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IDAHO DIVISION OF ENVIRONMENTAL QUALITY
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LOWER BOISE RIVER WATER QUALITY PLAN, INC.

Biological Assessment of the Lower Boise River, October 1995 Through January 1998, Ada and Canyon Counties, Idaho

Water-Resources Investigations Report 99–4178

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By William H. Mullins

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
inch (in.)	2.54	centimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\ °C) + (32)$$

Sea level: In this report, sea level refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Water-Quality Units

grams per square meter	(g/m^2)
micrometer	(µm)
milligram per square meter	(mg/m^2)
milliliter	(mL)

Biological Assessment of the Lower Boise River, October 1995 Through January 1998, Ada and Canyon Counties, Idaho

By William H. Mullins

Abstract

The lower Boise River, between Lucky Peak Dam and the mouth of the river near Parma, Idaho, is adversely affected by various land- and water-use activities. To assess the biotic integrity of the river and the effects of environmental perturbations on aquatic community structure, and to provide a baseline from which to identify future changes in habitat conditions, biological data were collected from October 1995 through January 1998 and evaluated using protocols developed for the U.S. Geological Survey National Water-Quality Assessment Program. Aquatic biological communities were sampled according to the following schedule: epilithic periphyton were collected in October 1995, October 1996, and August 1997; benthic macroinvertebrates were collected in October 1995, 1996, and 1997; and fish were collected in December 1996 and August 1997.

Qualitative measurements of instream and riparian habitat indicated an overall decrease in instream habitat quality in a downstream direction. Embeddedness was high at all sites but was lower at the Eckert Road site than at the downstream sites near Middleton and Parma. Silt/sand substrate increased from 17 percent at the Eckert Road site to 49 percent near the mouth of the river. The Eckert Road site had a mix of geomorphic channel units (pool/riffle/run), whereas the Middleton and Parma sites were dominated by runs with very little pool or riffle habitat.

Epilithic periphyton chlorophyll-*a* and ash-free dry weight values tended to increase downstream to the Middleton site and decrease from Middleton to the downstream sites near Caldwell and near Parma.

Benthic index of biotic integrity (B-IBI) scores for macroinvertebrates collected in 1995, 1996, and 1997 were highest at the Eckert Road site and decreased at sites downstream. IBI scores for fish collected in 1996 were similar at the Glenwood Bridge and Middleton sites (17 and 16, respectively) and were indicative of a low to moderate level of disturbance. In contrast, the IBI score of 6 at the site near Parma was markedly lower and was indicative of more degraded conditions.

INTRODUCTION

The lower Boise River, between Lucky Peak Dam and the mouth of the river near Parma, Idaho, is adversely affected by various land- and water-use activities. In 1994, the U.S. Geological Survey (USGS), in cooperation with the Idaho Division of Environmental Quality and the Lower Boise River Water Quality Plan, Inc., began a comprehensive study of the water quality and biotic integrity of the river. From October 1995 through January 1998, biological data were collected to assess the biotic integrity of the river. Water-quality conditions of the river and its tributaries and drains, based on data collected during May 1994 through February 1997, were described in a previous report (Mullins, 1998a).

Aquatic biological communities integrate physical and chemical conditions of their environment (Plafkin and others, 1989; Frenzel, 1990; Chandler and others, 1993; Cuffney and others, 1993; Maret, 1995). Therefore, an evaluation of ecological components of these communities is useful in assessing biotic integrity and the effects of environmental perturbations on aquatic community structure. Further, a program based on continued monitoring of these communities is useful in identifying long-term trends in biotic integrity and water quality in general. In addition, accompanying stream habitat studies are useful in furthering the understanding of the interaction among physical, chemical, and biological characteristics (Fitzpatrick and Giddings, 1997).

For this study, instream and riparian habitat conditions were assessed using protocols developed for the USGS National Water-Quality Assessment (NAWQA) Program (Meador and others, 1993a). Habitat assessments are useful in identifying physical factors that are limiting to biological communities and provide a baseline from which to identify future changes in habitat conditions.

A multimetric approach involving two taxonomic groups (benthic macroinvertebrates and fish) was used to assess biotic integrity (Intergovernmental Task Force on Monitoring Water Quality, 1992; Karr and Chu, 1997). Multiple metrics are based on the use of "meaningful indicator attributes in assessing the status of communities in response to perturbation" (Barbour and others, 1994, p. 4). A metric is defined as "a characteristic of the biota that changes in some predictable way with increased human influence" (Barbour and others, 1994, p. 4). Fish metrics are useful in evaluating stream habitat, whereas benthic macroinvertebrate metrics are useful for demonstrating short-term toxic effects because macroinvertebrates frequently are more sensitive than fish to the effects of urban land- and water-use activities (Barbour and others, 1997). A subset of benthic macroinvertebrate and fish community metrics based on community structure, trophic composition, and indicator assemblage (pollution tolerance) was chosen to assess biotic integrity (Plafkin and others, 1989; Chandler and others, 1993; Maret, 1995; Barbour and others, 1997). In addition, measurements of epilithic periphyton chlorophyll-*a* and biomass were used to compare nutrient enrichment among sites. Epilithic periphyton growth can be a useful measure of nutrient effects in receiving systems because nutrient additions to streams can increase periphytic growth and alter composition and spatial distribution of periphyton communities (Delong and Brusven, 1992).

Purpose and Scope

The purpose of this report is to describe and compare biotic integrity at five sampling sites and stream habitat conditions at three sampling sites located on the Boise River between Eckert Road, river mile (RM) 58, and a site located about 0.5 mi upstream from the mouth of the Boise River. This study was conducted between October 1995 and January 1998.

Acknowledgments

Appreciation is extended to the following people for assistance with collection of field samples and habitat measurements: Charles Berenbrock, Terry Maret, Susan Moore, Sabrina Nicholls, Doug Ott, and Ken Skinner of the U.S. Geological Survey; Robbin Finch, Brian DuFosse, Carsen Rahrer, Angel Deckers, and Walt Baumgartner of the City of Boise Public Works Department; and Dale Allen, Scott Grunder, and Steve Yundt of the Idaho Department of Fish and Game, for fish sampling. Appreciation also is extended to U.S. Geological Survey biologists Terry Short, Menlo Park, Calif., and Terry Maret, Boise, Idaho, for providing technical reviews of this manuscript.

DESCRIPTION OF THE LOWER BOISE RIVER BASIN

The 1,290-mi^2 lower Boise River Basin is located in Ada and Canyon Counties in southwestern Idaho between Lucky Peak Dam (RM 64) and the confluence of the Boise and Snake Rivers (fig. 1). The basin contains the most industrialized and urbanized areas in Idaho. The 1990 population of 296,000 in Ada and Canyon Counties composes about 29 percent of Idaho's total population.

The lower Boise River Basin is in the northern part of the western Snake River Plain. The southern boundary is a low ridge south of Indian Creek in southern Elmore, Ada, and Canyon Counties. Other basin boundaries are formed by a low ridge above the Snake River to the west, the Boise Mountains to the northeast, and a low range of foothills to the north. The upper basin, upstream from Lucky Peak Dam, is mountainous and sparsely populated. In addition to the Boise River, the study area is drained by several tributaries interconnected by a complex irrigation system of canals, laterals, and drains.

Climate in the lower Boise River Basin is characterized as semiarid; winters are cool and wet, and summers are warm and dry. Area climate is controlled primarily by the general atmospheric circulation over the northern Pacific Ocean. In summer, subtropical air from the Pacific Ocean and Gulf of Mexico circulates northward, resulting in high temperatures and generally dry conditions, although sporadic thunderstorms result in small amounts of precipitation. During the fall and winter, air movements shift to a westerly flow from the

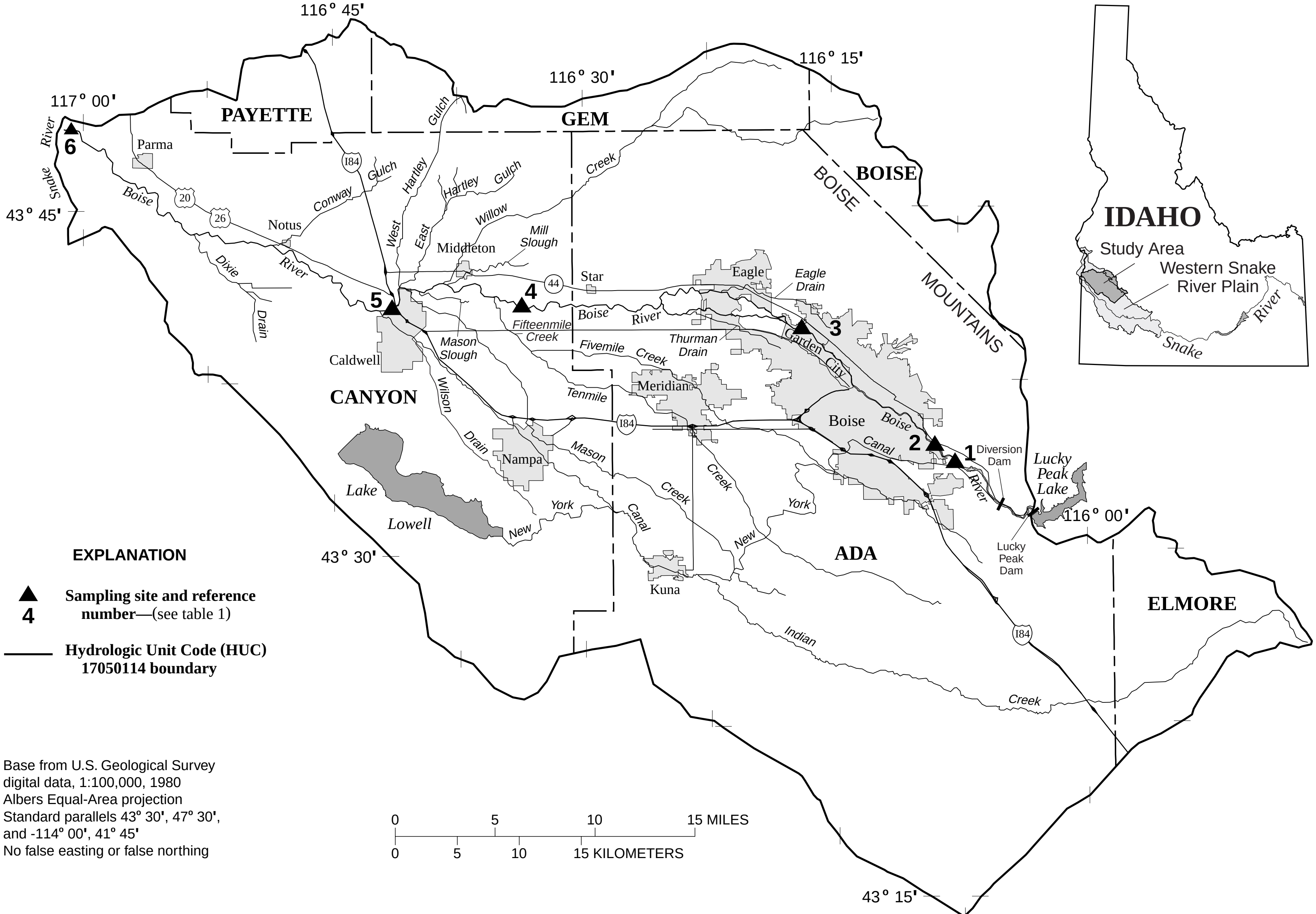

Figure 1. Location of lower Boise River Basin, Idaho, and six sampling sites.

Pacific Ocean, and most precipitation develops from frontal systems passing through the area. During the relatively wet spring months of March through May, a combination of thunderstorms and frontal systems produces nearly one-third of the annual precipitation. Mean annual precipitation as measured by the National Weather Service at the Boise airport during 1951–93 was about 11.9 in.

Lucky Peak Lake and Arrowrock and Anderson Ranch Reservoirs in the upper Boise River Basin east and southeast of the study area have a combined storage capacity of about 1.06 million acre-ft and are managed primarily for irrigation and flood control and secondarily for recreation and power generation. This management strategy largely defines the flow regime of the river downstream from Lucky Peak Lake. Flood-control releases from Lucky Peak Lake in the spring result in high streamflows that persist all the way to the Snake River. However, in years of severe and (or) consecutive drought, such as those in the late 1980's through the early 1990's, late-winter and spring flows remain low except for short periods of time. In wet years, such as those in the early 1980's and during the period 1995–97, high flows can last from December or January through June. Irrigation releases typically begin in mid-April (or following flood releases) and continue through mid-October. During the winter, minimum flows of about 150 ft^3/s are released from Lucky Peak Lake.

Mean annual flow during the period 1955–96 was 2,280 ft^3/s (2,014,000 acre-ft/yr) at the gaging station on the Boise River located at the outlet of Lucky Peak Lake (Brennan and others, 1997). Mean annual flow during 1982–96 was 1,198 ft^3/s (868,100 acre-ft/yr) at the gaging station on the Boise River at Glenwood Bridge, downstream from several major diversions (Brennan and others, 1997). Mean annual discharge during 1971–96 was 1,627 ft^3/s (1,179,000 acre-ft/yr) at the gaging station near Parma at the mouth of the Boise River. Annual mean discharge and mean monthly discharge during 1975–96 for the gaging station on the Boise River near Parma are shown in figure 2.

The Idaho Department of Fish and Game (IDFG) annually stocks catchable-sized rainbow trout (*Oncorhynchus mykiss*) in the Boise River. Numbers vary according to yearly fluctuations in flows. In 1997, about 23,000 trout were released in the river between Eckert Road (about 1 mi east of Boise) and Glenwood Bridge. In 1996, 50,000 fingerling brown trout (*Salmo trutta*) were released in the Boise River. However, the IDFG now believes the brown trout population is self-sustaining, so they no longer are stocked (Dale Allen, Idaho Department of Fish and Game, oral commun., 1998).

PREVIOUS INVESTIGATIONS

The IDFG surveyed fish populations in the Boise River between Barber Dam (RM 59) and the mouth from March 1974 through February 1975 (Gibson, 1975). Fish were collected at 31 locations, including main river channel and slough sites. Twenty-four fish species were documented, of which 13 were gamefish species. Principal gamefish species of catchable size consisted of mountain whitefish (*Prosopium williamsoni*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), rainbow trout (hatchery and wild), and channel catfish (*Ictalurus punctatus*). Mountain whitefish composed 93 percent of the gamefish species. Nongame fish composed about 94 percent of the total collection sample (three sampling periods) and were dominated by redside shiners (Richardsonius balteatus), chiselmouths *(Acrocheilus alutaceus*), and suckers (*Catostomus* sp.). Mountain whitefish were found in all reaches sampled, but rainbow trout were found predominantly from Barber Dam (RM 59) to Star (RM 44). Centrarchids (sunfish), dominated by largemouth bass, bluegills (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), and pumpkinseeds (*Lepomis gibbosus*) were found mainly in backwater sloughs characterized by deep, still pools with vegetative cover. Sculpins (*Cottus* sp.) were found only in the Boise area. Twenty-six benthic macroinvertebrate samples were collected by IDFG at six locations on the Boise River in August 1974. A total of 15 families (9 orders) were documented, and these were dominated by Hydropsychidae (caddisflies), Baetidae (mayflies), Chironomidae (midges), and Simuliidae (black flies).

