OPERATIONAL ECOLOGICAL MONITORING PROGRAM FOR NUCLEAR PLANT 2 1985 ANNUAL REPORT

Prepared By
Environmental Programs Department

WASHINGTON PUBLIC POWER
SUPPLY SYSTEM

850377

OPERATIONAL ECOLOGICAL

MONITORING PROGRAM

FOR

WNP-2

ANNUAL REPORT 1985

Washington Public Power Supply System
Environmental Programs
3000 George Washington Way
Richland, Washington 99352

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EXECUTIVE SUMMARY

This report presents the results of the Ecological Monitoring Program (EMP) conducted in the vicinity of Supply System Nuclear Plant No. 2 (WNP-2) during January through December of 1985. The objectives of the EMP are to provide an environmental data base which may be used to identify long-term trends and operational impacts in the areas of aquatic ecology, water quality, and terrestrial ecology.

Density and biomass of benthic macrofauna increased 145% and 141% over the 1984 measurements. Chironomidae and Hydrophyschidae accounted for 86% of the organisms counted and 67% of the measured biomass. Periphyton biomass (TOM) measurements were comparable for the preoperational and operational data sets. TOM was usually low in the spring and high in summer and fall. There was no measurable change in benthic macrofauna as a result of WNP-2 operation.

Periphyton were studied utilizing two techniques. The historical method of measuring total organic matter was compared with a new, more sensitive technique which directly measures carbon. The conclusion with both methods was that there was no measurable change in periphyton biomass as a result of WNP-2 operation.

Water quality in the Columbia River in 1985 met Washington State Class A standards for the measured parameters. Inter-station differences could not be detected for any of the measured parameters on most of the sampling dates. However, during the March and April sampling periods there were some marked differences in several parameters between the control station and the downstream station closest to the discharge. None of these differences extended beyond the mixing zone.

No fish were observed impinged and there was no significant fouling on the intake screens. Over 294 hours of entrainment sampling produced no fish, fish eggs, or larvae. No mortalities were observed when steelhead trout and chinook salmon were drifted through the thermal plume. Corbicula (clam) inspections continued to reveal that the organism is only rarely present in the plant and that it does not pose a hazard.

After one year of commercial operation, soils sampled from nine sites surrounding WNP-2 are within the ranges experienced in preoperational studies (1980-1984) with respect to seventeen chemical parameters. However, at sites G01, G02 and G03, those sites closest to the cooling towers, a marked increase in conductivity and a slight decrease in pH was evident.

Copper, sulfate, and chloride concentrations in the six species of plant tissues examined from 1980 to 1985 were relatively consistent and tended to cluster around the mean values reported in previous years. No correlations between soil and vegetation chemical concentrations were apparent.

Western meadowlarks, brown-headed cow birds, white-crowned sparrows, and black-billed magpies comprised 47% of the birds observed during the 1985 spring and fall surveys. Overall, deer densities were highest in the shrub and riparian biomes for spring and fall surveys. Preoperational and operational deer densities measured near WNP-2 are low compared to other areas sampled in and out of Washington State. As in previous years, the highest rabbit densities were in the shrub biome south of WNP-2.

In order to determine whether or not fish exposed to WNP-2's discharge might experience any acute toxic effects, two 96-hour bioassays were conducted on both steelhead trout and chinook salmon juveniles. Fish were held in various concentrations of water collected from the cooling tower; the maximum concentration tested was 100%. No fish mortalities were observed during any of the tests.

On four occasions representing extreme temperatures and low to moderate flows, three-dimensional thermal measurements were made of the discharge plume to document compliance with State of Washington water quality standards. In all cases, the temperature was well within allowable limits.

ACKNOWLEDGMENTS

This annual report, prepared by Washington Public Power Supply System, describes the aquatic, terrestrial and water quality programs for Nuclear Project No. 2 (WNP-2).

Project Team

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Terrestrial-Animal Task Leader	Lana S. Schleder
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1.0 INTRODUCTION

1.1 BACKGROUND

Washington Public Power Supply System (Supply System) began site preparation for Nuclear Plant Number 2 (WNP-2) near Richland, Washington in March 1973. WNP-2 loaded fuel in December 1983, reached approximately 75 percent thermal load in November 1984, and began commercial operation in December 1984.

The Site Certification Agreement (SCA) for WNP-2, executed on May 17, 1972, between the State of Washington and the Supply System requires that ecological monitoring be conducted during the preoperational and operational phases of site development and use. The Washington State Energy Facility Site Evaluation Council (EFSEC) approved a change in 1978 to the technical scope of environmental monitoring required by the SCA (EFSEC Resolution No. 132, January 23, 1978). In 1980, the aquatic and water quality portions of the preoperational monitoring were terminated (EFSEC Resolution No. 166, March 24, 1980). The following year the preoperational and operational terrestrial monitoring program scope for WNP-2 was modified (EFSEC Resolution No. 193, May 26, 1981). Prior to operation, the council reviewed the preoperational aquatic monitoring data and approved the operational monitoring program (EFSEC Resolution No. 214, November 8, 1982).

The Supply System in 1974 retained Battelle, Pacific Northwest Laboratories (BNW) to conduct the preoperational aquatic monitoring for WNP-2. The results of aquatic studies performed from September 1974 through August 1978 are presented in various reports (Battelle 1976, 1977, 1978, 1979a and 1979b). From August 1978 through March 1980 the aquatic studies were performed by Beak Consultants, Inc. (Beak 1980). In 1982 the Supply System analyzed the 1974-1980 aquatic data and presented the results and a recommended operational monitoring program to EFSEC (WPPSS 1982). The operational program was accepted with minor modifications and initiated in March 1983. Because of operational conditions the plant did not consistently discharge liquid effluents until the Fall 1984. Figures 1-1 through 1-3 present summaries of electrical generation and monthly discharges for 1985.

Terrestrial monitoring was initiated in 1974 and was conducted by BNW until 1979 (Battelle 1976b, 1977b, 1979b, 1979c). Beak Consultants, Inc. performed the vegetation monitoring program from 1980-1982 (Beak 1981, 1982a, 1982b). Since 1983 Supply System scientists have been responsible for the vegetation aspects of the program (Northstrom et. al. 1984, 1985). During 1981, the animal studies program was taken over by Supply System scientists and results were reported annually (Schleder 1982, 1983, 1984). The first comprehensive operational environmental report was prepared by Supply System scientists in 1984 (WPPSS 1985).

This report presents the results of the Ecological Monitoring Program (EMP) for the period January 1985 through December 1985.

1.2 THE SITE

The WNP-2 plant site is located 19 KM (12 miles) north of Richland, Washington in Benton County (Figure 1-4). The Supply System has leased 441 hectares (1089 acres) from the U.S. Department of Energy's Hanford Site for WNP-2.

WNP-2 lies within the boundaries of the Columbia Basin, an extensive area south of the Columbia River between the Cascade Range and Blue Mountains in Oregon and approximately two thirds of the area lying east of the Cascades in Washington. The plant communities within the region are described as shrub-steppe communities consisting of various layers of perennial grasses overlayed by a discontinuous layer of shrubs. In general, moisture relations do not support arborescent species except along streambanks. Approximately 5 km (3 1/4 miles) to the east, the site is bounded by the Columbia River. In August of

1984 a range fire destroyed much of the shrub cover which occupied the site and temporarily modified the shrub-steppe associations which were formerly present.

The aquatic and water quality sampling stations are located near the west bank of the Columbia River at approximately River Mile 352. Sampling was limited to the main channel Benton County side which, near the site, averages 370 m (1200 ft) wide at a river elevation of 105 m (345 ft) above sea level and ranges to 7.3 m (24 ft) deep. Sampling stations have been established in the river both upstream and downstream from the plant intake and discharge structures. The river-level in this area fluctuates considerably diurnally and from day-to-day in response to release patterns at the Priest Rapids Dam (River Mile 397) alternately exposing and covering large areas of river bottom. The river bottom within the study area varies from exposed Ringold conglomerate to boulders, cobble, gravel, and sand. River velocities at the surface average approximately 2 meters (5 to 6 feet) per second in this area of the river, and water temperature varies from approximately 0 to 22°C.

The flow of the Columbia River at WNP-2 is controlled by releases from Priest Rapids Dam. The minimum flow, measured at the USGS stream-quality station located at river mile 388.1 near the Vernita bridge, was 39,000 cfs, while average and maximum flows in 1985 were 101,900 cfs and 179,000 cfs, respectively (Figure 1-5).

The terrestrial sampling locations are all within an 8 Km (5 mile) radius from WNP-2. The topography is flat to gently rolling, gradually increasing from an elevation of 114 m (375 ft) at the riparian sampling locations to approximately 152 m (500 ft) at more distant shrubgrass sample sites.

1.3 OBJECTIVES

The purpose of the Ecological Monitoring Program is to measure the impact of WNP-2 on the environment. Prior to operation, the EMP provided baseline data on the aquatic and terrestrial communities. Specifically, the ecological studies provide information about the biota near the site, including species composition, relative abundance, and seasonal and spatial distribution. The aquatic ecology program monitors benthos, periphyton and fish in order that current results can be compared with previously collected data to assess WNP-2 operational impacts. The water quality program provides baseline physical and chemical data to evaluate the impact of WNP-2 discharges on the Columbia River. The terrestrial ecology program provides for collection of baseline and operational data to be used in assessments for mitigation purposes and cooling tower drift impacts.

1.4 SCOPE

A temporal summary of the field sampling periods for the various programs summarized in the 1985 EMP is illustrated in Table 1-1. The aquatic program is composed of several components, which include benthic macrofauna (Section 2.0), periphyton (Section 3.0), water quality (Section 4.0), fish impingement and intake structure fouling surveys (Section 5.0), Corbicula (clam) surveys (Section 6.0), fish bioassays, (Section 9.0), thermal plume (Section 10.0), fish drift (Section 11.0) and fish entrainment (Section 12.0). The terrestrial program components includes terrestrial-vegetation studies (Section 7.0) and terrestrial-animal studies (Section 8.0).

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Table 1-1. Summary of Field Sampling Periods for the 1985 WNP-2 Ecological Monitoring Program

Task	(Month Sampled)											
	J	F	M	A	M	J	J	A	S	O	N	D
Aquatic Ecology												
Benthic Macrofauna[(1)]			X			X			X			X
Periphyton												
Gradient[(1)]	X		X	X		X	X		X	X		X
Core[(1)]			X			X			X			X
Corbicula Survey							X				X	
Fish Impingement			X				X	X	X	X	X	
Fish Entrainment			X	X	X	X	X	X	X		X	
Fish Drift			X	X	X							
Water Quality	X	X	X	X	X	X	X	X	X	X	X	X
Terrestrial Ecology												
Vegetation					X							
Soil & Plant Chemistry					X							
Deer/Rabbit Survey							X					X
Bird Survey							X					X

[(1)]Denotes beginning and/or end of sampling period.

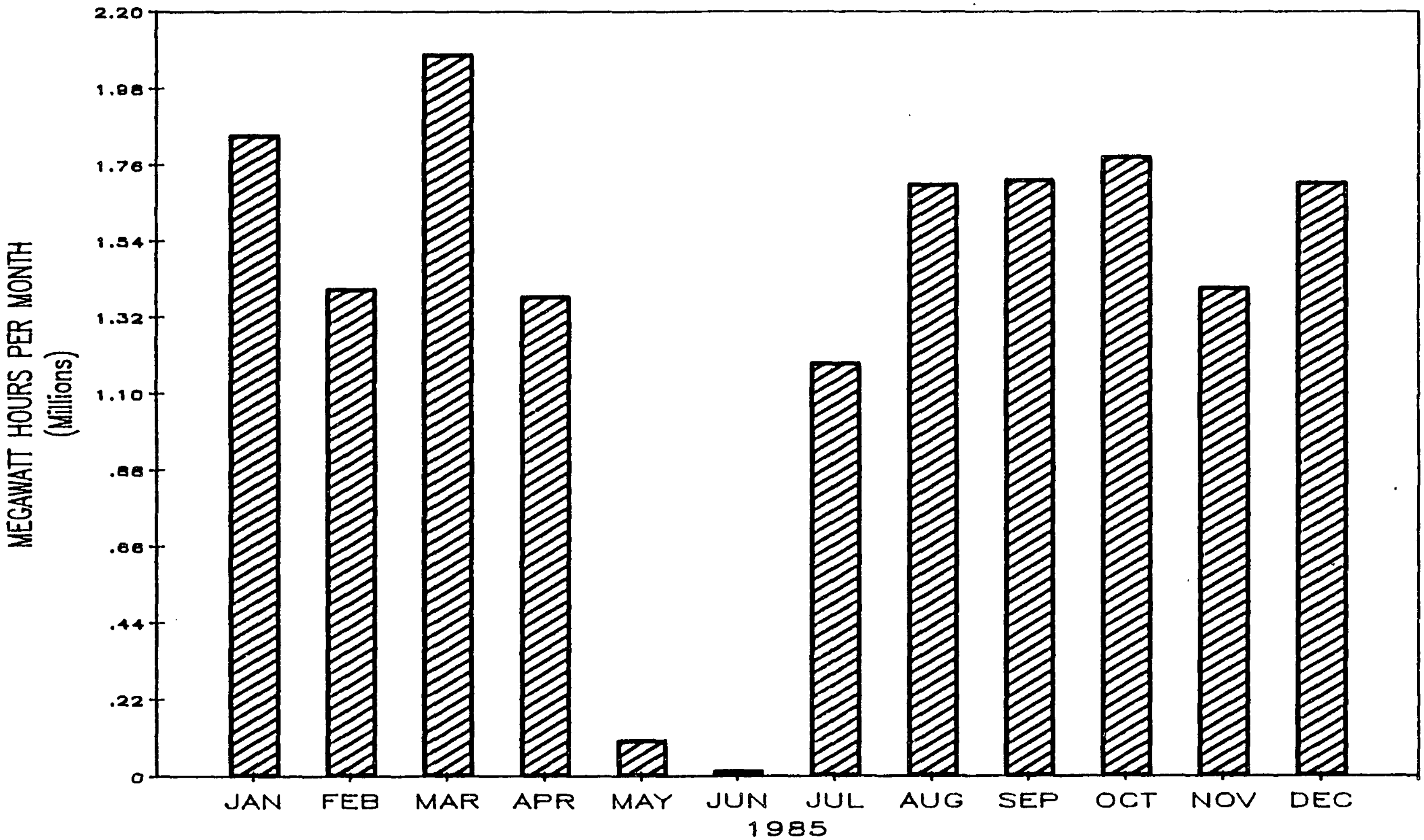

Figure 1-1. WNP-2 Gross Thermal Production for 1985

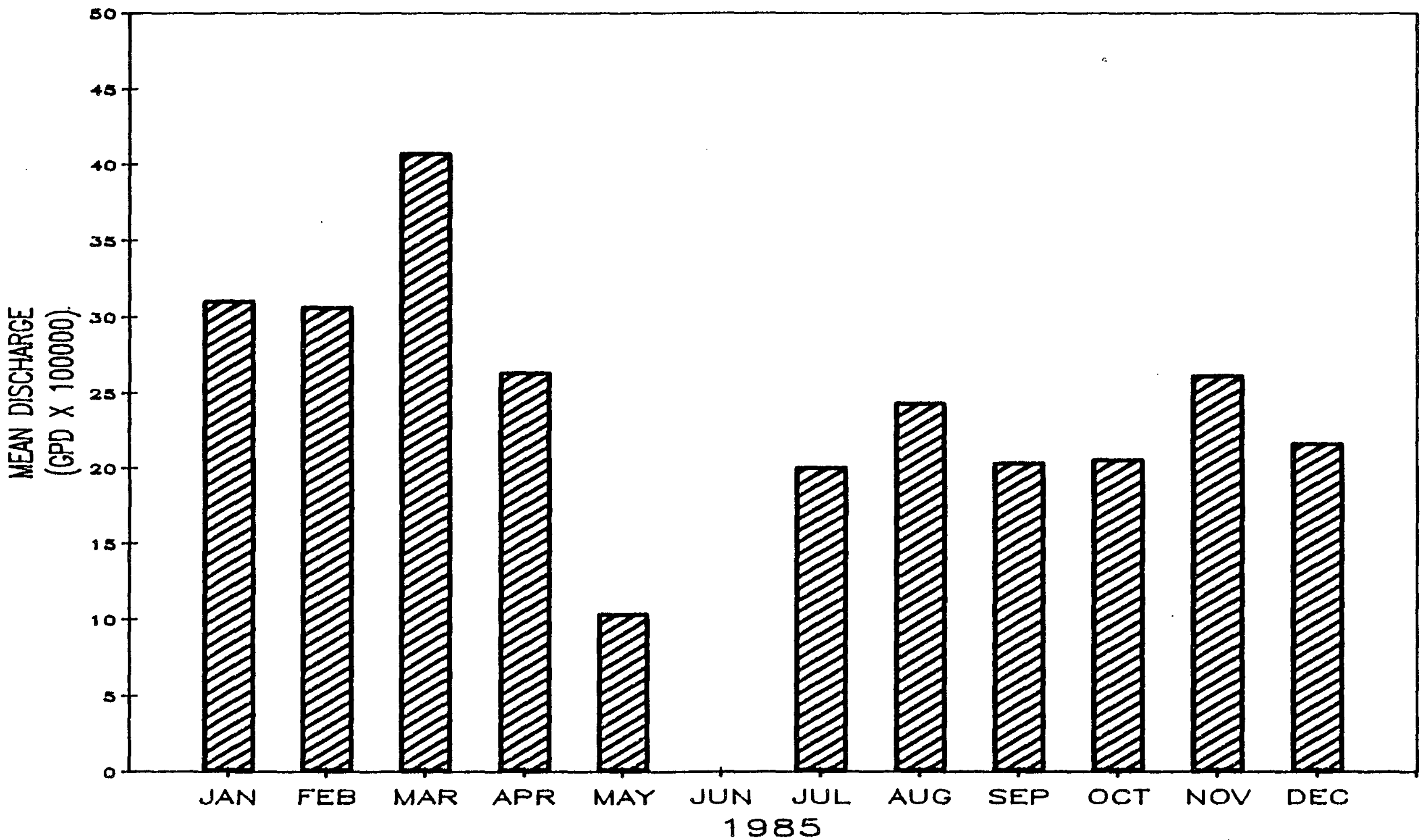

Figure 1-2. WNP-2 Monthly Mean Discharge for January - December 1985

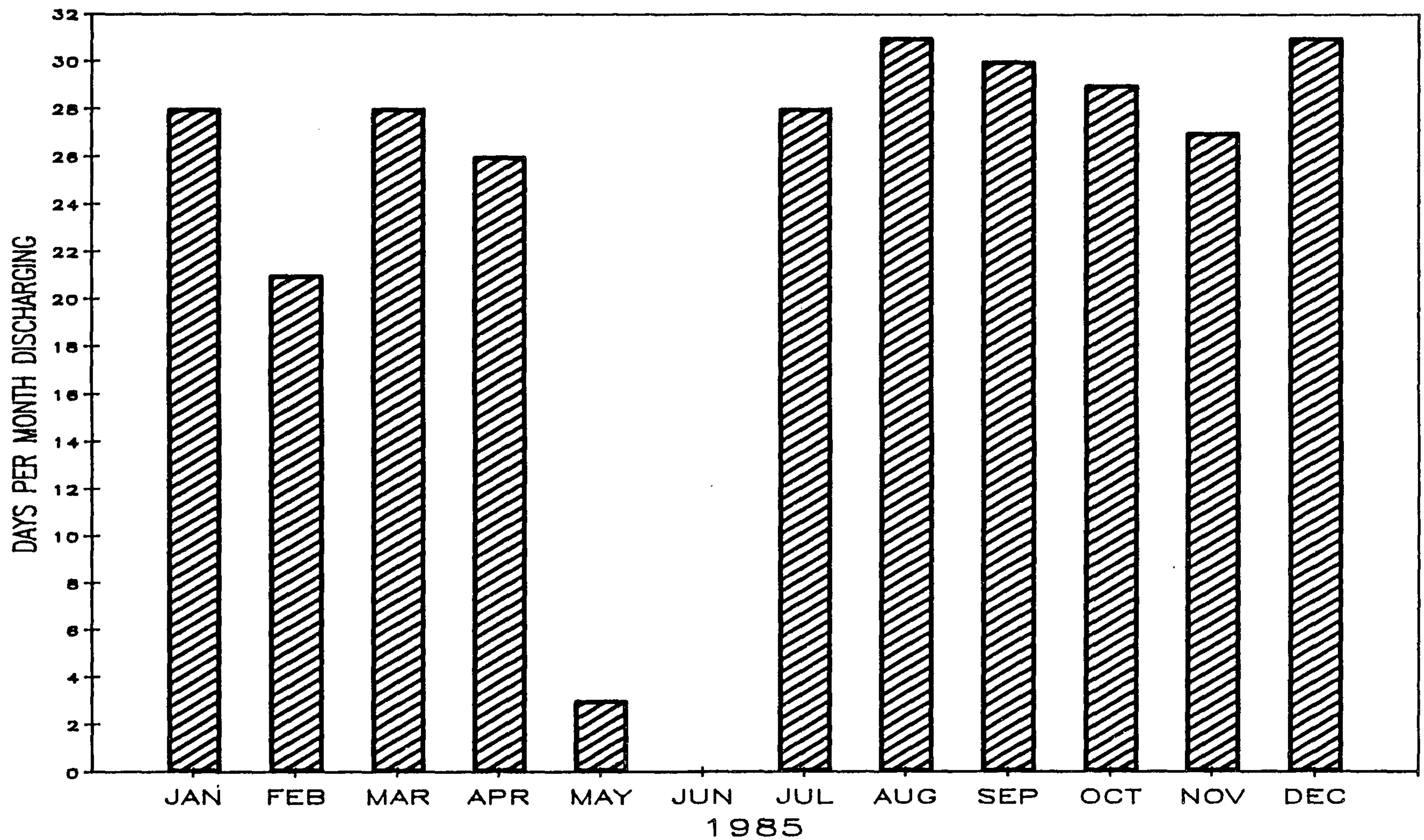

Figure 1-3. WNP-2 Numbers of Days Per Month Discharging for January - December 1985

