U.S. Department of the Interior
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In cooperation with the
City of Boise Public Works Department

Biotic Integrity of the Boise River Upstream and Downstream from Two Municipal Wastewater Treatment Facilities, Boise, Idaho, 1995–96

Water-Resources Investigations Report 98–4123

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By William H. Mullins

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1999

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CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
centimeter (cm)	0.3937	inch
cubic meter (m^3)	0.000811	acre-foot
cubic meter per second (m^3/s)	35.31	cubic foot per second
kilometer (km)	0.6214	mile
meter (m)	3.281	foot
micrometer (µm)	0.00003937	inch
milliliter (mL)	0.03382	ounce
millimeter (mm)	0.0394	inch
square meter (m^2)	10.76	square foot

To convert °C (degrees Celsius) to °F (degrees Fahrenheit), use the following equation:

$$°F = (1.8\ °C) + (32)$$

Abbreviated water-quality units:

µS/cm microsiemens per centimeter at 25°C
mg/L milligrams per liter

Biotic Integrity of the Boise River Upstream and Downstream from Two Municipal Wastewater Treatment Facilities, Boise, Idaho, 1995–96

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Abstract

Aquatic biological communities were used to assess the biotic integrity of the Boise River upstream and downstream from the Lander Street and West Boise municipal wastewater treatment facilities (WTFs) in Boise, Idaho. Samples of epilithic periphyton, benthic macroinvertebrates, and fish were collected in late February and early March 1995, in late October 1996, and in early December 1996. Epilithic periphyton biomass, 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 statistically significant. High within-site variance suggests that greater sampling intensity would improve statistical comparison. Index of Biotic Integrity (IBI) scores calculated for benthic macroinvertebrates were higher for the sites upstream from WTFs in 1995 and 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 sculpin (*Cottus*) 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.

INTRODUCTION

The City of Boise, Idaho, operates two municipal wastewater treatment facilities (WTFs) that provide secondary sewage treatment. The Lander Street WTF discharges treated effluent into the Boise River immediately downstream from the Veterans Memorial Parkway Bridge, and the West Boise WTF discharges into the south channel of the Boise River about 1.5 km upstream from the Eagle Highway Bridge (fig. 1).

In 1995, the U.S. Geological Survey (USGS), in cooperation with the City of Boise Public Works Department, began a study to assess the biotic integrity of the Boise River upstream and downstream from the Lander Street and West Boise WTFs as a followup to work done by the USGS during 1987–88. In that study, Frenzel (1988, 1990) examined physical, chemical, and biological characteristics of the Boise River upstream and downstream from the Lander Street and West Boise WTFs from October 1987 to March 1988 to determine whether trace-element concentrations were detrimental to aquatic communities. The trace-element concentrations that were detected were less than 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 effect on benthic macroinvertebrate communities following a 40-day colonization period on artificial substrates. Mean condition factors of whitefish upstream and downstream from WTFs indicated that the relative health of fish communities in the Boise River was not affected by WTF effluent.

Aquatic biological communities integrate physical and chemical characteristics of their environment (Plafkin and others, 1989; Frenzel, 1990; Chandler and others, 1993; Cuffney and others, 1993; Maret, 1995). Therefore, evaluating ecological components of these communities is useful in assessing biotic integrity and the effects of environmental perturbations on aquatic community structure. Further, continued monitoring of these communities is useful in identifying long-term trends in biotic integrity.

For this investigation, a multimetric approach using two taxonomic groups (benthic macroinvertebrates and fish) was used to assess biotic integrity (Intergovern-

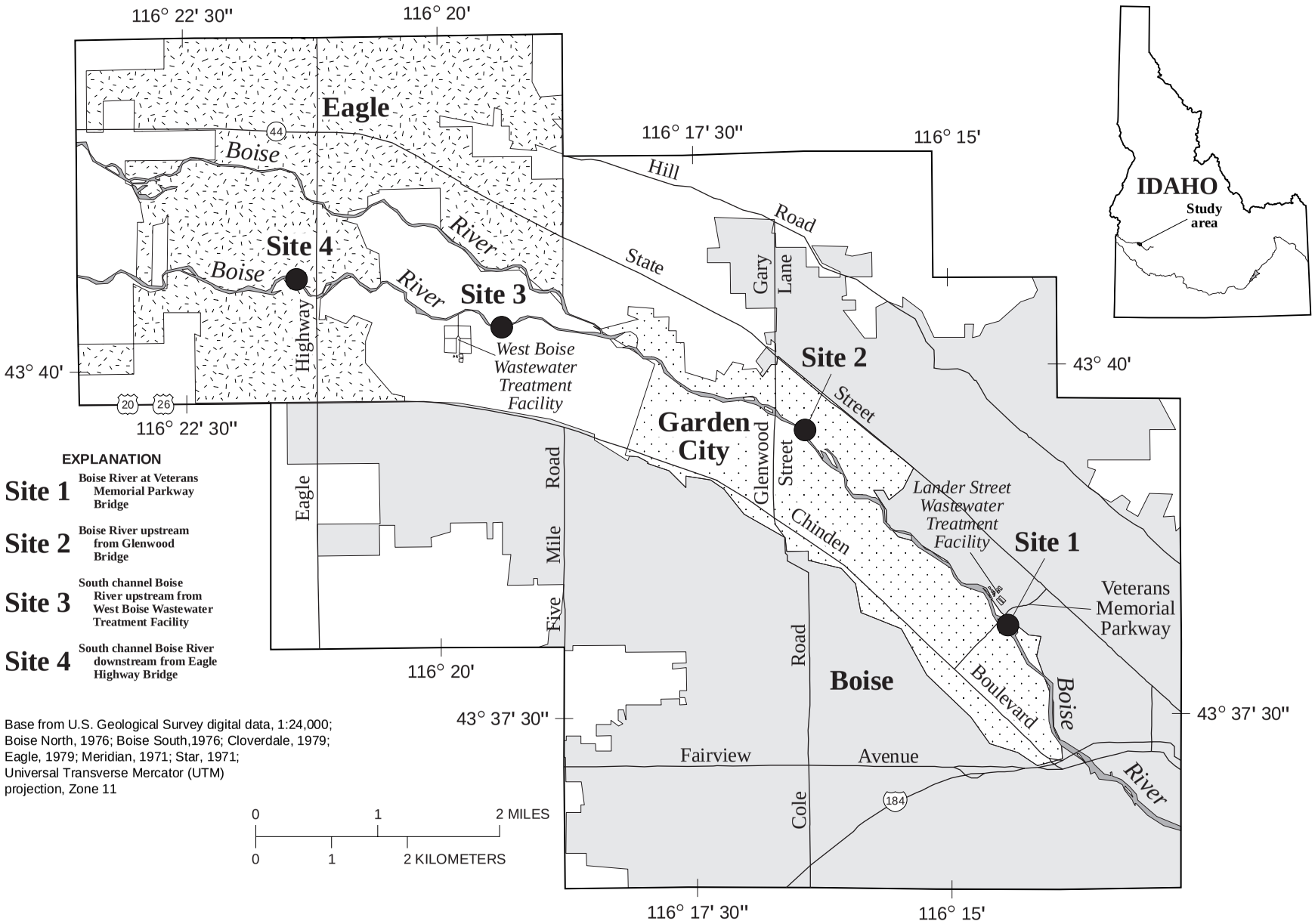

Figure 1. Study area and sampling sites.

