FISHERY RESEARCH

KOOTENAI RIVER FISHERIES RECOVERY INVESTIGATIONS: ECOSYSTEM REHABILITATION

PROGRESS REPORT
April 1, 2005—March 31, 2007

Photo: Corie Laude

Prepared by:

Ryan S. Hardy
Senior Fishery Research Biologist

IDFG Report Number 08-11
July 2008

Kootenai River Fisheries Recovery Investigations: Ecosystem Rehabilitation

Project Progress Report

2005-2007 Annual Report

By

Ryan S. Hardy

Idaho Department of Fish and Game
600 South Walnut Street
P.O. Box 25
Boise, ID 83707

To

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97283-3621

Project Number 1988-06500
Contract Number 00004691

IDFG Report Number 08-11
July 2008

TABLE OF CONTENTS

Page

ABSTRACT....1
INTRODUCTION....2
RESEARCH GOAL....3
OBJECTIVES....3
STUDY AREA....3
Nutrient Addition Location (Site Description)....6
Biomonitoring Locations....10
METHODS....11
Nutrient Addition Permitting....11
Metals....11
Nutrient Delivery System Development....12
Treatment Site Details....12
Nutrients: Dosing and Measurement....14
Delivery System....15
Mixing Zone....19
Photic Zone....20
Microinvertebrate Abundance....20
Fish Community Assessment....20
Species Abundance/Catch and Biomass Rates....20
Feeding Guilds and Tolerance....21
Relative Weight (Wr) and Condition Factor (K)....21
Age and Growth....22
RESULTS....22
Nutrient Addition Permitting....22
Metals....23
Nutrient Additions....24
Microinvertebrate Abundance....27
Fish Community Assessment....31
Species Diversity....31
Species Abundance/Catch and Biomass Rates....32
Relative Weight (Wr) and Condition Factor (K)....32
Age and Growth....32
DISCUSSION....38
Nutrient Addition Permitting....38
Metals....38
Nutrient Additions....38
Microinvertebrate Abundance....39
Fish Community Assessment....39
RECOMMENDATIONS....42
ACKNOWLEDGEMENTS....43
LITERATURE CITED....44
APPENDICES....47

LIST OF TABLES

Page

Table 1. The average total metals analysis of Kootenai River water (at rkm 265) and 250 ml samples (n = 2) of ammonium polyphosphate fertilizer (10-34-0; $NH_4P_2O_5$). Values of 10-34-0 represent concentration of fertilizer that will be diluted exponentially with summer flows in the Kootenai River.....24

Table 2. Average total metals analysis of mountain whitefish and largescale sucker tissues (n=14) sampled in 2004 at rkm 265 of the Kootenai River in comparison to USEPA and International standards set for human consumption. Nd = non-detectable. 24

Table 3. Species sampled at Kootenai River biomonitoring sites in September 2005 and 2006 with boat electrofishing gear. I = Intolerant; T = Tolerant; S = Sensitive (describes response to habitat perturbations; Zaroban et al. 1999). 33

Table 4. Catch per unit of effort (CPUE; fish/h) and biomass per unit of effort (BPUE; Kg/hr) for species sampled at Kootenai River biomonitoring sites in the fall (September) from 2002 through 2006 with boat electrofishing gear. Shaded cells indicate those areas sampled upstream of the treatment influence and therefore considered control locations. 33

Table 5. Mean relative weights (Wr) and Fulton's condition factor (K) of key species sampled at Kootenai River biomonitoring sites in September 2002-2006 with boat electrofishing gear. Shaded sections indicate nontreatment locations. SE = ± 1 standard error. 37

Table 6. Comparison of catch per unit of effort in treated and nontreated seasons of mountain whitefish by age class. Shaded sections indicate nontreatment locations. CPUE for pre-treatment years are a mean from 2002-2003 sample years. CPUE for post treatment represents 2006 sample year only. 37

Table 7. Comparison of mean total length (TL) at time of capture in treated and nontreated seasons of mountain whitefish by age class. Shaded sections indicate nontreatment locations. CPUE for pre-treatment years are a mean from 2002-2003 sample years. CPUE for post treatment represents 2006 sample year only.....38

LIST OF FIGURES

Page

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, Libby Dam, Bonners Ferry, and important points. 5

Figure 2. Kootenai River Drainage with location of the nutrient addition influence. 7

Figure 3. Location of nutrient application. Vertical blue line indicates the Idaho-Montana boarder. 8

Figure 4. Map showing the Kootenai River nutrient injection point in relation to adjacent property boundaries. 9

Figure 5. Kootenai River ecosystem study area and approximate locations of biomonitoring sites. 10

Figure 6. Nutrient tank layout. 13

Figure 7. Nutrient tank facility near Leonia, MT. 14

Figure 8. Schematic of nutrient delivery system to the Kootenai River. 17

Figure 9. Schematic of the flow measuring system on the lower platform. 18

Figure 10. Liquid phosphate (10-34-0) additions and Kootenai River flow at Leonia, MT in 2005. 26

Figure 11. Liquid phosphate (10-34-0) additions and Kootenai River flow at Leonia, MT in 2006. 27

Figure 12. Zooplankton densities (crustaceans) from June 2002 through October 2006 from the upper Kootenai River at rkm 283, 265, and 251. 28

Figure 13. Zooplankton densities (rotifers) from June 2002 through October 2006 from the upper Kootenai River at rkm 283, 265, and 251. 29

Figure 14. Kootenai River discharge at Leonia from June 2002 through October 2006 with zooplankton densities (rotifers) from the upper Kootenai River at rkm 283, 265, and 251. 30

Figure 15. Regression analysis of Kootenai River discharge at Leonia and rotifer densities from June 2002 through October 2006. 31

Figure 16. Total biomass per unit of effort (BPUE) for all species combined sampled with boat electrofishing gear at Kootenai River biomonitoring sites in September 2005 and 2006. 34

Figure 17. Total catch per unit of effort (CPUE) for all species combined sampled with boat electrofishing gear at Kootenai River biomonitoring sites in September 2005 and 2006. 35

Figure 18. Mean catch per unit of effort (CPUE) for fish species sampled in the Kootenai River near Shortys Island (section 1) with boat electrofishing gear before and after the rock substrate pilot project was added (September 2006). CPUE for pre-rock placement are a mean from 2002-2005 sample years. CPUE for post -treatment represents 2006 sample year only. 36

LIST OF APPENDICES

Page

Appendix A. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2002 during boat electrofishing at rkm 170–283 and electrofishing. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, BRNT = brown trout, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch. 48

Appendix B. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2003 during boat electrofishing at rkm 170—283. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch. 49

Appendix C. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2004 during boat electrofishing at rkm 170—283. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch. 50

Appendix D. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2005 during boat electrofishing at rkm 170—283. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, BRNT = brown trout, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch. 52

Appendix E. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2006 during boat electrofishing at rkm 170—283. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, BRNT = brown trout, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch. 53

ABSTRACT

A large-scale nutrient addition program was implemented on the Kootenai River during July 2005, to increase fisheries biomass by increasing primary production. The study included biomonitoring at four treatment and two control sites to monitor changes in the trophic community from algae, zooplankton, and up through to the fish population. Phosphate fertilizer (10-34-0 solution) was added to the river starting on July 13, 2005 at the rate of 0.31L/min at a river flow of 724 m^3/s; the objective at this concentration was to achieve 1.5 µg/L of Total Dissolved Phosphate (TDP) in the river. Within three weeks of application, algal growth was apparent on substrates. For the first season, phosphate additions were discontinued on September 28, 2005. No nitrate fertilizer was added to the river for algal production. Approximately 21,000 L of phosphate was used during the 11-week growing season. During the 2006 season, nutrient additions to the Kootenai River began July 12, 2006 at the rate of 0.43L/min and at a river flow of 512 m^3/s; the objective at this concentration was to achieve 3.0 µg/L of TDP in the river. As during 2005, nitrate was not added due to adequate levels of in-river nitrate (100 µg/L) throughout the duration of the experiment. Phosphate additions were discontinued on September 30, 2006. Approximately 35,225 L (9,305 gallons) of phosphate was used through the 80-day growing season. Fourteen species of crustaceans and 45 species of rotifers were identified in the filtered samples collected in 2005 and 2006. Mean crustacean densities through the sampling period ranged from 0.14 to 2.85/L. Mean rotifer densities were higher than crustacean densities, ranging from 1.16–95.82/L. Crustacean and rotifer densities from June of 2002 to October of 2006 have shown a general trend of decreasing numbers even in KR 10 (the reference or nontreatment reach of the nutrient program). Nutrient additions are not influencing zooplankton numbers or species diversity, and it is much more plausible at this time to relate the fluctuations in density with river discharge and zooplankton levels in Koocanusa Reservoir. Fifteen species of fish were identified in electrofishing samples during 2005 and 2006. Species diversity between sites ranged from 8-12, with the highest diversity located in the sample site below Bonners Ferry near Shortys Island (rkm 230). There was a notable increase in catch-per-unit-effort (CPUE) and biomass-per-unit-effort (BPUE) from pre- vs. post-treatment years within locations directly influenced by nutrient additions (rkm 265 and 250). This same increasing trend was, however, also seen in one of the two nontreatment reaches approximately 10 rkm above the nutrient injection location (rkm 283). A breakdown by species indicates that these increases in CPUE and BPUE in the nontreatment location (rkm 283) were primarily caused by increases in mountain whitefish and rainbow trout, while the increases in the treatment locations (rkm 250 and 265) were almost exclusively mountain whitefish. In 2006, one of the six sample locations at the Shortys Island reach was substantially altered by artificial habitat addition for the Kootenai River white sturgeon *Acipenser transmontanous* spawning habitat pilot project. This habitat alteration increased CPUE of species such as northern pikeminnow *Ptychocheilus oregonensis* and westslope cutthroat trout *Oncorhynchus clarkii* and reduced densities of peamouth chub *Mylocheilus caurinus*. Relative weight (Wr) of rainbow trout *O. mykiss* and mountain whitefish *Prosopium williamsoni* and condition factor (K) of largescale suckers *Catostomus macrocheilus* was highest in 2006 for all species at both treatment locations in the upper canyon. Mean CPUEs of mountain whitefish at each age group were highest in treatment locations as compared to the nontreatment sites. Similarly, mean total length-at-capture was slightly higher in treated sites than nontreated. Age two whitefish at rkm 250 represented the highest increase in CPUE (91 fish/hr) following nutrient additions. In an effort to develop evaluation criteria of this program that specifically targets angler catch rates of game fish based on the needs and desires of the public, a catch rate target of 0.34-0.67 trout/h was set for the Kootenai through an evaluation of recent creel data.

Author:

Ryan S. Hardy
Senior Fishery Research Biologist

INTRODUCTION

In the Kootenai River system, the natural flow and nutrient regimes no longer exist. As early as the 1880s, logging and mining physically changed streams by causing tributary discharge to flash and cause siltation (Northcote 1973). In 1892, the river was further disturbed by attempts to dike lower reaches for agricultural purposes (Northcote 1973). From 1953 through the 1970s, water quality was further deteriorated in tributaries and the mainstem Kootenai by mining and by the operation of a fertilizer plant on the St. Mary River, British Columbia (BC), increasing nutrients to unhealthy levels. The Kootenai River ecosystem's most damaging disturbance came with the construction of Libby Dam and impoundment of Lake Koocanusa. The dam was created under an International Columbia River Treaty between the U.S. and Canada to provide for cooperative water management of the Columbia River Basin (Columbia River Treaty 1964). Construction of Libby Dam began in 1966 by the U.S. Army Corps of Engineers (USACE). Hydroelectric power production served as the dam's main purpose, while other benefits included flood control and navigation. Impoundment of Lake Koocanusa and regulation of downstream flows began in March of 1972. After completion of the dam, mean monthly flows were reduced by 50% during spring and tripled during winter. An increase of winter water temperature of 3°C also occurred (Partridge 1983). Turbidity and nutrient loads in the Kootenai River were also reduced due to the impoundment of the Kootenai River.

Lake Koocanusa (reservoir) now acts as a nutrient and sediment trap. According to Woods and Falter (1982), the reservoir retains approximately 63% of the inflowing phosphorus (P) and 25% of the total nitrogen (N). Due to lower current velocities behind the reservoir, these nutrients bind to sediments and fall out of solution (Snyder and Minshall 1996), making them unavailable to organisms in the river below the dam. Consequently, the Idaho portion of the Kootenai River is now considered "nutrient poor" (ultraoligotrophic) and P-limited (Snyder and Minshall 1996; Snyder and Minshall 2001; Holderman and Hardy 2004). Lower nutrients cause a reduction in food production, which is thought to be a major contributor to poor sport fish production over the past two decades. In the late 1970s, concern for Kootenai River fisheries prompted a research investigation by the Idaho Department of Fish and Game (IDFG). Partridge (1983) focused on an inventory of the river's fisheries as well as learning more about the environmental impact to white sturgeon *Acipenser transmontanous*, burbot *Lota lota*, rainbow trout *Oncorhynchus mykiss*, mountain whitefish *Prosopium williamsoni*, and cutthroat trout *O. clarkii*. Partridge (1983) determined that regulation of spring discharge was the probable cause of poor recruitment of juvenile sturgeon, the winter burbot fishery was nearly eliminated due to water management and warmer ice-free conditions, the trout population was low, and trout spawning and rearing habitat was limited.

The Kootenai Tribe of Idaho (KTOI) and IDFG have implemented a nutrient restoration program on the Kootenai River, Idaho (Figure 1). Native populations of kokanee *O. nerka*, burbot, interior redband trout, mountain whitefish, and ESA threatened bull trout *Salvelinus confluentus* and endangered white sturgeon populations are declining in the river. Nutrient restoration to the Kootenai River Idaho may increase native fish survival, especially of juvenile recruits, for which food may be limiting. Nutrient supplementation may also improve growth rates and condition of these fish if the food base is increased.

No data were located for baseline or "natural" ambient nutrient concentrations (P or N) in the Kootenai River prior to human intervention. The phosphate fertilizer plant (Cominco, Ltd) located on the Saint Mary River, a major tributary to the upper Kootenai River, was in operation from 1953 to 1987. The plant discharged more than 8,000 metric tons of phosphate annually

into the river in the 1960s (Knudson 1993). This greatly skewed measures of ambient total phosphorus (TP). By the time the plant was closed, Libby Dam had been on line for over a decade. Phosphorous is considered a limiting nutrient when levels fall below 1 µg L L/hr soluble reactive phosphorus (SRP) or 2-3 µg L/hr total dissolved phosphorus (TDP) during the growing season (Ashley and Stockner 2003), or N:P ratios that are above 20:1 (Snyder and Minshall 1996). In the nutrient treatment reach, the autotrophic reach of the river that was potentially affected by nutrient additions, (approx. 40 rkm), ambient levels of SRP were below detection limits from July through September (C. Holderman, KTOI personal communication). According to Ashley and Stockner (2003) target concentrations of SRP (3-5 µg· L/hr) in streams is generally one-third to one-half nuisance concentrations (10 µg· L/hr), but need to be high enough to be effective over several river kilometers (rkm). Therefore, in order to increase productivity in all trophic levels, the target concentration of P was set at 3.0 µg· L/hr. Nitrogen was identified to have the potential to be colimiting in the Kootenai River as the growing season progresses (Snyder and Minshall 1996). Due to the potential of stripping NO^3 from solution by increased primary production, it may be necessary to add a combination of N as well to maintain levels of 30-50 µg· L/hr.

The Bonneville Power Administration (BPA) is funding the KTOI, in partnership with the IDFG, to add nutrients (nitrogen and phosphorus) to the Kootenai River ecosystem for up to five years. The goal of this project is to improve native fish populations and river health affected by the construction and operation of Libby Dam. The nutrients are expected to stimulate production in the Kootenai River's depleted food web and reverse downward trends in fish populations such as trout, kokanee, mountain whitefish, and possibly burbot, and white sturgeon.

RESEARCH GOAL

1. Restore fish communities in the Idaho reach of the Kootenai River and improve angler-fishing success.

OBJECTIVES

1. Develop a nutrient injection system for the Kootenai River.

2. Obtain permitting in order to initiate a nutrient addition experiment on the Kootenai River.

3. Initiate a full-scale nutrient addition experiment on the Kootenai River by spring of 2005.

4. Compare post-treatment fertilization changes in the microinvertebrate and fish community levels of the food web for the 2005 and 2006 treatment years.

STUDY AREA

The Kootenai River originates in southeastern British Columbia (BC), Canada (Figure 1). From there, the river flows southward into northwestern Montana where it is impounded by Libby Dam, forming Lake Koocanusa. From there, the river flows westward and flows into the northeastern portion of the Idaho Panhandle, then flows northward into Kootenay Lake, BC, and

then flows out of Kootenay Lake to the confluence with the Columbia River at Castlegar, BC. The Kootenai River is the second largest of the Columbia River tributaries and the third largest in drainage area (approximately 50,000 km^2; Bonde and Bush 1975). The study area consists of approximately 106 river kilometers (rkm; rkm 170 to 276) of the river that flows through the Idaho Panhandle, along with several reference (control) sections in Montana and BC.

The Montana and Idaho portion of the Kootenai River below Libby Dam (rkm 352) can be separated into three distinct stream habitat types. Directly below the dam, the river flows through a narrow canyon section characterized by steep canyon walls, high gradients, and boulder/cobble substrates (rkm 352 to 258.5). As the river flows through the northeast corner of the Idaho Panhandle, there is a gradient transition at Bonners Ferry. Upriver from Bonners Ferry, the channel has an average gradient of 0.6 m/km, and the velocities are often higher than 0.8m/s. There is a braided transition reach from the Moyie River (rkm 258.5) to Bonners Ferry (rkm 244.5). Downriver from Bonners Ferry, velocities slow to usually less than 0.4 m/s; average gradient is 0.02 m/km, the channel deepens, and the river meanders through the Kootenai Valley (rkm 244.5 to rkm 121).

