PACIFIC GAS AND ELECTRIC COMPANY

Pit 1 Hydroelectric Project
FERC Project No. 2687

Pit 1 Project 2009 Macroinvertebrate Study

July 2010

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Pit 1 Project 2009 Macroinvertebrate Study

Pit 1 Project (FERC No. 2687)

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1.0 Introduction

On 13 March 2003, the Federal Energy Regulatory Commission (FERC) renewed the license for Pacific Gas and Electric Company's (PG&E) Pit 1 Hydroelectric Project (FERC No. 2687). The 2003 license and State Water Resources Control Board (SWRCB) 401 Water Quality Certification (401 Certification) stipulate terms and conditions, including requirements for minimum instream flow releases and flushing flows. SWRCB 401 Certification Condition 16 requires water quality monitoring to determine the benefits/effects on water quality of required flow releases. Pursuant to SWRCB 401 Certification Condition 17, PG&E met with SWRCB and other regulatory agency staff on 11 May 2009 to review the results of five years of water quality monitoring (PG&E 2009). During this meeting, the Regional Water Quality Control Board requested a study to compare macroinvertebrate communities in the Pit 1 Bypass Reach before and after implementation of the new license-required flow regime. A study was implemented in 2009, utilizing methods consistent with a 1991-1992 (pre-license) study (McElravy 1993). This report presents the methods and results of the 2009 study and compares them to the results of the 1991-1992 study.

1.1 Regional Setting

The Pit 1 Hydroelectric Project (Project) is located in northeastern Shasta County, California (Figure 1.1). The Pit River is the only major river that drains the Modoc Plateau, which is an immense lava field covering most of northeastern California bordered on the west by the Cascade Range, to the south by the Sierra Nevada, and to the east by the Basin and Range geomorphic provinces (Norris and Webb 1990). At the transition between the northern Sierra Nevada and southern Cascade ranges, the Pit 1 Project is located at the southwestern edge of the Modoc Plateau. To generate electricity, the Project diverts much of the Fall River at the Pit 1 Forebay through a tunnel to the Pit 1 Powerhouse, which is located 6.6 miles (10.6 km) downstream of the confluence of the Pit and Fall rivers. The Pit 1 Bypass Reach includes 0.9 miles (1.5 km) of the lower Fall River to its confluence with the Pit River and 6.6 miles (10.6 km) of the Pit River downstream to the Pit 1 Powerhouse tailrace. Flows in the Pit River between the Pit 1 Powerhouse tailrace and Lake Britton fluctuate with powerhouse operations, but have a license-required minimum instream flow of 700 cubic feet per second (cfs) and power

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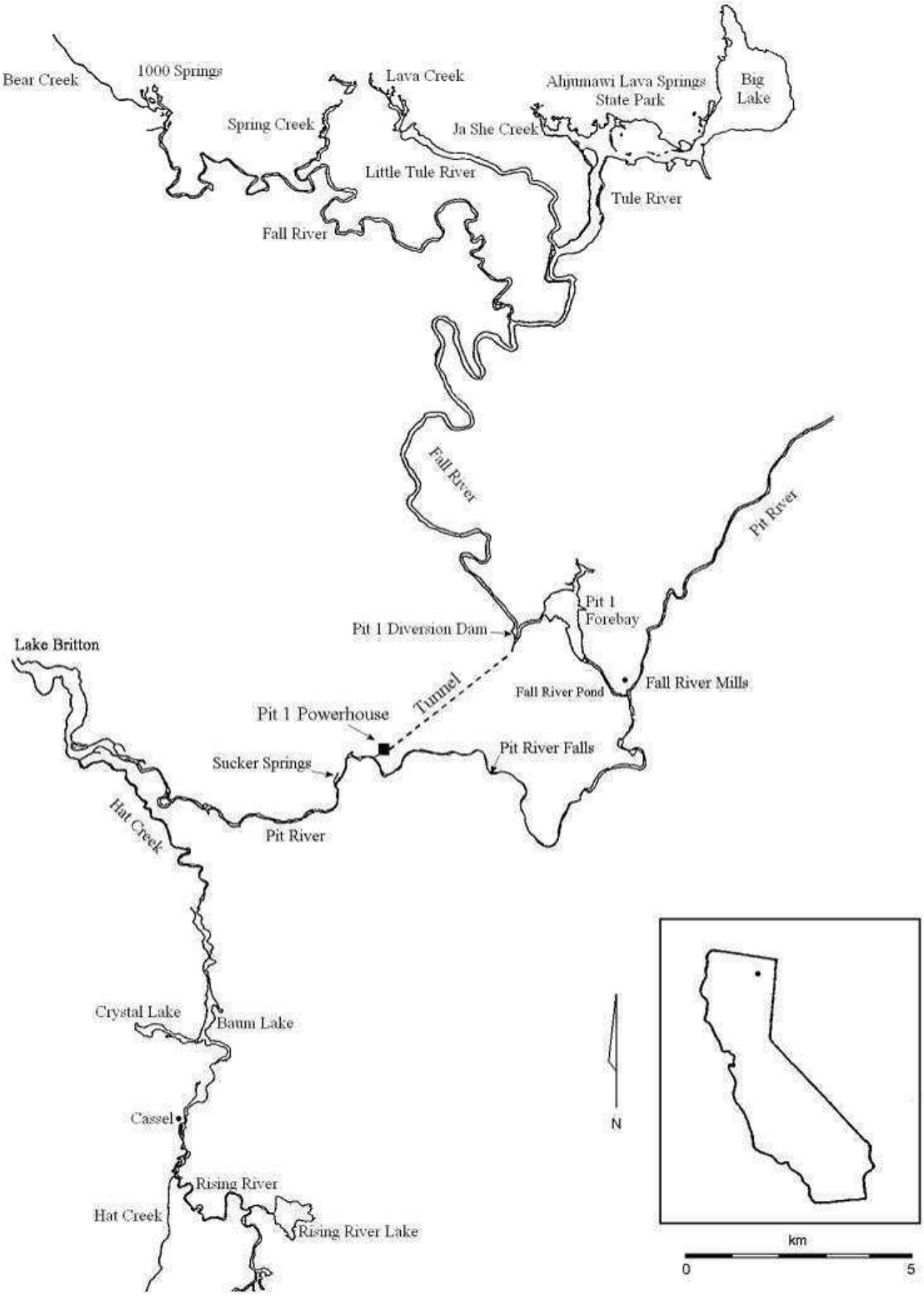

Figure 1.1 Pit 1 Project (FERC No. 2687) vicinity.

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generation must adhere to license-required ramping rates. Consequently, the amount of flow fluctuation in the Pit River downstream of the tailrace is reduced relative to previous license operations. This study focused on sections of the Pit River just upstream and downstream of the Pit 1 Powerhouse tailrace.

1.2 License Conditions

License Article 403 and SWRCB 401 Certification Condition 8 require PG&E to make continuous flow releases from the Pit 1 Forebay into the lower Fall River thence the Pit River (i.e., Pit 1 Bypass Reach) to maintain the following minimum instantaneous flows downstream of the Fall River Pond as measured at the Fall River Weir: 75 cfs from November 1 to November 15; 50 cfs from November 16 to May 15; 75 cfs from May 16 to May 31; and 150 cfs from June 1 to October 31. SWRCB 401 Certification Condition 13 requires PG&E to control surface aquatic vegetation and mosquito production in Fall River Pond by providing flushing flows for two consecutive weekend days, three times per year in May/June, July, and late August prior to Labor Day weekend. Condition 13 sets the magnitude of the flushing flows at 1250 cfs or the natural flow into the Pit 1 Forebay, whichever is less.

Prior to the 2003 license, there was no release from the Pit 1 Forebay into the Pit 1 Bypass Reach under the previous license, although there was some minor leakage through the Fall River Weir. There were no regularly scheduled flushing flows prior to the 2003 license either, although nine flushing flows were recorded from 1994 through 2002 (PG&E 2010).

Article 402 of the license requires PG&E to provide flows through the Pit 1 Powerhouse to the Project tailrace such that the total instantaneous flow in the Pit River downstream of the Project tailrace is a minimum of 700 cfs or greater, as measured at the U.S. Geological Survey (USGS) gage 11-3550.10 located downstream of the tailrace.

Prior to the 2003 license, the Pit 1 Powerhouse was typically operated on a block-loaded, peaking basis with flows downstream of the Pit 1 Powerhouse generally between 500 cfs and 2000 cfs.

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1.3 Macroinvertebrate Studies

In 1991–1992, a macroinvertebrate study was conducted to determine the effects of diel fluctuating flows on fish food organisms downstream of the Pit 1 Powerhouse tailrace (McElravy 1993). Macroinvertebrate diversity and density were compared between a non-fluctuating-flow site in the Pit 1 Bypass Reach at the footbridge one kilometer upstream of the Pit 1 Powerhouse tailrace (Footbridge) and a site in the Pit River downstream of the tailrace at the Lions Club Picnic Area (Lions Club). McElravy (1993) sampled on 15–17 October 1991, 17–18 February 1992, 20–22 April 1992, 6–7 July 1992, and 28–29 September 1992.

In order to assess the potential effects of the new license-required flow regime on macroinvertebrate assemblages in the Pit 1 Bypass Reach, the Footbridge and Lions Club sites sampled in the 1991–1992 study were sampled again in summer and fall 2009. This report compares the results from the 2009 study to those from the 1991–1992 study, and evaluates the current results, to the extent possible, in relation to the results from other macroinvertebrate studies in the region (GANDA 2001, 2006) and to regional indices of biological integrity (Rehn et al. 2005, Rehn 2010) and other multimetric indices (Stoddard et al. 2005a, Rehn 2010).

1.4 Multimetric Indices

Multimetric indices, such as the index of biotic integrity, combine the information contained in numerous metrics that describe each sample into a single metric. The index of biotic integrity (IBI) for benthic macroinvertebrates is typically composed of a set of metrics that together represent different attributes of assemblage composition, structure, and function such as species richness, tolerance guilds, trophic guilds, and habitat categories. Component metrics are selected for inclusion in a multimetric index based on their responsiveness to anthropogenic stressor gradients and/or their ability to discriminate between minimally disturbed reference sites and test sites that are known or suspected to have been exposed to stressors of interest.

A benthic multimetric index for the western United States (EMAP-W IBI) was developed by the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). The EMAP West Project collected over 1500 samples on 1340 perennial streams throughout twelve western states (Arizona, California, Colorado, Idaho, Montana, Nevada, North

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Dakota, Oregon, South Dakota, Utah, Washington and Wyoming) from 2000 through 2004 (Stoddard et al. 2005a). The Mountain Ecoregion, which is one of the three major climatic/topographic regions (Mountains, Plains and Xeric) within the EMAP West study area, includes the Cascade, Sierra Nevada, and Pacific Coast ranges in the coastal states; the Gila Mountains in the southwestern states; and the Bitterroot and Rocky mountains in the northern and central mountain states. A benthic multimetric index was developed for each ecoregion. The Mountain EMAP-W IBI was developed for the Mountain Ecoregion, which includes the mountainous areas of Arizona, California, Colorado, Idaho, Montana, Oregon, South Dakota, Utah, Washington, and Wyoming. The Pit River drainage, North Fork Feather River drainage, and coastal streams of northern California are part of the Mountain Ecoregion.

Within the EMAP West study area, two special interest areas were identified within California for additional site selection: the southern coastal streams and the northern coastal streams (Stoddard et al. 2005a). Benthic macroinvertebrate assemblage data sets have been analyzed based on comprehensively defined regional reference conditions in southern coastal streams (Ode et al. 2005) and northern coastal streams (Rehn et al. 2005) in California. The northern coastal California benthic IBI (NorCal B-IBI) was developed for the region that drains directly west to the Pacific Ocean from Marin County in the south to the Oregon border in the north (Rehn et al. 2005).

The Hydropower IBI was developed to assess biological conditions below hydropower diversion dams on west slope Sierra Nevada streams and to create an interpretive framework for evaluating benthic macroinvertebrate data collected during hydropower relicensing studies (Rehn 2010). To develop the index, streams were sampled both above and downstream of dams and associated reservoirs. Reference sites were also sampled to provide an interpretive index in the context of California reference conditions. The index shows partial habitat recovery as distance downstream from the dam increases and was validated with an independent data set. Lower index of biotic integrity (degree of alteration from original state) scores below dams were most strongly associated with altered stream flows, especially consistent flow levels.

The Hydropower MMI is an earlier version of the Hydropower IBI developed to describe the cumulative effects of hydropower operations on benthos (Rehn 2005 in GANDA 2006).

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GANDA used the Hydropower MMI to examine the effects of pulsed flows on benthic macroinvertebrates by comparing the Rock Creek Reach (recreation streamflow releases) with the Belden Reach (no recreation streamflow releases) of the North Fork Feather River drainage.

1.5 Study Objectives

Study objectives include the following:

- Compare composition and density of macroinvertebrates and summary macroinvertebrate metrics under pre- and post-license flow conditions.
    - Implement a macroinvertebrate study that repeats a portion of the 1991–1992 macroinvertebrate study on the Pit River in the vicinity of the Pit 1 Powerhouse (McElravy 1993).
    - Compare the composition and density of macroinvertebrates in the Pit 1 Bypass Reach (Footbridge) and downstream of the Pit 1 Powerhouse at the Lions Club Picnic Area (Lions Club) under the current flow regime (i.e., Footbridge minimum instream flows, three summer pulsed flows; Lions Club minimum instream flows of 700 cfs) with McElravy's findings under the previous flow regime (i.e., Footbridge no minimum instream flows, no regular pulsed flows; Lions Club minimum instream flows of 500 cfs).
- Evaluate metrics of the benthic macroinvertebrate (BMI) community to determine the current levels of biological and physical integrity and overall ecological quality of the Pit River in the Pit 1 Bypass Reach (Footbridge) and downstream of the Pit 1 Powerhouse (Lions Club). These metrics will be evaluated in relation to findings from other Pit River studies (GANDA 2001), regional indices of biological integrity (Rehn et al. 2005, Stoddard et al. 2005a), and the hydropower-specific multimetric index of biotic integrity (Rehn 2010, Rehn 2005 in GANDA 2006).

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2.0 Methods

Two sites sampled for drifting and benthic macroinvertebrates by McElravy (1993) in 1991–1992 were sampled again using the same methods in 2009 (Figure 2.1). One site was located upstream of the Pit 1 Powerhouse tailrace in the Pit 1 Bypass Reach (Footbridge), and one was located downstream of the tailrace at the Lions Club Picnic Area (Lions Club). During a site visit in July 2009, Eric McElravy, Ph.D. reviewed the specific sampling locations and methods used in 1991 and 1992 with Spring Rivers Ecological Sciences LLC staff. The locations chosen for drift samples and benthic samples at the Footbridge site and Lions Club site are shown in Figure 2.2 and Figure 2.3, respectively.

Materials and methods used during the 1991–1992 study were repeated for the 2009 study (McElravy 1993), except that sampling was only done in perennially wetted habitat and drift was only sampled once per day (in the morning) at each site. Eric McElravy reviewed the standard operation procedures for taking, processing, labeling, and preserving the samples for the 2009 study to ensure consistency with the earlier study. For comparison with McElravy's summer (6–7 July 1992) and fall (15–17 October 1991 and 28–29 September 1992) samples, drift and benthic samples were collected twice at each site, once during 11–13 August 2009 and once during 29–30 September 2009.

2.1 Sample Collection

The morning of each field day, three drift nets (mouth opening 11x11 inches, net area approximately 7 ft^2, and mesh size 0.125 mm) with attached collection jars were set in relatively close proximity to one another in a representative riffle habitat. Three drift nets were deployed per site and samples were taken for about one hour between the hours of 0800 and 1000. Each net was anchored into place by two pieces of steel rebar pounded into the substrate about 13 inches apart. The base of each net was positioned approximately 10 to 20 cm above the substrate. Water velocity was measured at the mouth of each net before and after each sampling period using a Marsh-McBirney flow meter to estimate the volume of water passing through the net (ASTM 1988). After the 1-hour sampling period, the nets were removed from the water

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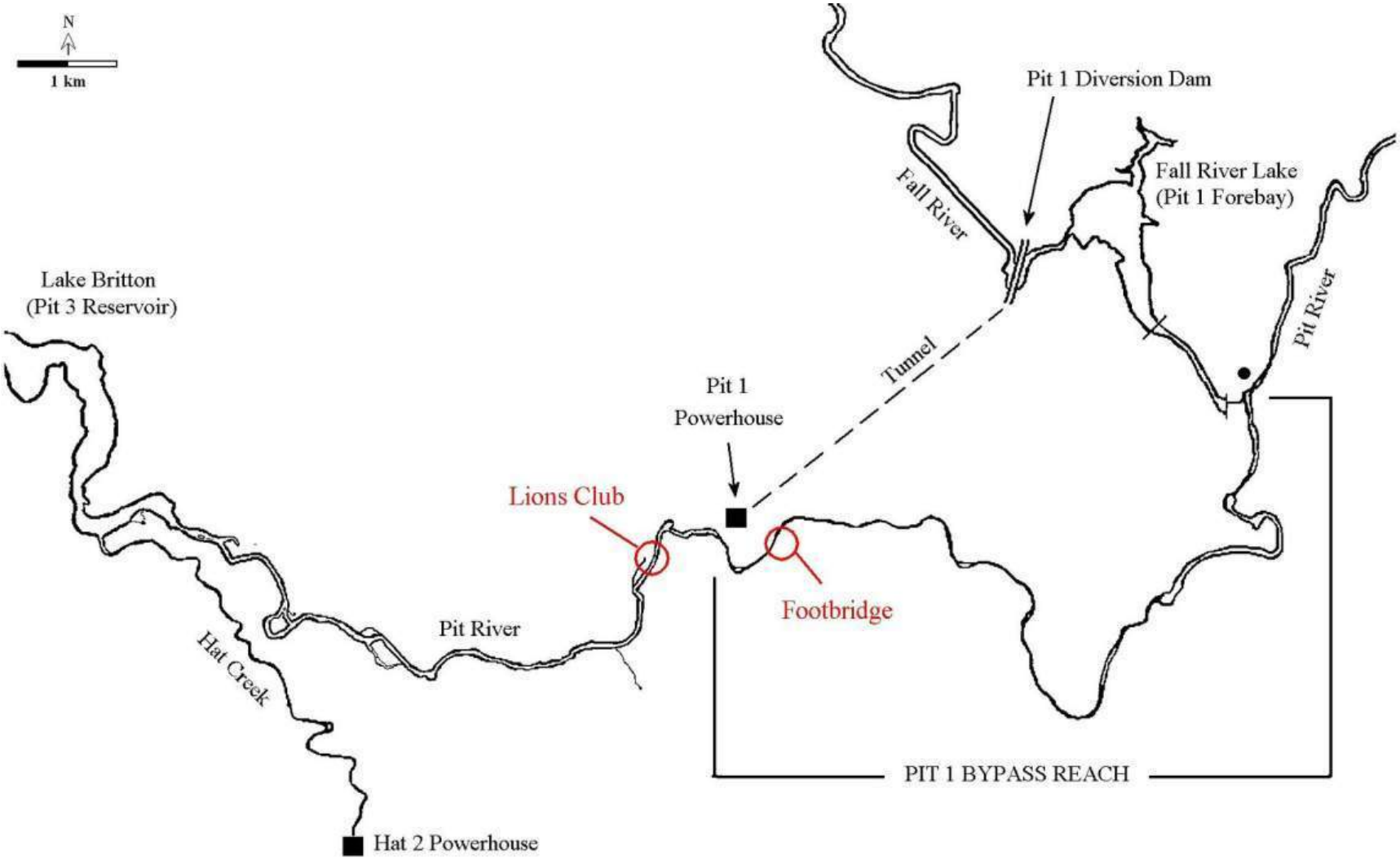

Figure 2.1 Macroinvertebrate sampling locations in 1991, 1992, and 2009.

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a)

b)

Figure 2.2 Footbridge sampling areas in 2009 (looking downstream): (a) drift sampling area and (b) Surber (left) and drift (right) sampling areas as viewed from the footbridge.

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a)

b)

Figure 2.3 Lions Club sampling areas in 2009: (a) drift sampling area looking upstream and (b) Surber sampling areas looking downstream.

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to stop sampling. The sides of each net were washed, from the outside in, with a water sprayer to concentrate collected material into the collection jar attached to the bottom of the net. The collection jars were then removed from the nets and the contents put into labeled, 1-liter polypropylene sample jars and preserved in 95% ethanol.

After drift sampling, the benthos was sampled using a modified Surber sampler enlarged by a factor of three to accommodate the large substrate in the Pit River (McElravy 1993). The area of the Surber frame was increased to 3 ft^2, and the net (500-µm mesh) was enlarged proportionately. A cloth skirt weighted with sand-filled bicycle inner tubes was attached to the bottom of the Surber frame to improve the seal between the sampler and the substrate.

Three samples were taken in suitable riffle habitat, and three were taken in suitable glide habitat. Prior to placement of the Surber sampler, a sample area was selected so that the Surber sampler would fit over movable substrate with a reasonable seal between the sampler and the channel bottom. The sampler was held in place during sampling. Surface substrate materials within the Surber frame were first cleaned by hand so that the macroinvertebrates were washed into the sampling net. Cobble and larger substrate were then placed in buckets that were hauled to shore to collect remaining macroinvertebrates. The remaining substrate within the Surber frame was vigorously agitated to loosen compacted material and associated macroinvertebrates. The sampler was then removed and the material collected in the netting was washed into the attached collecting jar. On shore, the macroinvertebrates and debris were removed from the collection jar and put in a sample jar with 95% ethanol. The Surber net was then examined for any remaining individuals. Macroinvertebrates removed from the net and from the retained rocks were added to the sample jar.

Retained substrate items were also visually inspected and the numbers of firmly attached, cased *Petrophila* (Lepidoptera: Pyralidae) and *Leucotrichia* (Trichoptera: Hydroptilidae) were estimated for each sample. Additionally, approximately 150 of the attached cases were removed from the retained substrate for the three riffle samples combined and for the three glide samples combined.

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2.2 Sample Processing

Drift samples containing mineral matter and all Surber samples were elutriated (sieve size = 0.125 mm) to separate organisms and organic debris from fine mineral matter (i.e., silt). The elutriate was then sieved through 4.0 mm and 0.125 mm sieves into a greater than 4.0 mm fraction and a fraction less than 4.0 mm but greater than 0.125 mm. Material passing through the 0.125 mm sieve was discarded. All elutriated and sorted samples were transferred to labeled polypropylene sampling jars containing 95% ethanol and shipped to ECORP Consulting, Inc. for processing and identification to Family level following the methods used in McElravy (1993). The entire greater than 4.0 mm sample was sorted at 10x. For large samples, the material less than 4.0 mm but greater than 0.125 mm was quartered (counted ¼ of the sample) or quartered twice (counted 1/16 of the sample), sorted at 10x, and then converted to real numbers (x4 or x16). Drift samples were sieved and sorted the same way as Surber samples. The samples of attached cases were inspected to determine taxonomic composition and the proportion of cases with viable larvae and pupae. These proportions were applied to total number of attached organisms to estimate the abundance of the two taxa (Pyralidae and Hydroptilidae) in the three riffle and three glide samples. Parasitic wasps in the family Ichneumonidae were also found within the attached case samples. The proportion of Ichneumonidae larvae and pupae found within the Pyralidae cases was determined based on the Ichneumonidae to Pyralidae ratio. A copy of ECORP's QA/QC procedures is included in Appendix A.