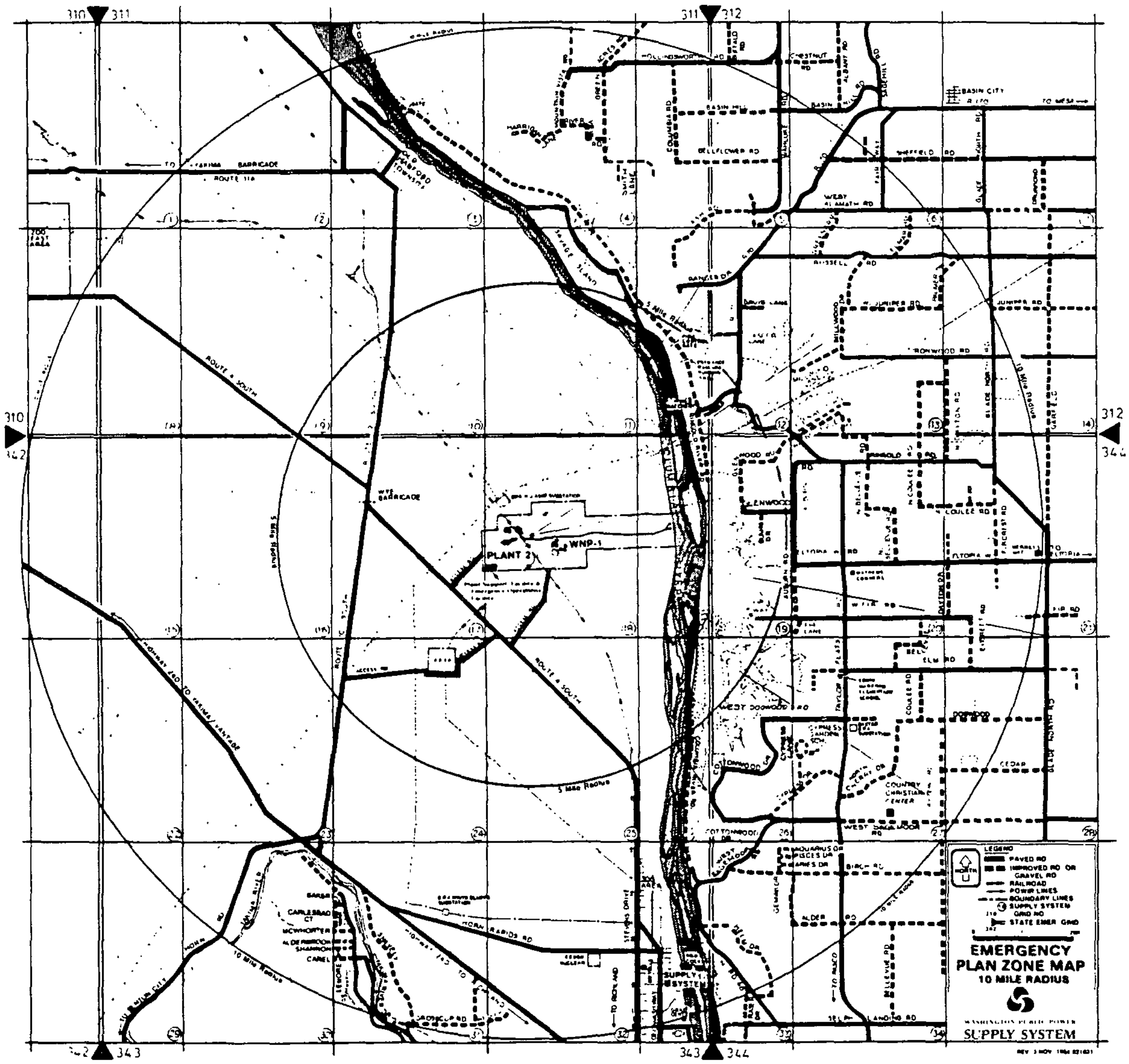

Figure 1-4. WNP-2 Location Map

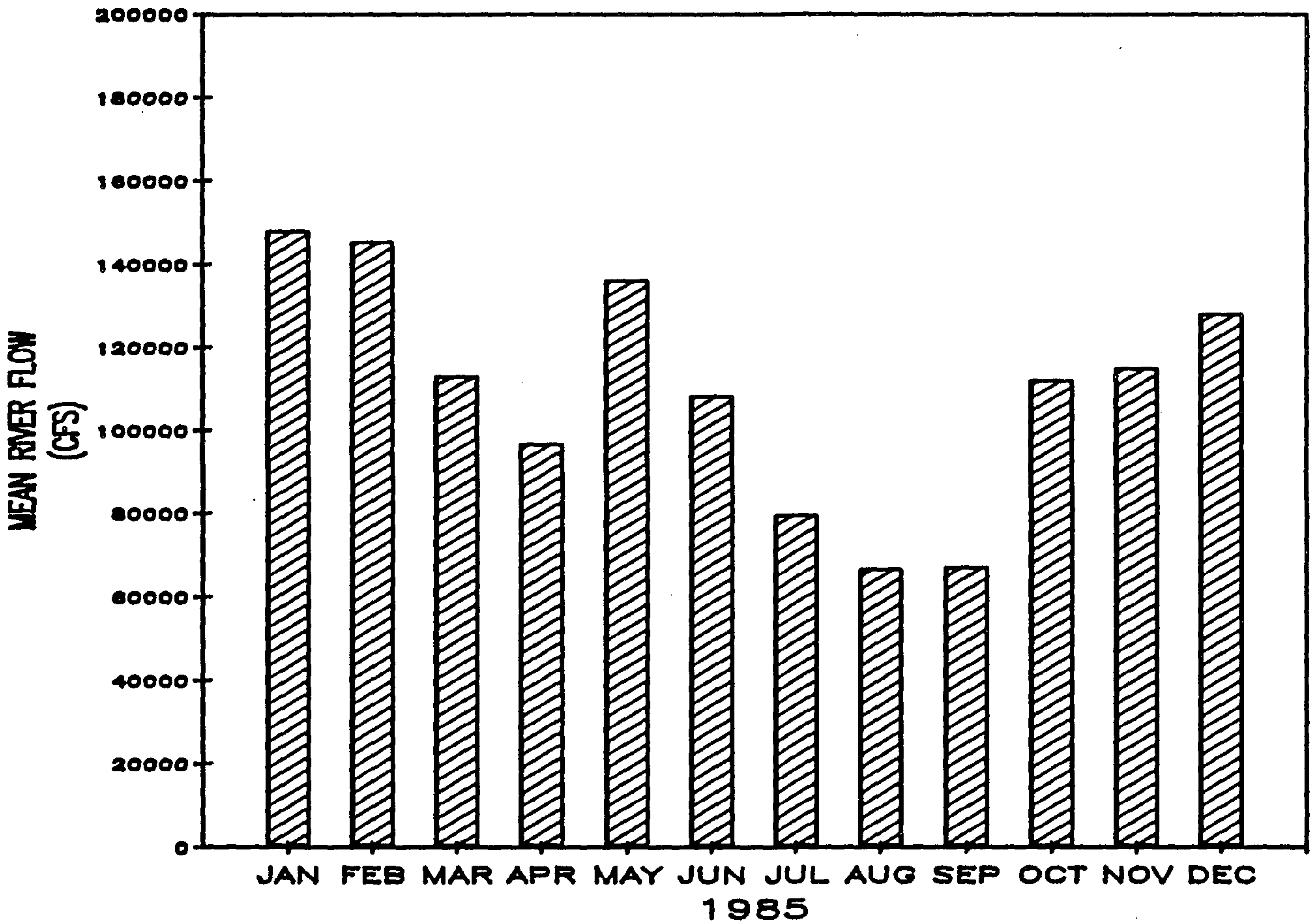

Figure 1-5. Columbia River Mean Monthly Flow for 1985

2.0 BENTHIC MACROFAUNA

2.1 INTRODUCTION

Benthic macrofauna are among the most susceptible Columbia River organisms monitored with respect to possible impacts from WNP-2 discharges. Sensitivity to chemical and thermal stress and a life cycle with limited mobility enable these organisms to serve as excellent monitors of environmental perturbations (EPA 1971). Benthos populations have been measured in the Columbia River's Hanford Reach from 1974 to the present. This study was designed to detect changes within the benthic community which may result from operation of WNP-2. This report covers the period September 1984 to September 1985.

2.2 MATERIALS AND METHODS

The artifical substrate method of collecting benthos was continued to be consistent with preoperational studies conducted since January 1975. This method incorporates a nickel-chrome plated wire basket (Figure 2-1) covering 412.9 cm^2 (64 in) of the river bottom. Each basket sampler contained 14 smooth river rocks measuring between 5.08 cm and 7.62 cm (2 to 3 inches) in diameter. Eight stations (Figure 2-2) were sampled with 3 replicates placed at each station (Figure 2-3). The baskets were retrieved by SCUBA divers after three months of incubation. Each basket was carefully placed in a 600 micron mesh bag before it was returned to the surface.

Samples were iced, transported to the Ecological laboratory, where rocks, bags and baskets were brushed, cleaned and rinsed into a 600 micron (U.S. #30 sieve) sieving bucket. Sieved contents were stained with Rose Bengal and then preserved with alcohol. Samples were identified to taxonomic categories (see Table 2-2) using Pennak, 1978; Merritt, 1978; and Ward, 1959. Samples were enumerated and weighted (blotted wet weight) to 0.1 mg. A quality assurance evaluation was performed on 10% of the samples with rotation among sample processors. Detailed procedures are incorporated into the Environmental Programs Instruction Manual (EPI 13-2.2 and EPI 13-2.4).

Data analysis included density, and biomass calculations for individual taxa. Statistical analyses included Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT).

The identification of organisms was carried to a lower level than practiced by past consultants. To standardize taxonomic classifications (i.e., Lithoglyphus/Fluminicola and Lanx/Fisherola) the EPA Bio-Storet Master List of Aquatic Organisms was used (Weber, 1983).

2.3 RESULTS AND DISCUSSION

A listing of all organisms identified including enumerations and biomass is presented in Table 2-2. Simulidae larvae dropped about 7 positions in the total count column of Table 2-2 while Oligochaetes increased by a similar number. Basically these two taxa exchanged positions. All other taxa generally retained their respective positions. The total of organisms enumerated and their biomass increased 145%, and 141%, respectively over the 1984 report period. The increases in abundance and biomass (Tables 2-3 and 2-4) may be due to thermal differences between sample years. Winter, Spring and Summer sample quarters river temperatures ranged 1 to 4°C below 1984 while Fall quarter 1985 was higher (0.5 to 2.0°C).

The centerline stations (1, 7M, 11M, and 8) density and biomass values for 1984 and 1985 sample years are presented in Figures 2-4, 2-5, 2-6, and 2-7. Stations 7M and 11M appear to be higher (density and biomass) more often than the control station in 1985 as compared to 1984.

In order to further explore these differences, one-way ANOVAS were conducted on total density and total biomass by station for each season (Table 2-5). Results of the ANOVA indicate whether or not there is a statistically significant difference between any of the stations. Duncan's multiple range test was then used to identify which stations differed (Table 2-6). There does not appear to be any indication that treatment and the upstream control stations differ in a predictable pattern. The downstream control (Station 8) continues to have a typically high density and biomass relative to other stations.

The analysis was continued to an expanded group of selected taxa (Table 2-7). The Duncan's multiple range test on this data is presented in Table 2-8 and 2-9. A comparison of each stations ranking in Table 2-8 and 2-9 was conducted and Station 1 was consistently lower than Stations 7M and 11M. In no situation was Station 1 significantly different from both 7M and 11M.

Density and biomass flucuations and possible natural causes were discussed in the 1984 report. Additional conditions possibly impacting the changes observed are staggered hatching times for some taxa, more than one generation per sample year and pupating times fluctuating due temperature changes. It appears that the discharge from WNP-2 did not measurably affect benthic macrofauna.

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Table 2-1. Macro Benthos Program Sampling Periods

Period	Date	Number of Days Exposed
Fall 1984	September 5 to December 10	96
Winter 1985	December 10 to March 11	90
Spring 1985	March 11 to June 4	85
Summer 1985	June 4 to September 4	92

Table 2-2. Total Counts and Weights of all Organisms Collected from September 1984 to September 1985

Taxa Lifestage	Number	Grams
Caddisfly-Hydropsychidae, Larvae	73239	377.6
Midges-Chironomidae, Larvae	62315	20.3
Midges-Chironomidae, Pupae	38356	24.9
Snail-Fluminicola, Adult	4873	111.7
Oligochaeta, Adult	4684	0.4
Mayfly-Baetidae, Nympth	3245	3.1
Caddisfly-Leptoceridae, Larvae	2926	5.9
Mayfly-Ephemerellidae, Nymph	2165	6.2
Caddisfly-Hydropsychidae, Pupae	1639	20.2
Caddisfly-Hydroptilidae, Larvae	1523	0.5
Blackfly-Simulidae, Larvae	1316	3.5
Blackfly-Simulidae, Pupae	1185	3.5
Snail-Parapholyx, Adult	1044	14.0
Caddisfly-Psychomyiidae, Larvae	892	0.9
Snail-Fisherola, Adult	806	23.4
Mites, Adult	306	0.1
Caddisfly-Hydroptilidae, Pupae	241	0.1
Mayfly-Tricorythidae, Nympth	173	0.2
Midges-Chironomidae, Adult	135	0.1
Clam-Bivalvia, Adult	111	0.7
Moth-Pyralidae, Larvae	109	0.3
Caddisfly-Glossosomatidae, Larvae	109	0.1
Mollusc, Adult	107	0.3
Mayfly-General, Nymph	79	0.5
Mayfly-Heptagenidae, Nympth	79	(1)
Snail-Physa, Adult	47	2.3
Snail-Lymnaea, Adult	39	7.7
Flat-worm, Adult	38	(1)
Caddisfly-Psychomyiidae, Pupae	37	0.1
Blackfly-Simulidae, Adult	23	(1)
Mites, Larvae	8	(1)
Caddisfly-Psychomiidae, Adult	7	(1)
Caddisfly-General, Pupae	7	0.1
Caddisfly-Hydropsychidae, Adult	6	0.1
Snail-Fisherola, Pupae	4	0.3
Scuds/Shrimps, Adult	3	(1)
Mayfly-Baetidae, Adult	2	(1)
Caddisfly-Glossosomatidae, Pupae	2	(1)
Mayfly-General, Adult	1	0.1
Caddisfly-Rhyacophilidae, Larvae	1	(1)
Unidentified	-	5.1
Round-Worm	-	-
TOTAL	201,881	634.3

(1) = Less than 0.1 grams

Table 2-3. Density of Benthic Macrofauna by Sample Quarter and Station

Season/Station	Sum(1)	Mean	Std. Dev.
Fall 84	1315798	54825	19201.8283
Station 1	157921	52574	14566.0143
Station 7W	120737	40246	867.4902
Station 7M	172567	57522	13782.3256
Station 7E	112696	37565	3517.8706
Station 11W	206160	68720	14318.2274
Station 11M	156703	52234	2572.0064
Station 11E	125823	41941	9188.3434
Station 8	263393	87798	23773.8671
Winter 85	64957	2707	1188.1048
Station 1	3221	1074	386.1434
Station 7W	10754	3585	1357.0475
Station 7M	6709	2236	402.6412
Station 7E	10826	3609	705.8387
Station 11W	9446	3149	349.3224
Station 11M	4214	1405	396.5315
Station 11E	9325	3108	1307.9135
Station 8	10463	3488	944.6077
Spring 85	417843	17410	6005.8145
Station 1	50378	16793	4598.5426
Station 7W	44613	14871	2079.5209
Station 7M	39793	13264	1858.1860
Station 7E	38413	12804	1303.3696
Station 11W	65854	21951	4126.5974
Station 11M	47181	15727	2942.7084
Station 11E	44928	14976	730.8552
Station 8	86683	28894	6943.1617
Summer 85	3114956	129790	44974.7777
Station 1	393599	131200	33349.2926
Station 7W	404829	134933	13475.3198
Station 7M	480549	160183	60109.5655
Station 7E	293296	97765	29928.1201
Station 11W	407380	135793	11120.9493
Station 11M	578285	192762	34885.0267
Station 11E	359158	119719	23394.7221
Station 8	228200(2)	76067	7786

(1)Number of organisms/m^2
(2)Number estimated from 2 replicates.

Table 2-4. Biomass of Benthic Macrofauna by Sample Period and Station

Season/Station	Sum(g/m²)	Mean	Std. Dev.
Fall 84	5791	241	117.0517
Station 1	438	146	33.3057
Station 7W	559	186	18.2961
Station 7M	1010	337	217.0328
Station 7E	489	163	30.4987
Station 11W	855	285	162.1643
Station 11M	806	269	45.6318
Station 11E	863	288	119.8828
Station 8	769	256	129.1972
Winter 85	460	19	19.0768
Station 1	12	4	1.9755
Station 7W	121	40	24.0312
Station 7M	30	10	3.9885
Station 7E	104	35	19.5620
Station 11W	61	35	5.2240
Station 11M	11	4	2.2612
Station 11E	104	35	26.1869
Station 8	18	6	1.3892
Spring 85	3411	142	63.8287
Station 1	428	143	76.7900
Station 7W	557	186	27.8748
Station 7M	280	93	41.3314
Station 7E	577	192	114.9634
Station 11W	558	186	60.3587
Station 11M	292	87	11.3356
Station 11E	405	135	51.9267
Station 8	314	105	22.1606
Summer 85	5698	237	107.4568
Station 1	543	181	119.4711
Station 7W	861	287	59.7071
Station 7M	899	300	190.3071
Station 7E	589	196	42.8842
Station 11W	929	310	68.8297
Station 11M	966	322	34.3557
Station 11E	614	205	72.1913
Station 8	306(1)	1027	8

(1)Weight estimated from 2 replicates.

Table 2-5. Summary of One-Way ANOVA of Station Density or Biomass Versus Season

Period	Density		Biomass	
	F	P(F)	F	P(F)
Fall 84	5.307	0.0028(1)	1.021	0.4538
Winter 85	4.420	0.0066	3.341	0.0216
Spring 85	6.739	0.0008	1.464	0.2486
Summer 85	3.290	0.0251	1.751	0.1715

(1)Probabilities which imply significant differences exist between stations are underlined (ALPHA = 0.05).

Table 2-6. Summary of Duncans Multiple Range Test on Seasons With Significant Between Station Density or Biomass Differences (Alpha = 0.05)

Density								
Fall	7E	7W	11E	11M	1	7M	11W	8
Winter	1	11M	7M	11E	11W	8	7W	7E
Spring	7E	7M	7W	11E	11M	1	11W	8
Summer	8	7E	11E	1	7W	11W	7M	11M
Biomass								
Winter	11M	1	8	7M	11W	7E	11E	7W

(1) Stations are listed in ascending order by size from left to right.

(2) Seasons not shown have had no significant differences.

Table 2-7. Summary of One-Way ANOVA for Selected Taxa Comparing Stations (Alpha = 0.05)

	Density		Biomass	
	F	P(F)	F	P(F)
Hydropsychidae larvae				
Fall	4.714	0.0049	1.069	0.4259
Winter	0.959	0.4914	2.460	0.0645
Spring	1.063	0.4291	1.772	0.1625
Summer	2.508	0.0640	1.192	0.3642
Hydropsychidae (All)				
Fall	4.721	0.0049	1.070	0.4256
Winter	1.022	0.4530	1.207	0.3870
Spring	1.082	0.4188	1.564	0.2165
Summer	2.357	0.0774	1.103	0.4097
Chironomidae larvae				
Fall	2.390	0.0706	2.181	0.0932
Winter	2.077	0.1071	2.364	0.0730
Spring	4.877	0.0042	3.825	0.0125
Summer	3.222	0.0271	1.543	0.2270
Chironomidae pupae				
Fall	1.098	0.4099	1.187	0.3638
Winter	6.070	0.0014	11.913	0.0000
Spring	1.337	0.2964	1.202	0.3562
Summer	3.876	0.0132	3.483	0.0202
Chironomidae (All)				
Fall	2.371	0.0724	0.843	0.5401
Winter	3.275	0.0234	1.354	0.3078
Spring	2.562	0.0565	1.617	0.2101
Summer	3.932	0.0124	4.828	0.0051
Fluminicola (All)				
Fall	8.215	0.0003	11.223	0.0000
Winter	2.971	0.0337	2.884	0.0376
Spring	2.881	0.0377	2.657	0.0500
Summer	6.115	0.0016	3.841	0.0137
Mollusca (All)				
Fall	6.615	0.0009	5.503	0.0028
Winter	0.765	0.6154	0.826	0.5774
Spring	3.367	0.0210	3.284	0.0231
Summer	9.291	0.0002	1.326	0.3043

Table 2-8. Summary of Duncans Multiple Range Test on Taxa with Significant between Station Density Differences (Alpha = 0.05) (1, 2)

Hydropsychidae Larvae								
Fall	7E	7W	11E	1	11M	7M	11W	8
Hydropsychidae (All)								
Fall	7E	7W	11E	1	11M	7M	11W	8
Chironomidae Larvae								
Spring	11E	1	7W	7E	11M	7M	11W	8
Summer	8	7E	11W	7W	11E	1	7M	11M
Chironomidae Pupae								
Winter	1	11M	11E	11W	7W	7M	7E	8
Summer	8	7E	11W	7W	11E	1	7M	11M
Chironomidae (All)								
Winter	1	11M	7M	11W	7W	11E	7E	8
Summer	8	7E	11W	7W	11E	1	7M	11M
Fluminicola (All)								
Fall	1	8	11M	7M	11W	7E	11E	7W
Winter	11M	8	1	7M	7E	11W	7W	11E
Spring	1	8	11M	7M	11E	7E	11W	7W
Summer	1	8	11M	11E	7M	7W	11W	7E
Mollusca (All)								
Fall	1	8	11M	7M	11W	11E	7E	7W
Spring	1	8	11M	7M	11E	11W	7E	7W
Summer	1	11M	11E	7M	8	11W	7W	7E

(1) Stations are listed in ascending order by size from left to right.
(2) Seasons not shown have had no significant differences.

Table 2-9. Summary of Duncans Multiple Range Test on Taxa with Significant between Station Biomass Differences (Alpha = 0.05) (1, 2)

Chironomidae Larvae								
Spring	7E	11E	7M	1	11M	7W	11W	8
Chironomidae Pupae								
Winter	1	11M	11E	7M	11W	7W	7E	8
Summer	8	7E	11E	1	7M	11W	7W	11M
Chironomidae (All)								
Summer	8	7E	11E	1	11W	7M	7W	11M
Fluminicola								
Fall	1	8	11M	7M	7W	7E	11W	11E
Winter	11M	8	1	7M	7E	11W	7W	11E
Spring	1	8	11M	7M	11E	7E	11W	7W
Summer	1	8	11E	11M	7E	7M	7W	11W
Mollusca (All)								
Fall	1	8	11M	7M	11W	7W	7E	11E
Spring	1	8	7M	11M	11E	11W	7W	7E

(1) Stations are listed in ascending order by size from left to right.
(2) Seasons not shown have had no significant differences.

