

*** PRELIMINARY REPORT ***

Do not cite without permission from
the author or

Dr. Joseph S. Meyer
Fisheries Department
Humboldt State University
Arcata, CA

PRAIRIE CREEK REPORT

by
David Mushet

for
Fisheries 320

3 December 1990

Prairie Creek Report

by

David Mushet

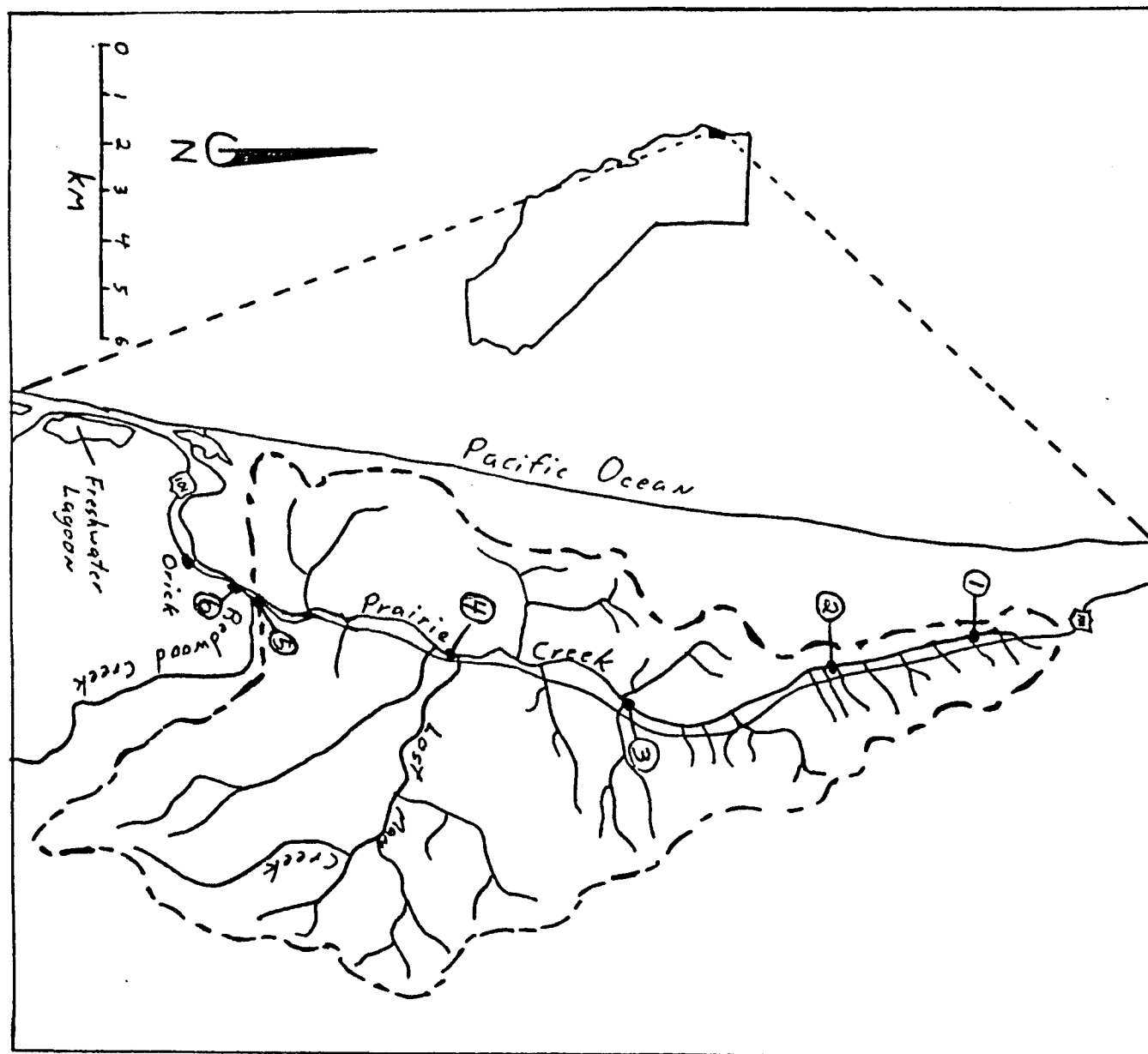
Introduction

On 29-30 September, 1990, the Fisheries 320 class of Humboldt State University conducted a study of various physical, chemical and biological parameters at 6 locations along the length of Prairie Creek, Humboldt County, CA. The purpose of this study was to test the "River Continuum Concept" proposed by Vannote et. al (1980). The "River Continuum Concept" states that river systems present gradients of physical and chemical conditions along their lengths, and in response to these gradients, the biotic communities which occur within the systems will vary depending upon their location along the length of the river system. A secondary purpose of this study was to see if any correlations could be found between observed conditions in Prairie Creek and the presence of the Highway 101 bypass in the upper portion of the Prairie Creek watershed.

Study Area

Prairie Creek is located approximately 1.6 km north of Orick in Redwood National Park, Humboldt County, CA (Figure 1). It is one of the last natural systems in the region, with its approximately 90.5 km² watershed being located primarily in old-growth redwoods. Six study sites were located along the length of Prairie Creek (Figure 1). Site #1 was located just above the

Figure 1. Location of Prairie Creek, Humboldt County, CA,
showing drainage basin and sampling sites #1-#6, 29-
30 September, 1990.



confluence of Ten Tapo Creek; site #2 was located at Zigzag Trail Bridge #2; site #3 was located at the ^{Prairie Creek State Park} ~~Redwood National Park~~ Visitor Center just downstream from the foot-bridge which crosses Prairie Creek; site #4 was located just below the confluence of Lost Man Creek; site #5 was located approximately 100 m above the confluence of Prairie Creek with Redwood Creek; and site #6 was located on Redwood Creek approximately 20 m below the confluence of Prairie Creek. Sites #1, #2 and #3 were sampled at 1400, 1130 and 0900 hrs (respectively) on 29 September, 1990. Sites #4, #5 and #6 were sampled at 0900, 1100 and 1300 hrs (respectively) on 30 September, 1990.

Materials and Methods

From topographic maps (USGS 1966a, 1966b, 1983a and 1983b), the drainage area, length, average slope and stream orders of Prairie Creek were determined. Drainage area, length and slope of sections of Prairie Creek corresponding to the different stream orders were also determined. Changes in stream order were located on the maps, using the assumption that solid blue lines (perennial streams) represented all of the first or greater-order streams. The drainage areas were determined by drawing a line along the ridges separating the Prairie Creek drainage from the other drainages of the region and also lines along the ridges separating the drainage areas of the different stream orders along Prairie Creek. A compensating polar planimeter was then used to measure the area enclosed by these lines. Also from the topographic maps, the length of Prairie Creek and also of the

sections of differing stream orders were measured. Slopes were determined by reading changes in elevation along a section directly from the contour maps and then dividing the change in elevation by the length of that section.

At each of the 6 study sites, water temperature and specific conductivity were measured with a YSI Model 33 S-C-T meter, and dissolved oxygen concentration (DO) was measured with a YSI Model 57 oxygen meter. Conductivity was corrected to 25°C using the formula $\text{Cond}_{25\text{C}} = \text{Cond}_t * (1 + [(25 - t) * 0.019])$, where t = temperature in °C and Cond_t = conductivity at temperature t . From water samples collected at each of the 6 sites, pH was measured with a Corning Model 610A No. 2 pH meter; total alkalinity (mg CaCO_3/L) was determined by titrating 100 ml subsamples with 0.02 N H_2SO_4 to pH 4.3 and using the formula given by Lind (1974) for calculating total alkalinity; and hardness was determined by adding a pH 10 buffer to 50 ml subsamples, adding Eriochrome Black T dye and titrating with .01 N EDTA solution to the color change.