The Idaho Cooperative Fish and Wildlife Research Unit surveyed potential and available salmonid habitat and relative abundance of salmonids in the Boise River between Barber Dam and Star for the IDFG in 1986–87 (Ashbridge and Bjornn, 1988). At flows averaging 4,430 ft^3/s downstream from Lucky Peak Dam, runs were the dominant habitat type, except in the north channel around Eagle Island (beginning at RM 46.4) and from Eagle Island to Star, where pools

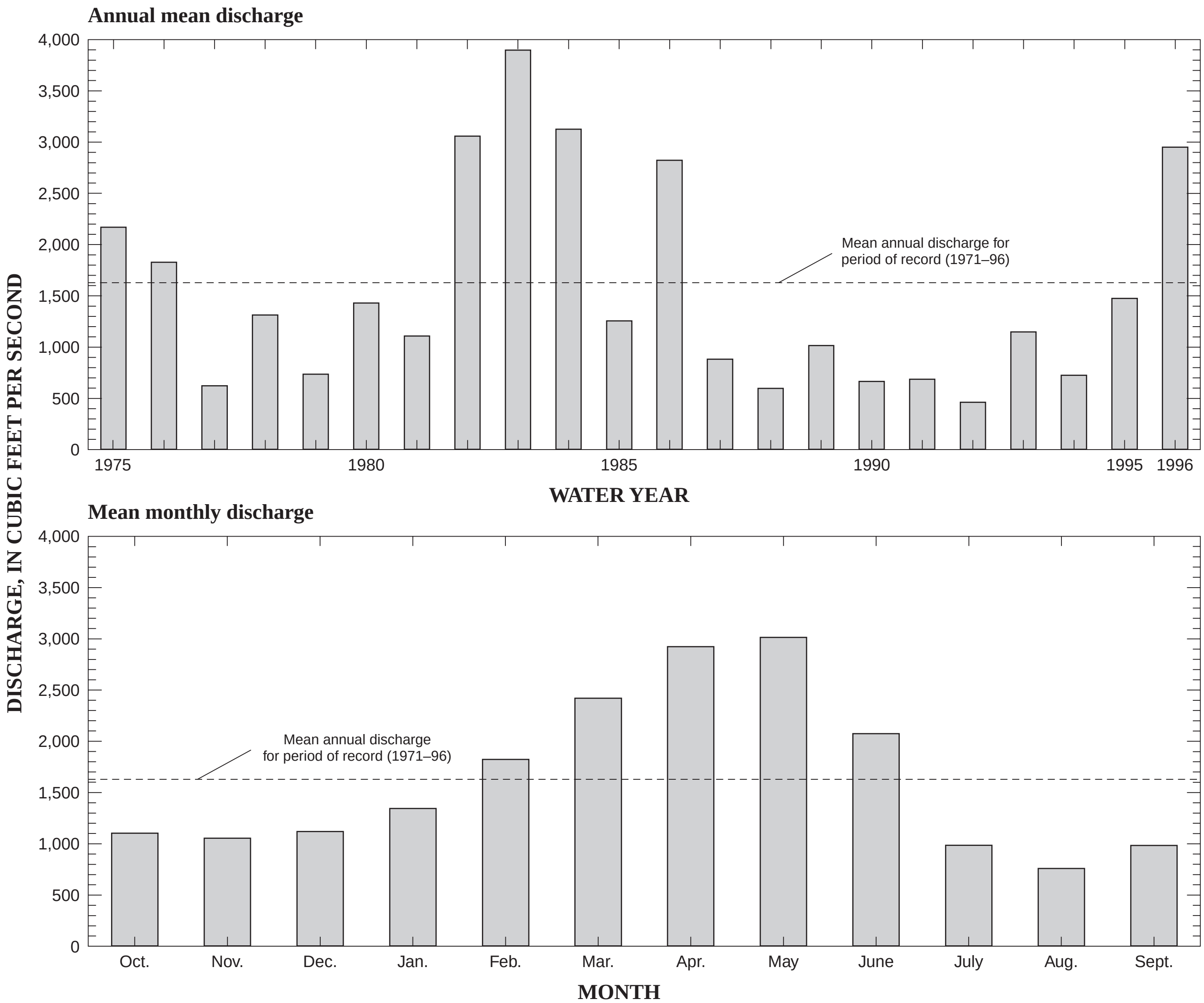

Figure 2. Annual mean discharge and mean monthly discharge in the lower Boise River near Parma, Idaho, water years 1975–96. (Site location shown in figure 1)

were the dominant habitat type. At low flows (180 ft^3/s downstream from Lucky Peak Dam), pools were the dominant habitat type throughout the study area. Water velocities exceeded the preference range for rainbow and brown trout in many areas during summer. River substrate was dominated by cobbles, and the stream bottom lacked "roughness elements" (physical characteristics such as boulders or large, woody debris that create and enhance aquatic habitat). Areas of spawning gravel were not abundant and, when present, were usually highly embedded with fines. Water temperature during late summer and early fall downstream from Glenwood Bridge exceeded optimum levels for trout growth. In addition, about 70 percent of the stream channel had no habitat cover elements for trout, except for a few areas of deeper water. The primary factors limiting trout abundance were listed as high summer water velocities, high summer water temperature, and lack of winter cover exacerbated by low minimum flows. Mountain whitefish were collected at all sites sampled and were the most abundant salmonid, whereas rainbow trout were the least abundant salmonid. Other species collected included brown trout, redside shiners, chiselmouths, sculpins, suckers, northern pikeminnow (*Ptychocheilus oregonensis*), and largemouth bass.

The USGS examined physical, chemical, and biological characteristics of the Boise River upstream and downstream from the Lander Street and West Boise wastewater treatment plants (WTFs) from October 1987 to March 1988 to determine whether trace-element concentrations were detrimental to aquatic communities (Frenzel, 1988, 1990). The trace-element concentrations that were detected were less than those based on chronic toxicity criteria (U.S. Environmental Protection Agency, 1986). Trace-element concentrations in bottom sediment were generally low and could not be attributed to WTF effluent. WTF effluent had little apparent toxic or enriching effects on benthic macroinvertebrate communities following a 40-day colonization period on artificial substrates. In addition, mean condition factors of mountain whitefish upstream and downstream from WTFs indicated that the relative health of fish communities in the Boise River was not adversely affected by WTF effluent.

The USGS assessed the biotic integrity of the Boise River upstream and downstream from the Lander Street and West Boise WTFs in 1995–96 on the basis of studies of epilithic periphyton, benthic macroinvertebrates, and fish (Mullins, 1998b). Epilithic periphyton, expressed as chlorophyll-*a* and ash-free dry weight, declined substantially between 1995 and 1996. Chlorophyll-*a* concentrations were higher at sites downstream from WTFs in both years, but differences in concentrations between sites upstream and downstream from WTFs were not significantly different. High within-site variance of chlorophyll-*a* and biomass values suggests that greater sampling intensity would improve statistical comparisons of among-site differences in chlorophyll-*a* and biomass. Benthic index of biotic integrity (B-IBI) scores calculated for macroinvertebrates were slightly higher for the sites upstream from WTFs in 1995 but were the same for all sites in 1996. Similarly, IBI scores calculated for fish were higher for the sites upstream from WTFs in 1995, were higher for the site upstream from the Lander Street WTF in 1996, and were the same for sites upstream and downstream from the West Boise WTF in 1996. Two species of sculpins (mottled sculpin, *Cottus bairdi*, and shorthead sculpin, *Cottus confusus*) were abundant at the site upstream from both WTFs but were absent at all other sites downstream from WTFs in 1995 and composed only 2 percent of the total number of fish collected downstream from the Lander Street WTF in 1996. Reasons for the lack of sculpins downstream from WTFs are not apparent and cannot be explained by any obvious changes in physical habitat conditions.

In earlier phases of this study, water temperature data were collected hourly over a 50-day period at five sites in the Boise River between July 18 and September 5, 1996, using Hobo continuous temperature recorders (Onset Computer Corporation). The State of Idaho standard for coldwater biota was exceeded by 34 percent near Middleton, 48 percent at Caldwell, and 80 percent near Parma (Mullins, 1998a).

METHODS OF DATA COLLECTION AND ANALYSIS

Instream and Riparian Habitat

Instream and riparian habitat variables were evaluated using criteria from reports by Meador and others (1993a), Platts and others (1987), and Barbour and others (1997) at three sites representing the range of conditions found throughout the lower Boise River (Boise River at Eckert Road, near Middleton, and at the mouth). Habitat evaluations were conducted in November 1997 and January 1998. At each site, representative reaches were selected on the basis of criteria outlined by Meador and others (1993a). Reach length ranged from 1,782 ft at the mouth near Parma to 2,135 ft near Middleton.

Two levels of data were collected at each stream reach. The first level included qualitative information on instream and riparian habitat variables. Information was collected using protocols developed by the U.S. Environmental Protection Agency (EPA) (Plafkin and others, 1989; Hayslip, 1993; Barbour and others, 1997). For each stream reach, a habitat assessment field sheet was used to record habitat variables (appendix A), and condition categories with their corresponding scores were assigned to each variable. Scores for all variables from each site were summed and a percentage of the total maximum score was calculated. The second level included a more detailed study of channel transects, channel substrate particle size, and canopy shading and density.

First-level reach characterization included channel, substrate, and bank measurements, and measurements of riparian canopy opening and density. These measurements were collected at each of six transects. A transect was located at each end of the reach, and the other four were located to represent predominant geomorphic channel units (pools, riffles, runs). The first, last, and one of the centrally located transects were designated as permanent transects. Three-ft sections of steel fenceposts were driven to within about 1 in. of the ground surface and used as reference marks at the ends of each of the three permanent transects. Flagging was used to mark the other three transects. Locations of stakes for permanent transects are listed in appendix B.

At each of the transects, channel depth, streamflow velocity, substrate type, and embeddedness were measured at the thalweg and at two other stream locations equally spaced along the transect. Reach length, transect width, and length of geomorphic channel units were measured with an electronic rangefinder. A pebble count (Wolman, 1954) was conducted along the three permanent transects to characterize substrate. Mean streambank cover was estimated using a concave spherical densiometer, and canopy angle, in degrees, was measured using a clinometer. A diagrammatic map of the reach was sketched showing the general layout of the river, transect locations, and geomorphic channel units. Photos were taken at each of the permanent transects from the same bank to photodocument reach conditions.

Second-level reach characterization focused on detailed measurements of channel geometry and longitudinal profiles of the water surface and channel thalweg. Repeated measurements of these sites over time will provide information on changes in channel geomorphology, such as aggradation, degradation, and lateral migration (Fitzpatrick and others, 1998). Channel geometry and longitudinal profiles were measured according to methods described by Berenbrock and Kjelstrom (1998). Horizontal and vertical controls were surveyed from a minimum of three sites (hubs) by using an electronic total-station instrument. Each of the six transects used for the first-level reach characterization was surveyed in a local coordinate system by using conventional surveying techniques. Transect data were transformed from the local coordinate system to a common, geographically referenced map unit by using the global positioning system (GPS) control data and a geographic information system.

Epilithic Periphyton

Quantitative epilithic periphyton samples were collected and processed using protocols developed by the USGS NAWQA Program to estimate and compare biomass (chlorophyll-*a* and ash-free dry weight) among sites (Porter and others, 1993). Epilithic periphyton samples were collected from 10 cobbles per riffle (5 cobbles from each of 2 adjacent benthic macroinvertebrate collection subsites). Periphyton samples were removed from cobbles by using a 30-mL syringe fitted with an O-ring to form a watertight seal against a rock surface. Periphyton within the syringe barrel were dislodged with a stiff-bristle brush and collected with a hand pipette. Samples were composited into a sample jar and mixed, and an aliquot of 10 mL was filtered through a 0.7-µm glass-fiber filter. Filters then were wrapped in aluminum foil, placed in a glass vial, and frozen until they were processed for chlorophyll-*a* and ash-free dry weight by the Bureau of Reclamation Pacific Northwest Regional Laboratory in Boise, Idaho.

Epilithic periphyton samples were collected in late October 1995 and 1996. Because members of the Lower Boise River Water Quality Plan Technical Advisory Committee expressed interest in the evaluation of algal production during the summer months, epilithic periphyton samples were collected in August instead of October 1997.

Benthic Macroinvertebrates

Semiquantitative benthic macroinvertebrate samples were collected using protocols developed by the USGS NAWQA Program (Cuffney and others, 1993). Sampling sites and subsites were the same as those used for periphyton collections. Richest targeted habitats, defined as “a habitat supporting the faunistically richest community of benthic invertebrates” (Cuffney and others, 1993) were selected for sampling. These habitats are usually coarse-grained, fast-flowing riffle areas in wadeable streams. Care was taken not to disturb the site by walking through or near it before samples were collected. Samples of benthic macroinvertebrates were collected in late October 1995, 1996, and 1997.

A Slack sampler (a modified Surber sampler developed by the USGS for the NAWQA Program) was used to collect invertebrates. The Slack sampler consists of a 0.5-m (1.6-ft) wide rectangular kick-net frame to which is attached a 425-µm mesh Nitex net. The sampler is held perpendicular to the direction of flow and pressed firmly against the stream bottom. Benthic invertebrates are collected from an area of 0.25 m^2 (2.7 ft^2) immediately upstream from the sampler. The sample area is delineated by a metal frame attached to the front of the sampler.

Invertebrates were removed by scrubbing individual cobbles in front of the net opening down to a depth of about 10 cm (4 in.). Once all large cobbles were sampled, the finer grained substrate (gravel, sand) was agitated by a crew member standing in front of the net opening and kicking the substrate for 30 seconds. Six samples were collected from three riffles within the reach and comprised a total sampling area of 1.5 m^2 (16 ft^2). Samples were processed onsite by removing any large or rare taxa that might be lost during laboratory processing, and by removing rocks and organic debris, such as leaves and twigs, from the sample. The remaining sample material was elutriated by repeated washings through a 425-µm mesh sieve and placed in a sample jar. Samples were fixed in 10-percent buffered formalin, which was replaced with 70-percent ethanol before they were shipped to the contractor for taxonomic processing. Invertebrate samples were processed and data were summarized by Bob Wisseman, Aquatic Biology Associates, Inc., Corvallis, Oregon.

Fish

Fish community surveys were conducted along each stream reach by electrofishing using protocols developed by the USGS NAWQA Program (Meador and others, 1993b). Fish from shallow riffle areas were collected using backpack electrofishing equipment (Smith-Root model 12). For deeper water, a drift boat or a pontoon boat carrying a Smith-Root model VI–A and a 5,000-watt, 240-volt generator with either multiple handheld or two bow-mounted electrodes was used. Netting crews consisted of four to six people and included personnel from IDFG, City of Boise, and USGS. Two electrofishing passes were made through the entire length of each reach, and an effort was made to sample all representative habitat types. Captured fish were held in live tanks until they were processed and released. Data collected included taxonomic identification, total lengths, weights, types and numbers of anomalies, and numbers of individuals. Fish taxonomy

Table 1. Sampling site locations, types of samples collected, and dates of collection, lower Boise River, Idaho, 1995–98

[Site locations shown in figure 1; USGS, U.S. Geological Survey; No., number]

Site reference No.	USGS gaging station name and number	Latitude	Longitude	Sample type and date collected			
				Habitat	Epilithic periphyton	Benthic macroinvertebrates	Fish
1	Boise River at Eckert Road near Boise (13203760)	43°33'57"	116°07'52"	11/97	10/95, 10/96, 8/97	10/95, 10/96, 10/97	
2	Boise River at Loggers Creek Diversion (13204100)	43°34'31"	116°09'00"				12/96
3	Boise River at Glenwood Bridge near Boise (13206000)	43°39'37"	116°16'41"		10/95, 10/96, 8/97	10/95, 10/96, 10/97	12/96
4	Boise River near Middleton (13210050)	43°41'06"	116°34'22"	11/97	10/95, 10/96, 8/97	10/95, 10/96, 10/97	12/96, 8/97
5	Boise River at Caldwell (13211000)	43°40'52"	116°41'18"		10/95, 10/96, 8/97	10/95, 10/96, 10/97	8/97
6	Boise River at mouth near Parma (13213030)	43°48'50"	117°00'55"	1/98	10/95, 10/96, 8/97	10/95, 10/96, 10/97	12/96, 8/97

follows Robins and others (1991). Onsite identifications of fish were made by Terry Maret, USGS, and Dale Allen, IDFG. Taxonomy of sculpin and dace (*Rhinichthys* sp.) was verified by Dr. Carl E. Bond and Dr. Douglas F. Markel, Oregon State University, Corvallis, and by Dr. Gordon Haas, University of British Columbia, Vancouver, Canada.

State collection permits were obtained from IDFG, and species data were provided to that agency as a provision of the permit. Specimens of selected species were retained for reference and verification of field identifications, and all sculpins and dace were preserved for further enumeration of specific taxa. Fish specimens were fixed in a 10-percent buffered formalin solution for a minimum of 1 week and archived in 70-percent ethanol. A voucher collection is located in the Orma J. Smith Museum of Natural History, Albertson College, Caldwell, Idaho.

In 1995, fish were sampled at the Glenwood Bridge site as part of a study being conducted for the City of Boise. No fish sampling was done in 1995 specifically for the lower Boise River study.