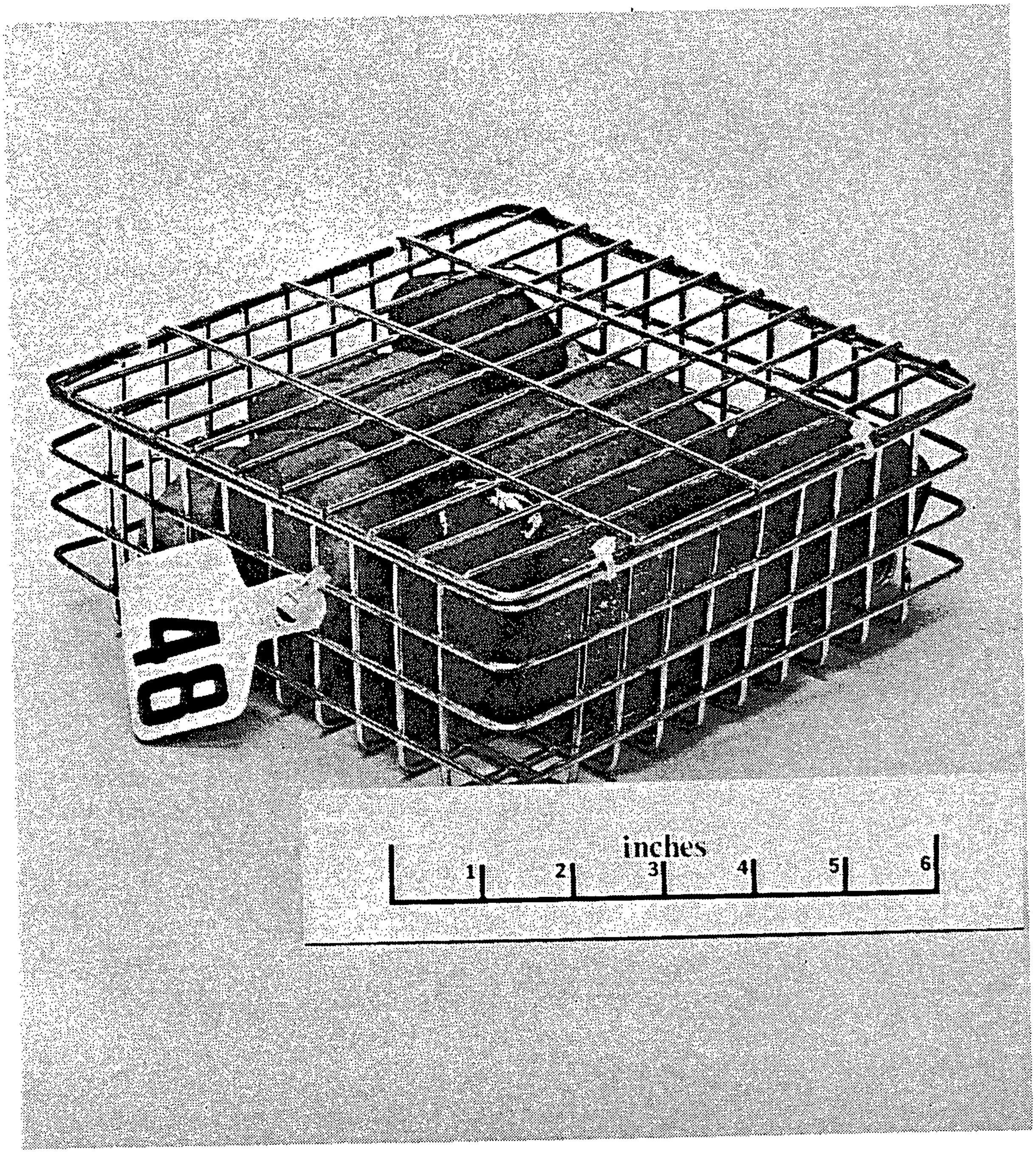

Figure 2-1. Sampler Used to Collect Benthic Macrofauna in Columbia River

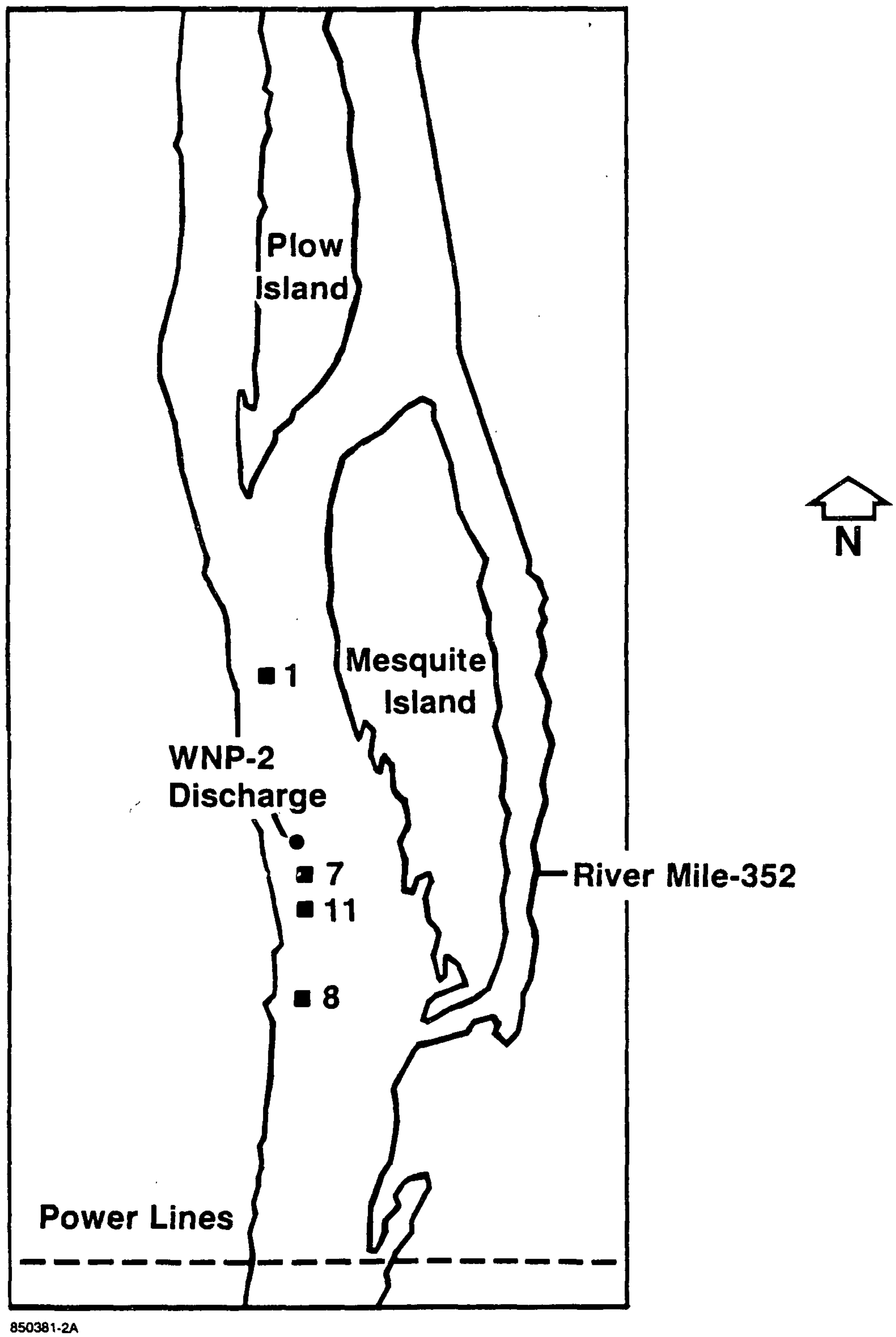

Figure 2-2. Location of Sampling Stations in the Columbia River

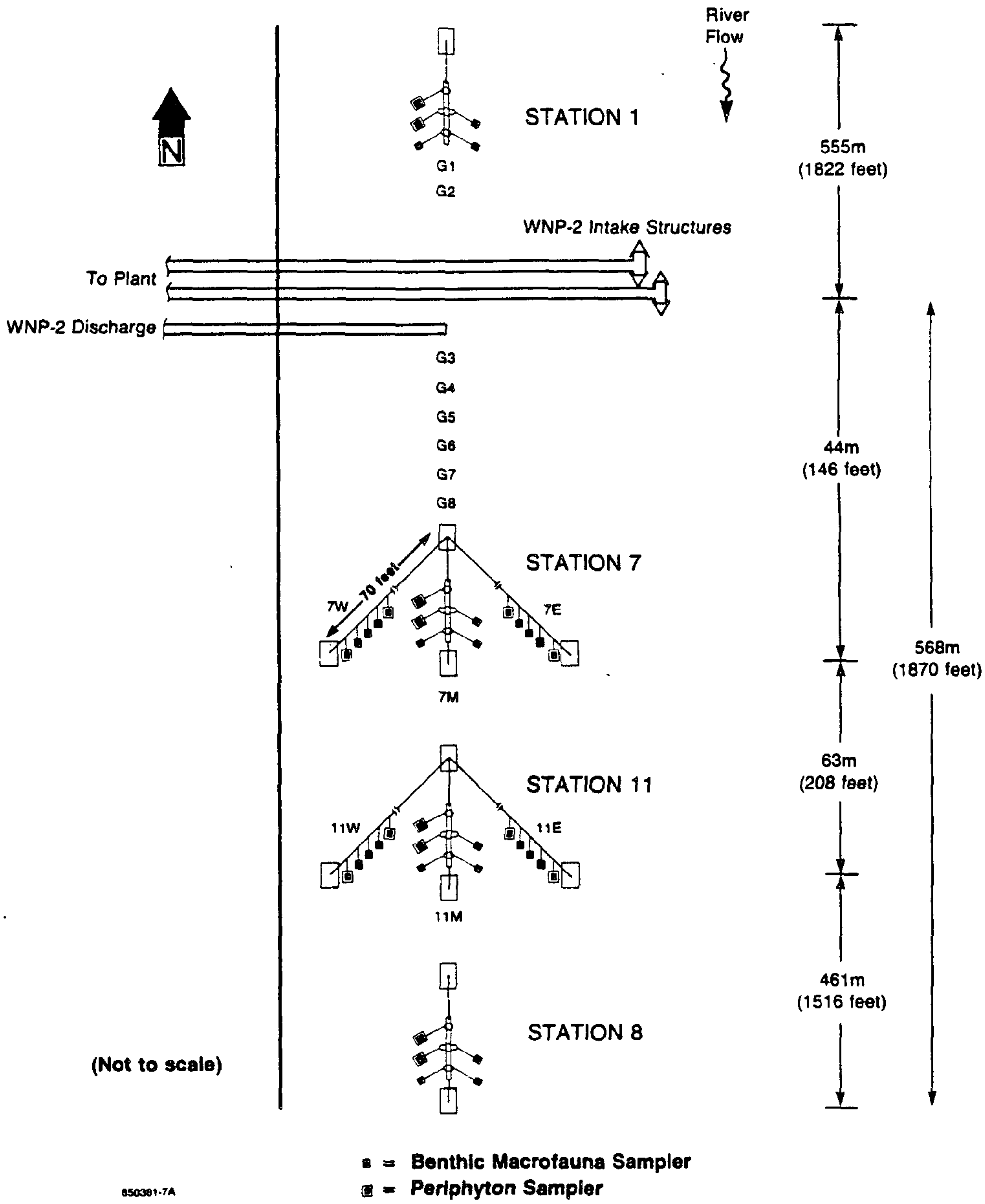

Figure 2-3. Diagrammatic Representation of the Aquatic Sampling Stations in the Columbia River

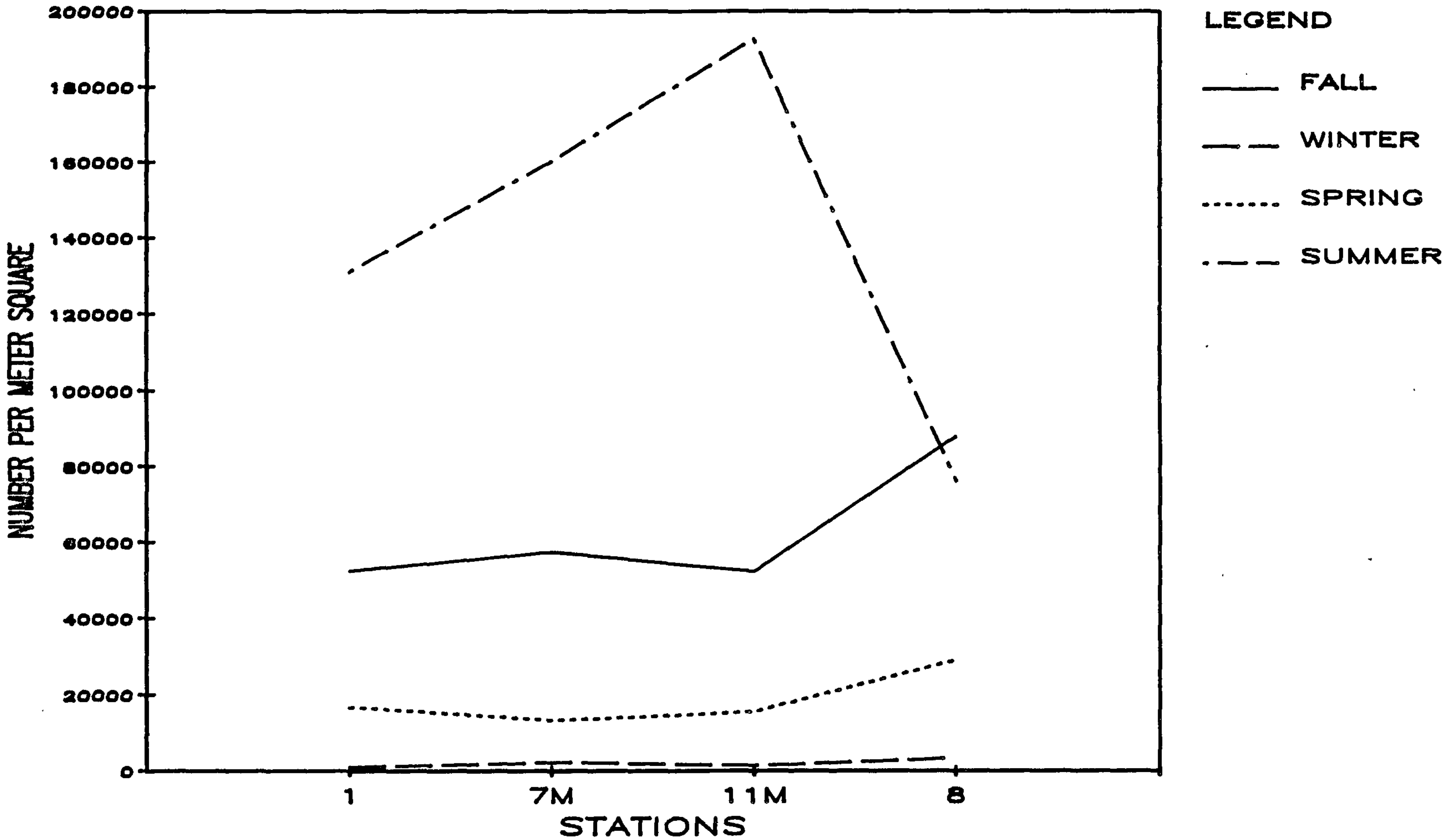

Figure 2-4. Benthos Total Density at Centerline Stations 1985

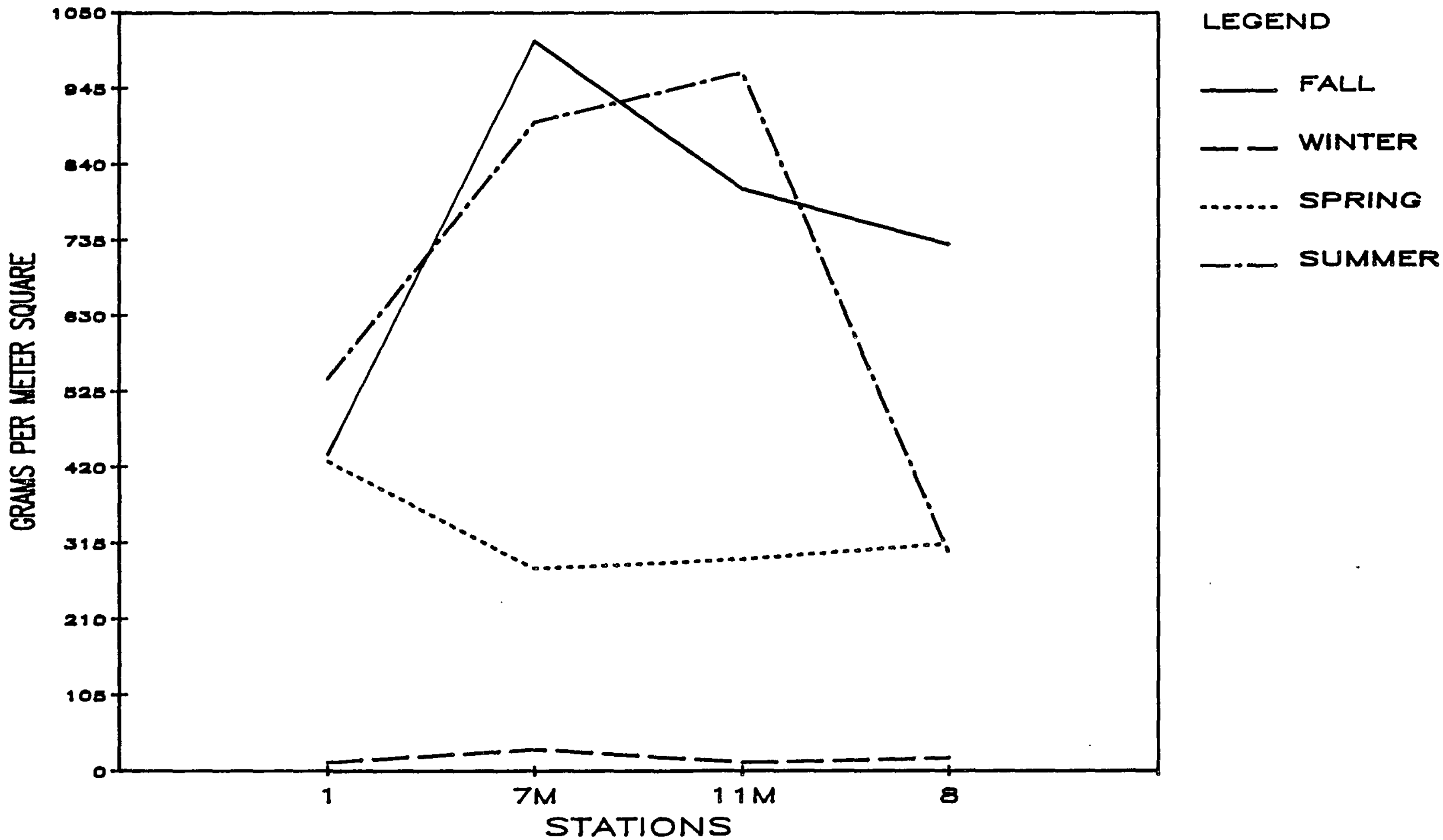

Figure 2-5. Benthos Total Biomass at Centerline Stations
1985

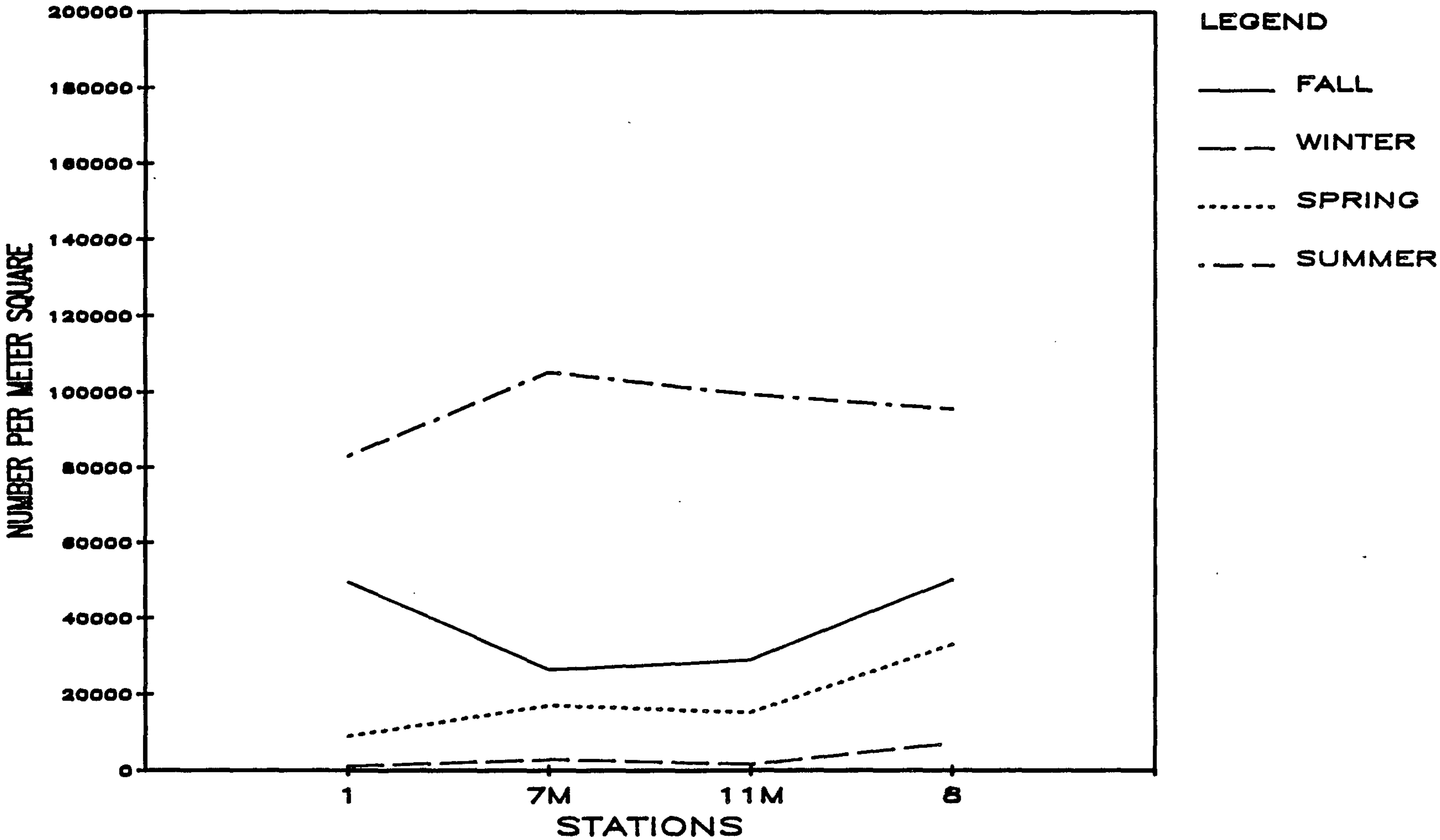

Figure 2-6. Benthos Total Density at Centerline Stations
1984

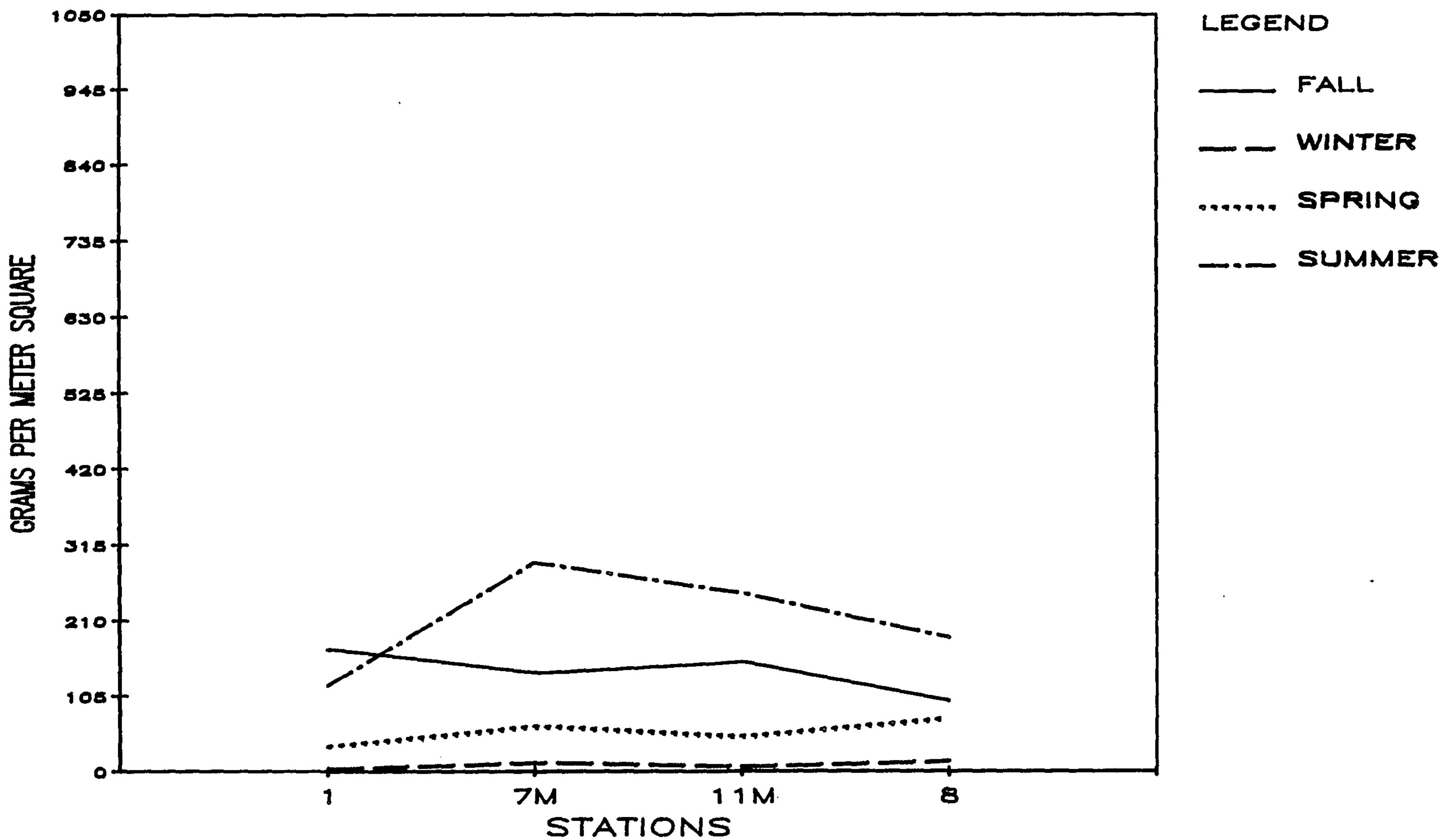

Figure 2-7. Benthos Total Biomass at Centerline Stations 1984

3.0 PERIPHYTON

3.1 INTRODUCTION

Periphyton can be a useful biological indicator of water quality because it forms a vital link in the aquatic food chain and is sensitive to thermal and chemical discharges (APHA, 1985). Because periphyton is attached to the substrate, any impact that occurs tends to be largest at its source and smaller as distance from the source increases, making the cause more easily identifiable. Periphyton were sampled near WNP-2 from 1977 to 1980 in studies that preceded those reported on in this section.

During preoperational sampling, diatoms dominated the benthic microflora in the Columbia River near WNP-2 due to favorable environmental conditions including cool water temperatures (Patrick, 1969). Elevated temperatures from power plant discharge could change this balance causing increased periphyton biomass, reduced species diversity, or changed species composition (e.g. Patrick, 1969; Cairns, 1956; Owens, 1971; Coutant and Owens, 1970). However, a study of the thermal tolerance of Columbia River periphyton indicated that an increase of as much as 10°C above ambient river temperature significantly changed (increased) biomass only during a short period in winter with the domination of diatoms persisting (Owens, 1971). Total residual chlorine concentrations of near 0.1 ppm, as in the discharge, can also affect periphyton by reducing growth (Brungs, 1976), but dilution of discharge water in the mixing zone rapidly lowers the concentration to levels that should not be harmful. Mixing also quickly reduces elevated temperatures (Section 10, this report).

3.2 MATERIALS AND METHODS

Periphyton samples were collected from the Columbia River in the vicinity of WNP-2 from December 1984 to December 1985. Two groups of stations were sampled. Eight stations used in earlier preoperational studies were sampled on a quarterly basis (Table 3-1). They will be referred to as the core program and are situated such that one is 555m upstream of the WNP-2 discharge port, six others are spaced over the length and breadth of the discharge plume, and another is 568m downstream of the discharge port, beyond the plume influence (Figure 2-3). Quarters will represent seasons as follows: December-February= Winter, March-May=Spring, June-August=Summer, September-November=Fall.

Because the impact of WNP-2 on the aquatic environment is expected to be small, six additional stations were established close to the discharge port. During 1985, a new station, G4A, was located between Station G3 and G4 as a result of concerns that G4, which is on top of an anchor, may be atypical. They will be referred to as the gradient program and are situated at 20-ft intervals along the discharge plume centerline, beginning at the discharge port and extending downstream 100 ft (Figure 2-3). These stations will be exposed to a gradient of thermal and chemical conditions resulting from the spreading and mixing of the discharge plume. Two control stations, 20 ft apart, were established near core Station 1. Samples were collected every six weeks to provide a large sample size and thorough seasonal coverage (Table 3-1) except that extreme environmental conditions prevented the normal replacement of early winter samples. Gradient program sampling periods will be referred to as early or late portions of seasons, e.g. early winter or late winter.

Sampling and analysis methods were the same for the core and gradient programs. Samples were collected using glass slide diatometers which were set out and retrieved by SCUBA divers (Figure 3-1). Two replicate diatometers were located at each station. Two methods of analyzing the diatometers were used during 1985 to allow a side-by-side comparison of the historical and a new technique. With the historical technique, two slides from each diatometer had the insects picked off with tweasers and the periphyton scraped into crucibles for determination of total organic matter (TOM). Two additional slides were preserved in case determination of species composition is required at a later date. Crucibles were dried at 105°C until a constant weight had been reached, ashed for one hour at 500°C, rewet, and dried to constant weight again at 105°C. TOM was the calculated difference between dry weight and ashed weight. Surveillance reweighings were performed on at least 10 percent of the crucibles from each sampling date.

The second method takes advantage of new instrumentation which directly measures total carbon (TC) on or in a sample. Two slides from each periphytometer were picked free of insects as in the historical technique. The slides were then air dried and total carbon was directly read out from the surface carbon determinator. For more information on the TC method, see Davis (1986).