2.3 Benthic Macroinvertebrate Metrics

Eric McElravy provided the original raw drift and Surber sampling data from McElravy (1993). To compare data sets from his study with the 2009 study, only the lowest taxa identified in both studies for a given taxonomic tree were counted in the taxa richness measures. The following adjustments were made to the data sets so that taxa richness (i.e., number of taxa) could be compared between studies. Because McElravy (1993) did not identify the Acari (=Hydracarina) to family, all 2009 Acari families were combined into the single taxon Acari, and thus counted as a single taxon. Similarly, if four Ephemeroptera families were identified but one Ephemeropteran could not be identified to family and was thus counted in the Order, then the number of Ephemeroptera taxa would be four. This prevented the possibility of counting a family twice. Similarly, counts of taxa richness combined aquatic and terrestrial (i.e., adult)

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organisms of the same taxon to avoid counting a taxon twice, which would skew the data. Master taxa lists of the 1991 and 1992 (McElravy 1993) and 2009 macroinvertebrate data analyzed in this study are provided in appendices B, C, D, and E.

Various benthic metrics were used to assess the biological and physical conditions and to measure the differences between sites. Summary metrics included a combination of invertebrate metrics from the California Stream Bioassessment Procedure (CDFG 2003a), U.S. EPA Benthic Monitoring Protocols (EPA 1999), and additional metrics (Table 2.1). For many of the metrics, there is an expected response to generalized ecological impairments and disturbances. For example, the Taxa Richness metric is expected to decrease in response to impairment, while the Percent Chironomidae metric is expected to increase (indicated by a plus sign) in response to impairment. In general, higher richness measures indicate a more diverse and robust macroinvertebrate community.

Metrics were calculated for each of the three replicate samples (i.e., drift, riffle, and glide) before calculating the mean (± 1 standard error) for each habitat at a site. Metrics included richness measures, composition measures, tolerance and intolerance measures, functional feeding group, and habitat measures. Richness measures include total number of taxa, number of EPT taxa (Ephemeroptera, Plecoptera, and Trichoptera combined), and the number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Composition measures look at the structure of the biological community, and include, among others, the percent of individuals in a taxon or group such as % Baetidae, %Hydropsychidae, % Chironomidae, and % EPT. Tolerance measures provide a measure of taxon tolerance to impairments (e.g., organic pollution, sediment) and range from 0 (highly intolerant) to 10 (highly tolerant). Tolerance measures in this report are based on California Tolerance Values, or CTV (CDFG 2003b). The Functional Feeding Group (FFG) metrics provide a measure of the balance of macroinvertebrate feeding strategies, including collector-gatherer, collector-filterer, scraper, predator, and shredder. Tables in Merritt and Cummins (1996) were used to assign taxa to their Functional Feeding Group shown in Appendices A through D and to their primary Habitat category, such as burrowing taxa (Kerans and Karr 1994).

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Table 2.1 Descriptions of benthic metrics and their expected response to environmental disturbance.

Metric	Description	Expected Response to Impairment
Richness Measures		
Taxa Richness	Total number of taxa (family for most taxa in this study)	Decrease
EPT Taxa Richness	The number of taxa (family level) from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Taxa within the EPT orders are generally among the more sensitive aquatic insects to degradation.	Decrease
Ephemeroptera Taxa Richness	Number of mayfly taxa (family level). Ephemeroptera are generally considered to be sensitive to habitat degradation.	Decrease
Plecoptera Taxa Richness	Number of stonefly taxa (family level). Plecoptera are the order most sensitive to habitat degradation. A high number of Plecoptera taxa is regarded as an indicator of good water quality.	Decrease
Trichoptera Taxa Richness	Number of caddisfly taxa (family level). Trichoptera are generally considered to be sensitive to habitat degradation.	Decrease
Coleoptera Taxa Richness	Number of beetle taxa (family level). Coleoptera are generally considered to be sensitive to habitat degradation.	Decrease
Diptera Tax Richnessa	Number of true fly taxa (family level)	Decrease
Non-Insect Taxa Richness	Number of non-insect taxa	Increase
Shannon Diversity	General measure of sample diversity that incorporates richness and evenness.	Decrease
Total Abundance	Total number of macroinvertebrates collected.	Decrease
Composition Measures		
EPT Index (%)	Percent of individuals from the orders Ephemeroptera, Plecoptera, and Trichoptera. Individuals from the EPT orders are generally sensitive to degradation.	Decrease
% Baetidae	Percent of individuals from the mayfly family Baetidae to the total invertebrate abundance.	Increase
% Hydropsychidae	Percent of individuals from the caddisfly family Hydropsychidae to the total invertebrate abundance.	Decrease
% Chironomidae	Percent of individuals from the dipteran family of midges Chironomidae to the total invertebrate abundance.	Increase
% Diptera	Percent of individuals from the true fly order Diptera to the total invertebrate abundance.	Increase
% Dominant Taxon	Percent of individuals in the single most abundant taxon. A measure of community evenness.	Increase
% 3 Dominant Taxa	Percent of individuals in the three most prevalent taxa. A community dominated by a few species may indicate environmental stress.	Increase
% 5 Dominant Taxa	Percent of individuals in the five most prevalent taxa. A community dominated by a few species may indicate environmental stress.	Increase
EPT: Chironomidae Ratio	Ratio of the number of individuals in the orders Ephemeroptera, Plecoptera, and Trichoptera to the number of individuals in the order Chironomidae. The generally more sensitive Ephemeroptera, Plecoptera, and Trichoptera will decrease relative to the more tolerant Chironomidae due to environmental degradation.	Decrease

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Table 2.1 Continued.

Metric	Description	Expected Response to Impairment [1]
% Non-Insect	Percent of individuals in non-insect taxa. Insects are often replaced by more tolerant non-insects (e.g., Oligochaeta) due to environmental degradation.	Increase
% Non-Insect Taxa	Percent taxa that are not insects.	Increase
Tolerance/Intolerance Measures		
Sensitive EPT Index	Percent of individuals in the orders Ephemeroptera, Plecoptera, and Trichoptera with California Tolerance Values (CTV) of 0, 1, 2, or 3.	Decrease
% Intolerant (CTV<3)	Percent of individuals that are highly intolerant to impairment as indicated by a California Tolerance Value of 0, 1 or 2	Decrease
% Tolerant (CTV>7)	Percent of individuals that are highly tolerant to impairment as indicated by a California Tolerance Value of 8, 9 or 10	Increase
% Tolerant Taxa (CTV>7)	Percent taxa that are highly tolerant to impairment as indicated by a California Tolerance Value of 8, 9 or 10	Increase
Tolerance Value	Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) or intolerant (lower values)	Increase
Functional Feeding Group		
% Collector-Gatherer	Percent of individuals that gather fine particulate matter.	Increase
% Collector-Filterers	Percent of individuals that filter fine particulate matter.	Increase
% Collector Gatherers + Filterers	Percent of individuals that gather and filter fine particulate matter.	Increase
% Scrapers	Percent of individuals that graze upon periphyton. They depend on the amount of primary production.	Variable
% non-Gastropoda Scrapers	Percent of individuals that graze upon periphyton excluding Gastropoda. They depend on the amount of primary production.	Decrease
% Predators	Percent of individuals classified as predators.	Variable
% Shredders	Percent of individuals that shreds coarse particulate matter. Their abundance may decrease with loss of riparian habitat.	Decrease
% Omnivore taxa	Percent taxa that are omnivores.	
Habitat Association		
% Burrowers	Percent of individuals that burrow into the substrate.	Increase
Multi-Metric Indices		
Mountain EMAP-W IBI	Regional benthic index of biotic integrity for perennial streams in the Mountain Ecoregion of the Western United States that is a composite index of six key metrics (Stoddard et al. 2005a, b).	Decrease
NorCal B-IBI	Regional benthic index of biotic integrity (B-IBI) for wadeable streams in Northern Coastal California that is a composite index of eight key metrics (Rehn et al. 2005).	Decrease
Hydropower IBI	Hydropower-specific multimetric index of biotic integrity (IBI) that is a composite index of seven key metrics (Rehn 2010).	Decrease
Hydropower MMI	An earlier version of the Hydropower IBI this composite multimetric index (MMI) uses five key metrics to describe the cumulative effects of hydropower operations on benthos (Rehn 2005 in GANDA 2006).	Decrease

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The following four different multimetric indices were calculated for each of the three replicate samples: (1) the Mountain EMAP-W IBI developed for the Cascade, Sierra Nevada, and Pacific Coast ranges in the coastal states; the Gila Mountains in the southwestern states; and the Bitterroot and Rocky mountains in the northern and central mountain states (Stoddard et al. 2005a, b); (2) the NorCal B-IBI developed for the region that drains directly west to the Pacific Ocean from Marin County in the south to the Oregon border in the north (Rehn et al. 2005); (3) Hydropower IBI was developed to assess biological conditions below hydropower diversion dams on west slope Sierra Nevada streams (Rehn 2010); and the (4) Hydropower MMI (Rehn 2005 in GANDA 2006), which is an earlier version of the Hydropower IBI, used by GANDA to evaluate pulsed flows in the North Fork Feather River. The taxonomic effort used to develop these indices was genus level in most cases. Chironomidae were identified to genus for the Mountain EMAP-W IBI, but only to family for the NorCal B-IBI and Hydropower IBI. Species level taxonomic effort was used for the Hydropower MMI.

The Mountain EMAP-W IBI is based on the following six component metrics: % noninsect individuals, % individuals in five dominant taxa; % omnivore taxa; % burrowing individuals; EPT taxa richness, and % tolerant taxa (Table MI-4, Figures BN-30, 72, 142, 184, 240, and 282 in Stoddard et al. 2005b). The NorCal B-IBI is based on the following eight component metrics: EPT taxa richness, Coleoptera richness, Diptera richness, % intolerant individuals, % non-Gastropoda scraper individuals, % predator individuals, % shredder taxa; and % noninsect taxa (Table 4 in Rehn et al. 2005). The Hydropower IBI is based on the following seven component metrics: ET taxa richness, % intolerant individuals, % scraper individuals, % noninsect taxa, Shannon diversity, % Predator individuals, and % tolerant individuals using “Level I” (EPT to genus and Chironomidae to family) taxonomy (Table 6 in Rehn 2010). The Hydropower MMI is based on the following five component metrics: EPT taxa richness, Coleoptera richness, % collector-filterer and collector-gather individuals, % non-Gastropoda scraper individuals, and % tolerant taxa (Table 2 in GANDA 2006). All individuals metrics were scored on a 0 to 10 scale for each individual sample. The multimetric index was the sum of all the component metrics adjusted to a 100-point scoring scale.

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2.4 Statistical Analysis

Mean density and mean relative abundance of each taxon were calculated based on the number and relative abundance within each of the three replicate whole samples. Drift densities (number of organisms per 1000 ft^3) were calculated using the volume of water (in cfs) that flowed through the net, while Surber density (number of organisms per ft^2) was calculated used the sampled area (3 ft^2). In addition to total macroinvertebrate drift density, the zooplankton-only drift density was calculated as the sum of the Cladocera, Copepoda, and Ostracoda. Mean values plus or minus standard error are reported in the text. Error bars on figures were calculated as plus and minus two standard errors because this range corresponds roughly to the 95% confidence interval.

Descriptive statistics and Bartlett's test for homogeneity of variances (Sokal and Rohlf 1981) of the variables indicated that there were departures from a normal distribution and heteroscedasticity. A logarithmic transformation of the density and count data ($\log_{10}(n+1)$) and an arcsine transformation of the square root of proportion data (arcsine $\sqrt{p}$) were sufficient to achieve homogeneity of variances. Data were analyzed using the general linear models procedure of Statistical Analysis Systems version 9.2 for Windows (SAS 2002-2008). The transformed data were analyzed using analysis of variance (General Linear Model [GLM] procedure) with the macroinvertebrate density and metric data as dependent variables. The densities of the major taxonomic groups (major invertebrate classes and insect orders) and summary macroinvertebrate metrics were first analyzed for the main effects of year (1991, 1992, 2009), season (summer, fall), location (footbridge, Lions Club), and habitat (riffle, glide) class in order to quantify the differences related to year, season, location, and habitat. A year-season interaction term was included to partition the variance related to sampling timing within a season during the different years. For instance, the effects of season could depend on year because summer sampling in 1992 occurred in July, but in 2009 it occurred in August. Responses were interpreted using Duncan's multiple range test on all main effect means (i.e., year, season, location, and habitat).

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The transformed data from the Footbridge and the Lions Club locations were also analyzed separately using analysis of variance testing for year (1991, 1992, 2009), season (summer, fall), and habitat (riffle, glide) effects to determine the effects of the license-required flow regime changes at each location (SAS 2002-2008). Responses were interpreted using Duncan's multiple range test on all main effect means (i.e., year, season, and habitat). A significance level of alpha=0.05 was used for all tests unless otherwise stated.

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3.0 Results

3.1 Drift Macroinvertebrates

3.1.1 August 2009, Footbridge

A total of 775 macroinvertebrates were collected in the three drift samples at the Footbridge site in August 2009. Mean invertebrate drift density was 50 ± 24 individuals/1000 ft^3 and mean zooplankton drift (i.e., Cladocera + Copepoda + Ostracoda) density was negligible (Table 3.1). Mean densities of the five numerically dominant taxa ranged from 17 to 2 individuals/1000 ft^3 (Table 3.1), with the following mean relative abundances: aquatic (=larval) Chironomidae (35%), Hydroptilidae (22%), Oligochaeta (15%), Baetidae (9%), and terrestrial (=adult) Chironomidae (5%). The five most dominant taxa constituted 84.9% of the macroinvertebrates found in all three samples (Table 3.2). Mean Taxa Richness (±1 standard error) at the Footbridge site was 13.7 ± 2.2 and Non-Insects constituted 20.6% ± 0.7% (Table 3.2).

3.1.2 August 2009, Lions Club

A total of 1901 macroinvertebrates were collected in the three drift samples at the Lions Club site in August 2009. Mean invertebrate drift density was 99 ± 9 individuals/1000 ft^3, including a mean zooplankton drift density of 63 ± 2 individuals/1000 ft^3 (Table 3.1). Mean densities of the five numerically dominant taxa ranged from 62 to 3 individuals/1000 ft^3 (Table 3.1), with the following mean relative abundances: Copepoda (63%), aquatic Chironomidae (16%), Oligochaeta (6%), Acari (3%), and terrestrial Chironomidae (3%). The five most dominant taxa constituted 90.9% of the macroinvertebrates found in all three samples (Table 3.2). Mean Taxa Richness (±1 standard error) was 20.0 ± 1.5 and Non-Insects constituted 74.1% ± 2.6% (Table 3.2).

3.1.3 September 2009, Footbridge

A total of 1251 macroinvertebrates were collected in the three drift samples at the Footbridge site in September 2009. Mean invertebrate drift density was 94 ± 14 individuals/1000 ft^3, including a mean zooplankton drift density of 2 ± 1 individuals/1000 ft^3 (Table 3.1). Mean densities of the five numerically dominant taxa ranged from 32 to 6 individuals/1000 ft^3 (Table 3.1), with the following mean relative abundances: aquatic Chironomidae (34%), Acari (19%), Baetidae (15%), Hydroptilidae (11%), and terrestrial Chironomidae (6%). The five most dominant taxa

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constituted 85.6% of the macroinvertebrates found in all three samples (Table 3.2). Mean Taxa Richness (±1 standard error) was 16.0 ± 0.6 and Non-Insects constituted 26.7% ± 1.1% (Table 3.2).

3.1.4 September 2009, Lions Club

A total of 1161 macroinvertebrates were collected in the three drift samples at the Lions Club site in September 2009. Mean invertebrate drift density was 56 ± 25 individuals/1000 ft^3, including a mean zooplankton drift density of 20 ± 10 individuals/1000 ft^3 (Table 3.1). Mean densities of the five numerically dominant taxa ranged from 20 to 3 individuals/1000 ft^3 (Table 3.1), with the following mean relative abundances: Copepoda (35%), aquatic Chironomidae (27%), Oligochaeta (9%), Baetidae (7%), and Acari (7%). The five most dominant taxa constituted 85.3% of the macroinvertebrates found in all three samples (Table 3.2). Mean Taxa Richness (±1 standard error) was 15.7 ± 3.2 and Non-Insects constituted 52.0 ± 3.1% (Table 3.2).

Table 3.1 Summary of the drift macroinvertebrates by date and location (n=3) with mean density (individuals/ft2) and relative abundance (%) of the five most abundant taxa collected above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 2009. Five most abundant taxa are bolded.

		August 2009				September 2009			
		Footbridge		Lions Club		Footbridge		Lions Club	
Taxon	CTV [1]	Mean	Percent	Mean	Percent	Mean	Percent	Mean	Percent
Chironomidae (Aquatic)	6	**17**	**35%**	**16**	**16%**	**32**	**34%**	**16**	**27%**
Chironomidae (Terrestrial)		**2**	**5%**	**3**	**3%**	**6**	**6%**	0	0%
Baetidae (Aquatic)	4	**5**	**9%**	2	2%	**14**	**15%**	**3**	**7%**
Hydroptilidae (Aquatic)	4	**12**	**22%**	2	2%	**11**	**11%**	2	4%
Acari	5	2	4%	**3**	**3%**	**18**	**19%**	**4**	**7%**
Copepoda		0	0%	**62**	**63%**	2	2%	**20**	**35%**
Oligochaeta	5	**8**	**15%**	**6**	**6%**	3	4%	**4**	**9%**
Zooplankton		0		63		2		20	
Total Invertebrates		50		99		94		56	

[1] CTV = California Tolerance Value

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Table 3.2 Summary of metrics for drift samples collected above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 2009. Metrics represent the mean (n=3) for each sampled site per date.

Metric	Expected Response to Impairment	August 2009 Footbridge	August 2009 Lions Club	September 2009 Footbridge	September 2009 Lions Club
Richness Measures					
Taxa Richness	Decrease	13.7	20.0	16.0	15.7
EPT Taxa	Decrease	4.7	8.0	5.7	5.3
Ephemeroptera Taxa	Decrease	2.7	2.3	3.0	2.0
Plecoptera Taxa	Decrease	0.0	0.7	0.0	0.0
Trichoptera Taxa	Decrease	2.0	5.0	2.7	3.3
Diptera Taxa	Decrease	3.3	2.3	2.3	2.7
Non-Insect Taxa	Increase	4.7	7.3	6.3	6.3
Shannon Diversity	Decrease	1.9	1.4	2.0	1.8
Total Abundance	Decrease	775	1901	1251	1161
Composition Measures					
EPT Index (%)	Decrease	36.4	6.1	31.3	17.9
% Baetidae	Increase	8.6	1.6	14.9	6.9
% Hydropsychidae	Decrease	3.5	1.5	2.5	5.6
% Chironomidae	Increase	39.2	18.8	39.9	27.5
% Diptera	Increase	42.0	19.4	41.0	28.0
% Dominant Taxon	Increase	33.9	63.7	34.1	35.8
% 3 Dominant Taxa	Increase	71.9	85.0	68.5	71.7
% 5 Dominant Taxa	Increase	84.9	90.9	85.6	85.3
EPT:Chironomidae Ratio	Decrease	0.9	0.3	0.8	0.7
% Non-Insect	Increase	20.6	74.1	26.7	52.0
Tolerance/Intolerance Measures					
Sensitive EPT Index	Decrease	0.0	0.5	0.2	0.8
% Intolerant (CTV<3) [1]	Decrease	0.0	0.5	0.1	0.8
% Tolerant (CTV>7) [1]	Increase	1.1	0.6	1.8	0.7
Tolerance Value	Increase	5.0	1.9	5.0	3.3
Functional Feeding Group					
% Collector-gatherer	Increase	60.2	23.6	55.2	43.7
% Collector-filterers	Increase	5.6	2.4	3.7	6.0
% Scrapers	Variable	23.4	2.6	12.7	6.9
% Predators	Variable	4.7	3.5	19.0	6.9
% Shredders	Decrease	0.0	0.1	0.0	0.0
% OTHER		6.0	67.9	9.3	36.4
Total Percentages		100.0	100.0	100.0	100.0

[1] CTV = California Tolerance Value

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3.2 Benthic Macroinvertebrates

3.2.1 August 2009, Footbridge, Riffle

A total of 5676 macroinvertebrates were collected for the three riffle samples at the Footbridge site in August 2009. Mean total invertebrate density was 631 ± 14 (Table 3.3). Mean densities of the five numerically dominant taxa ranged from 161 to 39 individuals/ft^2 (Table 3.3), with the following mean relative abundances: Hydroptilidae (26%), Hydropsychidae (21%), Asellidae (11%), Pyralidae (7%), and Chironomidae (6%). The five most dominant taxa constituted 71.0% of the macroinvertebrates found in all three samples (Table 3.4). Mean Taxa Richness (±1 standard error) was 25.0 ± 0.6 and the Shannon Diversity Index was 2.2 ± 0.1 (Table 3.4). There were 3.7 ± 0.3 Ephemeropteran taxa, 0.7 ± 0.3 Plecopteran taxa, 3.7 ± 0.3 Trichopteran taxa, and 4.3 ± 0.3 Dipteran taxa. The EPT Index was 58.9 ± 8.9% and the Sensitive EPT Index was 0.39 ± 0.1.

3.2.2 August 2009, Footbridge, Glide

A total of 6450 macroinvertebrates were collected for the three glide samples at the Footbridge site in August 2009. Mean total invertebrate density was 717 ± 237 (Table 3.3). Mean densities of the five numerically dominant taxa ranged from 218 to 48 individuals/ft^2 (Table 3.3), with the following mean relative abundances: Hydropsychidae (30%), Hydroptilidae (15%), Ancylidae (8%), Asellidae (7%), and Chironomidae (7%). The five most dominant taxa constituted 67.9% of the macroinvertebrates found in all three samples (Table 3.4). Mean Taxa Richness (±1 standard error) was 22.0 ± 1.0 and the Shannon Diversity Index was 2.2 ± 0.0 (Table 3.4). There were 3.3 ± 0.3 Ephemeropteran taxa, 0.3 ± 0.3 Plecopteran taxa, 3.0 ± 0.6 Trichopteran taxa, and 3.0 ± 1.0 Dipteran taxa. The EPT Index was 49.8 ± 11.4% and the Sensitive EPT Index was 0.33 ± 0.2.

3.2.3 August 2009, Lions Club, Riffle

A total of 13360 macroinvertebrates were collected for the three riffle samples at the Lions Club site in August 2009. Mean total invertebrate density was 1484 ± 129 (Table 3.3). Mean densities of the five numerically dominant taxa ranged from 322 to 119 individuals/ft^2 (Table 3.3), with the following mean relative abundances: Asellidae (22%), Hydroptilidae (20%), Chironomidae (14%), Hydropsychidae (11%), and Sphaeriidae (8%). The five most dominant

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taxa constituted 74.3% of the macroinvertebrates found in all three samples (Table 3.4). Mean Taxa Richness (±1 standard error) was 25.0 ± 1.2 and the Shannon Diversity Index was 2.2 ± 0.0 (Table 3.4). There were 3.3 ± 0.3 Ephemeropteran taxa, 1.0 ± 0.0 Plecopteran taxa, 4.3 ± 0.3 Trichopteran taxa, and 3.3 ± 0.3 Dipteran taxa. The EPT Index was 40.7 ± 10.5% and the Sensitive EPT Index was 0.36 ± 0.1.

3.2.4 August 2009, Lions Club, Glide

A total of 24470 macroinvertebrates were collected for the three glide samples at the Lions Club site in August 2009. Mean total invertebrate density was 2719 ± 1951 (Table 3.3). Mean densities of the five numerically dominant taxa ranged from 1189 to 122 individuals/ft^2 (Table 3.3), with the following mean relative abundances: Chironomidae (44%), Asellidae (20%), Oligochaeta (8%), Hydropsychidae (6%), and Acari (4%). The five most dominant taxa constituted 82.7% of the macroinvertebrates found in all three samples (Table 3.4). Mean Taxa Richness (±1 standard error) was 24.3 ± 1.7 and the Shannon Diversity Index was 1.9 ± 0.2 (Table 3.4). There were 3.0 ± 0.6 Ephemeropteran taxa, 0.7 ± 0.3 Plecopteran taxa, 5.7 ± 0.7 Trichopteran taxa, and 2.3 ± 0.3 Dipteran taxa. The EPT Index was 17.9 ± 9.6% and the Sensitive EPT Index was 0.17 ± 0.1.