mental Task Force on Monitoring Water Quality, 1992; Karr and Chu, 1997). Multiple metrics permit 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, and benthic macroinvertebrate metrics are useful for demonstrating short-term toxic effects and are more sensitive to the effects of urban land- and water-use activities (Barbour and others, 1997). A subset of benthic macroinvertebrate and fish community metrics representative of community structure, trophic composition, and indicator assemblage (pollution tolerance) was chosen from numerous relevant metrics to assess biotic integrity (Plafkin and others, 1989; Chandler and others, 1993; Maret, 1995). In addition, a third taxonomic group (epilithic periphyton) was used to compare relative enrichment through measurements of chlorophyll-*a* and biomass between sites. Epilithic periphyton growth is an excellent indicator of water quality because nutrient additions to streams increase periphytic growth and alter composition and spatial distribution of periphyton communities (Delong and Brusven, 1992).

The purpose of this report is to present the results of the 1995–96 assessment of the biotic integrity of the Boise River upstream and downstream from the Lander Street and West Boise WTFs. For the investigation, samples of epilithic periphyton, benthic macroinvertebrates, and fish were collected February 21–23 and March 1–3, 1995, and October 28–30 (periphyton and macroinvertebrates) and December 2, 3, 5, and 6 (fish), 1996 (water year 1997), at sites upstream and downstream from the two WTFs.

Appreciation is extended to the following people for their assistance with collection of field samples: U.S. Geological Survey—Terry Maret, Susan Moore, Doug Ott, James Schaefer, and Ken Skinner; City of Boise Public Works Department—Robbin Finch, Brian DuFosse, Carsen Rahrer, Angel Deckers, and Walt Baumgartner; Idaho Department of Fish and Game (fish sampling only)—Dale Allen, Scott Grunder, and Steve Yundt. Special thanks go to Terry Maret for his assistance with data analysis.

DESCRIPTION OF STUDY AREA

The combined population of Boise and Garden City, located in southwestern Idaho, was nearly 154,000 on July 1, 1994 (University of Idaho, 1996). The Boise River flows westward through Boise and Garden City (which uses Boise's WTFs) from its headwaters in the mountains to its confluence with the Snake River about 80 km downstream from Boise.

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 1,307 million m^3 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 through the Boise and Garden City areas. Flood-control releases from Lucky Peak Dam in the spring result in high streamflows that persist all the way to the Snake River. However, in years of severe and (or) years of consecutive drought, such as those in the late 1980's through the early 1990's, late-winter and spring flows remained low. In wet years, such as those in the early 1980's and during 1995–96, 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 6.8 m^3/s usually are released from Lucky Peak Lake to maintain aquatic habitat. Mean annual flow during 1982–91 was 35.9 m^3/s, measured at the gaging station on the Boise River at Glenwood Bridge, between the Lander Street and West Boise WTFs.

The Idaho Department of Fish and Game (IDFG) annually stocks catchable-sized rainbow trout in the Boise River. Numbers vary according to yearly fluctuations in flows. In 1997, 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 were released in the Boise River. However, 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).

METHODS OF DATA COLLECTION AND ANALYSIS

Stream reaches to be evaluated upstream and downstream from the two WTFs were selected on the basis of similar geomorphic channel features (repetition of two pool-riffle-run sequences) and riparian habitat characteristics (Meador and others, 1993b). Stream reaches ranged from 260 to 364 m in length and were at the Veterans Memorial Parkway Bridge (site 1), upstream from the Lander Street WTF; upstream from the Glenwood Bridge (site 2), downstream from the Lander

Street WTF; in the south channel of the Boise River about 0.4 km upstream from the outfall of the West Boise WTF (site 3); and in the south channel of the Boise River just downstream from the Eagle Highway Bridge (site 4), downstream from the West Boise WTF. Within each reach, three representative riffle habitat sites were selected; these were divided further into two subsites for the collection of epilithic periphyton and benthic macroinvertebrates. Sampling sites were selected on the basis of similar depth, velocity, and substrate characteristics. In 1995, additional quality assurance sites were selected in two of the sample reaches. Analyses consisted of chlorophyll-*a* and ash-free dry weight (epilithic periphyton) and benthic macroinvertebrate and fish community metrics. Statistical comparisons of mean data for epilithic periphyton from each site were made using two-tailed tests (t-tests) with a significance level of 0.05.

Habitat

During the 1995 sampling period, instream habitat variables (bottom substrate-percent fines, instream cover for fish, riffle embeddedness, velocity/depth, wetted channel shape, pool/riffle ratio, and width/depth ratio) and riparian habitat variables (bank vegetation protection, lower bank stability, disruptive pressures, and zone of influence) were characterized qualitatively by following rapid bioassessment protocols developed by the U.S. Environmental Protection Agency (Plafkin and others, 1989; Hayslip, 1993). Stream discharge and water-quality characteristics (water temperature, specific conductance, dissolved oxygen, and pH) were measured at each site concurrent with sample collection.

Epilithic Periphyton

Semiquantitative epilithic periphyton samples were collected and processed using protocols developed by the USGS National Water-Quality Assessment (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 representative cobbles per riffle (5 cobbles from each of the 2 adjacent benthic macroinvertebrate collection subsites). Periphyton samples were removed from cobbles 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 periphyton brush and collected with a hand pipette. Samples were composited into a sample jar and stirred, 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 by the Bureau of Reclamation Pacific Northwest Regional Laboratory in Boise, Idaho.

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.

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 0.25-m^2 frame hinged to a long handle. A Nitex net with 425-µm mesh openings is attached to the handle. The frame is held over the sampling site by one crew member while a second removes invertebrates (which are swept into the net by the current) from the area within the frame.