3.3 RESULTS AND DISCUSSION

Mean periphyton biomass at core program stations ranged from 0.91 g TOM or 0.38 g TC/m^2 at Station 11M during the spring to 4.07 g TOM or 1.91 g TC/m^2 at Station 7W during the winter (Table 3-2). The general seasonal pattern was for stations to have the highest biomass in the winter followed by a low biomass in the spring. The biomass during the summer and fall were generally between these two extremes (Figures 3-2 and 3-3).

A one-way analysis of variance (ANOVA) was performed on each season's data to determine whether or not there were any significant between-station differences in biomass. In all cases for both measurement techniques the hypothesis of a homogeneous density was rejected at the 0.05 level.

From the ANOVA, it is known that there are station differences. A Duncan's Multiple Range Test was performed on each of the data sets to determine which stations are different (Table 3-3). As in previous years, Station 1 stands out as having a consistently low biomass while Stations 8 and 11W tend to have higher than average values.

Mean periphyton TOM at gradient program stations ranged from 0.19 g/m^2 at Station G3 during the late fall to 2.26 g/m^2 at Station G8 during the early spring (winter samples excluded because of a three-month soak period). Similarly, mean TC ranged from 0.16 g/m^2 at Station G3 during the early fall to 1.70 g/m^2 at Station G8 during the early spring (Table 3-2 and Figures 3-4 and 3-5). Except for the late summer TOM samples, all periods exhibited significant between-station differences when analyzed with a one-way ANOVA at the 0.05 level. Results of the Duncan's Multiple Range Tests on these data are presented in Table 3-4.

Any change in periphyton biomass due to operation of WNP-2's discharge will be most significant at Station G3 which is only about two feet downstream and at Stations 4A and 4 which are the stations next closest to the discharge. All three of these stations were consistently typical of the gradient stations and showed no propensity to unusual readings. This is consistent with the findings of previous years. The only stations which did seem to have atypical trends were G1 and G2. These two stations have historically exhibited a below average biomass and, consequently, the observation is expected.

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Table 3-1. Periphyton Core and Gradient Program Sample Periods

Program	Sampling Period[1]	Period Name
Core	December 12, 1984 - March 11, 1985	Winter
	March 11 - June 4, 1985	Spring
	June 4 - September 3, 1985	Summer
	September 3 - December 2, 1985	Fall
Gradient	December 12, 1984 - March 11, 1985	Winter
	March 11 - April 22, 1985	Early Spring
	April 22 - June 4, 1985	Late Spring
	June 3 - July 16, 1985	Early Summer
	July 15 - September 4, 1985	Late Summer
	September 4 - October 21, 1985	Early Fall
	October 21 - December 2, 1985	Late Fall

(1)Actual time for sample collection frequently took several days. As a result, an individual sample may have been collected 1-2 days before or after the listed date.

Table 3-2. Mean Periphyton Density (g/m^2) by Season, Station, Subprogram, and Analytical Technique

Total Organic Matter Technique

A) Core Program

Season	Station 1	7W	7M	7E	11W	11M	11E	8	Average
Winter	1.54	4.07	3.02	3.43	3.58	3.28	3.34	3.82	3.26
Spring	1.81	1.16	1.02	0.96	2.16	0.91	1.11	1.75	1.36
Summer	1.12	1.79	2.06	1.66	2.94	1.85	1.48	2.73	1.95
Fall	0.97	2.79	1.46	1.72	2.45	1.96	1.94	2.31	1.95
Average	1.36	2.45	1.89	1.94	2.78	2.00	1.97	2.65	2.13

B) Gradient Program

Season	Station G1	G2	G3	G3A	G4	G5	G6	G7	G8	Average
Early Winter										
Late Winter	0.79	0.71	3.71	1.88	1.58	2.16	2.37	2.76	2.80	2.08
Early Spring	0.96	0.31	1.25	0.32	1.13	2.21	1.95	0.97	2.26	1.26
Late Spring	0.43	0.32	0.50	0.61	0.60	0.41	0.37	0.27	0.53	0.45
Early Summer	0.95		0.64						2.11	1.23
Late Summer	1.40	1.22	1.20	1.13	1.31	1.27	1.08	1.17	1.16	1.18
Early Fall	0.74	0.96	0.99	1.24	1.02	1.40	1.34	1.30	1.72	1.19
Late Fall	0.37	0.37	0.19	0.34	0.24	0.45	0.29	0.55	0.71	0.39
Average	0.71	0.64	0.83	0.73	0.86	1.15	1.01	0.85	1.28	0.89

Table 3-2 (cont.). Mean Periphyton Density (g/m^2) by Season, Station Subprogram, and Analytical Technique

Total Carbon Technique

A) Core Program

Season	Station: 1	7W	7M	7E	11W	11M	11E	8	Average
Winter	0.80	1.91	1.84	2.14	2.05	0.95	2.01	2.06	1.72
Spring	1.06	0.65	0.49	0.63	1.00	0.38	0.59	1.01	0.73
Summer	0.65	0.84	0.94	0.86	1.24	1.02	0.84	1.27	0.96
Fall	0.54	1.49	0.96	1.02	1.61	1.17	1.10	1.18	1.13
Average	0.76	1.22	1.06	1.16	1.48	0.88	1.14	1.38	1.13

B) Gradient Program

Season	Station: G1	G2	G3	G3A	G4	G5	G6	G7	G8	Average
Early Winter										
Late Winter	0.74	0.61	1.87	0.97	1.09	2.13	2.10	1.73		1.41
Early Spring	0.74		0.68	0.88	0.74	1.46	0.98	1.12	1.70	1.04
Late Spring	0.26	0.15	0.33	0.27	0.21	0.28	0.26	0.31	0.34	0.27
Early Summer	0.54	0.42	0.47	0.49	0.29	0.37	0.58	0.32	0.46	0.44
Late Summer	0.47	0.56	0.57	0.60	0.66	0.71	0.59	0.55	0.59	0.59
Early Fall	0.25	0.18	0.16	0.27	0.21	0.63	0.23	0.39	0.39	0.30
Late Fall	0.44	0.58	0.75	0.78	0.82	0.86	1.00	0.78	1.09	0.79
Average	0.45	0.38	0.49	0.55	0.49	0.72	0.61	0.58	0.76	0.57

Table 3-3. Significant Station Differences in the 1985 Periphyton Core Program as Determined by Duncan's Multiple Range Test[1]

Total Organic Matter								
Winter	1	7M	11M	11E	7E	11W	8	7W
Spring	11M	7E	7M	11E	7W	8	1	11W
Summer	1	11E	7E	7W	11M	7M	8	11W
Fall	1	7M	7E	11E	11M	8	11W	7W
Total Carbon								
Winter	1	11M	7M	7W	11E	11W	8	7E
Spring	11M	7M	11E	7E	7W	11W	8	1
Summer	1	7W	11E	7E	7M	11M	11W	8
Summer	1	7M	7E	11E	11M	8	7W	11W

(1) Stations are ranked from low to high. The bars identify groups with means which do not differ significantly at the 0.05 level.

Table 3-4. Significant Station Differences in the 1985 Periphyton Gradient Program as Determined by Duncan's Multiple Range Test

Start Date									
Total Organic Matter									
Dec 12[1]	2	1	4	4A	5	6	7	8	3
March 11	2	4A	1	7	4	3	6	5	8
April 22	7	2	6	5	1	3	8	4	4A
June 3[2]									
July 15	1	6	4A	8	7	3	2	5	4
Sep 4	1	2	3	4	4A	7	6	5	8
Oct 21	3	4	6	9	1	2	5	7	8
Total Carbon									
Dec 12[1,3]	2	1	4A	4	7	3	6	5	
March 11[3]	3	1	4	4A	6	7	5	8	
April 22	2	4	1	6	4A	5	7	3	8
June 3	4	7	5	2	8	3	4A	1	6
July 15	1	7	2	3	6	8	4A	4	5
Sep 4	1	2	3	4A	7	4	5	6	8
Oct 21	3	2	4	6	1	4A	7	8	5

(1) This represents a 3 month rather than 1-1/2 month sample because if was not possible to scuba dive during January 1985.

(2) Insufficient data to present.

(3) All stations are not presented due to breakage of slides.

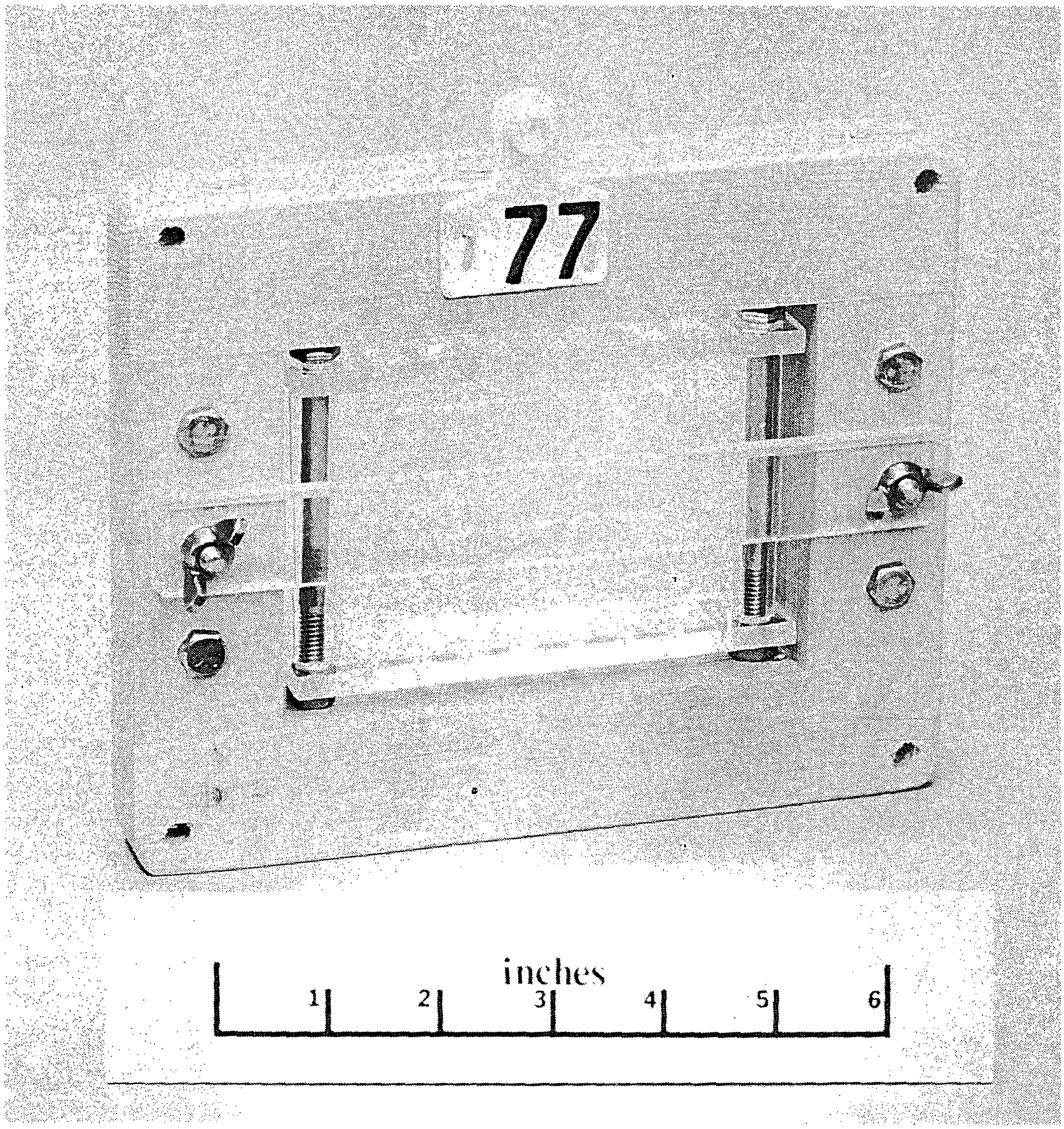

Figure 3-1 Glass slide diatometer used in Plant 2 periphyton program

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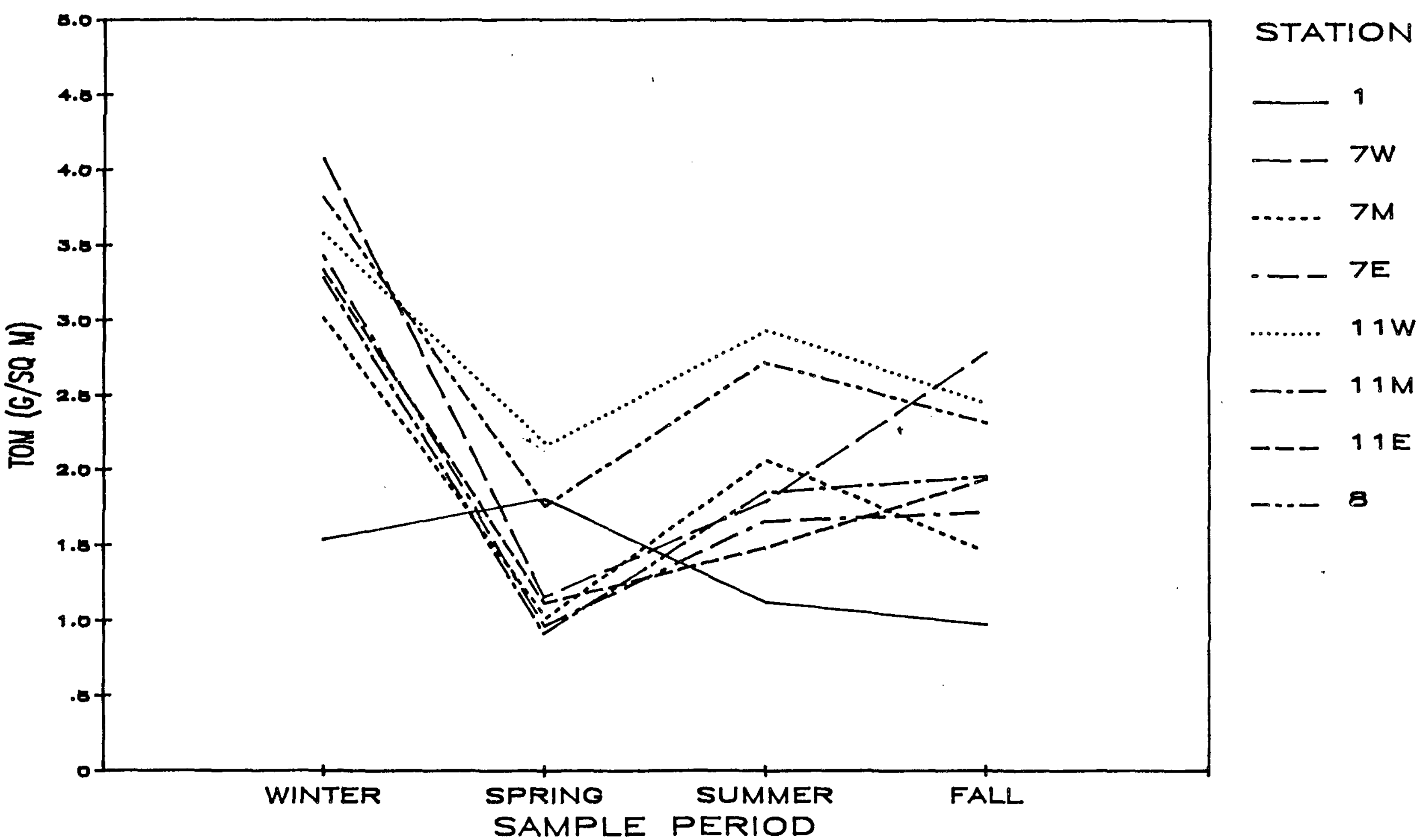

Figure 3-2. Core Program Total Organic Matter During 1985

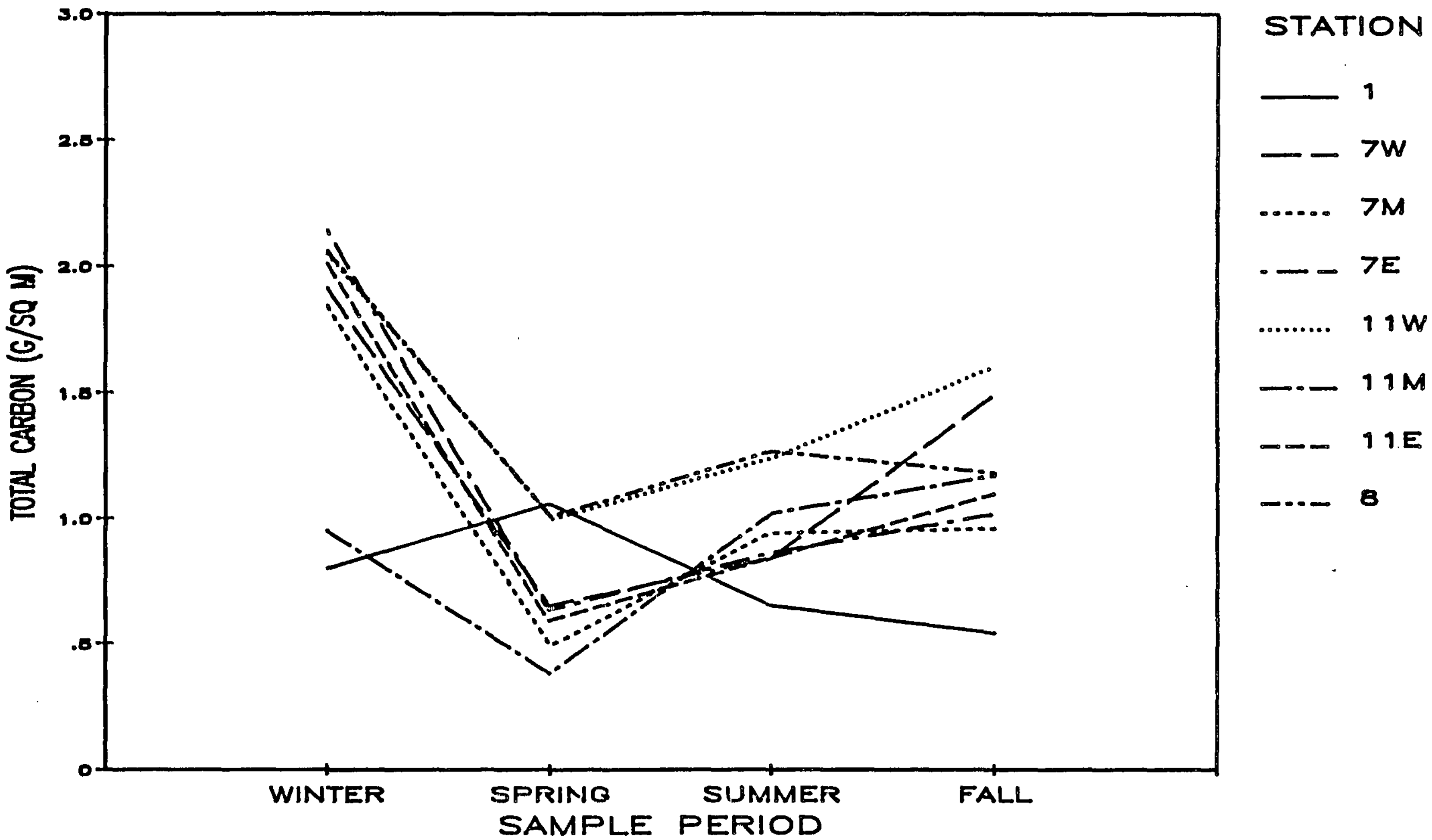

Figure 3-3. Core Program Total Carbon During 1985

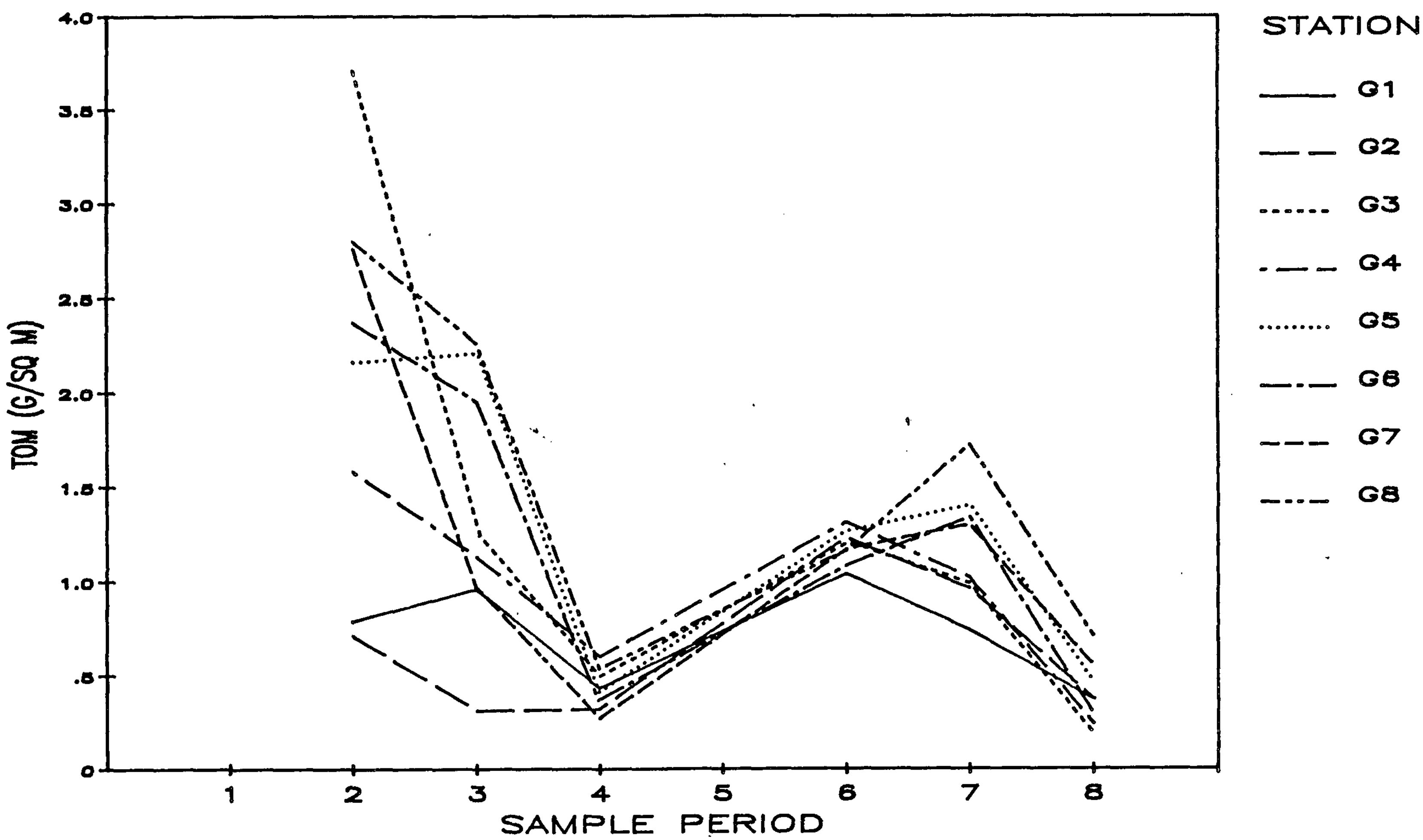

Figure 3-4. Gradient Program Total Organic Matter During 1985

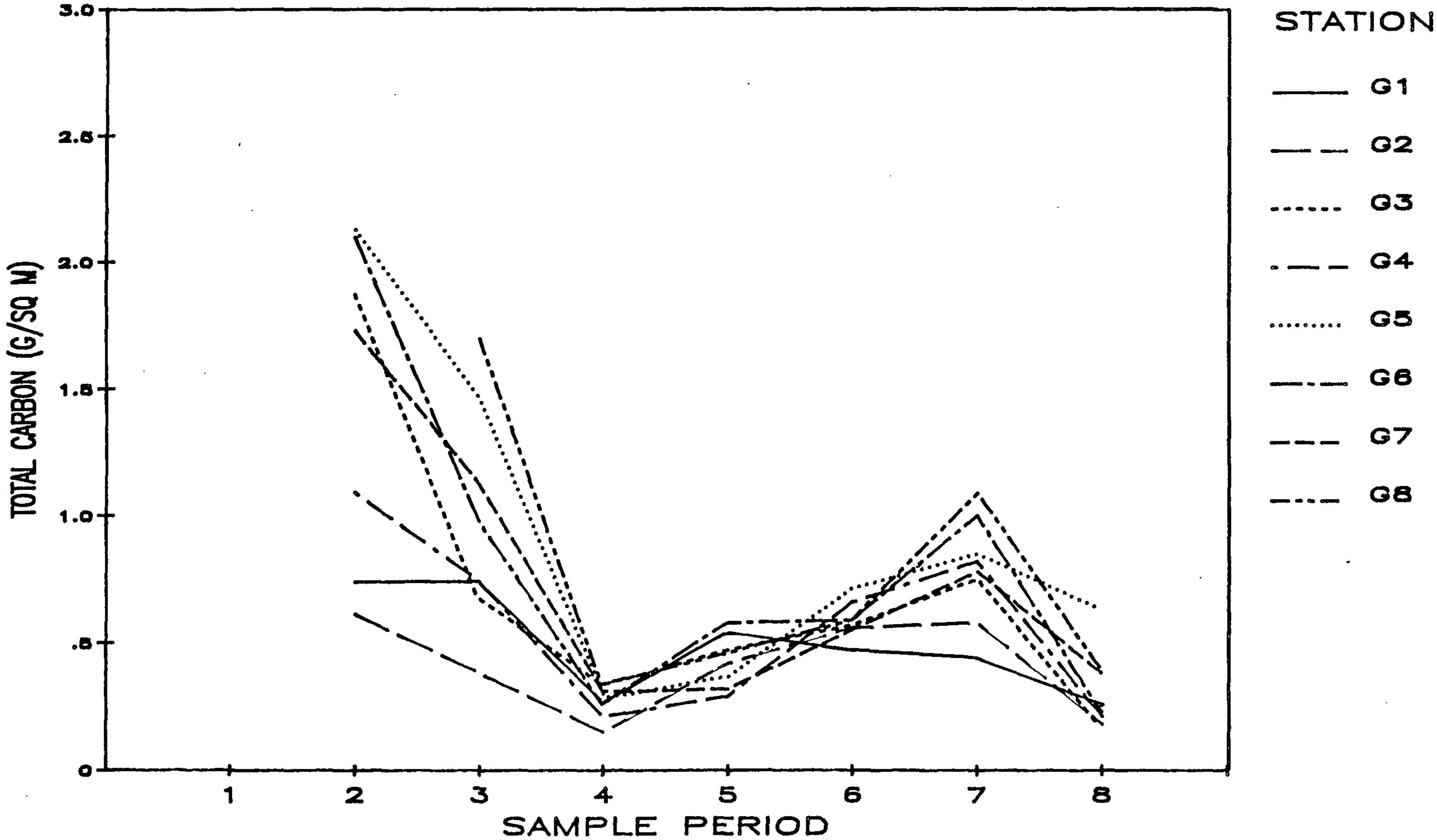

Figure 3-5. Gradient Program Total Carbon During 1985

4.0 WATER QUALITY

4.1 INTRODUCTION

The water quality monitoring program was initiated in April 1983 to document the chemical character of the Columbia River in the vicinity of the WNP-2 discharge. The monitoring data is used to assess if chemical changes in the Columbia River result from WNP-2 cooling tower blowdown. The program is performed to comply with EFSEC Resolution No. 214.