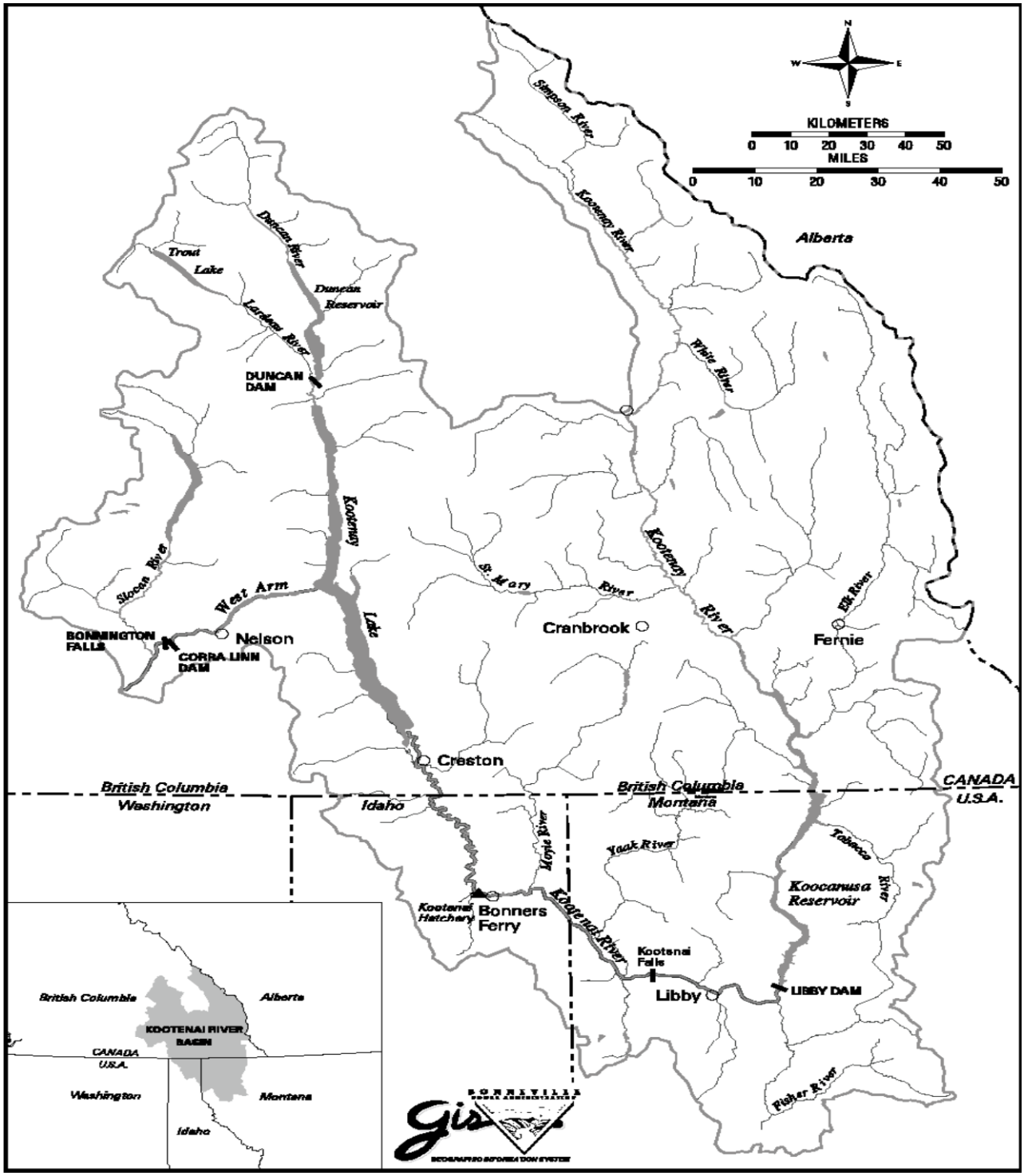

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, Libby Dam, Bonners Ferry, and important points.

Nutrient Addition Location (Site Description)

The nutrient treatment site (UTM: 11U 0570263 535385547) is near Leonia, Lincoln County, Montana in the E ½, SW ¼, SW ¼, SW ¼ of Section 17, Township 33N, Range 34E, near Leonia, Lincoln County, Montana (Figures 2, 3, and 4). This site is just north of the Leonia Bridge and east of the Montana/Idaho state border on Kootenai National Forest (KNF) land. An access road (Leonia Road) is on both Forest Service and private property. The Leonia Road travels from Highway 2 and descends to the Kootenai River at a now impassable bridge. Before this road begins its descent from the river bench, an unimproved road forks to the right and travels north along the river rim at approximately 2,000 ft (about 610 m) of elevation on the property of DLC Incorporated (private landowner; see Figure 4 for further location information and a reference to land ownership). About 2,410 ft (735 m) NNW of Leonia Road, there is a boundary showing KNF land, and the track becomes a footpath. The footpath continues NNW on the river bench to the state line, where there is a USGS marker. This is a distance of about 3,210 ft (980 m) from Leonia Road.

The upper canyon section of the Kootenai River is considered a more autotrophic reach and is primarily characterized by boulder and cobble substrates. It is postulated that the addition of nutrients may be best utilized in an area such as the Leonia site where only P is limited and ambient NO_3 levels may be high enough to stimulate production without becoming colimited (Ken Ashley, personal communication; Figure 2). A few rkm downstream (rkm 266.5), the Hemlock Bar site has been historically sampled at many levels of the food web since the early 1980s, providing baseline information to determine effects of the treatment.

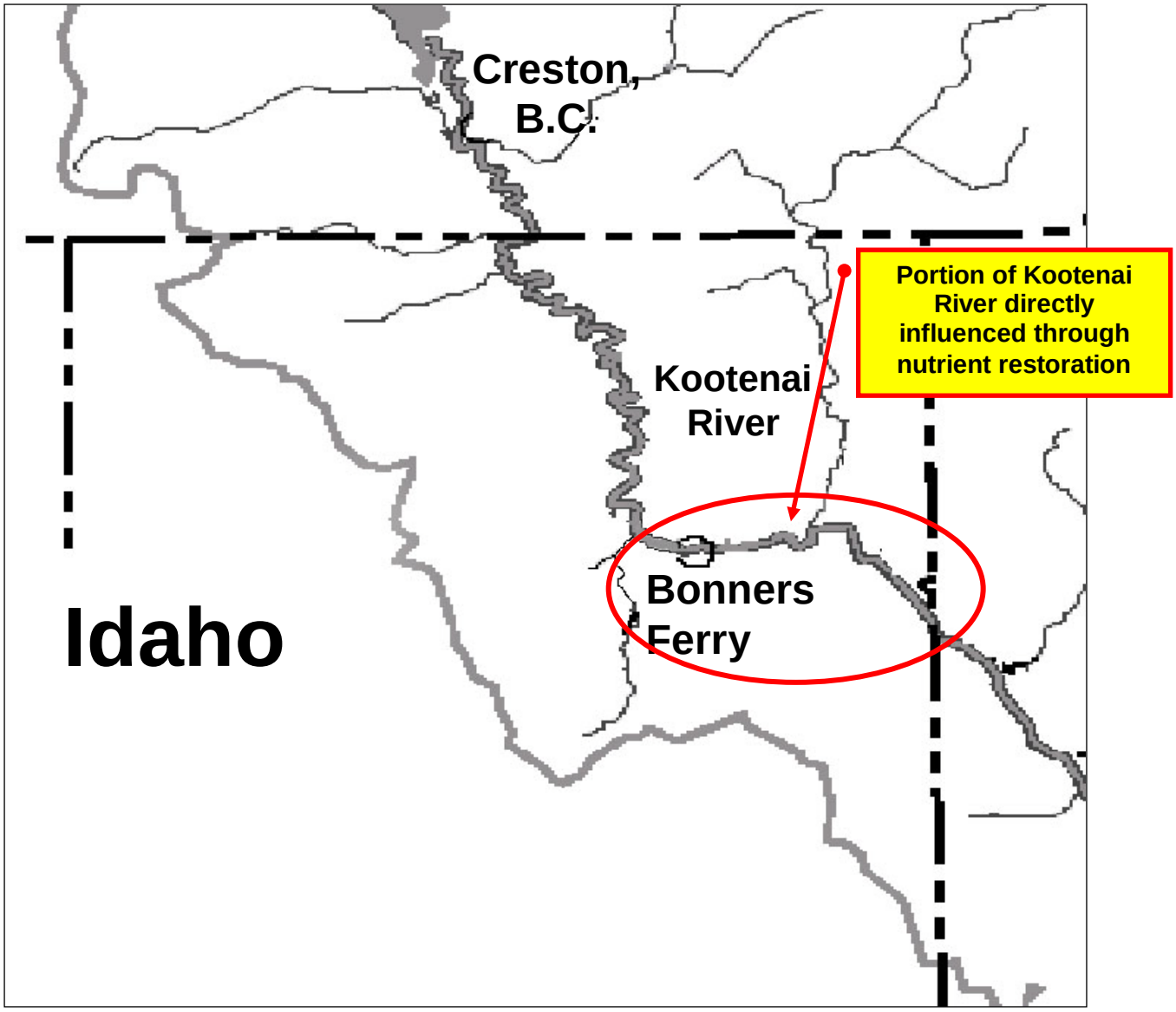

Figure 2. Kootenai River Drainage with location of the nutrient addition influence.

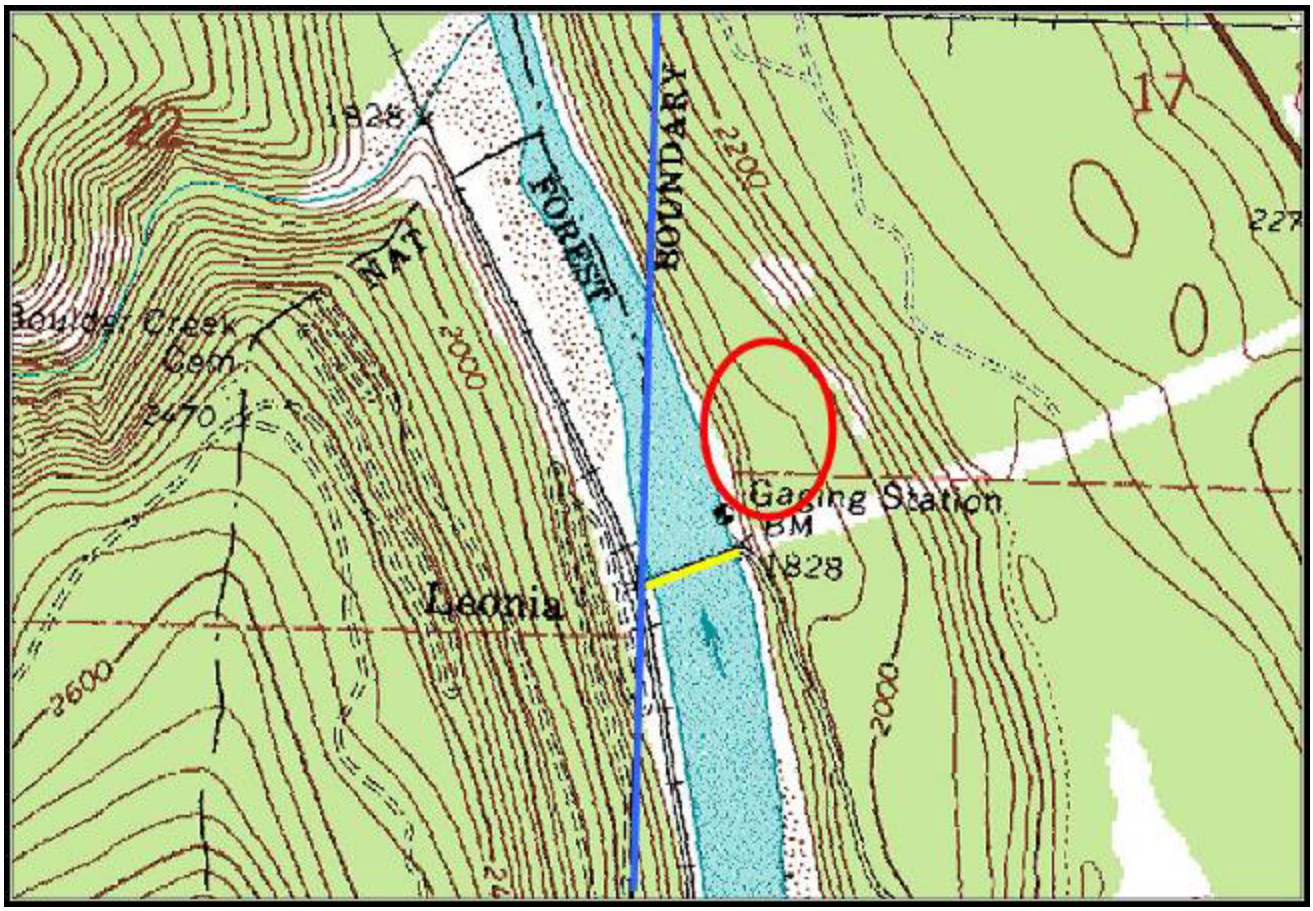

Figure 3. Location of nutrient application. Vertical blue line indicates the Idaho-Montana boarder.

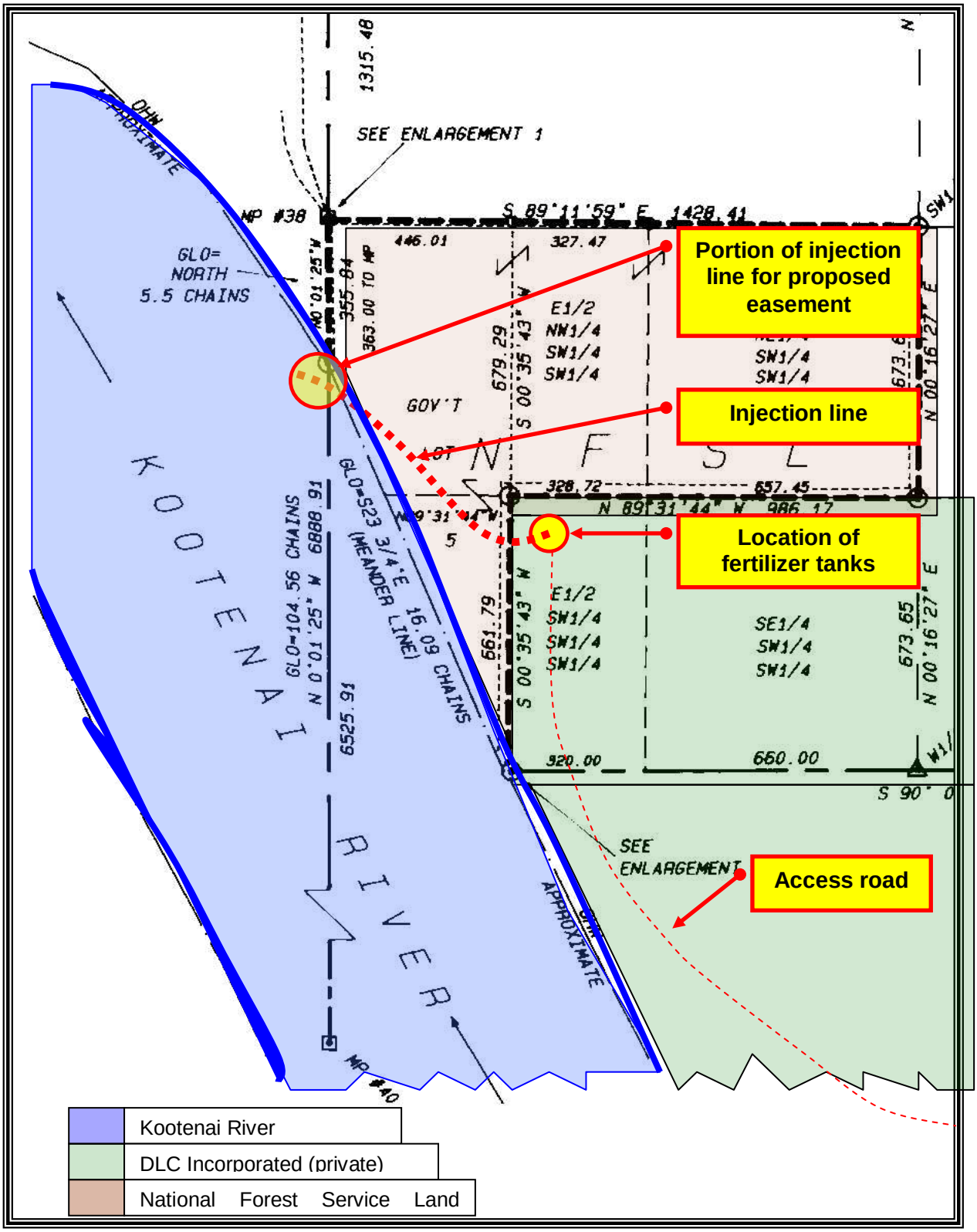

Figure 4. Map showing the Kootenai River nutrient injection point in relation to adjacent property boundaries.

Biomonitoring Locations

In the Kootenai River watershed, six ecosystem biomonitoring sites have been established to gather baseline data pre- and post-nutrient restoration (Figure 5). The first site, KR14, is in the southern part of BC near Wardner at rkm 565 (UTM 612607 5479569). This site serves not only as a nontreatment site, but also as a reference site without reservoir influence. The next site downstream, KR10, is below Libby Dam, and is in the Montana portion of the canyon section at rkm 283 (UTM 0574294 5381592). This location is often referred to as the Yaak River site due to its proximity to the Yaak River approximately 3 rkm upstream (Figure 5). This site serves as a nontreatment reference site below Libby Dam. The next site, KR9, in the canyon section is located at Hemlock Bar (often referred to as the Hemlock Bar site) approximately 18 km downstream at rkm 265 (UTM 0563707 5393213). A single site, KR6, is located in the braided canyon section above Bonners Ferry at rkm 250 (UTM 0554277 5394630) near the Cow Creek tributary, referred to as the Cow Creek site. The next two sites are located in the meander reach below Bonners Ferry at rkm 230 (UTM 0544834 5402535), referred to as the Shortys Island site (KR4), and at rkm 170 (UTM 0534892 5427171) near the Canadian border, referred to as the Porthill site (KR2).

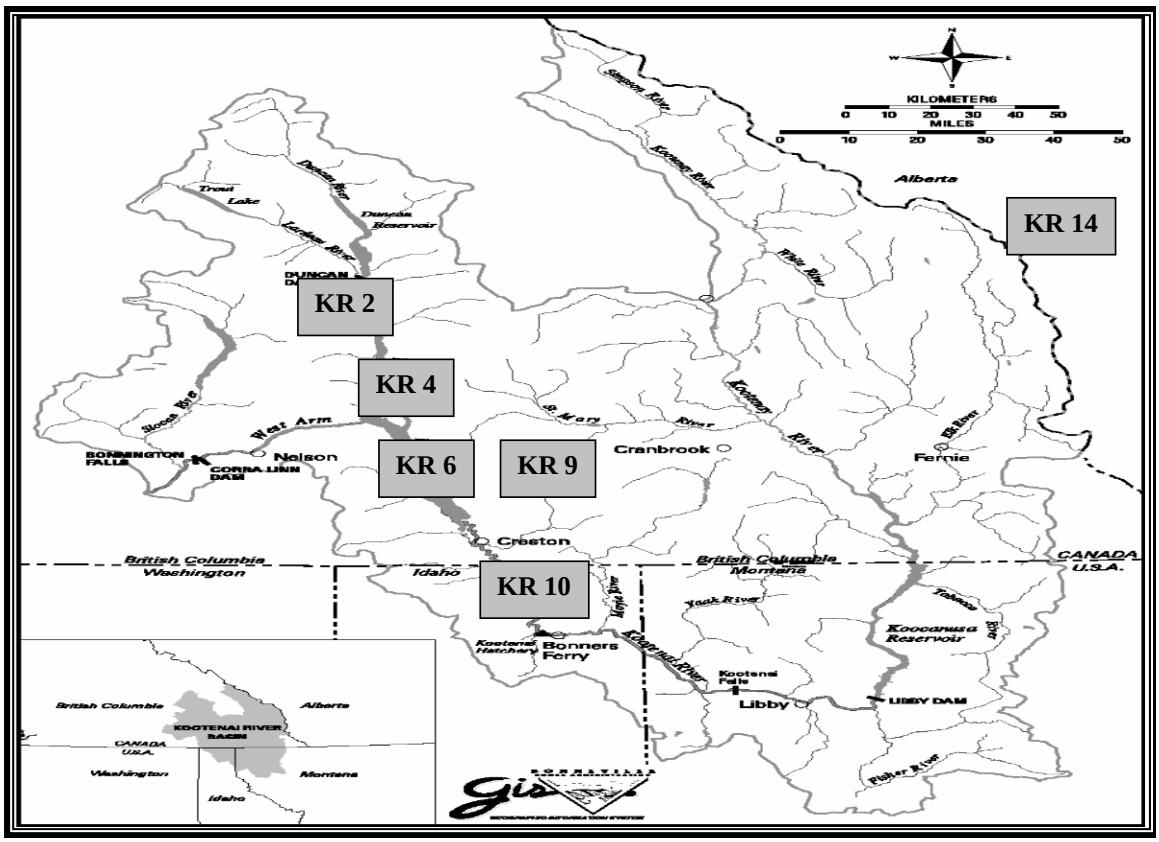

Figure 5. Kootenai River ecosystem study area and approximate locations of biomonitoring sites.