In December 1996, an attempt was made to sample the same five sites where epilithic periphyton and benthic macroinvertebrate samples had been collected. However, the Boise River at Loggers Creek site was chosen instead of the Boise River at Eckert Road site so that fish sampling efforts could be coordinated with IDFG. The Loggers Creek site is characterized by one long, shallow run with riffles on the upstream and downstream ends of the run. The absence of deep run and pool habitat resulted in a sample that was artificially biased toward species associated with riffle/run habitats, such as trout, mountain whitefish, and sculpins, and totally lacking in species associated with pools, such as suckers. The Caldwell site was not sampled in 1996 because of equipment failure on one occasion and access problems on subsequent sampling attempts.

In 1997, fish were collected in August instead of December to evaluate fish assemblages at mid- and lower river sites during the hotter summer months. Electrofishing was difficult at all sites because of high flows, and the data collected represent only a general qualitative species list rather than a semiquantitative list for each site sampled. Fish at the Middleton site were collected using a tote barge for electrofishing, and sampling was biased toward shallow riffles and runs. The Caldwell site was characterized by deep pools and runs; little riffle habitat was available to sample. High velocities in the Boise River at the mouth, which is characterized by predominantly deep- and shallow-run habitat, made netting fish difficult, so this sample was biased toward a large number of small fish collected in low-velocity areas.

Table 2. Habitat variables measured in the lower Boise River, Idaho, November 1997 through January 1998

[Site locations shown in figure 1; ft, feet; n, number of transects; ft/s, feet per second; <, less than; >, greater than; %, percent]

Habitat variable	Boise River at Eckert Road (Site 1)	Boise River near Middleton (Site 4)	Boise River at mouth near Parma (Site 6)
Instream habitat			
Reach length (ft)	2,134	2,135	1,782
Mean reach width (ft) (n=6)	135	210	203
Geomorphic channel units (percent)			
Pool	50	5	0
Riffle	25	10	5
Run	25	85	95
Mean velocity (ft/s) (n=18)	1.60	1.63	2.48
Mean depth (ft) (n=18)	1.62	1.98	2.75
Mean channel embeddedness[1] (n=18)	2.9	1.2	2.0
Riparian habitat			
Mean streambank cover (percent) (n=24)	4	7	10
Mean canopy opening (percent) (n=12)	68	84	79

[1] Embeddedness (1=>75%; 2=51 to 75%; 3=26 to 50%; 4=5 to 25%; 5=<5%). Data were averaged for each reach; therefore, the given number may fall between two categories.

BIOLOGICAL ASSESSMENT

Instream and Riparian Habitat

Instream and riparian habitat variables measured in the Boise River in November 1997 and January 1998 (table 1) are summarized in table 2 (more extensive data are listed in appendices C and D). Geomorphic channel units were fairly well balanced among pool/riffle/run sequences at site 1 but were dominated by runs at sites 4 and 6 (85 and 95 percent, respectively). Pool habitat was absent at site 6. Vegetative cover along the streambank was relatively sparse and ranged from 4 percent at site 1 to 10 percent at site 6. Canopy opening was similar at all sites and was 68 percent at site 1, 84 percent at site 4, and 79 percent at site 6. Mean channel embeddedness ranged from moderate to extreme at all sites and was highest at Middleton (site 4) and lowest at Eckert Road (site 1). Embeddedness at the mouth (site 6) was about midway between the highest and lowest scores (see appendix A for explanation of rating factors).

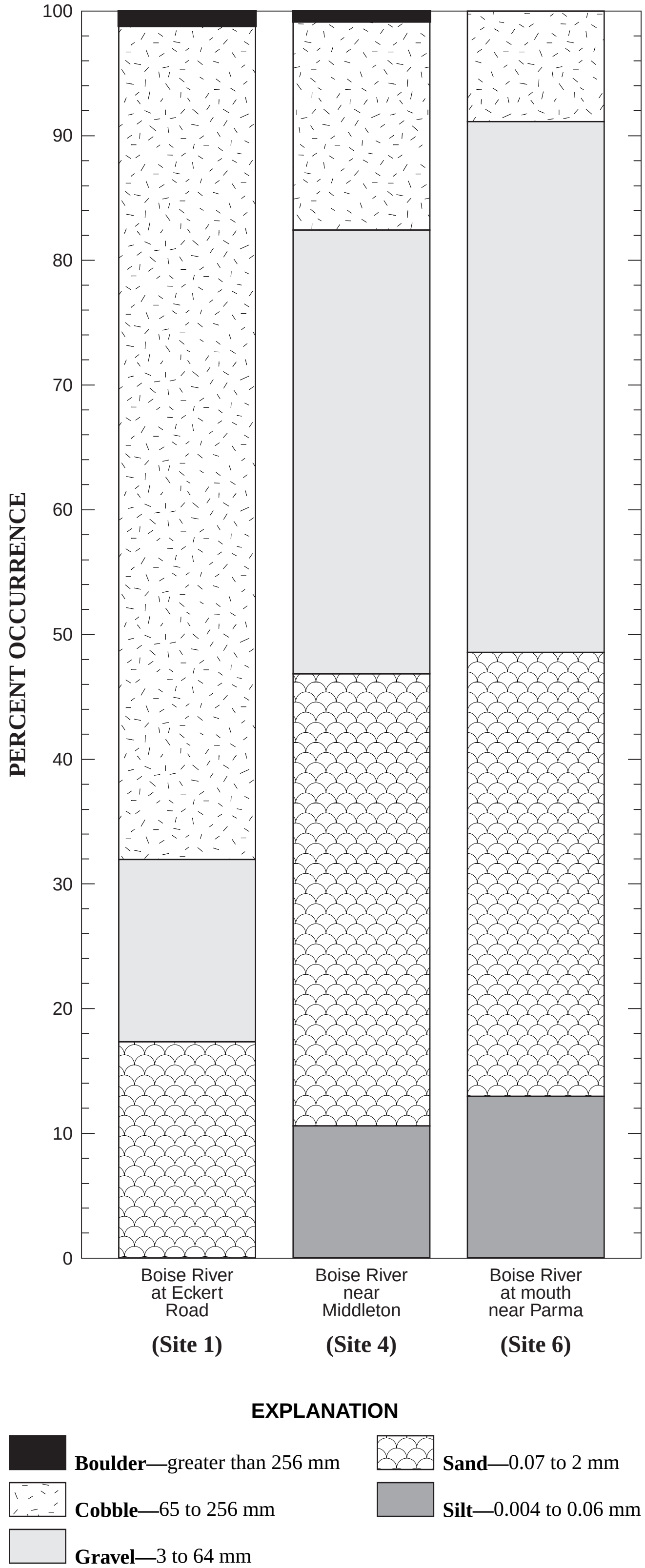

Figure 3. Pebble count data for the lower Boise River, Idaho, November 1997 through January 1998. (Site locations shown in figure 1)

Substrate characterized using a pebble count (Wolman, 1954) is graphically summarized in figure 3. Cobbles were dominant at site 1, composing about 68 percent of the substrate. Gravel composed about 36 percent of the substrate at site 4; sand composed about 17 percent of the substrate at site 1; and silt and sand composed about 47 percent of the substrate at site 4 and 49 percent at site 6.

Bjornn and others (1977) reported that riffle embeddedness in excess of 20 to 30 percent negatively affected the survival and emergence of salmonid embryos in streams within the Idaho batholith. They also reported that the number of juvenile trout that a stream can support in winter is greatly reduced when the interstices in the stream substrate are filled with sediment. Finally, they reported that the density and diversity of the benthic insect communities in the streams they studied were adversely affected when large amounts of sediment (for example, greater than 2/3 cobble embeddedness) were present in riffle habitat. On one test stream (Elk Creek), test plots were manually cleaned to reduce embeddedness. The cleaned plots had approximately four times more mayflies (Ephemeroptera) and eight times more stoneflies (Plecoptera) than did the uncleaned (embedded) plots.

Instream and riparian habitat variables that were assessed qualitatively on the basis of protocols developed by Barbour and others (1997) are summarized in table 3. In general, scores for most instream habitat variables were generally suboptimal at best at site 1 and tended to decrease among sites in a downstream direction (see appendix A for an explanation of condition categories). In contrast, riparian habitat variables did not follow this same trend. The only optimal scores were assigned to the instream variables velocity/depth regime and frequency of riffles (or bends) at site 1. Poor scores were assigned to the variable embeddedness at sites 4 and 6, and poor scores were assigned to the variables epifaunal substrate/available cover, velocity/depth regime, and frequency of riffles (or bends) at site 6. In general, the lower reaches are dominated by runs with little pool or riffle habitat, which results in reduced cover for fish and reduction in habitat diversity. Embeddedness is also high at all sites and increases at downstream sites. Total scores, expressed as a percentage of the potential maximum score, ranged from 65 percent at site 1 to 49 percent at site 6; site 4 scored in between at 59 percent.

Table 3. Habitat variables for the lower Boise River, Idaho, assessed using rapid bioassessment protocols, November 1997 through January 1998

[Site locations shown in figure 1; scoring criteria from Barbour and others (1997); example of field data sheet used for habitat assessment shown in appendix A]

Habitat variable	Boise River at Eckert Road (Site 1)		Boise River near Middleton (Site 4)		Boise River at mouth near Parma (Site 6)	
	Score	Condition category	Score	Condition category	Score	Condition category
Instream habitat						
Epifaunal substrate/available cover	9	Marginal	8	Marginal	5	Poor
Embeddedness	12	Suboptimal	5	Poor	5	Poor
Velocity/depth regime	17	Optimal	14	Suboptimal	5	Poor
Sediment deposition	12	Suboptimal	11	Suboptimal	7	Marginal
Channel flow status	14	Suboptimal	13	Suboptimal	15	Suboptimal
Channel alteration	14	Suboptimal	13	Suboptimal	13	Suboptimal
Frequency of riffles (or bends)	16	Optimal	14	Suboptimal	3	Poor
Riparian habitat						
Bank stability						
Left bank	8	Suboptimal	8	Suboptimal	8	Suboptimal
Right bank	7	Suboptimal	8	Suboptimal	4	Marginal
Vegetative protection						
Left bank	6	Suboptimal	5	Marginal	9	Optimal
Right bank	4	Marginal	8	Suboptimal	7	Suboptimal
Riparian vegetative zone width						
Left bank	7	Suboptimal	9	Marginal	9	Optimal
Right bank	4	Marginal	8	Suboptimal	8	Suboptimal
Total score	**130**		**124**		**98**	
Percent of potential maximum score of 200	**65**		**62**		**49**	

General site plans and individual transect elevations surveyed under the second-level reach characterization are shown in figures 4 through 9.

Epilithic Periphyton

Epilithic periphyton biomass data, expressed as chlorophyll-*a* and ash-free dry weight, are summarized in table 4 and figure 10. During 1995–96, median chlorophyll-*a* concentrations at sites 4, 5, and 6 downstream from Boise were higher than concentrations at sites 1 and 3 and ranged from 101 mg/m^2 near Parma to 765 mg/m^2 at Caldwell. Concentrations overall were lower in 1997 than in 1995–96, ranging from <0.3 mg/m^2 at Eckert Road to 135 mg/m^2 near Parma, but the trend of higher concentrations in the reaches downstream from Boise was still evident. Concentrations usually were highest near Middleton or Caldwell and decreased slightly downstream toward the mouth near Parma. The reason for the decreasing trend in chlorophyll-*a* in the most downstream reach is likely decreased water-column light penetration caused by turbidity from numerous tributary drains and possible scour from higher suspended sediment loads (Mullins, 1998a).

In general, chlorophyll-*a* concentrations among sites were highest in 1996 and lowest in 1997 (except near Parma, where the lowest chlorophyll-*a* concentrations were measured in 1995; see table 4.) However, in 1997, collections of epilithic periphyton were made in August rather than in October, which made comparisons between 1997 data and 1995 and 1996 data difficult.

Benthic Macroinvertebrates

Benthic macroinvertebrate taxa identified in the Boise River during 1995–97 are summarized in table

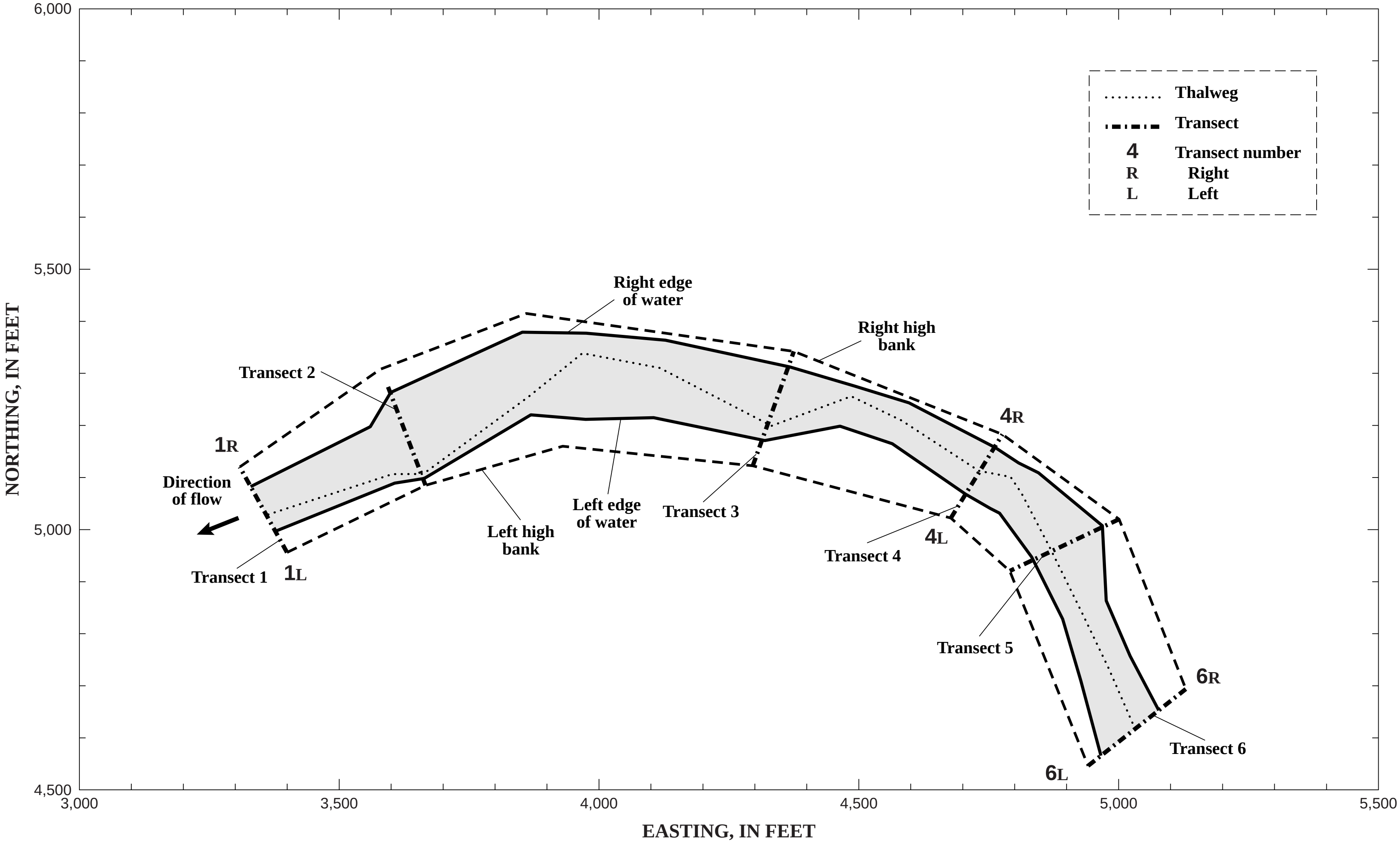

Figure 4. General site plan and individual transects, lower Boise River at Eckert Road (site 1), Idaho, November 1997. (Site location shown in figure 1)