4.2 MATERIALS AND METHODS

Columbia River surface water was sampled monthly January 1985 through December 1985. Samples were collected near River Mile 352 from four stations numbered 1, 7, 11, and 8 (Figure 2-2). Station 1 is upstream of the WNP-2 intake and discharge and represents a control. Station 7 provides a measure of nearfield discharge effects. Station 11 at 91 meters (300 feet) downstream from the discharge represents the extremity of the mixing zone allowed by WNP-2's National Pollutant Discharge Elimination System (NPDES) permit. Station 8 is approximately 549 meters (1800 feet) downstream from the discharge and represents a location where the discharge is well mixed in the Columbia River.

The samples were analyzed for temperature, dissolved oxygen (DO), pH, conductivity, turbidity, total alkalinity, total hardness, filterable residue (total dissolved solids), nonfilterable residue (total suspended solids), ammonia-nitrogen, nitrate-nitrogen, total phosphorus, orthophosphorus, sulfate, oil and grease, total residual chlorine, total copper, total iron, total zinc and total nickel. A summary of water quality parameters, stations and sample frequencies is presented in Table 4-1.

In addition, a well water sample is collected at WNP-2 if the well is being used for drinking water. The well water sample is collected quarterly from an onsite 695 ft deep well. The sample is analyzed for pH, alkalinity, nitrate-nitrogen, total phosphorus and orthophosphorus.

4.2.1 Sample Collection

Columbia River samples were collected by boat approximately 300 feet from the Benton County shore. Temperature, dissolved oxygen, and pH were determined in-situ with portable instruments. Water for total metal analyses was collected in one-liter polypropylene cubitainers and kept on ice until delivered to the Supply System's Environmental Programs Laboratory (EPL). In the laboratory the metals samples were acidified to 0.5% with concentrated Ultrex (J.T. Baker) nitric acid. Determinations for filterable residue, non-filterable residue, conductivity, sulfate, total phosphorus, orthophosphorus, ammonia-nitrogen, nitrate-nitrogen, total residual chlorine, turbidity, total alkalinity and total hardness were made on water samples collected in 3.8-liter polypropylene cubitainers and kept on ice until delivered to the Supply System's Radiological Services Laboratory (RSL). Water for oil and grease analysis was skimmed from the surface into solvent rinsed borosilicate glass bottles. After collection, samples were placed on ice and transported to the RSL for analysis.

Well water samples were collected in one-liter cubitainers by WNP-2 Plant personnel.

4.2.2 Field Equipment and Measurements

Surface temperature and dissolved oxygen measurements were made using a Yellow Springs Instruments (YSI) Model 57 meter. Temperature was recorded to within 0.1°C after the probe had been allowed to equilibrate in the river for a minimum of one minute. The field probe was calibrated, every two months, against an NBS-traceable thermometer in the laboratory.

The DO meter was air-calibrated prior to each field sample date per manufacturer's instruction. In addition, Winkler DO measurements were made every two months and results were compared to the field probe.

Conductivity measurements were made with an IBM Model EC105-1A meter. Prior to each sample date, measurements of conductivity standards were performed.

pH measurements were made with an IBM Model EC105-2A portable pH meter. Prior to each use the instrument was calibrated using pH standards of 4.0, 7.0, and 10.0. If necessary the probes were adjusted to within 0.1 unit of the standards.

4.2.3 Laboratory Measurements

Total residual chlorine, total copper, total zinc, total iron and total nickel were determined by Supply System Environmental Programs personnel. The remaining analyses were performed by Supply System's Radiological Services personnel. Sample holding times followed those recommended by the U.S. Environmental Protection Agency (USEPA 1983). Analyses were performed per USEPA (1983) approved methods (Table 4-2).

4.3 RESULTS

4.3.1 Temperature

Columbia River temperatures varied seasonally with a minimum temperature of 1.7°C at Station 1 in February and a maximum of 19.5°C at Stations 8 and 11 in July (Table 4-3). For any sample period the largest inter-station difference in temperature (0.4°C) occurred in April between Station 1 and Stations 7 and 8. River temperatures measured in 1985 are presented graphically in Figure 4-1.

4.3.2 Dissolved Oxygen (DO)

The mean and range of DO measurements for each sample station are presented in Table 4-3. Columbia River DO concentrations ranged from 9.3 mg/l in August and October to 14.2 mg/l in April. The mean DO concentrations ranged from 11.7 mg/l at Station 7 to 11.9 mg/l at station 8. The largest interstation difference in DO occurred between stations 1 and 7 (9.4 mg/l) and Station 8 (10.0 mg/l) in October.

DO concentrations were inversely related to river temperature as would be expected from solubility laws. DO levels were never below the 8 mg/l water quality standard for Class A waters (WDOE) indicating good water quality with respect to dissolved oxygen throughout the year. Dissolved oxygen measurements are presented graphically in Figure 4-2.

4.3.3 pH and Alkalinity

Columbia River mean pH values ranged from 7.99 at Station 1 to 8.08 at Station 11 (Table 4-3). pH varied with a measured minimum of 7.58 at Station 1 in November to a maximum of 8.60 at Station 7 in April. The variation in pH between sample stations is small. The largest difference of 0.42 standard units occurred between Station 1 (pH 7.58) and Station 8 (pH 8.00) in November.

The pH water quality standard for Class A waters is from 6.5 to 8.5 (WDOE 1977) and measured pH's were within this range. pH measurements, presented graphically in Figure 4-3, generally agree with historical data for the Columbia River (Silker 1964).

The alkalinity of a water is a measure of its capacity to neutralize acids and is generally due to the presence of carbonates, bicarbonates, phosphates, silicates, borates, and hydroxides. Columbia River alkalinities ranged from 42.5 to 102.5 mg/l as calcium carbonate (Table 4-4). Consistent temporal and spatial alkalinity differences were not observed. The high readings at Stations 8 and 11 in September are thought to be the result of contaminated sample containers. The alkalinity measurements are presented graphically in Figure 4-4.

4.3.4 Conductivity

Conductivity is a measure of the ionic content of a solution. Columbia River conductivity measurements ranged from 115.8 us/cm at 25°C at Station 1 in June to 167.0 us/cm at 25°C at Station 7 in April (Table 4-4). Station mean conductivities ranged from 140.0 us/cm at 25°C at Station 1 to 143.7 us/cm at 25°C at Station 7. The largest difference in conductivity (i.e. 14.9 us/cm) occurred between Station 7 (167.0 us/cm) and Station 8 (152.1 us/cm) in April 1984. The conductivity results are very comparable to those reported in earlier studies of the Columbia River (Silker 1964). The measurements are presented graphically in Figure 4-5.

4.3.5 Total Residual Chlorine (TRC)

Total residual chlorine measurements for all stations from January 1985 through December 1985 were less than the measured detection limit of 2 ug/l (Table 4-4). The IBM chlorine analyzer has a detection limit of 2 ug/l, however, the TRC measurements were reported as 0 since the Columbia River consistently exhibits a demand for total residual chlorine of greater than 20 ug/l.

4.3.6 Total Copper, Total Zinc, Total Iron and Total Nickel

Columbia River mean total copper values ranged from 1.6 ug/l at Station 1 to 3.9 ug/l at Station 7 (Table 4-5). Individual copper measurements ranged from 0.7 ug/l to 11.4 ug/l. The largest interstation difference in copper (10.1 ug/l) occurred between Station 1 (1.3 ug/l) and Station 7 (11.4 ug/l) in March. Our copper results show good agreement with earlier studies. In 1962, Silker (1964) analyzed 27 Columbia River samples collected upstream of WNP-2 and reported a mean copper concentration of 4.3 ug/l. Neutron activation analysis of Columbia River water was done in 1968-1969 by Cushing and Rancitelli (1972). They reported a mean copper concentration of 1.4 ug/l. Florence and Batley (1977) state that total copper concentrations in the range of 0.3 - 3.0 ug/l are found in many unpolluted fresh-water rivers throughout the world. The Hanford reach of the Columbia River would generally be in that category.

Mean total zinc measurements ranged from 7.6 ug/l at Stations 1 and 8, to 8.5 ug/l at Station 11 (Table 4-5). Individual zinc measurements ranged from 3.0 ug/l at Station 1 in August to 15.0 ug/l at Stations 7 and 11 in January. Generally, the highest zinc measurements were recorded during the winter months. The greatest inter-station difference (4.0 ug/l) occurred between Station 1 (3.0 ug/l) and Station 7 (7.0 ug/l) in August. The average zinc measurements for the present study are lower than the 18.2 and 14.0 ug/l mean zinc concentrations reported by Silker (1964) and Cushing and Rancitelli (1972).

Columbia River mean iron concentrations were very similar at each sample location and ranged from 41.0 ug/l at Station 11 to 45.3 ug/l at Station 7 (Table 4-5). The greatest inter-station difference in concentration of 20 ug/l occurred between Station 7 (44 ug/l) and Station 8 (24 ug/l) in April.

Mean total nickel concentrations were generally low, ranging from 0.5 ug/l at Station 1 to 0.7 ug/l at Station 8 (Table 4-6). Nickel concentrations showed little variation (0.1 to 1.9 ug/l) through time or between sample locations. Total copper, zinc, iron and nickel measurements are presented graphically in Figures 4-6, 4-7, 4-8 and 4-9.

4.3.7 Hardness

Hardness indicates the quantity of divalent metallic cations present in the system, principally calcium and magnesium ions. Hardness ranged from 55.0 to 88.0 mg/l as calcium carbonate (Table 4-6). Mean hardness values ranged from 65.9 mg/l at Station 7 to 66.9 mg/l at Station 11. The hardness measurements are presented graphically in Figure 4-10.

4.3.8 Oil and Grease

Columbia River oil and grease concentrations were typically low (Table 4-6). Oil and grease values ranged from $<$ 0.2 mg/l to 1.3 mg/l, whereas station mean concentrations ranged from 0.2 to 0.6 mg/l. Erroneous data for the months of September, October, November and December was traced to a faulty balance as well as probable contaminated sample containers and thus no data is reported herein for these sampling periods.

4.3.9 Ammonia-Nitrogen and Nitrate-Nitrogen

Ammonia and nitrate are forms of nitrogen commonly found in water systems. Both nitrate and ammonia are assimilated by plants and converted to proteins. Common sources of nitrate and ammonia to the aquatic system are breakdown of organic matter in the soil, industrial discharges, fertilizers and septic tank leachate.

Ammonia concentrations ranged from 0.010 to 0.027 mg-N/l (Table 4-7). Mean ammonia concentrations ranged from 0.001 mg-N/l at Stations 1, 8 and 11 to 0.008 mg-N/l at Station 7. Nitrate concentrations averaged 0.09 mg-N/l and ranged from 0.010 mg-N/l to 0.48 mg-N/l (Table 4-7). Values for all stations were considered higher (0.33 to 0.48 mg/l) on October 17, 1985, than of any of the other 1985 sampling periods. The reason for the high values is unknown. The nitrate measurements are presented graphically in Figure 4-11.

4.3.10 Total Phosphorus and Orthophosphorus

Phosphorus is a required nutrient for plant growth and, while found in certain minerals, is commonly added to streams through fertilizers, treated sewage, and septic tank leachate.

Measured total phosphorus concentrations ranged from 0.01 to 0.55 mg-P/l with mean values from 0.04 to 0.09 mg-P/l (Table 4-7). Orthophosphorus concentration followed a similar pattern and ranged from 0.01 to 0.03 mg-P/l (Table 4-8). Mean concentrations were 0.01 for all sample locations. With one exception, no seasonal or spatial trends were obvious for either total or orthophosphorus. A value of 0.55 mg/l total phosphorus was reported for Station 7 in April and is discussed below. Total phosphorus measurements are presented graphically in Figure 4-12.

4.3.11 Sulfate

Mean sulfate concentrations ranged from 11.0 mg/l at Station 8 to 12.3 mg/l at Station 11 (Table 4-8). Individual sulfate measurements ranged from 4.0 to 26.0 mg/l. Generally, sulfate concentrations between stations were similar with the largest difference of 12.0 mg/l occurring in April between Stations 7 and 8. Sulfuric acid is added at WNP-2 to control circulating water pH and a by-product is sulfate. Based on the river measurements, WNP-2 discharges are not appreciably altering river sulfate concentrations. Total sulfate measurements are presented graphically in Figure 4-13.

4.3.12 Total Dissolved Solids, Total Suspended Solids and Turbidity

Total dissolved solids or total filterable residue, TDS, is defined as that portion of the total residue that passes through a glass fiber filter and remains after ignition at 180°C for one hour. Total dissolved solids do not necessarily represent only the dissolved constituents but may also include colloidal materials and some small particulates. The mean TDS measured in the Columbia River varied from 60.2 mg/l at Station 8 to 63.0 mg/l at Station 7 (Table 4-8). There were no consistent differences in TDS concentrations between stations or through time.

Total suspended solids (TSS) or total nonfilterable residue is the material retained on a standard glass fiber filter after filtration of a well-mixed sample. TSS concentrations were generally low and varied from 0.6 to 10.1 mg/l (Table 4-9). Mean TSS concentrations ranged from 3.07 mg/l at Station 7 to 3.82 mg/l at Station 1.

Turbidity is a measure of the suspended matter that interferes with the passage of light through water. In the Columbia River, measured turbidities were low and ranged from 0.58 nephelometric turbidity units (NTU) to 1.50 NTU (Table 4-9). The largest difference of 0.50 NTU occurred in June between Station 1 (1.30 NTU) and Station 8 (0.80 NTU). Total dissolved solids, total suspended solids and turbidity data are presented graphically in Figures 4-14, 4-15 and 4-16.

4.3.13 Quarterly Drinking Well Measurements

The results of the 1985 quarterly drinking well water analyses for pH, alkalinity, nitrate-nitrogen, total phosphorus and orthophosphorus are presented in Table 4-10. pH values ranged from 7.95 to 8.36 and are comparable to river pH measurements (Table 4-3). The same conclusion is true for the other parameters which had the following value ranges: alkalinity, 62.5-107.5 mg/l, nitrate-nitrogen 0.01-.15 mg/l, total phosphorus 0.01-0.25 mg/l and orthophosphorus, 0.01-0.01 mg/l.

4.4 DISCUSSION

Upon examination of the data, it appears that, with respect to all of the measured parameters, the WNP-2 cooling tower discharge has had little effect upon Columbia River water quality and that all measurements are within the water quality standards for Class A waters both above and below the mixing zone.

On nearly all sampling periods, inter-station differences could not be detected for any of the measured parameters. However, during the March and April sampling periods (March 5, 1985 and April 11, 1985) there were some marked differences in several parameters between the control station (Station 1) and the downstream station closest to the discharge (Station 7). However, none of these differences extended beyond the mixing zone. This data is summarized in Table 4-11.

4.5 BIBLIOGRAPHY

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Table 4-1. Summary of Water Quality Parameters, Stations, and Sampling Frequencies for 1985

Parameter	Stations 1	7	11	8	Wells in Vicinity of Plant Site +
Quantity (flow)	-	C(2)	-	-	-
Temperature	M	M/C(2)	M	M	-
Dissolved Oxygen	M	M	M	M	-
pH	M	M/C(2)	M	M	Q
Turbidity	M	M	M	M	-
Total Alkalinity	M	M	M	M	Q
Filterable Residue (Total Dissolved Solid)	M	M	M	M	-
Nonfilterable Residue (Suspended Solids)	M	M	M	M	-
Conductivity	M	M	M	M	-
Iron (Total)	M	M	M	M	-
Copper (Total)	M	M	M	M	-
Nickel (Total)	M	M	M	M	-
Zinc (Total)	M	M	M	M	-
Sulfate	M	M	M	M	-
NH_4+ Nitrogen	M	M	M	M	-
NO_3- Nitrogen	M	M	M	M	Q
Ortho Phosphorus	M	M	M	M	Q
Total Phosphorus	M	M	M	M	Q
Oil and Grease	M	M	M	M	-
Chlorine, Total Residual	M	M/D(2)	M	M	-
Hardness	M	M	M	M	-

Symbols Key

C = Continuous
M = Monthly
Q = Quarterly
D = Daily, when chlorine is added
(1) Refer to Figure 2-1 for station location
(2)Monitored by plant staff on cooling tower blowdown line and reported to EFSEC in quarterly NPDES reports.
+ Samples will be collected if wells are being used for drinking water
- Analysis not required

Table 4-2. Summary of Water Quality Parameters and Associated EPA Methods

Parameter	EPA Method Number
Water Temperature (°C)	120.1
Turbidity, (NTU)	180.1
Conductivity (umhos/cm) at 25°C	120.1
Dissolved Oxygen (mg/l) probe	360.1
Dissolved Oxygen (mg/l) Modified Winkler	360.2
pH (Standard Unit)	150.1
Total Alkalinity (mg/l as $CaCO_3$)	310.1
Total Hardness (mg/l as $CaCO_3$)	130.2
Oil and Grease (mg/l)	413.2
Nitrogen, Ammonia, Total (mg/l as N)	350.2
Nitrate Nitrogen, Total (mg/l as N)	352.1
Total Phosphorus (mg/l as P)	365.2
Ortho Phosphorus (mg/l as P)	365.2
Sulfate (mg/l as SO_4)	375.4
Total Copper (ug/l as Cu)	220.2
Total Iron (ug/l as Fe)	236.2
Total Nickel (ug/l as Ni)	249.2
Total Zinc (ug/l as Zn)	289.2
Total Residual Chlorine (ug/l)	330.1
Filterable Residue: Total Dissolved Solids (mg/l)	160.1
Non-Filterable Residue: Total Suspended Solids (mg/l)	160.2

Table 4-3. Summary of Columbia River Temperature, Dissolved Oxygen and pH at Four Stations for 1985

Sample Date	Temperature (Degrees C)				Dissolved Oxygen mg/l				pH			
	1	7	8	11	1	7	8	11	1	7	8	11
01/10/85	2.8	2.7	2.6	2.8	12.40	12.20	12.40	12.30	7.92	7.82	7.89	7.82
02/19/85	1.7	2.0	2.0	2.0	13.60	13.80	13.80	13.80	7.94	8.05	8.04	7.92
03/05/85	2.5	2.5	2.5	2.6	13.60	13.70	13.70	13.80	8.04	8.19	8.01	8.21
04/11/85	7.8	8.2	8.2	8.0	13.90	13.90	14.20	14.00	8.41	8.60	8.54	8.57
05/14/85	9.8	9.8	9.9	9.8	12.60	12.30	12.70	12.30	8.31	8.20	8.27	8.28
06/18/85	15.8	15.9	16.0	15.9	10.80	10.60	10.60	10.60	7.98	7.97	8.00	8.00
07/16/85	19.3	19.4	19.5	19.5	9.90	10.10	10.20	10.20	8.08	8.09	8.06	8.08
08/13/85	18.9	19.1	19.3	19.2	9.40	9.50	9.80	9.50	8.11	8.19	8.01	8.19
09/12/85	17.9	17.9	17.7	17.9	9.60	9.60	9.80	9.50	7.75	7.75	7.98	7.89
10/17/85	14.4	14.4	14.4	14.4	9.40	9.40	10.00	9.50	7.79	7.88	7.96	7.96
11/26/85	6.0	6.0	6.0	6.0	13.80	13.40	13.40	13.30	7.58	7.78	8.00	7.88
12/17/85	3.2	3.2	3.2	3.2	12.20	12.20	12.20	12.10	8.01	8.12	8.12	8.11
Mean	10.0	10.1	10.1	10.1	11.77	11.73	11.90	11.74	7.99	8.05	8.07	8.08
SD	6.6	6.6	6.7	6.6	1.76	1.72	1.64	1.72	0.22	0.23	0.17	0.20
Min	1.7	2.0	2.0	2.0	9.40	9.40	9.80	9.50	7.58	7.75	7.89	7.82
Max	19.3	19.4	19.5	19.5	13.90	13.90	14.20	14.00	8.41	8.60	8.54	8.57

Table 4-4. Total Alkalinity Conductivity and Total Residual Chlorine at Four Stations for 1985

Sample Date	Total Alkalinity mg/l				Conductivity at 25°C us/cm				Total Residual Chlorine ug/l			
	1	7	8	11	1	7	8	11	1	7	8	11
01/10/85	50.00	55.00	62.00	60.00	158.50	158.50	155.10	158.50	0	0	0	0
02/19/85	52.50	52.50	52.50	52.50	144.90	145.90	149.00	151.80	0	0	0	0
03/05/85	52.50	55.00	55.00	55.00	147.00	150.00	147.00	149.00	0	0	0	0
04/11/85	65.00	65.00	65.00	62.50	154.70	167.00	152.10	156.20	0	0	0	0
05/14/85	55.00	55.00	60.00	57.80	149.00	149.40	149.20	148.00	0	0	0	0
06/18/85	42.50	43.50	43.50	45.00	115.80	116.00	117.30	115.90	0	0	0	0
07/16/85	50.00	45.00	45.00	47.50	118.00	118.00	117.00	122.00	0	0	0	0
08/13/85	60.00	60.00	65.00	65.00	124.10	144.10	128.60	126.10	0	0	0	0
09/12/85	52.50	60.00	100.00	102.50	136.60	136.60	136.50	136.60	0	0	0	0
10/17/85	52.50	60.00	95.00	65.00	141.60	140.60	140.00	143.00	0	0	0	0
11/26/85	55.00	52.55	52.50	57.50	144.90	146.20	144.90	145.30	0	0	0	0
12/17/85	58.00	60.00	60.00	60.00	145.40	145.70	146.40	145.90	0	0	0	0
Mean	53.79	55.30	62.96	60.86	140.04	143.17	140.26	141.53	0	0	0	0
SD	5.38	6.08	16.85	13.93	13.24	13.95	12.38	13.05	0	0	0	0
Min	42.50	43.50	43.50	45.00	115.80	116.00	117.00	115.90	0	0	0	0
Max	65.0	65.0	100.0	102.5	158.50	167.00	155.10	158.50	0	0	0	0

Table 4-5. Columbia River Total Copper, Zinc, and Iron at Four Stations for 1985

Sample Date	Copper ug/l				Zinc ug/l				Iron ug/l			
	1	7	8	11	1	7	8	11	1	7	8	11
01/10/85	2.0	1.0	2.0	5.0	13.0	15.0	14.0	15.0	18.0	21.0	17.0	17.0
02/19/85	1.5	1.7	1.5	6.8	11.0	11.0	11.0	14.0	44.0	33.0	38.0	37.0
03/05/85	1.3	11.4	1.7	3.9	6.0	6.0	7.0	7.0	43.0	48.0	47.0	44.0
04/11/85	1.7	11.0	1.4	4.7	7.0	10.0	7.0	7.0	26.0	44.0	24.0	32.0
05/14/85	1.4	2.0	1.7	1.6	10.0	10.0	11.0	10.0	68.9	61.2	55.7	58.9
06/18/85	1.7	2.0	1.8	2.0	4.0	4.0	4.0	4.0	57.0	52.0	59.0	56.0
07/16/85	1.8	6.9	1.8	4.3	4.0	7.0	3.0	3.0	61.0	58.0	54.0	49.0
08/13/85	1.8	4.4	1.9	6.4	3.0	7.0	3.0	6.0	46.0	47.0	54.0	46.0
09/12/85	1.9	2.3	1.8	1.8	5.0	5.0	4.0	4.0	38.0	51.0	35.0	37.0
10/17/85	1.2	1.3	1.3	0.9	10.0	8.0	8.0	11.0	42.0	46.0	47.0	41.0
11/26/85	1.3	1.6	0.9	1.1	5.0	4.0	5.0	8.0	39.0	43.0	39.0	37.0
12/17/85	1.5	0.9	0.7	2.1	13.0	14.0	14.0	13.0	36.0	39.0	35.0	37.0
Mean	1.6	3.9	1.5	3.4	7.6	8.4	7.6	8.5	43.2	45.3	42.1	41.0
SD	0.2	3.7	0.4	2.0	3.5	3.5	3.9	3.9	13.6	10.4	12.5	10.7
Min	1.2	0.9	0.7	0.9	3.0	4.0	3.0	3.0	18.0	21.0	17.0	17.0
Max	2.0	11.4	2.0	6.8	13.0	15.0	14.0	15.0	68.9	61.2	59.0	58.9