3.2.5 September 2009, Footbridge, Riffle

A total of 6241 macroinvertebrates were collected for the three riffle samples at the Footbridge site in September 2009. Mean total invertebrate density was 693 ± 123 (Table 3.3). Mean densities of the five numerically dominant taxa ranged from 246 to 26 individuals/ft^2 (Table 3.3), with the following mean relative abundances: Hydropsychidae (35%), Hydroptilidae (24%), Baetidae (16%), Oligochaeta (4%), and Heptageniidae (4%). The five most dominant taxa constituted 83.5% of the macroinvertebrates found in all three samples (Table 3.4). Mean Taxa Richness (±1 standard error) was 22.7 ± 1.8 and the Shannon Diversity Index was 1.8 ± 0.1 (Table 3.4). There were 3.0 ± 0.0 Ephemeropteran taxa, 0.7 ± 0.3 Plecopteran taxa, 3.7 ± 1.2 Trichopteran taxa, and 3.0 ± 0.6 Dipteran taxa. The EPT Index was 79.5 ± 3.4% and the Sensitive EPT Index was 0.22 ± 0.1.

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3.2.6 September 2009, Footbridge, Glide

A total of 3632 macroinvertebrates were collected for the three glide samples at the Footbridge site in September 2009. Mean total invertebrate density was 404 ± 121 (Table 3.3). Mean densities of the five numerically dominant taxa ranged from 116 to 32 individuals/ft^2 (Table 3.3), with the following mean relative abundances: Hydroptilidae (29%), Asellidae (13%), Pyralidae (12%), Hydropsychidae (10%), and Corbiculidae (8%). The five most dominant taxa constituted 72.1% of the macroinvertebrates found in all three samples (Table 3.4). Mean Taxa Richness (±1 standard error) was 23.0 ± 1.5 and the Shannon Diversity Index was 2.2 ± 0.1 (Table 3.4). There were 4.0 ± 0.0 Ephemeropteran taxa, 0.0 ± 0.0 Plecopteran taxa, 2.7 ± 0.3 Trichopteran taxa, and 2.3 ± 0.7 Dipteran taxa. The EPT Index was 44.1 ± 11.2% and the Sensitive EPT Index was 0.43 ± 0.2.

3.2.7 September 2009, Lions Club, Riffle

A total of 8120 macroinvertebrates were collected for the three riffle samples at the Lions Club site in September 2009. Mean total invertebrate density was 902 ± 92 (Table 3.3). Mean densities of the five numerically dominant taxa ranged from 316 to 54 individuals/ft^2 (Table 3.3), with the following mean relative abundances: Asellidae (35%), Hydroptilidae (22%), Sphaeriidae (7%), Hydropsychidae (6%), and Ancylidae (6%). The five most dominant taxa constituted 76.7% of the macroinvertebrates found in all three samples (Table 3.4). Mean Taxa Richness (±1 standard error) was 22.3 ± 0.3 and the Shannon Diversity Index was 2.0 ± 0.0 (Table 3.4). There were 2.0 ± 0.0 Ephemeropteran taxa, 0.0 ± 0.0 Plecopteran taxa, 5.0 ± 0.0 Trichopteran taxa, and 1.7 ± 0.3 Dipteran taxa. The EPT Index was 35.7 ± 9.1% and the Sensitive EPT Index was 0.11 ± 0.0.

3.2.8 September 2009, Lions Club, Glide

A total of 6429 macroinvertebrates were collected for the three glide samples at the Lions Club site in September 2009. Mean total invertebrate density was 714 ± 172 (Table 3.3). Mean densities of the five numerically dominant taxa ranged from 293 to 37 individuals/ft^2 (Table 3.3), with the following mean relative abundances: Asellidae (41%), Hydroptilidae (19%), Heptageniidae (8%), Ancylidae (6%), and Oligochaeta (5%). The five most dominant taxa constituted 79.6% of the macroinvertebrates found in all three samples (Table 3.4). Mean Taxa Richness (±1 standard error) was 22.0 ± 1.5 and the Shannon Diversity Index was 1.9 ± 0.0

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(Table 3.4). There were 2.3 ± 0.3 Ephemeropteran taxa, 0.0 ± 0.0 Plecopteran taxa, 5.0 ± 0.6 Trichopteran taxa, and 1.7 ± 0.3 Dipteran taxa. The EPT Index was 31.0 ± 5.8% and the Sensitive EPT Index was 0.12 ± 0.0.

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Table 3.3 Summary of the benthic macroinvertebrates collected in the Surber sampler by date, location, and habitat (n=3) with mean density (individuals/ft^2) and relative abundance (%) of the five most abundant taxa collected above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 2009. Five most abundant taxa are bolded.

		August 2009								September 2009							
		Footbridge				Lions Club				Footbridge				Lions Club			
		Riffle		Glide		Riffle		Glide		Riffle		Glide		Riffle		Glide	
Taxon	CTV [1]	Mean	Percent	Mean	Percent	Mean	Percent	Mean	Percent	Mean	Percent	Mean	Percent	Mean	Percent	Mean	Percent
Chironomidae	6	**39**	**6%**	**48**	**7%**	**209**	**14%**	**1189**	**44%**	10	1%	6	1%	34	4%	24	3%
Pyralidae	5	**43**	**7%**	38	5%	42	3%	104	4%	5	1%	**50**	**12%**	16	2%	22	3%
Baetidae	4	36	6%	34	5%	49	3%	11	0%	**109**	**16%**	11	3%	9	1%	9	1%
Heptageniidae	4	36	6%	39	5%	69	5%	54	2%	**26**	**4%**	23	6%	35	4%	**60**	**8%**
Hydropsychidae	4	**133**	**21%**	**218**	**30%**	**164**	**11%**	**159**	**6%**	**246**	**35%**	**42**	**10%**	**58**	**6%**	21	3%
Hydroptilidae	4	**161**	**26%**	**107**	**15%**	**290**	**20%**	**118**	4%	**169**	**24%**	**116**	**29%**	**201**	**22%**	**138**	**19%**
Acari	5	19	3%	29	4%	71	5%	122	**4%**	5	1%	4	1%	8	1%	7	1%
Asellidae	8	**71**	**11%**	**53**	**7%**	**322**	**22%**	**554**	**20%**	13	2%	**51**	**13%**	**316**	**35%**	**293**	**41%**
Corbiculidae	10	20	3%	32	5%	2	0%	4	0%	24	3%	**32**	**8%**	13	1%	5	1%
Sphaeriidae	8	1	0%	1	0%	**119**	**8%**	35	1%	2	0%	1	0%	**63**	**7%**	29	4%
Ancylidae	6	30	5%	**59**	**8%**	45	3%	73	3%	13	2%	17	4%	**54**	**6%**	**40**	**6%**
Oligochaeta	5	12	2%	20	3%	10	1%	**224**	**8%**	**30**	**4%**	30	7%	41	5%	**37**	**5%**
Total Invertebrates		631		717		1448		2719		693		404		902		714	

[1] CTV = California Tolerance Value

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Table 3.4 Summary of metrics for Surber samples collected above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 2009. Metrics represent the mean (n=3) for each sampled habitat per date.

	Expected	August 2009				September 2009			
	Response to	Footbridge		Lions Club		Footbridge		Lions Club	
Metric	Impairment	Riffle	Glide	Riffle	Glide	Riffle	Glide	Riffle	Glide
Richness Measures									
Taxa Richness	Decrease	25.0	22.0	25.0	24.3	22.7	23.0	22.3	22.0
EPT Taxa	Decrease	8.0	6.7	8.7	9.3	7.3	6.7	7.0	7.3
Ephemeroptera Taxa	Decrease	3.7	3.3	3.3	3.0	3.0	4.0	2.0	2.3
Plecoptera Taxa	Decrease	0.7	0.3	1.0	0.7	0.7	0.0	0.0	0.0
Trichoptera Taxa	Decrease	3.7	3.0	4.3	5.7	3.7	2.7	5.0	5.0
Diptera Taxa	Decrease	4.3	3.0	3.3	2.3	3.0	2.3	1.7	1.7
Non-Insect Taxa	Increase	8.7	8.3	9.7	9.7	8.7	10.3	10.3	10.0
Shannon Diversity	Decrease	2.2	2.2	2.2	1.9	1.8	2.2	2.0	1.9
Total Est. Abundance	Decrease	5676	6450	13360	24470	6241	3632	8120	6429
Composition Measures									
EPT Index (%)	Decrease	58.9	49.8	40.7	17.9	79.5	44.1	35.7	31.0
% Baetidae	Increase	5.6	4.3	3.5	0.5	16.8	2.5	0.9	1.4
% Hydropsychidae	Decrease	21.2	25.2	11.5	8.1	37.3	9.7	6.4	3.0
% Chironomidae	Increase	6.3	6.4	13.4	27.3	1.5	1.5	3.5	3.7
% Diptera	Increase	7.4	6.9	13.9	27.7	2.2	1.6	3.6	3.7
% Dominant Taxon	Increase	27.1	34.3	27.1	41.3	42.0	31.3	36.5	42.0
% 3 Dominant Taxa	Increase	58.5	59.5	60.1	68.0	75.0	61.8	67.5	69.6
% 5 Dominant Taxa	Increase	73.9	74.5	75.5	81.5	84.9	76.6	78.1	81.4
EPT : Chironomidae	Decrease	10.6	7.7	5.4	0.8	62.1	39.8	13.3	11.7
% Non-Insect	Increase	25.1	36.3	40.0	50.1	13.6	41.8	57.7	61.7
Tolerance/Intolerance Measures									
Sensitive EPT Index	Decrease	0.39	0.33	0.36	0.17	0.22	0.43	0.11	0.12
% Intolerant (CVT<3) [1]	Decrease	0.7	0.5	0.4	0.2	0.3	0.5	0.1	0.1
% Tolerant (CVT>7) [1]	Increase	15.1	20.8	30.2	30.3	5.9	26.6	43.7	47.9
Tolerance Value	Increase	5.0	5.3	5.6	6.1	4.4	5.5	6.1	6.2
Functional Feeding Group									
% Collector-gatherer	Increase	27.2	29.6	40.4	63.1	27.7	32.8	44.2	53.2
% Collector-filterers	Increase	24.9	31.4	19.7	10.7	41.8	18.9	14.5	7.3
% Scrapers	Variable	43.4	32.8	33.0	19.8	27.8	45.1	38.7	36.2
% Predators	Variable	4.3	5.8	5.8	5.3	2.6	3.0	2.1	2.6
% Shredders	Decrease	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
% OTHER		0.2	0.4	1.0	1.0	0.0	0.1	0.5	0.7
Total Percentages		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] CTV = California Tolerance Value

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4.0 Discussion

This study repeated the 1991–1992 macroinvertebrate sampling at two locations following the same methods used in that study (McElravy 1993) with one site in the Pit 1 Bypass Reach (Footbridge) and one site downstream of the Pit 1 Powerhouse (Lions Club). The objectives of this study were to (1) compare the composition and density of macroinvertebrates and summary macroinvertebrate metrics, including regional multimetric indices, under the current-license flow regime with those observed during the previous flow regime; and (2) determine the current levels of biological and physical integrity and overall ecological quality. Drift and benthic data from September 2009 were compared to data from October 1991 and September 1992; August 2009 data were compared to the July 1992 data. The analysis of variance model examined the effects of year (1991, 1992, 2009), season (summer, fall), location (Footbridge, Lions Club), habitat (riffle, glide), and year-season interaction on the composition and density of macroinvertebrates and on summary macroinvertebrate metrics.

Four different multimetric indices were calculated for each of the three replicate samples. Each multimetric index combined the information contained in numerous metrics that describe a sample into a single metric incorporating different attributes of the benthic macroinvertebrate community (e.g., species richness, tolerance guilds, trophic guilds, and habitat categories) that have been found to be responsive to anthropogenic stressors. Summary macroinvertebrate metrics were evaluated in relation to findings from other Pit River studies (GANDA 2001), the Mountain EMAP-W IBI (Stoddard et al. 2005a, b) and NorCal B-IBI (Rehn et al. 2005) regional indices of biological integrity, the hydropower-specific multimetric index of biotic integrity (Hydropower IBI, Rehn 2010), and the application of an earlier version of the Hydropower IBI to the North Fork Feather River (GANDA 2006). Comparisons of these multimetric indices within the Pit River provides a valuable tool for assessing the condition of the benthic macroinvertebrate community under the current-license flow regime with the one observed during the previous flow regime, as well as upstream and downstream of the Pit 1 Powerhouse. The multimetric indices provide information as to whether the current condition of the Pit River is more or less degraded as compared to the early 1990s.

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4.1 Flow Regime Differences between Years

The flow regime experienced by the benthic macroinvertebrates at the Footbridge site in 2009 was very different from the pre-2003 license flow regime. In 1992, there was no minimum instream flow release from the Fall River into the Pit 1 Bypass. Flow in the Pit 1 Bypass Reach was a combination of the flow from the upper Pit River (approximately 30 cfs in the summer) plus the approximately 100 cfs accretion of spring inflow within the canyon section of Pit 1 Bypass Reach. Under the current license, there is a minimum instream flow of 150-cfs continuous release from the Fall River during the summer in addition to the upper Pit River discharge and spring accretion flow. The flow regime under the current license also included three pulsed flows each summer in May/June, July, and late August between 2003 and 2009[1]. Prior to the current license, there were no regularly scheduled pulsed flows in the bypass reach, although nine summer pulsed flows occurred from 1994 through 2002 (PG&E 2010).

The October 1991 data from the Lions Club site may not be representative of a macroinvertebrate community experiencing daily peaking flows. Although discharge data for July, August, and September 1991 were largely lacking, Figure 4.1 shows daily peaking flows due to powerhouse operations prior to July. Starting in late September 1991, however, discharge was very stable (Figure 4.1). McElravy (1993) states that the powerhouse had not been operating in peaking-mode for one and a half weeks and that colonization of normally dewatered habitat occurred rather quickly. Under stable flow conditions, macroinvertebrates may have redistributed and become established in habitats normally not occupied because of dewatering during daily peaking flows.

In 1992, the Pit River below the Pit 1 Powerhouse experienced daily fluctuations as a result of powerhouse operations. Discharge ranged from approximately 500 cfs to 2000 cfs on a daily basis throughout the year (Figure 4.1). In 2009, discharge generally ranged between 1000 cfs and 2000 cfs with some higher winter and spring run-off events and relatively stable discharge conditions from mid-June to mid-October (Figure 4.1). The higher minimum flows and more gradual ramping rates under the current license reduced the amount of flow fluctuation in the Pit River downstream of the tailrace and largely eliminated the dewatering that occurred under the previous license.

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[1] There were only two flushing flows in the summer of 2003 because the August flushing flow was cancelled due to a major levee failure.

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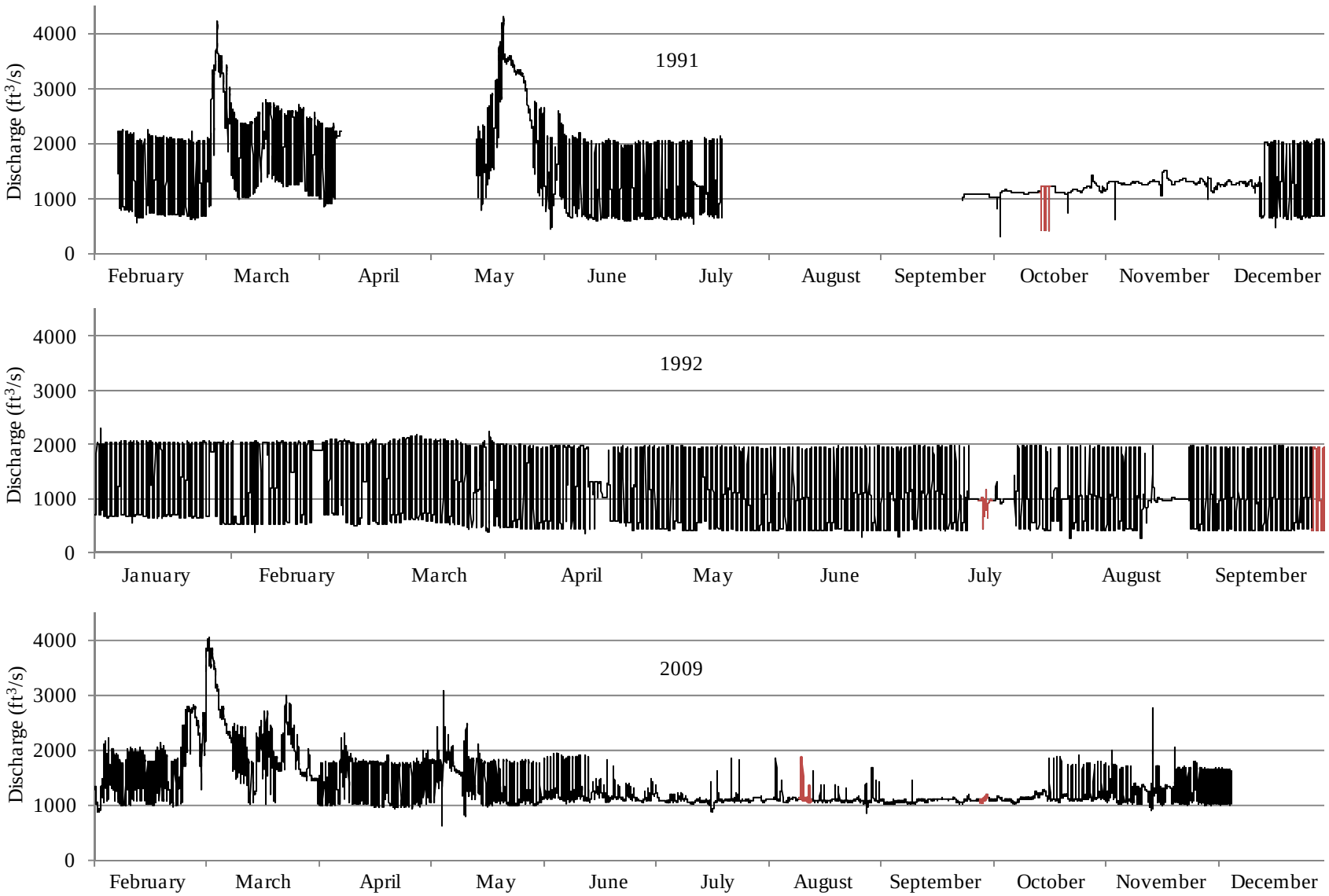

Figure 4.1 Discharge (cfs) downstream of the Pit 1 Powerhouse for 1991, 1992, and 2009. Sampling periods are in red.

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4.2 Drift Macroinvertebrates

Total mean macroinvertebrate drift density (Figure 4.2) and mean zooplankton-only (i.e., Copepoda + Cladocera + Ostracoda) drift density (Figure 4.3) were both much lower in 2009 compared to 1991 and 1992. Mean macroinvertebrate drift density ranged from 194 to 554 individuals per 1000 ft^3 in 1992 compared to 50 to 99 individuals per 1000 ft^3 in 2009 (Table 4.1). Zooplankton drift densities were lowest at the Footbridge in 2009, which may be explained by lower nutrient levels due to improved water quality, shorter retention time of water at Big Eddy, and the higher flow velocity in the canyon due to the 150-cfs minimum instream flow release that has been implemented since the issuance of new license in 2003. In addition, the high number of non-native filter-feeding Corbiculidae observed upstream of the Pit River Falls (Maria Ellis and Koen Breedveld personal observation), which were not found in the 1990s, would likely reduce zooplankton drift densities.

In general, aquatic Chironomidae was the most relative abundant taxa in drift samples for both 1992 and 2009. This taxon had a higher relative abundance in 2009, than in 1992 (Table 4.2). Relative abundance of Pyralidae and Cladocera was lower in 2009 than in 1992. Relative abundance of Copepoda was much lower at the Footbridge site in 2009 than in 1992, but their relative abundance was higher at the Lions Club site in 2009 compared to 1992 (Table 4.2). The increase abundance of Copepoda could be due to the higher base discharge in the Pit River downstream of the powerhouse in 2009, which was about twice the base discharge in the early 1990s.

Overall Taxa Richness and the EPT Taxa metrics were higher at both the Footbridge and Lions Club sample sites in 2009 as compared to 1992, which could indicate a more robust macroinvertebrate community in the river (Figure 4.4 and Figure 4.5). The EPT Index was lower at the Footbridge site in 1992 than in 2009, while it was higher at the Lions Club in 1992 compared to 2009. The percent Chironomidae and percent Diptera were both lower in 1992 compared to 2009. The percentage constituted by the five most dominant taxa was higher in 2009 compared to 1992 (Table 4.3).