Invertebrates were removed by scrubbing individual cobbles within the Slack frame down to a depth of about 10 cm. Once all large cobbles were sampled, the finer grained substrate (gravel, sand) within the frame was agitated by a crew member standing in the frame and kicking the substrate for thirty seconds. The process was repeated at the second subsite in the same riffle, and the samples were composited into a single sample. The total area sampled per riffle was 0.5 m^2 (1.5 m^2 per reach). Samples were processed further onsite by removing any large or rare taxa that might have been lost during laboratory processing and by removing rocks and organic debris, such as leaves or twigs, from the sample. The remaining sample material was elutriated through a 425-µm mesh and placed in a sample jar. Samples were fixed in 10-percent buffered formalin, which was replaced with 70-percent ethanol before shipping 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, 1993a). In 1995, electrofishing equipment and an operating crew were provided by the IDFG. A Coffelt DC 5,000-watt generator mounted on an inflatable raft was used. In 1996, IDFG used the same equipment at one site, and a Smith-Root model VI–A and a 5,000-watt, 240-volt generator with two electrodes mounted in a driftboat or in a tote barge was used at the other three sites. Netting crews consisted of personnel from IDFG, City of Boise, and USGS. Two electrofishing passes were made through the entire length of each reach. Captured fish were held in live tanks until they were processed and released. Data collected included taxonomic identification, lengths, weights, anomalies, and numbers of individuals. Fish taxonomy followed Robins and others (1991). Onsite identifications of fish were made by Terry Maret, USGS, and Dale Allen, IDFG. Taxonomy of sculpin and dace was verified by Dr. Carl E. Bond and Dr. Douglas F. Markel, Oregon State University, Corvallis; and Dr. Gordon Haas, University of British Columbia, Vancouver, B.C., Canada.

Several individuals of each species were fixed and preserved for archival purposes, 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.

ASSESSMENT OF BIOTIC INTEGRITY

Habitat

Instream and riparian habitat variables measured during the 1995 collection period are summarized in table 1. Stream discharge, water temperature, specific conductance, dissolved oxygen, and pH data are summarized in table 2. These data are provided for background information only; they were not used as part of the interpretation of any observed biological conditions. More detailed analysis of other water-quality data is beyond the scope of this study.

Qualitative ratings for instream habitat variables ranged from poor to optimal, and for riparian habitat variables, from marginal to optimal, on the basis of proto-

Table 1. Habitat variables measured in the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995

[Habitat variable ratings from protocols described by Hayslip (1993); WTF, wastewater treatment facility; O, optimal; S, suboptimal; M, marginal; P, poor]

Habitat variable	Boise River at Veterans Memorial Parkway Bridge (Site 1)	Boise River upstream from Glenwood Bridge (Site 2)	South Channel Boise River upstream from West Boise WTF (Site 3)	South Channel Boise River downstream from Eagle Highway Bridge (Site 4)
Instream variables				
Bottom substrate-percent fines	O	O	S	S
Instream cover (fish)	M	S	M	M
Embeddedness (riffle)	O	S	M	S
Velocity/depth	O	O	O	O
Channel shape (wetted channel)	P	O	S/M	S/M
Pool/riffle ratio	O	O	O	O
Width/depth ratio	P	P	P	P
Riparian variables				
Bank vegetation protection	S	O	S	S
Lower bank stability	S	S	S	S
Disruptive pressures[1]	M	S	M	M
Zone of influence[2]	M	M	M	M

[1]On stream bank, immediately adjacent to stream.

[2]Width of riparian zone, least-buffered side.

Table 2. Stream discharge and water-quality characteristics measured in the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995

[WTF, wastewater treatment facility; m^3/s, cubic meters per second; °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25°C; mg/L, milligrams per liter]

Water-quality characteristic	Boise River at Veterans Memorial Parkway Bridge (Site 1)	Boise River upstream from Glenwood Bridge (Site 2)	South Channel Boise River upstream from West Boise WTF (Site 3)	South Channel Boise River downstream from Eagle Highway Bridge (Site 4)
Stream discharge (m^3/s)	3.7	4.6	3.0	3.3
Water temperature (°C)	6.8	7.8	6.7	8.2
Specific conductance (µS/cm)	115	170	153	279
Dissolved oxygen				
Concentration (mg/L)	13.1	13.1	12.1	10.8
Percent saturation	114	120	107	100
pH (standard units)	9.3	8.6	10.4	8.5

cols described by Hayslip (1993; table 1). The habitat variables velocity/depth and pool/riffle ratio were rated optimal for all sites. Bottom substrate-percent fines was rated optimal for sites 1 and 2 but was rated suboptimal for sites 3 and 4. Riffle embeddedness was rated optimal only for site 1; this variable was rated suboptimal or marginal for the other three sites.

Epilithic Periphyton

Epilithic periphyton biomass data, expressed as chlorophyll-*a* and ash-free dry weight, are summarized in table 3. In 1995, chlorophyll-*a* (an indicator of primary production) and ash-free dry weight (a measure of biomass) were high at all sites. Mean concentrations of

Table 3. Epilithic periphyton chlorophyll-*a* and ash-free dry weight measured in the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and October 1996

[WTF, wastewater treatment facility; mg/m^2, milligrams per square meter; SD, standard deviation; CV, coefficient of variation; %, percent; DW, dry weight]

Metrics	Boise River at Veterans Memorial Parkway Bridge (Site 1)		Boise River upstream from Glenwood Bridge (Site 2)		South Channel Boise River upstream from West Boise WTF (Site 3)		South Channel Boise River downstream from Eagle Highway Bridge (Site 4)	
	1995	1996	1995	1996	1995	1996	1995	1996
Chlorophyll-*a* (mg/m^2)								
Riffle 1	341	146	819	317	652	296	623	466
Riffle 2	489	112	748	219	529	335	557	429
Riffle 3	743	50	693	265	523	405	646	172
Mean	524	103	753	267	568	345	609	356
SD	203.3	48.7	62.7	49.0	72.8	55.2	46.2	160.1
CV(%)	39	47	8	18	13	16	8	45
Ash-free DW (mg/m^2)								
Riffle 1	41,600	31,800	69,600	38,200	80,100	24,500	90,400	47,100
Riffle 2	67,600	30,300	47,400	27,700	61,700	30,000	64,900	41,600
Riffle 3	145,000	20,500	51,700	32,800	56,200	31,300	90,700	31,900
Mean	84,700	27,500	56,200	32,900	66,000	28,600	82,000	40,200
SD	53,800	6,140	11,800	5,250	12,520	3,610	14,810	7,700
CV(%)	64	22	21	16	19	13	18	19

chlorophyll-*a* were higher at the two sites downstream from WTFs, but differences in concentrations between sites upstream and downstream from WTFs were not significant. The mean concentration of chlorophyll-*a* was significantly higher at site 2 than at site 3 (probability = 0.008). Ash-free dry weight was highest at site 1 and lowest at site 2, but differences in concentrations at these sites were not significant. However, within-site variance was high, as indicated by standard deviation and coefficient of variation values (table 3).

In 1995, epilithic periphyton samples were collected during late winter, whereas in 1996, samples were collected in early autumn. Because epilithic periphyton growth is affected by many variables, including nutrient availability, light penetration, water temperature, and scour, and because samples were collected in two distinct seasons, direct comparisons of results between sampling years cannot be made. If all factors affecting epilithic periphyton growth are equal, chlorophyll-*a* and ash-free dry weight values in early autumn are anticipated to be greater than those observed at the beginning of the spring season. However, chlorophyll-*a* and ash-free dry weight declined substantially in 1996, possibly as a result of prolonged high flows during spring 1996. Also, samples in 1995 were collected at the end of a multiyear drought, which allowed epilithic periphyton growth to accumulate over several years (fig. 2). Chlorophyll-*a* concentrations in 1996 averaged less than half of those in 1995, ranging from 20 percent at site 1 to 61 percent at site 3. Ash-free dry weight in 1996 also averaged less than half of that in 1995, ranging from 32 percent at site 1 to 59 percent at site 2. Mean concentrations of chlorophyll-*a* were significantly higher at site 2 than at site 1 (probability = 0.035), and mean ash-free dry weight values were significantly higher at site 4 than at site 1 (probability = 0.011). Again, within-site variance was high, as indicated by standard deviation and coefficient of variation values.