METHODS

Nutrient Addition Permitting

In order to move forward with nutrient restoration on the Kootenai River, the KTOI and IDFG worked with permitting agencies to come to agreement on what potential risks to monitor and a list of priorities in reporting requirements. The following agencies were contacted for approval and guidelines during the beginning stages of the program: Environmental Protection Agency (EPA), Idaho Department of Environmental Quality (IDEQ), Montana Fish Wildlife and Parks (MFWP), USACE, Idaho Department of Lands (IDL), Montana Department of Environmental Quality (MDEQ), Idaho Department of Water Resources (IDWR), United States Forest Service (USFS), Montana State Historical Preservation Office (MSHPO), and United States Fish and Wildlife Service (USFWS).

Metals

Since the phosphorus in the 10-34-0 fertilizer is originally obtained through the mining of phosphate deposits around the earth, each ore body has its own unique amounts of heavy metals (Ashley and Stockner 2003). As such, special attention should be paid to the origin of the fertilizer in order to reduce heavy metal concentrations at the nutrient application site (only two major locations of mining of phosphorous exist in North America: Idaho and Florida). As a general rule, metals should be maintained at or near 1% of current ambient metal concentrations to avoid harming aquatic organisms (Ken Ashley, BCMWLAP, personal communication).

Prior to the initial nutrient additions, two 250 ml samples of the 10-34-0 fertilizer were sent to an independent lab (ALS Environmental LTD) for a full metals analysis in March 2005.

The protocol used for determining the heavy metal inputs into the Kootenai River were as follows:

1. Data on ambient concentrations in river;

2. Multiply by the volume, or flow, to get total weight of each metal present;

3. Analyze fertilizer to get concentration of metals;

4. Multiply by volume of fertilizer to be added to get weight of each metal;

5. Divide amount of each metal in fertilizer into the river to show what the concentration would be in the absence of any other loadings, and compare the weight of metals in fertilizer to the weight of metals naturally in the water to put the fertilizer load in perspective;

6. Finally, compare this to EPA guidelines for aquatic life and drinking water to determine if the resulting concentrations are a concern.

In a similar fashion, in 2003 we sent 14 fish samples to ALS for a full background of metals concentration in fish populations in the immediate proximity of treatment. Of the 14 fish sampled, eight were mountain whitefish and six were large-scale suckers *Catostomus macrocheilus*.

Nutrient Delivery System Development

Treatment Site Details

The 10-34-0 (Ammonium Polyphosphate) and 32-0-0 (Urea Ammonium Nitrate) used in the summer nutrient additions were housed in nine polypropylene tanks located approximately 100 m above the river. The treatment tank area was approximately 100 x 60 m and housed the treatment equipment. A semitruck turnaround for refilling the tanks was added near the tanks. A gravel pad was constructed for the nine treatment tanks (six 9,500 L and three 7,900 L), and was approximately 16 x 16 m (3 tanks long x 3 tanks deep adjacent to the river rim) and surrounded by concrete lock blocks (Figure 6). The interior of the pad, which housed the tanks, was lined with a heavy polypropylene containment bladder, designed specifically, as a precaution, for product recovery had there been any tank leakage. The tanks were additionally surrounded with a 9 ft chain link fence with blinds to reduce the chance of tampering of equipment. The tanks were housed under a 52 x 52 ft pole building (without sides) to reduce problems that may occur from weather damage (Figure 7). To prevent wind damage and reduce the risk of fire, the area around the tanks was cleared (1-2 average tree heights).

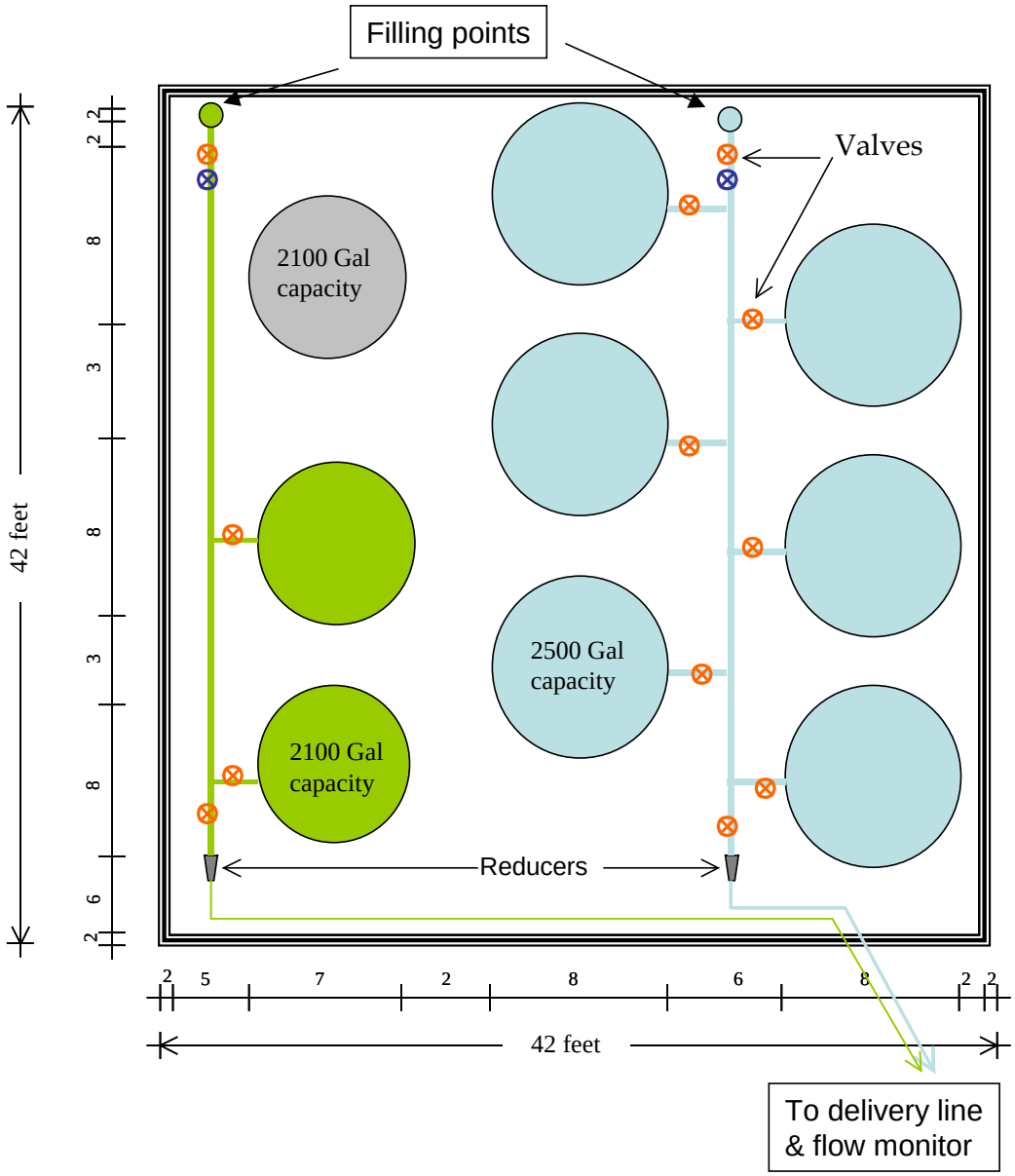

Figure 6. Nutrient tank layout.

Figure 7. Nutrient tank facility near Leonia, MT.

Nutrients: Dosing and Measurement

This project followed the nutrient addition protocols described by Ashley and Stockner (2003). In order to achieve our target of 3.0 µg· L/hr of TDP and 30-50 µg· L/hr of DIN (Dissolved Inorganic Nitrogen), the system was designed to add liquid ammonium polyphosphate (10-34-0; NH_4, P_2O_5) and liquid urea ammonium nitrate (32-0-0; CO $(NH_2)_2NH_4$ NO_3) fertilizer at loading rates directly proportional to the daily flow rates of the Kootenai River at the application site. Weekly fertilizer loading rates were determined using the following rationale: The 10-34-0 liquid nutrient commonly used for nutrient addition in rivers contains 34% phosphorus (by weight) as P_2O_5. There is 3.964 lbs per US gallon (0.475 kg/L) of P_2O_5 in the solution (J.R. Simplot Company product MSDS for liquid 10-34-0). The P_2O_5 has two components:

1. Orthophosphate (PO4) component, also called SRP, about 30 -35% of the total.

2. Polyphosphate component is equal to the rest, about 65-70% of the total.

The total for these components is the TDP. The SRP component of the fertilizer is that portion of phosphorous that is readily available for uptake by biota in the river. The

polyphosphate component hydrolyses slowly (days rather than hours) to produce available phosphorus (Ken Ashley, BCMWLAP, personal communication). Laboratory tests (performed by Ward and Associates LTD) of a sample of 10-34-0 that was used in 2005 showed a 33-67% split. For SRP equal to 33% of the total, the ratio TDP/SRP is 3:1.

Average SRP for two samples from lab testing 71,400 mg/L

Average TDP for two samples from lab testing 215,500 mg/L

The concentrations for P_2O_5 that were predicted based on dilution of the dosing flow with the river flow were divided by 2.29 to obtain the concentrations of phosphorus; this number is the ratio of P_2 / P_2O_5, based on molecular weights (P = 31, O = 16).

Example calculation for 10-34-0 dilution:

Assuming a nutrient flow of 0.274 L/min (= 0.00456 L/sec) of 10-34-0 is diluted in a river flow of 315 m3/s. Dilution amount is 69 million times.

Resulting concentration of P_2O_5in the river is:

0.475/69 million = 0.00688 x 10-6 kg/L = 0.00688 mg/L = 6.88 µg/L

Concentration of phosphorus = 6.88/2.29 = 3.0 µg/L

Additional specifications for liquid nutrients utilized in the Kootenai River nutrient program are:

Ammonium phosphate (10-34-0): Density 1400 kg/m^3, Viscosity 70 centipoise

Urea ammonium nitrate (32-0-0): Density 1280 kg/m^3, Viscosity 3.0 centipoise

Delivery System

Approximately 30 m of 38.1 mm diameter pipe ran from the upper tank storage to the lower platform where SeaMetric low-flow meters were housed. From there, approximately 180 m of high-density polyethylene (HDPE) piping extended from the tanks, following the slope of the land above ground down to the riverbank (Figure 8). A suitable value of internal diameter for this pipeline was found to be about 38.1 mm, and with this diameter the head needed to create dosing flow at the design condition (for 315 m^3/s discharge in the river) was found to be 1.21 m and for the high flow of 410 m^3/s was found to be 1.60 m. Under the extreme condition of an emergency release (valves fully open), the head created in the pipeline is found to be 12.34 m (Ward and Associates LTD, personal communications).

The end of the pipe (approximately 20 m) was secured to the bottom of the river (about 2-3 m deep at the time of treatment) with concrete weights and heavy weighted line. The majority of the pipeline was located on U.S. Forest Service-managed land (see Figure 4). After the 2005 and 2006 treatment season, the last 30 m of the hose was removed from the river and coiled near the riverbank to protect it for the following season's application. After the treatment was delivered, the HDPE pipe was emptied and left in place to reduce disturbance on the steep slope.

Plastic fittings used in the system were rated at maximum pressure values of 100 to 120 psi. With the tanks located on the bench at about 610 m elevation, the maximum difference in static head was approximately 55 m. Note that the liquid nutrients had densities that are 28% to 40% heavier than water. The calculated maximum pressure that may have developed against a closed valve close to the river was very near the rating for the plastic fittings.

A 3 x 2 m (10’ x 6’) wood platform 20 m downhill from the main tank location housed the control valves and the main safety alarms for the application system (Figure 9). The battery, gate valves, and SeaMetric meters were housed in a locked, metal rectangular box.

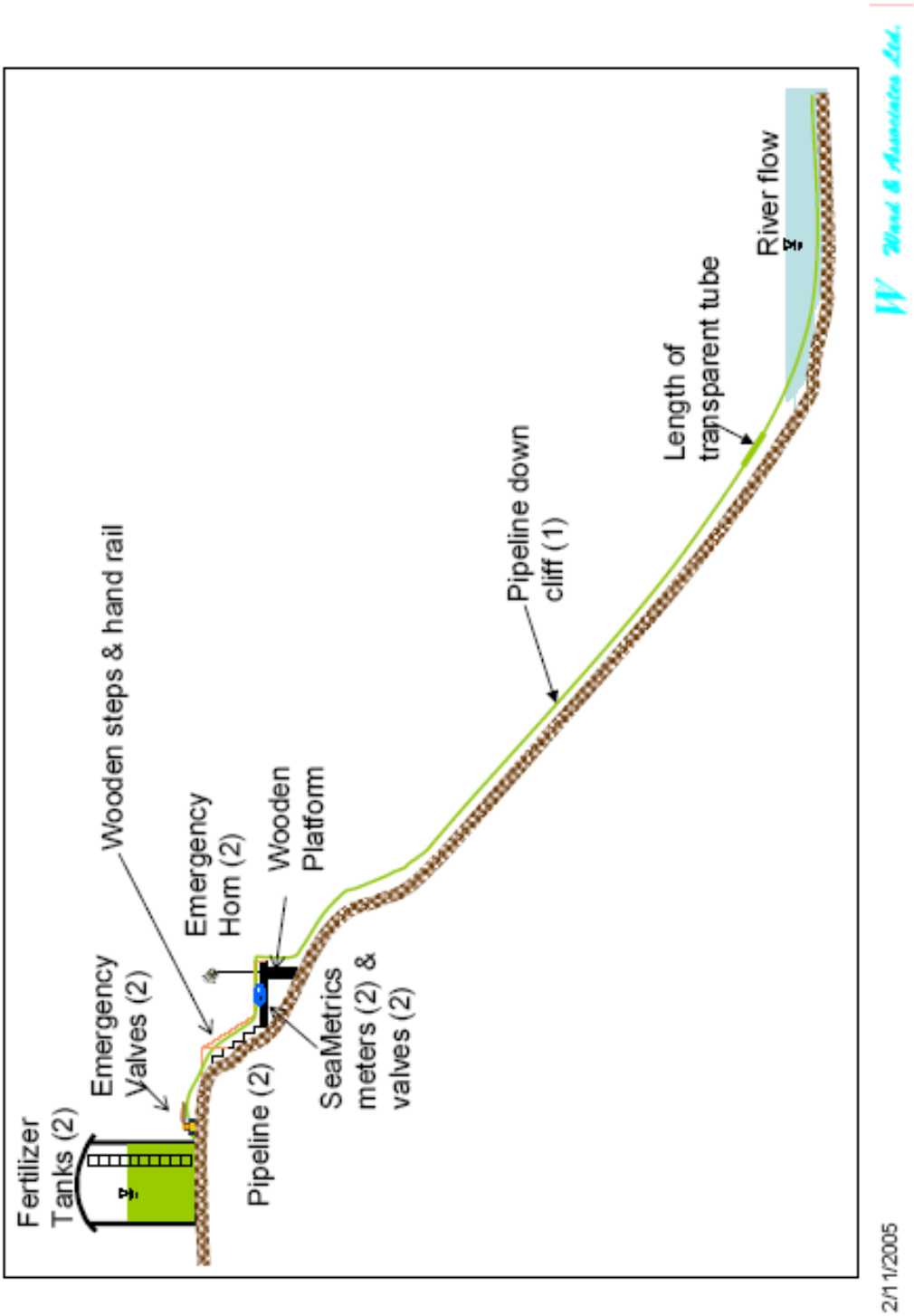

Figure 8. Schematic of nutrient delivery system to the Kootenai River.

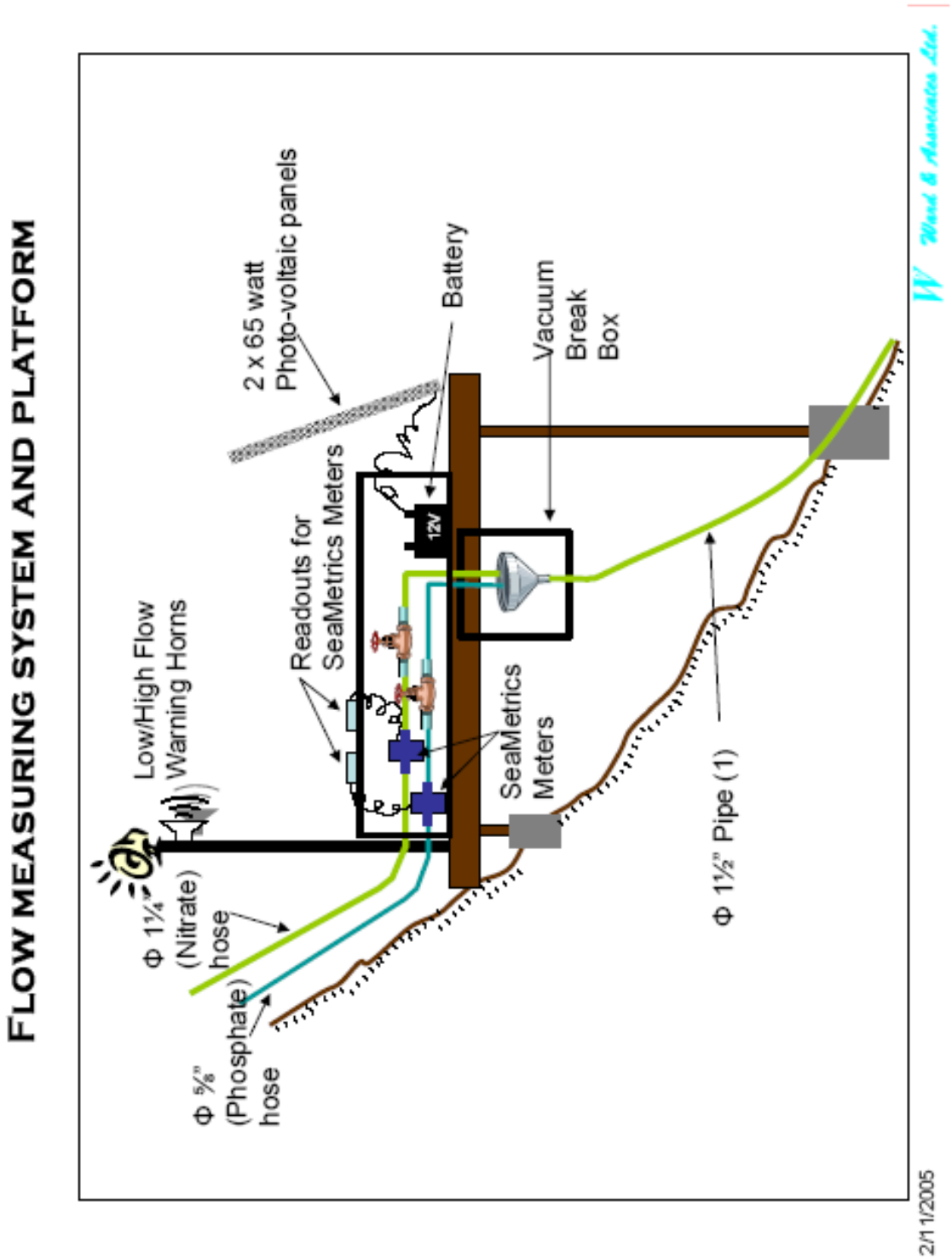

Figure 9. Schematic of the flow measuring system on the lower platform.