Table 4-6. Columbia River Total Nickel, Hardness, and Oil and Grease at Four Stations for 1985

Sample Date	Nickel ug/l				Hardness mg/l				Oil and Grease mg/l			
	1	7	8	11	1	7	8	11	1	7	8	11
01/10/85	0.4	0.5	1.9	0.2	88.0	76.4	79.0	77.0	0.2	0.2	0.2	0.6
02/19/85	0.6	0.6	0.6	0.6	67.0	67.0	68.0	70.0	0.2	1.3	0.2	0.2
03/05/85	0.3	0.7	0.7	0.8	73.0	73.0	73.0	72.0	0.2	0.7	0.2	0.2
04/11/85	0.7	1.0	0.3	0.3	74.0	80.0	76.0	78.0	0.2	0.7	0.2	0.2
05/14/85	0.6	0.3	0.4	0.4	69.0	66.0	67.0	67.5	0.2	1.2	0.2	1.3
06/18/85	0.5	0.3	0.4	0.3	57.0	58.5	55.0	59.0	0.2	0.2	0.2	0.2
07/16/85	0.1	0.5	0.7	1.2	57.0	58.5	57.5	57.0	0.2	0.2	0.7	0.7
08/13/85	1.7	1.5	1.1	1.7	57.1	56.0	59.0	63.0	0.4	0.5	0.5	0.7
09/12/85	0.7	0.6	1.6	0.8	62.0	62.0	63.0	62.0	(a)	(a)	(a)	(a)
10/17/85	0.1	0.2	0.1	0.1	58.0	58.0	62.5	61.0	(a)	(a)	(a)	(a)
11/26/85	0.2	0.3	0.1	0.1	67.5	66.0	68.5	67.0	(a)	(a)	(a)	(a)
12/17/85	0.1	0.1	0.1	0.1	69.5	69.2	70.5	69.5	(a)	(a)	(a)	(a)
Mean	0.5	0.6	0.7	0.6	66.6	65.9	66.6	66.9	0.2	0.6	0.2	0.5
SD	0.4	0.4	0.6	0.5	8.8	7.4	7.1	6.5	0.1	0.5	0.2	0.4
Min	0.1	0.1	0.1	0.1	57.0	56.0	55.0	57.0	0.1	0.1	0.1	0.1
Max	1.7	1.5	1.9	1.7	88.0	80.0	79.0	78.0	0.4	1.3	0.7	1.3

Table 4-7. Columbia River Ammonia-Nitrogen, Nitrate-Nitrogen, and Total Phosphorus at Four Stations for 1985

Sample Date	Ammonia mg/l				Nitrate mg/l				Total Phosphorus mg/l			
	1	7	8	11	1	7	8	11	1	7	8	11
01/10/85	<0.010	<0.010	<0.010	<0.010	0.18	0.18	0.17	0.18	0.03	0.03	0.03	0.06
02/19/85	<0.010	<0.010	<0.010	<0.010	0.16	0.15	0.15	0.16	0.02	0.02	0.02	0.05
03/05/85	<0.010	<0.010	<0.010	<0.010	0.05	0.06	0.04	0.03	0.02	0.04	0.02	0.05
04/11/85	0.020	0.020	0.027	<0.020	0.03	0.09	0.09	0.09	0.02	0.55	0.01	0.02
05/14/85	<0.010	<0.010	<0.010	<0.010	0.1	0.07	0.09	0.11	0.02	0.02	0.03	0.02
06/18/85	<0.010	<0.010	<0.010	<0.010								
07/16/85	<0.010	<0.010	<0.010	<0.010	0.01	0.01	0.01	0.01	0.02	0.03	0.13	0.03
08/13/85	<0.010	<0.010	<0.010	<0.010	0.03	0.03	0.03	0.03	0.01	0.06	0.01	0.04
09/12/85	<0.010	<0.010	<0.010	<0.010	0.04	0.04	0.04	0.04	0.22	0.21	0.22	0.19
10/17/85	<0.010	<0.010	<0.010	<0.010	0.33	0.48	0.33	0.33	<0.01	<0.01	<0.01	<0.01
11/26/85	0.010	0.010	0.010	0.010	0.04	0.04	0.04	0.04	0.03	0.02	0.03	0.04
12/17/85	0.010	0.010	0.010	0.010	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Mean	0.007	0.008	0.007	0.007	0.09	0.10	0.09	0.09	0.04	0.09	0.05	0.05
SD	0.004	0.004	0.006	0.004	0.09	0.13	0.09	0.09	0.06	0.16	0.06	0.05
Min	<0.010	<0.010	<0.010	<0.010	0.01	0.01	0.01	0.01	0.01	<0.01	<0.01	<0.01
Max	0.020	0.020	0.027	0.020	0.33	0.48	0.33	0.33	0.22	0.55	0.22	0.19

Table 4-8. Columbia River Ortho Phosphate, Sulfate, and Total Dissolved Solids at Four Stations for 1985

Sample Date	Ortho Phosphate mg/l				Sulfate mg/l				Total Dissolved Solids mg/l			
	1	7	8	11	1	7	8	11	1	7	8	11
01/10/85	0.02	0.02	0.02	0.03	11.5	9.5	10.0	13.5	92.0	95.0	88.0	86.0
02/19/85	0.01	0.01	0.01	0.03	13.0	12.0	11.0	13.5	77.0	99.0	86.0	83.0
03/05/85	0.01	0.01	0.01	0.02	14.0	13.5	12.8	15.0	77.0	72.0	78.0	73.0
04/11/85	<0.01	<0.01	<0.01	<0.01	18.0	26.0	14.0	17.0	102.0	98.0	95.0	100.0
05/14/85	0.01	0.01	0.01	0.01	14.0	14.0	13.5	12.5	104.9	111.1	102.0	103.6
06/18/85					8.0	7.5	11.0	8.0	75.0	67.0	84.0	67.0
07/16/85	<0.01	<0.01	<0.01	<0.01	10.7	11.5	9.3	12.4	64.5	63.2	60.2	61.9
08/13/85	<0.01	0.02	<0.01	0.01	12.5	14.0	11.0	11.5	73.0	81.0	78.0	77.0
09/12/85	<0.01	<0.01	<0.01	<0.01	4.5	4.0	6.0	6.5	62.0	63.0	73.0	74.0
10/17/85	<0.01	<0.01	<0.01	<0.01	9.3	8.5	11.0	13.5	106.0	101.0	102.0	101.0
11/26/85	0.02	0.02	0.02	0.02	9.5	9.5	11.0	11.5	73.0	81.0	81.0	78.0
12/17/85	<0.01	<0.01	<0.01	<0.01	11.5	11.5	11.5	12.5	80.0	84.0	72.0	80.0
Mean	0.01	0.01	0.01	0.01	11.4	11.8	11.0	12.3	82.2	84.6	83.3	82.0
SD	0.01	0.01	0.01	0.01	3.3	5.1	2.0	2.7	14.6	15.5	11.9	12.9
Min	<0.01	<0.01	<0.01	<0.01	4.5	4.0	6.0	6.5	62.0	63.0	60.2	61.9
Max	0.02	0.02	0.02	0.02	18.0	26.0	14.0	17.0	106.0	111.1	102.0	103.6

Table 4-9. Columbia River Total Suspended Solids and Turbidity at Four Sites for 1985

Sample Date	Total Suspended Solids mg/l				Turbidity NTU			
	1	7	8	11	1	7	8	11
01/10/85	2.90	4.00	4.10	3.50	0.61	0.62	0.61	0.61
02/19/85	2.90	0.60	4.80	1.00	0.65	0.82	0.68	0.75
03/05/85	1.30	1.60	1.90	1.50	1.00	1.00	1.10	1.00
04/11/85	3.40	4.00	3.20	3.90	0.89	1.00	0.95	1.00
05/14/85	10.10	3.90	6.00	5.40	1.50	1.50	1.50	1.50
06/18/85	5.00	4.70	6.80	4.00	1.30	1.10	0.80	1.00
07/16/85	6.50	6.80	6.80	6.10	1.20	1.10	0.90	0.74
08/13/85	4.00	4.00	2.40	5.00	0.90	0.80	0.80	0.80
09/12/85	2.90	3.40	2.80	3.30	0.82	0.76	0.98	0.70
10/17/85	2.30	1.90	2.30	2.50	0.58	0.66	0.90	0.60
11/26/85	2.80	1.30	1.40	1.80	0.90	0.80	0.80	0.70
12/17/85	1.70	0.60	0.70	1.30	0.82	0.77	0.76	0.72
Mean	3.82	3.07	3.60	3.28	0.93	0.91	0.90	0.84
SD	2.33	1.80	2.00	1.62	0.27	0.23	0.22	0.24
Min	1.30	0.60	0.70	1.00	0.58	0.62	0.61	0.60
Max	10.1	6.8	6.8	6.1	1.50	1.50	1.50	1.50

Table 4-10. Summary of Quarterly Drinking Well Water Monitoring Measurements for 1985

Sample Date	pH Standard Units	Alkalinity mg/l	Total Phosphorus mg/l	Ortho-phosphorus mg/l	Nitrate-Nitrogen mg/l
02/19/85	7.97	62.5	0.01	0.01	0.09
03/05/85	8.36	62.5	0.15	0.01	0.07
09/12/85	8.11	107.5	0.25	0.01	0.15
12/17/85	7.95	62.5	0.02	0.01	0.01

Table 4-11. Interstation Differences for Selected Parameters Detected During the 1985 WNP-2 Water Quality Sampling Program

Parameter	Date	1	7	11	8
Total Copper (ug/l)	03/05/85	1.3	11.4	3.9	1.7
Total Copper (ug/l)	04/11/85	1.7	11.0	4.7	1.4
Total Copper (ug/l)	07/16/85	1.8	6.9	4.3	1.8
Total Iron (ug/l)	04/11/85	26.0	44.0	32.0	24.0
Hardness (mg/l)	04/11/85	74.0	80.0	78.0	76.0
Sulfate (mg/l)	04/11/85	18.0	26.0	17.0	14.0
pH	04/11/85	8.41	8.60	8.57	8.54
Oil & Grease (mg/l)	04/11/85	0.2	0.7	0.2	0.2
Total Phosphates (mg/l)	04/11/85	0.02	0.55	0.02	0.01
Conductivity (us/cm)	04/11/85	154.7	167.0	156.2	152.1