Two transects of the stream channel (1 across a pool and 1 across a ^{fr}ripple) were made at each of the 6 study sites. At each transect, stream width was measured, and at least 10 depth measurements were taken at various locations across the channel. Using a Price AA current meter, water velocity was measured at 60% depth at the same locations of the depth measurements. If water depths were too shallow to use the Price AA current meter, a Teledyne-Gurley "Pygmy" current meter was used. Midstream surface velocity was also measured at each transect location by

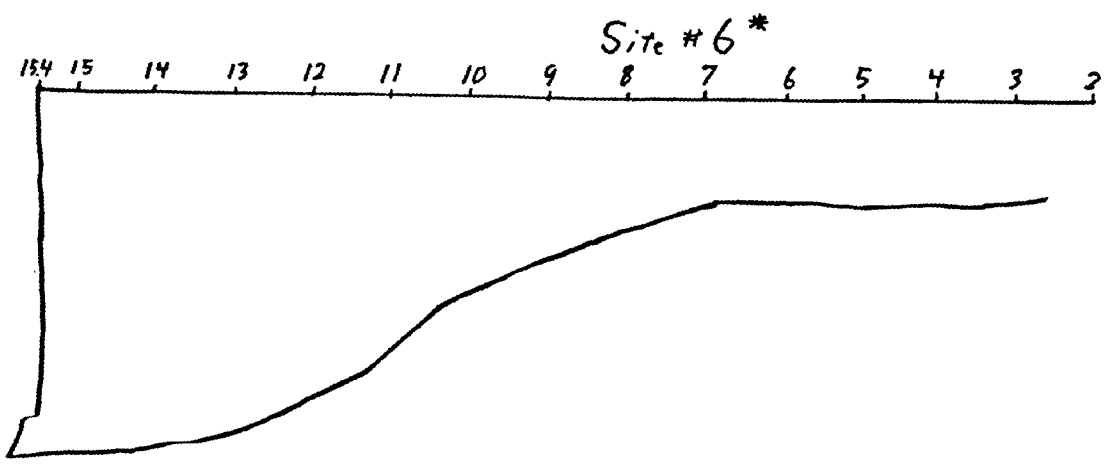
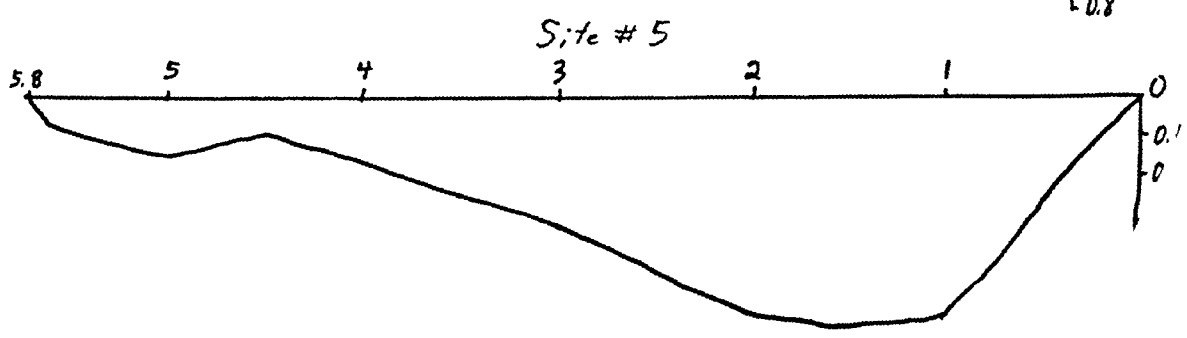
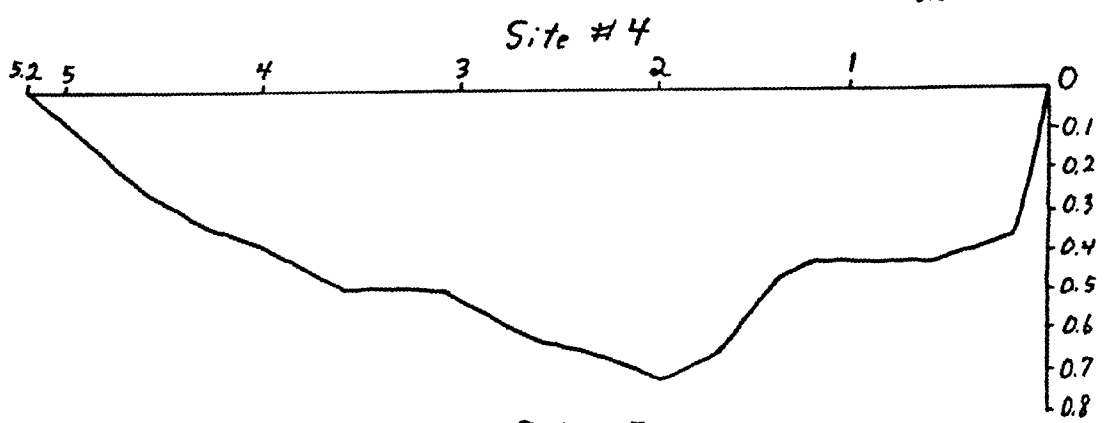
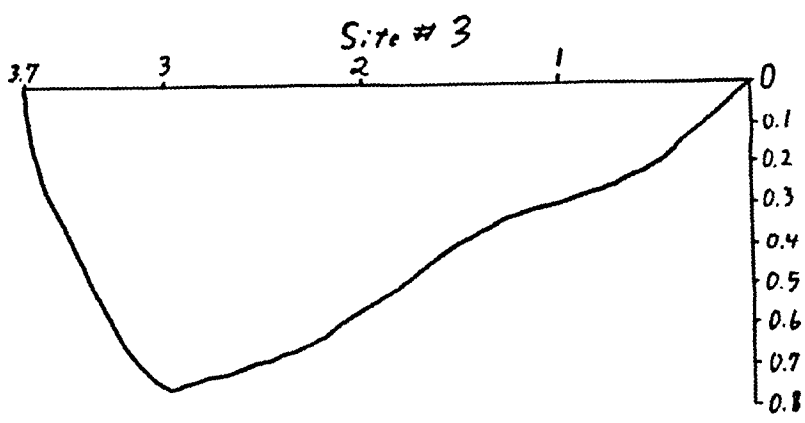
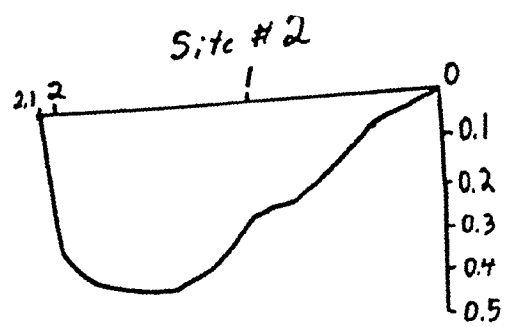
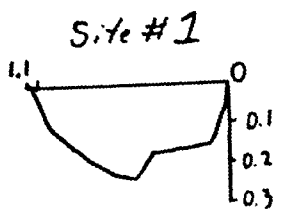
recording the time it took a floating object to travel a set distance. At each of the locations where depth measurements were taken, ocular estimations were made of the substrate size, and the substrate was classified as either clay (<0.0039 mm), silt ($0.0039-0.0625$ mm), sand ($0.0625-2.0$ mm), gravel ($2.0-64$ mm), cobble ($64-256$ mm) or boulder ($256-4096$ mm). Pebble counts were made at 3 locations at each study site (1 in a ^{ff}ripple, 1 in a pool and 1 in a transition zone) by recording the measurement of the secondary axis of 100 randomly chosen pebbles.