In the 2005 season, a gravity-fed dosing system for ammonium poly-phosphate solution (10-34-0) was designed, built, and operated as described previously. Additions of phosphate were initiated at 1.5 µg/L (half the optimum concentration of 3 µg/L for growth) in order to build insect numbers for the following season. This dosing was performed for initial concerns that an excess in algal production may accrue and be sent downriver with a lack of insect biomass for uptake and transfer through the river food web.

To maintain consistent flow during daily viscosity changes in the liquid nutrients, a low-energy pump-operated system was designed for dosing the liquid nutrients in 2006. These were small, solenoid operated diaphragm pumps running on a maximum power demand of 23 W, manufactured by ProMinent Dosiertechnik GmbH. The requirements at the Leonia site were such that two of the largest pumps in the Gamma/L model family (model GALA0232) were needed in order to supply a sufficient flow rate for dosing the Kootenai River at expected summer peak flows. Due to the absence of electric power at the site, the pump system was powered with solar photovoltaic panels. The two photovoltaic panels (Kyocera KC130 watt modules) were supported on a wooden rack, which could be adjusted in order to keep the panels perpendicular to the sun. The panels were connected in parallel so that a maximum current close to the target amount of 14.9 amps was supplied in full sunlight. A 50 foot (15 m) length of 2-conductor, heavy-duty (10 gauge) copper wire was used to connect the panels to the controller in the battery box. The pump system was installed in the line between the storage tanks and the gravity feed box. The needle valve for the 10-34-0 feed was left wide open so that it would not impede the flow supplied by the pumps. In addition, a ramping up of nutrient flow was done to achieve the desired 3 µg/L of TDP.

Mixing Zone

Prior to adding nutrients, it was necessary to determine the in-river mixing potential of the nutrients in order to satisfy partial requests on the “Short Term Activity Exemption” permit from IDEQ. For determining the mixing characteristics of the reach, it was decided to establish a long plume of dye using a diluted mixture of Rhodamine WT injected into the nutrient release pipe and into the river thalweg. To measure the mixing potential of the river we used a boat-mounted fluorometer to find the extent of transverse spread of the dye cloud. A *Turner* fluorometer was used with flow-through capability, so that a boat mounted pump could be used to pass water through the instrument and read the concentration of dye. Checks were made on the day before the experiment to see what the background reading for the river water was and what the reading at a variety of concentrations of Rhodamine WT were. A 210 L barrel was used to dilute the dye in order to hold a flow of approximately 1.7L/min (valves wide open) for approximately 2 hours. This would allow enough time for people in the river to determine the full mixing potential of the river at various locations below the outflow pipe. Fluorometer measurements were made at successively downstream (200 m) cross sections, following the dye cloud as it moved downstream over a 2 hr. period.

Water samples were taken weekly at 12 separate sites in the upper canyon reach. These samples were submitted weekly to determine the concentration of Total Dissolved Phosphorous (TDP), Nitrate+Nitrite (NO_3+NO_2), and Orthophosphate (SRP). If levels of Nitrate+Nitrite were to fall below our 20:1 ratio (60 µg/L at Phosphate additions of 3 µg/L) it would have triggered addition of 32-0-0 to increase Nitrate levels in order to reduce the risk of falling into nitrogen limitation or growing nuisance blue-green algal blooms. Results of these water samples will be reported by KTOI in their 2005-2006 annual ecosystem water quality report. Additional nutrient restoration response variables that were measured by the KTOI in

relation to this program, but not reported on in this annual report, include algal biomass, macrophyte biomass and density, and macroinvertebrate community dynamics.

Photic Zone

Ward and Associates Ltd. devised a crude method of determining how much area of the riverbed was available for aquatic growth, based on penetration of light through the water column to the bed. In order to obtain these data, 12 river cross-sections were measured in the river directly downstream of the nutrient release location with a boat when the river was at a very high stage (>1500 m^3/s) on June 16, 2006. Depths were obtained using a depth sounder and channel widths were obtained using GPS. Turbidity was recorded with a secchi disk. Based on previous accrual rates collected in the river, the assumption was made that algal growth was possible up to 2 to 3 times the secchi depth reading.

Microinvertebrate Abundance

Zooplankton were sampled in 2005 and 2006 to add to a trend dataset of species abundance and composition and to provide a comparison to baseline data following treatment of the Kootenai River with nutrients (inorganic N and P). Zooplankton were sampled at three biomonitoring sites (rkm 283, 265, and 250) on the Kootenai River from November 2005 through October 2006, with collections made once each month from the left, center, and right channel. Zooplankton were collected by filtering 10 L of water through a 1 L straining cup lined with a 63 µm mesh filter material. Samples were taken approximately 0.3 m below the water's surface (crustaceans and rotifers were assumed to be evenly mixed in a lotic system). Contents were then rinsed into 60 ml NALGENE® bottles and preserved with 0.1 ml of Lugol's iodine solution per 1 ml sample volume. Four 1 ml aliquots from each sample were analyzed to the most specific taxonomic identification of crustacia and rotifers. Resulting zooplankton counts from subsamples were then extrapolated to number per liter.

Fish Community Assessment

Species Abundance/Catch and Biomass Rates

In September of 2005 and 2006, each of the biomonitoring sites was electrofished to identify relative species abundance as catch per unit of effort (CPUE), abundance by weight as biomass per unit of effort (BPUE), relative weight (Wr) and condition (K), and trophic structure. One unit of effort was defined as 1 hr of shock time. These data will document trends in the fish community over time and will be used as a comparison to "pretreatment" data for the nutrient restoration of the Idaho section of the Kootenai River. Sites were sampled using a 5 m jet boat equipped with a Coffelt VVP-15 electroshocker powered by a 5000 watt Honda generator. Typically, electrofishing settings were set to generate 6-8 amps at 175-200 volts. The sampling crew consisted of two netters and one driver, who had control of the safety microswitch. All fish species, regardless of size, were netted in order to get a representative sample of the fish community structure at each site. To increase replication, each biomonitoring section (left and right shoreline) were divided into six equal subsections of 333 m with 150 m separating each to ensure each site was independent of the next. This protocol allowed one km of electrofishing on both banks for a total of two km of sampling. Electrofishing was performed at rkm 565, 284.5, 266, 251, 231, and 172 and working upstream at each site, respectively. A single pass was made through each subsection, starting with lower sections first to ensure no fish drifted into

areas not yet sampled. After each subsection was electrofished, the elapsed sampling time was recorded, and collected fish were taken back to a workup station (a convenient, safe spot on the shoreline). At the workup station, fish were anesthetized, identified to species, measured (total length [TL], mm), enumerated, and weighed (g). A subsample of scales from the most abundant species at each site was taken (10 fish in each 10 mm class interval) for aging.

Feeding Guilds and Tolerance

All species sampled were classified into feeding guild and relative resistance to habitat disturbances as specified in Zaroban et al. (1999). Feeding guild classifications included omnivore, invertivore, and invert-piscivore. Omnivores primarily eat plant and animal material (min of 25% each). Invertivores are described as those species that feed primarily on invertebrate prey, primarily insects. Invert-piscivores consume considerable proportions of fish and invertebrates and typically have an enlarged mouth relative to nonpiscivorous species (Zaroban et al. 1999). Disturbance (be they natural or man-caused) or pollution tolerance was classified as follows: sensitive—those species that tend to either disappear or are greatly reduced in association with human disturbances (Karr et al. 1986); tolerant—those species that tend to increase with human disturbances (Zaroban et al. 1999); and intermediate—species that tend to be neither tolerant nor sensitive to disturbance (increased siltation, turbidity, temperature, or lowered dissolved oxygen; Zaroban et al. 1999). These fish classifications along with other trophic data are to be used in the future to determine trends following nutrient additions.

Relative Weight (Wr) and Condition Factor (K)

We calculated relative weight (Wr), which compares Kootenai River fish weight to that of a standard developed for each species (Blackwell et al. 2000). Relative weight was calculated using the formula:

$$Wr = (W/Ws) \times 100,$$

where W is the actual fish weight and Ws is a standard weight for fish of the same length. A Wr of 100 was considered optimal. Relative weight was calculated for rainbow trout and mountain whitefish (Ws taken from Anderson and Neumann 1996). Minimum total lengths to calculate Ws were 120 mm for rainbow trout and 140 mm for mountain whitefish (Parker et al. 1995; Rogers et al. 1996; Simpkins and Hubert 1996). Statistical differences in condition and relative weights will be tested in future years to detect pre- vs. post-treatment differences by using 1-way ANOVA (GLM, general linear models; SYSTAT 7.0 1997). No statistical comparisons were performed on these data for 2005-2006.

Fulton's condition factor (K) was used as a measure to gauge changes in body form of largescale sucker since a standard (W*s*) used in the relative weight equation is not available at this time. K is a ratio between the observed weight and an expected weight dependent on the fish's length (Blackwell et al. 2000). Fulton's condition factor is calculated using the following formula:

$$K = (W/L^3) \times 10^5,$$

where W is the weight of the fish in g, L is the length in mm, and 10^5 is a constant used for scaling purposes. A condition of 1 represents optimal growth.

Age and Growth

Rainbow trout and mountain whitefish scales were impressed onto cellulose acetate slides and viewed on a microfiche reader at 42X magnification. Each annulus was measured and marked at the leading edge of the compressed rings indicating a single year of growth. For pre- vs. post-treatment data, only age 0-4 were compared due to the difficulty and variability in aging older fish by the use of scales. Due to a lag in data analysis and an effort to confirm ages of certain years for trout and mountain whitefish, only length-at-age at capture were described here for mountain whitefish during years 2002, 2003, and 2006. Age and growth for mountain whitefish and rainbow trout for all years of fertilization will be available in the 2007-2008 annual report. Statistical analysis of CPUE and TL at each age group pre- vs. post-treatment will be performed in future annual reports to allow all data to be analyzed together and to have more than one growing season at the same treatment rate (3 µg/l of TDP).

RESULTS

Nutrient Addition Permitting

The following agencies were contacted for permitting purposes to determine what permits, if any, were needed in relation to adding nutrients to the Kootenai River:

IDEQ: the Idaho Dept. of Environmental Quality issued the project a Short Term Activity Exemption in lieu of an NPDES permit and 401 certification for the program. Contact: June Bergquist 208 769-1422.

IDL: the Idaho Dept. of Lands issued a Land Use Easement to us to have the pipe entering Idaho state land within the high-water mark. Contact Jim Brady 208 769 1535.

MFWP: Montana Fish, Wildlife, and Parks issued a 124 Permit for any activity within the high-water mark for the project. Contact: Mike Hensler 406 293 4161.

MDEQ: Montana Dept. of Environmental Quality indicated that we did not need a 318 Permit (activities that may increase temporary turbidity) for this project. In addition, since the project created less than 1 acre worth of disturbance, we did not require a Storm-water Discharge Permit either. Contact: Jeff Ryan 406 444 4626.

USACE: the U.S. Army Corps of Engineers is responsible for issuing the Section 10 or 404 certification depending on the water body. On April 29, 2005, we were issued a “No Permit Required” document for the project based on no dredge or fill effects within the high water mark, since the area of nutrient injection is not considered a navigable waterway.

IDWR: Since the ACOE, upon review of the project, issued a no permit required statement, we needed to contact the Idaho Dept. of Water Resources to obtain a Stream Channel Alteration Permit for any type of work or activity in the river (including placement of the 30 feet of pipeline). Contact: Erv Ballou 208 287 4800.

USFS: US Forest Service (Kootenai National Forest) issued a Special Use Permit to the project to have the outflow pipe on their adjacent property. Contact: Brandon Smith 406 283 7785.

MSHPO: Following review of the project documents and cultural resources survey performed, the Montana State Historical Preservation Office sent concurrence dated April 26 for "No Adverse Effect" to historical properties on or near the project site. Contact Joseph Warhank.

USFWS: US Fish and Wildlife Service reviewed the Biological Assessment written by IDFG and issued a concurrence letter with findings of no significant adverse effects to listed species. They, however, are very concerned about the potential for white sturgeon egg predation by nongame species in the lower river. We indicated that if we see a significant increase in these species in that reach of the river as per biomonitoring, we will re-evaluate the longevity of the project. Contact: Scott Deeds USFWS Spokane branch.

Categorical Exclusion: May 31-June 4, 2005 was the initial construction period. With MSHPO and USFWS concurrence, we were allowed to do preliminary construction on the site. No work was to be done on USFS land until the EA was finalized. Contact Colleen Spiring (BPA): 503 230 5756

Environmental Assessment: BPA prepared an EA for the project. The final EA was finished and bound in late June. Once the EA was given to the USFS, we were issued the Special Use Permit to build the valve-housing platform and lay the fertilizer hose/line to the river.

Metals

Analysis of 10-34-0 fertilizer samples showed that the top three metals in the sample were aluminum, iron, and zinc (Table 1). Fish sampled in the Hemlock Bar and Cow Creek reaches of the river were found to be low in background metals prior to treatment (Table 2).

Table 1. The average total metals analysis of Kootenai River water (at rkm 265) and 250 ml samples (n = 2) of ammonium polyphosphate fertilizer (10-34-0; $NH_4P_2O_5$). Values of 10-34-0 represent concentration of fertilizer that will be diluted exponentially with summer flows in the Kootenai River.

Metals	Weight of Metals in 10-34-0 (mg/L)	Weight of Metals (mg/s) Added to River	Flow/d (l/s)	Diluted Weight of Metals (ug/l)	2002 Ambient Concentration (ug/l)	% increase in metals to the upper River
Aluminum	4,415	20	314,316	0.0642	21.4	0.30
Boron	43	0	314,316	0.0006	0.1	0.62
Cadmium	98	0	314,316	0.0014	0.1	1.42
Calcium	14	0	314,316	0.0002		
Chromium	373	2	314,316	0.0054	1.42	0.38
Copper	18	0	314,316	0.0003	13.9	0.00
Iron	5,240	24	314,316	0.0762		
Magnesium	509	2	314,316	0.0074		
Manganese	68	0	314,316	0.0010		
Molybdenum	16	0	314,316	0.0002		
Phosphorus	185,500	847	314,316	2.6961		
Potassium	1,005	5	314,316	0.0146		
Silicon	41	0	314,316	0.0006	2.2	0.03
Sodium	540	2	314,316	0.0078		
Titanium	58	0	314,316	0.0008		
Vanadium	696	3	314,316	0.0101		
Zinc	1,090	5	314,316	0.0158	6.4	0.25

Table 2. Average total metals analysis of mountain whitefish and largescale sucker tissues (n=14) sampled in 2004 at rkm 265 of the Kootenai River in comparison to USEPA and International standards set for human consumption. Nd = non-detectable.

	Kootenai River Fish Tissue (mg/kg)		Standards	
Metals	**Mean**	**SE**	**USEPA**	**International**
Arsenic	0.103	0.036	3	1.5
Cadmium	0.013	0.003	10	0.3
Chromium	nd	nd		1
Copper	0.494	0.031		20
Lead	0.025	0.001		2
Selenium	0.659	0.080	50	2
Zinc	4.570	0.319		45
Mercury	0.081	0.020		

Nutrient Additions

Phosphate fertilizer (10-34-0 solution) was added to the river beginning July 13, 2005 at the rate of 0.31L/min at a river flow of 25,559 cfs. At this concentration, additions were to achieve 1.5 µg/L of phosphate. During the 2005 season, nitrate (32-0-0 solution) was not added due to adequate levels of nitrate (85 µg/L) through the duration of the experiment (water quality

data available from KTOI; C. Holderman personal communication). Within three weeks of application, high algal growth was apparent on substrates lining the bank within 200 m of the application pipe (empirical water quality and chlorophyll data available from KTOI; C. Holderman). Throughout the application period, algal growth was visible in locations previously void of growth. Water samples taken throughout the summer indicated that orthophosphate levels were still extremely low (below detection limits of 0.5 µg/L) even within 1 rkm below the outlet pipe. For the first season, phosphate additions were discontinued on September 28, 2005. Approximately 21,000 L of phosphate was used during the 80-day growing season (Figure 10).

In the 2006 season, nutrient additions to the Kootenai River began July 12 at the rate of 0.43L/min and at a river flow of 18,085 cfs. At this concentration, additions were to achieve 3.0 µg/L of TDP. Nitrate was again not added due to adequate levels of nitrate (100 µg/L) throughout the duration of the experiment. Phosphate additions were discontinued on September 30, 2006. Approximately 35,225 L (9,305 gallons) of phosphate was used through the 80-day growing season (Figure 11). In both the 2005 and 2006 season, Kootenai River water quality samples indicated that river nutrients were well above a 20:1 N:P ratio (for values contact KTOI; C. Holderman), the minimum needed before having to add nitrogen to aid in algal growth.