Benthic Macroinvertebrates

Macroinvertebrate taxa identified in the Boise River in 1995 and 1996 are summarized in table 4. Fifty-

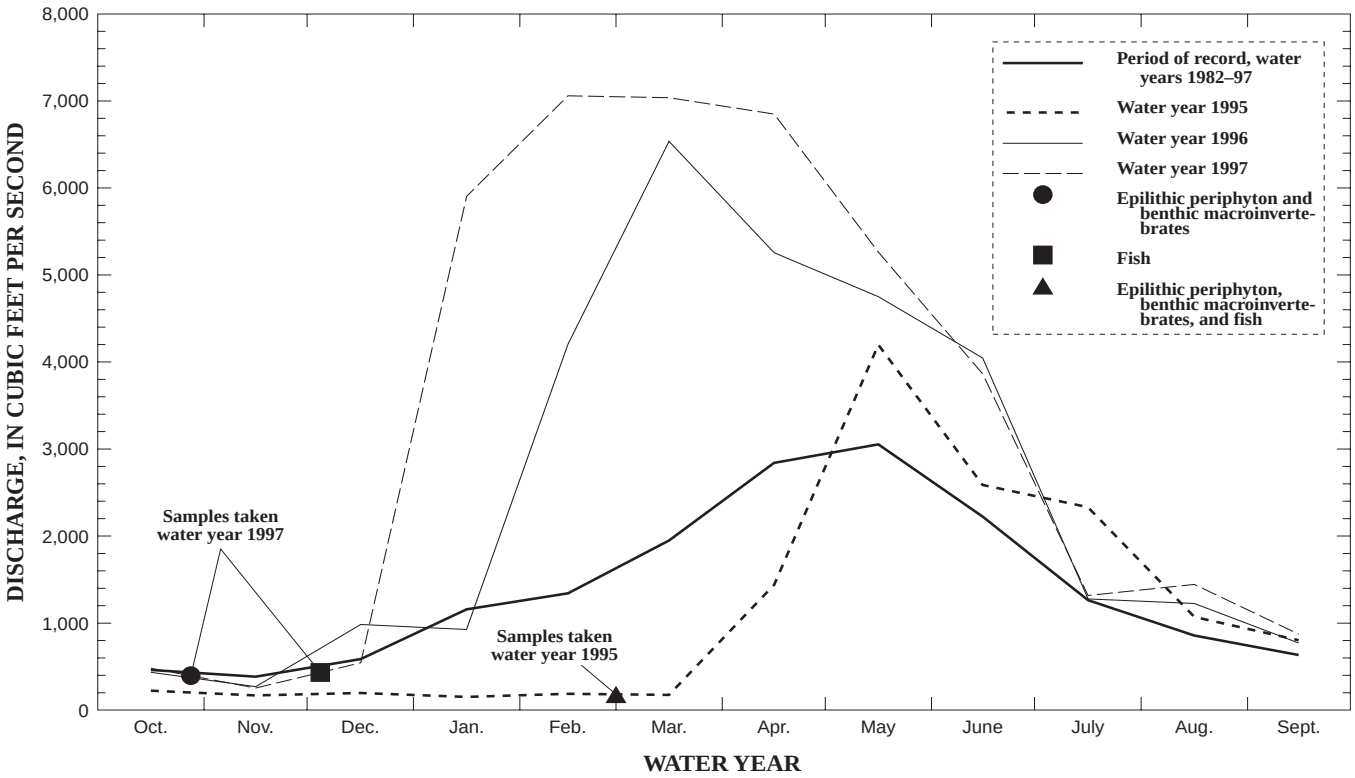

Figure 2. Mean monthly discharge for period of record, 1982 through 1997, in relation to biological samples collected in water years 1995 through 1997, Boise River at Glenwood Bridge. (Multiply cubic feet per second by 0.02832 to obtain cubic meters per second)

Table 4. Macroinvertebrate taxa identified in the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and October 1996

[WTF, wastewater treatment facility]

Taxon	Percent of sample							
	Boise River at Veterans Memorial Parkway Bridge (Site 1)		Boise River upstream from Glenwood Bridge (Site 2)		South Channel Boise River upstream from West Boise WTF (Site 3)		South Channel Boise River downstream from Eagle Highway Bridge (Site 4)	
	1995	1996	1995	1996	1995	1996	1995	1996
Turbellaria (Flatworms)	0	0	0.08	0	0.05	0	0.40	0
Nematoda (Roundworms)	.11	0	0	.06	.27	.06	0	.06
Anelida (Segmented worms)								
Oligochaeta (Aquatic earthworms)								
Enchytraeidae	3.68	0	6.16	.12	7.31	.18	5.55	.12
Lumbriculidae	.15	0	.63	0	.27	0	.10	0
Naididae	1.90	.69	3.16	.93	3.45	.12	.30	.93
Hirudinea (Leeches)	0	0	.16	0	0	0	0	0
Isopoda (Aquatic sow bugs)								
Asselidae								
Caecidotea sp.	0	0	0	0	.05	0	.10	0
Crustacea (Crustaceans)								
Amphipods (Scuds)								
Gammaridae								
Gammarus sp.	0	0	0	0	.09	.12	.50	0
Copepoda	.10	0	0	0	.05	0	.10	0
Decapoda (Crayfish)								
Astacidae								
Pacifastacus sp.	.03	0	0	0	0	0	0	0
Insecta (Insects)								
Ephemeroptera (Mayflies)								
Baetidae								
Acentrella turbida	0	.25	0	.06	0	.61	0	.06
Baetis tricaudatus	7.00	6.44	8.29	6.09	7.63	5.29	10.31	6.09
Ephemerella inermis/infrequens	.48	.50	0	.43	.05	.25	0	.43
Heptageniidae								
Heptagenia/Nixe sp.	.07	.56	.32	1.06	.09	.18	.10	1.06
Rhithrogena sp.	0	4.25	0	1.68	0	1.66	.10	1.68
Stenonema sp.	0	0	0	0	.09	0	0	0
Tricorythidae								
Tricorythodes minutus	.27	.06	.08	.06	.83	0	.30	.06
Plecoptera (Stoneflies)								
Perlodidae-early instar	1.80	.88	1.34	1.99	.86	.61	.20	1.99
Isoperla sp.	.06	0	0	0	.08	0	0	0
Trichoptera (Caddisflies)								
Glossomatidae								
Glossosoma sp.	0	.44	0	.06	.09	.37	1.49	.06
Protoptila sp.	0	0	0	0	.13	.06	0	0
Hydropsychidae								
Cheumatopsyche sp.	2.96	1.50	2.68	3.66	8.80	5.96	2.58	3.66
Hydropsyche sp.	63.55	60.50	64.40	70.12	58.60	71.85	52.43	70.12
Hydroptilidae								
Hydroptila sp.	0	.31	0	0	0	0	0	0
Leucotrichia sp.	.17	0	0	0	0	0	.10	0