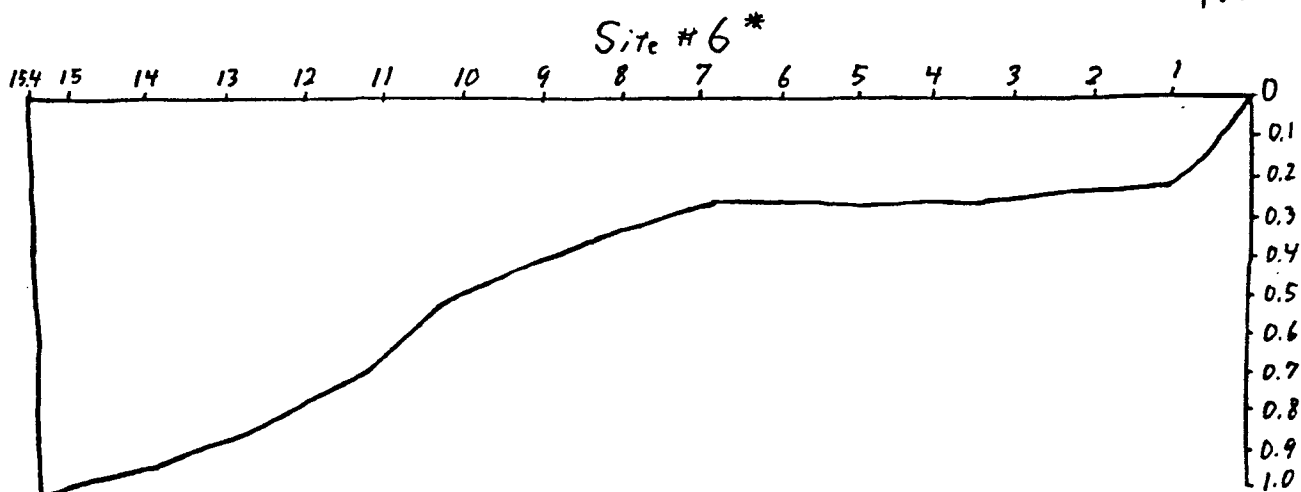
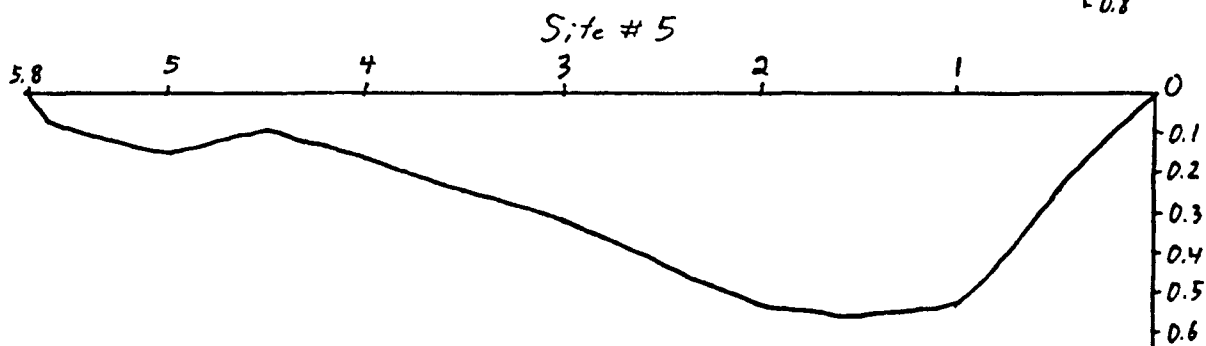
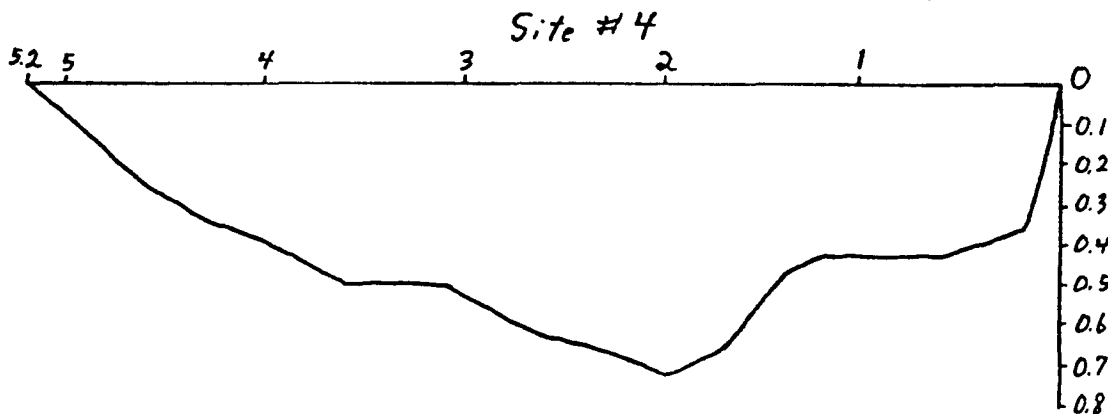
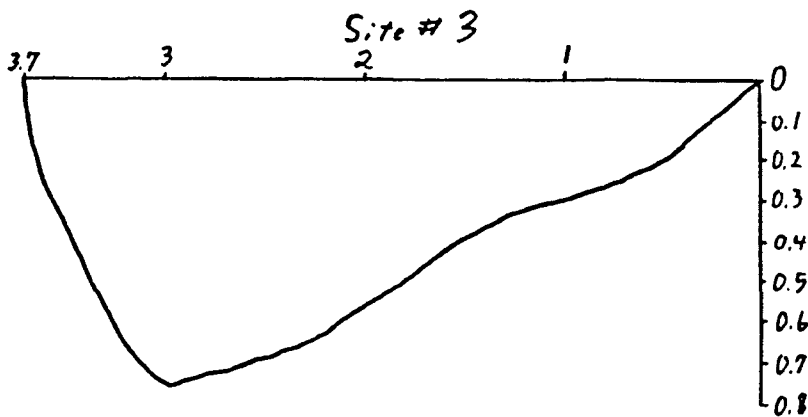
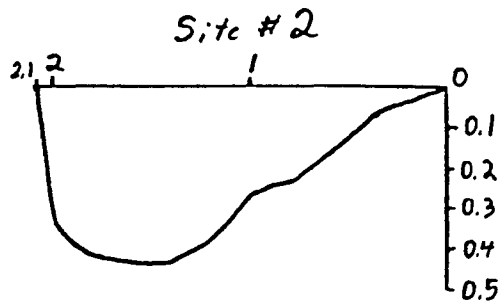
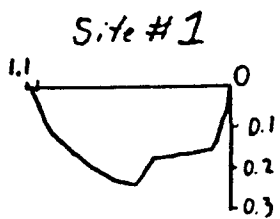
Cross-sectional areas of the transects were determined by drawing the cross-sections on graph paper (Figure 2 and 3), using the measured widths and depths and measuring the areas with a planimeter. Average depth was calculated by dividing the cross-sectional area by the width. Average velocity was determined to be the velocity measured at 60% depth in the thalweg. If this measurement was missing, the floating object velocity multiplied by 0.8 was used. Discharge was calculated by multiplying the average velocity by the cross-sectional area. Hydraulic radius was calculated by dividing the wetted perimeter by the width of stream.

In order to determine if the invertebrate community varied at different locations along the length of the Prairie Creek, invertebrate samples were taken at each study site. Six ^uSerber samples were taken at each site (2 in a pool, 2 in a riffle and 2 in a transition zone). Substrate was washed by hand into the ^uSerber Sampler for 10 minutes. The sample was then placed in a

Figure 2. Cross-sections of sites #1 - #6 through pools on
Prairie Creek, Humboldt County, CA, 29-30 September,
1990.