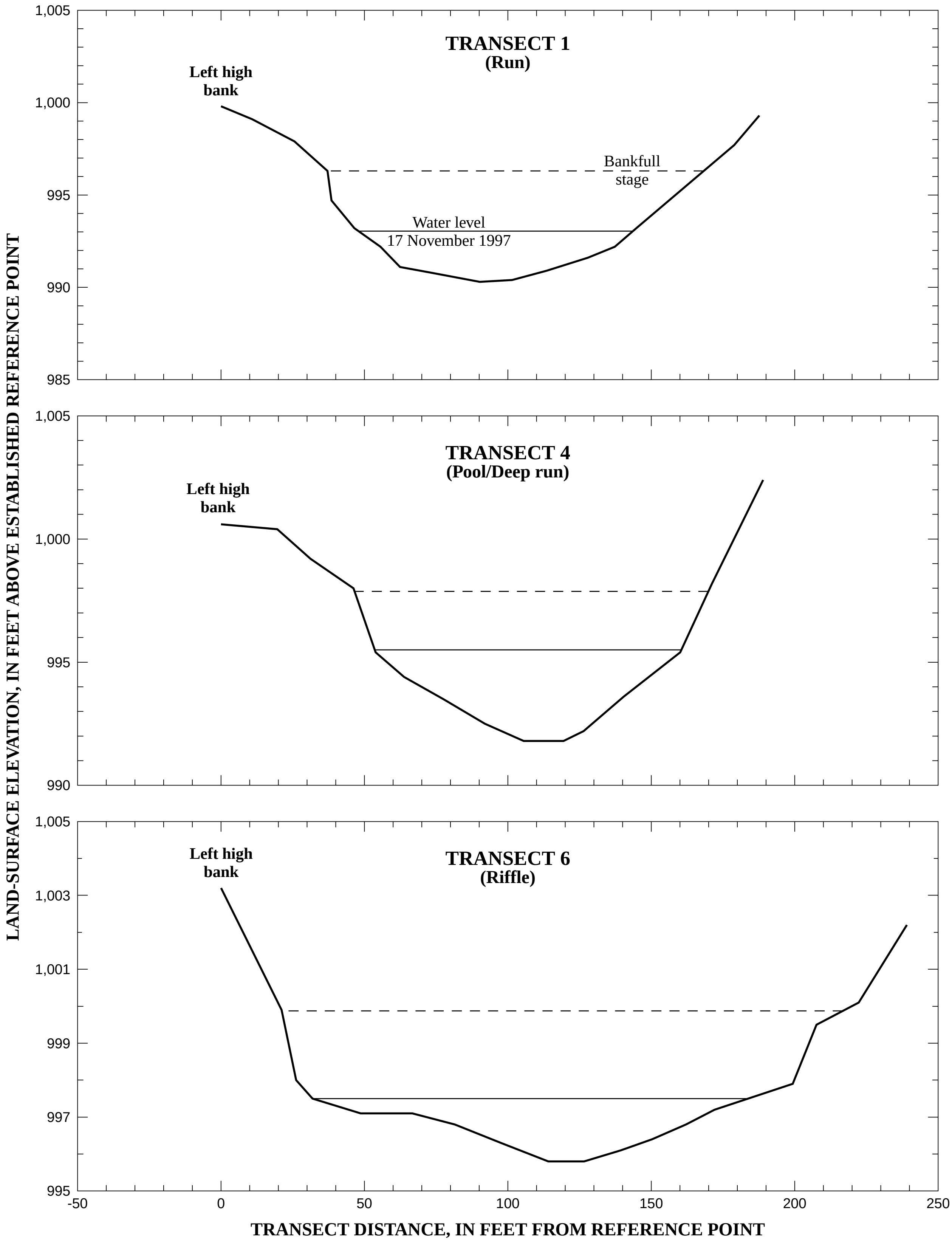

Figure 5. Channel transects for the lower Boise River at Eckert Road (site 1), Idaho, November 1997. (Bankfull stage estimated during survey; site location shown in figure 1)

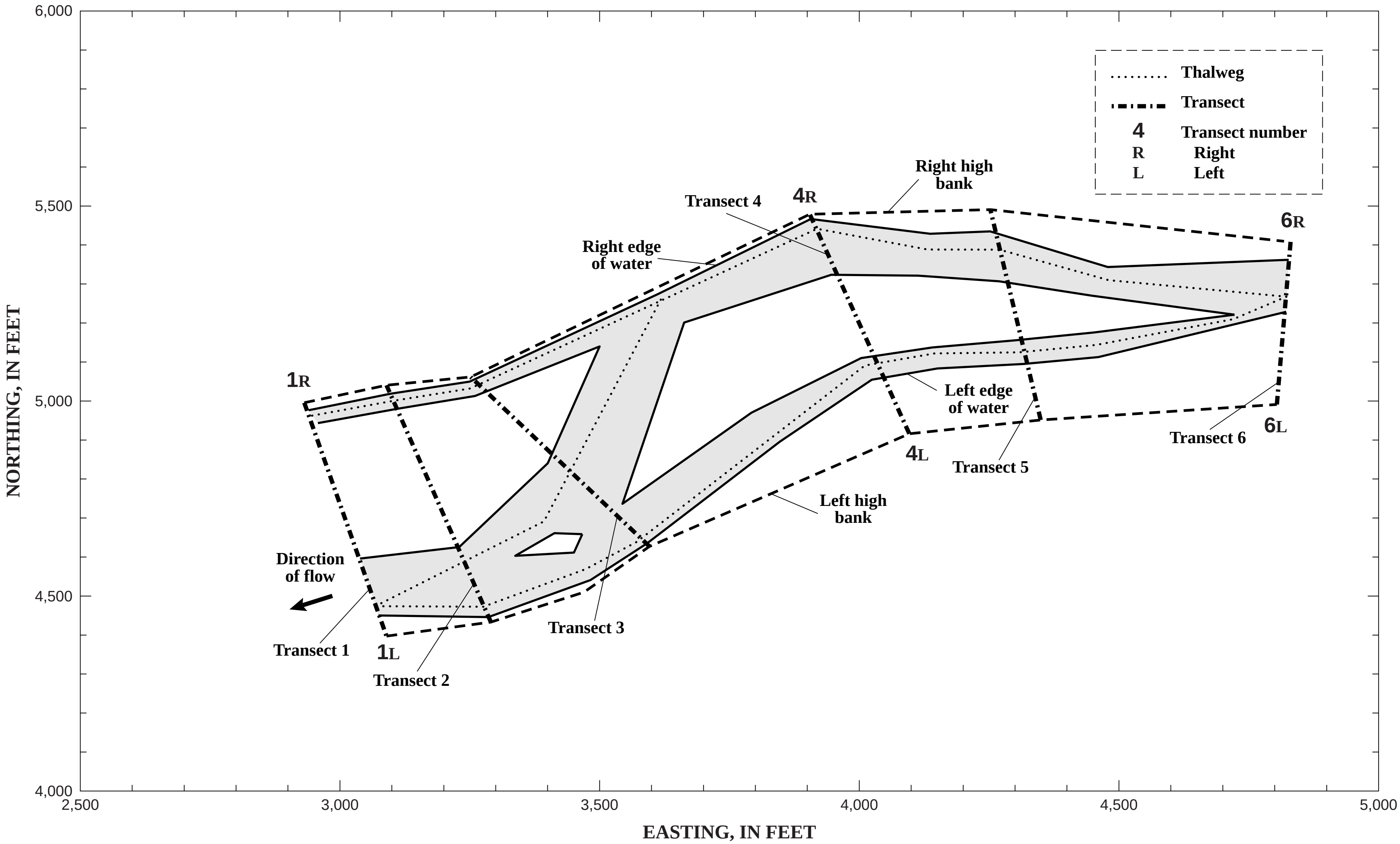

Figure 6. General site plan and individual transects, lower Boise River near Middleton (site 4), Idaho, November 1997. (Site location shown in figure 1)

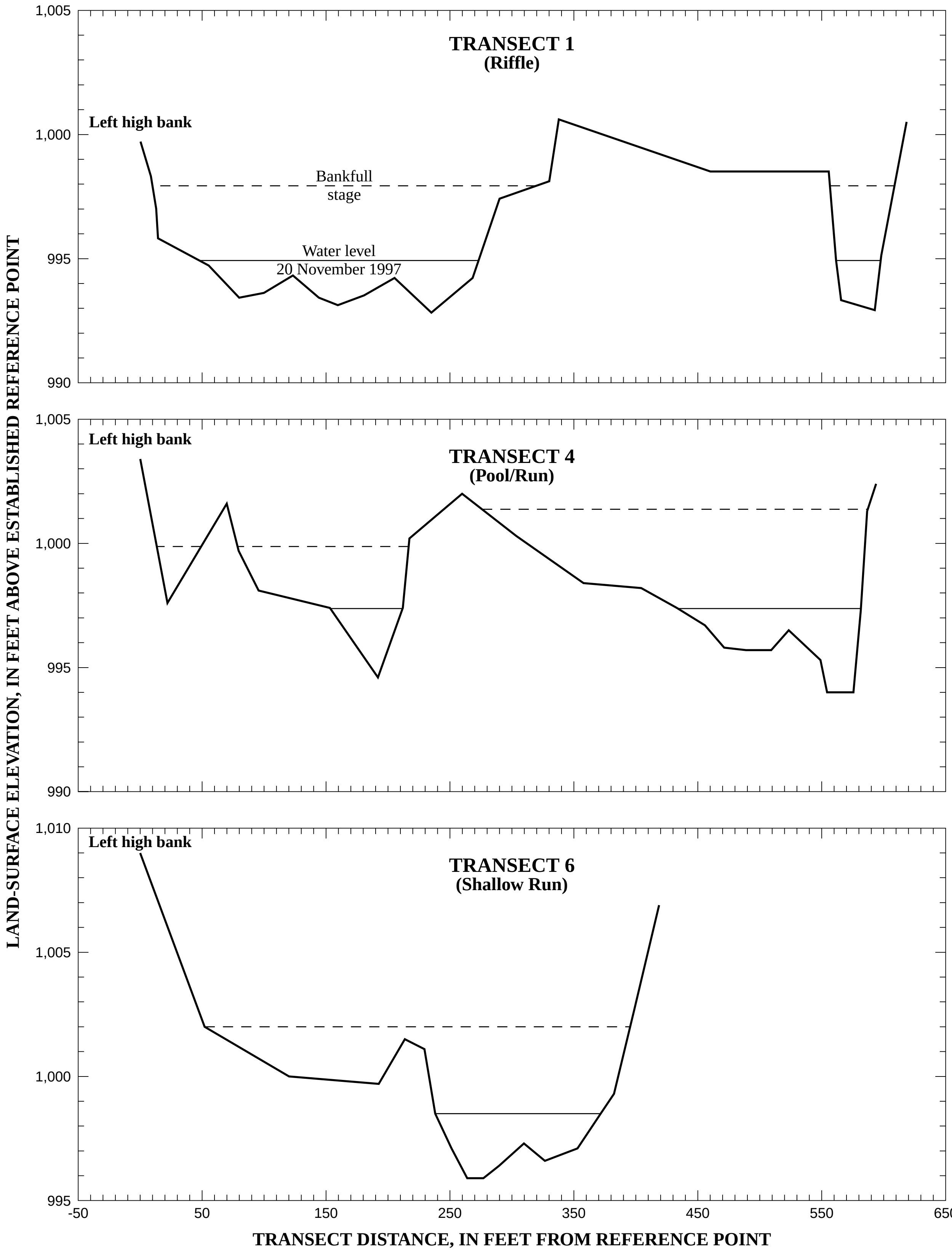

Figure 7. Channel transects for the lower Boise River near Middleton (site 4), Idaho, November 1997. (Bankfull stage estimated during survey; site location shown in figure 1)

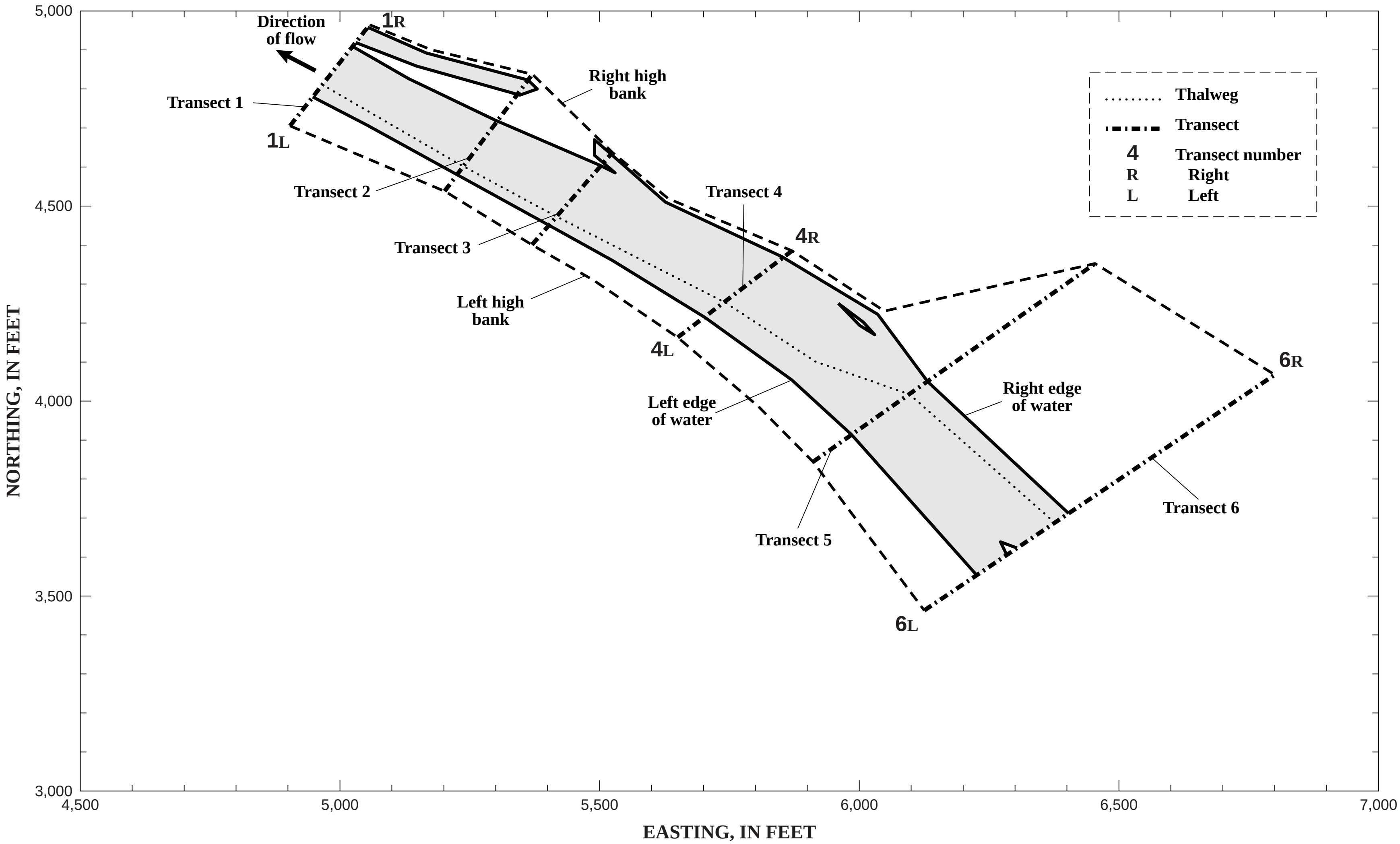

Figure 8. General site plan and individual transects, lower Boise River at mouth near Parma (site 6), Idaho, January 1998. (Site location shown in figure 1)