Table 4. Macroinvertebrate taxa identified in the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and October 1996—Continued

Taxon	Percent of sample							
	Boise River at Veterans Memorial Parkway Bridge (Site 1)		Boise River upstream from Glenwood Bridge (Site 2)		South Channel Boise River upstream from West Boise WTF (Site 3)		South Channel Boise River downstream from Eagle Highway Bridge (Site 4)	
	1995	1996	1995	1996	1995	1996	1995	1996
Leptoceridae								
Oecetis sp.	10	0	0	0	0	0	0	0
Psychomyiidae								
Psychomyia sp.	10	0	0	0	0	0	0	0
Lepidoptera (Moths, butterflies)								
Pyralidae								
Petrophila sp.	11.36	4.00	9.79	4.10	9.30	1.66	21.70	4.10
Coleoptera (Beetles)								
Elmidae								
Cleptelmis sp.	.04	0	0	0	0	0	0	0
Diptera (True flies)								
Chironomidae								
Chironomidae-pupae	.19	1.50	.16	2.36	.05	2.03	.30	2.36
Chironomini-early instar	0	0	0	0	.05	0	0	0
Brillia sp.	0	0	.16	0	.05	0	.10	0
Cardiocladius sp.	.06	4.50	0	2.05	0	.80	0	2.05
Cricotopus sp.	0	2.56	0	.62	0	.74	0	.62
Cricotopus trifascia Gr.	0	.31	0	0	0	0	0	0
Diamesa sp.	2.51	.31	0	.19	.07	.12	0	.19
Endochironomus sp.	0	0	.16	0	0	0	0	0
Eukiefferiella sp.	0	.75	0	.19	0	.68	.10	.19
Orthocladiinae-early instar	.13	0	0	0	0	0	0	0
Orthocladius Complex	.92	6.88	1.97	2.48	.18	4.55	2.58	2.48
Pagastia sp.	.07	0	0	0	.05	0	0	0
Parametriocnemus sp.	0	0	.08	0	0	0	0	0
Polypedilum sp.	0	0	0	0	0	.06	0	0
Potthastia gaedii Gr.	.20	.06	0	0	0	0	0	0
Potthastia longimana Gr.	.03	0	0	0	0	0	0	0
Rheotanytarsus sp.	0	0	0	0	.08	0	0	0
Synorthocladius sp.	0	0	0	0	.17	.12	0	0
Thienamannimyia sp.	0	.31	0	0	0	0	0	0
Tvetnia sp.	.95	0	.32	0	0	.06	.20	0
Simulidae								
Simulium sp.	.25	1.50	0	.19	.61	.49	0	.19
Tipulidae								
Antocha sp.	0	.38	0	.31	0	.12	0	.31
Dicranota sp.	0	0	0	0	.05	0	.10	0
Arachnoidea								
Acari (Water mites)	.74	.56	.08	1.18	.51	.55	.30	1.18
Mollusca								
Gastropoda (Snails, limpits)								
Planorbidae-juvenile	0	0	0	0	.05	0	0	0

four taxa were represented, including 6 insect orders and 12 noninsect taxa. In general, all sites were characterized by low taxa diversity and richness. 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, oral commun., 1998). Plecopterans (stoneflies) were noticeably rare to absent at all sites; only one identifiable genus, *Isoperla*, was collected during this study. About 5 to 10 plecopteran taxa would be expected in a river the size of the Boise River. Plecopterans can be adversely affected by high cobble embeddedness, low dissolved oxygen, warm water temperatures, and (or) excessive growth of filamentous algae (Bob Wisseman, oral commun., 1998).

A subset of macroinvertebrate community metrics used to assess biotic integrity is summarized in table 5. Five metrics were chosen to represent key biological attributes of the aquatic ecosystem. These metrics and the scoring criteria used to develop Index of Biotic Integrity (IBI) scores (table 5) have been used for Pacific Northwest streams (Fore and others, 1995). Total taxa (species richness) and invertebrate density (abundance) reflect the general health of the benthic invertebrate community; larger numbers and greater density of taxa generally indicate a healthy aquatic ecosystem. Similarly, the total EPT (Ephemeroptera-Plecoptera-Trichoptera) metric functions as a pollution barometer because these taxa are generally intolerant of pollution (Robinson and Minshall, 1994).

Table 5. Macroinvertebrate community metrics used to assess biotic integrity of the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and October 1996

[EPT, Ephemeroptera-Plecoptera-Trichoptera; scoring criteria from Fore and others, 1995; >, greater than; <, less than]

Category and metrics	Scoring criteria 5	3	1
Community indices			
Total taxa	>54	40–54	<40
Total EPT taxa	>29	20–29	<20
Total invertebrate density (abundance)	>1,500	500–1,500	<500
Indicator assemblage			
Percent tolerant taxa	<0.2	0.2–0.4	>0.4
Total intolerant taxa	>5	2–5	<2

Macroinvertebrate community metrics for all sites are summarized in table 6. In 1995, total taxa at site 2 were about 63 percent of the total at site 1, and total taxa

Table 6. Macroinvertebrate community metrics for the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and October 1996

[WTF, wastewater treatment facility; EPT, Ephemeroptera-Plecoptera-Trichoptera; invert., invertebrate; density, individuals per square meter; No./m^2, number per square meter]

Metrics	Boise River at Veterans Memorial Parkway Bridge (Site 1)		Boise River upstream from Glenwood Bridge (Site 2)		South Channel Boise River upstream from West Boise WTF (Site 3)		South Channel Boise River downstream from Eagle Highway Bridge (Site 4)	
	1995	1996	1995	1996	1995	1996	1995	1996
Community indices								
Total taxa	30	25	19	23	32	27	24	33
Total EPT taxa	11	11	6	10	11	10	9	13
Total invert. density (abundance)	7,332	4,267	845	4,293	4,981	4,339	673	4,005
Hilsenhoff Biotic Index	4.61	4.37	4.85	4.28	4.92	4.33	4.83	4.44
Community balance								
Percent chironomids	5.1	17.0	3.0	7.9	0.7	9.2	3.3	10
Trophic composition								
Density of scrapers (No./m^2)	859	395	85	296	486	171	158	299
Percent scrapers	12	9.3	10	6.9	9.8	3.9	23	7.5
Percent filterers	67	64	67	74	68	78	55	73
Indicator assemblage								
Percent tolerant taxa	3.5	1.9	2.9	3.7	10	6.0	3.0	2.6
Total intolerant taxa	3	0	0	0	2	0	0	0

at site 4 were about 75 percent of the total at site 3. Similarly, total EPT taxa at site 2 were about 55 percent of the total at site 1, and total EPT taxa at site 4 were about 82 percent of the total at site 3. Total invertebrate density (measured as individuals per square meter) was greater at both sites upstream from the WTFs (about 8.7 times greater at site 1 than at site 2, and about 7.4 times greater at site 3 than at site 4).