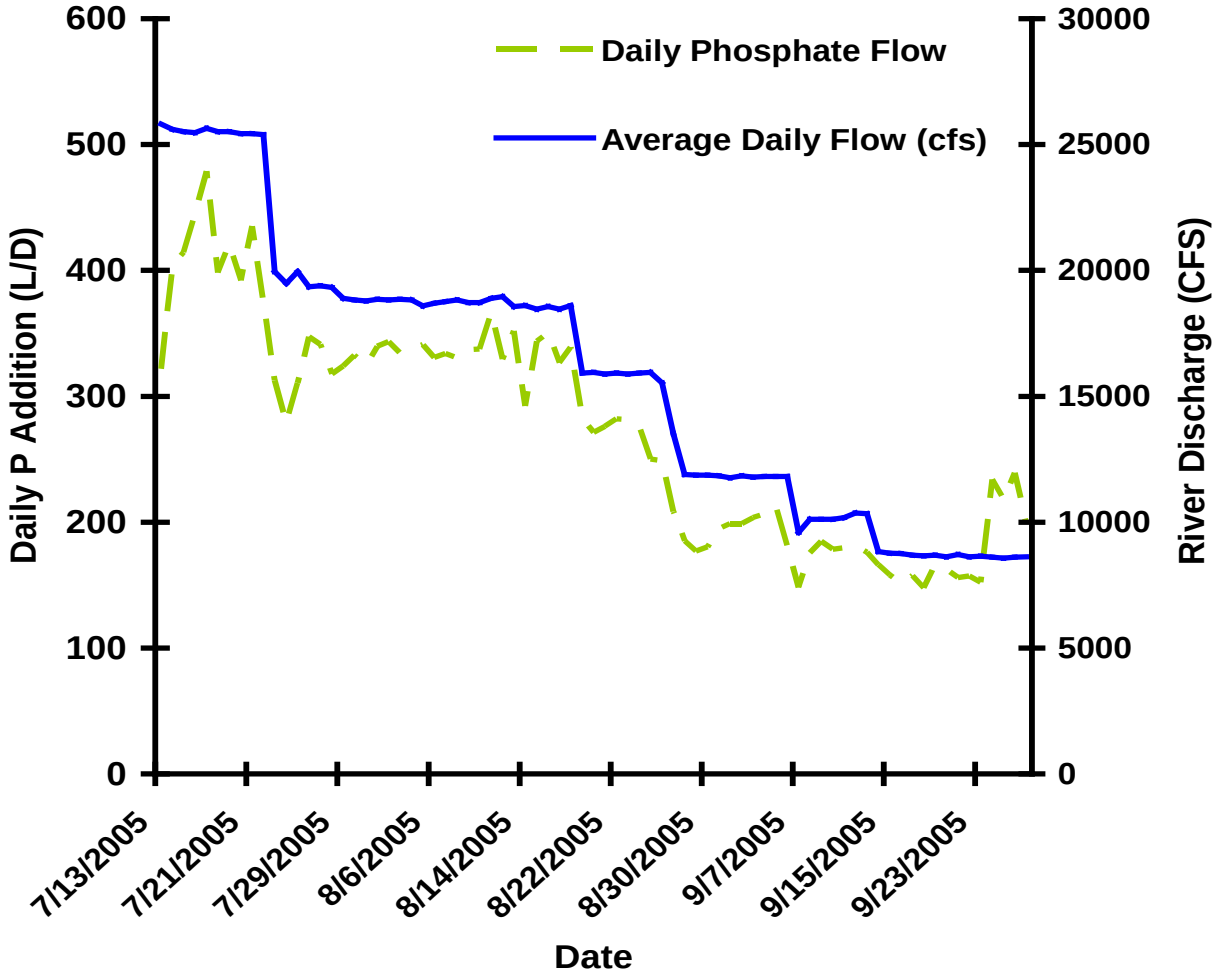

Figure 10. Liquid phosphate (10-34-0) additions and Kootenai River flow at Leonia, MT in 2005.

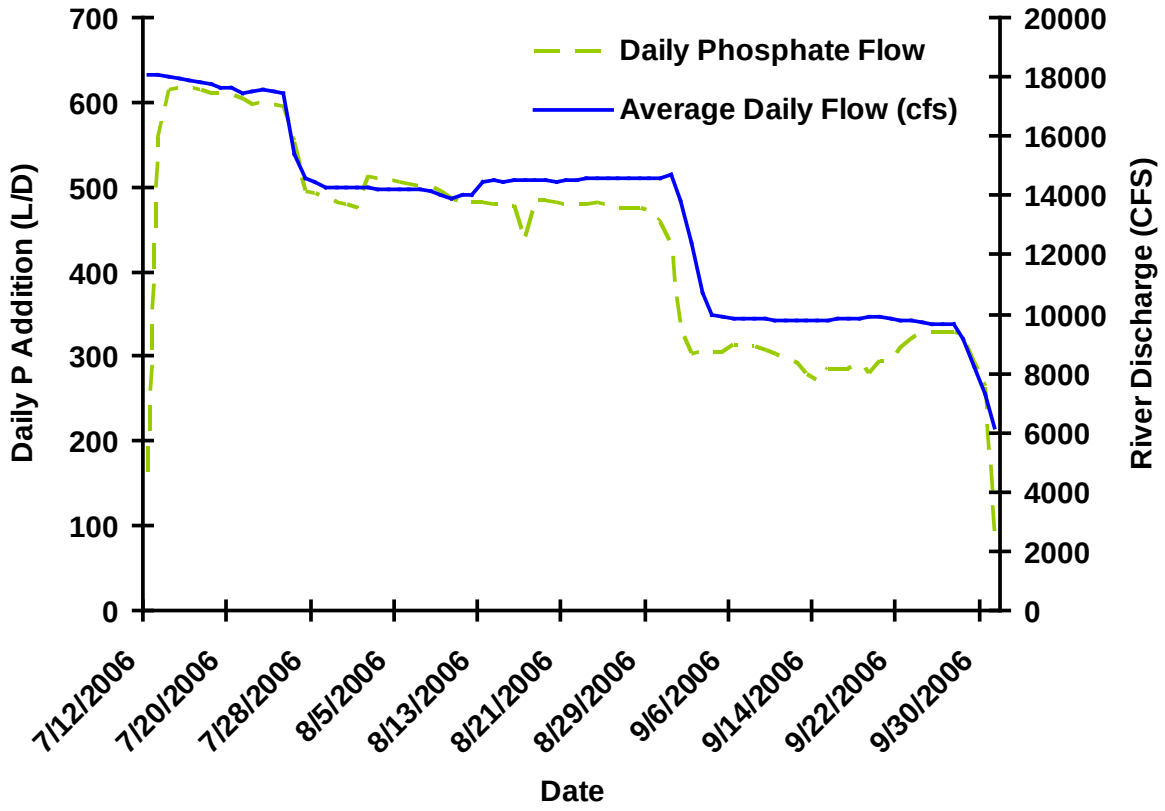

Figure 11. Liquid phosphate (10-34-0) additions and Kootenai River flow at Leonia, MT in 2006.

Microinvertebrate Abundance

Fourteen species of crustaceans and 45 species of rotifers were identified in the filtered samples (n = 201) collected in 2005 and 2006. Mean crustacean densities through the sampling period ranged from 0.14 to 2.85/L (standard error [SE] ± 0.0 – 0.66, respectively). Mean rotifer numbers were higher than crustacean ranging from 1.16–95.82/L (SE ± 0.24–17.46), respectively. Site-specific differences within each month were minimal. Crustacean and rotifer densities in collections from June of 2002 to October of 2006 have shown a general trend of decreasing numbers even in KR 10 (the reference or nontreatment reach of the nutrient program; Figure 12 and 13). Mean crustacean proportions were dominated by the subclass Copepoda (*Nauplii spp, Cyclopoid copepodite,* and *Harpacticoidea bryocamptus*) along with small proportions from the subclass Cladocera *(Bosmina longirostris, Chydorus sphaericus, Alona rustica and costata,* and *Daphnia spp*). Similar proportions of the same species were represented at all three of the sites (rkm 251, 265, and 283). Mean rotifer proportions at all sites were dominated by four main species: *Keratella cochlearis, Polyarthra remata, Polyarthra major,* and *Kellicottia longispina.* Again, similar proportions of the same species were represented at all three of the sites.

Through the experimental period, peak rotifer densities coincided with increased flow through Libby Dam (Figure 14). Peaks of rotifer densities in 2005 and 2006 were significantly lower in comparison to 2002-2004 spring events. Linear regression analysis of rotifer densities was significant (P = 0.025; Figure 15).

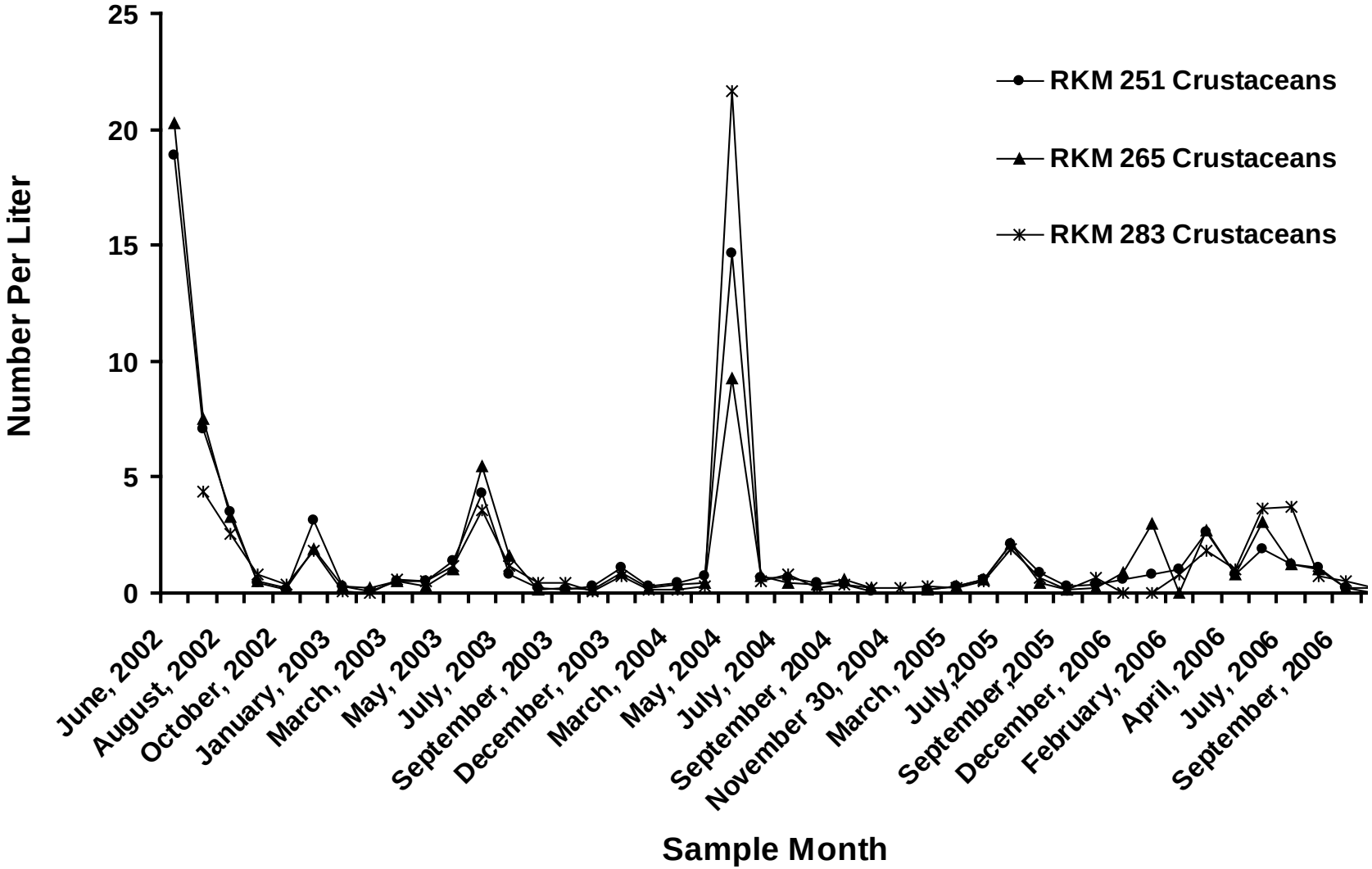

Figure 12. Zooplankton densities (crustaceans) from June 2002 through October 2006 from the upper Kootenai River at rkm 283, 265, and 251.

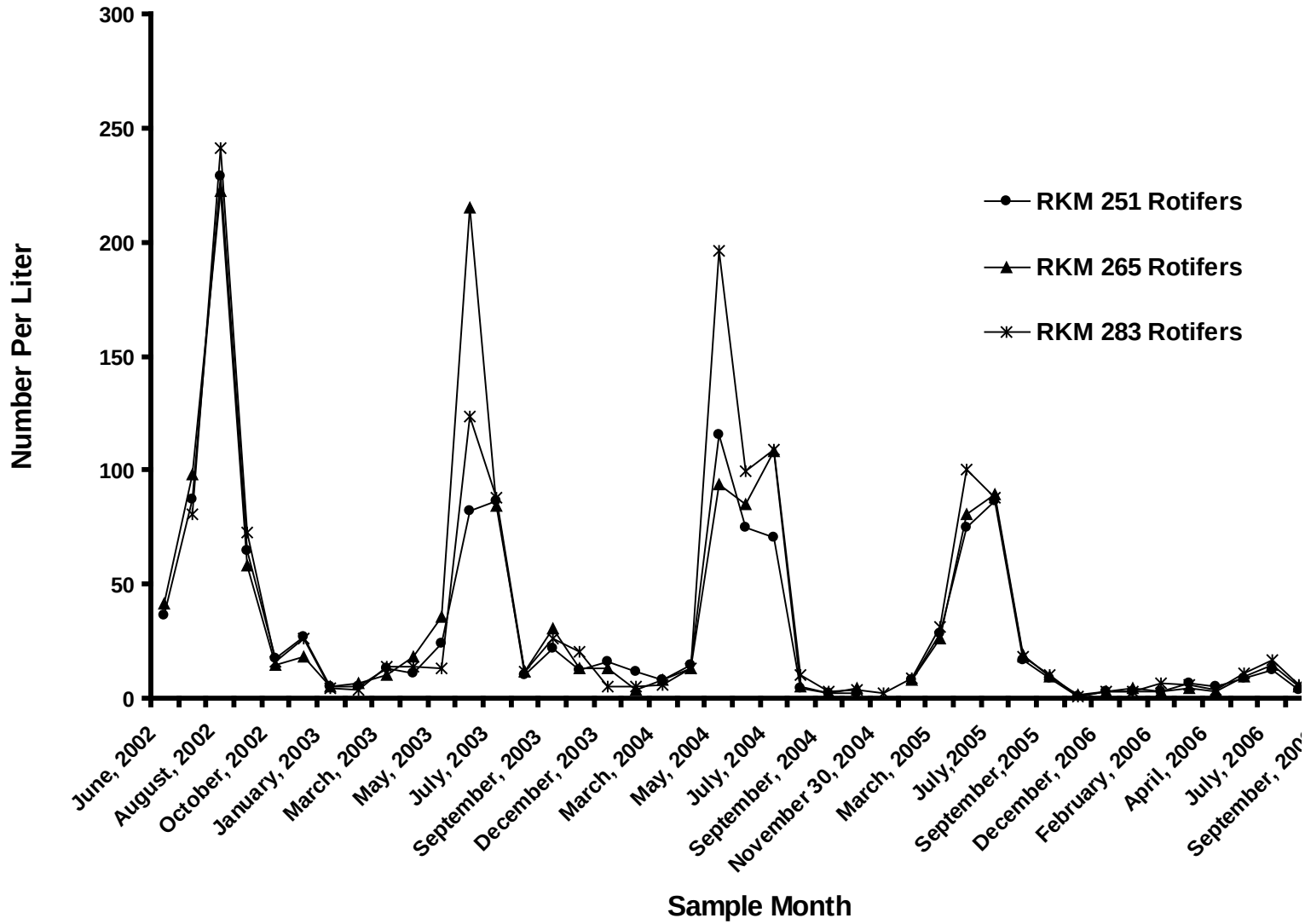

Figure 13. Zooplankton densities (rotifers) from June 2002 through October 2006 from the upper Kootenai River at rkm 283, 265, and 251.

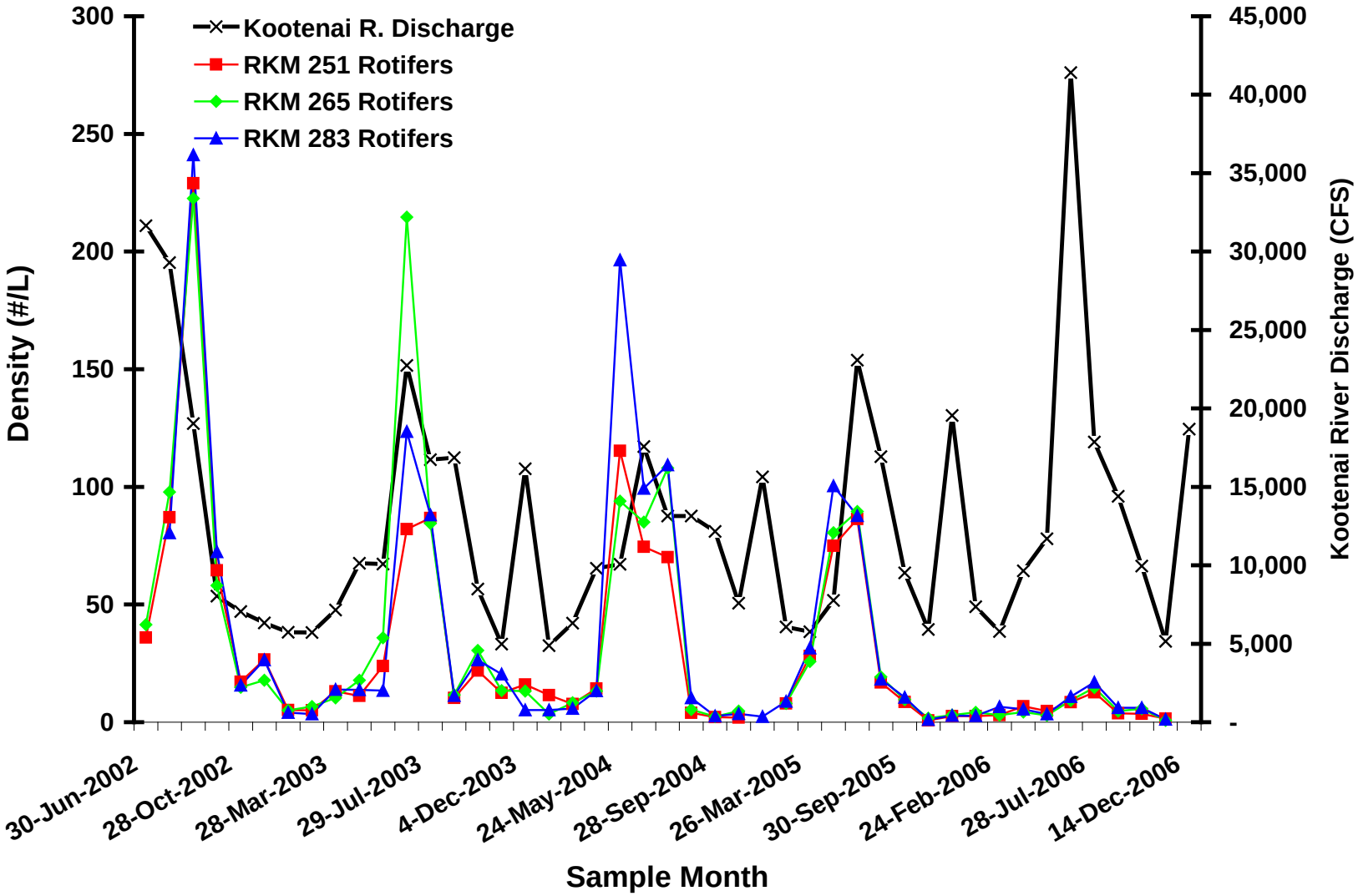

Figure 14. Kootenai River discharge at Leonia from June 2002 through October 2006 with zooplankton densities (rotifers) from the upper Kootenai River at rkm 283, 265, and 251.