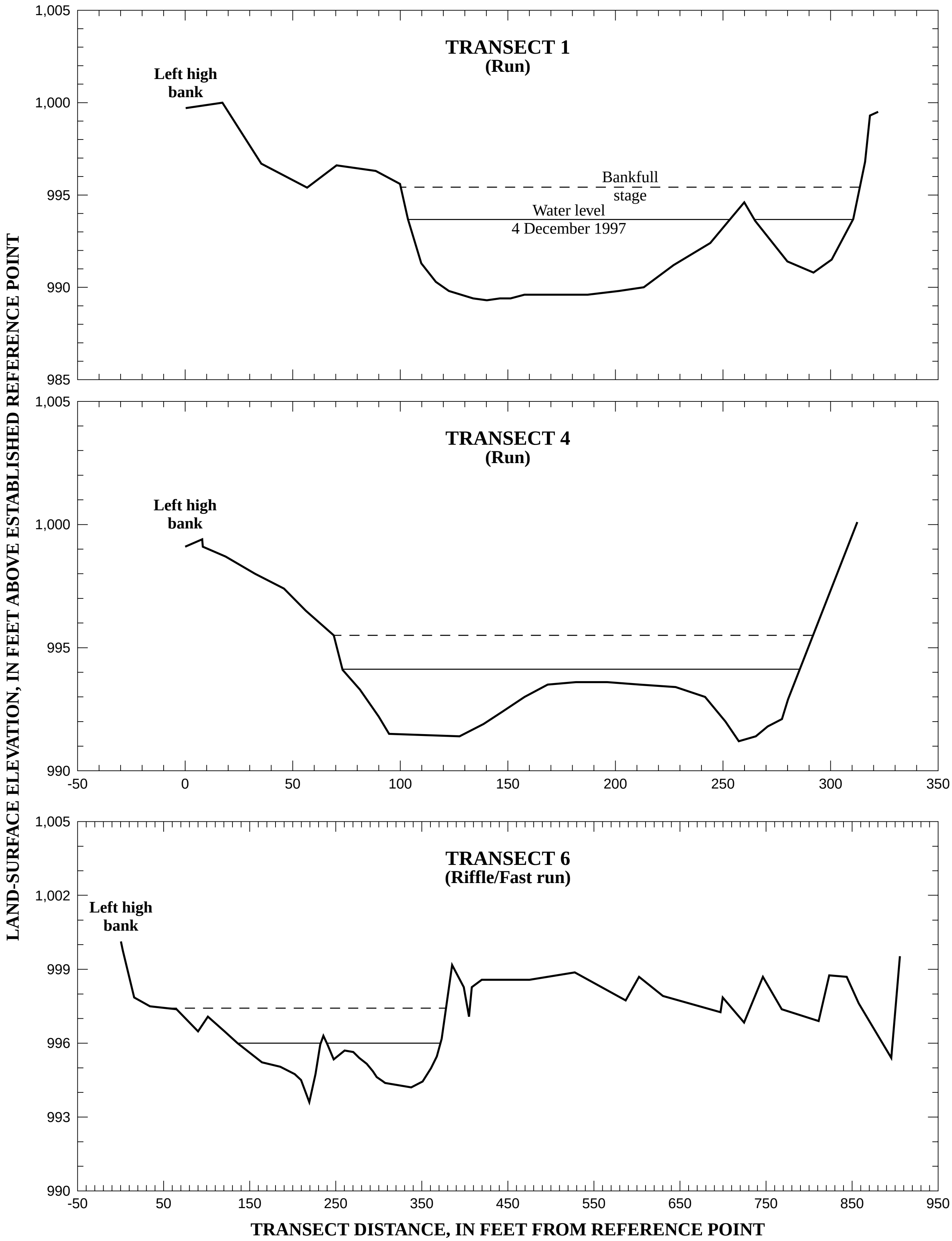

Figure 9. Channel transects for the lower Boise River at mouth near Parma (site 6), Idaho, January 1998. (Bankfull stage estimated during survey; site location shown in figure 1)

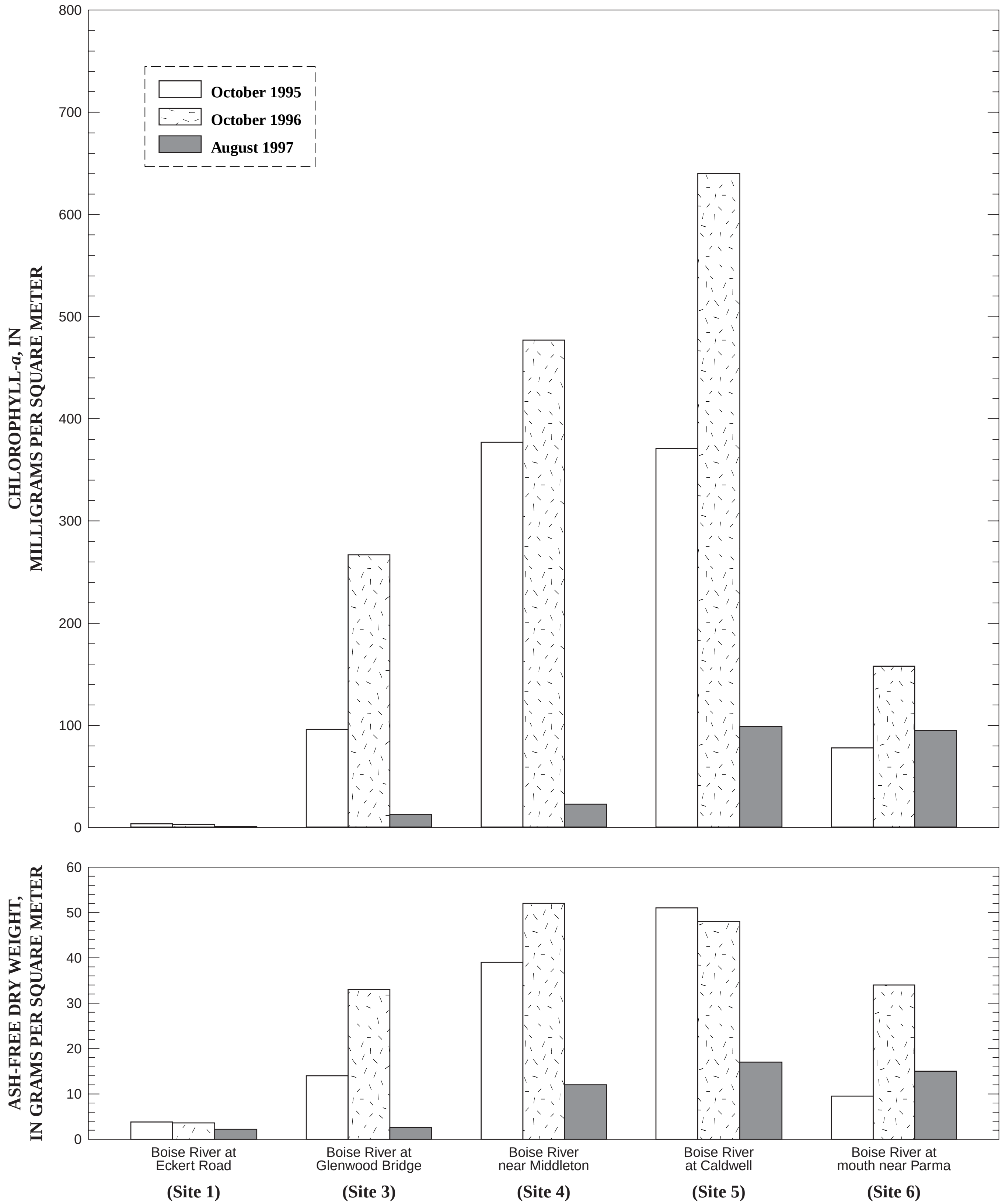

Figure 10. Spatial and temporal trends of chlorophyll-*a* and ash-free dry weight for epilithic periphyton in the lower Boise River, Idaho, October 1995, October 1996, and August 1997. (Site locations shown in figure 1)

Table 4. Chlorophyll-*a* and ash-free dry weight of epilithic periphyton collected in the lower Boise River, Idaho, October 1995, October 1996, and August 1997

[Site locations shown in figure 1; mg/m^2, milligrams per square meter; —, not calculated; ND, no data; g/m^2, grams per square meter; <, less than]

	Boise River at Eckert Road (Site 1)			Boise River at Glenwood Bridge (Site 3)			Boise River near Middleton (Site 4)			Boise River at Caldwell (Site 5)			Boise River at mouth near Parma (Site 6)		
Metric	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**
Chlorophyll-*a* (mg/m^2)															
Sample 1	1.8	0.3	<0.3	256	317	28	630	610	5.3	304	765	99	101	194	135
Sample 2	5.6	6.1	<.3	19	219	7.2	91	384	42	396	933	ND	28	188	42
Sample 3	ND	3.0	.8	14	265	3.5	410	436	21	412	223	ND	105	92	107
Median	**3.7**	**3.0**	**—**	**19**	**265**	**7.2**	**410**	**436**	**21**	**396**	**765**	**ND**	**101**	**188**	**107**
Ash-free dry weight (g/m^2)															
Sample 1	3.1	5.4	2.0	33	38	2.4	69	48	3.2	38	56	17	16	34	18
Sample 2	4.5	3.8	2.1	1.5	28	2.4	11	48	12	49	50	ND	8.3	35	8.6
Sample 3	ND	1.5	2.4	6.1	33	3.0	37	61	21	67	39	ND	14	33	17
Median	**3.8**	**3.8**	**2.1**	**6.1**	**33**	**2.4**	**37**	**48**	**12**	**49**	**50**	**ND**	**14**	**34**	**17**

5. Ninety taxa were represented, including 7 insect orders and 22 noninsect taxa. All sites were characterized by generally low taxa diversity. In general, hard-bottom (cobble/gravel) streams the size of the Boise River in the same or similar ecoregions in the Northwest exhibit taxa diversity of 30 to 50 (Bob Wisseman, Aquatic Biology Associates, written commun., 1995). Plecopterans (stoneflies) were noticeably rare or absent at all sites, and only members of the family Perlodidae were collected during this study. As a group, plecopterans are generally considered indicators of good water-quality and habitat conditions because they are adversely affected by high cobble embeddedness, low dissolved oxygen, warm water temperatures, and (or) excessive growth of filamentous algae.

Macroinvertebrate metrics observed for all sites are summarized in table 6. Thirteen metrics in three categories were chosen to represent key biological attributes of the aquatic ecosystem. Primary metrics are used to evaluate general community composition. Variables related to taxonomic composition (species richness) and density (abundance) can be indicative of the general health of the invertebrate community. For example, the total EPT (Ephemeroptera-Plecoptera-Trichoptera) metric functions as a pollution barometer because these taxa are generally intolerant of pollution (Robinson and Minshall, 1994).

Between 1995 and 1996, abundance declined at all sites, ranging from a 43-percent decline at site 1 to an 87-percent decline at site 5. In 1997, abundance levels were similar to 1995 levels at sites 1, 3, and 4, but only slightly higher than 1996 levels at sites 5 and 6. From 1995 to 1997, total taxa and EPT taxa richness increased from slightly less than 10 percent to nearly 30 percent among all sites except site 4, where EPT taxa richness increased slightly but total taxa richness decreased slightly. Mean taxa richness during 1995–97 ranged from 29 at site 3 to 37 at sites 4 and 5.

Percent dominant taxa is a measure of the contribution to total abundance of the most numerous taxa present in a sample. Invertebrate communities under stress frequently comprise fewer taxa and tend to comprise a few tolerant species that dominate. Percent dominant taxa (*Hydropsyche* sp.) was high at all sites and ranged from 27 at site 5 in 1996 to 72 at site 3 in 1997. No obvious trends in this metric between sites or between years were observed.

Positive indicators are types of metrics that tend to increase under improving water quality and (or) habitat conditions. For example, predator richness and scraper richness represent functional feeding groups that are more abundant in good-quality habitat. Percent Glossomatidae represents a family of intolerant scraper caddisflies that are adversely affected by high winter scour, heavy growths of filamentous algae, and deposits of fine sediment on rock surfaces (Wisseman, 1996).

Table 5. Mean density of macroinvertebrate taxa collected in the lower Boise River, Idaho, October 1995, 1996, and 1997

[Site locations shown in figure 1]

Taxon	Boise River at Eckert Road (Site 1)			Boise River at Glenwood Bridge (Site 3)			Boise River near Middleton (Site 4)			Boise River at Caldwell (Site 5)			Boise River at mouth near Parma (Site 6)		
	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997
Turbellaria (flatworms)	0	0	0	0	0	0	177	8	10	21	1	1	213	49	16
Nematoda (roundworms)	9	0	6	0	3	20	6	0	34	61	5	15	33	8	8
Annelida (segmented worms)															
Oligochaeta (aquatic earthworms)															
Enchytraeidae	8	0	17	154	5	0	0	0	0	0	0	0	0	0	0
Lumbricina	11	0	0	128	0	0	0	0	0	0	1	0	0	9	0
Lumbriculidae	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0
Naididae	20	24	8	1,064	40	79	90	18	66	219	258	117	34	35	32
Tubificidae	39	0	0	98	0	0	6	0	0	460	0	0	44	0	4
Hirudinea (leeches)	0	0	0	8	0	0	0	1	0	0	0	0	59	0	0
Isopoda (aquatic sow bugs)															
Asellidae															
Caecidotea sp.	0	0	0	0	0	0	0	1	0	0	3	2	0	9	8
Crustacea (crustaceans)															
Amphipoda (scuds)															
Gammaridae															
Gammarus sp.	4	0	0	0	0	0	0	2	0	7	7	0	0	0	4
Copepoda	5	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Decapoda (crayfish)															
Astacidae															
Pascifastacus sp.	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Ostracoda (seed shrimp)	0	0	0	0	0	0	0	0	0	3	2	0	0	5	0
Insecta (insects)															
Ephemeroptera (mayflies)															
Baetidae	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Acentrella turbida	274	27	141	656	3	76	2,008	87	302	155	14	41	1,197	261	360
Baetis bicaudatus	0	0	0	0	0	325	0	0	0	0	7	0	0	0	0
Baetis tricaudatus	2,153	1,179	1,756	2,584	261	194	787	221	831	158	1	55	1,519	179	228
Ephemerella inermis/infrequens	8	19	124	8	19	62	0	11	34	0	0	0	0	8	8
Heptageniidae															
Heptagenia/Nixe sp.	64	5	12	218	45	10	0	7	20	0	0	1	0	0	0
Rhithrogena sp.	128	157	576	83	72	51	0	0	25	0	0	2	0	5	116
Stenonema sp.	9	0	6	70	0	5	114	1	15	31	51	60	1,103	88	556
Leptophlebiidae															
Paraleptophlebia sp.	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0
Polymitarcyidae															
Ephoron album	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0
Tricorythidae															
Tricorythodes minutus	18	3	12	261	3	11	2,714	133	409	1,219	28	77	7,519	1,056	2,488
Odonata (dragonflies, damselflies)															
Coenagrionidae															
Argia sp.	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Table 5. Mean density of macroinvertebrate taxa collected in the lower Boise River, Idaho, October 1995, 1996, and 1997—Continued

Taxon	Boise River at Eckert Road (Site 1)			Boise River at Glenwood Bridge (Site 3)			Boise River near Middleton (Site 4)			Boise River at Caldwell (Site 5)			Boise River at mouth near Parma (Site 6)		
	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997
Odonata (dragonflies, damselflies)—Continued															
Gomphidae															
Ophiogomphus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Plecoptera (stoneflies)															
Perlodidae-early instar	5	5	3	9	85	121	0	8	177	0	0	0	0	0	0
Isoperla sp.	0	8	6	0	0	0	0	0	5	0	0	0	0	0	0
Trichoptera (caddisflies)															
Brachycentridae															
Brachycentrus occidentalis	9	0	0	0	0	0	0	0	11	0	0	0	0	0	0
Glossomatidae															
Glossosoma sp.	361	77	58	8	3	60	0	0	13	0	0	1	0	0	0
Protoptila sp.	0	0	0	0	0	0	33	5	8	0	0	0	170	3	20
Hydropsychidae															
Cheumatopsyche sp.	328	91	143	395	157	150	712	87	226	82	0	13	11	16	16
Hydropsyche sp.	5,143	3,141	6,857	6,663	3,011	7,737	3,707	2,510	6,412	5,646	414	1,848	3,167	2,168	2,504
Hydroptilidae															
Hydroptila sp.	0	35	162	0	0	0	13	1	11	0	0	0	0	0	0
Leucotrichia sp.	0	0	4	0	0	0	42	0	0	0	0	0	0	0	0
Leptoceridae															
Ceraclea sp.	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0
Nectopsyche sp.	0	0	0	0	0	0	6	1	0	0	0	0	0	0	0
Oecetis sp.	0	0	0	0	0	0	64	53	0	0	0	0	0	0	4
Limnephilidae-early instar	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
Psychomyiidae															
Psychomyia sp.	0	0	221	0	0	5	10	1	15	0	0	0	0	0	0
Lepidoptera (moths, butterflies)															
Pyralidae															
Petrophila sp.	0	27	284	599	176	399	30	12	107	30	6	110	44	27	444
Coleoptera (beetles)															
Elmidae															
Microcylloepus sp.	0	0	0	0	0	0	17	0	8	0	0	4	57	19	12
Diptera (true flies)															
Ceratopogonidae	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Chironomidae															
Chironomidae-pupae	138	59	20	240	101	90	269	112	418	335	74	141	204	195	172
Cardiocladius sp.	129	0	55	265	88	424	302	54	234	521	11	103	44	8	4
Cricotopus sp.	4	35	82	185	27	569	330	102	1,905	1,343	332	459	780	381	252
Cricotopus bicinctus Gr.	0	0	0	0	0	0	0	5	16	16	10	36	0	19	12
Cricotopus trifascia Gr.	0	11	11	16	0	5	33	0	13	583	79	184	874	579	172
Chriptochironomus sp.	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Diamesinae-early instar	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
Diamesa sp.	0	0	0	0	8	0	0	8	24	0	42	26	0	24	4
Dicrotendipes sp.	0	0	0	0	0	0	20	6	0	0	3	3	0	0	0
Endochironomus sp.	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Eukiefferiella sp.	131	32	58	96	8	36	6	4	79	70	33	4	10	152	84
Micropsectra sp.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4