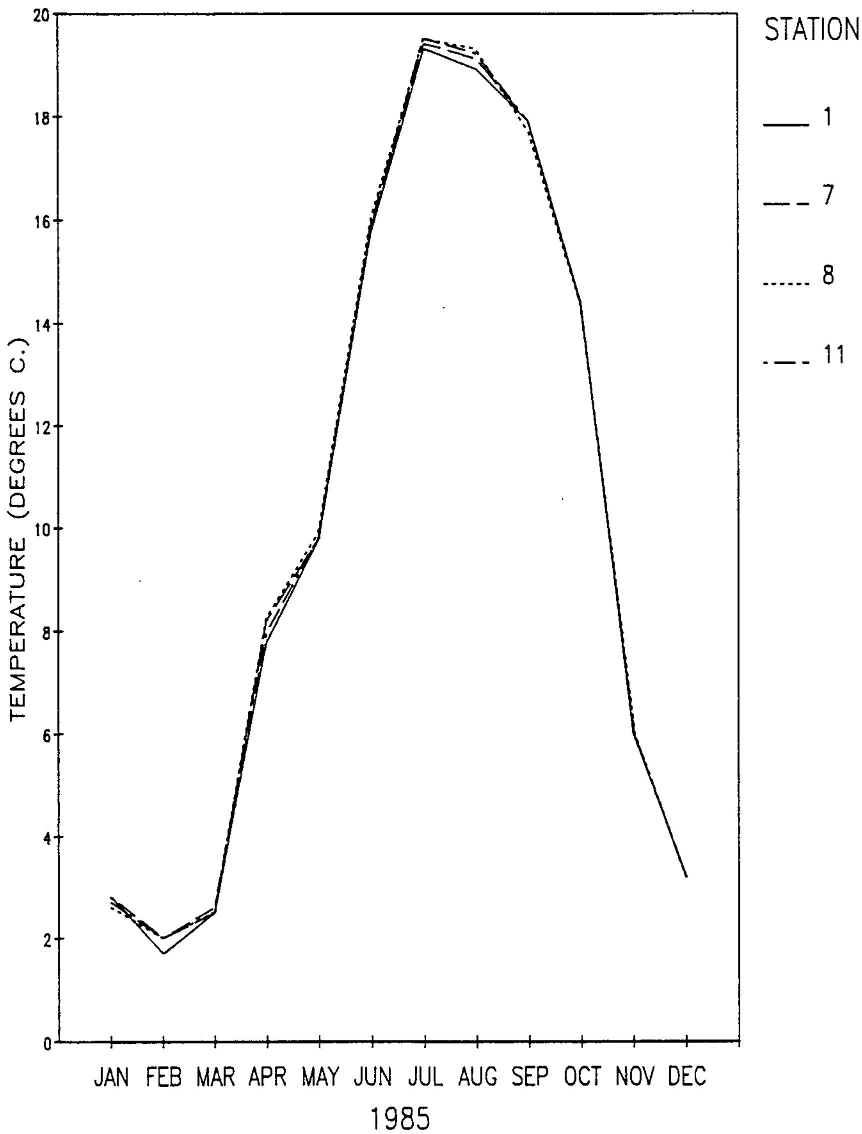

Figure 4-1. Columbia River Temperature at Four Stations for 1985

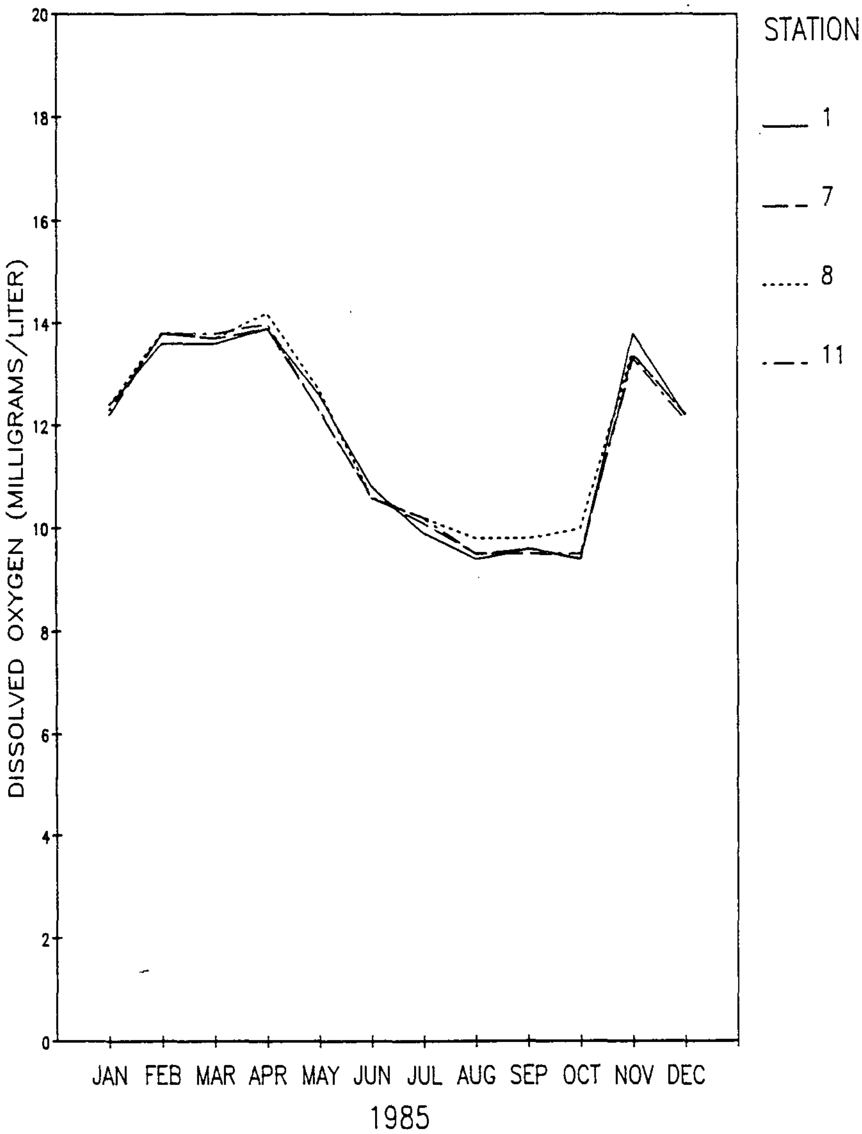

Figure 4-2. Columbia River Dissolved Oxygen at Four Stations for 1985

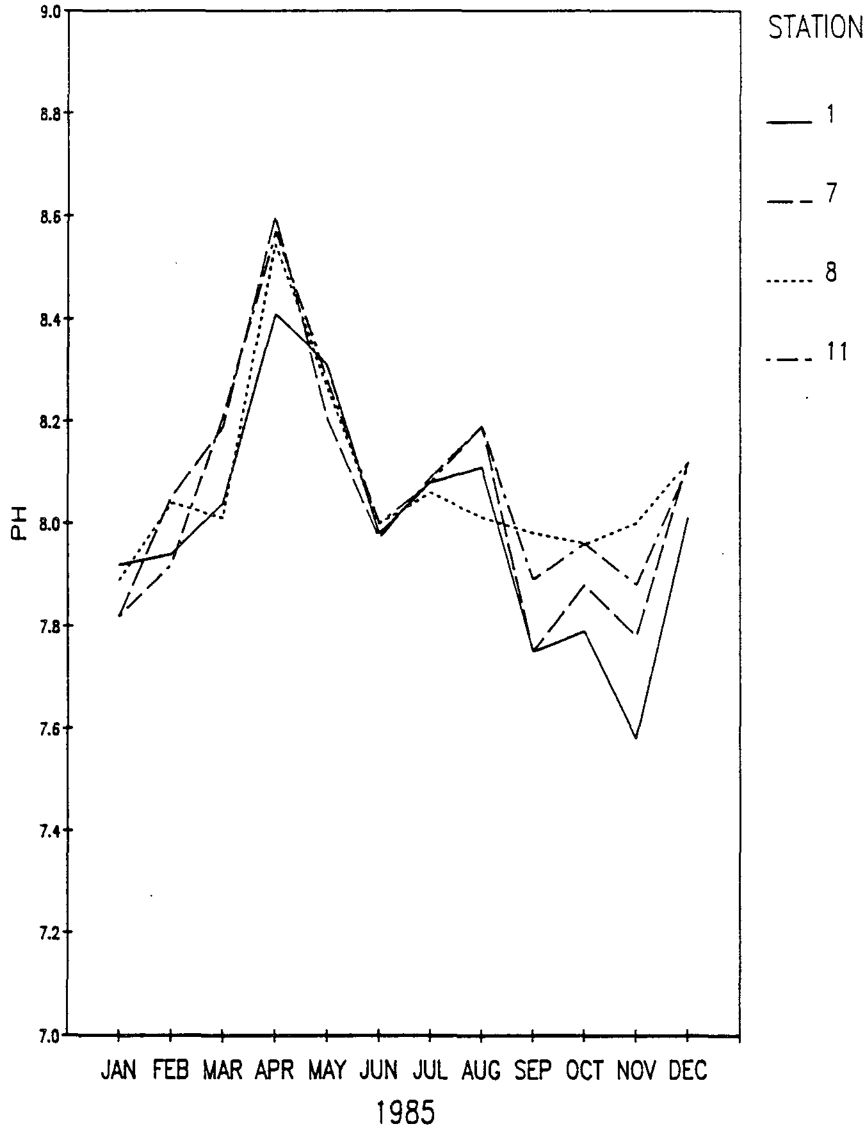

Figure 4-3. Columbia River pH at Four Stations for 1985

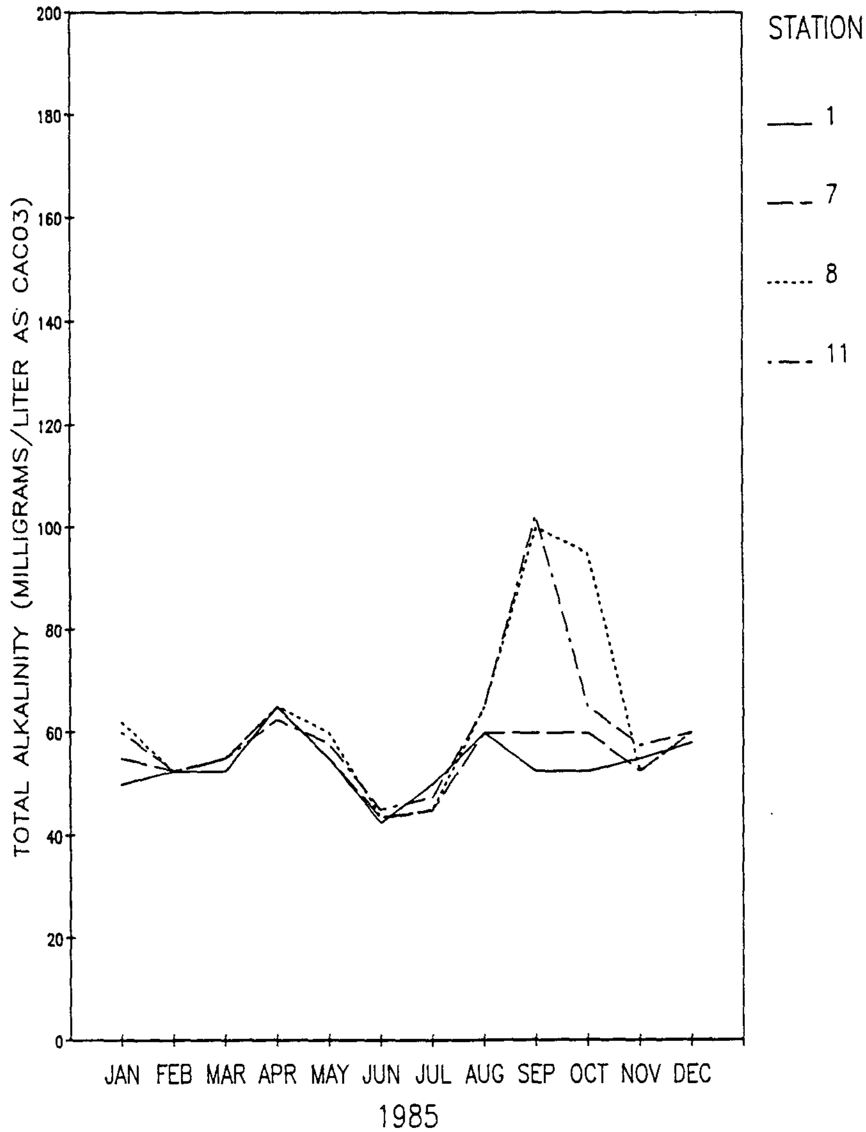

Figure 4-4. Columbia River Total Alkalinity at Four Stations for 1985

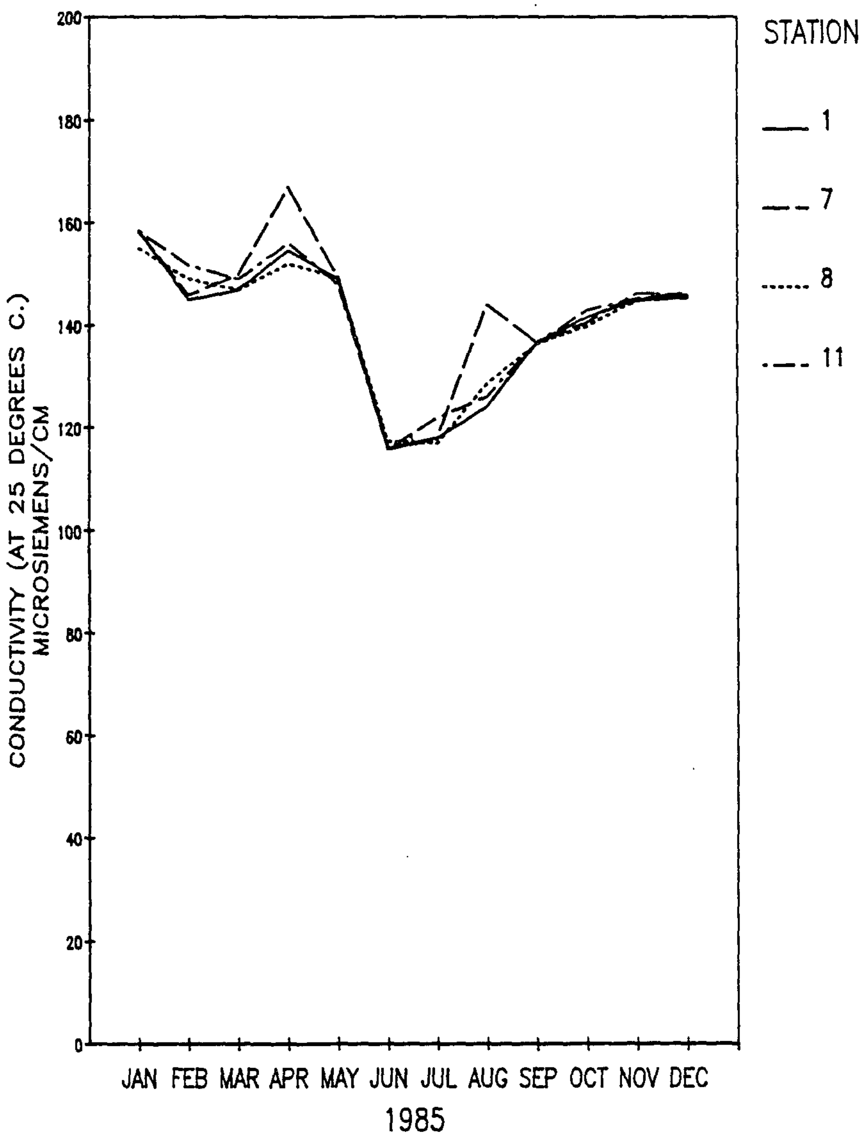

Figure 4-5. Columbia River Conductivity at Four Stations for 1985

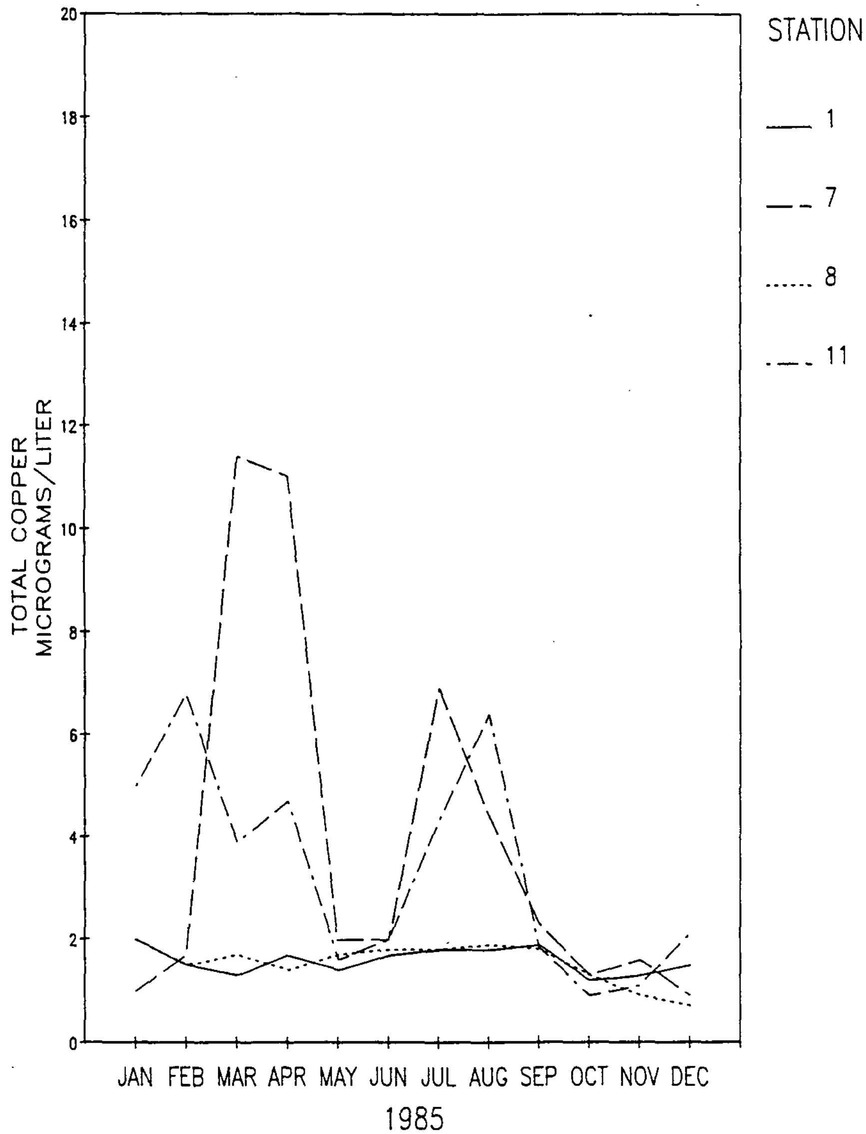

Figure 4-6. Columbia River Total Copper at Four Stations for 1985

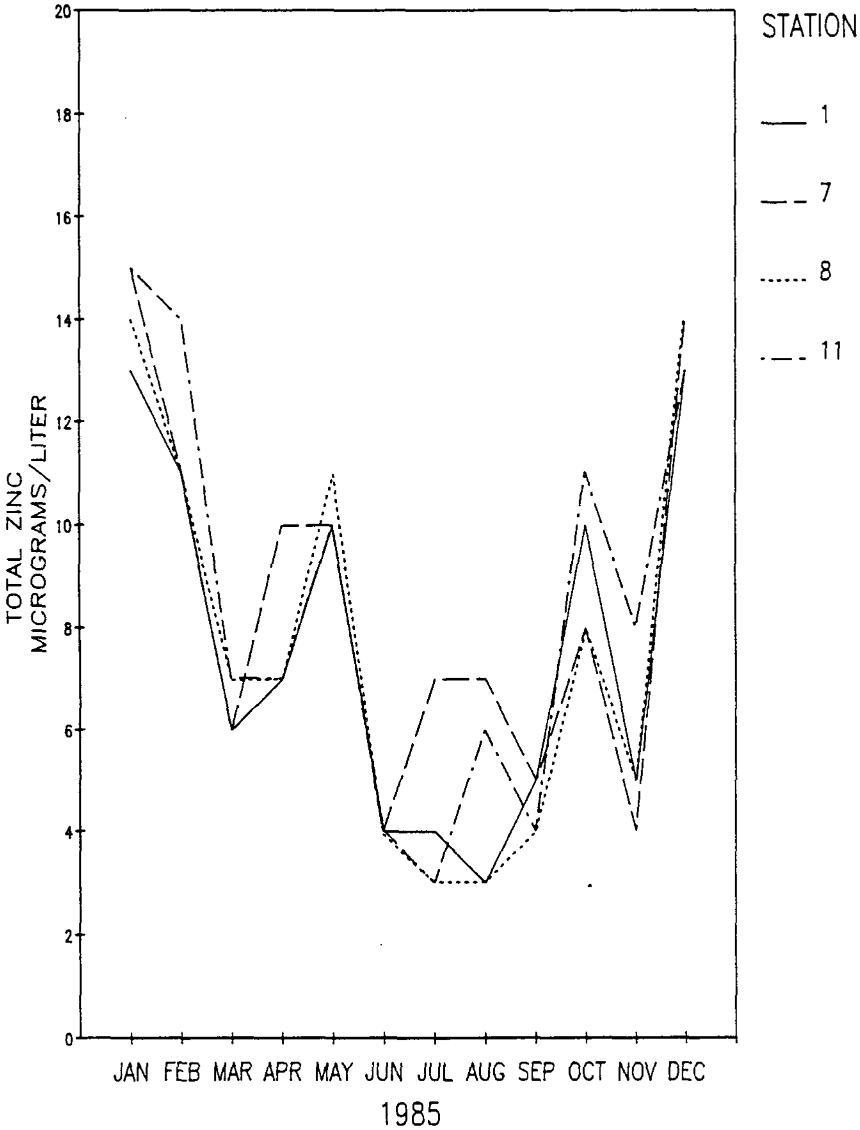

Figure 4-7. Columbia River Total Zinc at Four Stations for 1985

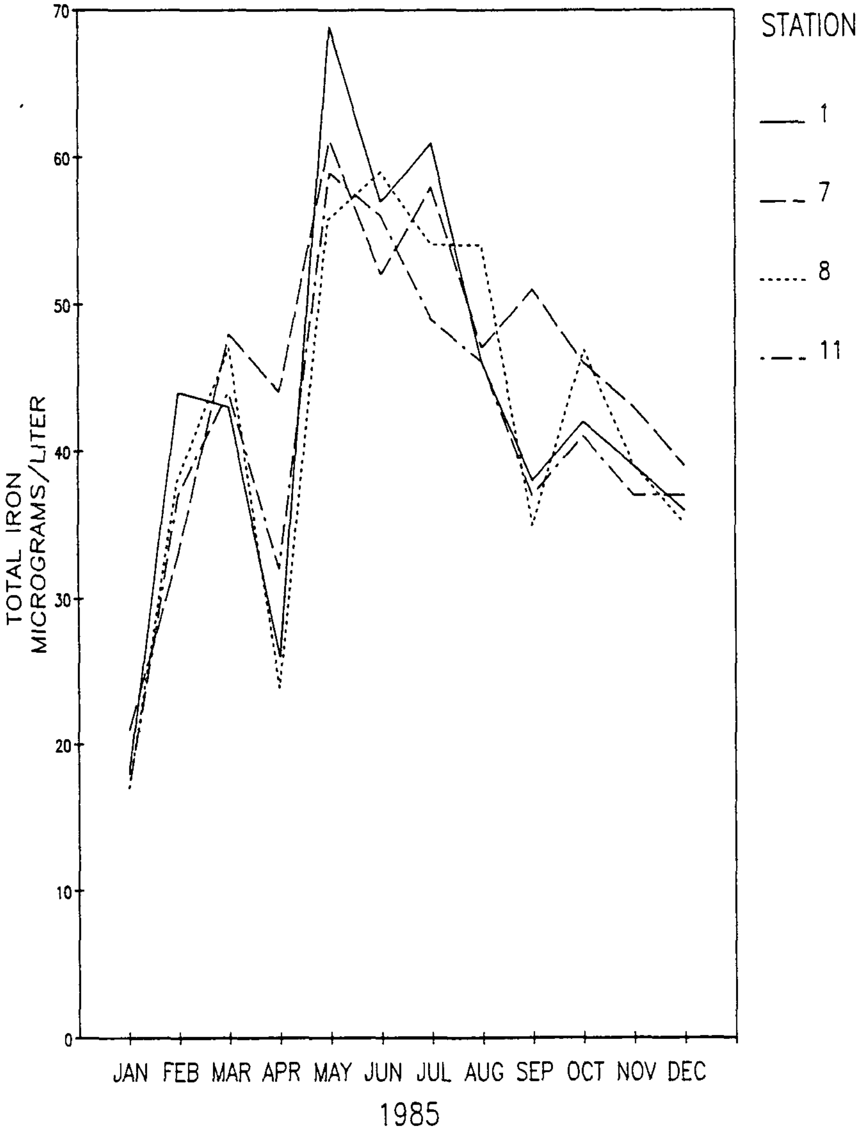

Figure 4-8. Columbia River Total Iron at Four Stations for 1985

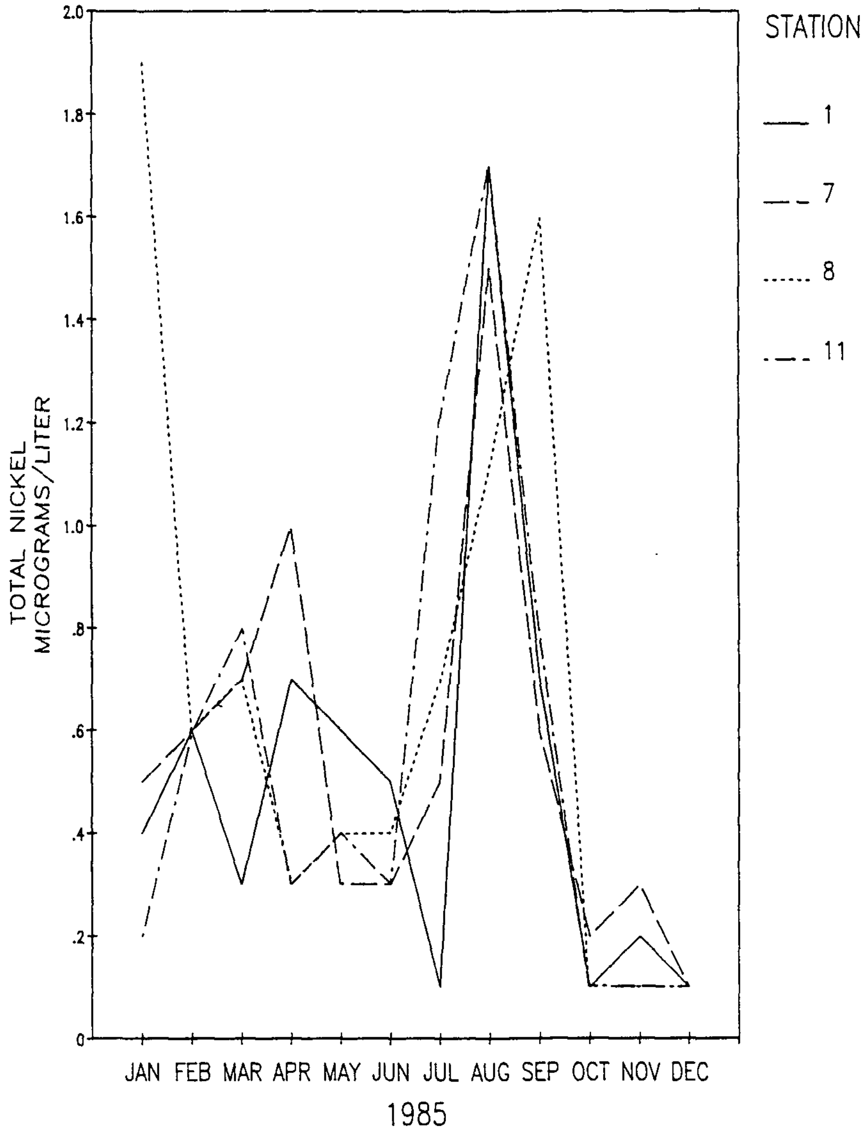

Figure 4-9. Columbia River Total Nickel at Four Stations for 1985

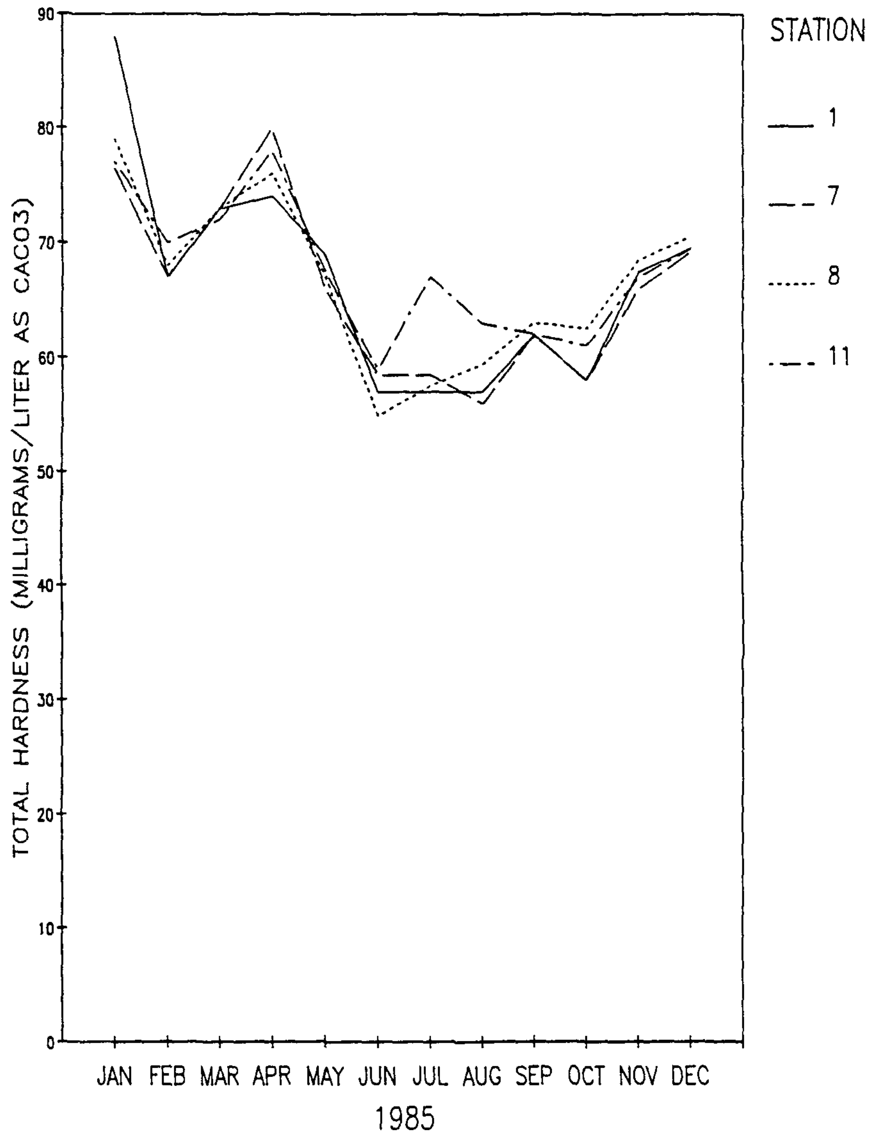

Figure 4-10. Columbia River Total Hardness at Four Stations for 1985

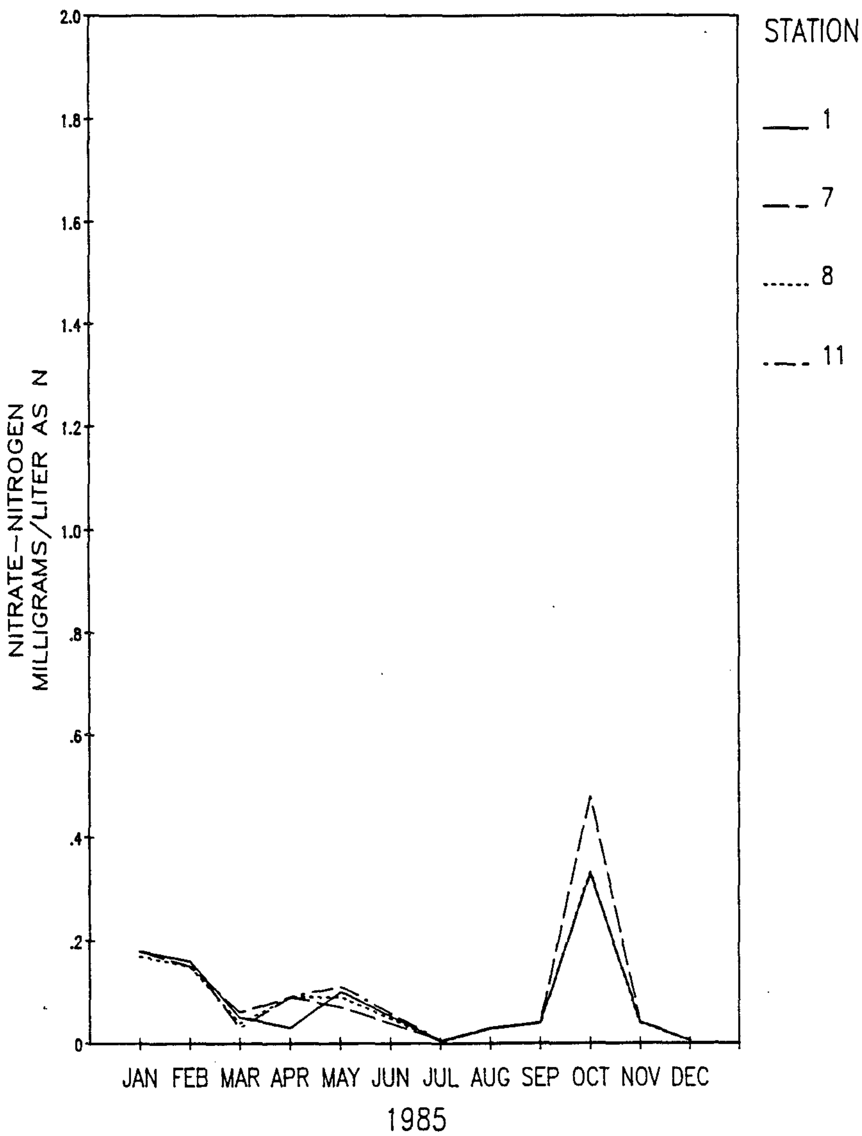

Figure 4-11. Columbia River Nitrate Nitrogen at Four Stations for 1985

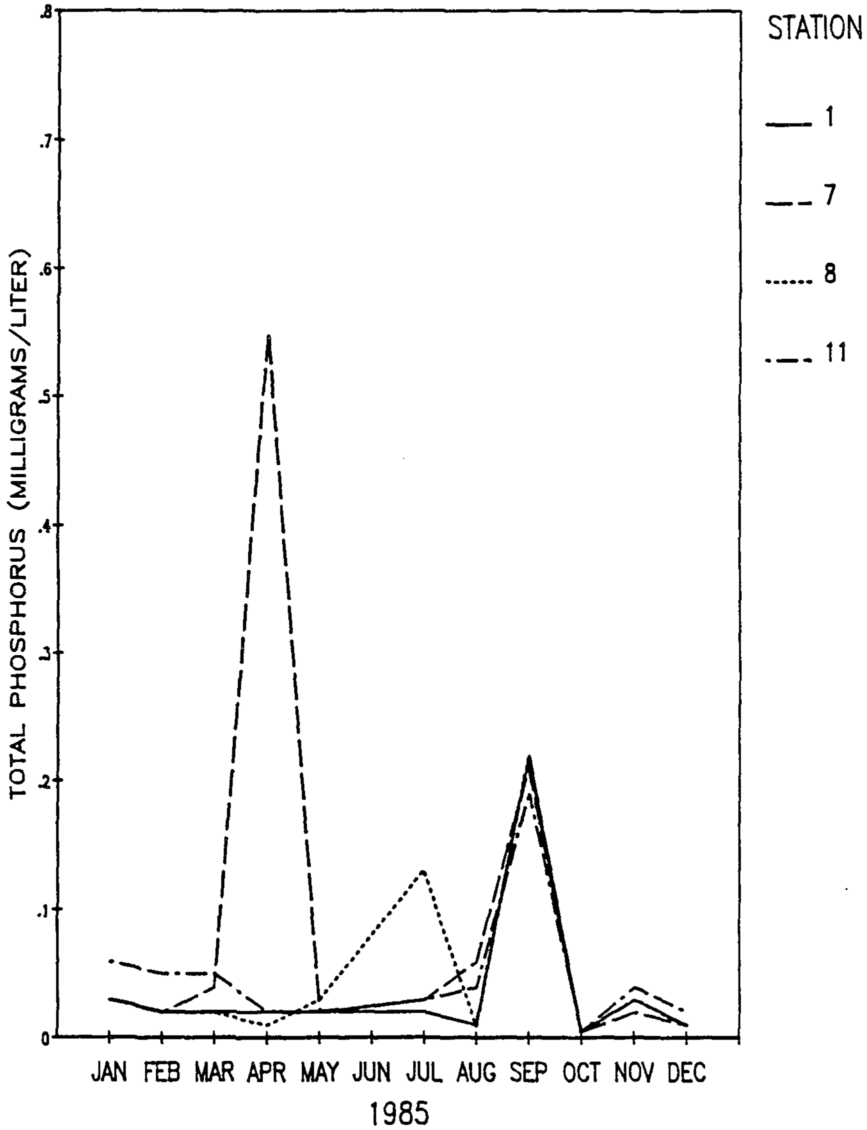

Figure 4-12. Columbia River Total Phosphorus at Four Stations for 1985

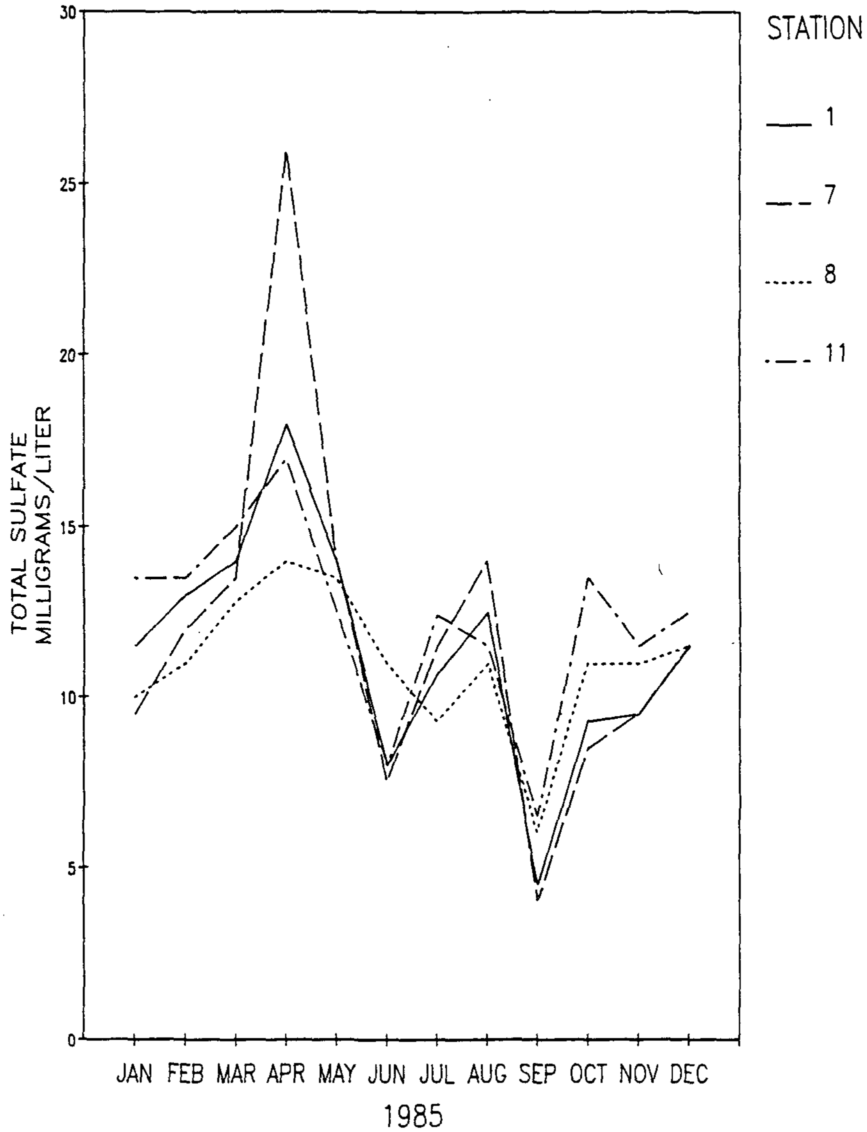

Figure 4-13. Columbia River Total Sulfate at Four Stations for 1985

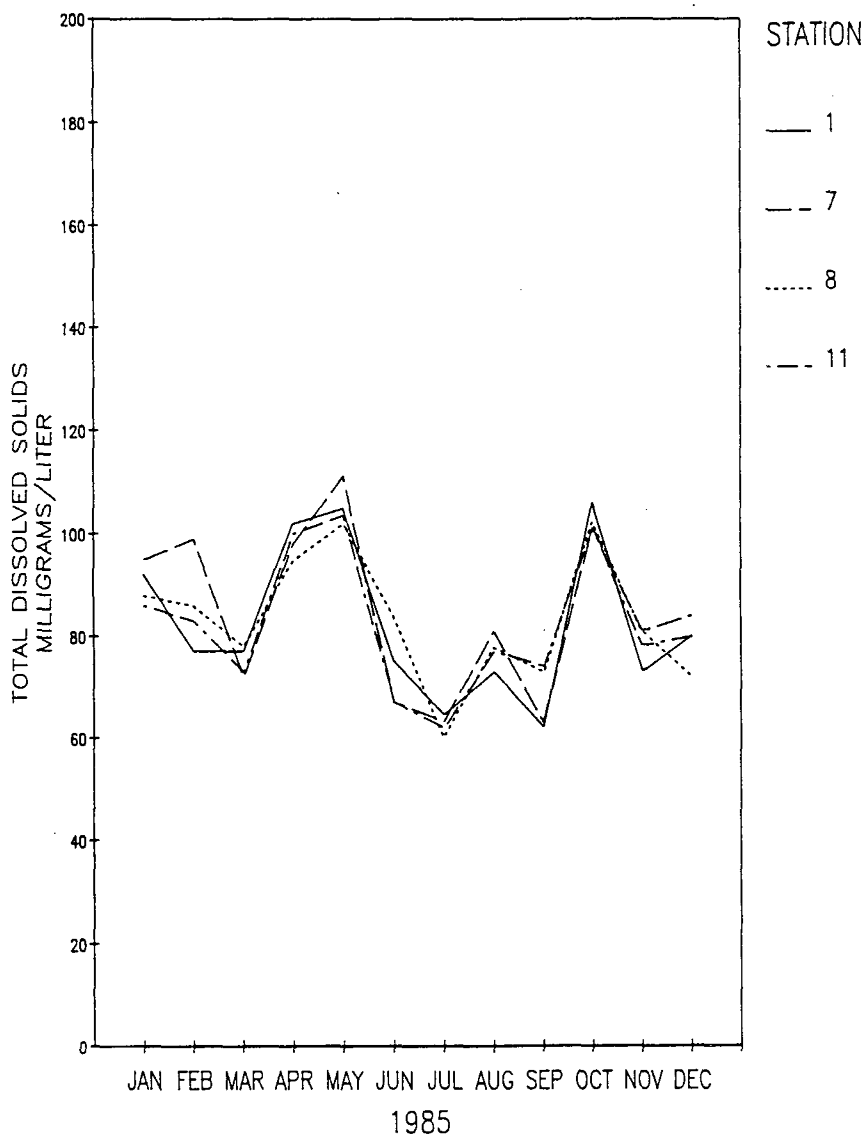

Figure 4-14. Columbia River Total Dissolved Solids at Four Stations for 1985

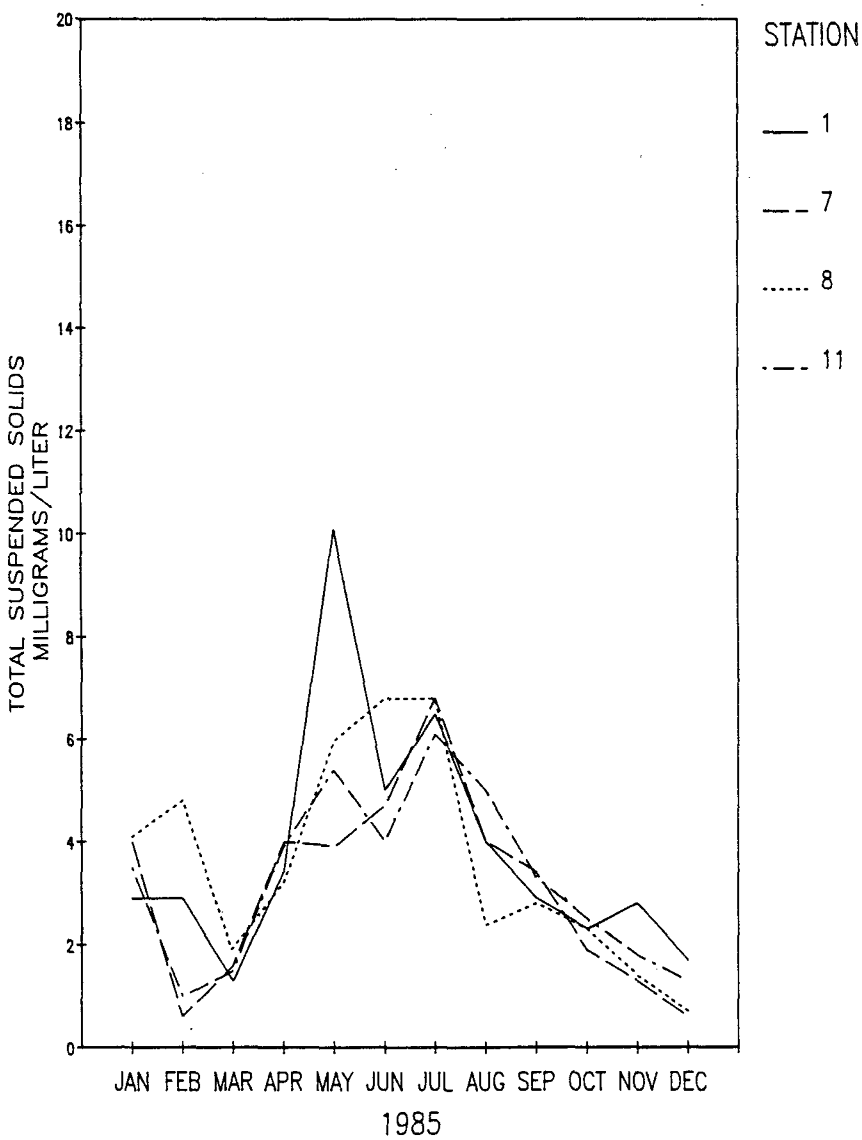

Figure 4-15. Columbia River Total Suspended Solids at Four Stations for 1985

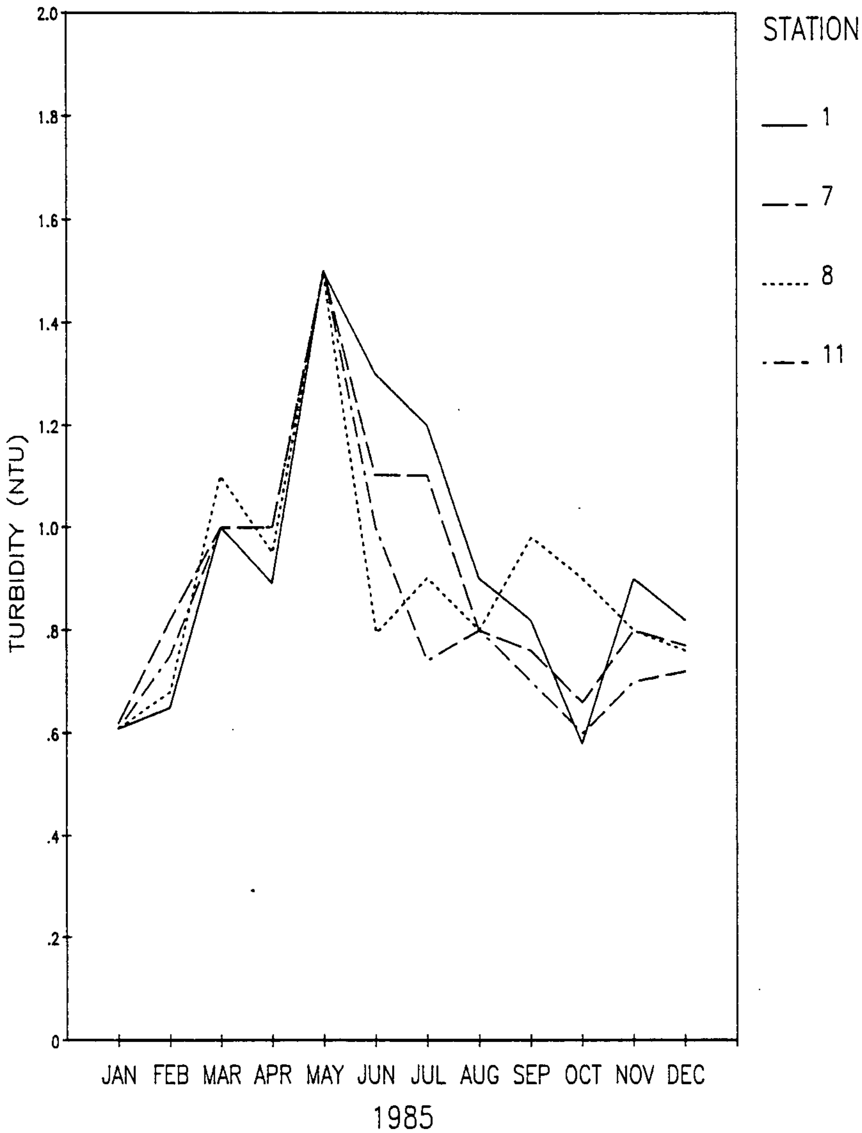

Figure 4-16. Columbia River Turbidity at Four Stations for 1985

5.0 FISH IMPINGEMENT AND INTAKE STRUCTURE FOULING SURVEYS

5.1 INTRODUCTION

Columbia River water is removed through two perforated stainless steel intake structures (Figure 5-1) and pumped to WNP-2 where it is primarily used to replace cooling water loss to evaporation and drift. Each intake structure is 107 cm (42 in) in diameter and approximately 6 m (20 ft) in length. Water is removed through four perforated pipe sections (2 each per intake structure) each 2 m (6.5 ft) in length with 0.95 cm (3/8 in) circular holes. A 91 cm (36 in) diameter perforated internal sleeve is used to equalize flow. Abnormal flow conditions may result in 47,300 to 94,600 liters per minute (lpm) (12,500 to 25,000 gpm) being removed from one intake structure, with the respective modeled (Washington Public Power Supply System, 1977) entrance velocities of 0.2 to 0.34 mps (0.50 and 1.1 fps). Under normal operating conditions 47,300 lpm (12,500 gpm) is removed through both intake structures (24,000 lpm or 6,250 gpm per structure) with an estimated entrance velocity of 0.05 mps (0.15 fps). River velocities measured near the perforated pipes ranged between 1.22 and 1.53 mps (4 to 5 fps). Inspections of the intake structures are to be conducted monthly March through November (Section 1.1).

5.2 METHODS AND MATERIALS

Historical studies were conducted between 1978 and 1979 (Beak Consultants, 1980; Mudge et. al., 1981) using SCUBA divers. Routinely divers inspect and report any fish impingement on or interaction with the intake structure, the need for maintenance, unusual conditions such as accumulation of submerged debris, and plugging of water entrance orifices by periphyton. Video tape record logs of intake fouling are made in the spring and fall at four stations (two per intake), each measuring approximately 400 cm^2 (64 in^2) in size. The intakes had been operating continuously prior to each survey.

5.3 RESULTS AND DISCUSSION

Nine surveys (Table 5-1) were conducted during the year. At no time were any fish observed impinged on the intake screens. All fish interactions with the intake structures were positive (of benefit to the fish). The intake supports and surrounding rip rap provide cover and resting areas for large scale suckers, white fish, sculpins, squawfish, bass, redside shiner and shad. An unusually dense growth of sponges was noted on the rip rap surrounding the intakes in July. By October the sponges had established several colonies on the intakes but had died back to normal abundance by the November survey. At no time during the year did fouling by algae, insects, sponges or plastic debris impact proper operation of the intakes.

Video recordings of the four stations were made in the spring and fall of 1985. These tapes provide a permanent record for monitoring changes in periphyton fouling.

5.4 BIBLIOGRAPHY

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Mudge, J.E., G.S. Jeane II, K.P. Campbell, B.R. Eddy and L.E. Foster. 1981. Evaluation of a perforated pipe intake structure for fish protection. In: Advanced intake technology for power plant cooling water systems.

Washington Public Power Supply System. 1977. WNP-2 environmental report operating license stage. Richland, WA.

Table 5-1. Impingement/Fouling Surveys for 1985

Date	TMU[1] Pumping Rate (GPM)[2]	River Flow (CFS)[3]	River Velocity (FPS)[4]	Video Record
March 13	21,000	90,000	--	Yes
April 22	15,000	100,000	--	--
May 20	7,000	120,000	--	--
June 5	7,500	113,000	--	--
July 25	19,000	83,000	4.8	--
August 13	22,000	73,000	--	--
September 5	20,500	70,000	--	Yes
October 8	16,000	110,800	--	--
December 3	18,000	135,000	--	--

[1]TMU = Tower Makeup Pumphouse located on the Columbia River.

[2]Gallons per minute.

[3]Estimated flow cubic feet per second.

[4]Feet per second (one foot below surface near intakes).

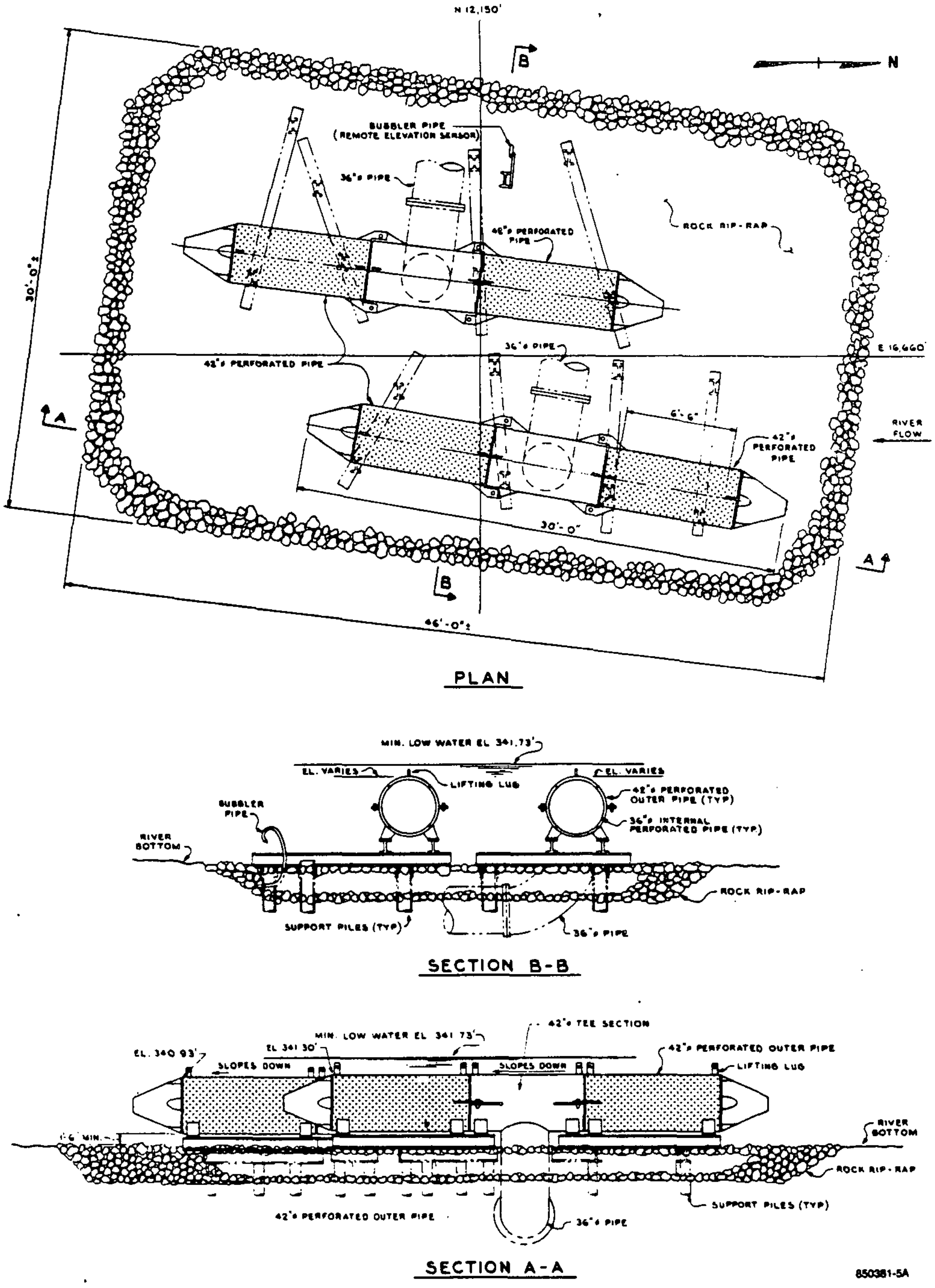

Figure 5-1. Vertical and Cross Sectional Views of WNP-2 Intake Structure

6.0 CORBICULA CLAM SURVEYS

6.1 INTRODUCTION

The Asiatic clam (Corbicula) has become a water system maintenance and production problem for many plants which utilize raw river or lake water throughout the United States. Originally introduced into the US in the Columbia River near Knappton, Washington in 1938 (Smith, 1979), by 1982 the clam had been reported from 35 of the continental states (McMahon, 1982). Initial reports of the clams becoming a nuisance were reported in 1953 from southern California. In 1960 the Tennessee Valley Authority reported cooling water system plugging problems at steam units. In 1980 biofouling by Corbicula of safety-related system components necessitated shutdown of Arkansas Nuclear One. Corbicula biofouling problems are usually limited to water systems using fresh untreated water. While the majority of damage is due to plugging by relic clam shells, screen plugging by clam bodies following massive natural die offs, and pump impeller damage has also been documented (Smith, 1979).