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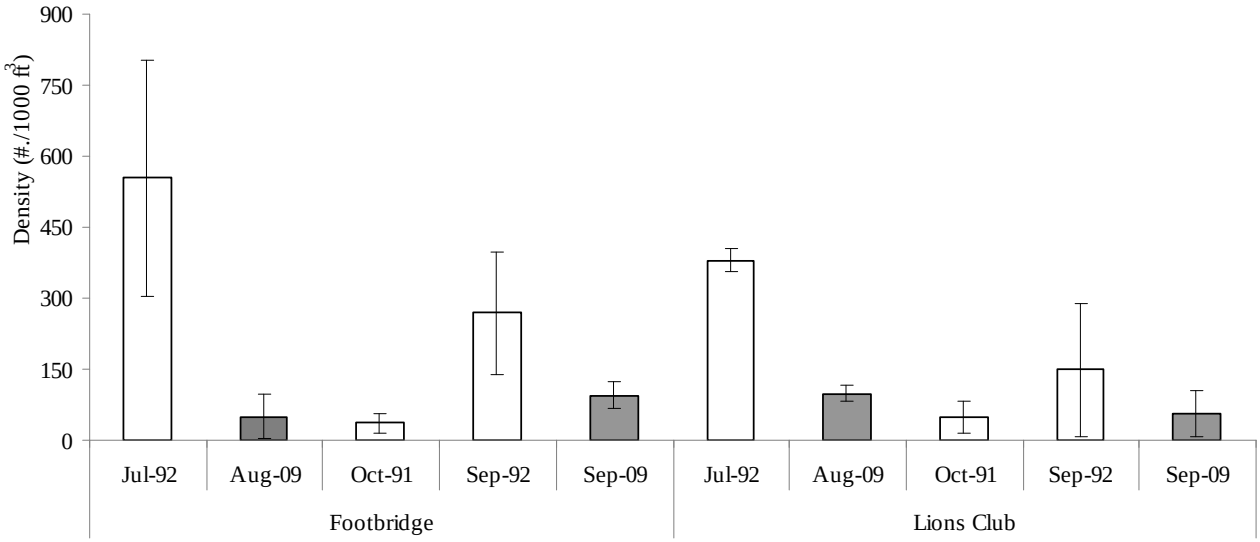

Figure 4.2 Mean (± 2 standard errors) density per 1000 ft^3 of all macroinvertebrates collected per drift sample (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

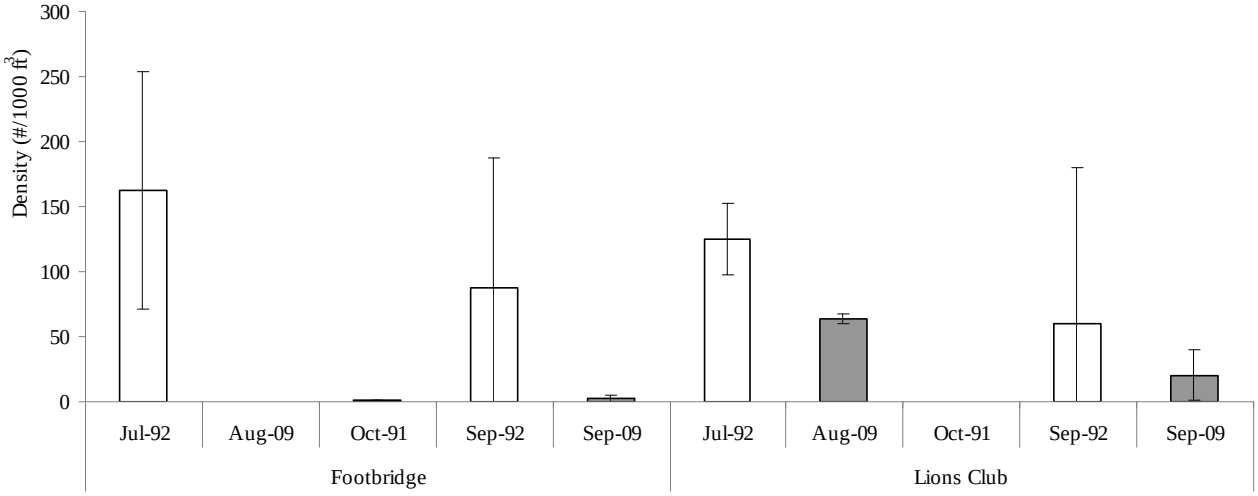

Figure 4.3 Mean (± 2 standard errors) density per 1000 ft^3 of zooplankton-only collected per drift sample (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

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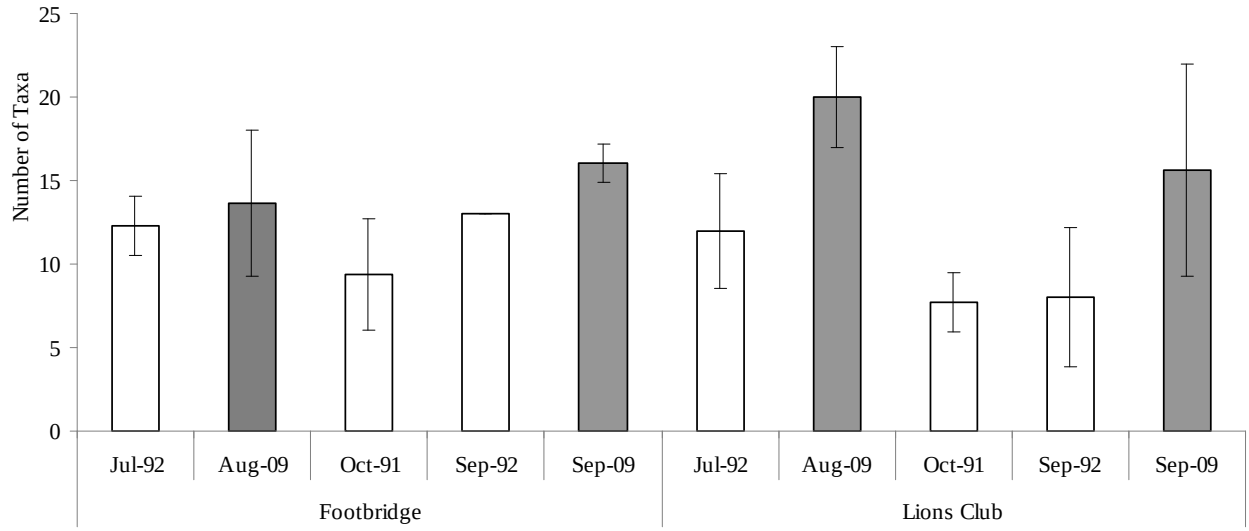

Figure 4.4 Mean (± 2 standard errors) number of taxa (i.e., Taxa Richness) per drift sample (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

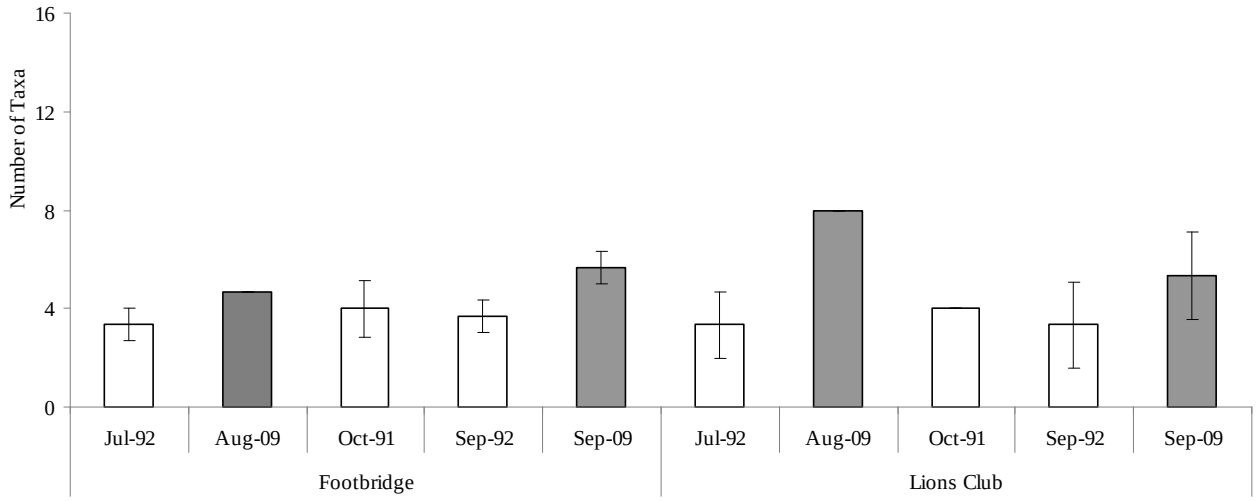

Figure 4.5 Mean (± 2 standard errors) number of EPT taxa per drift sample (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

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Table 4.1 Mean (n=3) density (# individuals/ft^2) of the most abundant macroinvertebrate and zooplankton taxa from drift samples collected above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991 and 1992 (McElravy 1993) and 2009. Five most abundant taxa are bolded.

		Footbridge					Lions Club				
Taxa	CTV [1]	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009
Chironomidae (Aq.)	6	**69**	**71**	**14**	**127**	**32**	**50**	**16**	**14**	**21**	**16**
Chironomidae (Terr.)		2	**2**	**4**	3	**6**	14	**3**	**13**	3	0
Baetidae (Aq.)	4	7	**5**	**4**	**143**	**14**	18	2	**5**	6	**3**
Pyralidae	5	**56**	0	**3**	32	0	**33**	0	2	5	1
Hydropsychidae (Aq.)	4	33	2	2	23	2	**61**	2	**6**	**15**	3
Hydroptilidae (Aq.)	4	34	**12**	**4**	9	**11**	10	2	1	4	2
Acari	5	**74**	2	0	**92**	**18**	22	**3**	0	2	**4**
Cladocera		55	0	0	57	0	**48**	1	0	**13**	1
Copepoda		**92**	0	1	**581**	2	**75**	**62**	0	**45**	**20**
Oligochaeta	5	**67**	**8**	2	**157**	3	31	**6**	**3**	**24**	**4**
Zooplankton		162	0	1	87	2	125	63	0	60	20
Total Invertebrates		554	50	36	268	94	380	99	48	149	56

[1] CTV = California Tolerance Value

Table 4.2 Mean (n=3) relative abundance (%) of the five most abundant macroinvertebrate taxa from drift samples collected above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991 and 1992 (McElravy 1993) and 2009. Five most abundant taxa are bolded.

		Footbridge					Lions Club				
Taxa	CTV [1]	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009
Chironomidae (Aq.)	6	**13**	**35**	**40**	**19**	**34**	**13**	**16**	**33**	**22**	**27**
Chironomidae (Terr.)		0	**5**	**16**	1	**6**	4	**3**	**27**	3	0
Baetidae (Aq.)	4	1	**9**	**6**	**9**	**15**	5	2	**9**	3	**7**
Pyralidae	5	**10**	1	6	4	0	**9**	0	3	**6**	2
Hydropsychidae (Aq.)	4	6	3	**6**	2	3	**16**	1	**12**	**12**	6
Hydroptilidae (Aq.)	4	6	**22**	**7**	3	**11**	3	2	2	4	4
Acari	5	**13**	4	1	**8**	**19**	6	**3**	0	2	**7**
Cladocera		9	0	0	3	0	**12**	1	0	4	0
Copepoda		**17**	0	2	**25**	2	**20**	**63**	0	**16**	**35**
Oligochaeta	5	**13**	**15**	5	**18**	4	8	**6**	**5**	**19**	**9**

[1] CTV = California Tolerance Value

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Table 4.3 Summary of metrics for drift samples collected above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991 and 1992 (McElravy 1993) and 2009. Metrics represent the mean (n=3) for each sampled habitat per date.

	Expected	Footbridge					Lions Club				
Metric	Response to Impairment	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009
Richness Measures											
Taxa Richness	Decrease	12.3	13.7	9.3	13.0	16.0	12.0	20.0	7.7	8.0	15.7
EPT Taxa Richness	Decrease	3.3	4.7	4.0	3.7	5.7	3.3	8.0	4.0	3.3	5.3
Ephemeroptera Taxa Rich.	Decrease	1.0	2.7	1.7	1.7	3.0	1.0	2.3	1.0	0.7	2.0
Plecoptera Taxa Richness	Decrease	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.3	0.3	0.0
Trichoptera Taxa Richness	Decrease	2.3	2.0	2.3	2.0	2.7	2.3	5.0	2.7	2.3	3.3
Diptera Taxa Richness	Decrease	1.3	3.3	2.0	3.0	2.3	1.3	2.3	1.3	1.0	2.7
Non-Insect Taxa Richness	Increase	6.3	4.7	2.3	5.3	6.3	6.3	7.3	1.3	3.0	6.3
Shannon Diversity	Decrease	2.3	1.9	1.9	2.0	2.0	2.2	1.4	1.8	1.7	1.8
Total Est. Abundance	Decrease	4170	258	84	6356	1251	6312	1901	42	1176	1161
Invertebrate Density		554	50	36	268	94	380	99	48	149	56
Zooplankton Density		162	0	0.8	87	2	125	63	0	60	20
Composition Measures											
EPT Index (%)	Decrease	14.6	36.4	30.3	15.1	31.3	24.9	6.1	29.4	23.6	17.9
% Baetidae	Increase	1.5	8.6	12.7	8.7	14.9	4.7	1.6	8.9	3.3	6.9
% Hydropsychidae	Decrease	5.7	3.5	5.1	2.0	2.5	16.1	1.5	11.9	11.9	5.6
% Chironomidae	Increase	13.8	39.2	52.5	19.9	39.9	16.8	18.8	60.2	25.5	27.5
% Diptera	Increase	14.5	42.0	55.4	22.5	41.0	17.0	19.4	61.1	25.5	28.0
% Dominant Taxon	Increase	18.8	34.5	42.2	31.9	34.0	20.4	63.4	32.9	37.4	36.9
% 3 Dominant Taxa	Increase	47.3	71.8	64.0	64.2	67.6	51.1	85.1	73.2	72.3	72.9
% 5 Dominant Taxa	Increase	68.1	85.3	80.9	80.8	85.1	73.8	91.1	88.7	88.0	85.9
EPT : Chironomidae	Decrease	1.1	0.9	0.6	1.1	0.8	1.8	0.3	0.5	1.5	0.7
% Non-Insect	Increase	60.7	20.6	7.6	58.7	26.7	49.6	74.1	6.2	44.7	52.0
Tolerance/Intolerance Measures											
Sensitive EPT Index	Decrease	0.2	0.0	0.7	0.0	0.2	0.6	0.5	5.2	4.9	0.8
% Intolerant (CVT <3) [1]	Decrease	0.2	0.0	0.7	0.0	0.1	0.6	0.5	5.2	4.9	0.8
% Tolerant (CVT >7) [1]	Increase	2.4	1.1	0.0	0.5	1.8	0.9	0.6	1.5	2.9	0.7
Tolerance Value	Increase	2.9	5.0	4.7	3.2	5.0	2.8	1.9	5.0	3.7	3.3
Functional Feeding Group											
% Collector-gatherer	Increase	34.2	60.2	57.3	50.3	55.2	27.5	23.6	48.0	47.8	43.7
% Collector-filterers	Increase	7.4	5.6	7.0	3.1	3.7	16.9	2.4	12.8	11.9	6.0
% Scrapers	Variable	5.8	23.4	10.8	3.3	12.7	3.3	2.6	6.6	8.2	6.9
% Predators	Variable	13.3	4.7	1.9	7.7	19.0	6.5	3.5	0.9	2.8	6.9
% Shredders	Decrease	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0
% OTHER		39.3	6.0	22.9	35.7	9.3	45.8	67.9	31.7	29.3	36.4
Total Percentages		100	100	100	100	100	100	100	100	100	100

[1] CTV = California Tolerance Value

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4.3 Benthic Macroinvertebrates

Mean density of total macroinvertebrates collected in Surber samples varied significantly (p=0.0015) between years (Figure 4.6). Density was lowest in 2009 (1033 ± 254 organisms/ft^2) as compared to 1992 (1224 ± 98 organisms/ft^2) and 1991 (1684 ± 257 organisms/ft^2). Mean densities of the more abundant taxa (Chironomidae p<0.0001; Hydropsychidae p=0.0004; Hydroptilidae p=0.0003) were significantly lower in 2009 compared to 1991 and/or 1992 (Tables 4.4 and 4.5). In general, the Tricoptera families of Hydropsychidae and Hydroptilidae were the most relative abundant benthic organisms in both 1992 and 2009 (Tables 4.6 and 4.7).

Tables 4.8 and 4.9 summarize the benthic metrics at each location. Mean EPT taxa richness (p=0.0091, Figure 4.7), Tricoptera taxa richness (p=0.0003), and Diptera taxa richness (p=0.0201) were significantly lower in 2009 as compared to 1991 and/or 1992. Non-insect taxa (p<0.0001) and percent non-insect (p<0.0001) were significantly higher in 2009 as compared to 1991 and/or 1992. Sensitive EPT Index (p<0.0001) and percent intolerant taxa (p<0.0001) were significantly lower in 2009 as compared to 1991 whereas percent tolerant taxa (p<0.0001) and tolerance value (p<0.0001) were significantly greater in 2009 as compared to 1991 and/or 1992 (Figures 4.8 and 4.9).

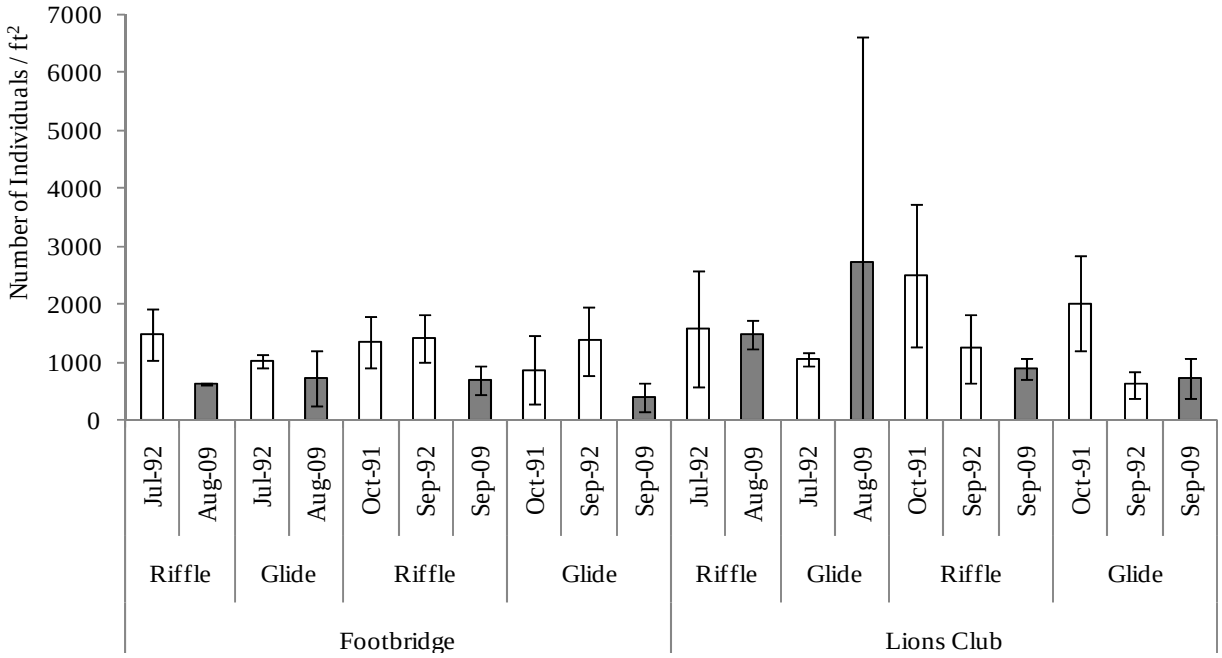

Figure 4.6 Mean (± 2 standard errors) density per Surber sample (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

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Table 4.4 Mean (n=3) density (# individuals/ft^2) of the five most abundant macroinvertebrate taxa from Surber samples at the Footbridge site above the Pit 1 Powerhouse in 1991 and 1992 (McElravy 1993) and 2009. Five most abundant taxa are bolded.

		Footbridge									
		Riffle		Glide		Riffle			Glide		
Taxa	CTV [1]	July 1992	Aug. 2009	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009	Oct. 1991	Sept. 1992	Sept. 2009
Chironomidae	6	**149**	**39**	**329**	**48**	**342**	**183**	10	**355**	**327**	6
Pyralidae	5	**121**	**43**	71	38	**102**	70	5	**100**	**100**	**50**
Baetidae	4	34	36	1	34	75	50	**109**	8	8	11
Heptageniidae	4	62	36	32	39	84	77	**26**	**33**	35	23
Hydropsychidae	4	**214**	**133**	35	**218**	**298**	**409**	**246**	**136**	**216**	**42**
Hydroptilidae	4	**513**	**161**	**140**	**107**	**185**	**303**	**169**	**129**	**290**	**116**
Acari	5	78	19	**73**	29	**105**	101	5	29	79	4
Asellidae	8	1	**71**	29	**53**	5	2	13	3	15	**51**
Corbiculidae	10	0	20	0	32	0	0	24	0	0	**32**
Sphaeriidae	8	41	1	1	1	49	7	2	4	3	1
Ancylidae	6	**88**	30	**106**	**59**	10	31	13	13	23	17
Oligochaeta	5	47	12	**122**	20	36	**91**	**30**	32	**160**	30
Total Invertebrates		1479	631	1024	717	1353	1421	693	871	1370	404

[1] CTV = California Tolerance Value

Table 4.5 Mean (n=3) density (# individuals/ft^2) of the five most abundant macroinvertebrate taxa from Surber samples at the Lions Club site below the Pit 1 Powerhouse in 1991 and 1992 (McElravy 1993) and 2009. Five most abundant taxa are bolded.

		Lions Club									
		Riffle		Glide		Riffle			Glide		
Taxa	CTV [1]	July 1992	Aug. 2009	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009	Oct. 1991	Sept. 1992	Sept. 2009
Chironomidae	6	**130**	**209**	**75**	**1189**	**167**	**52**	34	**246**	33	24
Pyralidae	5	42	42	36	104	129	51	16	**201**	**36**	22
Baetidae	4	**62**	49	4	11	84	**71**	9	11	2	9
Heptageniidae	4	12	69	24	54	20	42	35	44	13	**60**
Hydropsychidae	4	**473**	**164**	**164**	**159**	**1072**	**516**	**58**	**577**	**36**	21
Hydroptilidae	4	**590**	**290**	**453**	**118**	**491**	**293**	**201**	**389**	**203**	**138**
Acari	5	6	71	11	122	4	19	8	40	15	7
Asellidae	8	**100**	**322**	**95**	**554**	52	**97**	**316**	**102**	**90**	**293**
Corbiculidae	10	0	2	0	4	0	0	13	0	0	5
Sphaeriidae	8	45	**119**	15	35	**221**	18	**63**	55	8	29
Ancylidae	6	6	45	40	73	0	6	**54**	11	14	**40**
Oligochaeta	5	47	10	**60**	**224**	**161**	30	41	49	**95**	**37**
Total Invertebrates		1581	1448	1065	2719	2491	1237	902	2019	614	714

[1] CTV = California Tolerance Value

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Table 4.6 Mean (n=3) relative abundance (%) of the five most abundant macroinvertebrate taxa from Surber samples at the Footbridge site above the Pit 1 Powerhouse in 1991 and 1992 (McElravy 1993) and 2009. Five most abundant taxa are bolded.

		Footbridge									
		Riffle		Glide		Riffle			Glide		
Taxa	CTV [1]	July 1992	Aug. 2009	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009	Oct. 1991	Sept. 1992	Sept. 2009
Chironomidae	6	**10**	**6**	**32**	**7**	**25**	**13**	1	**41**	**4**	1
Pyralidae	5	**8**	**7**	**7**	5	**8**	5	1	**11**	4	**12**
Baetidae	4	2	6	0	5	6	4	**16**	1	**6**	3
Heptageniidae	4	4	6	3	5	6	5	**4**	**4**	5	6
Hydropsychidae	4	**14**	**21**	3	**30**	**22**	**29**	**35**	**16**	**42**	**10**
Hydroptilidae	4	**35**	**26**	**14**	**15**	**14**	**21**	**24**	**15**	**24**	**29**
Acari	5	5	3	**7**	4	**8**	7	1	3	2	1
Asellidae	8	0	**11**	3	**7**	0	0	2	0	**8**	**13**
Corbiculidae	10	0	3	0	5	0	0	3	0	0	**8**
Sphaeriidae	8	3	0	0	0	4	1	0	0	0	0
Ancylidae	6	**6**	5	**10**	**8**	1	2	2	1	1	4
Oligochaeta	5	3	2	**12**	3	3	**6**	**4**	4	2	7

[1] CTV = California Tolerance Value

Table 4.7 Mean (n=3) relative abundance (%) of the five most abundant macroinvertebrate taxa from Surber samples at the Lions Club site below the Pit 1 Powerhouse in 1991 and 1992 (McElravy 1993) and 2009. Five most abundant taxa are bolded.

		Lions Club									
		Riffle		Glide		Riffle			Glide		
Taxa	CTV [1]	July 1992	Aug. 2009	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009	Oct. 1991	Sept. 1992	Sept. 2009
Chironomidae	6	**8**	**14**	**7**	**44**	**7**	**4**	4	**12**	5	3
Pyralidae	5	3	3	3	4	5	4	2	**10**	**6**	3
Baetidae	4	**4**	3	0	0	3	**6**	1	1	0	1
Heptageniidae	4	1	5	2	2	1	3	4	2	2	**8**
Hydropsychidae	4	**30**	**11**	**15**	**6**	**43**	**42**	6	**29**	6	3
Hydroptilidae	4	**37**	**20**	**43**	4	**20**	**24**	**22**	**19**	**33**	**19**
Acari	5	0	5	1	**4**	0	2	1	2	2	1
Asellidae	8	**6**	**22**	**9**	**20**	2	**8**	**35**	**5**	**15**	**41**
Corbiculidae	10	0	0	0	0	0	0	1	0	0	1
Sphaeriidae	8	3	**8**	1	1	**9**	1	**7**	3	1	4
Ancylidae	6	0	3	4	3	0	1	**6**	1	2	**6**
Oligochaeta	5	3	1	**6**	**8**	**6**	2	5	2	**15**	**5**

[1] CTV = California Tolerance Value

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Table 4.8 Summary of metrics for Surber samples collected at the Footbridge site above the Pit 1 Powerhouse in 1991 and 1992 (McElravy 1993) and 2009. Metrics represent the mean (n=3) for each sampled habitat per date.