Right Hand





* note different scale

Right Hand Bank

Figure 3. Cross-sections of sites #1 - #6 through riffles on
Prairie Creek, 29-30 September, 1990.

Right

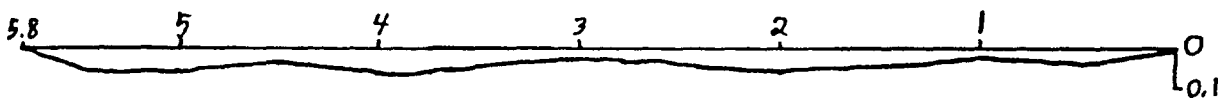
Hand

Bank

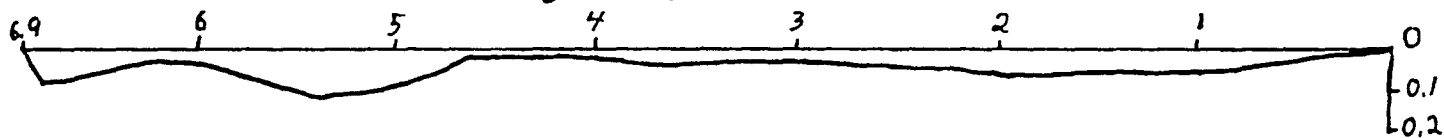
Site #1



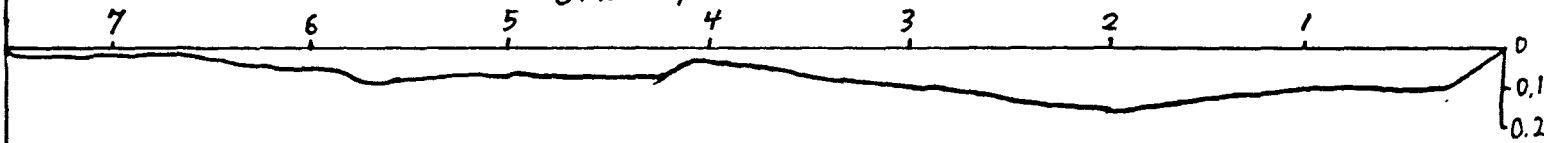
Site #2



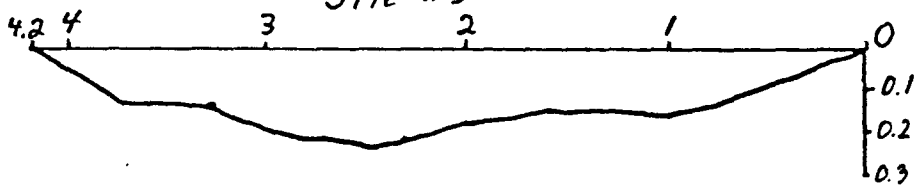
Site #3



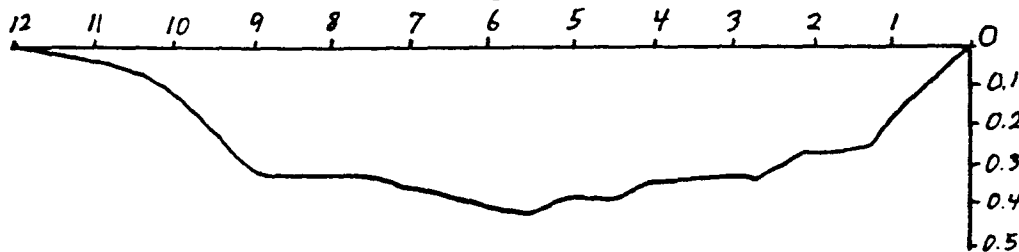
Site #4



Site #5



Site #6 *



* note different scale

white pan and a subsample of invertebrates was taken by transferring invertebrates from the pan to a jar for 15 minutes. Six other invertebrate samples were also taken at each site by using various sampling methods (predominantly kick-nets) to collect invertebrates for 10 minutes. These samples were "free-ranging" and were not limited to any habitat type. The same subsampling technique used for the Serber samples was used to subsample the invertebrates collected. All invertebrates were preserved in 10% formalin. In the lab, all invertebrates were identified to order (some to family) using Merrit and Cummings (1984) for the insects and Pennak (1978) for other invertebrates. The number of invertebrates in each taxa were recorded. Species richness and Shannon-Wiener diversity indices (Magurran 1988) were calculated for each habitat type at each site.

Results

Prairie Creek was determined to have a total length of 18.61 km. It has an average gradient of 0.012 and drains an area of approximately 90.5 km² (Table 1). Prairie Creek was found to be a first-order stream for its first 0.73 km until Hope Creek enters it, converting Prairie Creek to a second-order stream. Prairie Creek remains a second-order stream for 2.18 km until it becomes a third-order stream with the confluence of an unnamed creek approximately 0.5 km south of Zigzag Trail Bridge No. 3. After flowing another 10.97 km, Prairie Creek becomes a ^uforth-order stream where Lost Man Creek enters it. Prairie Creek remains a ^uforth-order stream for the remaining 4.73 km to its

Table 1. Length, slope and drainage area of stream order segments of Prairie Creek, Humboldt County, Ca.

Stream Order	Length (km)	Average Slope(m/km)	Drainage Area (km ²)
1	0.73	50	0.96
2	2.18	24	3.77
3	10.09	11	38.36
4	4.73	2	47.40
total	18.61	12	90.49

confluence with Redwood Creek.

The amount of oxygen in the waters of Prairie Creek was found to steadily decline as the waters flow downstream (Table 2). Alkalinity, Hardness, and pH remained fairly stable throughout the length of Prairie Creek, and all three increased with Prairie Creek's confluence with Redwood Creek (Table 2). Conductivity measurements were found to be much greater at sites #2 and #3 than at any other of the 6 study sites except for site #6 (Redwood Creek), where the conductivity was very similar to site #2 but still well under that of site #3 (Table 2).

As would be expected, stream width and depth increased downstream in both the pools and the ^{ff}ripples (Table 3 and 4). The only exceptions to this increase were at site #5, where the ^{ff}width of the ^{ff}ripple and the depth of the pool were substantially less than in the 2 preceding upstream sites. Average velocity measurements varied considerably between sites, but the general trend appears to be that the velocity of the water increases as it travels down stream. This increase is best seen in the velocities measured with meters at 60% depth in the riffles (Table 5). The extremely low velocity recorded at site #6 (Redwood Creek) in the pool is most likely a poor measurement of the true velocities at this site. When discharge for site #6 is calculated with the pool velocity, a value far below the actual discharge of Redwood Creek is obtained (Table 5).

The size of the substrate determined from pebble counts varied considerably (Figure 4) and is difficult to interpret.

Table 2. Chemistry of Prairie Creek, Humboldt County, CA, from various locations along its length, 29-30 September, 1990.

Site #	Temp. (C)	Cond.* (umhos/cm)	DO (mg/l)	pH	Alkalinity (mg CaCO ₃ /l)	Hardness (mg CaCO ₃ /l)
1	12.5	80	9.9	7.2	30	26
2	12.8	138	9.9	7.3	32	30
3	14.1	203	9.8	7.3	35	32
4	12.5	80	9.5	7.1	33	29
5	16.5	81	8.0	6.8	37	34
6	18.2	133	9.2	7.4	64	66

* Corrected to 25 C.

Table 3. Width, cross-sectional area and average depth of
Prairie Creek, Humboldt County, CA, at 6 locations, 29-
30 September, 1990.

