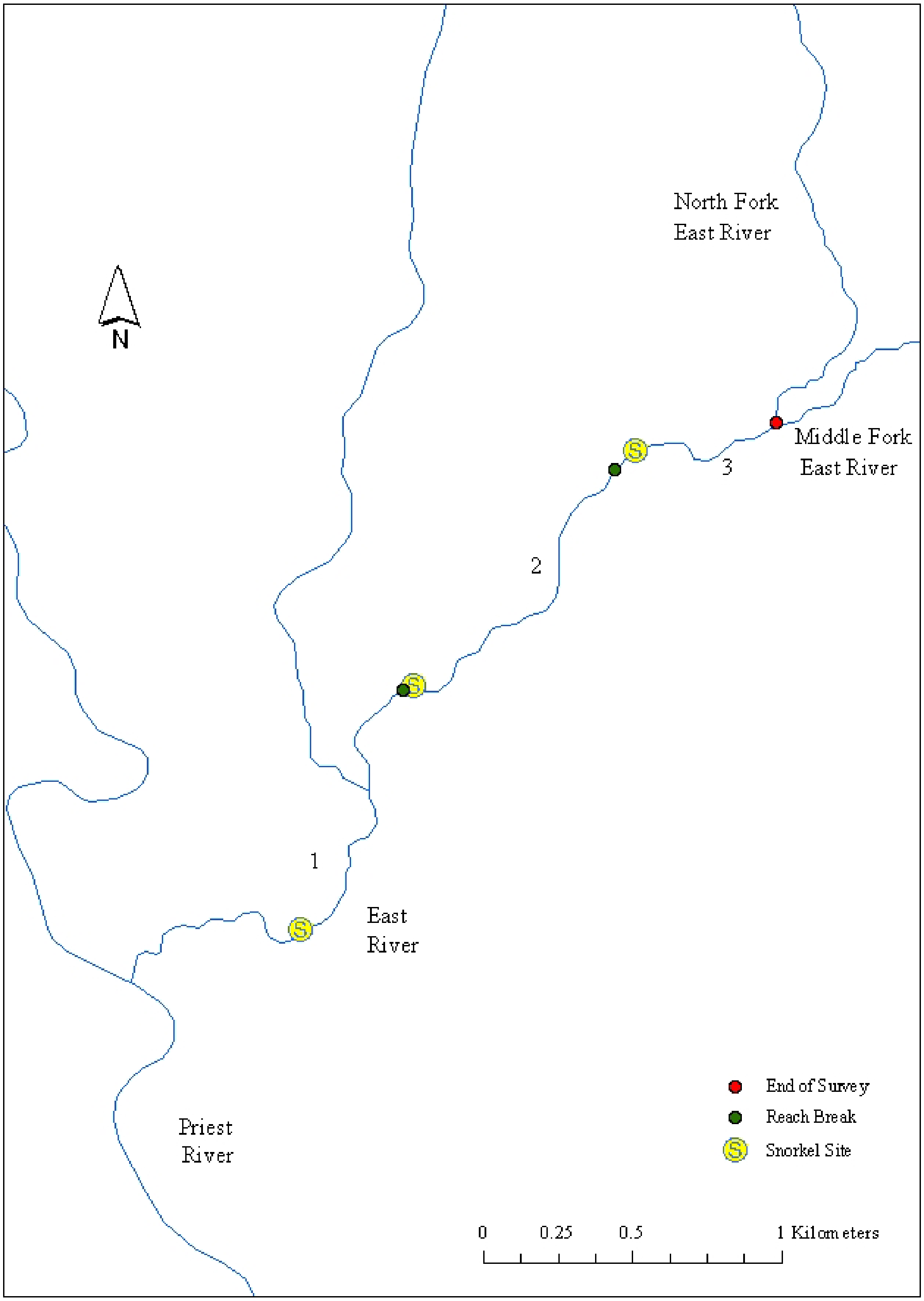

Figure 15. Reach breaks and snorkel stations in East River.

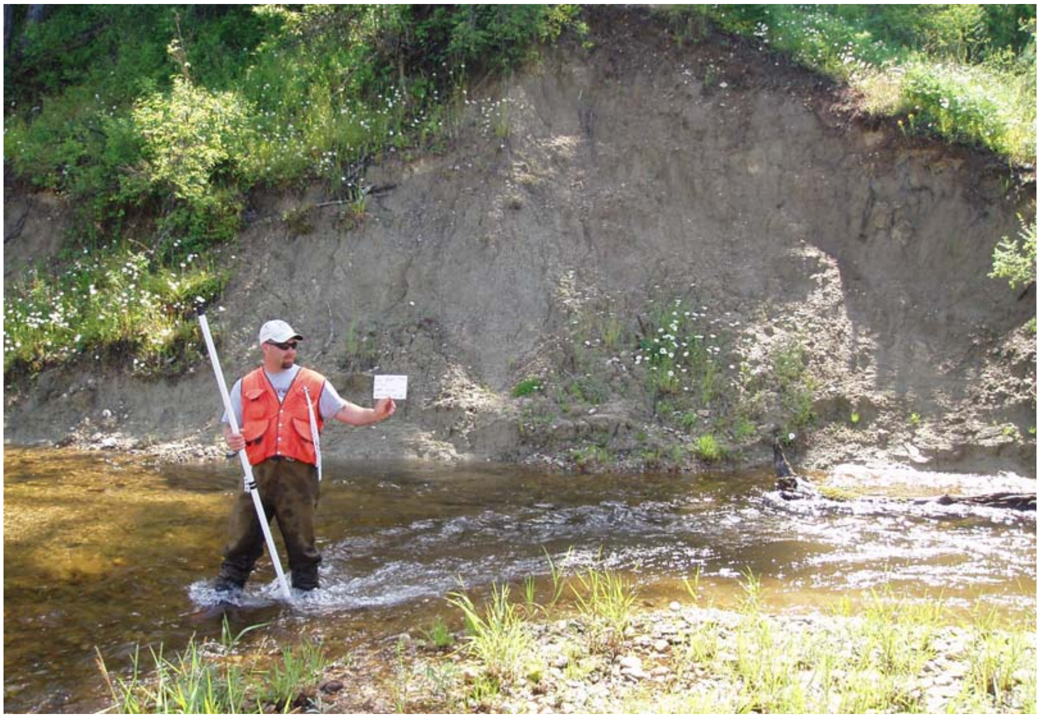

Figure 16. Unstable bank in reach 1 of East River.

Table 11. Fish densities for stations snorkeled in East River.

Density (Fish/100 m^2)			
Species	***Reach 1***	***Reach 2***	***Reach 3***
Bull Trout	0.00	0.00	0.08
Westslope Cutthroat Trout	0.61	0.40	0.23
Brook Trout	0.20	0.71	1.60
Rainbow Trout	0.00	0.001	0.00
Brown Trout	1.28	0.40	0.08
Mountain Whitefish	0.68	0.91	3.97
Dace	0.61	2.32	1.15
Suckers	0.20	0.00	0.38
Sculpin	2.09	0.91	2.37
Redside Shiner	0.34	0.00	0.00

All three reaches in East River were composed of C channel types. Reaches 1 and 2 were classified as C4 channel types and reach 3 was classified as a C3 channel type (Table 12). The average gradient and embeddedness values were both relatively low (Table 13). Spawning gravels were abundant with a high of 372.5 m^2 in reach 1 to a low of 15 m^2 in reach 3 and a total of 746.5 m^2 for all three reaches. Primary pool values were relatively low (R-1, 14.0 pools/Km, R-2, 9.1 pools/Km, and R-3, 7.6 pools/Km), however most of the primary pools were extremely large and encompassed multiple transects. Pool was the dominant habitat type in reach 1 (46%) and 3 (44%) (Table 14). In reach 2, riffle was the dominant habitat type (38%). LWD was sparse and ranged from 11.7 to 9.2 pieces/100m.

A thermograph was placed in reach 3 of East River and recorded water temperatures hourly. The thermograph was deployed on May 25th and collected on October 10th. The highest seven day average daily maximum temperature recorded was 17.9 °C on August 11th. The lowest seven day average daily maximum temperature recorded was 7.7 °C on October 10th (Figure 17). Seven day average daily maximum temperatures remained above 10 °C from June 10th until September 24th.

Table 12. Channel characteristics for reaches surveyed in East River.

East River				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	C4	1.4	Gravel	16
2	C4	1.8	Gravel	17
3	C3	1.9	Cobble	19

Table 13. East River limiting factors attributes.

East River							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	42	97	1.2	1.4	8.4	372.5	14.0
2	44	96	1.7	1.8	0.5	359.0	9.1
3	50	98	3.1	2.4	1.6	15.0	7.6

Table 14. Habitat attributes for reaches surveyed in East River.

East River							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	46.5	12.1	85.2	46	6	0	11.7
2	31.6	12.3	88.5	21	38	0	9.2
3	35.3	12.7	117.0	44	27	0	9.7

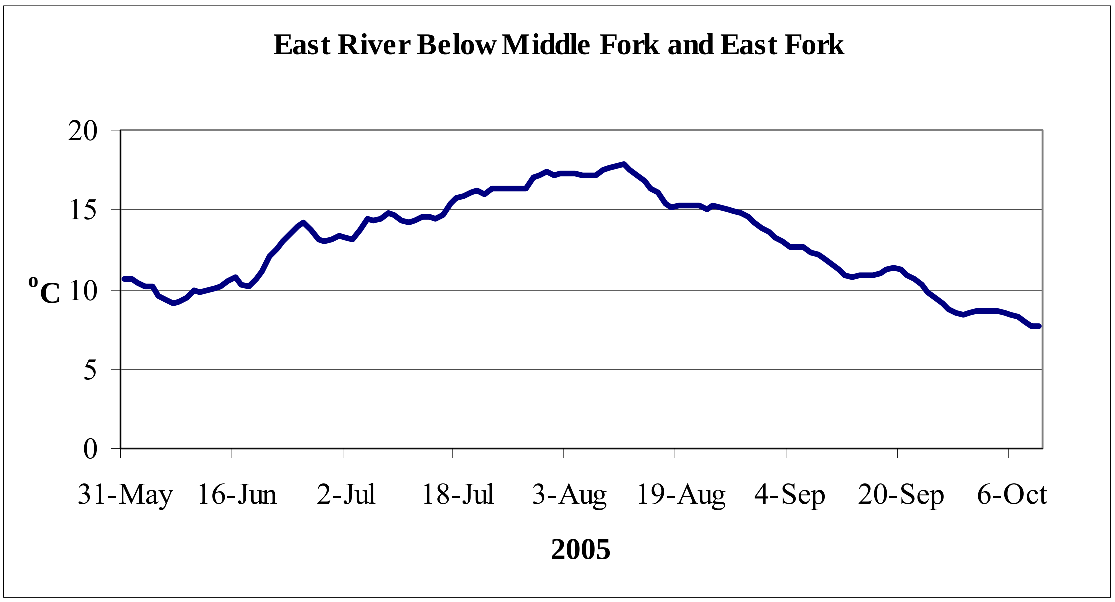

Figure 17. Seven day average daily maximum temperatures for East River.

Devil's Creek

One reach totaling 1.3 Km (0.8 miles) was surveyed in Devil's Creek. The survey began at the confluence of Devil's Creek and Middle Fork East River and was terminated in the headwaters. Reach 1 contained a possible fish passage barrier (Figure 18). Westslope cutthroat trout was the only species observed in the snorkel station (Figure 19). The westslope cutthroat trout density for reach 1 was 9.6 fish/100 m^2.

Devil's Creek reach 1 was classified as an A2b channel type with an average gradient of 13.2% (Table 15). The dominant substrate was rubble and embeddness was 52% (Table 16). Riffle was the dominant habitat type (68%) and provided good instream cover (3.4 rating). Both primary pools and LWD were common throughout the reach (47 pools/Km and 47.2 pieces/100 m^2 respectively) (Table 17).

A thermograph was deployed on May 25th in reach 1 of Devil's Creek and was retrieved on October 10th. The highest seven day average daily maximum temperature recorded (10 ^oC) occurred on August 11th and the lowest seven day average daily maximum temperature recorded (4.7 ^oC) occurred on October 10th (Figure 20). August 11th was the only day that the seven day average daily maximum temperature exceeded 10^oC.

Figure 18. Reach 1 Devil's Creek possible fish passage barrier.

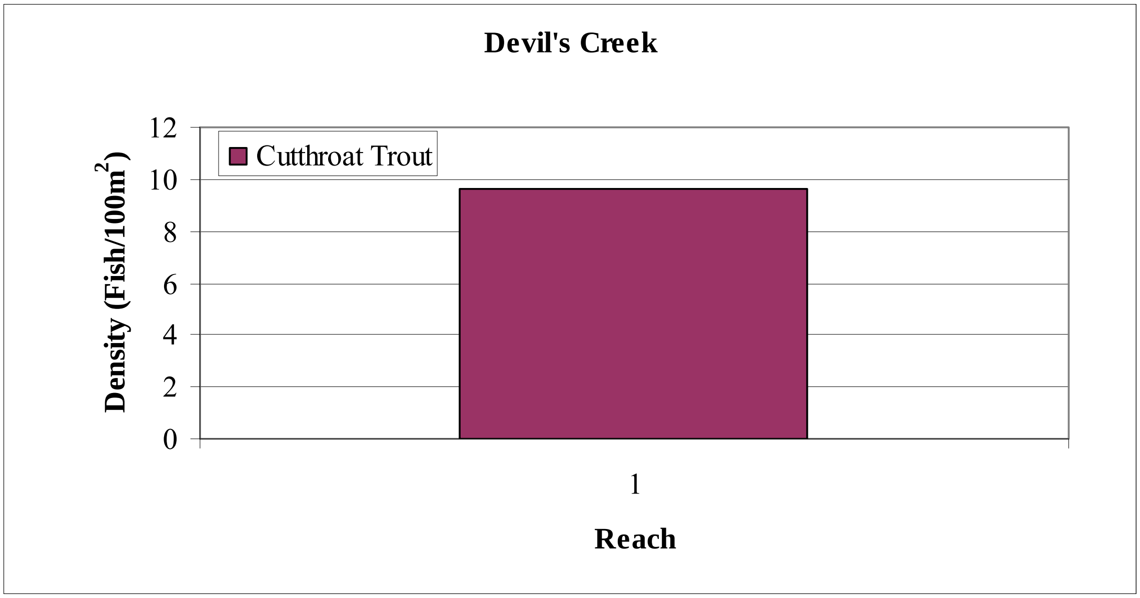

Figure 19. Fish densities for one station snorkeled in Devil's Creek.

Table 15. Channel characteristics for reaches surveyed in Devil's Creek.

Devil's Creek				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	A2b	13.2	Rubble	13

Table 16. Devil's Creek limiting factors attributes.

Devil's Creek							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	52	100	2.1	3.4	0.3	17.0	47.0

Table 17. Habitat attributes for reaches surveyed in Devil's Creek.