In 1996, differences in macroinvertebrate metrics between sites upstream and downstream from WTFs were not as apparent (table 6). Total taxa and total EPT declined slightly between sites 1 and 2, then increased slightly downstream to site 4. Total invertebrate density increased slightly between sites 1 and 3 and decreased slightly at site 4.

The Hilsenhoff Biotic Index (HBI) is a measure of organic pollution enrichment in communities inhabiting stream riffles; high HBI values are indicative of a high loading of organic pollution (Robinson and Minshall, 1994). In 1995, HBI scores for the Boise River ranged from 4.61 at site 1 to 4.92 at site 3 (on a 1-to-10 scale). HBI scores generally increased slightly downstream between sites 1 and 3, but the HBI score for site 4 was similar to that for site 2. In 1996, HBI scores ranged from 4.28 for site 2 to 4.44 for site 4 —a slight decrease from the 1995 HBI scores.

Chironomids are generally pollution tolerant; a high percentage of this taxon usually indicates a high sediment and organic pollution load (Robinson and Minshall, 1994). In 1995, percent chironomids was highest at site 1, approximately double that at sites 2 and 4, and over seven times that at site 3. In 1996, percent chironomids was again highest at site 1, about twice that at sites 2 and 3, and 1.7 times higher than at site 4.

Filterers and scrapers represent functional feeding groups (trophic composition). A high percentage of filterers suggests a high sediment and organic pollution load, and a high percentage of scrapers generally indicates good habitat quality (Robinson and Minshall, 1994). In 1995, percent filterers was equal at sites 1 and 2 (67) and was about 20 percent lower at site 4 than at site 3 (55 and 68, respectively). In 1996, percent filterers increased downstream from site 1 (64) and was highest at site 3 (78). Although the density of scrapers in 1995 was much greater at the sites upstream from WTFs (about 10 times greater at site 1 and 3 times greater at site 3), percent scrapers in the entire sample did not reflect this trend. Percent scrapers was similar at sites 1 and 2 (12 and 10, respectively), and was more than twice as great at site 4 than at site 3 (24 and 9.8, respectively). In 1996, the density of scrapers decreased between sites 1 and 2 by about 25 percent. In 1996, percent scrapers at all sites declined from that of 1995, ranging from a 22-percent decrease at site 1 to about a 77-percent decrease at site 4.

Percent tolerant taxa is a measure of the number of taxa that are tolerant to organic pollution. In 1995, this metric was similar (ranging from 2.9 percent at site 2 to 3.5 percent at site 1) at all except site 3, where the metric was 10 percent—about 3 times higher than at the other sites. In 1996, percent tolerant taxa increased downstream from site 1 to site 3, then declined sharply at site 4.

Conversely, total intolerant taxa is a measure of the number of taxa that are intolerant to organic pollution. In 1995, intolerant taxa were collected only at sites upstream from WTFs (three at site 1 and two at site 3). In 1996, no intolerant taxa were collected.

Metrics summarized in table 6 were scored using the criteria in table 5 to arrive at an IBI score, which is a summation of metric scores (table 7). In 1995, IBI scores for both sites upstream from WTFs were higher (11) than scores for the sites downstream from WTFs (7). In 1996, IBI scores for all sites were equal (9).

Fish

Information on fish species and numbers of individuals captured is summarized in table 8. Sixteen species of fish in five families were captured: minnows (Cyprinidae), suckers (Catostomidae), sunfish (Centrarchidae), trout and whitefish (Salmonidae), and sculpins (Cottidae). Information on fish species origin,

Table 7. Index of biotic integrity (IBI) composite scores for macroinvertebrates collected in the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and October 1996

[WTF, wastewater treatment facility]

Site	IBI composite score	
	1995	1996
Boise River at Veterans Memorial Parkway Bridge (Site 1)	11	9
Boise River upstream from Glenwood Bridge (Site 2)	7	9
South Channel Boise River upstream from West Boise WTF (Site 3)	11	9
South Channel Boise River downstream from Eagle Highway Bridge (Site 4)	7	9

Table 8. Fish species and numbers collected in the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and December 1996

[WTF, wastewater treatment facility; N, northern]

Family	Boise River at Veterans Memorial Parkway Bridge (Site 1)		Boise River upstream from Glenwood Bridge (Site 2)		South Channel Boise River upstream from West Boise WTF (Site 3)		South Channel Boise River downstream from Eagle Highway Bridge (Site 4)	
Common name	**1995**	**1996**	**1995**	**1996**	**1995**	**1996**	**1995**	**1996**
Cyprinidae								
Common carp	0	1	0	0	0	0	0	0
Chiselmouth	0	0	0	1	0	0	2	0
N. squawfish	1	7	0	2	1	0	1	2
Longnose dace	55	32	20	26	3	3	37	5
Umatilla dace	99	45	60	7	0	6	46	10
Redside shiner	8	0	3	16	0	1	24	9
Total	163	85	83	52	4	10	110	26
Catostomidae								
Bridgelip sucker	22	46	36	30	28	20	1	7
Largescale sucker	39	76	165	85	112	46	66	30
Mountain sucker	6	0	2	2	0	1	10	0
Total	67	122	203	117	140	67	77	37
Centrarchidae								
Smallmouth bass	0	0	0	0	0	0	0	1
Largemouth bass	0	0	0	0	0	28	0	0
Total	0	0	0	0	0	28	0	1
Salmonidae								
Rainbow trout	10	8	15	5	44	9	29	46
Mountain whitefish	169	229	93	68	651	234	125	238
Brown trout	0	3	1	2	3	2	0	7
Total	179	240	109	75	698	245	154	291
Cottidae								
Mottled sculpin	50	253	0	2	0	0	0	0
Shorthead sculpin	106	109	0	3	0	0	0	0
Total	156	362	0	5	0	0	0	0
Total individuals	565	809	395	249	842	350	341	355

trophic group, and tolerance to pollution is summarized in table 9.

Fish community metrics and scoring criteria used to assess biotic integrity are summarized in table 10. Seven metrics were chosen to represent key biological attributes of the aquatic ecosystem.

Percent sculpins and percent salmonids (trout and whitefish) reflect habitat quality because they share common habitats and are sensitive to similar pollutional stresses such as degraded water quality, sedimentation, and increased water temperature (Cannamela and others, 1995). A large number of salmonids is indicative of high-quality coldwater habitat, and a large number of sculpins and other benthic-feeding invertivorous fish is indicative of a healthy benthic food base (Robinson and Minshall, 1994).