Site #	Width (m)		Cross-sectional Area (m ²)		Avg. Depth (m)	
	Pool	Riffle	Pool	Riffle	Pool	Riffle
1	1.1	1.6	0.08	0.06	0.07	0.04
2	2.1	5.8	0.55	0.28	0.26	0.05
3	3.7	6.9	1.64	0.30	0.44	0.04
4	5.2	7.7	2.40	0.62	0.46	0.08
5	5.8	4.2	1.74	0.65	0.30	0.15
6	15.4	12.0	7.58	3.34	0.49	0.28

Table 4. Maximum depth and hydraulic radius of Prairie Creek, Humboldt County, CA, at 6 locations along its length, 29-30 September, 1990.

Site #	Max. Depth (m)		Hydraulic Radius	
	Pool	Riffle	Pool	Riffle
1	0.12	0.06	1.48	1.02
2	0.43	0.07	1.47	1.01
3	0.77	0.10	1.35	1.03
4	0.70	0.15	1.21	1.01
5	0.56	0.24	1.09	1.05
6	1.00	0.42	1.08	1.02

Table 5. Velocity and discharge of Prairie Creek, Humboldt County, CA, at 6 locations along its length, 29-30 September, 1990.

Site #	Avg. Velocity ¹ (m/sec)		Avg. Velocity ² (m/sec)		Discharge ³ (m ³ /sec)	
	Pool	Riffle	Pool	Riffle	Pool	Riffle
1	0.14	----	0.26	0.29	0.01	0.02*
2	0.12	0.07	0.12	0.46	0.07	0.02
3	----	0.41	0.06	0.57	0.10*	0.12
4	0.00	0.73	0.22	1.12	0.53*	0.45
5	0.26	0.81	0.30	----	0.46	0.53
6	0.01	0.34	----	----	0.08	1.14

1 Velocity at 60% depth in thalweg.

2 0.8 X floating object velocity.

3 Calculated from velocity at 60% depth in the thalweg.

* Calculated using 0.8 X floating object velocity.

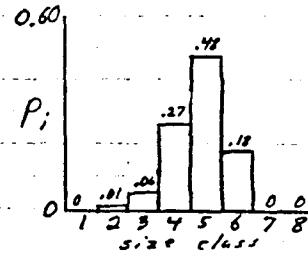
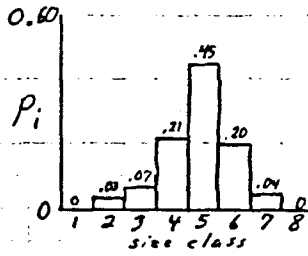
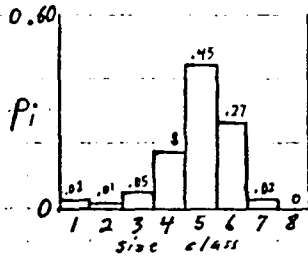
Figure 4. Proportion of pebbles in different size classes from 100 pebble counts in 3 habitat types of Prairie Creek, 29-30 September, 1990.

Habitat Type Transition

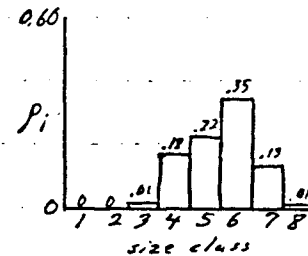
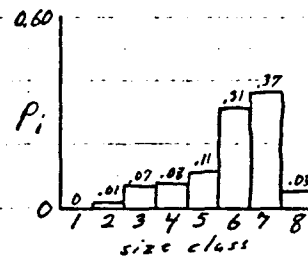
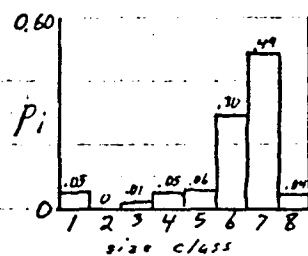
Pool

Riffle

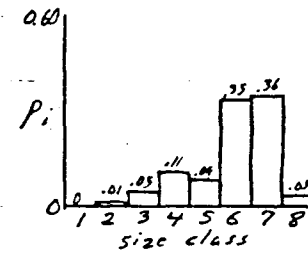
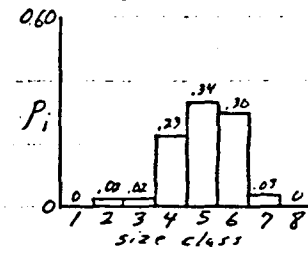
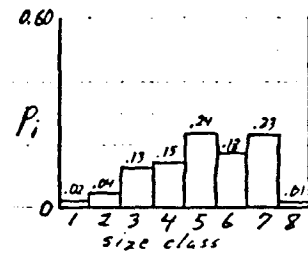
Site
#1



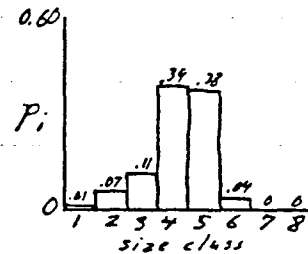
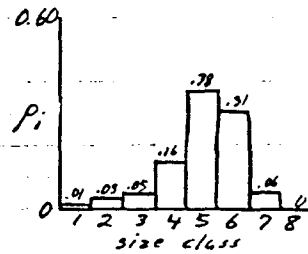
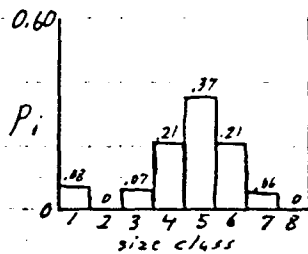
Site
#2



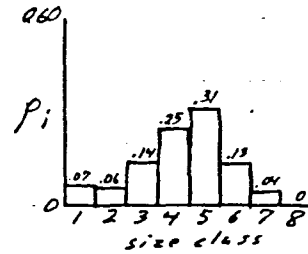
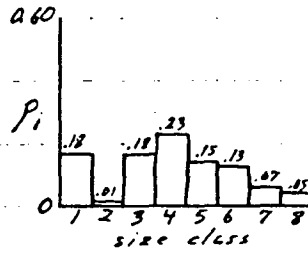
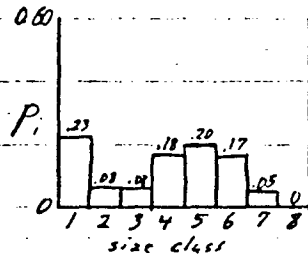
Site
#3



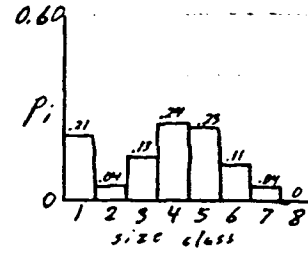
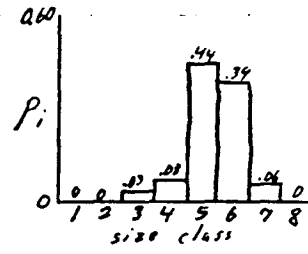
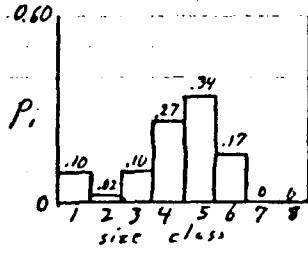
Site
#4



Site
#5



Site
#6



No general trends either increasing or decreasing of the size of the pebbles as one travels downstream were seen in the data. Also, no general trends were seen in the size of the pebbles between habitat types. These observations do not mean that trends do not exist. The size of the pebbles obviously varied from site to site, and patterns may appear if more data were available.