Devil's Creek							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	12.0	3.5	32.9	22	68	1	47.2

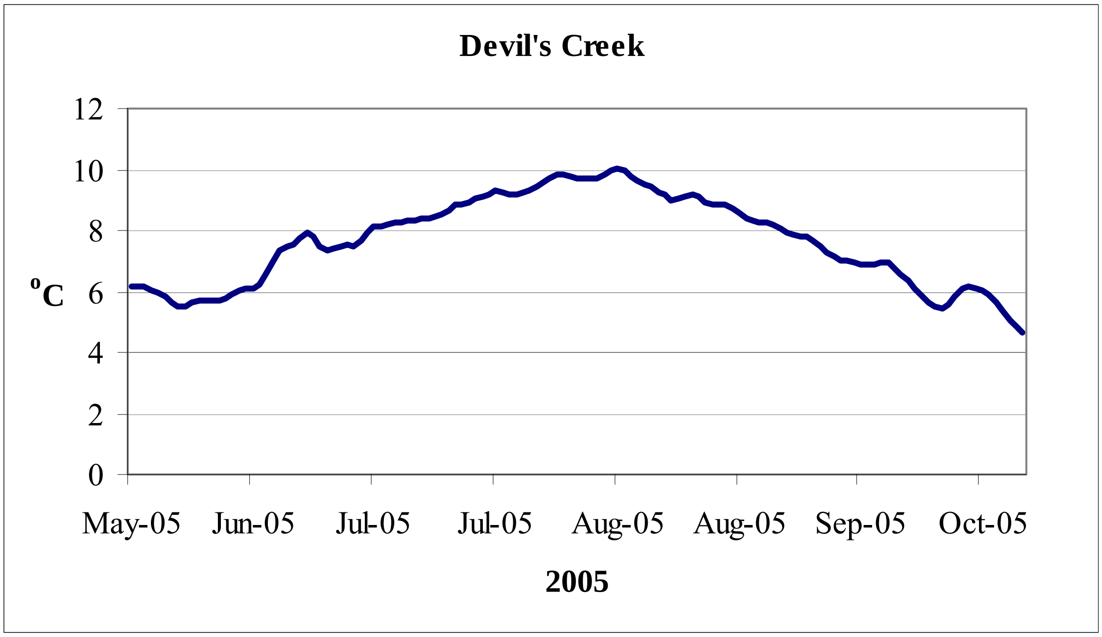

Figure 20. Seven day average daily maximum temperatures for Devil's Creek.

Middle Fork East River

Nine reaches totaling 14.1 Km (8.8 miles) were surveyed in Middle Fork East River (Figure 21). The survey began at the confluence of Middle Fork East River and East River and was terminated in the headwaters of Middle Fork East River. The riparian area of reach 1 was primarily composed of pasture land. In reach 3, the Middle Fork East River Road begins to encroach on the stream channel and remains in close proximity throughout the remainder of the survey. The entire length of reach 3 consisted of braided channel that appeared to be a result of a historic beaver dam complex. Reach 5 contained a possible fish passage barrier (Figure 22). Reach 5 is also the last reach that brook trout were observed. Reach 7 and 8 contained indications of logging within the riparian zones. Old logging cables, landings, and butts of saw logs were commonly observed.

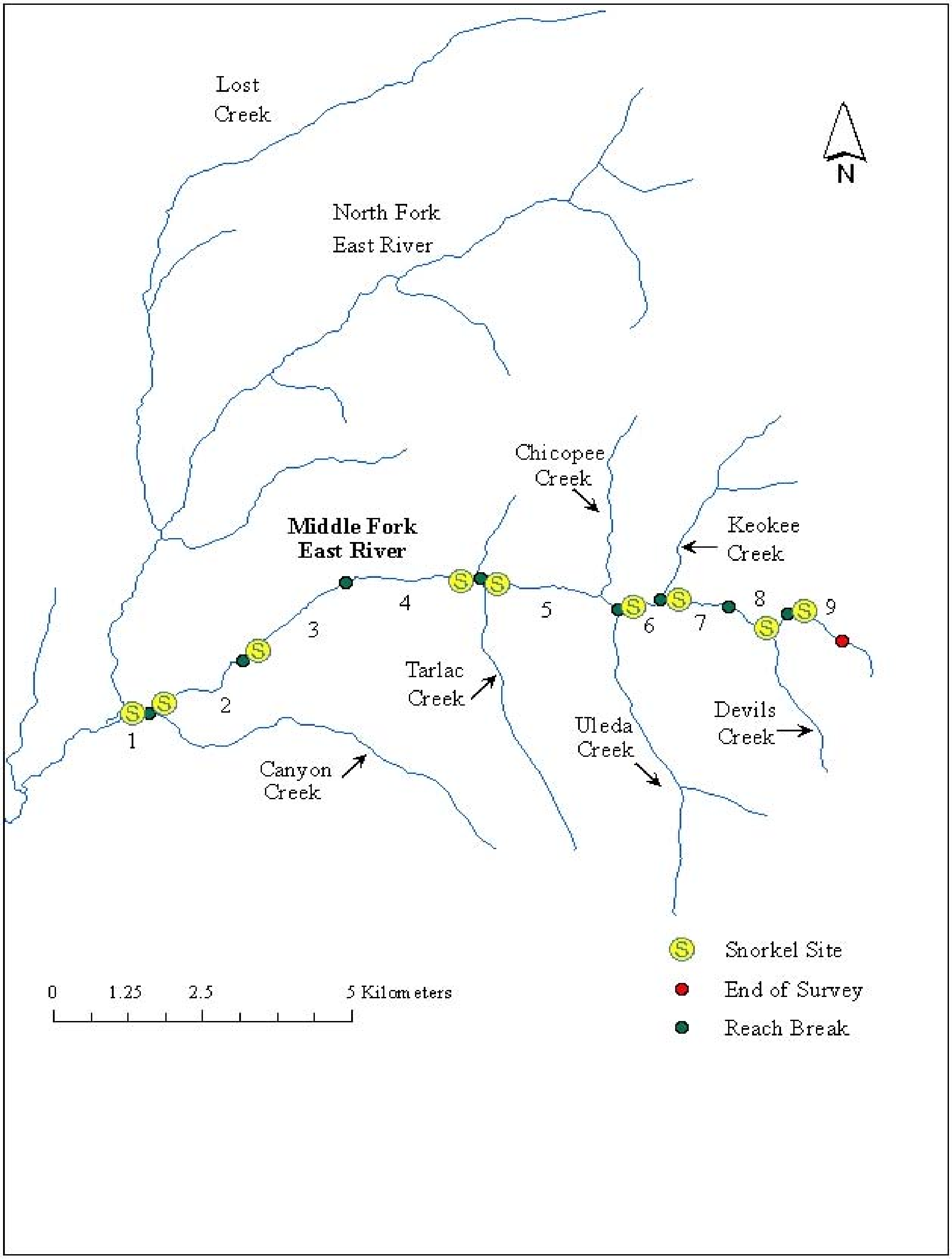

Figure 21. Reach breaks and snorkel stations in Middle Fork East River.

Figure 22. Possible fish passage barrier Middle Fork East River Reach 5.

Reaches one to five were all classified as B3 channel types (Table 18). Reaches 6-8 were classified as a B2a channel type and reach 9 was classified as an A3a+ channel type. The average overall gradient for the survey ranged from 2.3% in reach 1 to 11% in reach 9. Riffle was the dominant habitat type throughout the Middle Fork East River survey. Substrate embeddedness ranged from a high of 57% in reach 8 to a low of 35% in reach 2 (Table 19). Primary pool frequencies were low throughout the entire survey (high of 13.3 pools/Km in reach 6, low of 8.2 pools/Km in reach 4) (Table 20). Large woody debris densities were low in reaches 1-4. In reaches 5-8 LWD values were higher and reach 9 had the highest abundance of LWD with 43.8 pieces/100 m.

Table 18. Channel characteristics for reaches surveyed in Middle Fork East River.

Middle Fork East River				
Reach	Channel Type	Average Gradient (%)	Dominant Substrate	Bankfull W:D
1	B3	2.3	Cobble	23
2	B3	2.6	Cobble	18
3	B3	3.0	Cobble	17
4	B3	3.6	Rubble	15
5	B3a	4.9	Rubble	14
6	A2b	5.2	Boulders	16
7	A2b	6.2	Boulders	10
8	A2b	9.4	Boulders	12
9	A3a+	11.0	Rubble	12

Table 19. Middle Fork East River limiting factors attributes.

Middle Fork East River							
Reach	Substrate Embedded (%)	Bank Stability (%)	Bank Cover	Instream Cover	Pool : Riffle	Spawning Gravel (m^2)	Primary Pools / Km
1	42	100	2.3	2.5	0.6	132.0	11.1
2	35	99	2.9	2.5	0.2	33.0	8.3
3	42	100	1.9	2.4	0.2	3.0	8.3
4	46	100	2.7	2.7	0.2	43.5	8.2
5	52	99	2.0	2.8	0.2	35.0	10.8
6	52	99	2.2	2.9	0.1	47.0	13.3
7	53	98	2.6	2.7	0.1	10.0	10.3
8	57	100	2.5	2.5	0.2	8.0	10.8
9	44	99	3.4	2.7	0.2	11.0	9.3

Table 20. Habitat attributes for reaches surveyed in Middle Fork East River.

Middle Fork East River							
Reach	Average Depth (cm)	Average Width (m)	Residual Pool Depth (cm)	Percent Pool	Percent Riffle	Percent Pocketwater	Acting LWD (No./100m)
1	29.9	9.4	82.5	27	40	0	15.9
2	24.7	9.0	70.5	15	49	0	15.2
3	23.4	8.5	77.3	9	75	0	13.0
4	23.1	8.7	71.8	9	67	0	14.3
5	24.0	7.1	55.8	14	60	0	22.0
6	19.6	6.1	45.4	6	71	0	26.3
7	17.9	4.4	43.8	12	82	0	21.8
8	15.7	4.3	54.2	11	60	0	29.3
9	10.5	3.1	41.0	19	69	0	43.8

Bull trout, westslope cutthroat trout, brook trout, and brown trout were observed in the 9 snorkel stations in Middle Fork East River (Figure 23). In reaches 1-4 brook trout were the most abundant species. In reaches 5-9 westslope cutthroat trout were the most abundant species. Bull trout were observed in all reaches except reaches 3, 8, and 9. Westslope cutthroat trout were observed in every reach with the exception of reach 2. Brown trout were only observed at low densities in the first 3 reaches. Brook trout were only observed in the first 5 reaches.

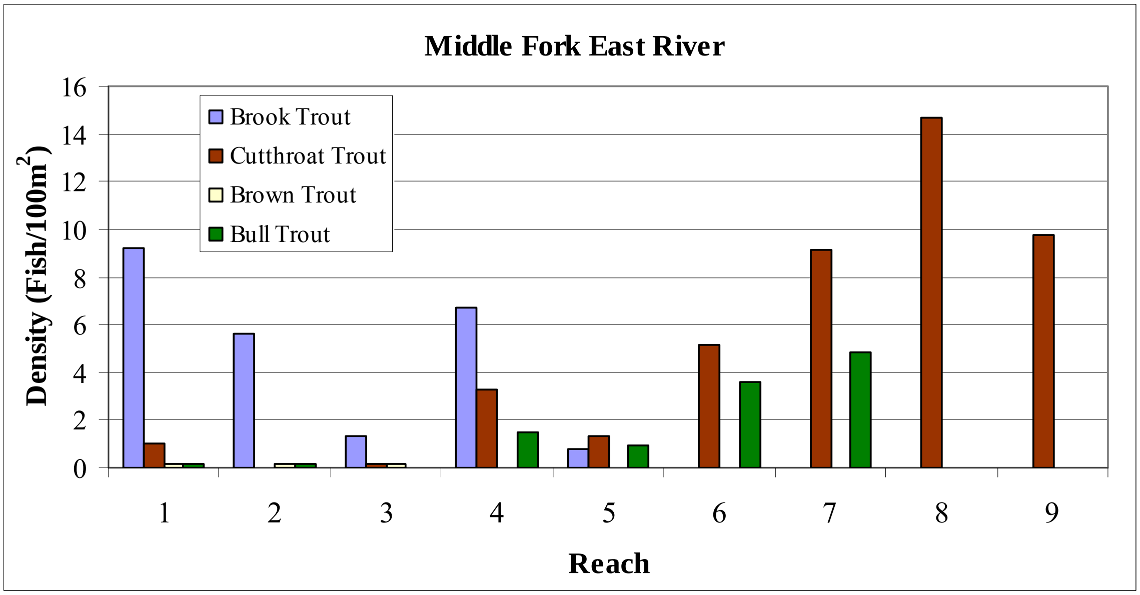

Figure 23. Fish densities for stations snorkeled in Middle Fork East River.

Five thermographs were placed in Middle Fork East River; 1) In the headwaters, 2) Just above Keokee Creek, 3) Below Tarlac Creek, 4) Upstream end of reach 2, 5) Just above the confluence with the North Fork East River. All thermographs were deployed on May 25th and collected on October 10th.

Middle Fork East River headwaters thermograph recorded its highest seven day average daily maximum temperature (9.7 °C) on August 11th and the lowest seven day average daily maximum temperature (4.9 °C) on October 10th (Figure 24). The seven day average daily maximum temperature never exceeded 10 °C. Middle Fork East River above Keokee Creek recorded a high seven day average daily maximum temperature of 10.9 °C on August 11th and a low seven day average daily maximum temperature of 5.2 °C on October 10th (Figure 25). The seven day average daily maximum temperature was above 10 °C from July 23rd to August 17th. Middle Fork East River below Tarlac Creek recorded a high seven day average daily maximum temperature of 11.8 °C on August 11th and a low seven day average daily maximum temperature of 5.7 °C on October 10th (Figure 26). The seven day average daily maximum temperature was above 10 °C from July 6th to August 28th. The Middle Fork East River at reach 2 thermograph recorded a high seven day average daily maximum temperature of 15.7 °C on August 11th and a low seven day average daily maximum temperature of 6.7 °C on October 10th (Figure 27). The seven day average daily maximum temperature was above 10 °C from June 21st to September 22nd. Middle Fork East River above North Fork East River recorded a high seven day average daily maximum temperature of 17.4 °C on August 11th and a low seven day average daily maximum temperature of 7.5 °C on October 10th (Figure 28). The seven day average daily maximum temperature was above 10 °C from June 16th to September 24th. It was interesting to observe the increases in temperature from thermographs placed in the upper portions of the watershed to the thermographs placed at the bottom of the watershed. From the headwaters of Middle Fork East River to the confluence with East River the temperature increased about 8 °C on August 11th.