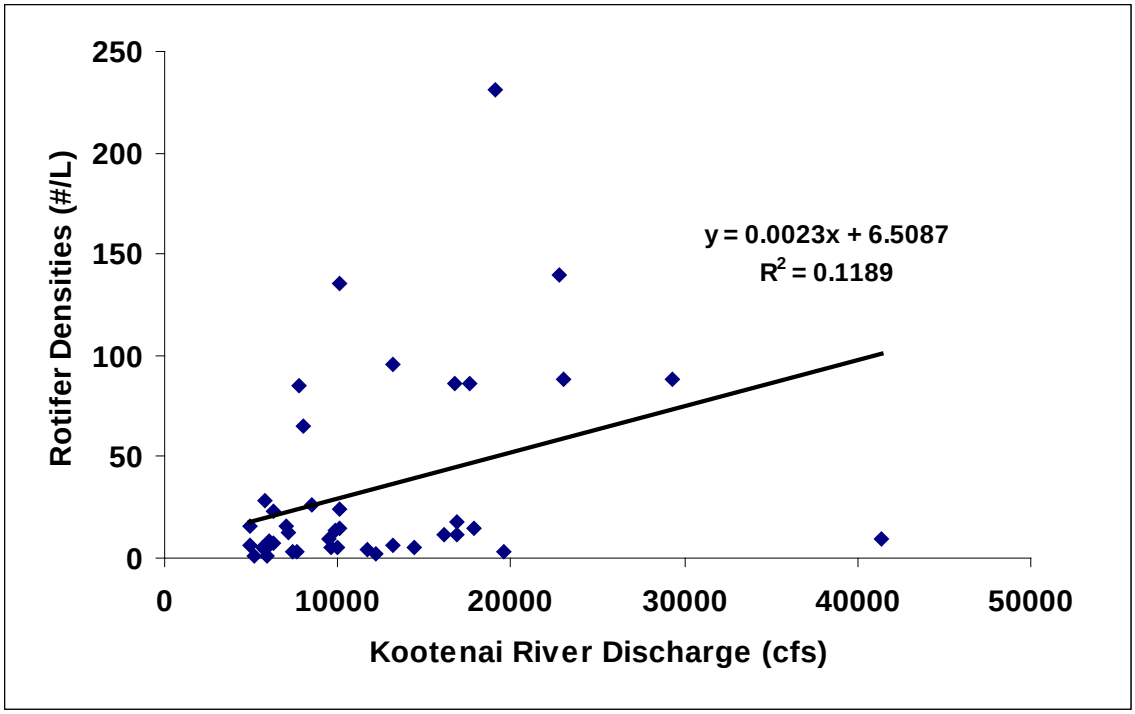

Figure 15. Regression analysis of Kootenai River discharge at Leonia and rotifer densities from June 2002 through October 2006.

Fish Community Assessment

Species Diversity

Fifteen species of fish were captured via electrofishing during the 2005 and 2006 sampling periods. Species diversity between sites ranged from 8-12 with the highest diversity located in the sample site near Shortys Island (rkm 230; Table 3). Species diversity did not change with the addition of nutrients during the 2005 and 2006 season. Four of the species (northern pikeminnow *Ptychocheilus oregonensis*, mountain whitefish, peamouth chub *Mylocheilus caurinus*, and largescale sucker) that are relatively tolerant or intermediately tolerant to habitat disturbances were found at all of the biomonitoring locations. With the exception of a very low number of rainbow trout, none of the species that are considered sensitive to such perturbations or natural habitat variation in a large river system (e.g., bull trout, westslope cutthroat trout, and kokanee) was located at the Porthill site (rkm 170; Table 3). Although burbot and Kootenai River white sturgeon are known to be present in small numbers, none was sampled in our index sites.

Species Abundance/Catch and Biomass Rates

Total catch per unit of effort (CPUE) and biomass per unit of effort (BPUE) across all species varied from upriver to downriver locations (Figure 16 and 17). Total effort ranged from 0.64 h to 1.80 h per site. The highest total CPUE in 2005 across species (305 fish/h) was recorded for the sample section approximately 10 rkm below the treatment location near Hemlock Bar (rkm 265). In 2006, the highest CPUE (459 fish/h) was recorded at the Cow Creek section (rkm 250) approximately 20 rkm from the nutrient release location (Table 4). The highest BPUE in 2005 (105 kg/h) and 2006 (136 kg/h) were sampled near Wardner, BC upstream of Koocanusa Reservoir at rkm 565 (Table 4). Breakdown of CPUE and BPUE by species are located in Appendices A-E.

Although not statistically significant, there was a notable increase in CPUE and BPUE from pre- vs. post-treatment years within those locations directly influenced by nutrient additions (rkm 265 and 250; Table 4). However, this same increasing trend was also seen in one of the two nontreatment reaches approximately 10 rkm above the nutrient injection location (rkm 283). A breakdown by species indicates that these increases in CPUE and BPUE in the nontreatment location (rkm 283) were primarily from mountain whitefish and rainbow trout, while the increases in the treatment locations (rkm 250 and 265) were almost exclusively mountain whitefish (Appendices A-E).

Catch and biomass at the Shortys Island reach approximately 40 rkm below the treatment location (rkm 230) has shown a decreasing trend since the main river fertilization began in the upper river. The primary species that makes up this decline is peamouth chub (Appendices A-E). In 2006, one of the six sample locations at the Shortys Island reach was substantially altered by installation of a pilot habitat project (large boulder field) for Kootenai River white sturgeon spawning habitat (Rust and Wakkinen 2007). This habitat alteration significantly increased CPUE of species such as northern pikeminnow and westslope cutthroat trout and reduced densities of peamouth chub (Figure 18).

Relative Weight (Wr) and Condition Factor (K)

With the exception of fish sampled near Wardner BC (rkm 565), relative weights in 2005 and 2006 for rainbow trout and mountain whitefish (all size classes) declined from upper to lower sites (rkm 283, 265, and 250 respectively; Table 5). Relative weight (Wr) of rainbow trout and mountain whitefish and condition factor (K) of largescale suckers was highest in 2006 for all species at both treatment locations in the upper canyon (Table 5).

Age and Growth

Mean CPUE of mountain whitefish at each age group was highest in treatment locations sampled as compared to the nontreatment sites (Table 6). Similarly, mean total length at capture was slightly higher in treated sites than nontreated (Table 7). Age two whitefish at rkm 250 represented the highest increase in CPUE (91 fish/h) following nutrient additions.

Table 3. Species sampled at Kootenai River biomonitoring sites in September 2005 and 2006 with boat electrofishing gear. I = Intolerant; T = Tolerant; S = Sensitive (describes response to habitat perturbations; Zaroban et al. 1999).

2005-2006	**Sample location**							
Species	**rkm 565**	**rkm 283**	**rkm 265**	**rkm 250**	**rkm 230**	**rkm 170**	**Feeding guild**	**Tolerance**
Brown Bullhead *Ameiurus nebulosus*						X	Invert-Piscivore	T
Brown trout *Salmo trutta*		X		X			Invert-Piscivore	I
Bull trout *Salvelinus confluentus*	X						Invert-Piscivore	S
Kokanee *Oncorhynchus nerka*	X	X	X	X	X		Invertivore	S
Largescale sucker *Catostomus macrocheilus*	X	X	X	X	X	X	Omnivore	T
Longnose dace *Rhinichthys cataractae*							Invertivore	I
Longnose sucker *Catostomus catostomus*	X		X		X	X	Invertivore	I
Mountain whitefish *Prosopium williamsoni*	X	X	X	X	X	X	Invertivore	I
Northern pikeminnow *Ptychocheilus oregonensis*	X	X	X	X	X	X	Invert-Piscivore	T
Peamouth chub *Mylocheilus caurinus*	X	X	X	X	X	X	Invertivore	I
Pumpkinseed *Lepomis gibbosus*					X		Invert-Piscivore	T
Rainbow trout *O. mykiss*	X	X	X	X	X	X	Invert-Piscivore	S
Redside shiner *Richardsonius balteatus*	X	X		X	X	X	Invertivore	I
Torrent sculpin *Cottus rhotheus*	X				X	X	Invert-Piscivore	I
Westslope cutthroat trout *O. clarkii lewisi*	X	X	X	X	X		Invert-Piscivore	S
Yellow perch *Perca flavescens*					X	X	Invert-Piscivore	I
Total number of species	11	9	8	9	12	10		

Table 4. Catch per unit of effort (CPUE; fish/h) and biomass per unit of effort (BPUE; Kg/hr) for species sampled at Kootenai River biomonitoring sites in the fall (September) from 2002 through 2006 with boat electrofishing gear. Shaded cells indicate those areas sampled upstream of the treatment influence and therefore considered control locations.

		Pre-Treatment Years			**Post-Treatment Years**	
Rkm	**Response Variable**	**2002**	**2003**	**2004**	**2005**	**2006**
565	CPUE			459	189	292
	BPUE			145	105	136
283	CPUE	144	159	158	282	340
	BPUE	35	37	41	72	66
265	CPUE	265	213	182	305	356
	BPUE	58	56	56	78	77
250	CPUE	312	267	303	287	459
	BPUE	43	53	51	63	68
230	CPUE	190	367	315	219	284
	BPUE	31	24	26	19	16
170	CPUE	210	251	341	209	418
	BPUE	18	25	19	18	40

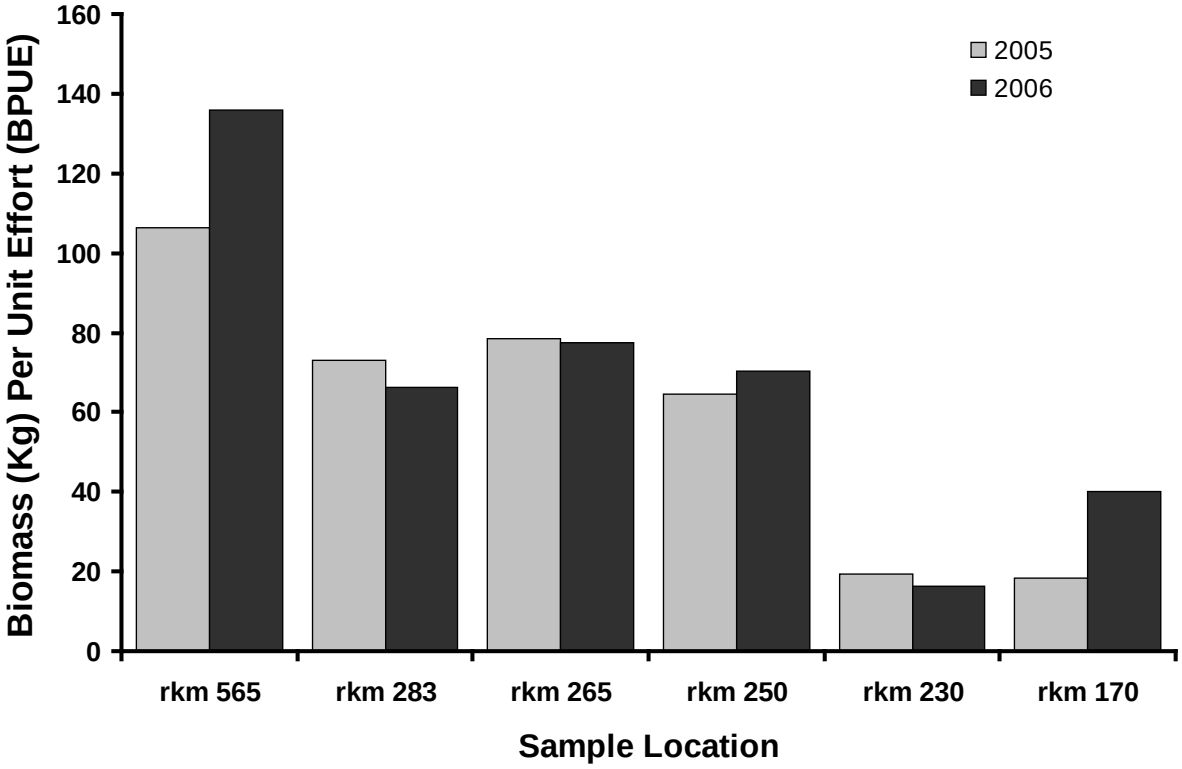

Figure 16. Total biomass per unit of effort (BPUE) for all species combined sampled with boat electrofishing gear at Kootenai River biomonitoring sites in September 2005 and 2006.

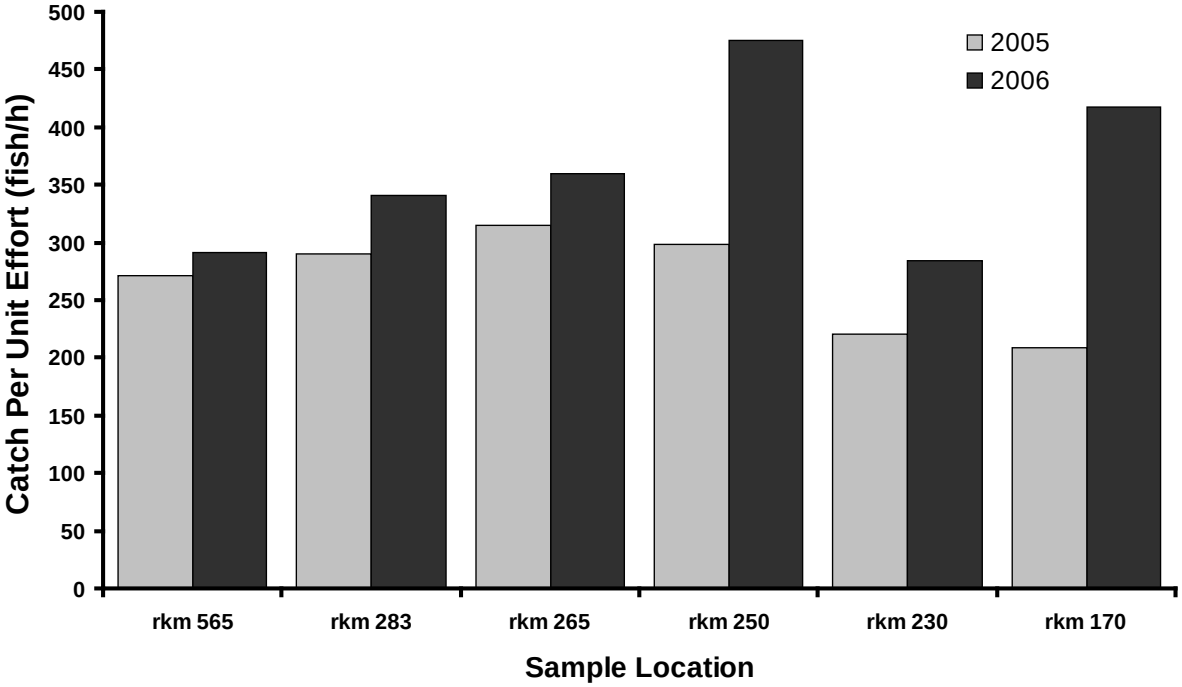

Figure 17. Total catch per unit of effort (CPUE) for all species combined sampled with boat electrofishing gear at Kootenai River biomonitoring sites in September 2005 and 2006.

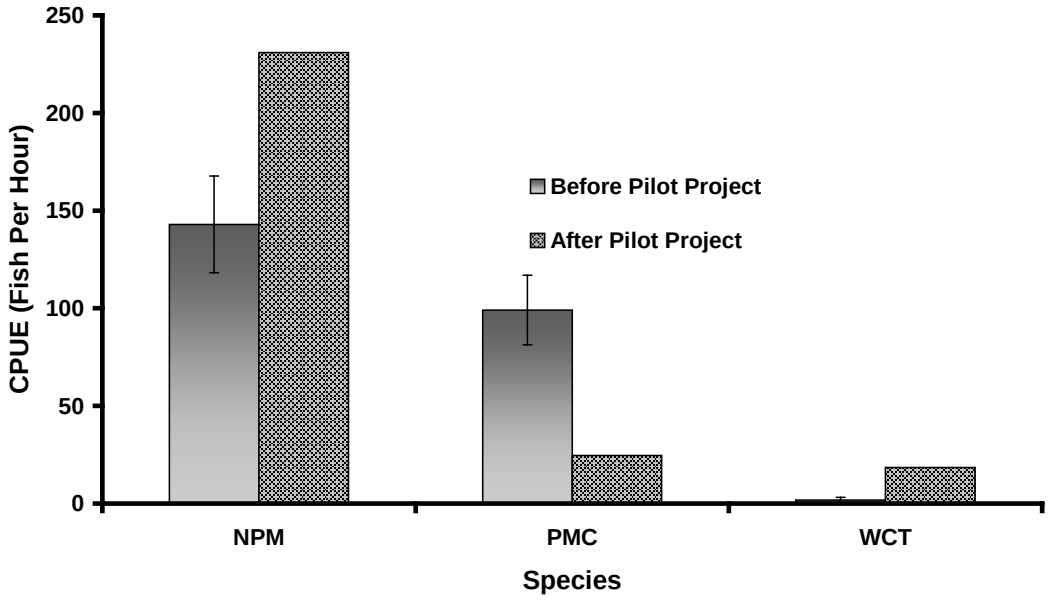

Figure 18. Mean catch per unit of effort (CPUE) for fish species sampled in the Kootenai River near Shortys Island (section 1) with boat electrofishing gear before and after the rock substrate pilot project was added (September 2006). CPUE for pre-rock placement are a mean from 2002-2005 sample years. CPUE for post -treatment represents 2006 sample year only.

Table 5. Mean relative weights (Wr) and Fulton's condition factor (K) of key species sampled at Kootenai River biomonitoring sites in September 2002-2006 with boat electrofishing gear. Shaded sections indicate nontreatment locations. SE = ± 1 standard error.