Invertebrate Data collected using the free-ranging method is not comparable between sites, because it was collected using a variety of sampling techniques in a variety of habitat types and will therefore not be included in any analysis of results. In general, no trends were seen in the variation in the number of invertebrate taxa between sites (Table 6). A difference in the number of taxa was found between habitat types. In all but a few cases, the riffles had fewer taxa present than either the pools or the transition zones. Both the pools and the transition zones were very similar in the number of taxa present. Taxa diversity (Table 7) showed a slightly different trend. At all but 1 site (Site #6), taxa diversity was greater in the pools than in either the transition zone or the riffles which had very similar diversity indices. Site 4 had greater taxa diversity in the pool and the riffle than the other 5 sites.

Discussion

Prairie Creek is one of the most pristine creeks in Northern California. This makes it ideal for testing the "River Continuum Concept", which is based on natural systems. The waters of

Table 6. Number of aquatic macroinvertebrate taxa found at 6 sites and 3 habitat types in Prairie Creek, Humboldt County, CA, 29-30 September 1990.

Site #	Pool	Transition	Riffle	Other
1	5	3	3	8
2	4	4	4	11
3	5	6	4	11
4	6	6	7	8
5	5	5	2	11
6	3	8	4	9

Table 7. Diversity of invertebrates (Shannon-Weiner) collected from 3 habitat types at 6 locations with Serber Samplers and in a mixture of habitat types with various sampling methods (Other) from Prairie Creek, Humboldt County, CA, 29-30 September, 1990.

Site #	Pool	Transition	Riffle	Other
1	1.39	0.79	0.92	1.50
2	1.23	0.96	1.11	1.80
3	1.39	1.36	0.81	1.78
4	1.66	1.24	1.44	1.71
5	1.36	1.30	0.46	1.79
6	0.66	1.39	0.52	1.61

Prairie Creek were very clear from site #1 through site #3. Sites #4 through #6 showed increasing amounts of suspended sediments in the water and fine silts on the bed. Sites #1, #2 and #3 had very dense canopies overhanging the water effectively reducing the amount of light striking the stream surface. Sites #4 and #5 were fairly open with only about 30 - 50% shading. Site #6 had no shading from a canopy and received full sunlight until the sun dropped behind the surrounding ridges. Thus the amount of light reaching the water surface of Prairie Creek increases in a downstream direction.

The quantity and quality of Prairie Creek's water is strongly influenced by its surrounding watershed and any disturbance of this watershed can have great impacts on the waters of Prairie Creek. Logging can increase erosion and thus the amounts of sediments entering the creek; and it can alter runoff from the hillsides causing quick rises and falls in water depth (Carolyn Meyer, pers. commun.). The construction of the Highway 101 Bypass in the Prairie Creek watershed in October, 1989 caused large amounts of sediments to be washed into Prairie Creek thus silting in many spawning gravels (Carolyn Meyer, pers. commun.). The great differences between the alkalinity and hardness of Prairie Creek water and those of Redwood Creek water (Table 2) is most likely due to the differences in the watersheds through which these 2 systems flow.

The trends seen in the stream velocity and gradient (Tables 1 and 5) are consistent with those of most river systems. As the

water travels downstream, the stream gradient decreases but the water velocity increases. These seemingly contradictory results are explained by considering the factors which affect the rate that water will flow: slope, weight, and resistance (mostly from the bed). Even though the decrease in slope tends to slow the water down, this effect is overcome by the increased weight and decreased resistance from the bed resulting in an increased velocity as the water travels downstream.

The results from this study support the "River Continuum Hypothesis". From the headwaters to the downstream extent, the available light, width, depth, velocity and discharge of Prairie Creek all increased (Tables #3 and #5). The temperature data needs to be considered carefully since the measurements were taken on 2 different days and at different times. There appears to be a trend of increasing temperatures as one travels downstream. The high temperature of the water at site 3 may have been due to the waters of Boyes Creek entering upstream from the study site. This site was sampled in the morning and should have one of the lowest temperatures, if the trend of increasing temperature with increasing distance downstream is valid. The high conductivity measurements of sites #2 and #3 are also probably due to incoming streams altering the physical and chemical characteristics of Prairie Creek at specific points. Dissolved oxygen, hydrogen ion concentration, alkalinity and hardness all increase as one goes downstream in Prairie Creek. Thus Prairie Creek presents a gradient of physical and chemical

conditions which the invertebrate community should respond to. Due to the fact that a very large percentage of the invertebrates were only keyed down to order, and the invertebrates that were keyed to family were not random subsamples from all the study sites, I Found it impossible to make valid comparisons of the feeding strategies of invertebrates between sites.

The results of this study concerning effects of the Highway 101 bypass upon Prairie Creek are inconclusive. There appeared to be more suspended particles and silts in the downstream waters which could have come from runoff from the bypass. However, this increase in suspended particles is also consistent with the "River Continuum Concept" which states that fine particulate organic matter in the water will increase as you go downstream. Ideally, to determine if the amount of suspended particles and silts in Prairie Creek are at abnormally high levels due to runoff from the 101 bypass, measurements of conditions in the creek before and after the construction of the bypass should be compared. If pre-construction data is not available, the present study can be compared with studies which should be conducted in the future to see if Prairie Creek is trying to return to a lower suspended particle and silt load (suggesting that the present conditions are abnormally high) or if it ^{remains} at an equilibrium given present conditions.

In contrast to Prairie Creek, Redwood Creek runs through a much more disturbed watershed. Of the approximately 700 km² drainage area of Redwood Creek, only 40% is in Redwood National

Park and thus protected from disturbance by logging, gravel mining and other activities of man which increase erosion and runoff from the watershed. Most of the 40% of Redwood Creek's watershed which is now protected was disturbed by logging, etc. before becoming part of the park. The greatly disturbed watershed through which Redwood Creek flows is most likely the cause of alkalinity and hardness measurements found here being greater than those of Prairie Creek. The temperature of Redwood Creek is also greater due to the disturbed, open landscape through which it flows.

Executive Summary

Prairie Creek is located approximately 1.6 km north of Orick in Redwood National Park, Humboldt County, CA. It is one of the last natural systems in the region, with its approximately 90.5 km² watershed being located primarily in old-growth redwoods. The amount of oxygen in the waters of Prairie Creek was found to steadily decline as the waters flow downstream. Alkalinity, Hardness, and pH remained fairly stable throughout the length of Prairie Creek and all three increased with Prairie Creek's confluence with Redwood Creek. Conductivity measurements were found to be much greater at sites #2 and #3 than at any of the other 6 study sites, possibly due to the incoming streams in this area. Stream width and depth increased downstream in both the pools and the ^{ft}ripples. The size of the substrate determined from pebble counts varied considerably. The riffles had fewer invertebrate taxa present than either the pools or the transition

zones. No trends were seen in the variation in the number of invertebrate taxa between study sites. Taxa diversity was greater in the pools than in either the transition zone or the riffles which had very similar diversity indices. The amount of light reaching the water surface of Prairie Creek increases in a downstream direction.

The quantity and quality of Prairie Creek's water is strongly influenced by its surrounding watershed and any disturbance of this watershed can have great impacts on the waters of Prairie Creek. The trends found in the stream velocity and gradient are consistent with those of most river systems. As the water travels downstream, the stream gradient decreases but the water velocity increases. The results from this study support the "River Continuum Hypothesis". The results of this study concerning effects of the Highway 101 bypass upon Prairie Creek are inconclusive. The present study can be compared with studies which should be conducted in the future to see if Prairie Creek is trying to return to a lower suspended particle and silt load or if it ^{remains} at an equilibrium given present conditions. In contrast to Prairie Creek, Redwood Creek runs through a much more disturbed watershed.