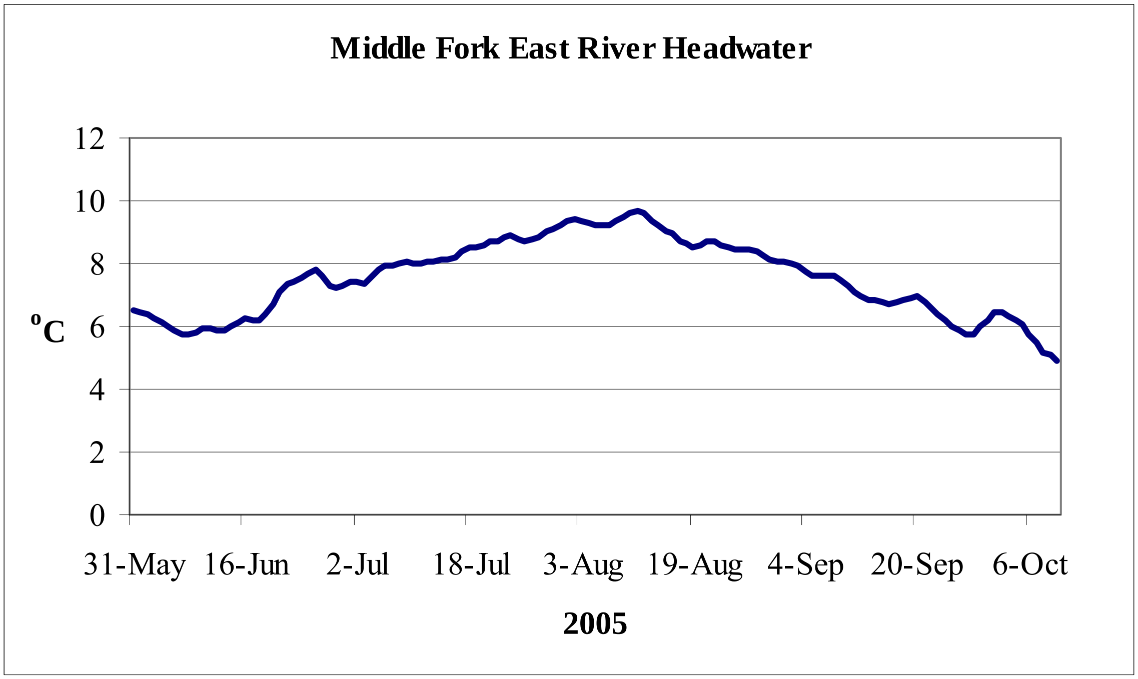

Figure 24. Seven day average daily maximum temperatures for Middle Fork East River Headwater.

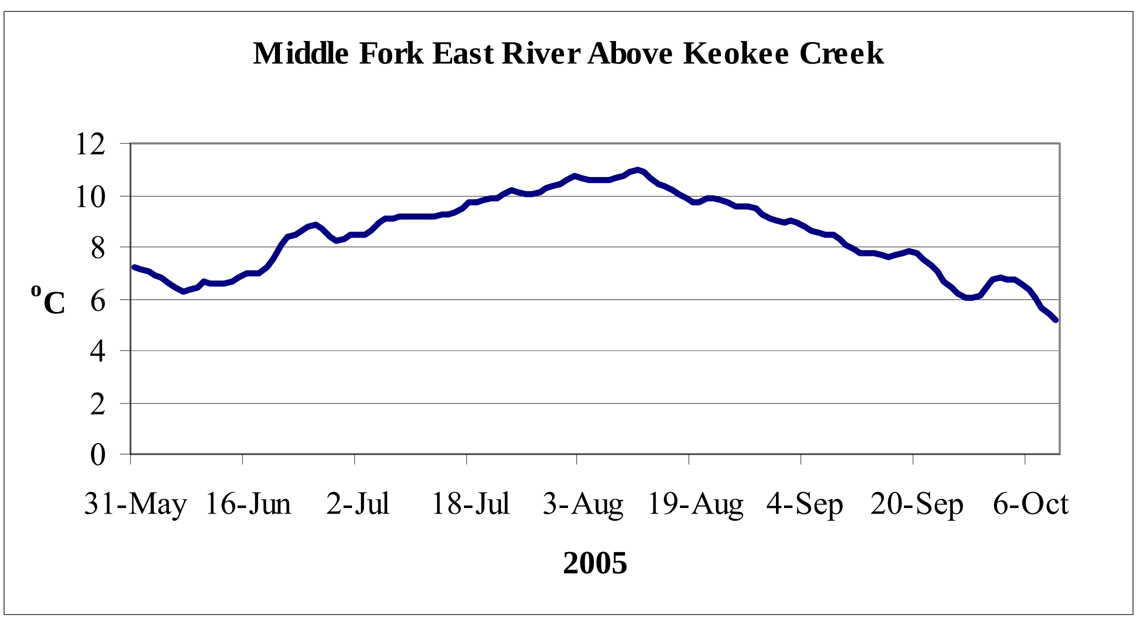

Figure 25. Seven day average daily maximum temperatures for Middle Fork East River above Keokee Creek.

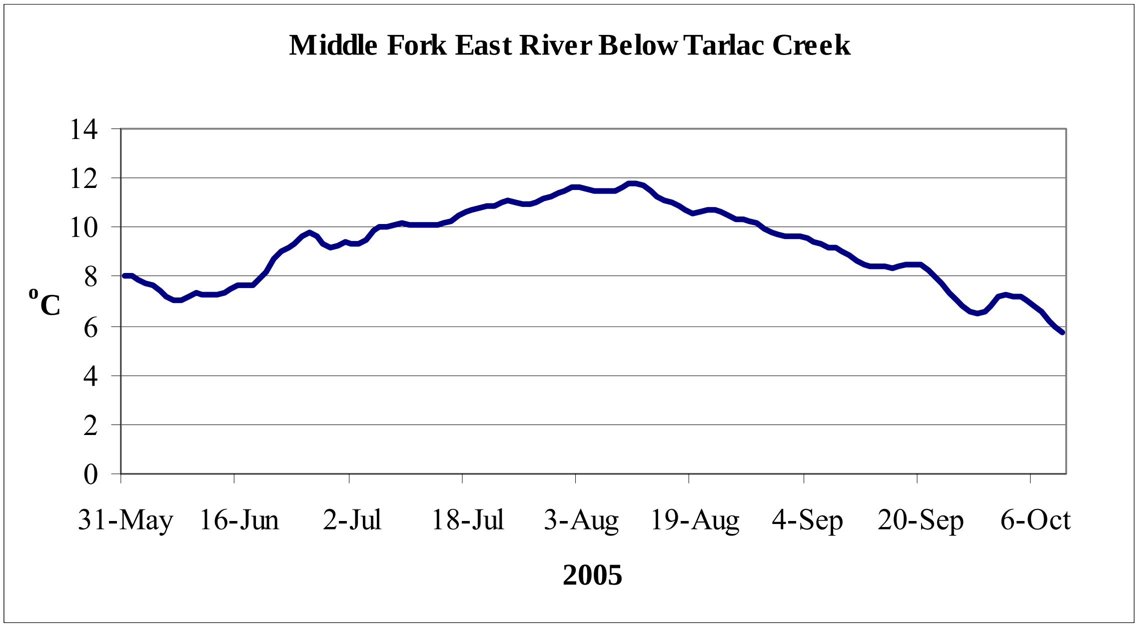

Figure 26. Seven day average daily maximum temperatures for Middle Fork East River below Tarlac Creek.

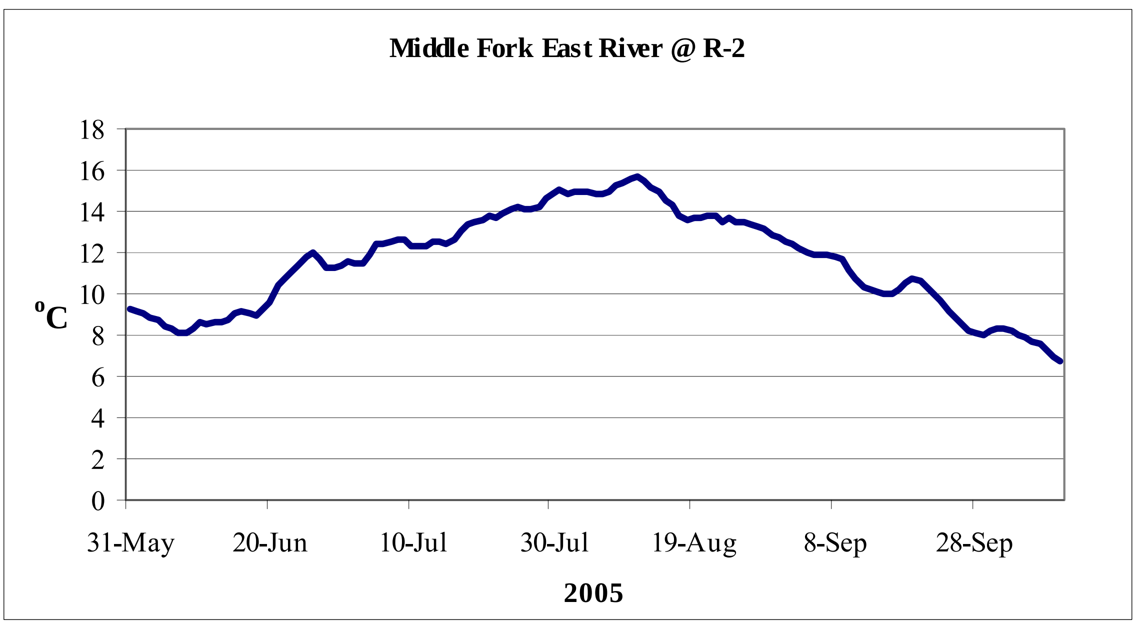

Figure 27. Seven day average daily maximum temperatures for Middle Fork East River at reach 2.

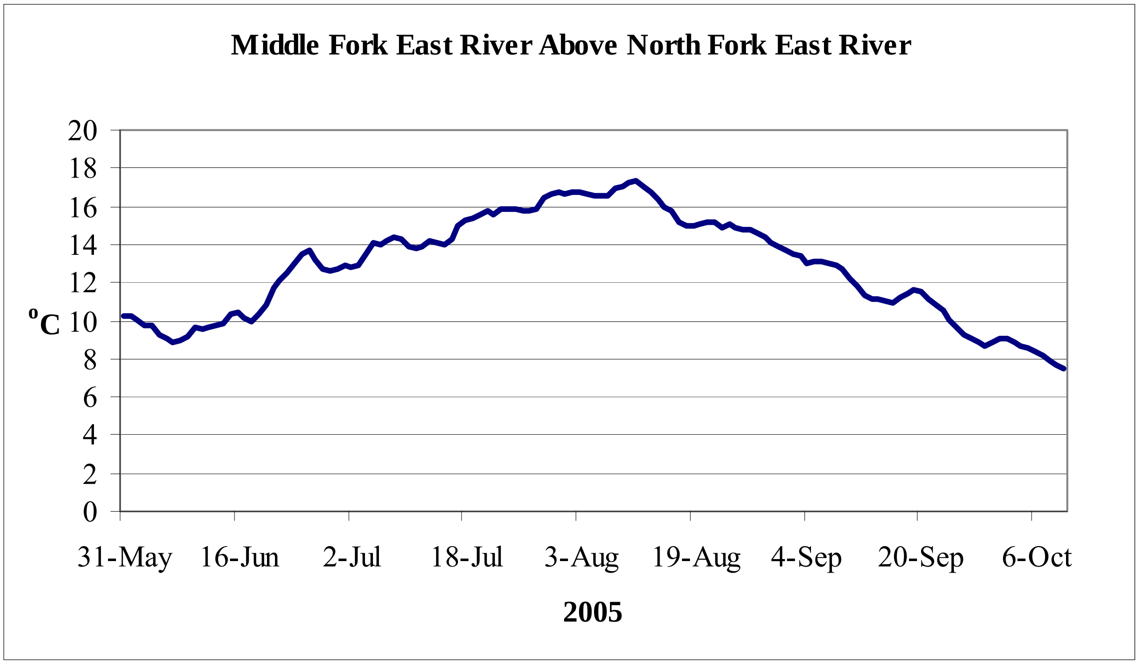

Figure 28. Seven day average daily maximum temperatures for Middle Fork East River above North Fork East River.

2005 NON-NATIVE FISH REMOVALS

DESCRIPTION OF STUDY AREA

Diamond Fork Creek is a headwater tributary to West Branch LeClerc Creek (Figure 29). The non-native fish removal project started approximately 300 m upstream from the confluence near an elevation of 1,120 m. The removal project was terminated 1.6 Km (1 mile) upstream near an elevation of 1,290 m. In addition to the mainstem Diamond Fork Creek, 0.4 km of a tributary was also treated.

Saucon Creek is also located in the headwater portion of West Branch LeClerc Creek. The removal began just upstream of the confluence of Saucon (elevation 1,103 m) and the West Branch LeClerc Creek. The removal was terminated 2.0 Km (1.2 miles) upstream at an elevation of 1,280 m.

Tributary 2 (an un-named tributary) is located just west of Saucon Creek. The removal was started at an elevation of 1,097 m and was terminated 1.4 Km (0.9 mile) upstream at an elevation of 1,219 m. 1.2 Km of a tributary to Tributary 2 was also treated.

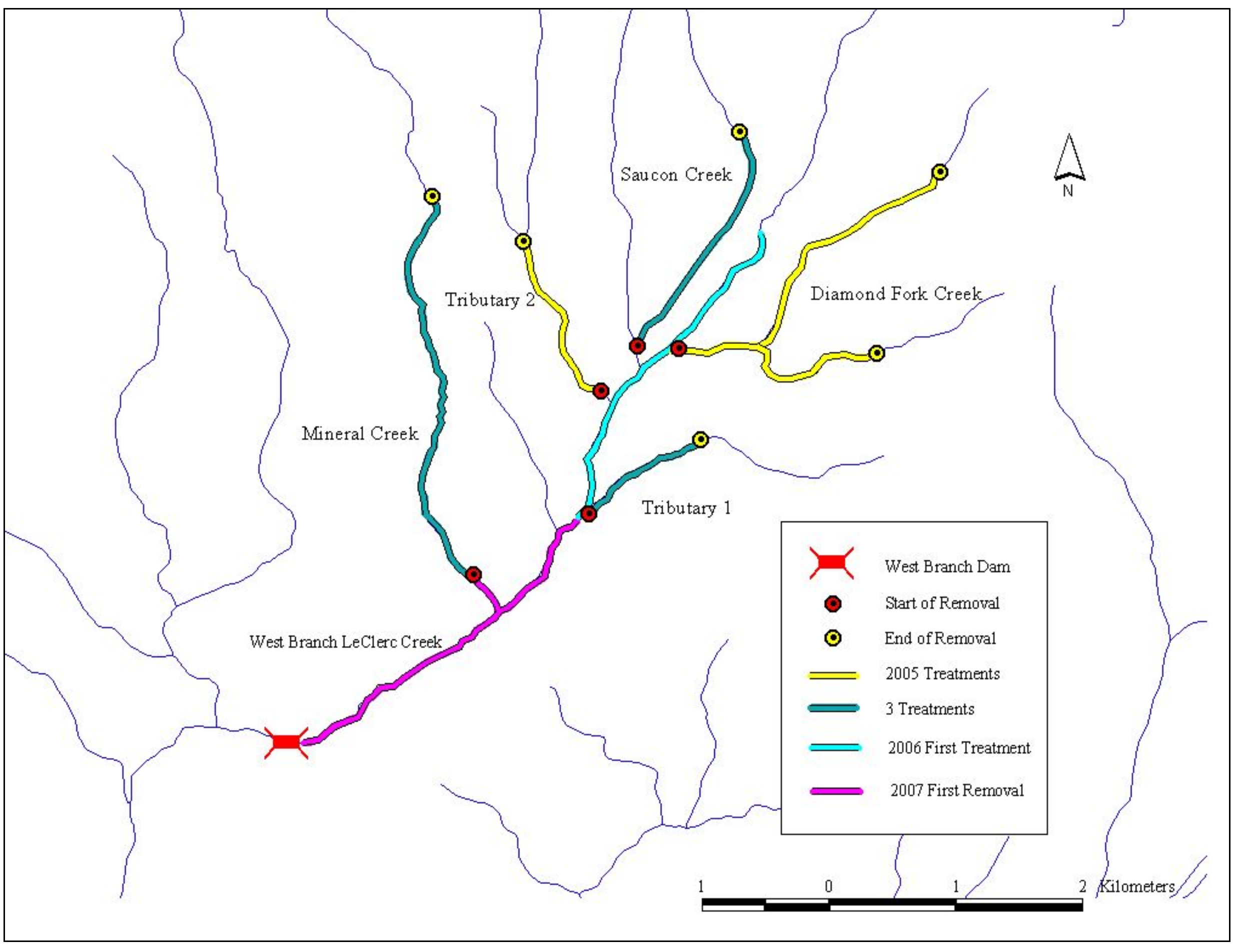

Figure 29. Location of non-native fish removal sites.