Table 5. Mean density of macroinvertebrate taxa collected in the lower Boise River, Idaho, October 1995, 1996, and 1997—Continued

Taxon	Boise River at Eckert Road (Site 1)			Boise River at Glenwood Bridge (Site 3)			Boise River near Middleton (Site 4)			Boise River at Caldwell (Site 5)			Boise River at mouth near Parma (Site 6)		
	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997
Diptera (true flies)—Continued															
Microtendipes sp.	0	0	4	0	0	0	20	198	0	0	0	0	0	0	0
Orthocladiinae-early instar	20	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Orthocladius Complex	48	144	59	330	107	20	80	72	635	340	35	35	189	29	20
Parakiefferiella sp.	0	0	0	0	0	0	0	0	0	7	13	5	0	0	4
Paralimnophyes sp.	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Phaenopsectra sp.	0	0	0	0	0	0	0	5	0	0	2	0	0	0	0
Polypedilum sp.	0	0	0	0	0	0	53	75	8	16	0	0	57	0	4
Potthastia longimana Gr.	0	0	0	8	0	0	7	0	0	0	0	0	0	0	0
Paratanytarsus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4
Rheocricotopus sp.	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
Rheotanytarsus sp.	0	0	0	9	0	0	22	5	19	3	0	2	0	8	4
Robackia sp.	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Stenochironomus sp.	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Synorthocladius sp.	71	0	0	34	0	0	17	0	0	0	1	3	0	0	0
Tanytarsus sp.	0	0	0	0	0	0	0	0	0	10	4	0	0	5	4
Thienemannimyia sp.	0	0	18	0	0	26	0	0	0	0	0	0	0	0	0
Thienemanniella sp.	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0
Tvetenia sp.	4	19	15	10	0	15	0	0	0	0	0	0	0	0	0
Empididae															
Chelifera sp.	0	0	4	0	0	10	0	0	5	0	3	2	0	0	0
Hemerodromia sp.	0	0	4	0	0	10	6	1	0	23	3	2	11	3	4
Brachycera	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
Ephydridae	0	0	0	0	0	0	0	0	0	0	12	0	11	0	0
Simuliidae															
Simulium sp.	1,256	968	800	75	8	32	129	1	52	204	16	26	214	104	92
Tipulidae	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0
Antocha sp.	0	0	30	0	13	0	0	0	0	0	0	0	0	0	0
Tipula sp.	0	0	0	0	0	0	0	0	0	0	5	0	0	3	0
Arachnoidea (spiders, mites)															
Acari (water mites)	244	21	83	345	99	183	623	52	466	459	9	60	212	27	60
Mollusca (mollusks)															
Gastropoda (snails, limpets)															
Hydrobiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Potamopyrgus antipodarum	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Ancylidae															
Ferrissia sp.	0	0	0	10	0	0	0	0	0	7	15	1	33	0	4
Lymnaeidae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Physidae															
Physella sp.	0	0	0	0	0	0	0	3	0	0	1	0	0	3	4
Planorbidae	0	0	0	9	0	0	0	1	0	3	1	3	0	0	0
Pelecypoda (clams, mussels)															
Sphaeriidae	4	0	0	17	0	0	0	0	0	0	7	0	44	0	0
Corbiculidae															
Corbicula sp.	0	0	0	0	0	0	0	0	0	0	0	3	33	0	12

Table 6. Macroinvertebrate community metrics for taxa collected in the lower Boise River, Idaho, October 1995, 1996, and 1997

[Site locations shown in figure 1; m², mean density per square meter; EPT, Ephemeroptera, Plecoptera, Trichoptera]

	Boise River at Eckert Road (Site 1)			Boise River at Glenwood Bridge (Site 3)			Boise River near Middleton (Site 4)			Boise River at Caldwell (Site 5)			Boise River at mouth near Parma (Site 6)		
Metric	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**	**1995**	**1996**	**1997**
Primary metrics															
Total abundance (m²)	10,642	6,085	11,666	14,663	4,293	10,736	12,529	3,827	12,612	12,037	1,513	3,452	17,865	5,528	7,752
Total taxa richness	30	22	37	33	23	30	38	39	34	30	43	37	28	35	39
EPT taxa richness	12	12	17	12	10	13	13	14	16	6	6	10	7	9	10
Percent dominant taxa	48	52	59	45	70	72	30	66	51	47	27	54	42	39	32
Positive indicators															
Predator richness	2	2	6	3	2	5	2	5	4	2	4	4	3	3	2
Scraper richness	4	7	5	7	4	6	5	7	7	4	6	7	4	4	6
Percent intolerant mayflies	0	0	0	0	0	3	0	0	0	0	.4	0	0	0	0
Percent Glossomatidae	3.4	1.3	.05	.05	.06	.5	.3	.1	.2	0	0	.04	1	.05	.3
Negative indicators															
Percent parasites	2.4	.4	.8	2.4	1.2	1.9	1.4	4	.8	4.3	.9	2.2	.6	.9	.4
Percent Oligochaeta	.7	0	.3	9.9	.1	.7	.8	.5	.5	5.6	17.1	3.4	.4	1.4	.5
Percent tolerant mollusks	0	0	0	.13	0	0	0	.1	0	.1	1.3	.1	.1	.05	.1
Percent tolerant mayflies	.3	.04	.2	2.3	.06	.15	23	3.5	3.4	10.4	5.2	3.4	48.3	20.7	39.3
Percent Chironomidae	5.1	4.9	2.7	8.1	7.9	11.1	9.6	17	26.6	27	42.4	29	12.1	25.4	9.6

Table 7. Scoring criteria for macroinvertebrate community metrics used to assess biotic integrity of the lower Boise River, Idaho

[Scoring criteria from Wisseman (1996); m², mean density per square meter; EPT, Ephemeroptera, Plecoptera, Trichoptera; —, not applicable; >, greater than; <, less than]

Metric	Response to disturbance	Scoring criteria 4	3	2	1	0	Maximum score
Primary metrics							
Total abundance (m²)	Decrease	—	—	>10,000	5,000–9,999	<5,000	2
Total taxa richness	Decrease	>40	30–39	20–29	10–19	<10	4
EPT taxa richness	Decrease	>25	20–24	15–19	10–14	<10	4
Percent dominant taxa	Increase	<25	25–29	30–40	40–50	>50	4
Subtotal primary metrics							**14**
Positive indicators							
Predator richness	Decrease	—	—	>10	5–10	<5	2
Scraper richness	Decrease	—	—	>10	5–10	<5	2
Percent intolerant mayflies	Decrease	>4	3.0–3.9	1.0–2.9	<1	0	4
Percent Glossomatidae	Decrease	—	—	>1	<1	0	2
Subtotal positive indicators							**10**
Negative indicators							
Percent parasites	Increase	—	—	—	<2	>2	1
Percent Oligochaeta	Increase	—	—	<1	1.0–4.9	>5	2
Percent tolerant mollusks	Increase	0	<1	1.0–4.9	5.0–9.9	>10	4
Percent tolerant mayflies	Increase	0	<1	1.0–4.9	5.0–9.9	>10	4
Percent Chironomidae	Increase	<10	10–19	20–29	30–39	>40	4
Subtotal negative indicators							**15**
Potential maximum score							**39**

Table 8. Benthic index of biotic integrity scores for macroinvertebrates collected in the lower Boise River, Idaho, October 1995, 1996, and 1997

[Site locations shown in figure 1; m^2, mean density per square meter; EPT, Ephemeroptera, Plecoptera, Trichoptera]

Metric	Boise River at Eckert Road (Site 1)			Boise River at Glenwood Bridge (Site 3)			Boise River near Middleton (Site 4)			Boise River at Caldwell (Site 5)			Boise River at mouth near Parma (Site 6)		
	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997
Primary metrics															
Total abundance (m^2)	2	1	2	2	0	2	2	0	2	2	0	0	2	1	1
Total taxa richness	3	2	3	3	2	3	3	3	3	3	4	3	2	3	3
EPT taxa richness	1	1	2	1	1	1	1	1	2	0	0	1	0	0	1
Percent dominant taxa	1	0	0	1	0	0	2	0	0	1	3	0	1	2	2
Subtotal primary metrics	**7**	**4**	**7**	**7**	**3**	**6**	**8**	**4**	**7**	**6**	**7**	**4**	**5**	**6**	**7**
Positive indicators															
Predator richness	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0
Scraper richness	0	1	1	1	0	1	1	1	1	0	1	1	0	0	1
Percent intolerant mayflies	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0
Percent Glossomatidae	2	2	1	1	1	1	1	1	1	0	0	1	1	1	1
Subtotal positive indicators	**2**	**3**	**3**	**2**	**1**	**5**	**2**	**3**	**2**	**0**	**2**	**2**	**1**	**1**	**2**
Negative indicators															
Percent parasites	0	1	1	0	1	1	1	0	1	0	1	0	1	1	1
Percent Oligochaeta	2	2	2	0	2	2	2	2	2	0	0	1	2	1	2
Percent tolerant mollusks	4	4	4	3	4	4	4	3	4	3	2	3	3	3	3
Percent tolerant mayflies	3	3	3	2	3	3	0	2	2	0	1	2	0	0	0
Percent Chironomidae	4	4	4	4	4	3	4	3	2	2	0	2	3	2	4
Subtotal negative indicators	**13**	**14**	**14**	**9**	**14**	**13**	**11**	**10**	**11**	**5**	**4**	**8**	**9**	**7**	**10**
Total score	**22**	**21**	**24**	**18**	**18**	**24**	**21**	**17**	**20**	**11**	**13**	**14**	**15**	**14**	**19**

Predator richness and scraper richness were relatively low at all sites, and no obvious trends in these metrics between sites or between years were observed. Glossomatidae were absent at site 5 in 1995 and 1996 and were low at most other sites. The highest percentage of this taxa (3.4) was at site 1 in 1995.

Negative indicators are types of metrics that tend to increase in response to decreasing water quality and (or) habitat conditions. For example, parasites such as Acari (mites) and nematode worms tend to increase in stressed aquatic ecosystems. Oligochaete worms are often abundant in areas where organic-rich sediment has accumulated. In addition, some species of mollusks are tolerant of habitat conditions characterized by fine sediment, warm water temperature, and low dissolved oxygen concentrations. Similarly, some mayfly taxa are indicative of nutrient enrichment and high summer water temperature, and many Chironomid species tend to increase in degraded water and (or) habitat quality (Wisseman, 1996). Metric scores based on percent parasites, percent Oligochaeta, and percent tolerant mollusks did not display any obvious trends between sites or between years, but percent tolerant mayflies and percent Chironomidae increased in an incremental fashion at sites downstream from site 1.

Individual metrics shown in table 6 were scored using the criteria outlined in table 7 to develop a B-IBI score, which represents a summation of individual metric scores (table 8). These metrics and the scoring criteria used to develop the B-IBI scores were modified from a draft biomonitoring protocol being developed for Western montane streams (Wisseman, 1996). The scoring criteria are subjective in nature and represent best professional judgment. These scoring criteria and the resulting scores are intended for among-site comparisons rather than comparison of individual sites with a single reference site, because no reference site for the lower Boise River is known to exist. These protocols represent one of the few available interpretive tools for assessing benthic macroinvertebrate communities because a B-IBI has not been specifically developed for any Idaho streams. Scores were highest at site 1 (score

Table 9. Fish taxa collected in the lower Boise River, Idaho, February 1995, December 1996, and August 1997

[Site locations shown in figure 1; No., number; %, percent]

Taxon	Boise River at Loggers Creek Diversion (Site 2)		Boise River at Glenwood Bridge (Site 3)				Boise River near Middleton (Site 4)				Boise River at Caldwell (Site 5)		Boise River at mouth near Parma (Site 6)			
	1996		1995		1996		1996		1997		1997		1996		1997	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Cyprinidae (minnows)																
Common carp	0	0	0	0	0	0	32	7.5	3	0.3	5	2.5	3	2.5	7	3.1
Chiselmouth	1	.4	0	0	1	.4	2	.5	362	37.1	20	9.9	0	0	14	6.3
Northern pikeminnow	0	0	0	0	2	.8	0	0	86	8.8	0	0	0	0	0	0
Longnose dace	0	0	20	5.1	26	10.4	33	7.8	145	14.9	0	0	13	10.7	13	5.8
Umatilla dace	3	1.3	60	15.2	7	2.8	150	35.3	61	6.3	0	0	1	.8	1	.4
Redside shiner	0	0	3	.7	16	6.4	0	0	66	6.8	120	59.1	0	0	1	.4
Tui chub	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	10.8
Total	**4**	**1.7**	**83**	**21.0**	**52**	**20.8**	**217**	**51.1**	**723**	**74.2**	**145**	**71.5**	**17**	**14.0**	**60**	**26.8**
Catostomidae (suckers)																
Bridgelip sucker	0	0	36	9.1	30	12.0	12	2.8	99	10.2	18	8.9	59	48.8	69	30.9
Largescale sucker	0	0	165	41.8	85	34.1	76	17.9	120	12.3	34	16.7	32	26.4	74	33.2
Mountain sucker	0	0	2	.5	2	.8	8	1.9	0	0	0	0	0	0	0	0
Total	**0**	**0**	**203**	**51.4**	**117**	**46.9**	**96**	**22.6**	**219**	**22.5**	**52**	**25.6**	**91**	**75.2**	**143**	**64.1**
Cobitidae (loaches)																
Oriental weatherfish	0	0	0	0	0	0	0	0	1	.1	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**.1**	**0**	**0**	**0**	**0**	**0**	**0**
Ictaluridae (freshwater catfishes)																
Channel catfish	0	0	0	0	0	0	0	0	0	0	1	.5	0	0	4	1.8
Tadpole madtom	0	0	0	0	0	0	0	0	1	.1	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**.1**	**1**	**.5**	**0**	**0**	**4**	**1.8**
Centrarchidae (sunfish)																
Pumpkinseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	.4
Bluegill	0	0	0	0	0	0	0	0	1	.1	0	0	0	0	0	0
Smallmouth bass	0	0	0	0	0	0	0	0	1	.1	0	0	0	0	9	4.0
Largemouth bass	0	0	0	0	0	0	1	.2	9	.9	0	0	3	2.5	2	.9
Total	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**.2**	**11**	**1.1**	**0**	**0**	**3**	**2.5**	**12**	**5.3**
Salmonidae (trout/whitefish)																
Rainbow trout (wild)	17	7.1	5	1.3	2	.8	1	.2	0	0	0	0	0	0	0	0
Rainbow trout (hatchery)	4	1.7	10	2.5	3	1.2	0	0	1	.1	0	0	0	0	0	0
Brown trout	3	1.3	1	.3	2	.8	0	0	0	0	0	0	0	0	0	0
Mountain whitefish	94	39.2	93	23.5	68	27.3	110	25.9	19	1.9	5	2.5	10	8.3	4	1.8
Total	**118**	**49.3**	**109**	**27.6**	**75**	**30.1**	**111**	**26.1**	**20**	**2.0**	**5**	**2.5**	**10**	**8.3**	**4**	**1.8**
Cottidae (sculpins)																
Mottled sculpin	65	27.1	0	0	2	.8	0	0	0	0	0	0	0	0	0	0
Shorthead sculpin	53	22.1	0	0	3	1.2	0	0	0	0	0	0	0	0	0	0
Total	**118**	**49.2**	**0**	**0**	**5**	**2.0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total individuals	**240**		**395**		**249**		**425**		**975**		**203**		**121**		**223**	
Electrofishing time (seconds)	(Not recorded)		1,628		2,370		2,226		3,429		1,392		3,916		1,695	

was tied with that for site 3 in 1997), decreased to the lowest scores at site 5, then increased slightly at site 6. Scores were highest at all sites except site 4 in 1997 and were lowest at all sites except site 5 in 1996. Prolonged high flows in 1997 could have contributed to the slightly higher B-IBI scores in 1997.