Mountain Whitefish				Largescale Sucker				Rainbow Trout			
Rkm	**Year**	**Mean Wr**	**SE**	**Site**	**Year**	**Mean K**	**SE**	**Site**	**Year**	**Mean Wr**	**SE**
565	2004	85.1	2.3	565	2004	0.98	0.03	565	2004	81.2	0.0
	2005	84.2	2.3		2005	0.86	0.02		2005	83.1	6.0
	2006	83.9	0.9		2006	0.92	0.01		2006	81.1	0.0
283	2002	92.6	2.0	283	2002	0.93	0.04	283	2002	93.2	2.0
	2003	95.4	1.8		2003	0.94	0.02		2003	93.4	1.8
	2004	91.8	0.7		2004	0.93	0.01		2004	85.6	0.4
	2005	91.6	1.3		2005	0.97	0.02		2005	89.2	1.8
	2006	89.4	0.7		2006	0.97	0.04		2006	89.7	1.6
265	2002	83.8	1.6	265	2002	0.86	0.03	265	2002	91.3	2.2
	2003	90.3	1.2		2003	0.86	0.03		2003	90.8	2.0
	2004	88.0	5.1		2004	0.86	0.01		2004	87.6	1.7
	2005	92.3	1.1		2005	0.91	0.02		2005	88.6	0.9
	2006	93.3	0.7		2006	1.03	0.03		2006	96.5	0.7
250	2002	79.1	1.1	250	2002	0.81	0.02	250	2002	86.0	3.6
	2003	82.0	4.3		2003	0.83	0.01		2003	90.0	0.0
	2004	82.2	2.1		2004	0.93	0.05		2004	84.7	1.1
	2005	79.7	1.7		2005	0.87	0.01		2005	79.1	3.8
	2006	86.4	1.0		2006	0.98	0.02		2006	91.2	2.8

Table 6. Comparison of catch per unit of effort in treated and nontreated seasons of mountain whitefish by age class. Shaded sections indicate nontreatment locations. CPUE for pre-treatment years are a mean from 2002-2003 sample years. CPUE for post treatment represents 2006 sample year only.

		CPUE at Age				
Rkm	**Treatment Years**	**0**	**1**	**2**	**3**	**4**
283	Pre	2	6	14	27	20
	Post	2	14	47	82	73
265	Pre	2	19	29	50	41
	Post	15	28	71	85	75
250	Pre	16	75	52	43	41
	Post	67	46	144	35	21

Table 7. Comparison of mean total length (TL) at time of capture in treated and nontreated seasons of mountain whitefish by age class. Shaded sections indicate nontreatment locations. CPUE for pre-treatment years are a mean from 2002-2003 sample years. CPUE for post treatment represents 2006 sample year only.

		TL (mm) at Age				
Rkm	**Treatment Years**	**0**	**1**	**2**	**3**	**4**
283	Pre	110	195	242	274	300
	Post	125	187	230	274	310
265	Pre	107	188	230	263	294
	Post	110	192	234	266	310
250	Pre	102	186	227	256	277
	Post	107	179	234	266	280

DISCUSSION

Nutrient Addition Permitting

All permitting went relatively smoothly; however, anyone attempting this type of stream restoration work with federal funds of any kind needs to anticipate a longer period of time to follow the NEPA permitting process. The permitting for this program took approximately 1.2 years for full completion, and even then, we were fortunate to operate under a short term activity exemption for the 2005 season while the final EPA NPDES permit was being finalized for the 2006 season.

Metals

Nutrient additions in the Kootenai River may have increased the aluminum and zinc concentrations when compared to ambient diluted levels; however, the increase in these metals makes up less than 0.5% following nutrient additions in the spring. This low level of increase should have little, if any, effect on increasing metals accumulation through the food web. More fish tissue sampling should be performed following a few more seasons of fertilization to accurately assess the levels of accumulation in fish flesh. Without knowing the full influence of the metals in the river, EPA requested that signs be posted at the point source of nutrient additions informing swimmers and boaters that water was not to be consumed within 200 m of the pipe when nutrients are still in the proposed mixing zone.

Nutrient Additions

The nutrient delivery system design and operation performed very well for the 2005 and 2006 season. As seen in Figures 10 and 11, the addition of the mechanical pumps installed by Ward and Associates as well as a pole-barn roof over the holding tanks (both before the 2006 season) greatly reduced oscillations in nutrient flow that were originally due to changes in viscosity (primarily caused by increases in air temperature). This reduction in flow oscillation allowed a more precise addition putting addition error at only 2% off the 3.0 µg/L target for the 2006 season. Stipulations laid out by the NPDES permit issued by the EPA allowed us to have

a river water to nutrient dilution ratio of 53 million:1. Our operation stayed well within this boundary because of the precise measuring equipment utilized.

Nitrate nitrogen in the form of 32-0-0 solution was kept on hand but not added since ambient nitrogen in the river was adequate throughout the two growing seasons to grow the proper species of algae. Following protocol described in Ashley and Stockner 2003, should ambient nitrogen have slipped below 60 µg/L nitrogen would have been added to keep the river's N:P ratio above the 20:1 level, reducing the risk of problematic algal blooms. Additional operational management details of the site are located in the Best Management Plan for Kootenai River Dosing System (2006).

Although not described in detail in this report, nutrient uptake within the first two rkms was very rapid, as indicated by low nutrient detection beyond two rkm. Although orthophosphate fell below detection limits within such a short distance, increased algal growth was seen as far as Bonners Ferry (25 rkm from the addition site; KTOI; C. Holderman personal communication). Additional results and discussion on nutrient uptake through lower trophic levels are available from KTOI; C. Holderman.

Microinvertebrate Abundance

Zooplankton densities in the upper treated reach as well as in the nontreated sample locations experienced similar declines since the start of the nutrient additions. Prior to the beginning of the experiment, the objective was to determine if nutrients could increase this level of the food web despite the population challenges in a lotic environment. The upper Kootenai River (canyon reach) zooplankton densities in 2005 and 2006 were the lowest on average recorded since this program began. In a more natural river state, zooplankton numbers would be expected to increase (at least immature stages) during the most productive months of June through August. Saunders and Lewis (1988) reported zooplankton densities fell to very low levels in the Caura River, Venezuela during peak discharges, yet densities increased sharply at the tail end of the flow in late June and early July. Much of the "true" plankton in large river systems originates in backwater sloughs, side channels, or other gently flowing areas (Hynes 1970). If the retention time of a stream or lake is short, (just as we see in the upper Kootenai River), then little plankton may develop (Hynes 1970). Seasonal fluctuations in river level regulate the development of source areas suitable for zooplankton growth and control the export of plankton from the source areas (Saunders and Lewis 1988). It is evident that nutrient additions are not increasing zooplankton numbers or species diversity. It is much more plausible at this time to relate the fluctuations in density with river discharge and zooplankton levels in Lake Koocanusa (see Paragamian 1995 for similar findings), although it is difficult to directly correlate these two factors since many other mountain lake and stream systems drain into the Kootenai after the dam and before the current sample locations.

Fish Community Assessment

Substantial changes in fish assemblages have occurred in the Kootenai River since the construction of Libby Dam (Paragamian 2002). As previously noted, it is likely that the reduction in river productivity has indirectly reduced fish numbers through lower food abundance (i.e. insect densities; for examples see Hardy 2003). With the implementation of the nutrient addition program, it was evident that the increase in just a minute amount of nutrients was sufficient to show an increase in catch and biomass of mountain whitefish in the treated reaches of the river. However, attributing the increase in mountain whitefish density exclusively to nutrients should

not be done until a few more seasons of nutrient restoration have taken place. Although it is possible that CPUE increased as a result of better overwinter survival or due to an attraction to higher food abundance, we did not expect to see an increase in density of fish until they have had a chance to spawn and fully recruit to the sampling gear (approximately 2 years of age for mountain whitefish and longer for rainbow trout). Our nontreatment location experienced similar increases in total CPUE as were seen in treated reaches. This could be indicative of strong year classes as a result of other environmental factors acting independently of nutrients.

According to Walters (2002), rainbow trout recruitment in the upper canyon reach may not be limited only by habitat but additionally by low river productivity. To date, rainbow trout in the biomonitoring locations have not shown an increase in CPUE or BPUE that could be attributed to nutrient additions. Although other factors such as reduced spawning habitat may play a role in reduced trout abundance, we anticipate an increase in rainbow trout in the next few seasons of nutrient additions to improve food, survival, and fecundity (assuming no other limiting factors preclude this from becoming evident in the data). It took several seasons of nutrient additions until an increase in density and biomass was evident in rainbow trout populations following nutrient additions to Big Silver and Adams Creek in BC, Canada (Slaney et al. 1993; Toth et al. 1993).

The decreasing catch and biomass at the Shortys Island reach is primarily attributable to an increase in aquatic macrophyte production. Although fish were presumed present (due to the obvious water disruption when during sampling), it is becoming increasingly difficult to capture fish because the surface water is covered by a thick layer of macrophytes (such as sago pondweed Potamogeton pectinatus), making netting difficult. This was confirmed when comparing the CPUE of one section that the USACE placed rock structures for sturgeon spawning in 2006—the catch of northern pikeminnow and cutthroat trout increased while densities of peamouth decreased. It is presumed that a combination of increased netting efficiency (with no macrophyte growth established), and the attraction of these species to this particular substrate caused the increases in CPUE.

Relative weight of trout and mountain whitefish, as well as condition of largescale sucker populations, showed a substantial increase in the 2006 season 20 rkm below the treatment location. Although these measures were still at relatively suboptimal levels in relation to other populations, we expect these to continue to increase with continued nutrient additions in the future. Low relative weights may be indicative of a paucity of suitable prey items (Blackwell et al. 2000). In contrast, fish in relatively good condition should be able to utilize more energy for gamete production than fish that are in poor condition. Significant positive correlations between the percentage of mature eggs and fish biomass and Wr have been reported in numerous studies (Wege and Anderson 1978; Neumann and Murphy 1992; Neumann and Willis 1995). The low numbers of rainbow trout in samples may not allow us to draw any substantial conclusions about their relative weight; however, we speculate that the same factors driving body growth for the other fishes are influencing rainbow trout as well at this time.

Mean length at age of capture showed that there was a notable increase in mean length pre- vs. post treatment at both 10 rkm and 20 rkm below the treatment locations. In addition to this, CPUE by age group shows that in 2006 there was a significant increase in the number of two-year-old fish in the catch (especially 20 rkm below [rkm 250] the treatment location). Although we do not expect a density increase in two-year-old fish until 2007, it is quite possible that nutrients will have increased overwinter survival of young of year whitefish already in the system at the time of fertilization. The comparison of age and growth data for mountain whitefish was similar to that reported by Walters (2002). Mean whitefish ages reported in 1980, 1981, and

1982 by Partridge (1983) were higher on average, giving some indication of the reduction in productivity of the lower river over the last two decades. Length at age data for rainbow trout from the past decade appears to be consistent between years. However, with no data available for years before or near the construction of Libby Dam, we are left speculating on what adequate length-at-age should be for fish in the Kootenai River. Bennett and Underwood (1988) reported substantially higher growth of rainbow trout in the Spokane River than our calculations for trout in the Kootenai. Mean age-1 fish ranged from 134-153 mm, whereas mean age-1 fish in the Kootenai ranged from 89-101 mm. Similar differences were also reported by Paragamian (1995). This information coincides with relative system productivity: the Spokane River has exhibited macroinvertebrate densities as high as 60,000 insects/ m^2 (Kadlec 2000) as compared to the Kootenai River's 900 insects/m^2 most recently reported by Holderman and Hardy (2004).

As an agency, IDFG is very interested in how nutrient additions are making fishing better for the public. In order to assess fully how this program is accomplishing this task, it will be necessary in the near future to develop evaluation criteria that specifically targets angler catch rates of game fish (rainbow and cutthroat trout and mountain whitefish) based on the needs and desires of the public as well. A full evaluation of these measures, as well as desired CPUE by species, will allow biologists to determine the success of the experiment from a social as well as a biological standpoint. In order to develop these sociological criteria fully, a full assessment of what is known about trout catch rates on the Kootenai River must be discussed. Trout (rainbow and westslope cutthroat) angler catch rates for the Kootenai River, Idaho were 0.06, 0.03, 0.21, and 0.14 fish/h in 1982, 1993, 2001, and 2002, respectively (Partridge 1983; Paragamian 1995; Walters 2003; IDFG unpublished data). These rates are low when compared to the Kootenai River, Montana where trout catch rates of 0.36 to 0.48 fish/h were reported for 1978 and 1979 respectively, the most recent year-round creel data for Montana (May and Huston 1983). Catch rates in other north Idaho streams included 0.73 trout/h and 0.55 trout/h in the N. Fork Coeur d'Alene River in 1992 and 1996, respectively; 0.89 trout/h in the St. Joe River in 1996 (Fredericks et al. 1997); and 0.3 trout/h in the Spokane River. Schill (1991) summarized statewide trout fishery statistics for Idaho and reported trout catch rates of 0.7, 0.95, and 1.18 fish/h (average = 0.94 fish/h) for streams with "General" trout regulations. Considering differences in stream productivity, angler expectations, and other attributes that affect anglers' satisfaction of their fishing experience (e.g., aesthetics of the stream and surroundings, uncrowded fishing conditions), it is subjective to determine a target catch rate for the Kootenai River, Idaho. However, Varley (1984) reported that a majority (about 60%) of anglers in Yellowstone National Park were satisfied with their fishing trip after catching two trout. Based on the average trip length (3 h) on the Kootenai River, Idaho, a catch rate of 0.67 trout/h would result in the typical angler catching two trout per trip. This rate also falls within the range of other north Idaho stream trout fisheries. Catch rates of 0.34 trout/h would result in the average angler catching one trout/fishing trip, and would be more comparable to the catch rates reported for Montana. Therefore, I propose a catch rate target range of 0.34-0.67 trout/h for the Kootenai River, Idaho.

Prior to nutrient restoration of the Kootenai River, the largest river that has been intentionally fertilized was the Mesilinka River in BC, which typically had flows of 30-60 m^3/s during nutrient addition. The Kootenai River has a 4-6 fold greater weekly discharge than the Mesilinka River, ranging from 200-400 m^3/s during the growing season. Thus, the Kootenai River is the largest river in the world to have nutrients intentionally added for restoring fish populations, and the only river in the lower U.S. to be involved in such a program. Restoring nutrients to a river of this magnitude requires special considerations. One concern prior to this experiment was that orthophosphate would be utilized within a very short distance of the river (<5 rkm), and positive effects would be limited. It is our current assessment that shows positive effects ranged as far downstream as Bonners Ferry (approx. 22 rkm below the treatment location). The KTOI

and IDFG will continue to work directly with nutrient restoration experts (e.g., Ken Ashley, BCME) and other ecologists on the International Kootenai River Ecosystem Recovery Team (IKERT) to determine the exact formulation of nutrients needed to achieve the set objectives.

RECOMMENDATIONS

1. Continue adding nutrients in the form of liquid N and P fertilizer at the concentration of 3 µg/L to restore river productivity.

2. Further development of fisheries evaluation criteria to determine success of nutrient additions.

3. Perform additional creel surveys on the Kootenai River in the future to assess how nutrient addition is indirectly affecting angler catch rates.

4. Discontinue zooplankton sampling for density and abundance due to no effect from nutrient additions.

ACKNOWLEDGEMENTS

Thanks go to the following people that took part in all of the sampling effort: C. Holderman and crew (KTOI); G. Hoyle (KTOI); J. Dunnigan and crew (MFWP); J. Walters, P. Rust, C. Laude, Kirk Handley (IDFG); G. Hoffman (ACOE). Thanks to B. High, G. Hoffman, D. Schill, and V. L. Paragamian for the reviewed drafts of this report. Finally, thanks goes to V. L. Paragamian for continued guidance and C. Leben (IDFG) for preparing the report for printing.

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APPENDICES

Appendix A. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2002 during boat electrofishing at rkm 170–283 and electrofishing. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, BRNT = brown trout, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch.

Site	Species	Count	% of total	CPUE	Kg	% of total	BPUE	Mean Wt	Effort
283	BLT	2	1.06	1.53	5.13	11.23	3.92	2563	1.31
	LSS	33	17.46	25.21	19.54	42.81	14.92	592	1.31
	MWF	93	49.21	71.04	15.18	33.26	11.60	163	1.31
	NPM	9	4.76	6.87	0.72	1.58	0.55	80	1.31
	PMC	2	1.06	1.53	0.28	0.62	0.22	142	1.31
	RBT	24	12.70	18.33	4.18	9.15	3.19	174	1.31
	RSS	25	13.23	19.10	0.37	0.81	0.28	15	1.31
	WCT	1	0.53	0.76	0.24	0.53	0.18	240	1.31
	Grand Total	**189**	**100**	**144**	**46**	**100.00**	**35**		**1.31**
265	LSS	28	14.66	39	15.42	36.96	21.35	551	0.72
	MWF	132	69.11	183	20.38	48.87	28.23	154	0.72
	NPM	10	5.24	14	4.71	11.29	6.52	470	0.72
	RBT	7	3.66	10	0.89	2.13	1.23	127	0.72
	RSS	12	6.28	17	0.12	0.29	0.17	10	0.72
	SCULPIN	1	0.52	1	0.00	0.01	0.00	3	0.72
	WCT	1	0.52	1	0.19	0.44	0.26	185	0.72
	Grand Total	**191**	**100**	**265**	**42**	**100**	**58**		**0.72**
250	BRNT	1	0.37	1.24	0.05	0.17	0.07	54	0.73
	LSS	16	5.88	18.91	8.93	27.44	12.25	558	0.73
	LND	1	0.37	1.15	0.00	0.00	0.00	1	0.73
	LNS	1	0.37	0.00	0.27	0.81	0.36	265	0.73
	MWF	219	80.51	251.05	18.67	57.39	25.61	85	0.73
	NPM	6	2.21	7.52	1.45	4.46	1.99	241	0.73
	PMC	4	1.47	4.55	0.78	2.41	1.08	196	0.73
	RBT	15	5.51	17.26	1.86	5.73	2.56	124	0.73
	RSS	8	2.94	9.58	0.07	0.20	0.09	8	0.73
	WCT	1	0.37	1.09	0.45	1.39	0.62	452	0.73
	Grand Total	**272**	**100**	**312**	**33**	**100**	**43**		**0.73**
230	LSS	75	23.58	44.87	37.64	74.39	22.46	502	1.67
	LNS	4	1.26	2.39	1.90	3.75	0.53	475	1.67
	MWF	3	0.94	1.79	0.12	0.24	0.07	40	1.67
	NPM	93	29.25	55.64	2.06	4.07	1.23	22	1.67
	PMC	77	24.21	46.07	7.73	15.28	5.74	100	1.67
	RBT	6	1.89	3.59	0.72	1.41	0.43	119	1.67
	RSS	59	18.55	35.30	0.35	0.70	0.18	6	1.67
	YP	1	0.31	0.60	0.08	0.16	0.05	79	1.67
	Grand Total	**318**	**100**	**190**	**51**	**100**	**31**		**1.67**
170	LSS	41	12.77	26.83	21.03	75.38	13.76	513	1.53
	LNS	3	0.93	1.96	0.23	0.81	0.15	76	1.53
	MWF	4	1.25	2.62	0.06	0.22	0.04	15	1.53
	NPM	146	45.48	95.53	4.13	14.80	2.70	28	1.53
	PMC	29	9.03	18.97	1.86	6.65	1.21	64	1.53
	RBT	93	28.97	60.85	0.56	2.02	0.37	6	1.53
	SCULPIN	3	0.93	1.96	0.02	0.07	0.01	6	1.53
	WCT	2	0.62	1.31	0.01	0.05	0.01	7	1.53
	Grand Total	**321**	**100**	**210**	**28**	**100**	**18**		**1.53**

Appendix B. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2003 during boat electrofishing at rkm 170—283. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch.