METHODS

Non-native Fish Removal

Streams were electrofished using a battery operated Smith-Root LR-24 electrofishing backpack unit. To avoid imminent re-invasion by brook trout, electrofishing commenced at a point in the channel where fish passage was difficult if not impossible. When multiple passes were made, the stream was partitioned into 100 m reaches using 1-cm mesh block nets at both ends of the reach to prevent immigration or emigration of fish before and during electrofishing. All passes were electrofished with relatively constant effort and care was taken to remove all possible stunned fish. In Diamond Fork Creek and its tributary, two electrofishing passes were made in each 100 m section. All fish captured in each pass were removed from the electrofished section. Captured cutthroat trout were released in the adjacent, downstream section (which had previously been electrofished). Captured brook trout were transported in a holding tank to another location and released. Electrofishing occurred upstream until brook trout were absent in the catch in three consecutive 100 m sections.

In 2005, Saucon Creek was treated for the third consecutive year and West Branch LeClerc Creek Tributary 2 was treated for the second consecutive year. The same methods were used; however, only one pass was made, so block nets were not utilized.

RESULTS

Non-native Fish Removal

A total of twenty 100 m sections of Diamond Fork Creek and its tributary were electrofished using a two-pass treatment to remove non-native fish. Brook trout were not captured in the last 100 m section. A total of 4,209 brook trout were captured and relocated to various sites (Table 21). Westslope cutthroat trout were less abundant; 221 were captured and returned to Diamond Fork Creek.

Table 21. Number of fish captured during electrofishing removals in 2005.

Stream Name	No. Passes	Cutthroat Trout	Brook Trout	Totals
Tributary 2	1	142	957	1099
Saucon Creek	1	238	237	475
Diamond Fork Creek	2	221	4209	4430

A total of twenty-five 100 m sections of stream were treated in West Branch LeClerc Creek Tributary 2, using a single pass treatment. A total of 957 brook trout were captured and relocated to various sties, while 142 cutthroat trout were captured and returned back into the stream (Table 21).

Twenty 100 m sections in Saucon Creek were electrofished using a single pass treatment. A total of 237 brook trout were captured and relocated (Table 21). Two hundred and thirty eight cutthroat trout were captured and returned to the stream.

DISCUSSION

The second phase of brook trout removal in Diamond Fork Creek will occur in 2006. Because they are more difficult to sight and capture, age 0^+ brook trout can have relatively low removal efficiencies (Thompson and Rahel, 1996). All of the channels that have been selected for removals contain an abundant volume of woody debris, making removal difficult with only one treatment. Therefore, Diamond Fork Creek will be electrofished again, with a single pass, in 2006.

In 2005, Saucon Creek received a third treatment to further remove non-native brook trout. The non-native fish removal in Saucon Creek has shifted the population from one dominated by brook trout to one with westslope cutthroat trout and brook trout at a 1:1 ratio (Figure 30). In 2005, a total of 238 westslope cutthroat trout were captured along with 237 brook trout. The removal has greatly decreased the number of brook trout in the Saucon Creek treatment site. Saucon Creek will be monitored in 2007.

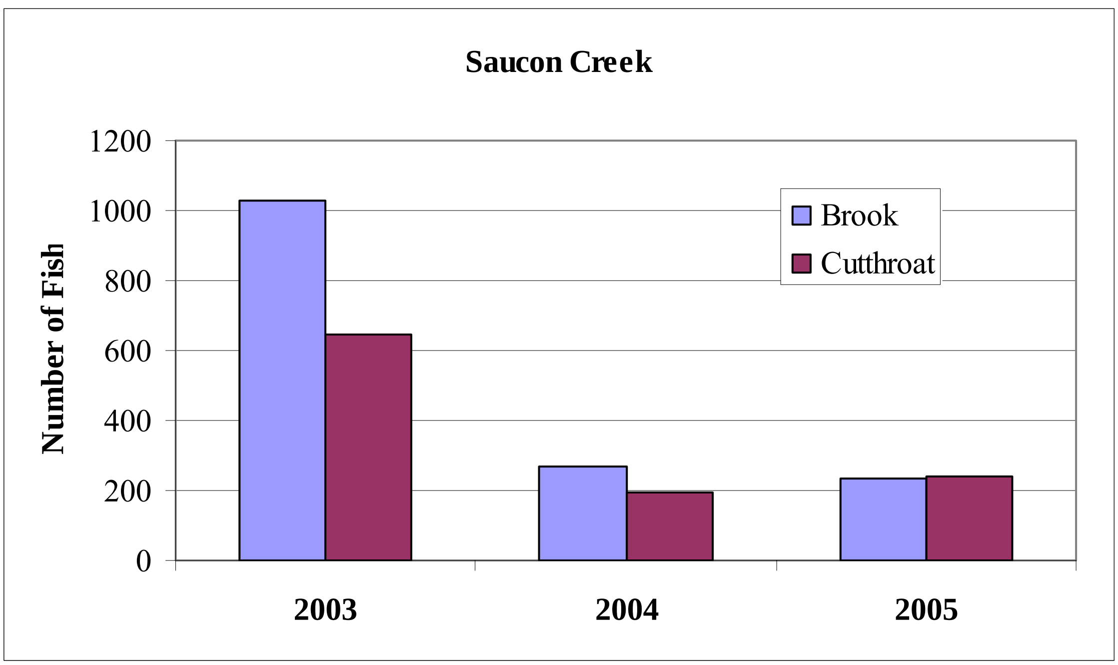

Figure 30. Number of brook trout and westslope cutthroat trout captured in all treatments of Saucon Creek.

A similar project in Montana was conducted in Sheppard Creek. The stream length treated and numbers of fish captured in the first two treatments were similar to Saucon Creek. However, the third treatment in our project produced a much lower number of brook trout. The Sheppard Creek project has been considered a success by the USFS.

LARGEMOUTH BASS HABITAT ENHANCEMENT MONITORING

DESCRIPTION OF STUDY AREA

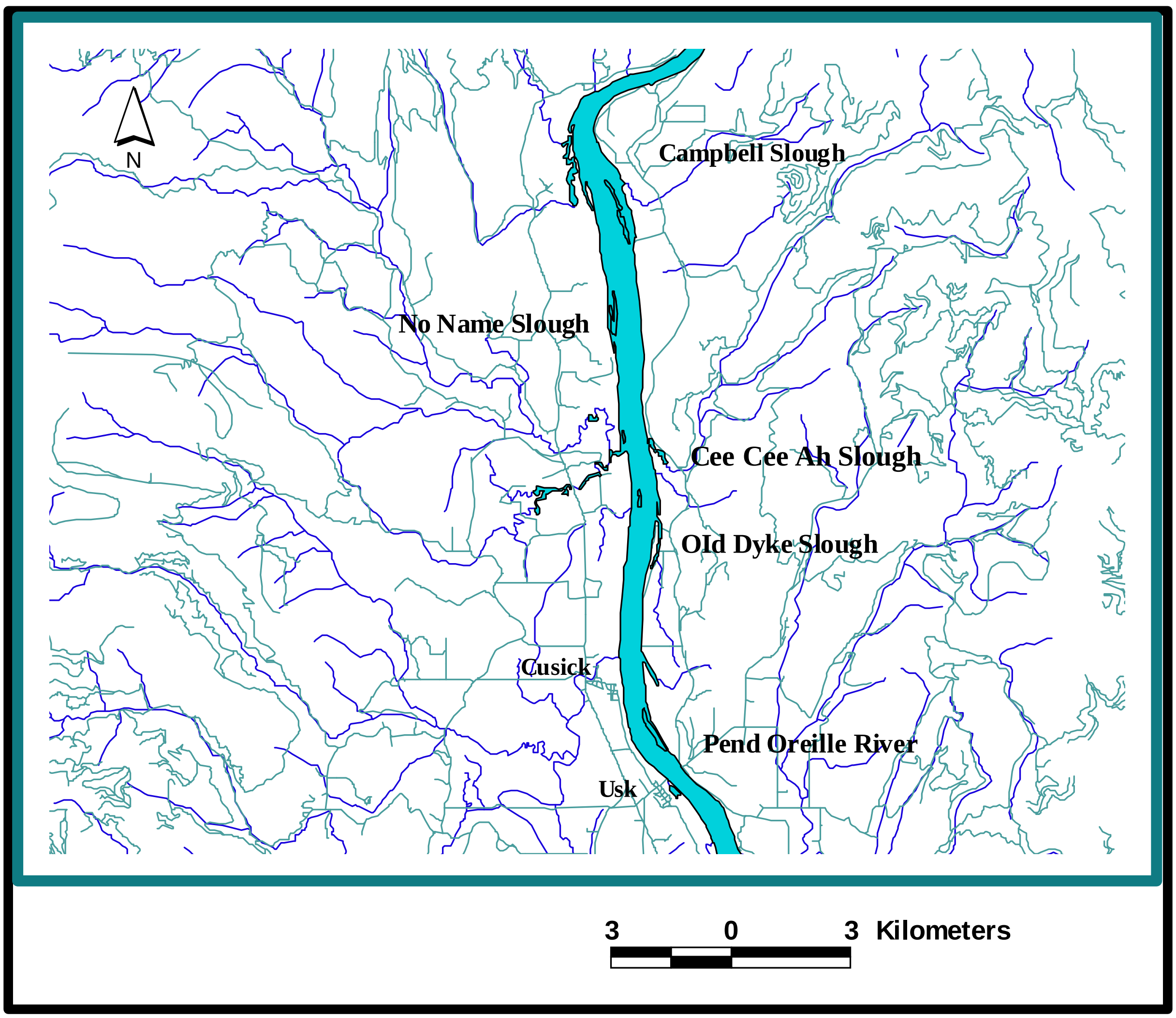

Figure 31. Location of the largemouth bass habitat enhancement sites.

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 (Figure 31).

2) No Name slough located directly across the reservoir from Campbell slough, on the west side of the reservoir, at river km 99.

3) Cee Cee Ah slough, located within the Kalispel Reservation on the east side of the reservoir, at river km 109.

4) Old Dike slough, contained within the Kalispel Reservation and located on the east side of the reservoir, at river km 107.

METHODS

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. Largemouth bass (LMB) 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 LMB.

RESULTS

From 1997 (pre-assessment) to fall 2005, LMB relative abundance increased at every sampling site. Sampling of the LMB enhancement sites did not occur in the fall of

1998, 2000, and 2003. Early sub-freezing temperatures iced the sloughs over in early November and the ice remained throughout the month.

In Cee Cee Ah Slough #1, LMB relative abundance was 2 in the fall of 1997 and again in the fall of 2002, however in 2005, 4 LMB were captured (Figure 32). In Cee Cee Ah Slough #2, LMB have been present in the catch in the fall of 1999 (n=2, Figure 33), 2002 (n=1), spring and fall of 2004 (n=1, n=3), and in the fall of 2005 (n=1).

In No Name Slough #1, LMB relative abundance appeared to increase significantly in the fall of 1999 when 14 were collected (Figure 34). No LMB were collected in the 1997 pre-assessment or the 1999 to 2003 spring post assessments. One LMB was collected at this site in the spring and fall of 2005. No bass were present in the 1997 pre-assessment sample in No Name Slough #2 (Figure 35). 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, 2000, 2001, or 2003 spring sampling periods and 6 LMB were present in the 2001, 2002, and 2004 fall samples. In 2005, one LMB was collected in each the spring and fall samples.

In Old Dyke #1, two LMB were captured in the 1997 pre-assessment (Figure 36). Prior to fall of 2004, LMB were collected in only four other sampling periods: one in the fall of 1999, 3 in the fall of 2001and 39 in the fall of 2002. No LMB were present in the catch in any of the spring sampling periods. However, in the fall of 2002, 2004, and 2005 high densities of LMB were captured (39, 18, and 25 respectively). In Old Dyke #2, LMB were present in the catch in all sample periods except in the spring of 2001 (Figure 37). Sixteen LMB were captured in 2005. In Old Dyke #1 2005, yielded the second highest overall LMB catch (n=25). The Old Dyke Slough sampling sites seem to be the most productive and stable with regards to LMB relative abundance numbers since the habitat structures were placed.

In Campbell Slough #1, LMB have been present in the catches of all sampling periods. LMB relative abundance increased dramatically from pre-assessment (n=1) to fall 2004 (n=15, Figure 38). LMB abundance in the spring of 1998 and 2001 was also relatively high with 19 and 17 LMB captured, respectively. LMB relative abundance initially increased in Campbell Slough #2 (Figure 39). The 1997 pre-assessed abundance was 1. Large increases were observed in spring 1998 (n=19) and spring 1999 (n=18). Five LMB were captured in fall 1999. LMB numbers declined in the fall of 1999 (n=5) and spring of 2000 (n=1). However in 2001 and 2004, fall LMB relative abundance was relatively high at 30 and 31, respectively. In 2005 the relative abundance dropped down to 1 LMB in the spring and 9 LMB in the fall.

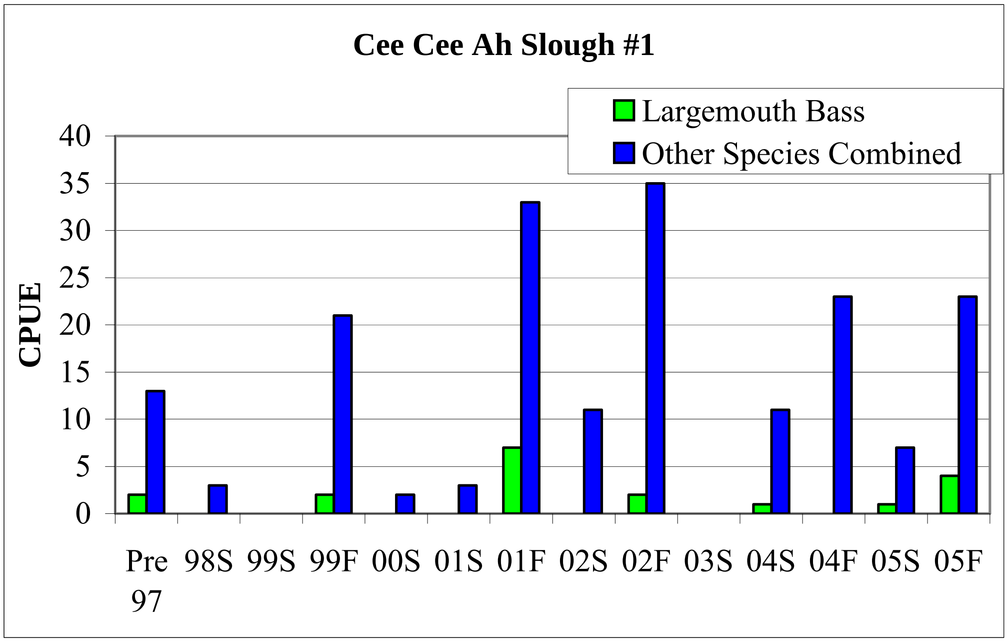

Figure 32. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #1.