Two species of sculpins (mottled sculpin, *Cottus bairdi*, and shorthead sculpin, *Cottus confusus*) composed nearly 28 percent of the total number of fish captured at site 1 in 1995 and composed 45 percent in 1996 (table 11). Sculpins composed 2 percent of the number captured at site 2 in 1996 and were absent from all other sites in both years. In 1995, percent salmonids ranged from 28 at site 2 to nearly 83 at site 3. In 1996, percent

Table 9. Fish origin, trophic group, and tolerance to organic compounds, sediment, and warmwater pollution in the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and December 1996

[Data from Zaroban and others, accessed January 22, 1998, online; I, introduced; N, native]

Family Common name	Species	Origin	Trophic group of adults	Tolerance to pollution	Tolerance score	Temperature preference
Cyprinidae						
Common carp	*Cyprinus carpio*	I	Omnivore	Tolerant	10	Warm
Chiselmouth	*Acrocheilus alutaceus*	N	Herbivore	Intermediate	7	Cool[1]
Northern squawfish	*Ptychocheilus oregonensis*	N	Invertivore/ Piscivore	Tolerant	9	Cool
Longnose dace	*Rhinichthys cataractae*	N	Invertivore	Intermediate	5	Cool
Umatilla dace	*R. osculus umatilla*	N	Invertivore	Intermediate	6	Cool
Redside shiner	*Richardsonius balteatus*	N	Invertivore	Intermediate	6	Cool
Centrarchidae						
Smallmouth bass	*Micropterus dolomieui*	I	Piscivore	Tolerant	4	Cool
Largemouth bass	*M. salmoides*	I	Piscivore	Tolerant	6	Warm
Catostomidae						
Bridgelip sucker	*Catostomus columbianus*	N	Herbivore	Tolerant	7	Cool
Largescale sucker	*C. macrocheilus*	N	Omnivore	Tolerant	8	Cool
Mountain sucker	*C. platyrhynchus*	N	Herbivore	Intermediate	4	Cool
Salmonidae						
Rainbow trout	*Oncorhynchus mykiss* sp.	N	Invertivore/ Piscivore	Sensitive	2	Cold
Mountain whitefish	*Prosopium williamsoni*	N	Invertivore	Intermediate	3	Cold
Brown trout	*Salmo trutta*	I	Invertivore/ Piscivore	Intermediate	3	Cold
Cottidae						
Mottled sculpin	*Cottus bairdi*	N	Invertivore	Intermediate	4	Cold
Shorthead sculpin	*C. confusus*	N	Invertivore	Intermediate	3	Cold

[1] The term "cool" refers to eurythermic temperature tolerance.

Table 10. Fish community metrics used to assess biotic integrity of the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and December 1996

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

Category and metrics	IBI scoring criteria			
	5	3	1	0
Species richness and composition				
Percent sculpins	>50	25–50	<25	Absent
Percent salmonids	>50	25–50	<25	Absent
Percent pollution tolerant	<25	25–50	>50	—
Trophic composition				
Percent invertivores	>50	20–50	<20	Absent
Condition and age structure				
Percent juvenile trout (<100 mm)[1]	>75	25–75	<25	Absent
Percent juvenile whitefish (<210 mm)[1]	>75	25–75	<25	Absent
Percent anomalies	<1	1–5	>5	—

[1] Age structure information from Dale Allen, Idaho Department of Fish and Game (oral commun., 1995).

salmonids ranged from 30 at sites 1 and 2 to 82 at site 4. Most of the salmonids captured in both years were mountain whitefish (*Prosopium williamsoni*). This species composed 81 percent of total salmonids at site 4 and 94 percent of total salmonids at site 1 in 1995; and 82 percent at site 4 and 95 percent at sites 1 and 3 in 1996.

Percent pollution-tolerant species (represented primarily by large-scale suckers, *Catostomus macrocheilus*, and bridgelip suckers, *Catostomus columbianus*, also indicates the relative quality of the aquatic habitat—the larger the number of tolerant species, the lower the habitat quality. In 1995, percent pollution-tolerant fish was nearly 4 times higher at site 2 (42) than at site 1 (11), and was about 1.5 times higher at site 4 (20) than at site 3 (13) (table 11). In 1996, percent pollution-tolerant fish was nearly 3 times higher at site 2 (47) than at site 1 (16) but was nearly 2 times higher at site 3 than at site 4 (11).

Percent juvenile trout and percent juvenile whitefish (Dale Allen, Idaho Department of Fish and Game,

Table 11. Fish community metrics for the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and December 1996

[WTF, wastewater treatment facility; <, less than]

Category and metrics	Boise River at Veterans Memorial Parkway Bridge (Site 1)		Boise River upstream from Glenwood Bridge (Site 2)		South Channel Boise River upstream from West Boise WTF (Site 3)		South Channel Boise River downstream from Eagle Highway Bridge (Site 4)	
	1995	1996	1995	1996	1995	1996	1995	1996
Species richness and composition								
Percent sculpins	28	45	0	2	0	0	0	0
Percent salmonids	32	30	28	30	83	70	45	82
Percent pollution tolerant	11	16	42	47	13	19	20	11
Trophic composition								
Percent invertivores	88	84	49	52	83	73	77	89
Condition and age structure								
Percent juvenile trout (<100 mm)[1]	0	0	0	0	0	0	0	0
Percent juvenile whitefish (<210 mm)[1]	27	77	8	9	51	59	68	58
Percent anomalies	1	.5	1	0	.1	.3	1	.3

[1] Age structure information from Dale Allen, Idaho Department of Fish and Game (oral commun., 1995).

oral commun., 1995) are measures of spawning success and recruitment of fish into the population. No juvenile (less than 100 mm) rainbow trout (*Oncorhynchus mykiss*) were captured at any of the sites in either year, which indicates poor recruitment of this species throughout the study area. Percent juvenile (less than 210 mm) mountain whitefish ranged from 8 at site 2 to 68 at site 4 in 1995, and from 9 at site 2 to 77 at site 1 in 1996.

Percent invertivores is another metric linking fish with the quality of the food base; the larger the number of invertivores, the higher the habitat quality. In 1995, percent invertivores ranged from 49 at site 2 to 88 at site 1. In 1996, percent invertivores ranged from 52 at site 2 to 89 at site 4.

The seven metrics summarized in table 11 were scored using the criteria in table 10 to arrive at an IBI score (table 12). In 1995, IBI scores for both sites upstream from WTFs were higher than scores for sites downstream from WTFs (table 12). In 1996, the IBI score for site 1 was higher than that for site 2 (26 and 18, respectively); scores for sites 3 and 4 were both 23.