		Footbridge									
	Expected	Riffle		Glide		Riffle			Glide		
Metric	Response to Impairment	July 1992	Aug. 2009	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009	Oct. 1991	Sept. 1992	Sept. 2009
Richness Measures											
Taxa Richness	Decrease	25.7	25.0	25.7	22.0	20.3	24.0	22.7	23.3	23.3	23.0
EPT Taxa	Decrease	11.0	8.0	8.3	6.7	7.7	10.0	7.3	9.0	9.0	6.7
Ephemeroptera Taxa	Decrease	3.0	3.7	2.7	3.3	3.0	2.7	3.0	3.0	2.7	4.0
Plecoptera Taxa	Decrease	1.7	0.7	0.0	0.3	1.0	1.7	0.7	1.0	0.7	0.0
Trichoptera Taxa	Decrease	6.3	3.7	5.7	3.0	3.7	5.7	3.7	5.0	5.7	2.7
Diptera Taxa	Decrease	3.7	4.3	3.0	3.0	4.0	4.0	3.0	3.7	3.0	2.3
Coleoptera Taxa	Decrease	1.0	1.0	1.3	1.3	1.3	1.0	1.7	1.3	1.0	1.3
Non-Insect Taxa	Increase	7.3	8.7	10.3	8.3	5.0	6.3	8.7	6.3	7.3	10.3
Shannon Diversity	Decrease	2.2	2.2	2.2	2.2	2.0	2.1	1.8	1.9	2.0	2.2
Total Est. Abundance	Decrease	13311	5676	9214	6450	12175	12785	6241	7841	12330	3632
Density (Indiv./ft^2)		1479	631	1024	717	1353	1421	693	871	1370	404
Composition Measures											
EPT Index (%)	Decrease	56.6	58.9	25.6	49.8	47.3	61.3	79.5	47.3	37.7	44.1
% Baetidae	Increase	2.2	5.6	0.2	4.3	5.0	3.4	16.8	5.0	0.4	2.5
% Hydropsychidae	Decrease	13.2	21.2	3.4	25.2	19.8	29.2	37.3	19.8	13.4	9.7
% Chironomidae	Increase	10.6	6.3	32.3	6.4	25.4	12.9	1.5	25.4	28.1	1.5
% Diptera	Increase	11.8	7.4	32.7	6.9	27.0	13.8	2.2	27.0	28.5	1.6
% Dominant Taxon	Increase	35.1	27.1	32.3	34.3	35.6	29.2	42.0	35.6	35.2	31.3
% 3 Dominant Taxa	Increase	60.1	58.5	61.4	59.5	63.7	63.9	75.0	63.7	67.5	61.8
% 5 Dominant Taxa	Increase	75.5	73.9	76.6	74.5	83.0	78.0	84.9	83.0	81.2	76.6
EPT : Chironomidae	Decrease	5.9	10.6	0.8	7.7	2.6	4.9	62.1	2.6	2.4	39.8
% Non-Insect	Increase	19.6	25.1	34.6	36.3	15.9	18.0	13.6	15.9	25.8	41.8
Tolerance/Intolerance Measures											
Sensitive EPT Index	Decrease	1.5	0.4	3.4	0.3	0.3	1.2	0.2	1.2	0.6	0.4
% Intolerant (CVT<3) [1]	Decrease	1.5	0.7	3.4	0.5	0.4	1.3	0.3	1.2	0.6	0.5
% Tolerant (CVT>7) [1]	Increase	2.7	15.1	3.7	20.8	3.4	0.9	5.9	1.2	3.7	26.6
Tolerance Value	Increase	4.5	5.0	5.1	5.3	4.8	4.4	4.4	4.8	4.9	5.5
Functional Feeding Group											
% Collector-gatherer	Increase	19.8	27.2	48.5	29.6	34.9	25.0	27.7	38.7	47.4	32.8
% Collector-filterers	Increase	17.4	24.9	7.4	31.4	23.4	32.0	41.8	22.6	15.1	18.9
% Gatherer + Filterers	Increase	37.3	52.1	55.9	61.0	58.3	57.0	69.6	61.3	62.5	51.8
% Scrapers	Variable	54.6	43.4	34.2	32.8	31.0	34.5	27.8	33.6	29.5	45.1
% Scrapers (excl. Gastropods)	Decrease	48.1	38.3	23.8	24.0	30.2	32.2	25.5	31.6	27.6	40.6
% Predators	Variable	7.9	4.4	9.2	5.8	10.7	8.4	2.6	4.8	7.5	3.0
% Shredders	Decrease	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Omnivore	Increase	0.0	0.1	0.0	0.1	0.3	0.0	0.1	1.3	0.7	0.1
Habitat Association											
% Burrower	Increase	18.3	12.2	45.2	15.1	32.5	21.7	20.5	37.6	42.4	23.0

[1] CTV = California Tolerance Value

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Table 4.9 Summary of metrics for Surber samples collected at the Lions Club site below the Pit 1 Powerhouse in 1991 and 1992 (McElravy 1993) and 2009. Metrics represent the mean (n=3) for each sampled habitat per date.

		Lions Club									
	Expected	Riffle		Glide		Riffle			Glide		
Metric	Response to Impairment	July 1992	Aug. 2009	July 1992	Aug. 2009	Oct. 1991	Sept. 1992	Sept. 2009	Oct. 1991	Sept. 1992	Sept. 2009
Richness Measures											
Taxa Richness	Decrease	20.3	25.0	20.3	24.3	19.3	21.7	22.3	21.7	19.7	22.0
EPT Taxa	Decrease	7.7	8.7	8.7	9.3	7.3	9.3	7.0	8.7	7.3	7.3
Ephemeroptera Taxa	Decrease	2.3	3.3	2.3	3.0	2.0	3.3	2.0	3.0	2.7	2.3
Plecoptera Taxa	Decrease	0.3	1.0	0.0	0.7	1.0	1.3	0.0	0.3	0.0	0.0
Trichoptera Taxa	Decrease	5.0	4.3	6.3	5.7	4.3	4.7	5.0	5.3	4.7	5.0
Diptera Taxa	Decrease	2.0	3.3	1.0	2.3	2.7	1.7	1.7	2.3	1.0	1.7
Coleoptera Taxa	Increase	1.0	1.3	0.7	1.0	1.0	1.0	1.3	0.7	0.7	1.0
Non-Insect Taxa	Increase	7.7	9.7	8.3	9.7	6.3	7.7	10.3	8.0	8.7	10.0
Shannon Diversity	Decrease	1.6	2.2	2.0	1.9	1.8	1.8	2.0	2.0	2.1	1.9
Total Est. Abundance	Decrease	14226	13360	9589	24470	22421	11132	8120	18175	5529	6429
Density (Indiv./ft^2)		1581	1484	1065	2719	2491	1237	902	2019	614	714
Composition Measures											
EPT Index (%)	Decrease	73.0	40.7	63.8	17.9	68.5	75.6	35.7	64.9	47.1	31.0
% Baetidae	Increase	2.8	3.5	0.4	0.5	3.8	4.9	0.9	0.5	0.3	1.4
% Hydropsychidae	Decrease	23.2	11.5	14.9	8.1	43.8	40.3	6.4	27.2	5.9	3.0
% Chironomidae	Increase	7.7	13.4	7.0	27.3	7.1	4.3	3.5	11.3	5.6	3.7
% Diptera	Increase	8.1	13.9	7.0	27.7	7.5	4.4	3.6	11.6	5.6	3.7
% Dominant Taxon	Increase	52.2	27.1	52.2	41.3	43.8	41.7	36.5	35.6	33.7	42.0
% 3 Dominant Taxa	Increase	77.3	60.1	77.3	68.0	73.5	74.8	67.5	63.6	64.4	69.6
% 5 Dominant Taxa	Increase	88.6	75.5	88.6	81.5	86.4	85.6	78.1	83.3	76.1	81.4
EPT : Chironomidae	Decrease	13.1	5.4	9.8	0.8	10.7	20.1	13.3	6.9	8.6	11.7
% Non-Insect	Increase	15.3	40.0	25.8	50.1	17.9	15.2	57.7	13.7	41.4	61.7
Tolerance/Intolerance Measures											
Sensitive EPT Index	Decrease	1.1	0.4	2.1	0.2	1.4	1.3	0.1	12.1	3.0	0.1
% Intolerant (CVT<3) [1]	Decrease	1.1	0.4	2.1	0.2	1.4	1.3	0.1	12.0	3.0	0.1
% Tolerant (CVT>7) [1]	Increase	10.6	30.2	12.9	30.3	9.6	9.8	43.7	8.4	17.5	47.9
Tolerance Value	Increase	4.6	5.6	4.8	6.1	4.6	4.5	6.1	4.5	4.9	6.2
Functional Feeding Group											
% Collector-gatherer	Increase	21.8	40.4	22.4	63.1	20.7	19.6	44.2	19.8	36.2	53.2
% Collector-filterers	Increase	25.8	19.7	16.5	10.7	51.8	42.5	14.5	29.8	8.8	7.3
% Gatherer + Filterers	Increase	47.6	60.1	38.9	73.8	72.5	62.1	58.7	49.5	45.0	60.5
% Scrapers	Variable	50.3	33.0	56.4	19.8	26.3	34.7	38.7	47.2	47.4	36.2
% Scrapers (no Gastropods)	Decrease	49.6	28.2	50.5	11.7	26.3	33.8	29.7	46.5	44.9	28.5
% Predators	Variable	2.0	5.8	3.5	5.3	1.1	2.5	2.1	2.9	4.8	2.6
% Shredders	Decrease	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% Omnivore	Increase	0.1	0.1	1.4	0.1	1.0	1.3	0.2	1.3	1.0	0.1
Habitat Association											
% Burrower		14.0	16.8	14.3	15.1	22.6	9.1	22.6	16.6	23.7	30.8

[1] CTV = California Tolerance Value

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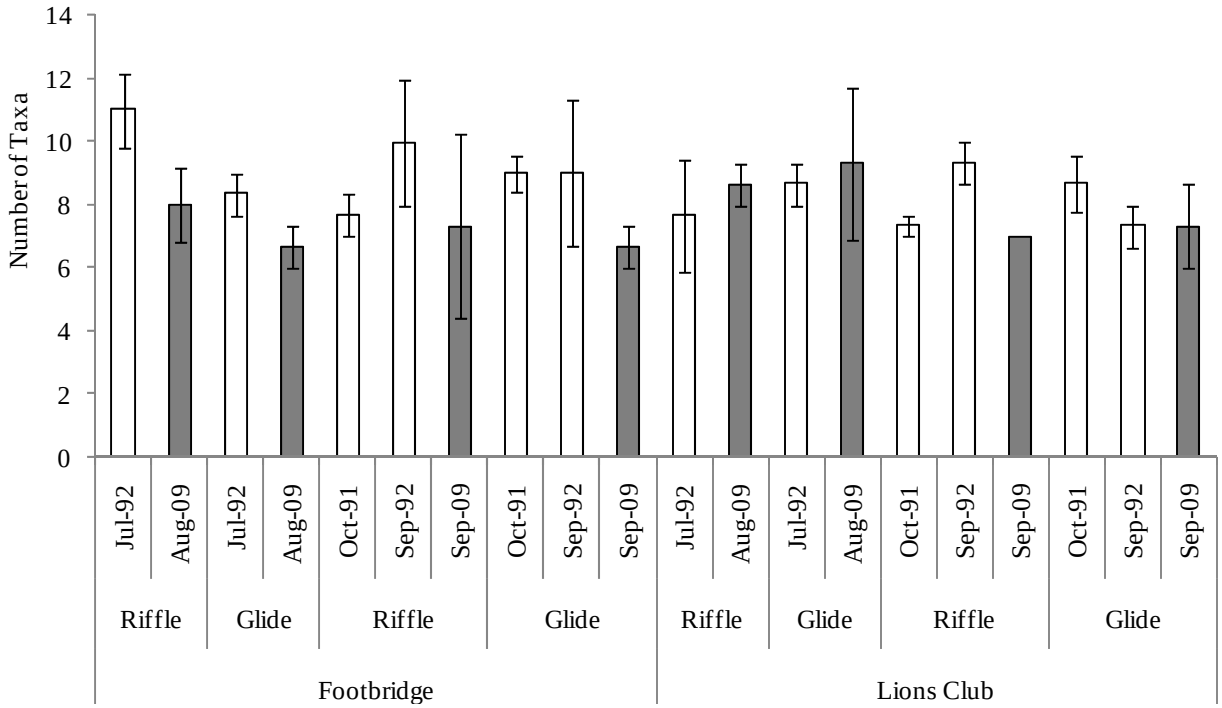

Figure 4.7 Mean (± 2 standard errors) number of EPT Taxa per Surber sample (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

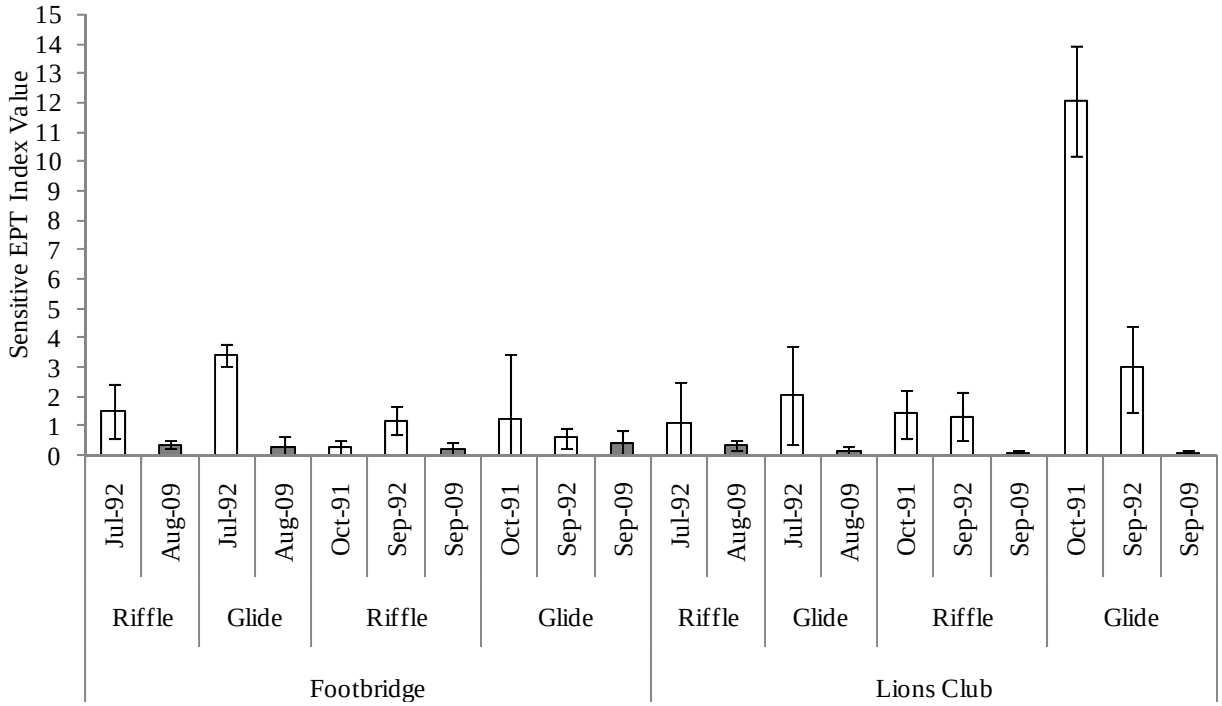

Figure 4.8 Mean (± 2 standard errors) Sensitive EPT Index values per Surber sample (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

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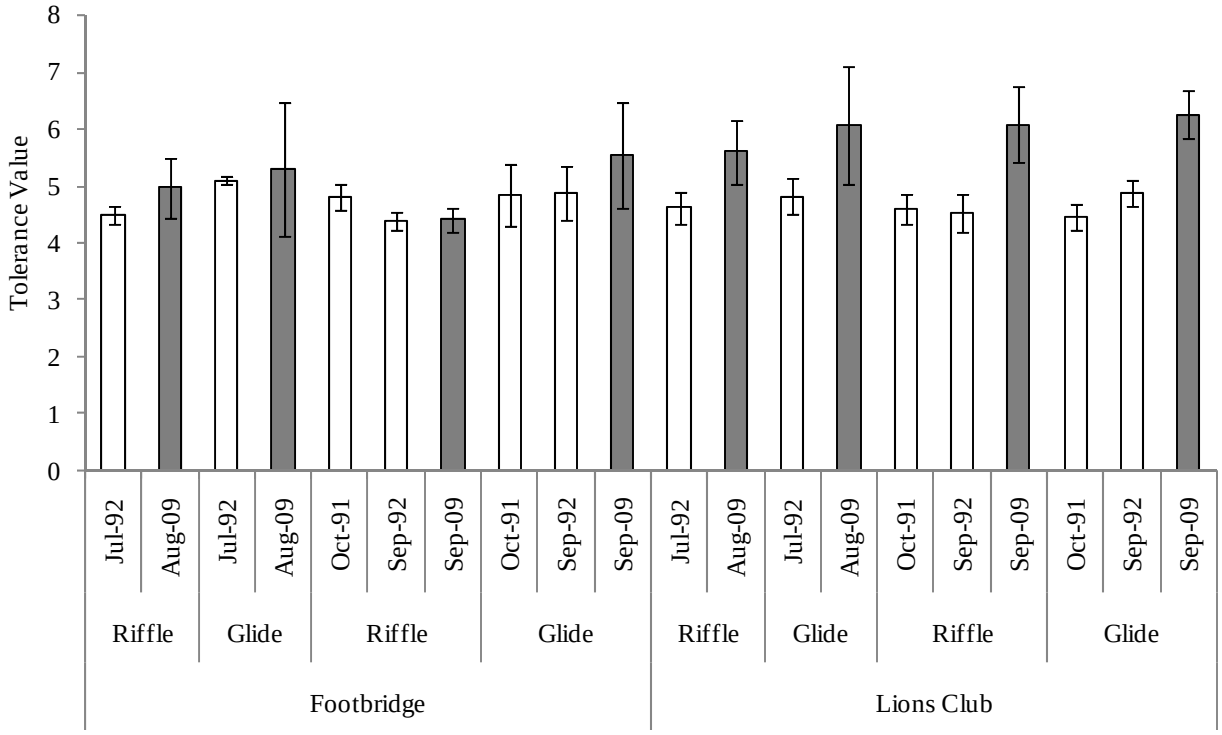

Figure 4.9 Mean (± 2 standard errors) Tolerance Value per Surber sample (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

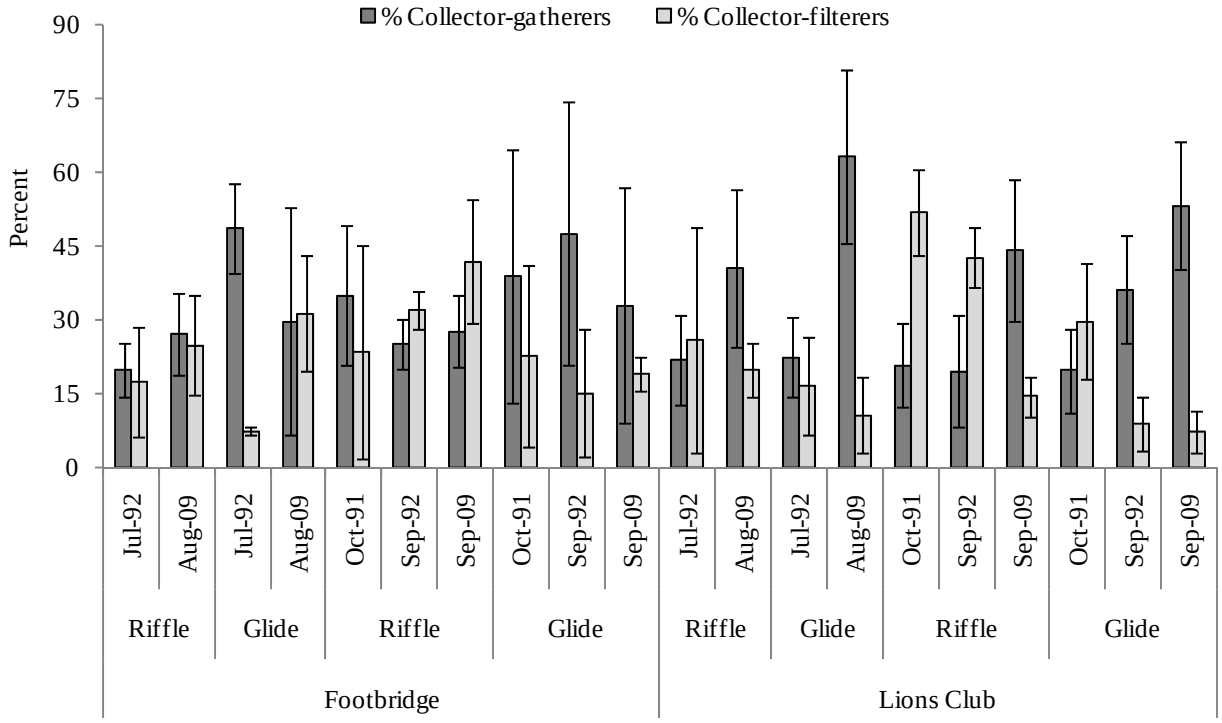

Figure 4.10 Mean (± 2 standard errors) percent composition of collector-gatherers and collector-filterers per Surber sample (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

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The percent collector-gatherers was variable at the Footbridge site, but was consistently higher at the Lions Club site in 2009 compared to 1992 (Figure 4.10). Collector-filterers were consistently higher at the Footbridge site and lower at the Lions Club site in 2009, as compared to 1992 (Figure 4.10). Overall functional feeding group metrics, however, showed an increase in the combined percent of collector-gatherers and collector-filterers, which generally indicates a less robust macroinvertebrate community.

All four multimetric indices (Mountain EMAP-W p=0.0002; NorCal IBI p<0.0001; Hydro IBI p<0.0001; and Hydro MMI p<0.0001) were significantly lower in 2009 as compared to 1991 and 1992 (Table 4.10, Figures 4.11 through 4.14). Tolerance Measures indicated a decline in the robustness of the macroinvertebrate communities in 2009 as compared to the early 1990s (Tables 4.8 and 4.9). Based on the lower intolerance and higher tolerance measures, functional feeding group metrics, and benthic multimetric indices, it appears that the macroinvertebrate communities in the Pit River may be more degraded now as compared to the early 1990s.

Table 4.10 Regional multimetric indices presented as the mean (± standard deviation) of all samples for each location and year (n=6 in 1991, n=12 in 1992 and 2009).