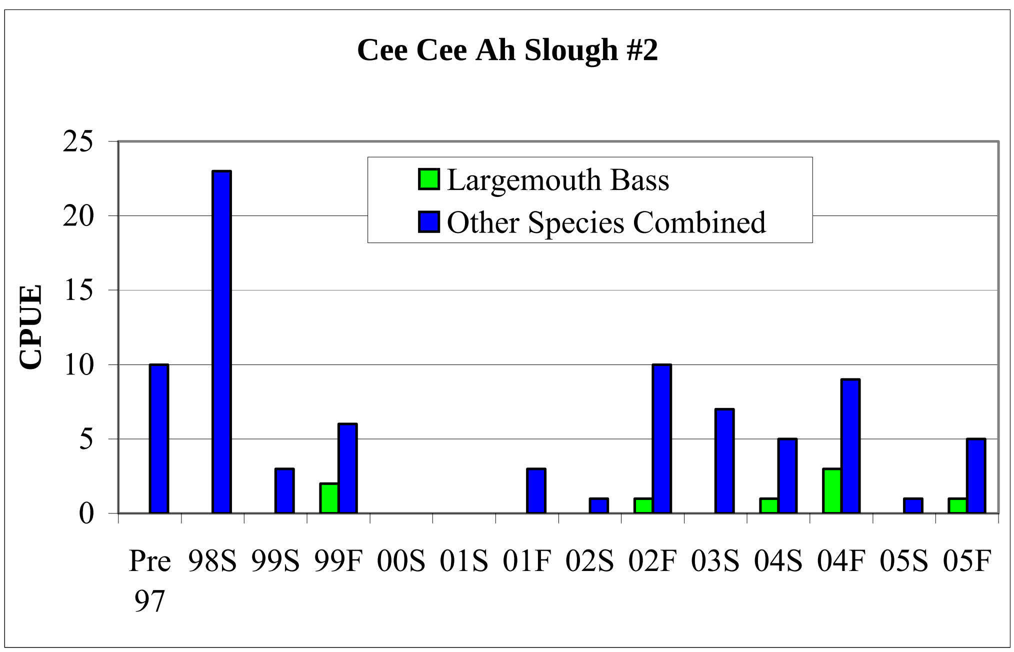

Figure 33. Largemouth bass and combined fish relative abundance for transects in Cee Cee Ah Slough #2.

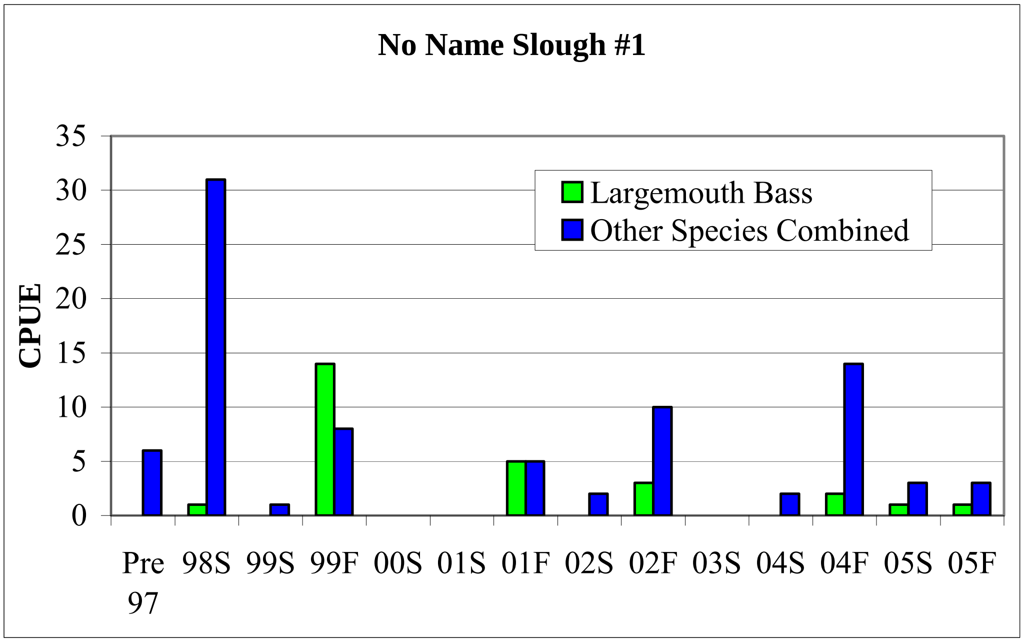

Figure 34. Largemouth bass and combined fish relative abundance for transects in No Name Slough #1.

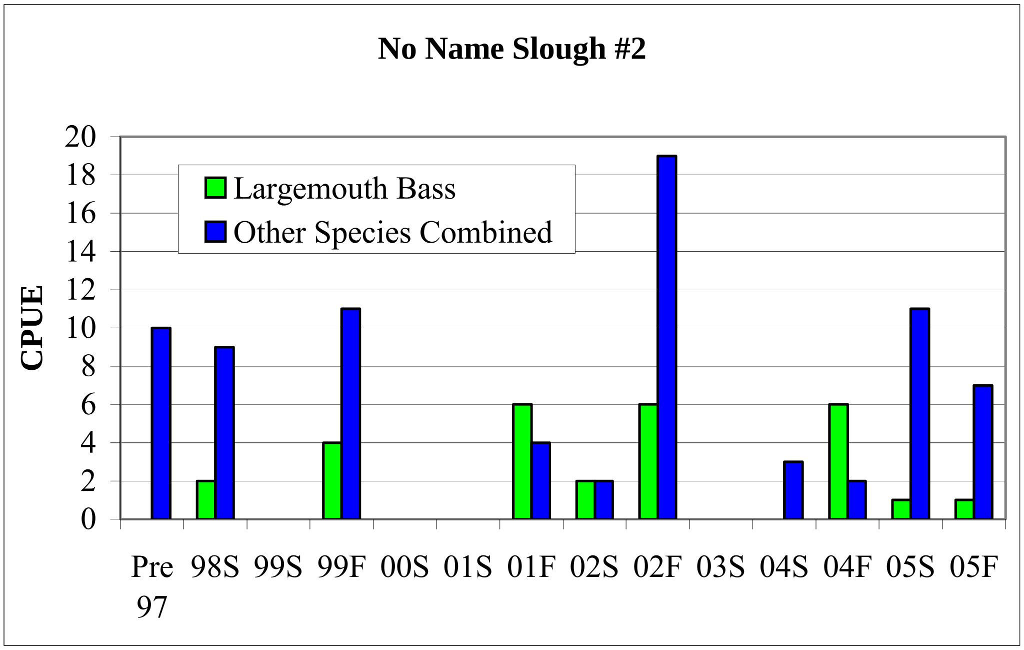

Figure 35. Largemouth bass and combined fish relative abundance for transects in No Name Slough #2.

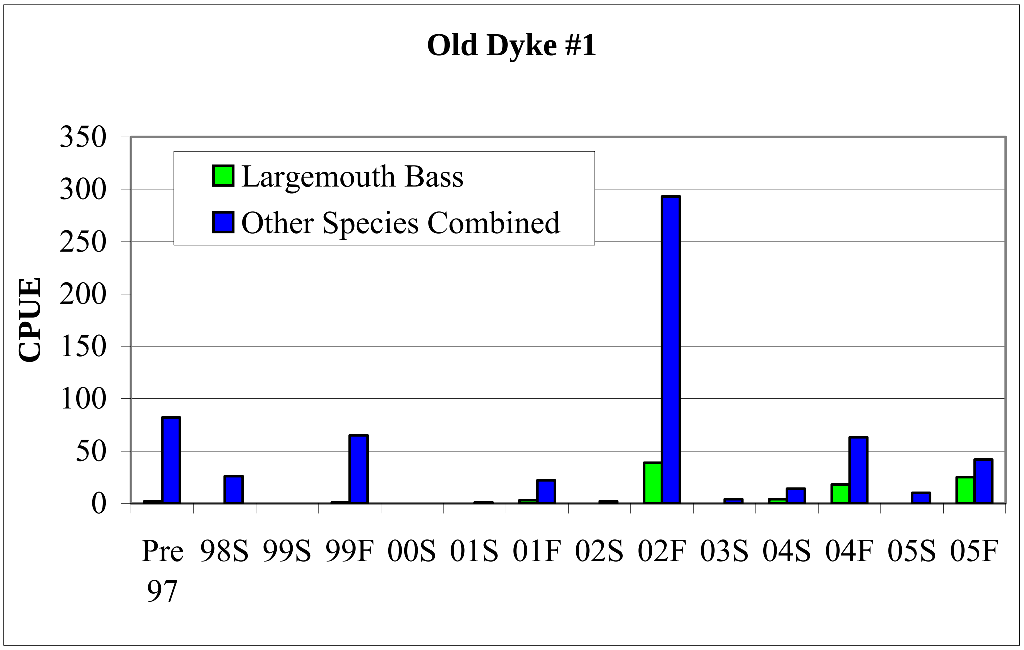

Figure 36. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #1.

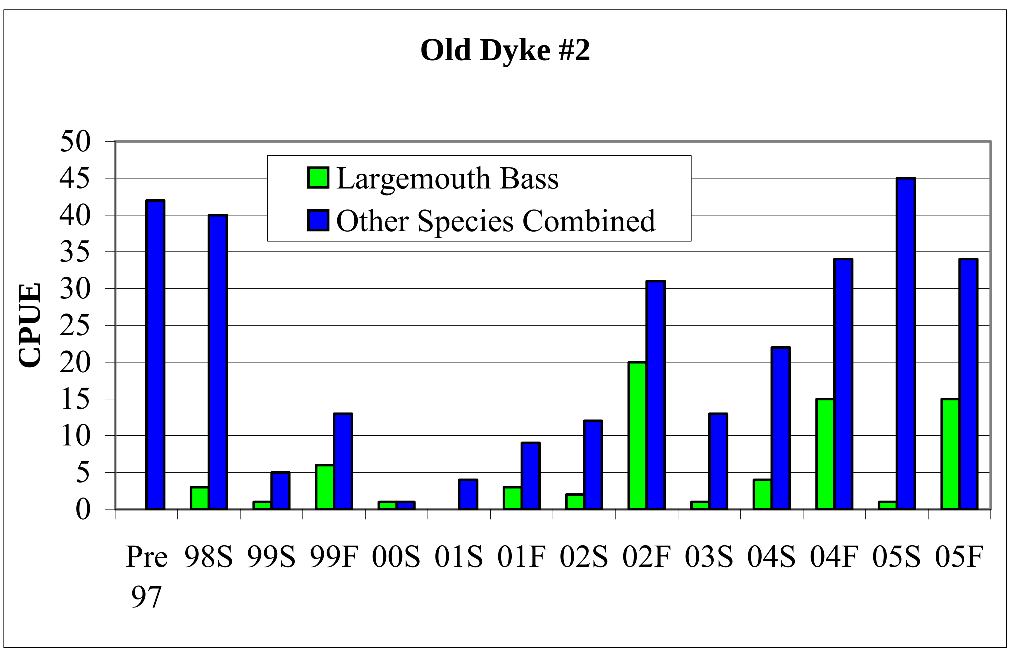

Figure 37. Largemouth bass and combined fish relative abundance for transects in Old Dyke Slough #2.

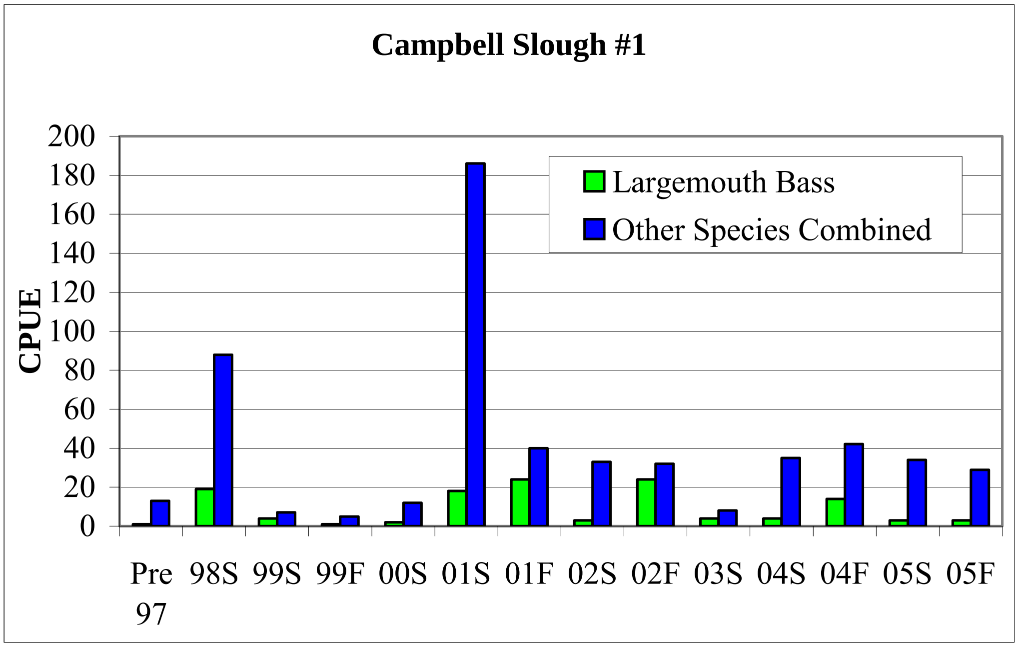

Figure 38. Largemouth bass and combined fish relative abundance for transects in Campbell Slough #1.