The highest B-IBI scores were observed at site 1 (mean score 22), well below the potential maximum score of 39, which indicates a somewhat stressed system at a site upstream from most sources of urban and agricultural discharges. At site 3 (Glenwood Bridge), a site affected primarily by urban sources (for example, a WTF, storm runoff), the mean B-IBI declined slightly to 20. At site 4 (Middleton), which is downstream from most urban sources but upstream from most agricultural sources, the mean B-IBI score further declined slightly to 19. At site 5 (Caldwell), located downstream from several agricultural drains (seven major tribu-

Table 10. Attributes of fish collected in the lower Boise River, Idaho, February 1995, December 1996, and August 1997

[Data from Zaroban and others, accessed January 22, 1998, online. Origin: I, introduced; N, native. Tolerance: T, tolerant; I, intolerant; S, sensitive]

Family/common name	Species	Origin	Toler-ance	Adult habitat guild	Temp-erature preference	Adult trophic guild
Cyprinidae (minnows)						
Common carp	*Cyprinus carpio*	I	T	Benthic	Warm	Omnivore
Chiselmouth	*Acrocheilus alutaceus*	N	I	Benthic	Cool	Herbivore
Northern pikeminnow	*Ptychocheilus oregonensis*	N	T	Water column	Cool	Invertivore/ Piscivore
Longnose dace	*Rhinichthys cateractae*	N	I	Benthic	Cool	Invertivore
Umatilla dace	*Rhinichthys osculus umatilla*	N	I	Benthic	Cool	Invertivore
Redside shiner	*Richardsonius balteatus*	N	I	Water column	Cool	Invertivore
Tui chub	*Gila bicolor*	N	T	Water column	Warm	Omnivore
Catostomidae (suckers)						
Bridgelip sucker	*Catostomus columbianus*	N	T	Benthic	Cool	Herbivore
Largescale sucker	*Catostomus macrocheilus*	N	T	Benthic	Cool	Omnivore
Mountain sucker	*Catostomus platyrhynchus*	N	I	Benthic	Cool	Herbivore
Cobitidae (loaches)						
Oriental weatherfish	*Misgurnus anguillicaudatus*	I	T	Benthic	Warm	Omnivore
Ictaluridae (freshwater catfishes)						
Channel catfish	*Ictalurus punctatus*	I	T	Benthic	Warm	Invertivore/ Piscivore
Tadpole madtom	*Noturus gyrinus*	I	T	Hider	Warm	Invertivore/ Piscivore
Centrarchidae (sunfish)						
Pumpkinseed	*Lepomis gibbosus*	I	T	Water column	Warm	Invertivore/ Piscivore
Bluegill	*Lepomis macrochirus*	I	T	Water column	Warm	Invertivore/ Piscivore
Smallmouth bass	*Micropterus dolomieui*	I	I	Water column	Cool	Piscivore
Largemouth bass	*Micropterus salmoides*	I	T	Water column	Warm	Piscivore
Salmonidae (trout/whitefish)						
Rainbow trout	*Oncorhynchus mykiss*	N	S	Hider	Cold	Invertivore/ Piscivore
Mountain whitefish	*Prosopium williamsoni*	N	I	Benthic	Cold	Invertivore
Brown trout	*Salmo trutta*	I	I	Hider	Cold	Invertivore/ Piscivore
Cottidae (sculpins)						
Mottled sculpin	*Cottus bairdi*	N	I	Benthic	Cool	Invertivore
Shorthead sculpin	*Cottus confusus*	N	S	Benthic	Cold	Invertivore

tary/drains enter the Boise River between the Middleton and Caldwell sites), the mean B-IBI score further declined to 13. However, at site 6 near the mouth of the Boise River, located downstream from three additional major tributary/drains, the mean I-IBI increased slightly to 16. Scores for all five sites during 1995–97 are shown graphically in figure 11.

Fish

Results of the fish surveys are summarized in table 9. Twenty-two species of fish in seven families were captured: minnows (Cyprinidae), suckers (Catostomidae), loaches (Cobitidae), bullhead catfishes (Ictaluridae), sunfish (Centrarchidae), trout and whitefish (Salmonidae), and sculpins (Cottidae). Information on fish species origin, tolerance to pollution, adult habitat and trophic guild, and temperature preference is shown in table 10.

Fish community metrics observed for all sites are summarized in table 11. Five metrics were chosen to represent key biological attributes of the aquatic ecosystem. Only the 1996 data were used to develop the fish metrics. Data collected in 1997 were of poor qual-

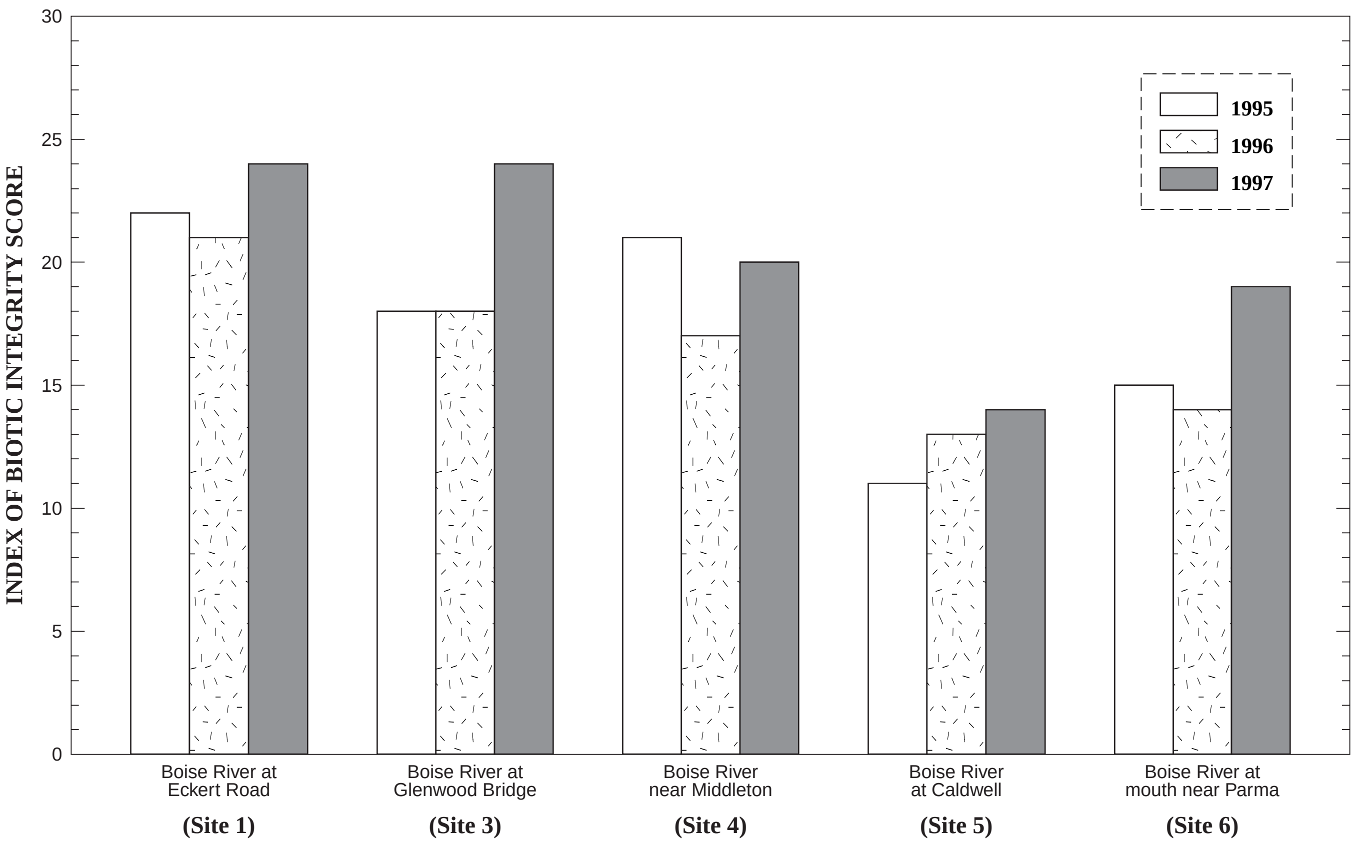

Figure 11. Benthic index of biotic integrity scores for macroinvertebrates collected in the lower Boise River, Idaho, during October 1995, 1996, and 1997. (Site locations shown in figure 1; potential maximum score, 39)

ity because of problems associated with high-flow sampling, as discussed previously, and the Loggers Creek site (site 2) data were not included because of the lack of comparable pool/deep run habitats and the general paucity of fish fauna.

Percent cottids (sculpins) and percent salmonids (trout and whitefish) are metrics generally indicative of good-quality habitat. Both taxonomic groups prefer similar habitat conditions and both are sensitive to pollutional stresses such as degraded water quality, sedimentation, and increased water temperature (Cannamela and others, 1995). A high percentage of salmonids is indicative of high-quality coldwater habitat, whereas a high percentage of cottids and other benthic-feeding insectivorous fish is indicative of a healthy benthic food base (Robinson and Minshall, 1994).

Sculpins were absent at all sites except site 3, where they composed 2 percent of the fish sample. In other sampling efforts on the lower Boise River, sculpins were abundant in the Boise River at Veterans Memorial Parkway and at Loggers Creek Diversion (Mullins, 1998b). Mountain whitefish composed most of the salmonids captured. Percent salmonids ranged from about 30 at site 3 to about 8 at site 6. Trout composed a smaller proportion of the salmonids captured and ranged from about 1 percent at site 3 to 0 at site 6 (table 9).

Percent pollution-tolerant species, represented primarily by largescale suckers (*Catostomus macrocheilus*) and bridgelip suckers (*Catostomus columbianus*), also provides a measure of the relative quality of the aquatic habitat; a high percentage of tolerant species is indicative of poor-quality habitat. Pollution-tolerant species ranged from 28 percent at site 4 to 78 percent at site 6.

Percent invertivores is another metric linking fish with the quality of the food base; a high percentage of invertivores generally is indicative of high-quality habitat. Values for this metric ranged from 20 percent at site 6 to 69 percent at site 4.

Table 11. Fish community metrics for taxa collected in the lower Boise River, Idaho, December 1996

Category and metric	Boise River at Glenwood Bridge (Site 3)	Boise River near Middleton (Site 4)	Boise River at mouth near Parma (Site 6)
Species richness and composition			
Percent cottids	2	0	0
Percent salmonids	30	26	8
Percent pollution tolerant	47	28	78
Trophic composition			
Percent invertivores	53	69	20
Condition			
Percent anomalies	0	.9	2

Table 13. Index of biotic integrity scores for fish collected in the lower Boise River, Idaho, December 1996

Category and metric	Boise River at Glenwood Bridge (Site 3)	Boise River near Middleton (Site 4)	Boise River at mouth near Parma (Site 6)
Species richness and composition			
Percent cottids	1	0	0
Percent salmonids	3	3	1
Percent pollution tolerant	3	3	1
Trophic composition			
Percent insectivores	5	5	1
Condition			
Percent anomalies	5	5	3
Total score	**17**	**16**	**6**

Percent anomalies is a measure of the general health and condition of individual fish. Anomalies occur rarely or are absent at unimpacted reference sites and tend to increase downstream from major sources of point and nonpoint pollution (Plafkin and others, 1989). No anomalies were observed on fish collected at site 3. Anomalies were observed on 0.9 percent of the fish collected at site 4 and on 2.5 percent of the fish collected at site 6.

The five metrics summarized in table 11 were scored using the criteria in table 12 to arrive at an IBI score (table 13). Total scores were similar at sites 3 and 4 (17 and 16, respectively) and declined to 6 at site 6. The low IBI score at site 6 falls far short of the maximum potential score of 25, which indicates a poor-quality coldwater fishery composed primarily of suckers and minnows.

SUMMARY AND CONCLUSIONS

The U.S. Geological Survey began a comprehensive study in 1994 to describe water quality of the lower Boise River and its tributaries and drains, assess the biotic integrity of the river, and monitor the long-term trends in water quality and biotic integrity. Water-quality conditions of the river, based on data collected during May 1994 through February 1997, were described in a previous report. From October 1995 through January 1998, biological data were collected at six sampling sites on the Boise River between Eckert Road and the mouth of the river to assess biotic integrity. Habitat variables were measured from November 1997 through January 1998; epilithic periphyton were collected in October 1995, October 1996, and August 1997; benthic macroinvertebrates were collected in October 1995, 1996, and 1997; and fish were collected in December 1996 and August 1997.

Table 12. Scoring criteria for fish community metrics used to assess biotic integrity of the lower Boise River, Idaho

[Scoring criteria modified from Plafkin and others (1989); <, less than; >, greater than; %, percent; —, not applicable]

Category and metric	Scoring criteria 5	3	1	0
Species richness and composition				
Percent cottids	>50%	25–50%	<25%	Absent
Percent salmonids	>50%	25–50%	<25%	Absent
Percent pollution tolerant	<25%	25–50%	>50%	—
Percent invertivores	>50%	20–50%	<20%	Absent
Condition				
Percent anomalies	<1%	1–5%	>5%	—

In general, instream habitat conditions tended to decline in a downstream direction, but riparian habitat conditions did not follow this trend. Mean channel embeddedness ranged from moderate to extreme at all three of the habitat assessment sites and was high enough at most sites to adversely affect salmonid (trout) spawning/juvenile survival and benthic macroinvertebrate density and diversity. Sites near Middleton and at the mouth were dominated by runs with little pool/riffle habitat. Instream cover for fish and vegetative cover along the streambank were limited at all three sites. Temperatures exceeding State of Idaho standards for coldwater biota could also limit coldwater species at downstream sites.

Chlorophyll-*a* concentrations were consistently lowest at the Eckert Road site, were usually highest at the Middleton or Caldwell sites, then decreased toward the river mouth. Median chlorophyll-*a* values ranged from <0.3 milligrams per square meter (mg/m^2) at the Eckert Road site in 1997 to 765 mg/m^2 at the Caldwell site in 1996. Increased turbidity in the lower reaches of the Boise River caused by numerous tributary/drains could contribute to decreased light penetration in the water column and increased scour on substrate. These factors could explain the decrease in chlorophyll-*a* and ash-free dry weight measured at the most downstream sites.

In general, all sites were characterized by low benthic macroinvertebrate taxa diversity, compared with diversity in other Northwestern streams. Benthic index of biotic integrity (B-IBI) scores for macroinvertebrates tended to decrease from Eckert Road to Caldwell, then increase slightly at the mouth. Although B-IBI scores were highest at Eckert Road, the average score for the 3-year period (22) represents about 57 percent of the potential maximum score of 39, which indicates a somewhat stressed system. The lowest 3-year average score (13) was observed at Caldwell, which represents about 32 percent of the potential maximum score of 39.

Index of biotic integrity scores developed for fish were similar at sites 3 and 4 and declined sharply at site 6. The decline at site 6 was largely the result of a high percentage of pollution-tolerant species, a large reduction in salmonids and invertivores, and a 2.5-percent occurrence of anomalies.

In general, an assessment of the biotic integrity of the lower Boise River, as described by a combination of instream and riparian habitat variables, measurements of primary productivity, and assessment of benthic invertebrate and fish community assemblages, indicates the river is moderately impaired in the upper reaches and declines gradually downstream, although some reduction in primary production (epilithic periphyton) and a slight recovery of benthic macroinvertebrate populations are evident at the mouth of the river. High levels of embeddedness throughout the lower reaches of the Boise River contribute to degradation of benthic habitat conditions and likely limit the occurrence of certain groups of benthic macroinvertebrates (such as stoneflies, which require clean, well-oxygenated gravel and cool water temperatures) and could limit trout spawning. In addition, lack of certain preferred habitat components, such as well-developed pools and riffles and fish cover features, coupled with periods of extended low winter flows, limits the carrying capacity for fish.

Continued annual monitoring of epilithic periphyton and benthic macroinvertebrates, and continued monitoring of instream and riparian habitat and fish communities on a 3- to 5-year cycle, will help identify future trends in the biotic integrity of the lower Boise River.

REFERENCES CITED

Ashbridge, G., and Bjornn, T.C., 1988, Survey of potential and available salmonid habitat in the Boise River: Idaho Department of Fish and Game, Federal Aid in Fish Restoration, Job Completion Report, Project F–71–R–12, Subproject III, Job No. 3, 71 p.