		Footbridge			Lions Club		
	Impaired Threshold	1991	1992	2009	1991	1992	2009
Mountain EMAP-W IBI	≤ 57	49 ± 1	51 ± 2	48 ± 4	47 ± 2	46 ± 3	30 ± 2
NorCal B-IBI	≤ 52	44 ± 2	44 ± 1	37 ± 1	38 ± 1	36 ± 0.2	35 ± 1
Hydro IBI		45 ± 4	46 ± 1	34 ± 2	39 ± 3	37 ± 2	27 ± 1
Hydro MMI		52 ± 5	55 ± 2	43 ± 4	45 ± 4	47 ± 3	30 ± 4

There were, however, significant differences between the two sampling locations with the Footbridge site having greater taxa richness (p=0.0093), Ephemeroptera richness (p=0.0026), Plecoptera richness (p=0.0656), and Diptera richness (p<0.0001) as compared to Lions Club. The Footbridge site also had significantly greater percent Baetidae (p=0.0055), percent Diptera (p=0.0189), and percent predators (p<0.0001) as compared to Lions Club. Lions Club had significantly greater total density (p=0.0144), non-insect richness (p=0.0063), tolerance value (p=0.0251), percent tolerant taxa (p<0.0001), percent non-insect taxa (p=0.0128), and percent omnivore taxa (p<0.0001) compared to the footbridge. Although mean densities of

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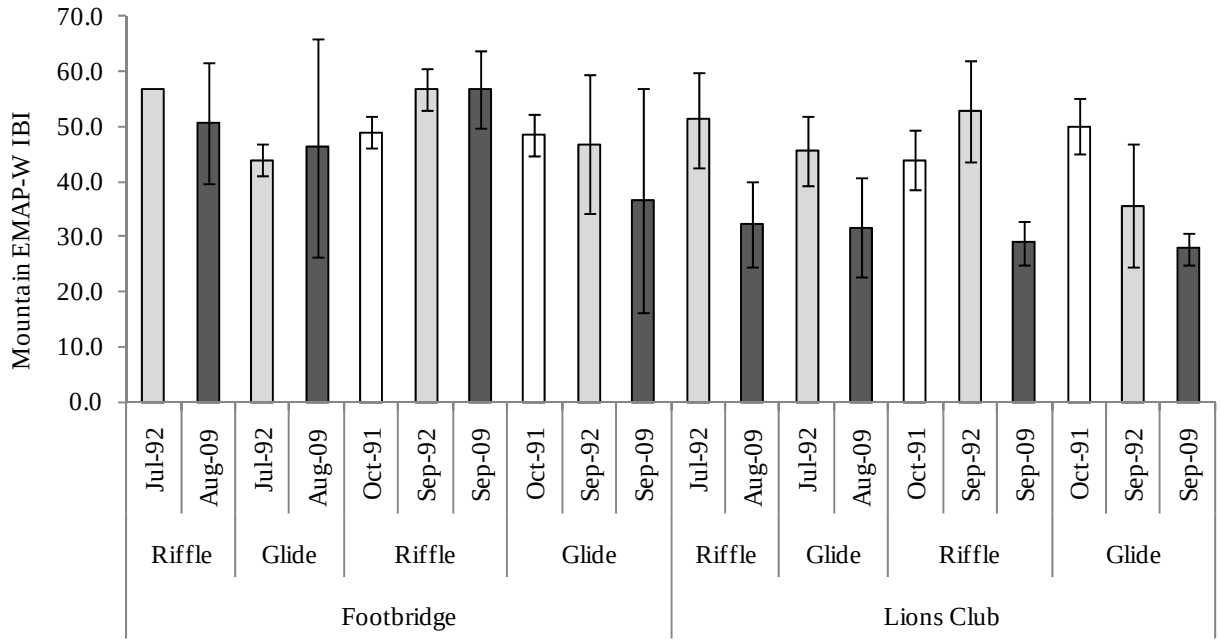

Figure 4.11 Mountain EMAP-W IBI (mean ± 2 standard errors) comparison for Surber samples (n=3) from above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992 and 2009.

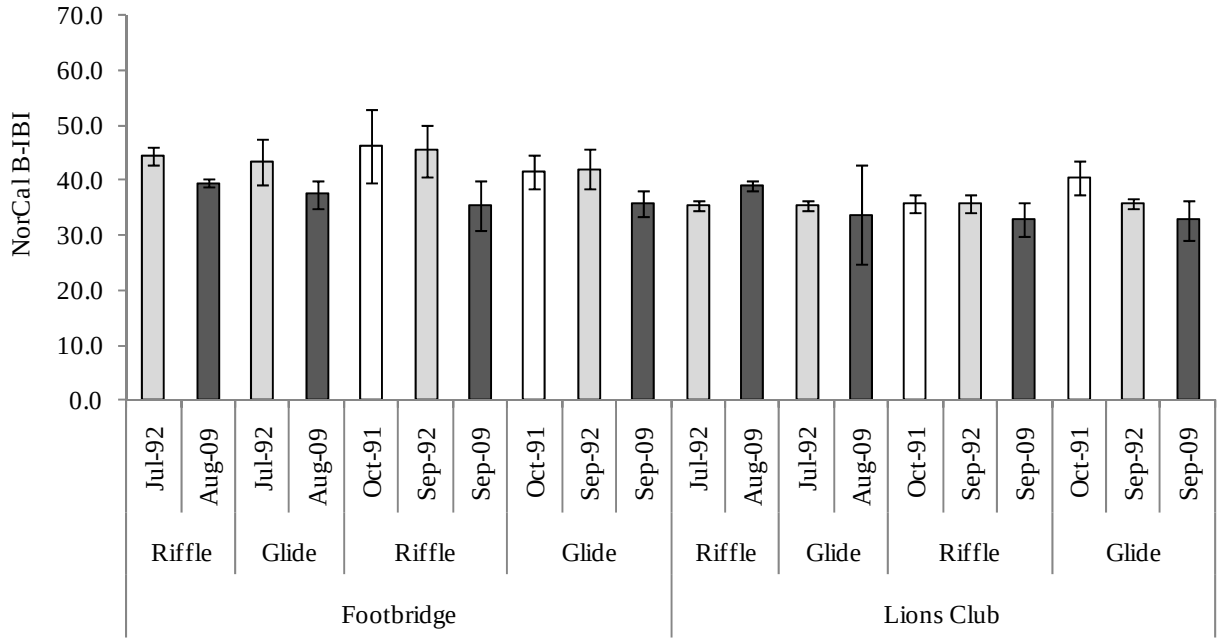

Figure 4.12 NorCal B-IBI (mean ± 2 standard errors) comparison for Surber samples (n=3) from above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992 and 2009.

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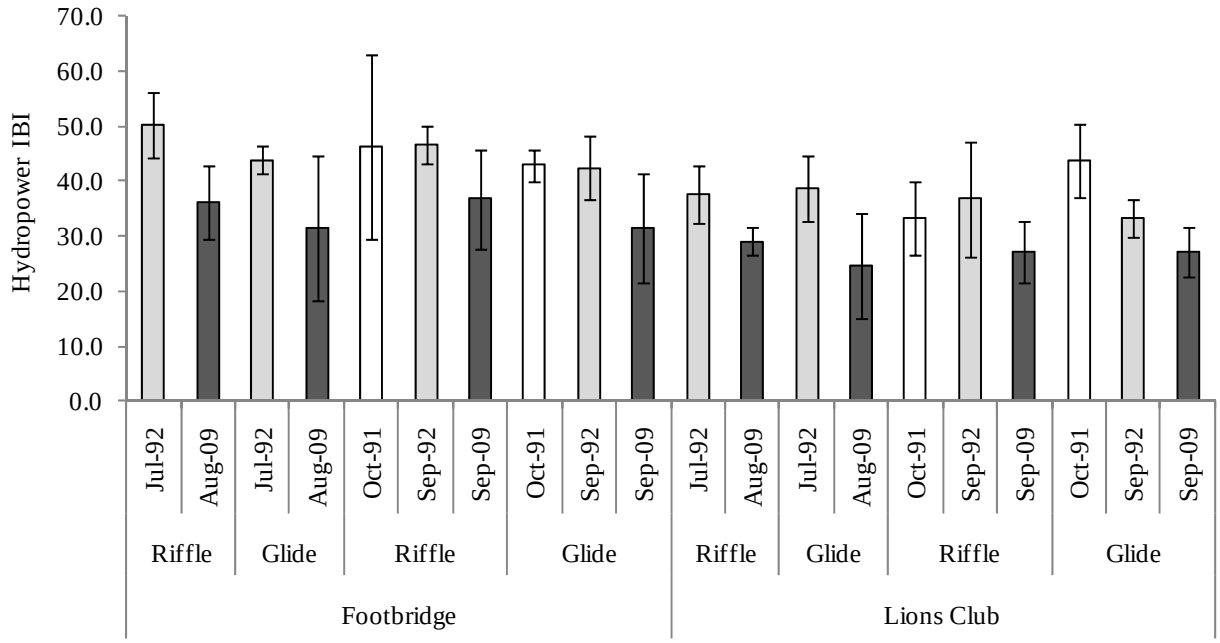

Figure 4.13 Hydropower IBI (mean ± 2 standard errors) comparison for Surber samples (n=3) from above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992 and 2009.

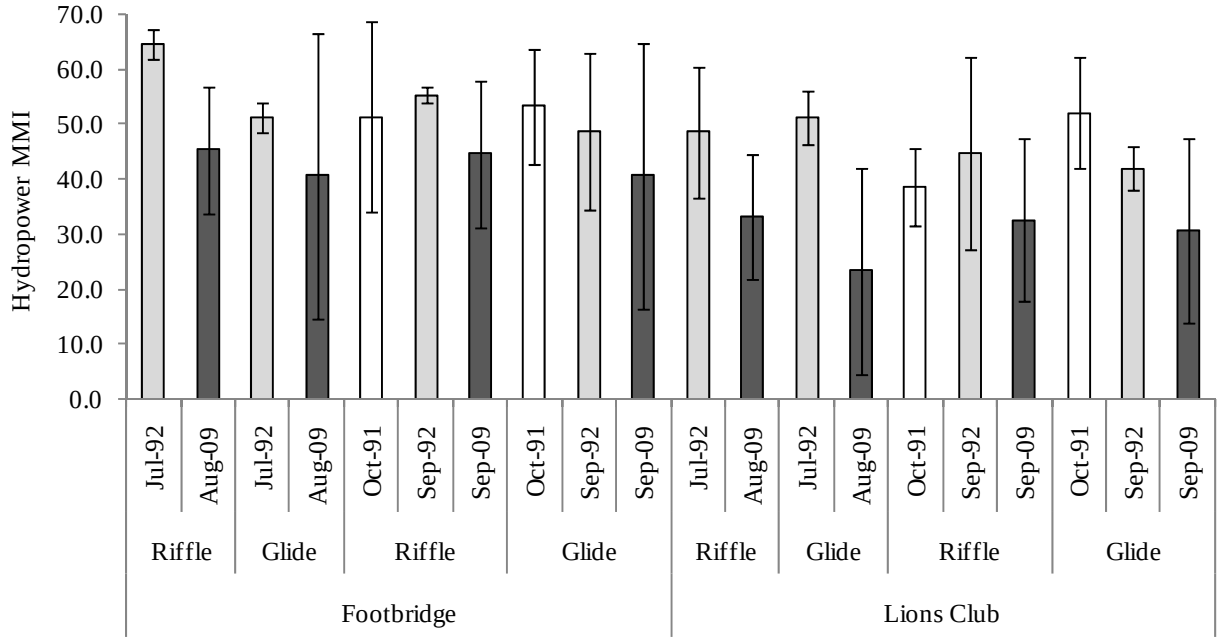

Figure 4.14 Hydropower MMI (mean ± 2 standard errors) comparison for Surber samples (n=3) from above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992 and 2009.

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Chironomidae decreased between the early 1990s and 2009 at the Footbridge site (Table 4.4), mean densities of Chironomidae increased at the Lions Club during summer 2009 as compared to 1992 (Table 4.5), particularly in the glide habitat. Non-insect taxa, such as the isopod family Asellidae, a taxon with a high tolerance value (CTV=8), were significantly higher at the Lions Club compared to the Footbridge ($p<0.0001$) and increased between 1991/1992 and 2009 ($p<0.0001$). Both Chironomidae and Asellidae are generally expected to increase as a response to impairment. The multimetric indices were lower and declined more between the early 1990s and 2009 at the Lions Club location as compared to the Footbridge location (Table 4.10, Figures 4.11 through 4.14).

Based on these benthic macroinvertebrate results, the condition of the Pit River appears to have declined since the early 1990s more downstream of the tailrace (Lions Club) than in the Pit 1 Bypass Reach (Footbridge).

4.3.1 Footbridge Benthic Macroinvertebrates

Analysis of the Surber sample data from the Footbridge location alone generally showed effects consistent with the combined data. Mean density of all benthic macroinvertebrates was significantly lower at the Footbridge site in 2009 as compared to both 1991 and 1992 ($p=0.0001$). At the Footbridge site, densities in 2009 (611 ± 73 organisms/ft^2) were generally approximately half the densities in 1991 (1112 ± 198 organisms/ft^2) and 1992 (1323 ± 106 organisms/ft^2). Mean densities of most of the more abundant taxa (Chironomidae, Hydropsychidae, Hydroptilidae) were lower in 2009 compared to 1991 and 1992 for all sampling dates at the Footbridge site (Table 4.4). At the Footbridge site, the percent Baetidae and Hydropsychidae was generally lower in 1992 than in 2009, while the percent Chironomidae was higher in 1992 than in 2009 (Table 4.8). There were significant year effects with decreased EPT taxa richness ($p=0.0015$), Tricoptera taxa richness ($p<0.0001$), sensitive EPT Index ($p=0.0006$), and percent intolerant taxa ($p=0.0032$) in 2009 (Figures 4.7 and 4.8). The reverse trend was observed for non-insect taxa richness ($p<0.0001$) and percent tolerant taxa ($p=0.0004$), which were greater in 2009. Mean EPT taxa richness was significantly lower in 2009 as compared to 1992; 1991 was not significantly different from either 2009 or 1992. Mean Tricoptera taxa richness was significantly lower in 2009 as compared to 1991 and 1991 was significantly lower than 1992. Sensitive EPT index and percent intolerant taxa were significantly lower in both

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2009 and 1991 compared to 1992. Non-insect taxa were significantly higher in 2009 and 1992 as compared to 1991 and percent tolerant taxa was significantly higher in 2009 as compared to both 1991 and 1992.

Two multimetric indices (NorCal IBI $p<0.0001$; Hydro IBI $p=0.0012$) at the Footbridge were significantly lower in 2009 as compared to both 1991 and 1992 (Figures 4.12 and 4.13). The Hydro MMI ($p=0.0576$) also had a lower value in 2009 as compared to 1991 and 1992 (Figure 4.14, Table 4.10). Based on these benthic macroinvertebrate results, the condition of the Pit 1 Bypass Reach in 2009 appears to have declined compared to 1992, but the trend is less clear or consistent than the Lions Club.

4.3.2 Lions Club Benthic Macroinvertebrates

Although generally consistent with the combined data, the pattern by year at the Lions Club location was often not consistent, with an increasing or decreasing trend from 1991, 1992, and 2009. At the Lions Club site, there was not a consistent trend in mean macroinvertebrate densities in 2009 (1455 ± 481 organisms/ft^2) as compared to 1992 (1124 ± 164 organisms/ft^2) and 1991 (2255 ± 348 organisms/ft^2) as shown in Figure 4.6. The mean densities of Chironomidae as well as total macroinvertebrates increased at the Lions Club, particularly in the glide habitat, during summer 2009 as compared to 1992 (Table 4.5, Figure 4.6). Mean densities of two of the more abundant taxa (Hydropsychidae $p<0.0001$; Hydroptilidae $p=0.0053$) and the percent Hydropsychidae ($p<0.0001$) were significantly lower in 2009 compared to 1991 and 1992 at the Lions Club site (Tables 4.5 and 4.9). The percent Hydropsychidae was significantly smaller in 2009 compared to 1992, and 1992 was significantly smaller than in 1991 (Tables 4.7).

There were significant year effects with increased taxa richness ($p=0.0034$), non-insect taxa richness ($p<0.0001$), tolerance value ($p<0.0001$), percent tolerant taxa ($p<0.0001$), percent non-insect ($p<0.0001$), percent collector-gathers ($p<0.0001$), and percent shredders ($p=0.0006$) in 2009 (Figures 4.7 and 4.10). The reverse trend was observed for EPT Index ($p<0.0001$), sensitive EPT Index ($p<0.0001$), percent Hydropsychidae ($p<0.0001$), percent intolerant taxa ($p<0.0001$), and percent collector-filterers ($p<0.0001$), which were smaller in 2009 (Figures 4.7 and 4.8). Non-insect taxa richness was significantly greater in 2009 as compared 1992, and 1992 was significantly greater than 1991. The tolerance value (Figure 4.9), percent tolerant taxa,

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percent non-insect, percent collector-gathers, and percent shredders were significantly greater in 2009 as compared to both 1992 and 1991. The EPT Index was significantly lower in 2009 as compared to both 1992 and 1991. The sensitive EPT Index, percent Hydropsychidae, percent intolerant taxa, percent collector-filterers was significantly lower in 2009 as compared 1992, which was significantly lower than 1991.

Three multimetric indices (Mountain EMAP-W $p<0.0001$; Hydro IBI $p=0.0003$; and Hydro MMI $p=0.0031$) at the Lions Club were significant in the model. The Mountain EMAP-W, Hydro IBI, and Hydro MMI were significantly lower in 2009 as compared to both 1992 and 1991 (Figures 4.11 through 4.14). The NorCal IBI was significantly lower in 2009 as compared to 1991; 1992 was not significantly different from either 2009 or 1991 (Table 4.10). Based on these benthic macroinvertebrate results from the Lions Club, the condition of the Pit River downstream of the Pit 1 Powerhouse in 2009 appears to have declined compared to the early 1990s.

4.4 Regional Comparisons

In order to assess the current condition of the Pit River within the study area, comparisons were made with other studies and rivers within the region. Studies within the Pit River drainage are the most comparable because the geological and hydrological conditions are similar. The geological and hydrological conditions in the Pit River render it sufficiently different from other rivers. The only major river draining the Modoc Plateau, the Pit River upstream of the confluence with Fall River is a runoff-dominated river with a substantial snowmelt component from the Warner Mountains. Through its course across the Modoc Plateau from Goose Lake down to Fall River, the Pit River loses water to percolation or groundwater recharge (MacDonald 1966, Norris and Webb 1990). The character of the Pit River, however, changes significantly at the confluence of the Fall River. Large, high-volume springs are formed at the edge of the Modoc Plateau where the porous, highly fractured, volcanic rock layer rests on top of a layer of impermeable lacustrine deposits (Norris and Webb 1990). Springs associated with the Fall River system collectively produce a nearly constant discharge of more than 1,000 cfs. Spring accretion of more than 100 cfs occurs within the canyon section of the Pit 1 Bypass Reach. Additional springs, including high-volume springs in Hat Creek (i.e., Rising River and Big Spring) and

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Burney Creek, enter the Pit River downstream of the study area. Collectively, the Fall River, Hat Creek, and other springs in the midreaches of the Pit River drainage are one of the largest freshwater spring systems in the United States (Meinzer 1927). The spring-dominated base flow in the Pit River is larger than that of any other river in California.

The only other known macroinvertebrate study within the Pit River was done by GANDA (2001) during the relicensing of PG&E's Pit 3, 4, and 5 Hydroelectric Project (FERC No. 233). Densities found at both the Footbridge (611 ± 73 organisms/ft2) and Lions Club (1455 ± 481 organisms/ft^2) locations in 2009, which were generally lower than the densities found in the early 1990s, were of similar magnitude to those found in the Pit River downstream of the Pit 1 Project. Mean macroinvertebrate densities in the Pit 3, 4, and 5 reaches were estimated to be approximately 900 organisms/ft^2 in 2000 (GANDA 2001).

Regional multimetric indices offer a means of assessing the biological condition of rivers within a region. Several caveats should be recognized, however, before the scores from the multimetric indices in the Pit River are compared to regional thresholds of impairment. In order to directly compare the Pit River scores with the regional thresholds of impairment, the field methods, sample sizes, and taxonomic levels should be the same as those used to develop each index (Ode et al. 2008). Because the primary objective of the current study was to compare the Pit River macroinvertebrate communities under pre- and post-license flow conditions, however, the chosen field methods, sample sizes, and taxonomic levels were the ones used during the 1991–1992 macroinvertebrate study (McElravy 1993). Differences in the taxonomic effort used in the current study (family level) with the ones used to determine the regional thresholds for impairment (genus level in most cases) makes direct comparisons less appropriate unless the metric scoring scales are adjusted to account for differences in taxonomic effort (Rehn 2010).

The only benthic multimetric index developed for an ecoregion that includes the Pit River drainage is the Mountain EMAP-W IBI, which was developed for rivers throughout all the mountainous areas of twelve western states (i.e., Arizona, California, Colorado, Idaho, Montana, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming) (Stoddard et al. 2005a). An EPT scoring range established from reference site data combined across such a large spatial extent will not necessarily reflect local reference conditions (Ode et al. 2008). This

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would likely be the case for the Pit River drainage because the geological and hydrological conditions are sufficiently different from other rivers. The scoring ranges established for other ecoregions, such as northern California coast streams (NorCal B-IBI), would be even less likely to reflect local reference conditions in the Pit River drainage.

As an example, the scoring range for the number of EPT taxa, which is a nearly ubiquitous metric in multimetric indices (Karr and Chu 1999), is known to vary among regions (Ode et al. 2008). Invertebrate taxa richness in streams draining mountainous regions of California (Coast Range Mountains and Sierra Nevada) is higher than streams draining other mountainous regions in the western USA (Vinson and Hawkins 1996). The level of taxonomic effort would also affect the multimetric index score resulting in underscoring of richness measures. For instance, EPT taxa richness, which was used in all four multimetric indices (ET taxa richness in Hydropower IBI), would increase with greater taxonomic effort. Identification to genus or species level increases the number of taxa (i.e., the number of species is greater than the number of genera, which is greater than the number of families) resulting in higher EPT taxa richness and higher multimetric index scores. In the case of the percentage metrics, differences in taxonomic effort could result in either underscoring or overscoring (see Table 6 in Rehn 2010).

Understanding the above caveats and acknowledging that the Pit River was likely underscored because identification was to family, the Pit River multimetric indices were compared to regional thresholds for impairment. Based on the thresholds used for the ecological assessment of western streams and rivers in the mountain ecoregion (Stoddard et al. 2005b), the Mountain EMAP-W IBI in the least-disturbed rivers was greater than or equal to 71 (upper 25th percentile). The Mountain EMAP-W IBI in the most-disturbed rivers was less than 57 (lowest 5th percentile). Based on the Mountain EMAP-W IBI thresholds, the Pit River would classify as a most-disturbed river for both locations in 2009 as well as in 1992 and 1991 (Table 4.10).

The only regional index of biotic integrity developed for northern California is the NorCal B-IBI, which is for the northern coastal California region that drains directly west to the Pacific Ocean from Marin County in the south to the Oregon border in the north (Rehn et al. 2005) and does not include the Pit River drainage. The threshold for determining impaired waters used for the ecological assessment of northern California coastal streams and rivers was two standard

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deviations below the mean reference site, which was a B-IBI score of 52 (Rehn et al. 2005). Using this threshold, only 6% of the mapped, wadeable, sampleable stream length in northern coastal California is impaired (Rehn et al. 2005). Based on the NorCal B-IBI threshold, the Pit River would classify as a most-disturbed river for both locations in 2009 as well as in 1992 and 1991.

The two multimetric indices, the Hydropower IBI and the earlier Hydropower MMI, were developed to assess biological conditions below hydropower diversion dams on west slope Sierra Nevada streams (Rehn 2010, Rehn 2005 in GANDA 2006) south of the Pit River drainage. At the northern border of the Sierra Nevada, it is not unreasonable to consider the Pit River drainage within the region of these indices. Both the Footbridge and Lions Club locations are below hydropower diversion dams (i.e., Pit 1 Diversion Dam) as well as the Pit 1 Forebay Dam, Fall River Weir, and Pit River Weir. Both locations are also further affected by hydropower operations. In the Pit 1 Bypass Reach, the Footbridge location has reduced flows and has had pulsed flows three times a summer since 2003[1]. Downstream of the Pit 1 Powerhouse, the flows at the Lions Club location fluctuate with powerhouse operations. Both locations are several miles downstream of a diversion dam, however, and the hydropower indices show partial habitat recovery as distance downstream from the dam increases. Furthermore, the dams included in the study (Rehn 2010) were non-peaking unlike the Pit River downstream of the Pit 1 Powerhouse. The hydropower indices had lower scores (greater degree of alteration from original state) shorter distances below dams, and were most strongly associated with altered stream flows, especially consistent flow levels (Rehn 2010). The reference sites used for the Rehn (2010) study had a mean Hydropower IBI value of 80. The mean Hydropower IBI value was about 33 immediately downstream of the dams and about 60 two kilometers downstream from the dams (Rehn 2010). In the Pit River, the mean Hydropower IBI value was between 27 (Lions Club in 2009) and 46 (Footbridge in 1992, Table 4.10).