Acknowledgments

Thanks is given to David Grettum, James Eisner and Rizwan Sheikh for their aid in field sampling. David Grettum's help sorting and identifying aquatic invertebrates is greatly

appreciated. Dr. D. R. Lauck provided his much needed expertise identifying aquatic invertebrates and Carolyn Meyer provided a very informative introduction to the Prairie Creek system.

Thanks is also given to Dr. Joe Meyer for his help throughout this project and for grading this report with a kind and generous heart.

References

- Lind, O. T. 1974. Handbook of common methods in limnology. The C.V. Mosby Co., St Louis, MO, USA. pgs 5-81.
- Magurran, A. M. 1988. Ecological diversity and its measurement. Princeton University Press. Princeton, NJ, USA. 179pp.
- Merritt, R. W. and K. W. Cummins. 1984. An introduction to the aquatic insects of North America. Kendall/Hunt Pub. Co. Dubuque, Iowa, USA. 722 pp.
- Pennak, R. W. 1978. Fresh-water invertebrates of the United States. Wiley. New York, NY, USA. 803 pp.
- U.S.G.S. 1966a. Fern Canyon quadrangle, CA, 7.5 minute series (topographic). U.S.G.S. Washington, DC, USA.
- U.S.G.S. 1966b. Orick quadrangle, CA, 7.5 minute series (topographic). U.S.G.S. Washington, DC, USA.
- U.S.G.S. 1983a. Ah Pah Ridge quadrangle, CA, 7.5 minute series (topographic). U.S.G.S. Washington, DC, USA.
- U.S.G.S. 1983b. Holter Ridge, CA, 7.5 minute series (topographic). U.S.G.S. Washington, DC, USA.
- Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, C. E. Cushing. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37:130-137.

Appendix A. Aquatic invertebrates identified in Prairie Creek,
Humboldt County, CA, 29-30 September 1990.

Phylum	Class	Order	Family	Site 1				Site 2			
				Riffle n=2	Trans. zone n=2	Pool n=2	Other n=5	Riffle n=2	Trans. zone n=1	Pool n=2	Other n=6
Annelida	not identified			—	—	1	1	—	—	—	3
	Hirudinea		not identified	—	—	—	3	—	—	—	—
	Oligochaeta		not identified	—	—	3	—	—	—	2	3
Arthropoda	Arachnida	Acari	not identified	—	—	—	—	—	—	—	—
	Crustacea	Amphipoda	not identified	13	8	13	13	—	—	—	16
			Talitridae	—	11	—	48	—	—	—	1
		Mysidacea	not identified	—	—	—	2	—	—	—	
Insecta	Coleoptera	not identified	—	—	—	—	—	—	—	—	5
		Dytiscidae	—	—	—	—	—	—	—	—	—
		Elmidae	—	—	—	—	—	—	—	—	—
		Halipilidae	—	—	—	—	—	—	—	—	
		Hydrophilidae	—	—	—	—	—	—	—	—	
		Ptilodactylidae	—	—	—	—	—	—	—	—	
	Diptera	not identified	—	—	—	—	—	2	—	6	
Ceratopogonidae		—	—	—	—	—	—	—	—	—	
Chironomidae		—	—	—	—	—	—	—	—	—	
Culicidae		—	—	—	—	—	—	—	—	2	
Ptychopteridae		—	—	—	—	—	—	—	—	—	
Simuliidae		—	—	—	1	—	—	1	—	—	
Tipulidae		—	—	—	—	—	—	—	—	—	
Ephemeroptera		not identified	—	—	3	—	10	—	—	51	
	Baetidae	—	—	—	—	—	—	—	11		
	Ephemeridae	—	—	—	—	—	—	—	2		
	Heptageniidae	—	—	—	6	6	—	5	7		
	Leptophlebiidae	—	—	—	—	—	—	—	—		
	Siphonuridae	—	—	—	—	—	—	—	—		
	Tricorythidae	—	—	—	1	—	6	—	—		
Hemiptera	not identified	—	—	—	—	—	—	—	—	—	
	Belostomatidae	—	—	—	—	—	—	—	—	—	
	Corixidae	—	—	—	—	—	—	—	—	—	
	Gerridae	—	—	—	—	—	—	—	—	1	
	Ptychopteridae	—	—	—	—	—	—	—	—	—	
Megaloptera	not identified	—	—	—	—	—	—	—	—	—	
	Corydalidae	—	—	—	—	—	—	—	—	1	
	Sialidae	—	—	—	—	—	—	—	—	—	
Odonata	not identified	—	—	—	—	—	—	—	—	1	
	Gomphidae	—	—	—	—	—	—	—	—	—	
Plecoptera	not identified	3	3	11	4	4	—	—	37		
	Chloroperlidae	—	—	—	—	—	—	—	—	—	
	Isoperlidae	—	—	—	—	—	—	—	—	—	
	Leuctridae	—	—	—	—	—	3	—	—	—	
	Neomuridae	—	—	—	—	—	—	—	—	1	
	Peltoperlidae	—	1	—	—	1	—	—	4		
	Perlidae	—	3	—	33	3	29	—	7		
	Perlodidae	—	—	—	—	—	—	—	7		
	Pteronarcyidae	—	—	—	1	1	—	—	1		
	Trichoptera	not identified	5	1	2	6	—	—	—	37	
	Brachycentridae	—	—	—	3	—	—	5	—	—	
	Glossosomatidae	—	—	—	—	—	—	—	—	2	
Hydropsychidae	—	—	—	2	2	—	—	—	—		
Hydroptilidae	—	—	—	—	—	—	—	—	—		
Lepidostomatidae	—	—	—	—	—	—	—	—	3		
Lianephilidae	—	—	—	—	—	—	—	—	—		
Philopotamidae	—	—	—	—	3	—	—	4			
Rhyacophilidae	—	1	—	2	—	—	—	1			
Sericostomatidae	—	—	—	—	—	—	—	—	—		
Mollusca	Gastropoda	not identified	—	—	—	—	8	—	8		
		Pulmonata	Physidae	—	—	—	—	—	—	6	
		Planorbidae	—	—	—	—	—	—	—	—	
		Ctediobranchiata	Pleuroceridae	—	1	—	7	1	—	42	
	Pelecypoda	Eulamellibranchiata	Sphaeriidae	—	—	—	—	—	—	—	

Appendix A cont.