Table 12. Index of biotic integrity (IBI) composite scores for fish collected in the Boise River upstream and downstream from municipal wastewater treatment facilities, Boise, Idaho, February and March 1995 and December 1996

[WTF, wastewater treatment facility]

Site	IBI composite score	
	1995	1996
Boise River at Veterans Memorial Parkway Bridge (Site 1)	22	26
Boise River upstream from Glenwood Bridge (Site 2)	13	18
South Channel Boise River upstream from West Boise WTF (Site 3)	23	23
South Channel Boise River downstream from Eagle Highway Bridge (Site 4)	19	23

SUMMARY AND CONCLUSIONS

The City of Boise operates two municipal wastewater treatment facilities (WTFs) that provide secondary sewage treatment. The Lander Street WTF discharges treated effluent into the Boise River immediately downstream from the Veterans Memorial Parkway Bridge, and the West Boise WTF discharges into the south channel of the Boise River about 1.5 km upstream from the Eagle Highway Bridge.

The biotic integrity of the Boise River was assessed upstream from the Lander Street WTF at Veterans Memorial Parkway Bridge (site 1), downstream from the Lander Street WTF near the Glenwood Bridge (site 2), about 0.4 km upstream from the outfall of the West Boise WTF (site 3), and downstream from the West Boise WTF near the Eagle Highway Bridge (site 4). Assessments were made using semiquantitative epilithic periphyton and benthic macroinvertebrate samples and fish surveys. In addition, water-quality characteristics (water tempera-

ture, specific conductance, dissolved oxygen, and pH) and instream and riparian habitat features were measured during the first year of the study.

Qualitative ratings for instream habitat variables ranged from poor to optimal and, for riparian habitat variables, from marginal to optimal. Only the variables velocity/depth and pool/riffle ratio were rated optimal for all sites. Specific conductance generally increased downstream and was higher at sites downstream from the WTFs than at sites upstream. Dissolved oxygen concentration and percent saturation declined slightly downstream from site 2 (but were well within State standards), and pH values showed no obvious spatial trend.

Epilithic periphyton biomass, expressed as chlorophyll-*a* and ash-free dry weight, was used to assess the potential for nutrients in WTF effluent to increase primary production downstream from these sites. Mean chlorophyll-*a* concentrations were 1.6 to more than 5 times higher in 1995 than in 1996, and ash-free dry weight was 1.7 to more than 3 times higher in 1995. Sampling in 1995 took place after a period of prolonged drought, whereas sampling in 1996 took place after 2 years of high spring runoff. In 1995 and 1996, mean chlorophyll-*a* concentrations were higher at the sites downstream from WTFs, but differences in concentrations at these sites were not significant. Ash-free dry weight values in 1996 followed a trend similar to that of chlorophyll-*a* concentrations, but the highest value in 1995 was at site 1, upstream from both WTFs. Potentially significant differences between sites probably were masked by the high within-site variance; therefore, greater sampling intensity would improve statistical comparison for future studies.

In 1995, benthic macroinvertebrate metrics (total taxa, density, total EPT taxa), which reflect general invertebrate community health, were higher at sites upstream from WTFs. In 1996, differences in macroinvertebrate metrics between sites upstream and downstream from WTFs were not as apparent. Again, this might be the result of the 2 years of high runoff between sampling periods.

Chironomids, which are generally a pollution-tolerant taxon, represented the largest percentage of the invertebrate community at site 1 in both years. In 1995, percent filterers, which tend to increase under a high sediment and organic pollution load, was similar at all sites (65 to 68) except at site 4, where the percent declined to 55. In 1996, percent filterers increased only slightly between sites 1 and 3, then decreased slightly at site 4. An increase in percent scrapers generally follows an increase in habitat quality. In 1995, this metric changed little between sites 1 and 3, then nearly doubled at site 4. In 1996, this metric declined steadily between sites 1 and 3, then increased slightly at site 4. In 1996, percent scrapers declined from 1995 levels, the opposite of what would be expected if high flows between March 1995 and October 1996 were assumed to have improved habitat by flushing sediment and organic material.

Percent tolerant taxa reflect the number of taxa that are tolerant to organic pollution. In 1995, this metric was similar at all sites except at site 3, where the metric value was about 2 to 3 times higher than at the other sites. In 1996, percent tolerant taxa increased downstream from site 1 to site 3, then declined sharply at site 4.

Plecopterans (stoneflies) were noticeably rare at all sites; only one genus, *Isoperla*, was collected during this study.

Index of biotic integrity (IBI) scores calculated for benthic macroinvertebrates in 1995 were 11 for sites upstream from WTFs and 7 for sites downstream from WTFs. In 1996, IBI scores for all sites were equal (9). Because of the wide variability in data collected from individual riffles within each reach, greater sampling intensity would improve statistical comparisons for future studies.

Sculpins and salmonids are coldwater species that are generally pollution intolerant and therefore generally decrease in number as water quality declines. Two species of sculpins composed nearly 28 percent of the total number of fish captured at site 1 in 1995 and composed 45 percent in 1996. Sculpins composed 2 percent of the fish captured at site 2 in 1996 and were absent from all other sites in both years. In 1995, percent salmonids (represented primarily by mountain whitefish) ranged from 28 at site 2 to nearly 83 at site 3. In 1996, percent salmonids ranged from 30 at sites 1 and 2 to 82 at site 4.

Percent juvenile trout and percent juvenile whitefish are measures of the spawning success and recruitment of these species into the population. A lack of juvenile trout at all sites in both years indicates poor natural recruitment of this species throughout the study area.

Percent pollution-tolerant species, represented by suckers, carp, chiselmouth, and northern squawfish, generally increases as water quality declines. In 1995, percent pollution-tolerant species was nearly 4 times higher at site 2 than at site 1 and was about 1.5 times higher at site 4 than at sites upstream from the West Boise WTF. In 1996, percent pollution-tolerant species was nearly 3 times higher at site 2 than at site 1 but was nearly 2 times higher at site 3 than at site 4.

Percent invertivores is a metric linking fish with the quality of the food base; the larger the number of invertivores, the higher the habitat quality. In 1995, per-

cent invertivores was higher at both sites upstream from WTFs. In 1996, percent invertivores was again higher at site 1 than at site 2, but the trend was reversed between sites 3 and 4.

In 1995, IBI scores calculated for fish were higher for sites upstream from WTFs. In 1996, IBI scores were again higher for site 1 than for site 2 and were equal for sites 3 and 4.

Habitat assessment done for this study and for a similar study being conducted in cooperation with the Idaho Division of Environmental Quality and the Lower Boise River Water Quality Plan, Inc., indicates no abrupt changes in physical habitat conditions that would readily explain the sudden disappearance of sculpins downstream from Veterans Memorial Parkway. Disappearance of sculpins downstream from site 1 warrants further study to help determine causative factors.

Fish sampling was difficult, especially in 1996, because of the size of the Boise River throughout the study area. Many areas are too deep to wade, and many fish that are shocked cannot be captured because of depth and velocity constraints. Also, it is not possible to sample identical representative habitats; some sites could be biased toward or against certain species guilds. Accurate measurement of total fish populations is therefore not possible, and relative numbers of fish might not accurately reflect actual population ratios at any given site. Therefore, the fish data provided in this report likely provide only rough estimates of actual populations sampled.

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