The mean Hydropower MMI scores from the Pit River were between 30 (Lions Club in 2009) and 55 (Footbridge in 1992, Table 4.10). These scores are quite comparable to the Hydropower

[1] There were only two flushing flows in the summer of 2003 because the August flushing flow was cancelled due to a major levee failure.

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MMI scores from the North Fork Feather River, which is the drainage that is probably most similar to the Pit River. The mean Hydropower MMI scores from kick samples in the Rock Creek Reach (with recreation streamflow releases) were between 30 and 38 and between 36 and 49 in the Belden Reach (no recreation streamflow releases) (GANDA 2006).

4.5 Invasive Species

Two invasive invertebrate species known to occur in the study area, the signal crayfish (*Pacifastacus leniusculus*) and the Asian clam (*Corbicula fluminea*), are both more abundant in 2009 as compared to 1992 (Ellis personal observation). In both 1992 and 2009, zero to two signal crayfish were collected per Surber sample. In 1992, 4 of 24 Surber samples collected crayfish, while 7 of 24 Surber samples collected crayfish in 2009. Although the number of samples with crayfish is higher in 2009 than in 1992, no conclusions should be drawn. Surber samplers are not the best method to sample signal crayfish abundance or density. Since they are capable swimmers they are not necessarily swept into the net and can instead escape.

Asian clams, which were not collected and had yet to be discovered in the reach in 1992, were present at both sites in 2009. Asian clams can alter benthic substrates (Sickel 1986) and compete with native species for limited resources (Devick 1991). They would most likely compete with other collector-filterers, such as native Sphaeriid clams and Hydropsychidae caddisflies for food (e.g., zooplankton) and habitat. A comparison of densities provided not enough information on the effects of Corbiculidae on the other two species. At the Footbridge site, where Corbiculidae densities were higher than at the Lions Club site in 2009, Sphaeriidae densities were lower in 2009 compared to 1992. At the Lions Club site, Sphaeriidae densities were higher in 2009 compared to 1992 despite the presence of Corbiculidae (Figure 4.15). Hydropsychidae densities were lower for nearly all sampling dates in 2009 compared to 1992, but it is not known whether that was the result of the presence of Corbiculidae in 2009 (Figure 4.16).

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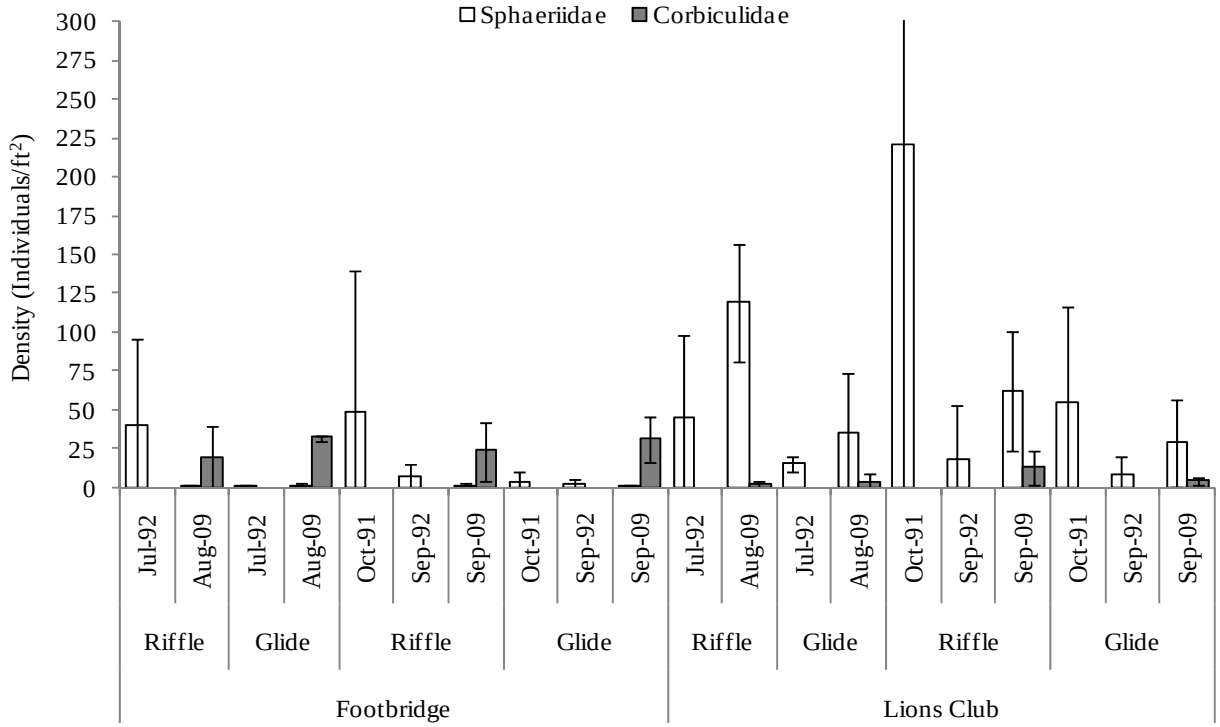

Figure 4.15 Mean (± 2 standard errors) density of the taxa Sphaeriidae and Corbiculidae in Surber samples (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

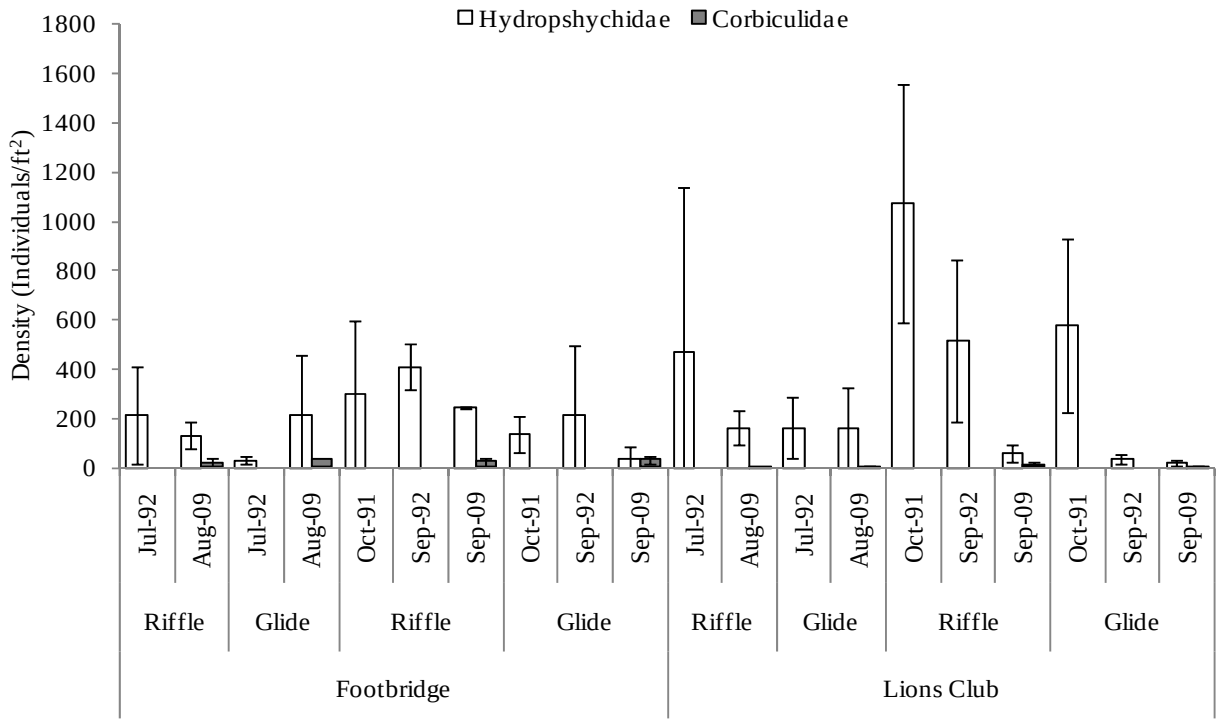

Figure 4.16 Mean density (± 2 standard errors) of the taxa Hydropsychidae and Corbiculidae in Surber samples (n=3) above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991, 1992, and 2009.

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4.6 Conclusions

The introduction of a new invasive invertebrate species, the Asian clam (*Corbicula fluminea*), to the midreaches of the Pit River drainage has undoubtedly changed trophic interactions and substrate characteristics in the study area. The increased abundance of non-native invasive signal crayfish (*Pacifastacus leniusculus*), likely facilitated by dispersal during the summer pulsed flows, has also changed the macroinvertebrate community since the early 1990s (Ellis personal observation).

Discharge through the Pit 1 Bypass Reach is higher under the current license than during the previous license due to minimum instream flow releases, which have reduced the retention time of water in this section, especially for the Big Eddy section. The Bypass Reach also has had three pulsed flows per summer since 2003[1]. Zooplankton production in the slow flowing Big Eddy section has likely been reduced due to the additional flow, which, among other possible factors, may help explain the lower density of zooplankton at the Footbridge site in 2009 than in 1992. The high number of non-native filter-feeding Corbiculidae (personal observation) observed upstream of the Pit 1 Falls may also be a factor. Based on the benthic macroinvertebrate results from this study, the condition of the Pit 1 Bypass Reach in 2009 appears to have declined compared at least with 1992.

The Pit River downstream of the Pit 1 Powerhouse tailrace has higher minimum flows and more gradual ramping rates under the current license, which has reduced the amount of flow fluctuation and largely eliminated the dewatering that occurred under the previous license. Despite these changes, the macroinvertebrate community as measured at the Lions Club site below the Pit 1 Powerhouse under the current license appears to be more degraded now as compared to the early 1990's, based on the data collected by the 1993 study and this study. The reduced peaking, more run-of-the-river conditions under the current license may be more conducive to tolerant, but less hydrodynamic taxa such as isopod crustaceans (Family Asellidae). The difference in condition of the Pit River between 2009 and 1991-1992 is more distinct

[1] There were only two flushing flows in the summer of 2003 because the August flushing flow was cancelled due to a major levee failure.

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downstream of the Pit 1 Powerhouse at the Lions Club site and is less clear or consistent upstream of the powerhouse at the Footbridge site.

In 2009, zooplankton density was higher at the Lions Club compared to the Footbridge location. During spring and autumn sampling, McElravy (1993) observed substantial numbers of zooplankton (and Chironomidae) drifting into the Pit River via the Pit 1 Tailrace, which he speculated originated in Fall River Lake. This higher zooplankton density at the Lions Club compared to the Footbridge location may also be due to an influx from Fall River Lake.

The following caveats should be recognized before the multimetric indices for the Pit River are compared to regional thresholds of impairment: (1) the field methods, sample sizes, and taxonomic levels should be the same as those used to develop each index; (2) the specified region of the index is too broad and dissimilar to the Pit River in the case of the Mountain EMAP-W index; (3) the Pit River is not within the region of the northern California coastal stream index (NorCal B-IBI), which is the only regional index in northern California; (4) the hydropower multimetric indices were developed for use in non-peaking reaches a short distance downstream of diversion dams; and (5) the macroinvertebrate community in the Pit River is likely to differ from other rivers due to the unique geology and hydrology of the drainage. Understanding the above caveats and acknowledging that the Pit River was likely underscored because macroinvertebrate identification was to family, the biological condition of the Pit River does not appear to compare favorable to other western mountain rivers. The Pit River did score similarly on the Hydrologic MMI compared to the North Fork Feather River, which may be more similar to the Pit River in terms of dominant meteorological and hydrological conditions than most rivers.

Based on the macroinvertebrate results of this study and comparisons with McElravy's (1993) study in the early 1990s, including lower intolerance and higher tolerance measures, functional feeding group metrics and benthic multimetric indices, it appears that the macroinvertebrate communities in the Pit River has not improved and may actually be more degraded under the new flow regime.

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Appendix A—ECORP Consulting, Inc.'s QA/QC procedures for macroinvertebrate processing and identification.

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ECORP Consulting, Inc., Bioassessment Laboratory

QUALITY ASSURANCE (QA) PROCEDURES

(revision date – February 10, 2007)

QA for the Laboratory

Samples arriving at the ECORP Consulting, Inc., Bioassessment Laboratory (Bioassessment Laboratory) are compared with the list of samples provided in the chain-of-custody (COC) form that must accompany all samples. A Laboratory Number is then assigned to each sample, and is recorded on the COC along with the name and address of the Bioassessment Laboratory. When all samples have been accounted for, the client must sign the "Released By" portion of the COC and the laboratory signs the "Received By" portion of the form. The original COC remains in the laboratory and a copy is provided to the client. Additional copies are also placed into the ECORP Consulting, Inc. project file and lab files.

All sorters are checked on all processed samples until five samples processed consecutively pass a 10% QA. Following five consecutive passes, subsequent QA checks are conducted on 1 out of every 10 samples as long as each of the QA samples passes. If one of these 10 fails, the initial QA procedures are repeated. The QA verification is conducted by the Laboratory Supervisor using sample remnants.

Taxonomy Validation

Based on SWAMP recommendations, a 10% bioassessment validation is conducted for whole samples of 300 (or more) identified BMIs using randomly selected samples from each project. ECORP Consulting, Inc. contracts with the CDFG Water Pollution Control Laboratory to verify BMI identification. Ten to twenty percent of the identified samples are randomly chosen and sent to CDFG for taxonomic verification depending upon project contractual obligations. CDFG then provides a QA report to the Bioassessment Laboratory with the results.

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Appendix B—Master taxa list for macroinvertebrates collected in drift samples in 2009.

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Table B-1 Master taxa list for macroinvertebrates collected in drift samples above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 2009.

			August 2009						September 2009					
			Footbridge			Lions Club			Footbridge			Lions Club		
Taxa	CTV	FFG	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3
ARTHROPODA														
INSECTA														
Coleoptera														
Elmidae (Aq.)	4	cg	0	1	0	1	0	0	1	0	0	0	0	0
Elmidae (Terr.)	4		0	0	0	0	0	0	1	0	0	0	0	0
Diptera														
Ceratopogonidae	6	p	1	0	0	1	0	0	0	0	0	0	0	0
Chironomidae (Aq.)	6	cg	85	69	109	97	117	88	152	178	97	64	56	206
Chironomidae (Terr.)	6		9	12	13	14	26	14	24	39	14	1	0	5
Empididae	6	p	1	0	0	0	0	0	0	1	0	1	0	1
Psychodidae		cg												
Simuliidae (Aq.)	6	cf	6	1	10	4	2	3	5	5	0	0	1	1
Simuliidae (Terr.)	6													
Tipulidae (Aq.)	3	p	3	0	2	0	0	0	4	0	0	0	0	1
Ephemeroptera														
Baetidae (Aq.)	4	cg	16	17	34	19	5	7	56	92	42	14	24	36
Baetidae (Terr.)	4		0	0	1	0	0	0	0	0	0	0	0	0
Heptageniidae	4	sc	1	1	0	2	3	1	3	2	5	2	0	4
Leptohyphidae	4	cg	4	2	4	0	0	1	5	10	3	0	0	1
Tricorythidae (Aq.)		cg												
Tricorythidae (Terr.)														
Ephemeroptera (Terr.)			2	0	0	0	0	0	0	1	0	0	0	0
Hemiptera														
Homoptera			0	0	0	0	0	1	0	0	0	0	0	0
Cicadellidae			0	0	0	0	0	0	1	0	0	0	0	0
Lepidoptera			1	0	0	0	0	0	0	2	1	0	0	5
Pyralidae	5	sc	4	0	2	2	2	1	2	0	3	5	5	6
Odonata		p	0	0	0	0	1	1	0	0	0	0	0	0
Coenagrionidae		p	0	0	0	0	0	0	0	0	0	0	1	0

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Table B-1 Continued

			August 2009						September 2009					
			Footbridge			Lions Club			Footbridge			Lions Club		
Taxa	CTV	FFG	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3
Plecoptera			0	0	0	0	1	0	0	0	0	0	0	0
Nemouridae	2	sh	0	0	0	1	0	0	0	0	0	0	0	0
Perlidae	1	p												
Trichoptera			0	0	0	1	0	1	0	0	1	0	0	0
Brachycentridae	1	cf												
Hydropsychidae (Aq.)	4	cf	3	8	17	15	7	6	11	9	10	11	20	29
Hydroptilidae (Aq.)	4	sc	56	38	82	5	16	12	39	56	42	14	9	14
Hydroptilidae (Terr.)	4													
Lepidostomatidae	1	sh	0	0	0	0	1	0	0	0	0	0	0	0
Leptoceridae	4	om	0	0	0	0	2	0	0	0	0	0	0	0
Philopotamidae (Terr.)	3		0	0	0	0	0	1	2	0	0	0	0	0
Polycentropodidae	6	p	0	0	0	1	0	0	0	0	0	0	0	0
Psychomyiidae (Aq.)	2	sc	0	0	0	2	1	2	0	0	0	2	2	3
Rhyacophilidae	0	p	0	0	0	1	0	1	0	1	0	0	0	1
ARACHNOIDEA														
Acari (Hydracarina)	5	p	9	10	12	18	19	21	85	109	46	10	18	56
BRANCHIOPODA														
Cladocera			0	0	0	13	8	2	0	0	0	3	1	7
MALACOSTRACA														
Amphipoda														
Hyalellidae	8	cg	0	1	0	1	0	0	0	0	3	0	0	3
Isopoda														
Asellidae	8	cg	3	1	1	3	2	0	3	6	2	0	1	4
MAXILLOPODA														
Copepoda			2	0	0	377	350	483	3	6	16	50	118	248
OSTRACODA	8	cg	0	0	0	0	0	0	0	1	0	0	0	1
CNIDARIA														
HYDROZOA														
Hydroida														
Hydridae	5	p	0	0	0	1	1	0	0	0	0	0	0	0

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Table B-1 Continued

			August 2009						September 2009					
			Footbridge			Lions Club			Footbridge			Lions Club		
Taxa	CTV	FFG	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3
MOLLUSCA														
GASTROPODA														
Pulmonata														
Planorbidae	6	sc	0	0	0	0	0	0	0	2	0	0	0	0
BIVALVIA														
Pelecypoda														
Corbiculidae	10	cf	1	0	0	0	2	0	0	0	2	0	0	2
Sphaeriidae	8	cf	0	0	0	2	1	0	3	0	0	0	0	2
ANNELIDA														
HIRUDINEA														
Erpbodellidae	8	p	1	0	0	0	0	0	0	0	1	0	0	0
OLIGOCHAETA	5	cg	37	24	57	43	43	18	11	13	18	34	13	43
POLYCHAETA														
Canalipalpata														
Sabellidae		cf	0	0	0	2	1	0	0	0	0	0	0	0
PLATYHELMINTHES														
TURBELLARIA														
Tricladida														
Planariidae	4	p	1	0	0	0	0	0	0	0	1	0	0	0
NEMATODA	5		0	0	0	0	0	0	0	0	0	0	0	2
TARDIGRADA		cg												
Total Estimated Abundance			246	185	344	626	611	664	411	533	307	211	269	681

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Appendix C—Master taxa list for macroinvertebrates collected in drift samples in 1992 (McElravy 1993).

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Table C-1 Master taxa list for macroinvertebrates collected in drift samples above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1992 (McElravy 1993).

			July 1992						September 1992					
			Footbridge			Lions Club			Footbridge			Lions Club		
Taxa	CTV	FFG	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3
ARTHROPODA														
INSECTA														
Coleoptera														
Elmidae (Aq.)	4	cg												
Elmidae (Terr.)	4													
Diptera														
Ceratopogonidae	6	p												
Chironomidae (Aq.)	6	cg	320	512	704	102	462	323	256	304	288	112	32	40
Chironomidae (Terr.)	6		16	21	0	26	128	96	16	24	16	0	16	8
Empididae	6	p												
Psychodidae		cg	0	0	0	0	0	0	0	0	32	0	0	0
Simuliidae (Aq.)	6	cf	0	0	0	0	0	0	16	16	0	0	0	0
Simuliidae (Terr.)	6													
Tipulidae (Aq.)	3	p	48	0	0	0	0	16	16	24	24	0	0	0
Ephemeroptera														
Baetidae (Aq.)	4	cg	0	107	64	64	128	96	112	72	408	0	8	40
Baetidae (Terr.)	4													
Heptageniidae	4	sc												
Leptohyphidae	4	cg												
Tricorythidae (Aq.)		cg	48	0	0	0	0	0	16	24	0	0	0	0
Tricorythidae (Terr.)			0	64	0	0	0	0	0	0	0	0	0	0
Ephemeroptera (Terr.)														
Hemiptera			16	0	0	0	0	0	0	0	0	0	0	0
Homoptera														
Cicadellidae														
Lepidoptera														
Pyralidae	5	sc	192	341	768	64	154	368	64	40	80	0	32	8
Odonata		p												
Coenagrionidae		p												

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Table C-1 Continued

			July 1992						September 1992					
			Footbridge			Lions Club			Footbridge			Lions Club		
Taxa	CTV	FFG	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3
Plecoptera														
Nemouridae	2	sh												
Perlidae	1	p	0	0	0	0	0	0	0	0	0	0	0	8
Trichoptera														
Brachycentridae	1	cf	0	21	0	0	0	0	0	0	0	0	0	0
Hydropsychidae (Aq.)	4	cf	160	128	448	243	384	336	40	8	64	16	40	56
Hydroptilidae (Aq.)	4	sc	128	149	512	77	0	49	24	48	144	0	16	16
Hydroptilidae (Terr.)	4		0	0	0	13	0	0	0	0	0	0	0	0
Lepidostomatidae	1	sh												
Leptoceridae	4	om	0	0	0	13	0	0	0	0	0	0	0	0
Philopotamidae (Terr.)	3													
Polycentropodidae	6	p												
Psychomyiidae (Aq.)	2	sc	0	0	0	0	0	48	0	0	0	32	0	8
Rhyacophilidae	0	p												
ARACHNOIDEA														
Acari (Hydracarina)	5	p	464	299	768	128	128	65	120	72	248	16	0	0
BRANCHIOPODA														
Cladocera			224	192	832	154	282	352	8	32	168	0	0	96
MALACOSTRACA														
Amphipoda														
Hyalellidae	8	cg												
Isopoda														
Asellidae	8	cg												
MAXILLOPODA														
Copepoda			352	661	1088	230	435	592	232	152	1720	0	0	344
OSTRACODA	8	cg	48	21	320	26	0	0	16	0	8	0	16	0
CNIDARIA														
HYDROZOA														
Hydroida														
Hydridae	5	p	0	0	0	0	0	16	0	0	0	0	0	8

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Table C-1 Continued

			July 1992						September 1992					
			Footbridge			Lions Club			Footbridge			Lions Club		
Taxa	CTV	FFG	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3
MOLLUSCA														
GASTROPODA														
Pulmonata														
Planorbidae	6	sc												
BIVALVIA														
Pelecypoda														
Corbiculidae	10	cf												
Sphaeriidae	8	cf												
ANNELIDA														
HIRUDINEA														
Erpbodellidae	8	p	0	0	0	0	0	16	0	0	0	0	0	0
OLIGOCHAETA	5	cg	272	555	704	64	308	176	172	360	384	80	24	96
POLYCHAETA														
Canalipalpata														
Sabellidae		cf	32	0	256	0	0	64	0	8	0	0	0	0
PLATYHELMINTHES														
TURBELLARIA														
Tricladida														
Planariidae	4	p												
NEMATODA	5		0	0	0	13	0	16	0	0	0	0	0	0
TARDIGRADA		cg	80	0	576	0	57	0	0	0	480	0	0	8
Total Estimated Abundance			2400	3071	7040	1217	2466	2629	1108	1184	4064	256	184	736

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Appendix D—Master taxa list for macroinvertebrates collected in drift samples in 1991 (McElravy 1993).