RKM	Species	Count	% of total	CPUE	Kg	% of total	BPUE	Mean Wt	Effort
283	BLT	1.00	0.41	0.66	4.75	8.52	3.13	4750	1.52
	LNS	6.00	2.48	3.95	0.68	1.22	0.45	114	1.52
	LSS	35.00	14.46	23.03	16.76	30.05	11.03	479	1.52
	MWF	128.00	52.89	84.21	24.20	43.39	15.92	189	1.52
	NPM	14.00	5.79	9.21	1.54	2.75	1.01	110	1.52
	RBT	31.00	12.81	20.39	6.47	11.60	4.25	209	1.52
	RSS	25.00	10.33	16.45	0.34	0.60	0.22	13	1.52
	WCT	2.00	0.83	1.32	1.05	1.88	0.69	523	1.52
	Grand Total	**242**	**100**	**159**	**56**	**100**	**37**		**1.52**
265	LSS	22.00	13.17	28.02	18.18	41.64	23.15	826	0.79
	MWF	107.00	64.07	136.26	16.30	37.33	20.76	152	0.79
	NPM	8.00	4.79	10.19	2.86	6.55	3.64	358	0.79
	PEA	2.00	1.20	2.55	0.22	0.51	0.29	112	0.79
	RBT	20.00	11.98	25.47	6.02	13.78	7.66	301	0.79
	RSS	8.00	4.79	10.19	0.08	0.19	0.10	10	0.79
	Grand Total	**167.00**	**100.00**	**212.66**	**43.66**	**100.00**	**55.60**		**0.79**
250	LSS	18.00	10.91	29.10	14.53	44.48	23.49	807	0.62
	MWF	139.00	84.24	224.70	15.49	47.41	25.04	114	0.62
	NPM	6.00	3.64	9.70	2.59	7.93	4.19	432	0.62
	RBT	1.00	0.61	1.62	0.05	0.15	0.08	50	0.62
	RSS	1.00	0.61	1.62	0.01	0.02	0.01	8	0.62
	Grand Total	**165**	**100**	**267**	**33**	**100**	**53**		**0.62**
230	BLT	1.00	0.20	0.72	0.07	0.20	0.05	67	1.39
	LNS	13.00	2.55	9.36	2.37	7.20	1.71	183	1.39
	LSS	74.00	14.51	53.26	15.72	47.68	11.31	212	1.39
	MWF	28.00	5.49	20.15	0.37	1.11	0.26	13	1.39
	NPM	196.00	38.43	141.06	6.78	20.57	4.88	35	1.39
	PEA	97.00	19.02	69.81	5.45	16.53	3.92	56	1.39
	PMS	2.00	0.39	1.44	0.02	0.07	0.02	11	1.39
	RBT	2.00	0.39	1.44	0.20	0.59	0.14	98	1.39
	RSS	92.00	18.04	66.21	0.80	2.42	0.58	9	1.39
	SCULPIN	1.00	0.20	0.72	0.00	0.01	0.00	4	1.39
	WCT	3.00	0.59	2.16	1.17	3.55	0.84	390	1.39
	YP	1.00	0.20	0.72	0.02	0.05	0.01	17	1.39
	Grand Total	**510**	**100**	367	**33**	**100**	**24**		**1.39**
170	LNS	6.00	1.54	3.87	0.74	1.88	0.48	123	1.55
	LSS	37.00	9.51	23.88	23.23	59.16	15.00	628	1.55
	NPM	202.00	51.93	130.39	8.37	21.32	5.40	41	1.55
	PEA	82.00	21.08	52.93	6.24	15.89	4.03	76	1.55
	RSS	59.00	15.17	38.08	0.61	1.54	0.39	10	1.55
	SCULPIN	1.00	0.26	0.65	0.01	0.02	0.00	7	1.55
	Y.PERCH	2.00	0.51	1.29	0.08	0.20	0.05	40	1.55
	Grand Total	**389**	**100**	**251**	**39**	**100**	**25**		**1.55**

Appendix C. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2004 during boat electrofishing at rkm 170—283. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch.

RKM	Species	Count	% of total	CPUE (hr)	Kg	BPUE (hr)	% of total	Mean Wt (g)	Effort (h)
565	BLT	5	1.36	6.26	9.19	11.49	7.92	1837	0.80
	LND	1	0.27	1.25	0.00	0.00	0.00	1	0.80
	LNS	4	1.09	5.01	2.06	2.57	1.77	514	0.80
	LSS	83	22.62	103.86	65.82	82.36	56.78	793	0.80
	MWF	260	70.84	325.34	36.63	45.84	31.60	141	0.80
	NPM	5	1.36	6.26	0.98	1.23	0.85	196	0.80
	RBT	1	0.27	1.25	0.13	0.16	0.11	126	0.80
	RSS	3	0.82	3.75	0.03	0.04	0.03	10	0.80
	SCULPIN	1	0.27	1.25	0.01	0.01	0.01	11	0.80
	WCT	4	1.09	5.01	1.08	1.36	0.93	271	0.80
	Grand Total	**367**	**100.00**	**459.23**	**115.92**	**145.06**	**100.00**		0.80
283	LSS	18	9.68	15.30	14.88	12.65	31.09	827	1.18
	MWF	115	61.83	97.78	22.67	19.27	47.37	197	1.18
	NPM	11	5.91	9.35	1.60	1.36	3.35	146	1.18
	PMC	10	5.38	8.50	1.23	1.05	2.58	123	1.18
	RBT	29	15.59	24.66	7.25	6.17	15.16	250	1.18
	RSS	2	1.08	1.70	0.05	0.04	0.09	23	1.18
	WCT	1	0.54	0.85	0.17	0.15	0.36	173	1.18
	Grand Total	**186**	**100.00**	**158.15**	**47.85**	**40.69**	**100.00**		1.18
265	LSS	29	22.31	40.69	23.92	33.56	59.69	825	0.71
	MWF	72	55.38	101.01	9.75	13.68	24.33	135	0.71
	NPM	4	3.08	5.61	0.74	1.04	1.85	186	0.71
	RBT	23	17.69	32.27	5.05	7.08	12.60	219	0.71
	RSS	1	0.77	1.40	0.00	0.00	0.01	3	0.71
	WCT	1	0.77	1.40	0.61	0.85	1.52	608	0.71
	Grand Total	**130**	**100.00**	**182.39**	**40.07**	**56.22**	**100.00**		0.71
250	LSS	11	5.42	16.41	8.16	12.17	23.79	742	0.67
	MWF	159	78.33	237.22	19.10	28.49	55.67	120	0.67
	NPM	6	2.96	8.95	4.23	6.31	12.33	705	0.67
	RBT	18	8.87	26.85	2.55	3.80	7.43	142	0.67
	RSS	8	3.94	11.94	0.08	0.12	0.23	10	0.67
	WCT	1	0.49	1.49	0.19	0.28	0.54	186	0.67
	Grand Total	**203**	**100.00**	**302.86**	**34.31**	**51.18**	**100.00**		0.67
230	LNS	1	0.28	0.87	0.46	0.40	1.52	464	1.15
	LSS	25	6.89	21.67	11.70	10.14	38.32	468	1.15
	MWF	39	10.74	33.80	1.10	0.95	3.59	28	1.15
	NPM	123	33.88	106.60	5.27	4.57	17.27	43	1.15
	PMC	138	38.02	119.60	9.87	8.56	32.35	72	1.15
	RBT	6	1.65	5.20	0.91	0.79	2.99	152	1.15
	RSS	28	7.71	24.27	0.26	0.23	0.86	9	1.15
	WCT	2	0.55	1.73	0.93	0.81	3.06	467	1.15
	YP	1	0.28	0.87	0.01	0.01	0.04	13	1.15
	Grand Total	**363.00**	**100.00**	**314.59**	**30.52**	**26.45**	**100.00**		1.15
170	BULLHEAD	1	0.22	0.74	0.13	0.10	0.50	129	1.35
	LNS	2	0.43	1.48	0.28	0.21	1.08	139	1.35
	LSS	19	4.11	14.03	8.23	6.08	32.10	433	1.35

Appendix C Continued.

RKM	Species	Count	% of total	CPUE (hr)	Kg	BPUE (hr)	% of total	Mean Wt (g)	Effort (h)
	MWF	18	3.90	13.29	0.61	0.45	2.38	34	1.35
	NPM	114	24.68	84.15	4.48	3.30	17.46	39	1.35
	PMC	212	45.89	156.49	10.64	7.85	41.49	50	1.35
	RBT	1	0.22	0.74	0.36	0.27	1.41	362	1.35
	RSS	94	20.35	69.39	0.91	0.67	3.55	10	1.35
	SCULPIN	1	0.22	0.74	0.01	0.00	0.02	5	1.35
	Grand Total	**462**	**100.00**	**341.03**	**25.64**	**18.92**	**100.00**		1.35

Appendix D. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2005 during boat electrofishing at rkm 170—283. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, BRNT = brown trout, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch.

RKM	Species	Count	% of total	CPUE	Kg	BPUE	% of total	Mean Wt	Effort
565	BLT	6	4.17	7.89	14.03	18.46	17.59	2339	0.76
	LNS	4	2.78	5.26	2.58	3.39	3.23	645	0.76
	LSS	57	39.58	75.00	48.87	64.30	61.26	857	0.76
	MWF	71	49.31	93.42	12.31	16.20	15.43	173	0.76
	RBT	5	3.47	6.58	1.98	2.60	2.48	395	0.76
	Sculpin	1	0.69	1.32	0.01	0.01	0.01	6	0.76
	Grand Total	**144**	**100.00**	**189.474**	**79.775**	**104.97**	**100.00**		**0.76**
283	BRNT	1	0.32	0.90	0.20	0.18	0.24	196	1.112
	LSS	51	16.24	45.88	32.81	29.51	40.89	643	1.112
	MWF	211	67.20	189.81	37.51	33.74	46.75	178	1.112
	NPM	7	2.23	6.30	1.81	1.63	2.26	259	1.112
	PMC	4	1.27	3.60	0.50	0.45	0.62	125	1.112
	RBT	36	11.46	32.38	6.72	6.04	8.38	187	1.11
	RSS	2	0.64	1.80	0.03	0.03	0.04	17	1.11
	WCT	2	0.64	1.80	0.65	0.59	0.81	327	1.11
	Grand Total	**314**	**100.00**	**282.459**	**80.228**	**72.17**	**100.00**		1.11
265	LNS	1	0.48	1.45	0.46	0.66	0.85	456	0.69
	LSS	21	10.00	30.51	16.24	23.60	30.43	773	0.69
	MWF	165	78.57	239.71	31.45	45.69	58.92	191	0.69
	NPM	4	1.90	5.81	0.80	1.16	1.49	199	0.69
	PMC	4	1.90	5.81	0.52	0.76	0.98	130	0.69
	RBT	15	7.14	21.79	3.91	5.68	7.33	261	0.69
	Grand Total	**210**	**100.00**	**305.085**	**53.38**	**77.55**	**100.00**		0.69
250	LSS	24	13.11	37.62	20.42	32.01	50.64	851	0.64
	MWF	152	83.06	238.24	18.32	28.71	45.42	120	0.64
	NPM	3	1.64	4.70	0.79	1.23	1.95	262	0.64
	RBT	4	2.19	6.27	0.80	1.26	1.99	201	0.64
	Grand Total	**183**	**100.00**	**286.83**	**40.33**	**63.21**	**100.00**		**0.64**
230	LNS	6	1.83	4.02	3.29	2.21	11.33	549	1.49
	LSS	30	9.17	20.12	13.77	9.24	47.41	459	1.49
	MWF	23	7.03	15.43	0.74	0.49	2.54	32	1.49
	NPM	91	27.83	61.03	3.86	2.59	13.29	42	1.49
	PMC	73	22.32	48.96	4.80	3.22	16.52	66	1.49
	PS	2	0.61	1.34	0.01	0.01	0.03	3	1.49
	RBT	12	3.67	8.05	1.44	0.97	4.96	120	1.49
	RSS	85	25.99	57.01	0.49	0.33	1.69	6	1.49
	SCULP	1	0.31	0.67	0.01	0.00	0.02	5	1.49
	WCT	4	1.22	2.68	0.64	0.43	2.21	160	1.49
	Grand Total	**327**	**100.00**	**219.32**	**29.05**	**19.48**	**100.00**		**1.49**
170	BULLHEAD	2	0.53	1.11	0.21	0.12	0.65	107	1.80
	LSS	33	8.75	18.29	21.91	12.14	66.90	664	1.80
	MWF	9	2.39	4.99	0.22	0.12	0.67	24	1.80
	NPM	110	29.18	60.98	4.01	2.22	12.25	36	1.80
	PMC	100	26.53	55.43	5.10	2.82	15.56	51	1.80
	RBT	5	1.33	2.77	0.52	0.29	1.59	104	1.80
	RSS	113	29.97	62.64	0.75	0.42	2.29	7	1.80
	SCULP	5	1.33	2.77	0.03	0.02	0.09	6	1.80
	Grand Total	**377**	**100.00**	**208.98**	**32.75**	**18.15**	**100.00**		**1.80**

Appendix E. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2006 during boat electrofishing at rkm 170—283. BLT = bull trout; LND = longnose dace; LNS = longnose sucker, LSS = largescale sucker, BRNT = brown trout, MWF = mountain whitefish, NPM = northern pikeminnow, PMC = peamouth chub, RBT = rainbow trout, RSS = redside shiner, WCT = westslope cutthroat trout, YP = yellow perch.

RKM	Species	Count	% of total	CPUE	Kg	%of total	BPUE	Mean Wt	Effort
565	BLT	4	2.07	6.04	7.63	8.48	11.53	1908	0.66
	LNS	6	3.11	9.06	4.09	4.54	6.17	681	0.66
	LSS	76	39.38	114.81	58.81	65.36	88.84	774	0.66
	MWF	96	49.74	145.03	17.35	19.29	26.21	181	0.66
	NPM	4	2.07	6.04	1.51	1.68	2.29	378	0.66
	PMC	1	0.52	1.51	0.07	0.08	0.11	70	0.66
	RBT	1	0.52	1.51	0.13	0.15	0.20	134	0.66
	RSS	4	2.07	6.04	0.07	0.07	0.10	16	0.66
	WCT	1	0.52	1.51	0.32	0.35	0.48	317	0.66
	Grand Total	**193**	**100.00**	**292**	**90**	**100**	**136**		**0.66**
283	BRNT	1	0.31	1.06	0.33	0.53	0.35	329	0.94
	LSS	14	4.38	14.89	9.21	14.76	9.80	658	0.94
	MWF	234	73.13	248.86	40.74	65.27	43.33	174	0.94
	NPM	6	1.88	6.38	0.91	1.46	0.97	152	0.94
	RBT	60	18.75	63.81	10.53	16.86	11.19	175	0.94
	RSS	2	0.63	2.13	0.03	0.05	0.04	17	0.94
	WCT	3	0.94	3.19	0.66	1.06	0.71	221	0.94
	Grand Total	**320**	**100.00**	**340.32**	**62.42**	**100.00**	**66.38**		**0.94**
265	LSS	25	9.73	34.66	21.81	39.22	30.23	872	0.72
	MWF	213	82.88	295.26	30.77	55.34	42.65	145	0.72
	NPM	6	2.33	8.32	0.71	1.27	0.98	118	0.72
	RBT	13	5.06	18.02	2.32	4.17	3.22	178	0.72
	Grand Total	**257**	**100.00**	**356.257**	**55.6**	**100**	**77.07**		**0.72**
250	BNT	1	0.30	1.39	0.16	0.33	0.22	160	0.72
	LSS	34	10.33	47.39	23.00	47.48	32.06	676	0.72
	MWF	247	75.08	344.25	19.74	40.74	27.51	80	0.72
	NPM	19	5.78	26.48	2.15	4.44	3.00	113	0.72
	PMC	1	0.30	1.39	0.04	0.08	0.06	41	0.72
	RBT	22	6.69	30.66	3.27	6.76	4.56	149	0.72
	RSS	5	1.52	6.97	0.08	0.16	0.11	16	0.72
	Grand Total	**329**	**100.00**	**458.537**	**48.443**	**100**	**67.52**		**0.72**
230	LNS	6	1.36	3.88	1.57	6.19	1.02	262	1.55
	LSS	27	6.14	17.44	10.59	41.66	6.84	392	1.55
	MWF	61	13.86	39.40	0.66	2.59	0.42	11	1.55
	NPM	206	46.82	133.02	5.69	22.39	3.67	28	1.55
	PMC	52	11.82	33.57	4.57	18.00	2.95	88	1.55
	PSS	6	1.36	3.87	0.10	0.38	0.06	16	1.55
	RBT	9	2.05	5.81	1.62	6.38	1.05	180	1.55
	RSS	66	15.00	42.58	0.57	2.24	0.37	9	1.55
	Sculpin	6	1.36	3.87	0.04	0.15	0.02	6	1.55
	YP	1	0.23	0.65	0.01	0.02	0.00	5	1.55
	Grand Total	**440**	**100.00**	**283.820**	**25.41**	**100**	**16.39**		**1.55**
170	BULLHEAD	1	0.16	0.66	0.16	0.26	0.11	163	1.52
	LSS	72	11.30	47.26	49.36	80.11	32.39	686	1.52
	LNS	1	0.16	0.66	0.07	0.11	0.05	70	1.52
	MWF	2	0.31	1.31	0.02	0.03	0.01	9	1.52

Appendix E. Continued.

RKM	Species	Count	% of total	CPUE	Kg	%of total	BPUE	Mean Wt	Effort
	NPM	284	44.58	186.40	6.64	10.78	4.36	23	1.52
	PMC	49	7.69	32.16	3.49	5.66	2.29	71	1.52
	RBT	2	0.31	1.31	0.22	0.35	0.14	108	1.52
	RSS	215	33.75	141.11	1.47	2.38	0.96	7	1.52
	Sculpin	4	0.63	2.63	0.03	0.04	0.02	6	1.52
	YP	7	1.10	4.59	0.16	0.26	0.11	23	1.52
	Grand Total	**637**	**100.00**	**418.086**	**61.609**	**100**	**40.44**		**1.52**

Prepared by:

Ryan S. Hardy
Senior Fishery Research Biologist

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

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Ed Schriever, Chief
Bureau of Fisheries

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Daniel J. Schill
Fisheries Research Manager