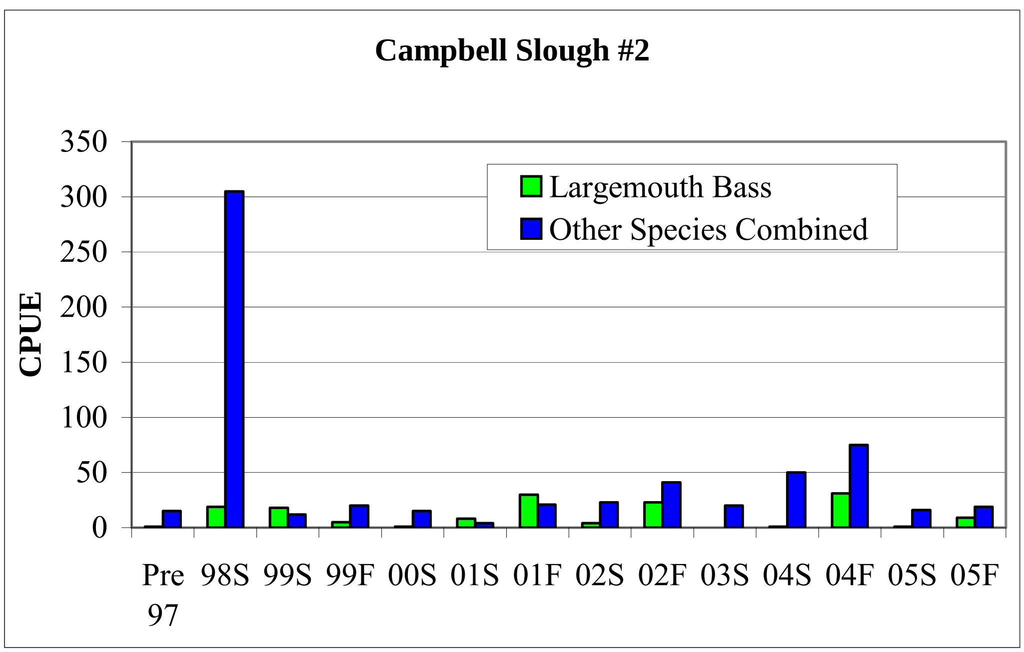

Figure 39. Largemouth bass and combined fish relative abundance for transects in Campbell Slough #2.

DISCUSSION

Juvenile LMB are more likely to be present in the catch in the fall while larger adults are captured more frequently in the spring (Figure 40). The length frequency graph appears to have distinct modes for age 0+, age 1+, and age 2+ LMB. The means were 61 mm, 118 mm and 172 mm for age 0+, age 1+, and age 2+ fish, respectively. Dampening of the length frequency modes occurred for fish older than 1+.

In the fall of 1997, before any bass structures had been placed (pre-assessment), no adult LMB were captured in any of the sample sloughs. In 2005, twenty-eight adults were captured in the fall sampling period (Figure 41). A total of seven juvenile LMB were captured in the pre-assessments of fall 1997. Juvenile numbers have increased from pre-assessment value in all fall sampling periods and a total of 31 age 0+ and 1+ LMB were captured in 2005.

The percent of the catch has increased for all bass combined (Figure 42). LMB comprised 3.5% of the catch in the 1997 pre-assessment. Percent of catch was higher in all post assessment samples and ranged from 7.7% in the spring of 1998 to 44% in the spring of 1999.

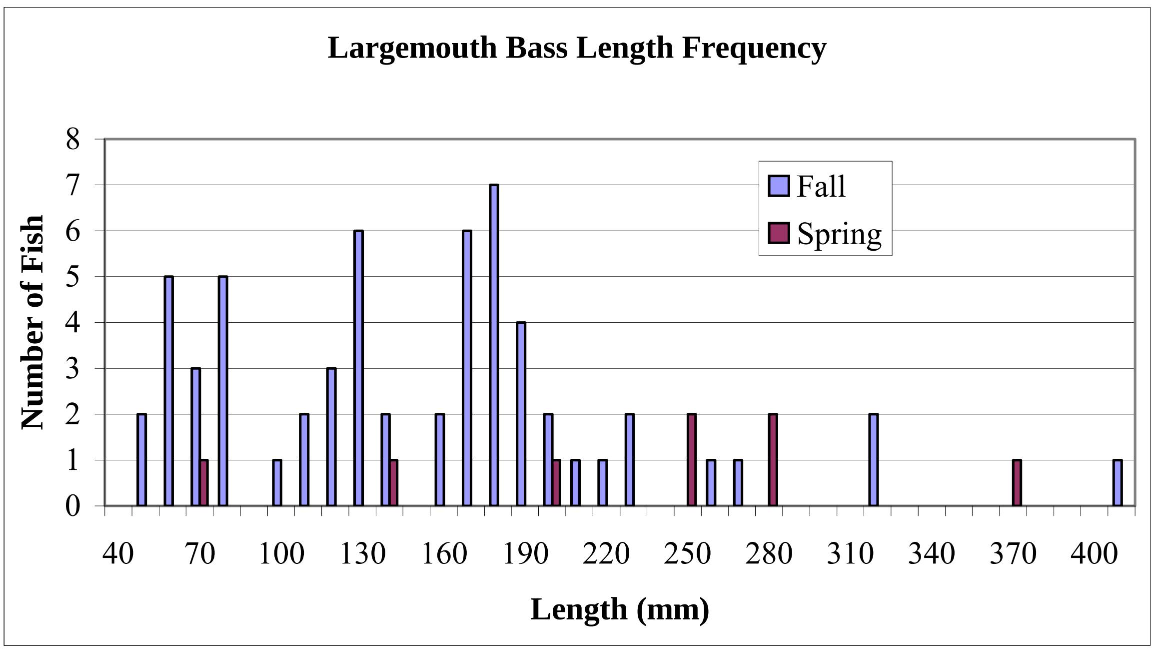

Figure 40. Largemouth bass length frequency for all stations sampled from 1997 to 2005.

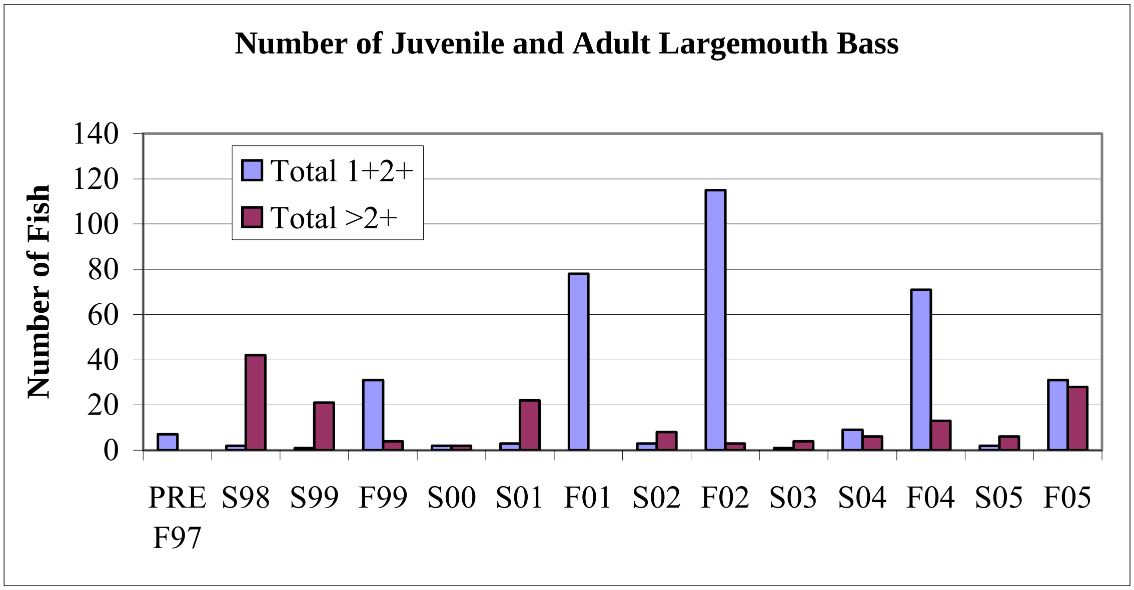

Figure 41. Numbers of juvenile and adult largemouth bass captured during spring and fall sampling periods from 1997 to 2005.

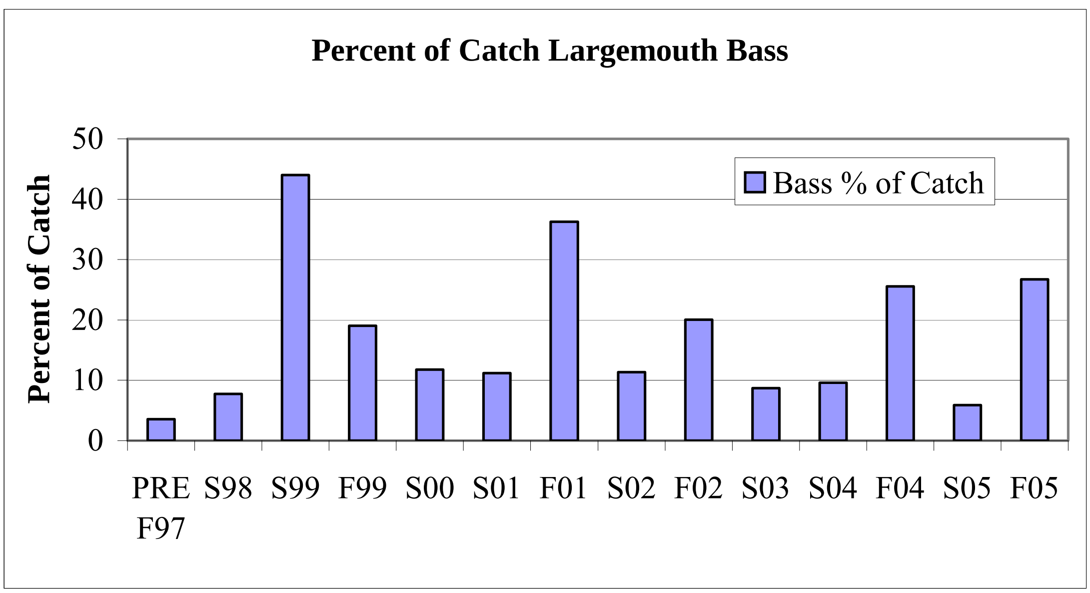

Figure 42. Annual percent of the catch of largemouth bass for all sampling transects.

Overall, largemouth bass CPUE and percent of catch have increased since bass habitat enhancement structures were implemented in 1997. However, distinct differences in seasonal utilization of the structures by juvenile and adult LMB were apparent. 83% of the LMB captured in the spring were adults while 87% of the LMB captured in the fall were juveniles. In the fall of 2005 however, adult LMB were more abundant than in any other fall sample. This overlap may be due to bass utilizing the structures all year long. The goal for this project is to provide overwinter cover to juvenile LMB. Increased habitat complexity has been shown to enhance over-winter survival of juvenile LMB by providing shelter from predators (Miranda and Hubbard 1994), and may prevent fish from being washed downstream (Carlson 1995). Juvenile bass appear to have relatively low utilization of the structures in the spring. However, total juvenile relative abundance has increased from 7 in the fall of 1997 to 80 in the fall of 2004. In November, macrophytes in the sloughs and mainstem of the Pend Oreille River are likely providing significant cover for LMB. In the spring however, macrophytes have decomposed and the artificial structures may then be the primary cover component. Adult LMB may seek out the cover of the structures and displace the juvenile bass, which are vulnerable to predation. It is not known when the shift between juvenile and adult LMB utilization of the structures takes place. However, given the increase in fall juvenile relative abundance, it appears that the enhancement structures may be resulting in increased overwinter survival for juvenile LMB.

HABITAT ENHANCEMENT

DESCRIPTION OF STUDY AREA

West Branch LeClerc (WBL) and South Fork Granite (SFG) creeks are located in the northeast corner of Washington (Figure 43). SFG is a major tributary to Granite Creek, which flows into Priest Lake in Idaho. At the location of the reference reach, SFG is a 3rd order stream. WBL is also a 3rd order tributary and joins East Branch LeClerc Creek before flowing into the Pend Oreille River in Washington. The elevation of the reference reach on SFG was 3,520 ft and watershed area was 22,194 acres. Elevation of WBL was 2,120 ft and the watershed drained 31,336 acres. Both watersheds had glacial and alluvial deposits in the drainage bottoms and upper slopes were composed of predominantly grandiorite. Both streams flowed mainly in a southern direction. Discharge in SFC was estimated at 13.1 cfs (Table 1). Measured discharge in WBL was 17.4 cfs.

Timber harvest and associated road building have occurred throughout the WBL watershed. Most of watershed is publicly owned and managed by the U.S. Forest Service for multiple use – primarily commercial timber production and cattle grazing. Lower portions of the WBL watershed are owned by the state of Washington and private individuals. The SFC watershed is nearly all public land administered by the U.S. Forest Service. Historic timber harvest in SFC has been negligible and the watershed is largely roadless.

METHODS

The restoration plan for WBL was guided by parameters surveyed in a relatively un-impacted stream reach in SFC. SFC was selected because watershed size, geology, aspect, and bankfull widths were similar to WBL. Surveys were conducted in one reach of SFC and throughout the entire restoration reach on WBL. A longitudinal survey was completed for each reach using a laser level and measuring rod and using methods described in Harrelson et al. (1994). Elevations were measured at the thalweg, wetted edges, and bankfull edges at points where changes in bed slope were apparent. Bankfull water surface slope and mean bankfull depth were calculated from elevation and length data collected during the longitudinal channel survey.

Cross sectional elevations were also surveyed using a laser level and measuring rod. Four pools in each reach were surveyed; streambed and bank elevations were measured at five cross sections for each pool. Bed and bank elevations were also measured at one cross section in four riffles of each reach.

A Wolman Pebble Count (1954) was completed in one riffle of each reach to determine stream bed composition. A core sample was extracted in a depositional bar at each site using methods described by Rosgen (1996). Data from the pebble counts were tallied using the Wentworth size classification. The data was then plotted by size class and cumulative frequency. Core samples from the depositional bar were sieved to sort particles into Wentworth size classes. Each size class was weighed and cumulative frequency was based on the weight of each size class.

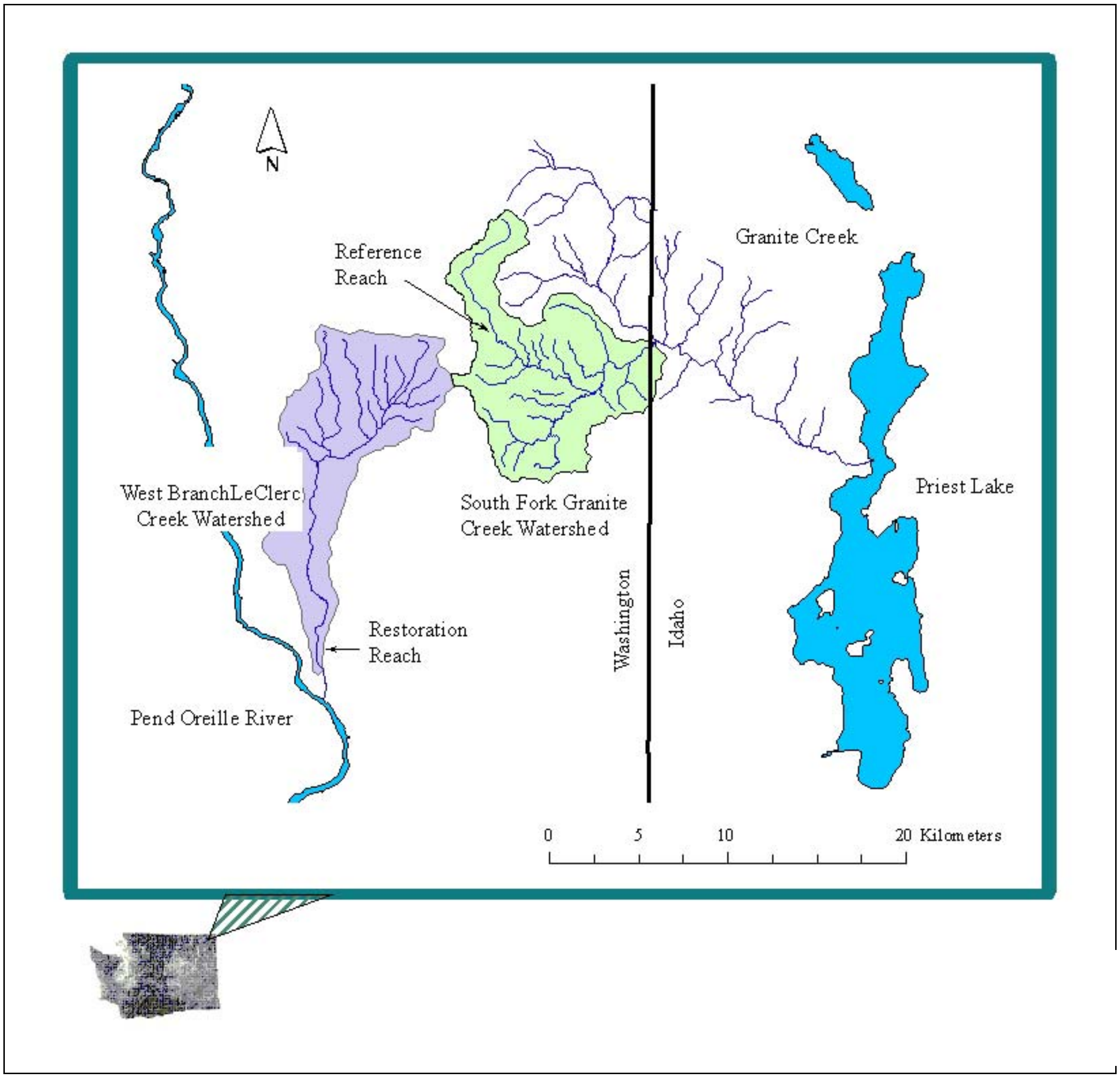

Figure 43. Location of the reference reach in South Fork Granite Creek and the restoration reach in West Branch LeClerc Creek.