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Table D-1 Master taxa list for macroinvertebrates collected in drift samples above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991 (McElravy 1993).

			October 1991					
			Footbridge			Lions Club		
Taxa	CTV	FFG	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3
ARTHROPODA								
INSECTA								
Coleoptera								
Elmidae (Aq.)	4	cg						
Elmidae (Terr.)	4							
Diptera								
Ceratopogonidae	6	p						
Chironomidae (Aq.)	6	cg	31	52	22	10	21	11
Chironomidae (Terr.)	6		11	10	5	8	15	11
Empididae	6	p						
Psychodidae		cg						
Simuliidae (Aq.)	6	cf	1	3	0	1	0	0
Simuliidae (Terr.)	6		1	0	0	0	0	0
Tipulidae (Aq.)	3	p	0	4	0	0	0	0
Ephemeroptera								
Baetidae (Aq.)	4	cg	9	9	6	5	1	4
Baetidae (Terr.)	4		3	5	0	0	0	0
Heptageniidae	4	sc	1	1	0	0	0	0
Leptohyphidae	4	cg						
Tricorythidae (Aq.)		cg						
Tricorythidae (Terr.)			3	0	0	0	0	0
Ephemeroptera (Terr.)			0	0	0	0	0	1
Hemiptera								
Homoptera								
Cicadellidae								
Lepidoptera								
Pyralidae	5	sc	10	6	2	2	1	1
Odonata		p						
Coenagrionidae		p						

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Table D-1 Continued

			October 1991					
			Footbridge			Lions Club		
Taxa	CTV	FFG	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3
Plecoptera								
Nemouridae	2	sh						
Perlidae	1	p	0	0	0	1	0	0
Trichoptera								
Brachycentridae	1	cf	2	0	0	0	0	0
Hydropsychidae (Aq.)	4	cf	3	4	4	6	6	3
Hydroptilidae (Aq.)	4	sc	11	7	6	0	2	1
Hydroptilidae (Terr.)	4							
Lepidostomatidae	1	sh						
Leptoceridae	4	om						
Philopotamidae (Terr.)	3							
Polycentropodidae	6	p						
Psychomyiidae (Aq.)	2	sc	0	0	0	1	4	1
Rhyacophilidae	0	p						
ARACHNOIDEA								
Acari (Hydracarina)	5	p	2	0	0	0	0	0
BRANCHIOPODA								
Cladocera			0	1	0	0	0	0
MALACOSTRACA								
Amphipoda								
Hyalellidae	8	cg						
Isopoda								
Asellidae	8	cg	0	0	0	1	1	0
MAXILLOPODA								
Copepoda			2	3	0	0	0	0
OSTRACODA	8	cg						
CNIDARIA								
HYDROZOA								
Hydroida								
Hydridae	5	p						

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Table D-1 Continued

			October 1991					
			Footbridge			Lions Club		
Taxa	CTV	FFG	Net 1	Net 2	Net 3	Net 1	Net 2	Net 3
MOLLUSCA								
GASTROPODA								
Pulmonata								
Planorbidae	6	sc						
BIVALVIA								
Pelecypoda								
Corbiculidae	10	cf						
Sphaeriidae	8	cf						
ANNELIDA								
HIRUDINEA								
Erpbodellidae	8	p						
OLIGOCHAETA	5	cg	7	4	2	4	2	0
POLYCHAETA								
Canalipalpata								
Sabellidae		cf						
PLATYHELMINTHES								
TURBELLARIA								
Tricladida								
Planariidae	4	p						
NEMATODA	5							
TARDIGRADA		cg						
Total Estimated Abundance			97	109	47	39	53	33

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Appendix E—Master taxa list for macroinvertebrates collected in Surber samples in 2009.

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Table E-1 Master taxa list for macroinvertebrates collected in Surber samples at riffle (R) and Glide (G) habitat above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 2009.

			August 2009												September 2009											
			Footbridge						Lions Club						Footbridge						Lions Club					
Taxa	CTV	FFG	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3
ARTHROPODA																										
INSECTA																										
Coleoptera																										
Elmidae	4	cg	39	11	14	7	80	4	124	65	18	96	16	5	57	82	63	4	2	6	51	9	27	10	0	27
Psephenidae	4	sc	0	0	0	0	0	2	0	4	0	0	0	0	2	0	4	0	0	3	0	0	6	2	0	0
Diptera																										
Atherricidae	2	p	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	1	0	0	0	0	0	0	0	0
Blephariceridae	0	sc	12	6	2	4	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae	6	cg	119	84	152	44	234	158	1215	460	203	9906	162	635	42	25	21	9	9	32	180	46	77	38	111	67
Dolichopodidae	4	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Empididae	6	p	2	0	2	0	4	6	1	0	4	0	0	3	4	0	0	1	0	2	0	0	0	0	0	0
Psychodidae		cg	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Simuliidae	6	cf	0	13	0	3	0	0	0	1	4	0	0	0	0	3	24	0	0	0	0	0	0	0	0	0
Stratiomyidae	8	cg																								
Tabanidae	8	p																								
Tipulidae	3	p	8	14	2	3	0	0	44	12	0	96	3	9	2	0	0	0	0	0	5	2	0	2	0	0
Odonata																										
'Zygoptera'		p	0	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coenagrionidae		p	4	0	14	8	28	18	0	0	0	0	0	0	28	6	2	18	2	20	0	0	0	0	0	0
Gomphidae	4	p																								
Megaloptera																										
Sialidae	4	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Lepidoptera																										
Pyralidae	5	sc	119	74	194	4	150	191	56	97	220	791	42	104	2	38	4	210	34	208	55	27	65	40	39	119
Hymenoptera																										
Ichneumonidae			2	2	5	0	12	14	19	22	78	53	8	19	0	0	0	0	0	0	2	2	5	2	2	7
Ephemeroptera																										
Beatidae	4	cg	133	147	44	40	212	57	103	213	129	72	5	20	212	330	437	43	10	43	37	9	31	14	43	21
Heptageniidae	4	sc	198	65	64	69	165	116	240	130	252	345	32	107	129	55	46	98	55	55	95	124	94	168	154	215
Leptohyphidae	4	cg	6	6	26	4	41	15	0	1	0	0	11	3	7	7	6	36	17	7	0	0	0	0	7	0

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Table E-1 Continued

			August 2009												September 2009											
			Footbridge						Lions Club						Footbridge						Lions Club					
Taxa	CTV	FFG	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3
Leptophlebiidae	2	cg	2	0	4	5	0	0	6	4	4	0	1	0	0	0	0	5	4	1	0	0	0	0	0	0
Tricorythidae		cg																								
Plecoptera																										
Chloroperlidae	1	p	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nemouridae	2	sh	0	0	0	0	0	0	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perlidae	1	p	0	3	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
Pteronarcyidae	0	om	0	0	0	1	0	0	0	0	4	0	1	1	0	3	0	0	0	0	0	0	0	0	0	0
Trichoptera																										
Brachycentridae	1	cf	0	2	0	0	0	0	0	0	0	0	0	1	0	3	2	0	0	0	0	0	0	0	0	0
Glossosomatidae	0	sc	0	0	0	0	0	0	9	0	6	3	0	4	0	0	0	0	0	0	1	0	1	0	0	0
Helicophsychidae	3	sc																								
Hydrophsychidae	4	cf	289	554	358	113	1342	510	290	610	572	915	31	484	737	753	719	104	34	242	173	91	261	31	72	87
Hydroptilidae	4	sc	558	628	265	41	495	429	347	988	1272	697	21	347	242	1145	137	378	3	664	237	694	879	268	45	931
Lepidostomatidae	1	sh	0	0	2	0	0	0	12	4	0	3	13	22	0	0	0	0	1	0	32	2	3	10	14	6
Leptoceridae	4	om	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limnephilidae	4	sc	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0
Philopodamidae	3	cf	0	0	0	0	0	2	0	0	4	0	6	3	0	2	0	0	0	0	0	7	0	3	14	0
Polycentropodidae	6	p	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5	0	2	2	1	3
Psychomyiidae	2	sc	4	2	4	0	4	4	6	1	0	0	1	4	0	1	0	0	0	0	0	0	0	2	0	0
Rhyacophilidae	0	p																								
ARACHNIDA																										
Acari (Hydracarina)	5	p	76	45	54	31	136	98	350	84	208	918	32	145	24	12	6	13	7	20	45	16	13	14	22	30
MALACOSTRACA																										
Amphipoda																										
Hyalellidae	8	cg	0	0	2	0	0	0	0	0	0	0	3	0	0	4	0	0	1	1	18	0	0	3	5	0
Talitridae	8																									
Decapoda																										
Astacidae	6	om	2	0	0	0	0	1	1	1	1	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0
Isopoda																										
Asellidae	8	cg	225	107	305	383	32	66	1361	674	860	3738	974	272	35	75	7	292	134	32	1468	680	697	614	846	1175
OSTRACODA	8	cg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

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Table E-1 Continued

			August 2009												September 2009											
			Footbridge						Lions Club						Footbridge						Lions Club					
Taxa	CTV	FFG	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3
CNIDARIA																										
HYDROZOA																										
Hydroida																										
Hydridae	5	p																								
MOLLUSCA																										
BIVALVA																										
Corbiculidae	10	cf	9	60	112	102	98	92	15	2	5	3	29	5	127	58	30	135	63	86	71	14	32	7	17	20
Sphaeriidae	8	cf	6	2	4	1	12	0	468	326	279	213	94	6	11	4	0	6	1	3	303	130	130	12	90	157
GASTROPODA																										
Basommatophora																										
Ancylidae	6	sc	78	80	116	81	222	227	220	40	144	252	266	141	43	16	55	88	15	54	146	218	120	181	69	113
Physidae	8	sc	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0
Planorbidae	6	sc	2	0	0	0	0	2	144	33	60	75	47	6	0	0	0	4	0	2	131	43	1	11	21	18
Neotaenioglossa																										
Hydrobiidae	8	sc	0	0	10	1	4	2	6	20	0	0	16	5	2	2	6	9	2	3	5	6	49	5	12	3
ANNELIDA																										
HIRUDINEA																										
Erpobdellidae	8	p	0	3	2	8	0	0	74	16	8	39	38	6	0	3	0	14	5	3	27	13	19	19	24	20
OLIGOCHAETA	5	cg	51	9	48	34	139	4	56	30	5	1614	74	330	87	150	32	95	87	85	131	112	126	54	140	142
Polychaeta																										
Canalipalpata																										
Sabellidae		cf																								
PLATYHELMINTHES																										
TURBELLARIA																										
Tricladida																										
Planariidae	4	p	2	3	0	0	24	5	0	0	0	24	0	0	22	31	7	0	0	1	0	14	8	3	0	0
TARDIGRADA																										
Total Estimated Abundance [1]			1947	1923	1806	988	3438	2024	5173	3846	4340	19855	1928	2687	1820	2810	1612	1571	486	1575	3213	2261	2646	1515	1750	3165

[1] Total Estimated Abundance does not always number reported due to rounding.

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Appendix F—Master taxa list for macroinvertebrates collected in Surber samples in 1992 (McElravy 1993).

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Table F-1 Master taxa list for macroinvertebrates collected in Surber samples at riffle (R) and Glide (G) habitat above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1992 (McElravy 1993).

			July1992												September 1992											
			Footbridge						Lions Club						Footbridge						Lions Club					
Taxa	CTV	FFG	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3
ARTHROPODA																										
INSECTA																										
Coleoptera																										
Elmidae	4	cg	10	319	129	4	4	0	8	6	154	0	1	1	70	65	109	0	9	150	1	34	10	0	5	1
Psephenidae	4	sc	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0
Diptera																										
Atherricidae	2	p	0	1	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	1	0	0	0	0	0	0
Blephariceridae	0	sc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0
Chironomidae	6	cg	471	470	400	1023	1005	934	411	93	666	254	143	278	419	767	458	1020	1270	652	82	211	173	111	110	76
Dolichopodidae	4	p																								
Empididae	6	p	5	4	8	4	6	5	0	0	0	0	0	0	8	9	3	0	0	10	0	0	0	0	0	0
Psychodidae		cg																								
Simuliidae	6	cf	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stratiomyidae	8	cg	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
Tabanidae	8	p	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Tipulidae	3	p	18	66	55	0	8	8	19	7	53	0	0	0	12	14	43	13	4	27	0	9	3	0	0	0
Odonata																										
'Zygoptera'		p																								
Coenagrionidae		p	0	4	16	0	0	0	0	0	0	0	0	0	0	9	0	0	5	0	0	0	0	0	0	0
Gomphidae	4	p	0	0	0	1	0	0	0	0	0	0	0	0	0	8	0	4	0	0	0	0	0	0	0	0
Megaloptera																										
Sialidae	4	p																								
Lepidoptera																										
Pyralidae	5	sc	359	339	394	243	189	204	109	80	192	73	85	162	136	236	255	151	202	551	246	148	65	113	138	69
Hymenoptera																										
Ichneumonidae																										
Ephemeroptera																										
Beatidae	4	cg	57	89	158	0	8	5	16	35	511	24	8	8	67	104	278	0	4	67	24	474	142	12	0	2
Heptageniidae	4	sc	137	144	281	49	95	145	49	14	41	136	45	39	186	289	214	42	71	206	38	303	36	79	5	31
Leptohyphidae	4	cg																								

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Table F-1 Continued.

			July1992												September 1992											
			Footbridge						Lions Club						Footbridge						Lions Club					
Taxa	CTV	FFG	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3
Leptophlebiidae	2	cg																								
Tricorythidae		cg	5	16	24	42	8	28	0	1	0	0	0	4	6	41	0	105	47	58	16	8	2	8	27	2
Plecoptera																										
Chloroperlidae	1	p																								
Nemouridae	2	sh																								
Perlidae	1	p	1	13	10	0	0	0	0	0	11	0	0	0	2	10	20	0	0	1	0	4	2	0	0	0
Pteronarcyidae	0	o	0	1	1	0	0	0	0	0	0	0	0	0	0	2	2	0	0	1	0	0	1	0	0	0
Trichoptera																										
Brachycentridae	1	cf	0	41	43	109	72	104	0	0	0	0	0	0	16	8	49	8	16	26	0	0	0	0	0	0
Glossosomatidae	0	sc	18	5	8	0	0	0	0	0	0	10	1	4	0	0	0	0	0	0	1	0	0	0	0	1
Helicophsychidae	3	sc	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
Hydrophsychidae	4	cf	285	404	1236	76	90	146	598	260	3397	848	231	397	951	1331	1399	163	289	1493	1067	2540	1037	139	138	48
Hydroptilidae	4	sc	1360	1365	1889	481	209	567	1548	2007	1756	1361	1463	1255	736	1019	968	445	281	1887	1193	920	524	549	769	511
Lepidostomatidae	1	sh	0	0	0	0	0	0	0	1	12	74	21	9	0	0	0	0	4	8	32	1	16	36	2	20
Leptoceridae	4	om																								
Limnephilidae	4	sc																								
Philopodamidae	3	cf	1	11	8	23	27	58	0	1	0	8	14	5	2	2	0	21	43	11	0	0	0	0	3	0
Polycentropodidae	6	p	1	6	0	16	5	0	90	3	29	116	56	18	0	16	1	4	9	0	43	16	43	65	81	22
Psychomyiidae	2	sc	3	27	31	1	9	2	2	1	6	1	0	0	13	4	6	0	0	8	0	0	1	0	0	0
Rhyacophilidae	0	p																								
ARACHNIDA																										
Acari (Hydracarina)	5	p	217	271	212	209	255	192	26	15	16	34	33	33	132	300	480	271	195	243	24	60	90	68	32	33
MALACOSTRACA																										
Amphipoda																										
Hyalellidae	8	cg																								
Talitridae	8		0	0	0	4	0	4	0	0	0	8	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Decapoda																										
Astacidae	6	om	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Isopoda																										
Asellidae	8	cg	0	12	0	89	38	131	428	198	272	104	435	316	0	16	1	29	38	66	91	541	240	184	408	216
OSTRACODA	8	cg	0	24	0	20	13	16	0	0	0	0	0	0	0	33	16	220	16	8	0	0	0	4	0	0

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Table F-1 Continued.

			July1992												September 1992											
			Footbridge						Lions Club						Footbridge						Lions Club					
Taxa	CTV	FFG	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3
CNIDARIA																										
HYDROZOA																										
Hydroida																										
Hydridae	5	p	0	0	0	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MOLLUSCA																										
BIVALVA																										
Corbiculidae	10	cf	4	82	281	4	8	1	93	24	292	59	48	32	0	42	24	0	16	9	0	1	159	12	61	2
Sphaeriidae	8	cf	2	16	9	8	4	8	0	1	0	1	12	4	1	9	0	4	0	0	0	2	8	4	104	6
GASTROPODA																										
Basommatophora																										
Ancylidae	6	sc	397	165	228	297	256	399	48	2	0	144	100	118	64	151	64	119	31	60	29	18	10	27	62	36
Physidae	8	sc																								
Planorbidae	6	sc	0	4	0	4	4	0	24	3	12	80	48	77	0	16	0	8	0	0	26	1	0	8	0	4
Neotaenioglossa																										
Hydrobiidae	8	sc																								
ANNELIDA																										
HIRUDINEA																										
Erpobdellidae	8	p	0	4	0	0	1	9	35	14	85	58	44	100	0	0	0	4	0	0	2	28	26	26	75	18
OLIGOCHAETA	5	cg	74	125	223	599	401	99	234	46	143	123	176	237	91	500	232	1033	171	239	22	136	108	85	448	322
Polychaeta																										
Canalipalpata																										
Sabellidae		cf	12	130	17	41	25	5	1	14	6	8	4	0	99	80	30	16	45	55	16	9	1	56	43	3
PLATYHELMINTHES																										
TURBELLARIA																										
Tricladida																										
Planariidae	4	p	0	36	16	0	0	0	0	3	4	0	0	0	13	0	0	0	0	1	0	0	1	0	5	4
TARDIGRADA			0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0
Total Estimated Abundance			3438	4194	5679	3364	2779	3071	3739	2829	7658	3524	2968	3097	3024	5091	4670	3685	2799	5846	2961	5473	2698	1586	2516	1427

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Appendix G—Master taxa list for macroinvertebrates collected in Surber samples in 1991.

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Table G-1 Master taxa list for macroinvertebrates collected in Surber samples at riffle (R) and Glide (G) habitat above (Footbridge) and below (Lions Club) the Pit 1 Powerhouse in 1991 (McElravy 1993).

			October 1991											
			Footbridge						Lions Club					
Taxa	CTV	FFG	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3
ARTHROPODA														
INSECTA														
Coleoptera														
Elmidae	4	cg	4	6	199	0	11	2	52	29	32	12	4	0
Psephenidae	4	sc	1	0	0	0	2	1	0	0	0	0	0	0
Diptera														
Atherricidae	2	p	0	1	14	0	1	0	0	0	0	0	0	0
Blephariceridae	0	sc												
Chironomidae	6	cg	1861	618	602	2710	222	263	544	315	648	876	1098	241
Dolichopodidae	4	p												
Empididae	6	p	14	3	23	1	2	1	0	0	0	0	0	0
Psychodidae		cg	0	1	0	0	1	0	0	0	0	0	0	0
Simuliidae	6	cf	0	0	0	0	0	0	0	2	0	0	1	0
Stratiomyidae	8	cg												
Tabanidae	8	p	0	0	0	0	0	0	0	1	0	0	0	0
Tipulidae	3	p	52	41	46	36	6	4	12	11	40	16	16	11
Odonata														
'Zygoptera'		p												
Coenagrionidae		p	0	1	0	0	1	3	0	0	0	0	0	0
Gomphidae	4	p	0	0	0	0	2	0	0	0	0	0	0	0
Megaloptera														
Sialidae	4	p												
Lepidoptera														
Pyralidae	5	sc	234	364	318	387	407	105	433	321	410	420	973	415
Hymenoptera														
Ichneumonidae														
Ephemeroptera														
Beatidae	4	cg	88	72	515	12	27	34	296	348	112	32	49	17
Heptageniidae	4	sc	0	0	0	0	0	0	0	0	0	4	4	0
Leptohyphidae	4	cg	436	90	226	144	76	74	116	6	56	200	129	68

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Table G-1 Continued.

			October 1991											
			Footbridge						Lions Club					
Taxa	CTV	FFG	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3
Leptophlebiidae	2	cg												
Tricorythidae		cg	28	6	8	5	24	8	0	0	0	0	12	0
Plecoptera														
Chloroperlidae	1	p												
Nemouridae	2	sh												
Perlidae	1	p	0	3	15	0	1	0	16	2	4	1	0	0
Pteronarcyidae	0	om	0	0	0	1	0	2	0	0	0	0	0	0
Trichoptera			0	0	6	0	0	0	0	0	0	0	0	0
Brachycentridae	1	cf												
Glossosomatidae	0	sc	0	2	0	1	0	0	0	0	0	0	0	0
Helicophsychidae	3	sc	0	0	0	0	0	0	0	1	8	0	12	0
Hydrophsychidae	4	cf												
Hydroptilidae	4	sc	664	247	1767	188	569	466	4660	2550	2440	2137	2364	688
Lepidostomatidae	1	sh	383	807	474	606	408	145	2533	815	1075	532	1304	1666
Leptoceridae	4	om	0	0	0	1	8	5	16	2	0	6	54	6
Limnephilidae	4	sc												
Philopodamidae	3	cf	0	0	0	0	0	0	0	0	0	4	0	0
Polycentropodidae	6	p	7	2	0	24	17	13	0	0	0	0	8	1
Psychomyiidae	2	sc	0	6	0	6	0	45	88	51	128	720	1108	409
Rhyacophilidae	0	p	1	0	0	0	0	0	0	0	0	0	0	0
ARACHNIDA														
Acari (Hydracarina)	5	p	396	397	151	150	77	34	24	0	16	102	211	45
MALACOSTRACA														
Amphipoda														
Hyalellidae	8	cg												
Talitridae	8		0	0	0	0	0	1	0	1	0	0	0	0
Decapoda														
Astacidae	6	om	0	0	2	1	0	0	0	1	0	0	1	0
Isopoda														
Asellidae	8	cg	44	4	0	1	4	18	204	8	260	521	232	169
OSTRACODA	8	cg	0	0	0	0	0	0	0	0	0	8	0	0

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Table G-1 Continued.

			October 1991											
			Footbridge						Lions Club					
Taxa	CTV	FFG	R1	R2	R3	G1	G2	G3	R1	R2	R3	G1	G2	G3
CNIDARIA														
HYDROZOA														
Hydroida														
Hydridae	5	p												
MOLLUSCA														
BIVALVA														
Corbiculidae	10	cf												
Sphaeriidae	8	cf	16	3	419	0	32	3	1604	179	204	145	334	12
GASTROPODA														
Basommatophora														
Ancylidae	6	sc	55	24	10	17	77	23	4	0	0	23	61	18
Physidae	8	sc												
Planorbidae	6	sc	0	0	0	0	4	0	0	0	0	13	12	5
Neotaenioglossa														
Hydrobiidae	8	sc												
ANNELIDA														
HIRUDINEA														
Erpobdellidae	8	p	0	0	0	0	6	0	36	0	60	74	45	30
OLIGOCHAETA	5	cg	187	10	124	21	160	109	387	331	732	232	130	79
Polychaeta														
Canalipalpata														
Sabellidae		cf	45	2	30	2	13	9	45	38	84	28	16	10
PLATYHELMINTHES														
TURBELLARIA														
Tricladida														
Planariidae	4	p	0	0	0	0	0	1	20	6	4	0	0	1
TARDIGRADA														
Total Estimated Abundance			4516	2710	4949	4314	2158	1369	11090	5018	6313	6106	8178	3891

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