Barbour, M.T., Bowman, M.L., and White, J.S., 1994, Evaluation of the biological condition of streams in the Middle Rockies Central-Ecoregion, Wyoming: Owing Mills, Md., Tetra-Tech, Inc., for the Wyoming Department of Environmental Quality [variously paged].

Barbour, M.T., Gerritsen, J., Snyder, B.D., and Stribling, J.B., 1997, Revision to rapid bioassessment protocols for use in streams and rivers—periphyton, benthic macroinvertebrates, and fish: Washington, D.C., U.S. Environmental Protection Agency, Office of Water Report EPA 841–D–97–002 [variously paged].

Berenbrock, C., and Kjelstrom, L.C., 1998, Preliminary water-surface elevations and boundary of the 100-year peak flow in the Big Lost River at the Idaho National Engineering and Environmental Laboratory, Idaho: U.S. Geological Survey Water-Resources Investigations Report 98–4065, 13 p.

Bjornn, T.C., Brusven, M.A., Molnau, M.P., Milligan, J.H., Klamt, R.A., Chaco, E., and Schaye, C., 1977, Transport of granitic sediment in streams and its effects on insects and fish: U.S. Department of the Interior, Office of Water Research and Technology, Research Technical Completion Report, Project B–036–IDA, 43 p.

Brennan, T.S., Lehmann, A.K., O'Dell, I., and Tungate, A.M., 1997, Water resources data, Idaho, water year 1996, v. 2, Upper Columbia River Basin and Snake River Basin below King Hill: U.S. Geological Survey Water-Data Report ID–96–2, 377 p.

Cannamela, D.A., Dudley, S., and Scarpella, R., 1995, Shorthead sculpin (*Cottus confusus*), *in* Rare Fishes Status Review Workshop Results, Boise, Idaho, March 15, 1995: American Fisheries Society, Idaho Chapter, p. 17–20.

Chandler, G.L., Maret, T.R., and Zaroban, D.W., 1993, Protocols for assessment of biotic integrity (fish) in Idaho streams: Boise, Idaho Department of Health and Welfare, Division of Environmental Quality, Water Quality Monitoring Protocols Report no. 6, 40 p.

Cuffney, T.F., Gurtz, M.E., and Meador, M.R., 1993, Methods for collecting benthic invertebrate samples as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93–406, 66 p.

Delong, M.D., and Brusven, M.A., 1992, Patterns of periphyton chlorophyll-*a* in an agricultural nonpoint source impacted stream: Water Resources Bulletin, v. 28, no. 4, p. 731–741.

Fitzpatrick, F.A., and Giddings, E.M.P., 1997, Stream habitat characteristics of fixed sites in the western Lake Michigan drainages, Wisconsin and Michigan, 1993–95: U.S. Geological Survey Water-Resources Investigations Report 95–4211–B, 58 p.

Fitzpatrick, F.A., Waite, I.R., D’Arconte, P.J., Meador, M.R., Maupin, M.A., and Gurtz, M.E., 1998, Revised methods for characterizing stream habitat in the National Water-Quality Assessment Program: U.S. Geological Survey Water-Resources Investigations Report 98–4052, 67 p.

Frenzel, S.A., 1988, Physical, chemical, and biological characteristics of the Boise River from Veterans Memorial Parkway, Boise to Star, Idaho, October 1987 to March 1988: U.S. Geological Survey Water-Resources Investigations Report 88–4206, 48 p.

——— 1990, Effects of municipal wastewater discharges on aquatic communities, Boise River, Idaho: Water Resources Bulletin, v. 26, no. 2, p. 279–287.

Gibson, H.R., 1975, Survey of fish populations and water quality in the Boise River from its mouth upstream to Barber Dam: Idaho Department of Fish and Game, Snake River Fisheries Investigations, Job Performance Report, Project F–63–R–4, Job No. IV, 64 p.

Hayslip, G.A., ed., 1993, EPA Region 10 in-stream biological monitoring handbook for wadable streams in the Pacific Northwest: Seattle, Wash., U.S. Environmental Protection Agency, Environmental Services Division, 75 p.

Intergovernmental Task Force on Monitoring Water Quality, 1992, Ambient water-quality monitoring in the United States—first year review, evaluation, and recommendations: Washington, D.C., Report to the Office of Management and Budget, 26 p., 3 apps.

Karr, J.R., and Chu, E.W., 1997, Biological monitoring and assessment—using multimetric indexes effectively: Seattle, University of Washington, EPA 235–R97–001, 149 p.

Maret, T.R., 1995, Water-quality assessment of the upper Snake River Basin, Idaho and western Wyoming—summary of aquatic biological data for surface water through 1992: U.S. Geological Survey Water-Resources Investigations Report 95–4006, 59 p.

Meador, M.R., Hupp, C.R., Cuffney, T.F., and Gurtz, M.E., 1993a, Methods for characterizing stream habitat as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93–408, 48 p.

Meador, M.R., Cuffney, T.F., and Gurtz, M.E., 1993b, Methods for sampling fish communities as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93–104, 40 p.

Mullins, W.H., 1998a, Water-quality conditions of the lower Boise River, Ada and Canyon Counties, Idaho, May 1994 through February 1997: U.S. Geological Survey Water-Resources Investigations Report 98–4111, 32 p.

——— 1998b, Biotic integrity of the Boise River upstream and downstream from two municipal wastewater treatment facilities, Boise, Idaho, 1995–96: U.S. Geological Survey Water-Resources Investigations Report 98–4123, 17 p.

Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross, S.K., and Hughes, R.M., 1989, Rapid bioassessment protocols for use in streams and rivers—benthic macroinvertebrates and fish: Washington, D.C., U.S. Environmental Protection Agency, Office of Water Report EPA/444/4–89–001 [variously paged].

Platts, W.S., Armour, C., Booth, G.D., Bryant, M., Bufford, J.L., Cuplin, P., Jensen, S., Lienkaemper, G.W., Minshall, G.W., Monson, S.B., Nelson, R.L., Sedell, J.R., and Tuhy, J.S., 1987, Methods for evaluating riparian habitats with applications to management: Ogden, Utah, U.S. Forest Service General Technical Report INT–221, 177 p.

Porter, S.D., Cuffney, T.F., Gurtz, M.E., and Meador, M.R., 1993, Methods for collecting algal samples as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93–409, 39 p.

Robins, C.R., Bailey, R.M., Bond, C.E., Brooker, J.R., Lachner, E.A., Lea, R.N., and Scott, W.B., 1991, Common and scientific names of fishes from the United States and Canada: Bethesda, Md., American Fisheries Society Special Publication 20, 183 p.

Robinson, C.T., and Minshall, G.W., 1994, Biological metrics for regional monitoring and assessment of small streams in Idaho: Pocatello, Idaho State University, Department of Biological Sciences, 113 p., 4 apps.

U.S. Environmental Protection Agency, 1986, Quality criteria for water, 1986: Washington, D.C., U.S. Government Printing Office, not paged.

Wisseman, B., 1996, Benthic invertebrate biomonitoring & bioassessment in western montane streams: Corvallis, Oreg., Aquatic Biology Associates, Inc., 18 p.

Wolman, M.G., 1954, A method for sampling coarse riverbed material: Transactions of the American Geophysical Union, v. 35, p. 951–956.

Zaroban, D.W., Mulvey, M.P., Maret, T.R., and Hughes, R.M., 1998, Fish species attributes for Oregon, Washington, and Idaho, accessed March 25, 1998, at http://www.epa.gov/r10earth/offices/oea/fishlist.htm

APPENDICES

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Appendix A. Habitat assessment field data sheet

DRAFT REVISION—July 28, 1997

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #________ RIVERMILE________	STREAM CLASS	
LAT ____________ LONG ____________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ______ TIME ______ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Sow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Appendix A. Habitat assessment field data sheet—Continued

DRAFT REVISION—July 28, 1997

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Appendix B. Locations of stakes for permanent transects at habitat assessment sites, Boise River, Idaho, November 1997 through January 1998

[Site locations shown in figure 1; No., number; GPS, global positioning system; ft, feet; L, left; R, right]

Site name	Date sampled	Transect No.	Latitude	Longitude	GPS error (ft)
Boise River at Eckert Road (Site 1)	11/19/97	1L	43°34'11.32"	116°08'17.87"	±21
		1R	43°34'13.17"	116°08'18.25"	±24
		4L	43°34'08.07"	116°08'01.17"	±34
		4R	43°34'09.40"	116°07'59.27"	±21
		6L	43°34'02.06"	116°08'00.06"	±31
		6R	43°34'03.64"	116°07'56.88"	±37
Boise River near Middleton (Site 4)	11/24/97	1L	43°41'12.79"	116°35'40.00"	±35
		1R	43°41'16.24"	116°35'40.03"	±33
		4L	43°41'15.09"	116°35'24.75"	±21
		4R	43°41'20.58"	116°35'24.99"	±29
		6L	43°41'13.88"	116°35'15.23"	±22
		6R	43°41'18.03"	116°35'13.57"	±32
Boise River at mouth near Parma (Site 6)	1/26/98	1L	43°48'37.68"	117°00'35.70"	±23
		1R	43°48'40.40"	117°00'33.53"	±24
		4L	43°48'32.70"	117°00'25.20"	±21
		4R	43°48'34.92"	117°00'22.40"	±14
		6L	43°48'25.70"	117°00'18.72"	±12
		6R	43°48'28.38"	117°00'14.94"	±12

Appendix C. Detailed instream habitat variables measured in the Boise River, Idaho, November 1997 through January 1998

[Site locations shown in figure 1; ft, feet; ft/s, feet per second; Y, yes; N, no; CO, cobble; GR, gravel; SA, sand; <, less than; >, greater than; % percent]

Site name	Date sampled	Tran-sect	Geomorphic channel unit	Channel width (ft)	Depth		Velocity		Bottom substrate		Embed-dedness range[1]	Silt present (Y/N)	Woody debris (percent)
					Mean (ft)	Range (ft)	Mean (ft/s)	Range (ft/s)	Dom-inant	Subdom-inant			
Boise River at	11/19/97	1	Run	98	2.42	(1.71–2.82)	0.80	(0.43–1.05)	CO	SA	2	N	<5
Eckert Road		2	Riffle	175	.85	(0.46–1.18)	2.78	(2.59–3.04)	CO	GR	3–4	N	0
(Site 1)		3	Pool/deep run	147	1.84	(1.12–2.30)	1.19	(0.16–2.04)	CO	GR	2–4	N	0
		4	Pool/deep run	103	2.69	(1.84–3.54)	.64	(0.03–1.38)	CO	GR	2–3	N	0
		5	Riffle	146	.92	(0.72–1.18)	2.27	(1.06–2.92)	CO	SA	3–4	N	0
		6	Riffle	143	1.10	(0.79–1.25)	1.93	(1.50–2.20)	CO	GR	2–4	N	0
Mean for site				**135**	**1.64**						**2.9**		
Boise River	11/24/97	1	Riffle	202	1.02	(0.66–1.25)	2.82	(1.88–3.54)	CO	GR	1	N	0
near Middleton		2	Run	273	1.83	(1.02–2.56)	1.12	(0.58–1.89)	CO	GR	1	Y	0
(Site 4)		3	Riffle/run	261	2.30	(1.38–3.94)	2.03	(0.56–3.29)	CO	GR	2	N	0
		4	Pool/run	203	2.09	(1.18–3.38)	1.60	(0.69–2.36)	CO	GR	1–2	Y	0
		5	Run	188	2.71	(2.40–3.22)	.90	(0.07–1.38)	CO	SA	1	N	0
		6	Shallow run	135	1.91	(1.15–2.49)	1.35	(1.05–1.75)	CO	SA	1	N	0
Mean for site				**210**	**1.98**						**1.2**		
Boise River at	1/26/98	1	Run	167	4.10	(4.10)	1.53	(1.38–1.67)	CO	GR	1	Y	<5
mouth near		2	Deep run	162	2.95	(1.64–4.27)	.79	(0.26–1.31)	GR	SA	0–1	Y	<5
Parma		3	Run	178	2.56	(1.18–3.94)	2.44	(2.07–2.82)	CO	GR	1	Y	<5
(Site 6)		4	Run	212	1.51	(0.72–2.69)	3.13	(2.36–4.63)	GR	CO	2–4	Y	0
		5	Shallow run	161	2.97	(2.76–3.28)	2.79	(2.43–3.15)	GR	CO	2–3	Y	<5
		6	Riffle/fast run	248	2.43	(1.44–3.08)	4.20	(3.45–4.69)	CO	GR	3–4	Y	0
Mean for site				**188**	**2.75**						**2.0**		

[1]Embeddedness (0, 100%; 1=>75%; 2=51 to 75%; 3=26 to 50%; 4=5 to 25%; 5=<5%. Data were averaged for each reach; therefore, the given number may fall between two categories.

Appendix D. Detailed riparian habitat variables measured in the Boise River, Idaho, November 1997 through January 1998

[Site locations shown in figure 1; ft, feet; L, left; R, right. Bank surface stability: 1, less than 25 percent cover; 2, 25 to 49 percent cover; 3, 50 to 79 percent cover; 4, greater than 80 percent cover. Bank shape: CC, concave; LN, linear. Bank substrate: dom, dominate; codom, codominate; CO, cobble; SA, sand; GR, gravel; CO, cobble; SI, silt; RR, riprap. Bank erosion: N, none; CB, scallop]

Site name	Date sampled	Tran-sect	Bank angle (degrees)		Bank width (ft)		Bank height (ft)		Bank surface stability		Bank shape		Bank substrate (dom/codom)		Bank erosion		Aspect (degrees)	Bank canopy density (percent)	Canopy opening (degrees)
			L	R	L	R	L	R	L	R	L	R	L	R	L	R			
Boise River at	11/19/97	1	10	10	10	30	3	3	1	1	LN	LN	CO/SA	CO/SA	N	N	245	1	120
Eckert Road		2	30	9	4	48	3	3	1	1	LN	LN	CO/SA	CO/SA	N	N	250	5	150
(Site 1)		3	30	5	5	5	3	3	1	1	LN	LN	CO/SA	CO/SA	N	N	270	1	130
		4	25	10	3	12	3	3	1	1	LN	LN	CO/SA	CO/SA	N	N	300	2	150
		5	5	10	20	22	3	3	1	1	LN	LN	CO/SA	CO/SA	N	N	350	1	130
		6	20	5	7.5	35	3	3	1	1	LN	LN	CO/CO	CO/SA	N	N	340	13	120
Mean for site			**20**	**8**	**8**	**25**	**3**	**3**	**1**	**1**								**4**	**133**
Boise River	11/24/97	1	5	5	55	72	3	3	2	2	LN	LN	SA-GR/CO	SA-GR/CO	N	N	285	5	150
near Middleton		2	15	5	16	68	4	4	2	1	CC	LN	SA/SI	SA/CO	CB	N	260	1	160
(Site 4)		3	30	5	13	40	4	4	2	1	LN	LN	RR/SA	CO/SA	N	N	200	11	165
		4	3	35	75	9	4	4	1	1	LN	LN	SA/SI	RR/SA	N	N	270	13	145
		5	15	30	9	8	4	4	1	1	LN	LN	SA/CO	CO/SA	CB	N	270	0	140
		6	10	10	15	18	4	4	1	1	LN	LN	CO/SA	CO-SA/GR	CB	N	270	0	150
Mean for site			**13**	**15**	**31**	**36**	**3.8**	**3.8**	**[1]1.5**	**1.2**								**5**	**152**
Boise River at	1/26/98	1	15	20	75	7	5	5	2	2	LN	LN	SA/SA	SA/SI	N	CB	304	13	145
mouth near		2	45	5	42	41	4	3	2	2	LN	LN	SA/SA	SA/GR	N	N	300	14	140
Parma		3	25	20	32	40	4	4	2	2	LN	LN	SA/SA	SA/SI	N	N	290	11	145
(Site 6)		4	10	40	52	5	4	4	3	2	LN	CC	SA/SA	SA/SI	N	CB	304	18	150
		5	5	15	61	18	3	3	2	3	LN	LN	SA/SI	SA/SA	N	N	320	7	135
		6	5	10	121	10	3	4	3	2	LN	LN	SA/GR	CO/GR	N	N	320	0	145
Mean for site			**18**	**18**	**64**	**20**	**3.8**	**3.8**	**2.3**	**2.2**								**10**	**143**

[1]Data were averaged for each reach; therefore, the given number may fall between two categories.

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