Large woody debris (LWD) was counted throughout each reach. Only wood that was stable in the channel was tallied. Estimates of LWD size and orientation in the channel were made for each piece encountered. In SFC, discharge was estimated using the float method. An orange was floated through a 5.6 m riffle with a measured cross section 13 times and mean velocity was calculated. Discharge for WBL was calculated using velocities measured with a Price AA flow meter at a measured cross section just upstream of the restoration reach.

Critical dimensionless shear stress was estimated using a calculation modified by Rosgen (2001):

$$\tau_{ci} = 0.0834\,(d_{50}/ds_{50})^{-0.872}$$

Where: τ_{ci} = critical dimensionless shear stress,
d_{50} = median diameter of bed material
ds_{50} = median diameter of bar sample

The critical dimensionless shear stress value was then used to calculate the bankfull mean depth and water surface slope required to entrain the largest particle in the bar samples:

$$d_r = \tau_{ci}\,\gamma_s D_i\,/\,S$$

Where: d_r = Required bankfull mean depth
γ_s = Submerged specific weight of sediment
D_i = Largest particle from bar sample
S = Existing bankfull water surface slope and,

$$S_r = \tau_{ci}\,\gamma_s D_i\,/\,d$$

Where: S_r = Required bankfull water surface slope
d = Existing bankfull mean depth

These values were used to validate the ability of the channel to move the largest bedload particle entrained at bankfull flows.

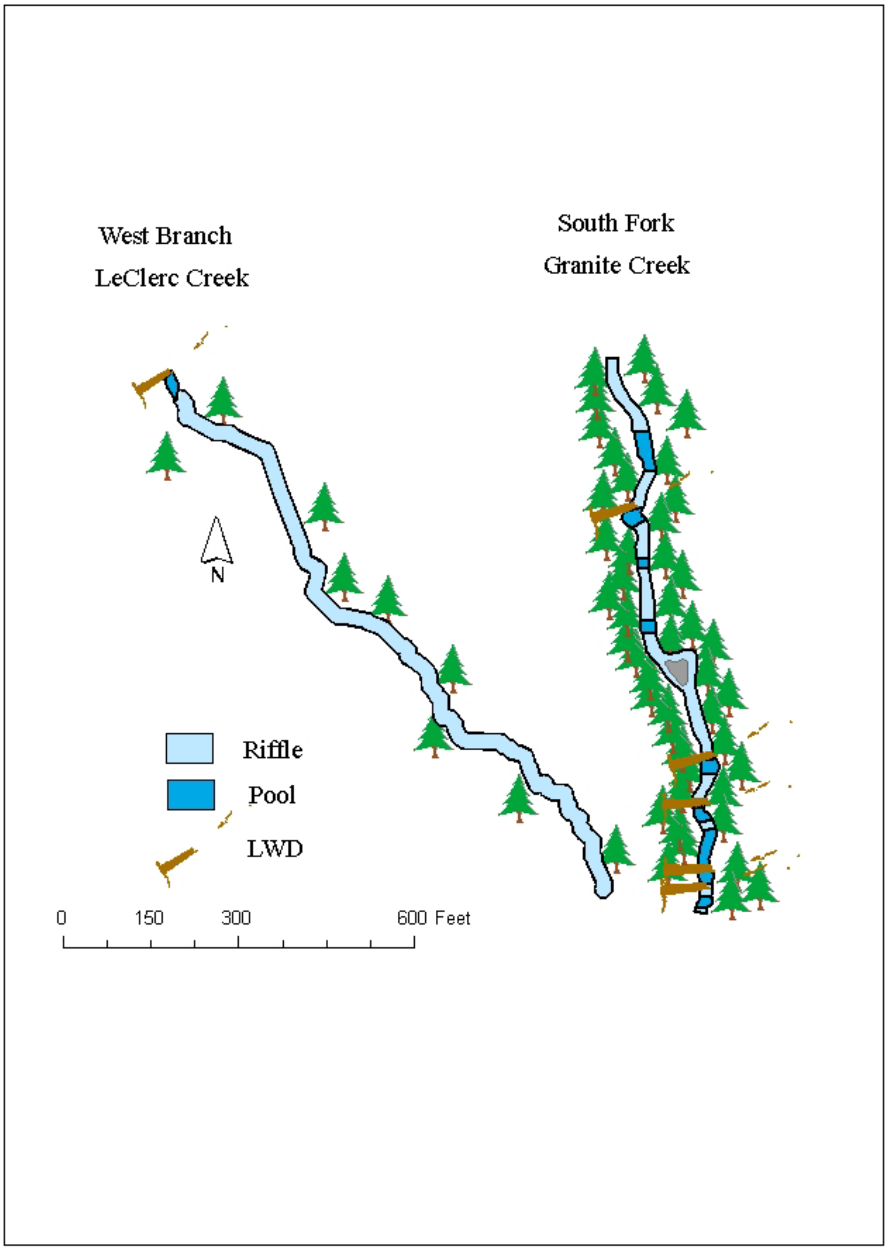

Figure 44. Site map of the WBL restoration reach and the SFG reference reach.

RESULTS

Surveys were conducted in 1,020 ft and 1,182 ft of channel in SFG and WBL, respectively. Figure 44 illustrates plan views of the reference and restoration reach; in WBL the thalweg was GPS'ed so the view accurately portrays distances and orientation. However, we were unable to collect GPS data in SFG so the planiform view is a general representation based on measured lengths between known points along the channel.

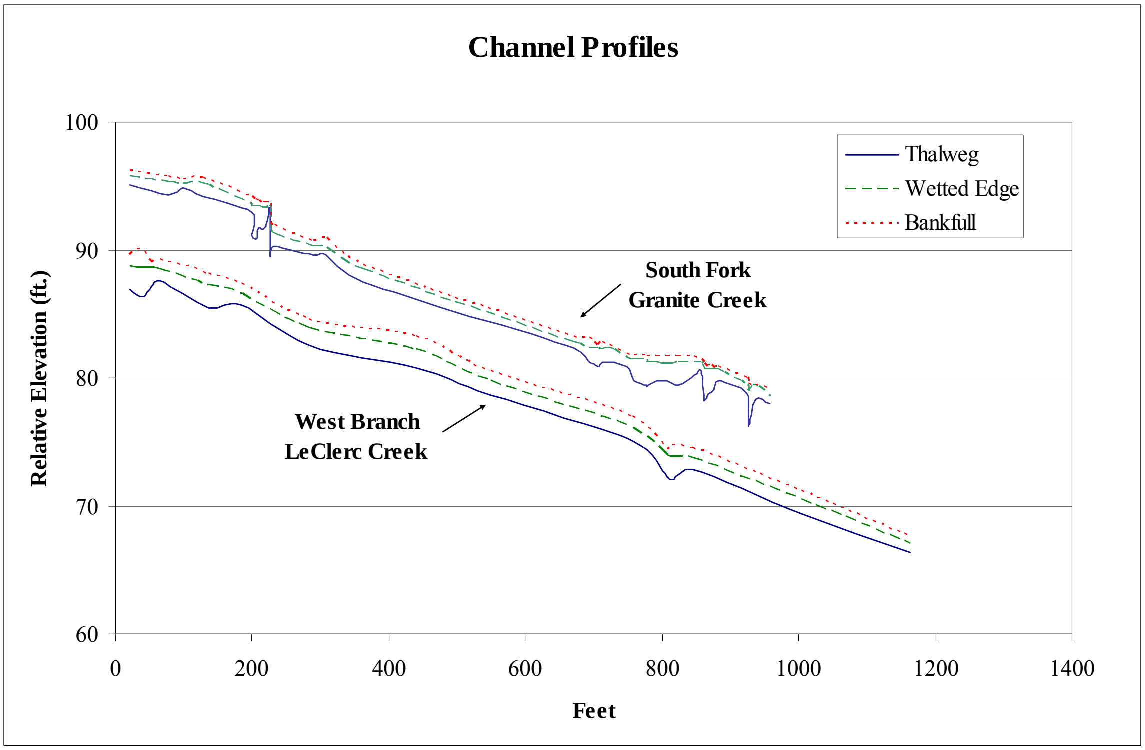

Figure 45. Longitudinal profile of restoration and reference reaches in WBL and SFG, respectively.

Figure 45 is the longitudinal profile that graphs thalweg, wetted edge, and bankfull elevations (elevations are relative) that were surveyed along the reaches in WBL and SFG.

Table 22 summarizes attributes for each surveyed reach. Channel slope, bankfull width, and mean bankfull depth were similar for both reaches. However, pool numbers and percent habitat composition in SFG (pool n=8, 30%) were much higher than in WBL (pool n=1, 4%). Although mean bankfull depth was larger in WBL (1.23 ft vs. 0.76 ft in SFG), mean pool depth and residual depth were similar in SFG (1.3 ft and 1.4 ft, respectively) and WBL (1.4 ft and 1.4 ft, respectively). LWD was common in the SFG reach; frequency was 3.9 pieces/100 ft and 62% of the pools (n=5) were formed by LWD. The LWD frequency in WBL was low (0.01 pieces/100 ft); however, wood was the formative feature in the only pool present in the study reach.

Percent fines (<4 mm) were significantly greater in the sampled riffle in WBL when compared to SFG (p-value = 0.006). However, particles size distribution was similar between the two reaches (Figure 46); the D_{50} for WBL and SFG were 41 mm and 46 mm, respectively (Figure 47). In the bar sample, percent fines were also significantly greater in WBL (p-value <0.001). Fine sediment composition in the WBL bar sample was 30.1% and 13.8% in the SFG bar sample. Particle sizes were greater in the SFG bar sample relative to WBL (Figure 48). The median diameter size was also larger in the SFG bar sample; D_{50} in the SFG bar sample was 53 mm and in the WBL bar sample D_{50} was 20 mm (Figure 49).

Table 22. Summarized surveyed attributes in the SFG reference reach and the WBL restoration reach.

Parameter	South Fork Granite Creek	West Branch LeClerc Creek
Length of Surveyed Channel (ft)	1020	1182
Channel Slope	1.8%	1.7%
Bankfull Width (ft)	20.0	28.7
Bankfull Mean Depth (ft)	0.76	1.23
Bankfull W:D	27.2	23.3
Rosgen Type	B4c	B4c
Discharge (cfs)	13.1	17.4
Percent Pool Habitat	30	4
No. of Pools	8	1
Pool Frequency (no. pools per BFW)	0.16	0.03
Expected No. Pools (Leopold et al. 1964)	10 - 12	8-10
Pool Mean Maximum Depth @ Bankfull (ft)	2.64	2.97
Pool Mean Depth (ft)	1.3	1.4
Mean Pool Volume @ Bankfull (ft^3)	814	1051
Mean Pool Residual Depth (ft)	1.4	1.4
LWD Frequency (no. per 100 ft)	3.9	0.1
No. of Full Channel-spanning LWD	9	0
Percent Wood Formed Pools	62% (n=5)	100% (n=1)
Mean Estimated Diameter of LWD (in)	23.6	26.0
Pebble Count Size Distribution		
% Fines	6%	19%
D_{15}	10 mm	2 mm
D_{35}	32 mm	24 mm
D_{50}	46 mm	41 mm
D_{84}	90 mm	115 mm
D_{95}	170 mm	160 mm
Dimensionless Shear Stress		
Critical Dimensionless Shear - τ_{ci}*	0.019	0.045
Bankfull Depth Required to Move Largest Particle - D_r (ft)	0.59	1.03
BF Water Surface Slope Required to Move Largest Particle - S_r	0.014	0.015

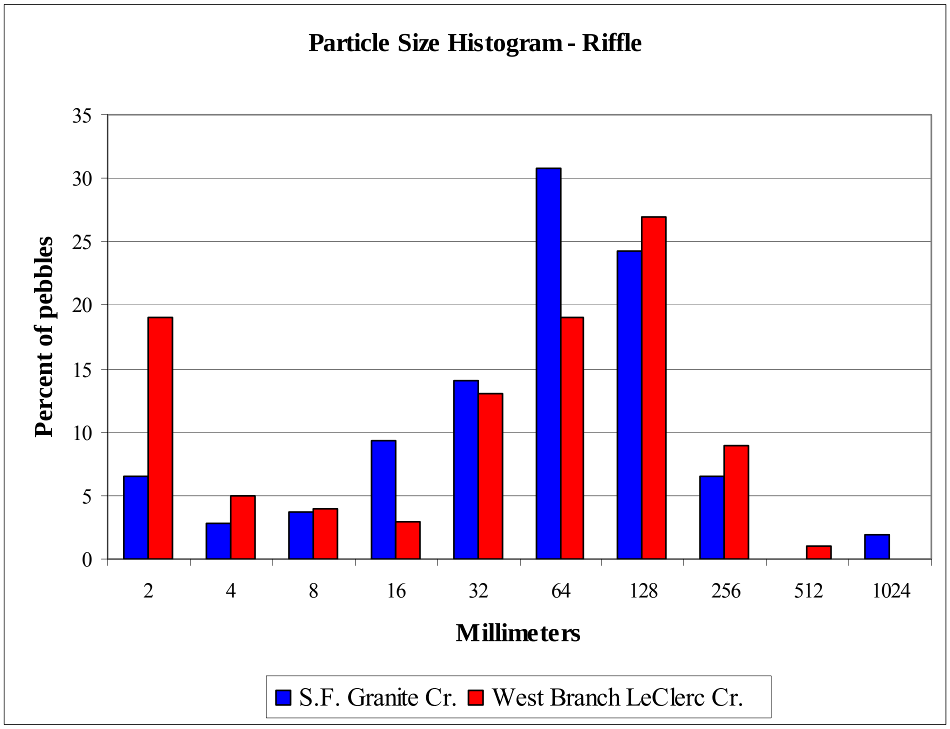

Figure 46. Particle size composition for riffles sampled in SFG and WBL.