Phylum	Class	Order	Family	Site 3				Site 4			
				Riffle n=1	Trans. zone n=2	Pool n=2	Other n=6	Riffle n=2	Trans. zone n=2	Pool n=2	Other n=5
Annelida	not identified			—	—	—	2	1	—	—	4
	Hirudinea	not identified		—	2	—	—	—	—	—	
	Oligochaeta	not identified		—	—	1	—	2	13	1	
Arthropoda	Arachnida	Acari	not identified	—	—	—	1	—	—	—	—
	Crustacea	Amphipoda	not identified	—	—	—	5	1	—	—	—
		Talitridae	33	—	—	—	1	—	—	—	—
		Mysidacea	not identified	—	—	—	—	—	—	—	
Insecta	Coleoptera	not identified	—	3	—	16	—	—	2	3	
		Dytiscidae	—	—	—	1	—	—	6	3	
		Elmidae	—	—	—	3	—	1	—	—	
		Haliplidae	—	—	—	—	—	—	16		
		Hydrophilidae	—	—	—	3	—	—	—		
		Ptilodactylidae	—	—	—	—	—	—	—		
	Diptera	not identified	—	—	—	—	5	—	—	—	
Ceratopogonidae		—	—	—	—	—	—	—	—		
Chironomidae		—	—	—	—	—	—	—	—		
Culicidae		—	—	—	—	—	—	—	—		
Ptychopteridae		2	—	1	3	—	—	—	—		
Simuliidae		—	—	2	1	—	—	—	—		
Tipulidae		—	—	—	—	—	—	—	—		
			—	—	—	—	—	—	—		
	Ephemeroptera	not identified	—	20	1	28	59	—	10	62	
Baetidae		—	—	—	—	—	—	1	7		
Ephemeridae		—	—	—	1	—	—	—	—		
Heptageniidae		—	—	—	11	—	43	1	21		
Leptophlebiidae		—	—	—	—	—	—	5	—		
Siphonuridae		—	—	—	—	—	6	—	—		
Tricorythidae		—	—	—	—	—	—	—	—		
			—	—	—	—	—	—	—		
	Hemiptera	not identified	—	—	—	—	—	—	—	2	
Belostomatidae		—	—	—	—	—	—	—	—	1	
Corixidae		—	—	—	—	—	—	—	—	—	
Gerridae		—	—	—	—	—	—	—	—	3	
Ptychopteridae		—	—	—	—	—	—	—	—	—	
	Megaloptera	not identified	—	—	—	—	—	—	—	—	
Corydalidae		—	—	—	1	—	—	—	—	—	
Sialidae		—	—	—	—	—	—	—	—	4	
	Odonata	not identified	—	—	—	5	—	—	—	—	
Gomphidae		—	—	—	1	—	—	—	—	—	
	Plecoptera	not identified	—	3	—	19	15	—	5	14	
Chloroperlidae		—	—	—	—	—	—	—	—	—	
Isoperlidae		—	—	—	—	—	—	—	—	—	
Leuctridae		4	—	—	—	—	—	—	—	—	
Neonuridae		—	—	—	—	—	—	—	—	—	
Peltoperlidae		—	—	—	—	—	—	—	—	—	
Perlidae		2	—	—	12	—	21	—	—	34	
Perlodidae		—	—	—	—	—	—	—	—	—	
Pteronarcyidae		—	—	—	—	—	—	—	—	—	
	Trichoptera	not identified	—	28	6	61	11	—	19	44	
Brachycentridae		—	—	—	1	—	—	—	—	—	
Glossosomatidae		—	—	—	2	—	2	—	—	4	
Hydropsychidae		—	—	—	—	4	—	1	—	—	
Hydroptilidae		—	—	—	—	—	—	—	—	5	
Lepidostomatidae		—	—	—	—	—	—	1	—	8	
Limnephilidae		—	—	—	5	1	—	5	—	14	
Philopotamidae		—	—	—	—	—	—	—	—	—	
Rhyacophilidae		—	—	—	—	—	—	1	—	—	
Sericostomatidae		—	—	—	4	—	—	—	—	3	
			—	—	—	—	—	—	—	—	
Mollusca	Gastropoda	not identified	—	6	—	—	—	—	—	3	
		Pulmonata	Physidae	—	1	—	25	3	—	9	5
		Planorbidae	—	—	—	—	—	—	—	—	
	Ctodiobranchiata	Pleuroceridae	3	—	2	56	12	—	3	41	
Pelecypoda	Eulamellibranchiata	Sphaeriidae	—	—	—	—	—	4	—	—	

Appendix A cont.

Phylum	Class	Order	Family	Site 5				Site 6			
				Riffle n=2	Trans. zone n=2	Pool n=2	Other n=5	Riffle n=2	Trans. zone n=2	Pool n=1	Other n=6
Annelida	not identified	not identified	not identified	—	—	—	2	—	—	—	—
			Hirudinea	—	—	—	—	—	—	—	15
			Oligochaeta	—	—	—	—	—	1	—	—
Arthropoda	Arachnida	Acari	not identified	—	—	1	1	—	3	—	8
			not identified	—	—	—	—	—	—	—	2
			Talitridae	—	—	—	—	—	—	—	—
	Crustacea	Amphipoda	not identified	—	—	—	—	—	—	—	—
			Mysidacea	—	—	—	—	—	—	—	—
			not identified	—	—	—	—	—	—	—	—
	Insecta	Coleoptera	not identified	—	—	1	14	—	1	—	1
			Dytiscidae	—	1	—	4	1	—	—	1
			Elmidae	—	—	—	—	—	—	—	—
			Halophilidae	—	—	—	—	—	—	—	—
			Hydrophilidae	—	—	—	2	—	—	—	—
			Ptilodactylidae	—	—	—	—	—	—	—	—
		Diptera	not identified	—	1	—	1	1	8	2	36
			Ceratopogonidae	—	—	—	—	—	1	—	—
			Chironomidae	—	—	—	14	11	15	—	9
			Culicidae	—	—	—	—	—	—	—	—
			Ptychopteridae	—	—	—	—	—	—	—	—
			Simuliidae	—	—	—	1	—	—	—	6
		Tipulidae	Tipulidae	—	—	—	1	—	—	—	—
			not identified	—	—	2	65	2	40	—	91
			Baetidae	—	1	—	—	4	—	—	25
		Ephemeroptera	Ephemeridae	—	—	1	—	—	—	—	1
			Heptageniidae	10	5	2	—	—	—	—	2
			Leptophlebiidae	—	—	—	2	—	—	—	—
			Siphonuridae	—	—	—	—	—	—	—	—
			Tricorythidae	—	—	—	—	7	11	11	39
		Hemiptera	not identified	—	—	—	1	—	—	—	—
			Belostomatidae	—	—	—	—	—	—	—	—
			Corixidae	—	—	—	3	—	—	—	—
			Gerridae	—	—	—	—	—	—	—	—
			Ptychopteridae	—	—	—	—	—	—	—	—
		Megaloptera	not identified	—	—	—	6	—	—	—	—
			Corydalidae	—	—	—	—	—	—	—	—
			Sialidae	—	—	—	1	—	—	—	—
		Odonata	not identified	—	—	—	—	—	—	—	—
			Gomphidae	—	—	—	2	—	—	—	—
		Plecoptera	not identified	—	—	—	12	—	2	—	12
			Chloroperlidae	—	—	—	4	—	—	—	1
			Isoperlidae	—	—	—	2	—	—	—	—
			Leuctridae	—	—	—	—	—	—	—	—
			Neomuridae	—	—	—	—	—	—	—	—
			Peltoperlidae	—	—	—	—	—	—	—	—
			Perlidae	1	3	—	3	—	—	—	1
			Perlodidae	1	—	—	—	—	—	—	—
			Pteronarcyidae	—	—	—	—	—	—	—	—
		Trichoptera	not identified	—	1	—	51	75	27	—	30
			Brachycentridae	—	—	—	—	—	—	—	—
			Glossosomatidae	—	—	—	—	—	—	—	—
			Hydropsychidae	—	—	—	—	—	—	—	—
			Hydroptilidae	—	—	—	—	83	—	—	8
			Lepidostomatidae	—	—	—	4	—	7	—	2
			Limnephilidae	—	8	—	5	—	—	—	1
			Philopotamidae	—	—	—	—	—	—	—	—
			Rhyacophilidae	—	—	2	—	—	—	—	—
			Sericostomatidae	—	—	—	22	—	—	—	—
Mollusca	Gastropoda	not identified	not identified	—	—	—	—	—	—	—	3
			Physidae	—	—	—	2	—	—	—	—
			Planorbidae	—	—	—	2	—	—	—	—
	Ctediobranchiata	Pleuroceridae	Pleuroceridae	—	—	—	12	—	2	1	6
			not identified	—	—	—	—	—	—	—	—
			not identified	—	—	—	—	—	—	—	—
Pelecypoda	Eulamellibranchiata	Sphaeriidae	Sphaeriidae	—	—	1	—	—	—	—	—
			not identified	—	—	—	—	—	—	—	—
			not identified	—	—	—	—	—	—	—	—