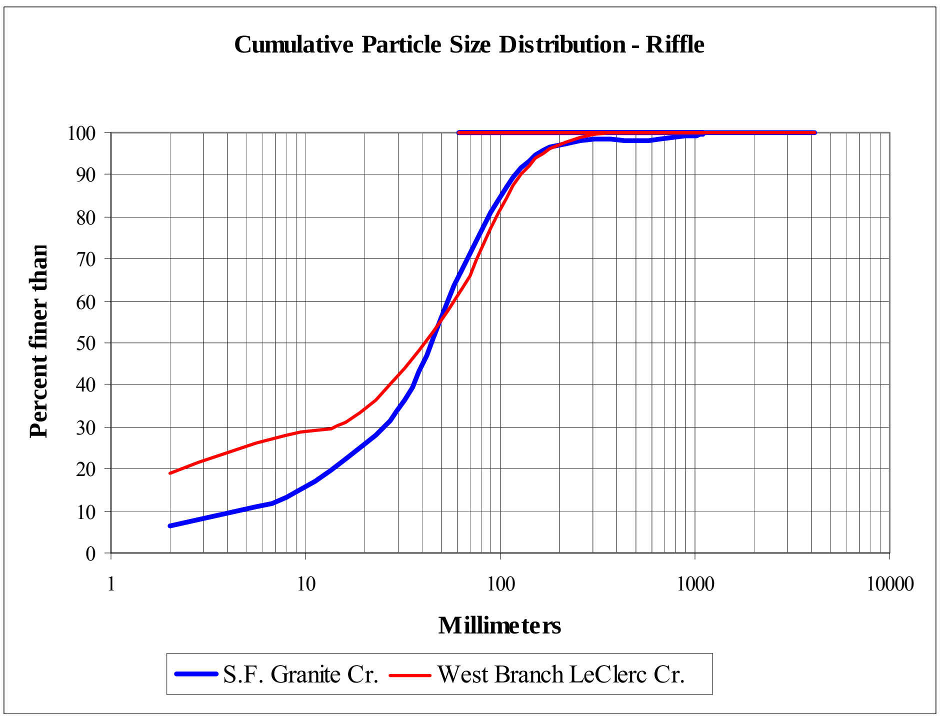

Figure 47. Cumulative frequency of particle sizes sampled in riffles of SFG and WBL.

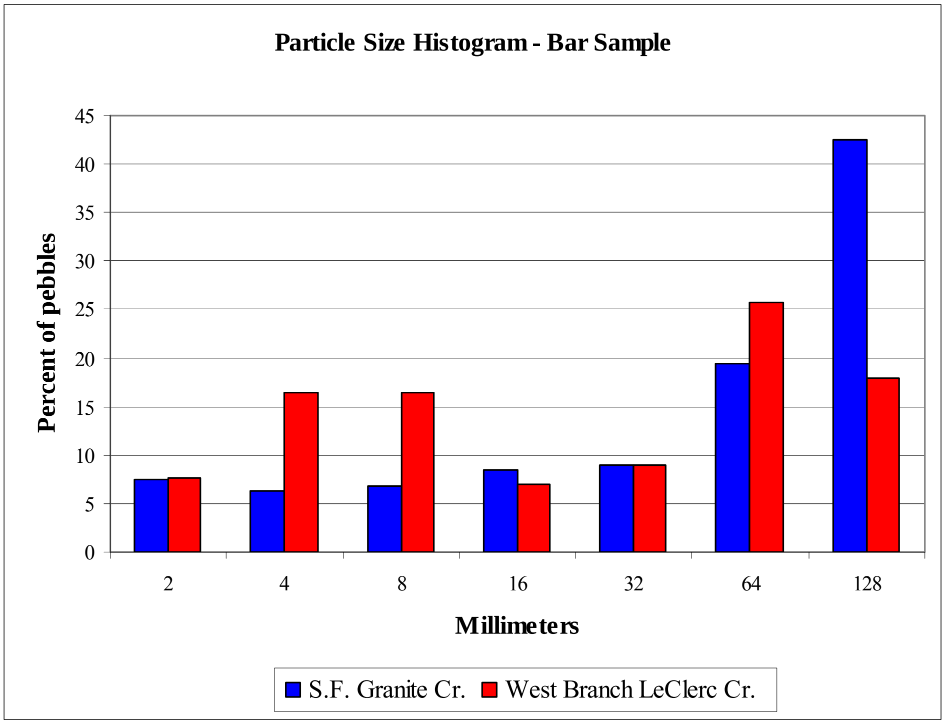

Figure 48. Particle size composition for depositional bars sampled in SFG and WBL.

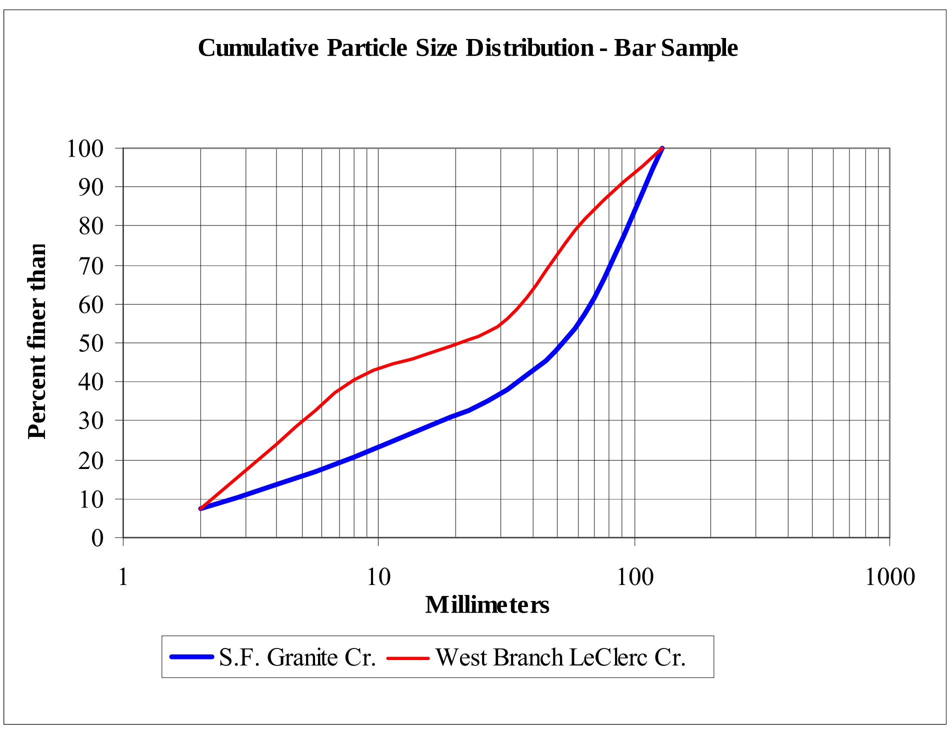

Figure 49. Cumulative frequency of particle sizes sampled in depositional bars of SFG and WBL.

Figure 50. A pool formed by LWD that spans the channel of SFG.

In WBL, the critical dimensionless shear stress value 0.045. Based on that value, the mean bankfull depth required to move the largest bar particle was calculated at 1.03 ft and the bankfull water surface slope required to move the largest particle was 0.015.

DISCUSSION

Impacts from past land management activities appear to have simplified the stream channel in WBL. LWD appears to play a major role in pool formation in SFG; 62% of the pools were formed by LWD pieces which spanned the entire channel width (Figure 50). LWD was sparse in WBL and likely resulted in a relatively low pool frequency. None of the LWD pieces observed in WBL spanned the entire channel. LWD in both channels appeared to be relatively stable; the bases of the LWD were buried in well vegetated banks and the wood appeared to have been in the channel for a relatively long time. LWD sizes were similar in both channels; mean LWD diameter in WBL was 26 in (SD = 1.9) and mean diameter was 23.6 in (SD = 6.2) in SFG. Based on the size of LWD pieces, apparent stability, and a lack of large accumulations (jams), large wood likely recruits to the channel from nearby riparian areas and mobility is minimal. Numerous large (>30” diameter), old stumps were observed along the channel in the WBL. These trees would likely have fallen in the channel and stabilized at a nearby location creating pool habitat and storing sediment. Given the loss of these trees, LWD in the WBL reach has not likely recruited at a rate to compensate for the decomposition of pre-existing LWD, resulting in a simplified channel.

The critical dimensionless shear stress for the WBL reach was 0.045. Based on that value, estimated bankfull mean depth required for entrainment of the largest bar sample (78 mm) was 1.03 ft. The estimated bankfull water surface slope required for entrainment was 0.015. Both estimates were less than the measured values (1.23 ft mean depth and 0.017 bankfull slope). No indicators of vertical channel instability were observed in WBL. Therefore, we estimate that the restoration channel in WBL is competent in sediment transportation.

Restoration Plan and Monitoring

Ten LWD structures will be placed in the WBL restoration reach to create pools. The increase in pools will improve fish habitat and provide for storage of fine sediment. We will be using a guideline of one structure per 5-7 bankfull widths (110-154 ft). Structures will consist of small LWD that will be fitted together to simulate larger, single wood pieces (Figures 51 and 52). For each structure, small diameter logs (8-12 in) are interlocked with spars and create a hollow cylinder. Each structure will be 8 to 15 ft in length and 24 to 32 in. in diameter. The void in the center of the cylinder will be filled with cobble to provide ballast. If possible, structures will be placed on the upstream side of large boulders, tree trunks, or root wads to further provide stability. Given the size of the structure and the increase in weight provided by the cobbles, we anticipate no further anchoring will be required. Structures will be installed in pairs to create an upstream-oriented V-shaped log sill. The tops of the structures will be sloped down towards the center of the channel. The ends of each structure will be keyed into the streambank or butted up to the streambank and buried with large cobble. Structures may also be paired with existing natural features (e.g. natural LWD, root wads, boulders) to increase channel constriction and promote scour.

Prior to structure implementation, placement sites will be surveyed, using a laser level and measuring rod, to determine cross sectional channel profiles. Bankfull mean width, depth, and maximum depth will be monitored to determine the effectiveness of the structures to create pool habitat. The cross sections will be benchmarked and represent pre-implementation (baseline) conditions. Three cross sections will be surveyed at each site: one upstream to monitor deposition and two downstream to monitor scour. Two pebble counts, one upstream and one downstream, will also be completed at each structure site to monitor substrate composition. Monitoring will also be conducted on the fish population. Prior to structure installment, fish population estimates will be made using multiple pass electrofishing techniques. The entire restoration reach will be electrofished to determine baseline population numbers. In 2005, a 100-m reach, located on WBL approximately five miles upstream, was electrofished so that natural variability can be monitored. The first post-implementation monitoring period will take place two years after the structures have been in place. However, the structures will be inspected and maintained on an annual basis and after any significant flow events.

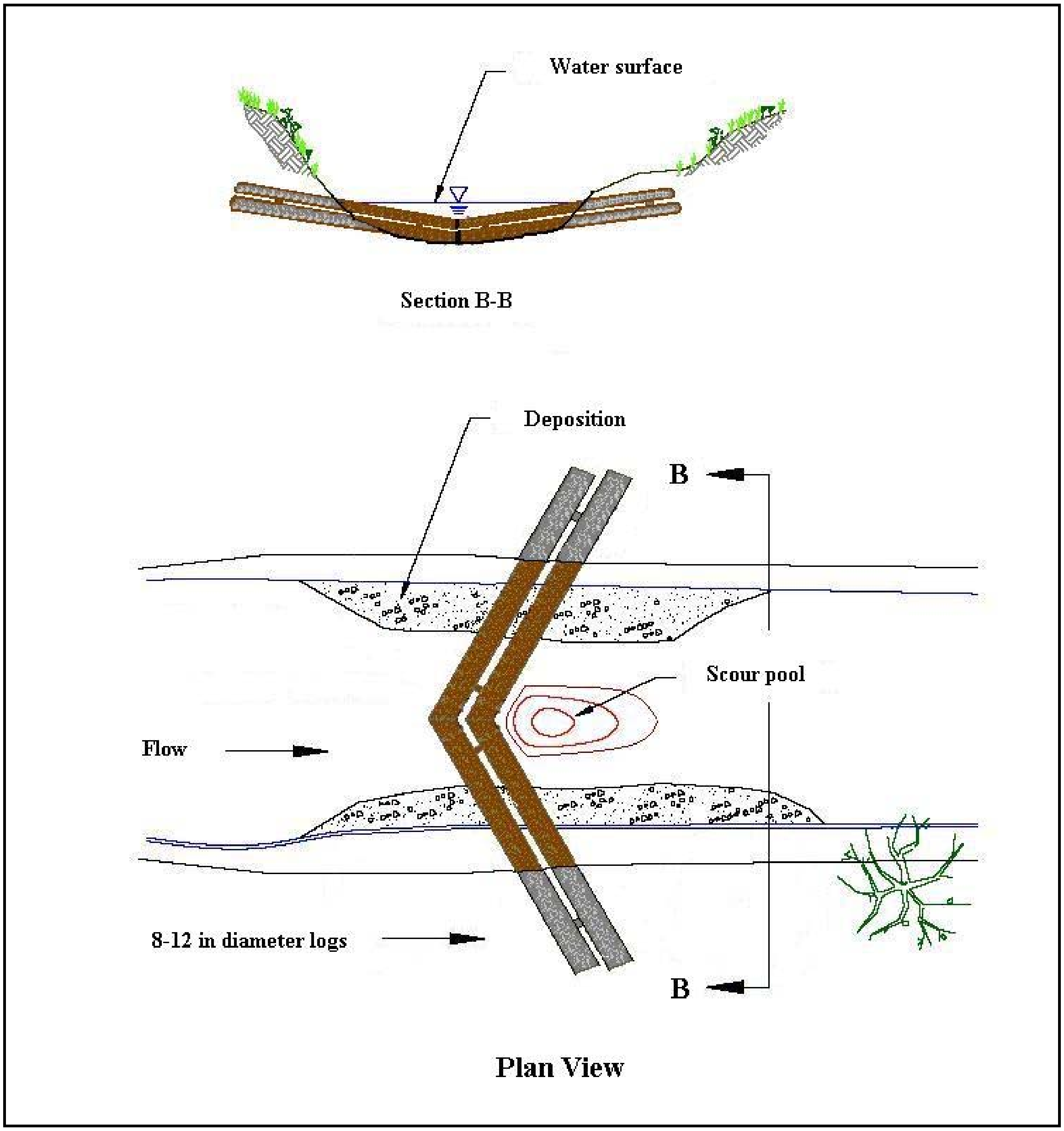

Figure 51. Conceptual design for LWD structures.

Figure 52. Engineered LWD piece constructed in 2005 in East Branch LeClerc Creek.

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