The clams live from 1 to 6 years and in warm water may grow to 21 mm (0.8 in), 31 mm (1.2 in), 36 mm (1.4 in) and 40 mm (1.6 in) after 1, 2, 3, and 4 years, respectively. The clams incubate their young in their gill cavity. The veliger larvae are discharged and passively carried by water currents for several hours at which time the pediveliger larvae has developed a foot and byssal thread which assists in attachment to a substrate.

Densities of 10,000 to 20,000 clams/m^2 have been reported (Dreier, 1980). Spring and fall spawning has been reported for some populations. Corbicula clams can inhabit water down to 12 m (40 feet) and are not susceptible to desiccation, enabling them to be transported for long distances by man or water fowl.

In response to the Nuclear Regulatory Commissions Inspection and Enforcement Bulletin 81-03 the Supply System developed a Corbicula monitoring program to detect clam infestations of cooling/emergency water systems prior to a problematic population level.

6.2 MATERIALS AND METHODS

Inspections by SCUBA divers of the Tower Makeup (TMU) Pumphouse (TMU), cooling tower basins, circulating water pumphouse, and the auxillary cooling spray ponds were undertaken. Additional inspections of screens, water boxes, and fire lines have been conducted.

6.3 RESULTS AND DISCUSSION

During 1985 nine inspections were conducted to evaluate the range of inhabitation in plant systems (Table 6-1). Live Corbicula clams were observed in the rip rap at the foot of the river intake structures (Figure 5-1). In addition, relic shells were recovered from the circulating water pumphouse screens and one shell was collected from the main condenser.

Previously, clams, relic shells and the fresh water mussel (Margaritifera) have been found at the TMU pump house.

In summary, a population of Corbicula clams resides around the intake water structure in the Columbia River and the TMU pumphouse basin. As only shells have been recovered from the circulating water pumphouse and the condenser water box, the circulating water biofouling control program appears to be controling clam infestations.

6.4 BIBLIOGRAPHY

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McMahon, R.F. 1982. The occurrence and spread of the introduced asiatic freshwater clam, Corbicula fluminea (Müller), in North America: 1924-1982. The Nautilus, 96(4).

Smith, A.L., et al. 1979. Clams-a growing threat to inplant water systems. Plant Engineering. June 14, 1979. File No. 7510.

Table 6-1. Summary of *Corbicula* Clam Surveys

Date	Location	Area Inspected	Observation
January 21	Plant Standpipe Crossconnect	15,000 gal	None Located
March 1	Spray Pond A & B	150 sq ft/ea	None Located
May 13	Cooling Towers-	Several Towers	None Located
	Circulating Water	All	15-20 Shells
	Pumphouse Main Condensers-Water Boxes	All	1 Relic Shell
June 5	Tower Makeup Pumphouse	Small Area	None Located
October 25	Plant Yard Fire Mains	20,000 gal	None Located
October 25	Plant Yard Fire Mains	40,000 gal	None Located
November 15	Tower Makeup Pumphouse	200 sq ft	Adult and Juvenile Clams and Relic Shells Collected
November 26	Plant Standpipe Crossconnection	20,000 gal	None Located
December 21	Deluge System #51	10,000 gal	None Located

7.0 TERRESTRIAL - VEGETATION

7.1 INTRODUCTION

In 1974, Battelle Northwest was awarded a contract to conduct preoperational terrestrial monitoring for Washington Public Power Supply System Nuclear projects 1, 2, and 4 (Rickard and Gano 1977, 1979). In 1980, Beak Consultants Inc. took over the program and continued through 1982 (Beak 1980, 1981, 1982) when the Supply System assumed responsibility (Northstrom et. al. 1984, 1985). Vegetation studies were conducted from May 1 through May 14, 1985 as a continuation of the program.

The purpose of the vegetation studies is to identify any impact of cooling tower operation upon the surrounding plant communities as well as any edaphic impacts. The program includes the measurement of herbaceous and shrub canopy cover, shrub density, herbaceous phytomass, vegetation chemistry, and soil chemistry. Soil chemical parameters measured include pH, carbonate, bicarbonate, fluoride, sulfate, chloride, sodium, potassium, calcium, magnesium, copper, zinc, lead, chromium, nickel, cadmium, mercury and conductivity. Vegetation chemistry includes extractable sulfate, chloride and total copper.

WNP-2 is located approximately 5 km from the west bank of the Columbia River and 19 km north of the Richland city center (Figure 7-1). Elevation ranges from 114 m at the river to approximately 152 m at the most distant study plots. Climatically, the area exhibits rather extreme seasonal temperature fluctuations with a mean maximum July temperature of about 33°C and a January mean minimum temperature of -4°C. Annual rainfall averages 20 cm with less than 25% falling between April and October (Phillips 1972).

The site lies within the boundaries of the Columbia Basin, an extensive area south of the Columbia River between the Cascade Range and Blue Mountains in Oregon and approximately two thirds of the area lying east of the Cascades in Washington. Underlying the study area is the Columbia River Basalt Formation, a vast area formed during the Miocene epoch from huge lava outflows and ranging in thickness from 600 to 1500 meters (Franklin and Dyrness 1973). All of the soils in the Columbia Basin were apparently formed under grassland conditions, however, a diversity of soil types exists most of which correlate to regional climatic differences. The dominant soils include Camborthids, Haploxerolls, Xerorthents, Haplargids, Haplaquolls, Torripsamments and Rockland (Franklin and Dyrness 1973).

Most of the plant growth in the region occurs quickly during May and June followed by a gradual death of herbaceous foilage as the summer progresses. Frequently, perennial and annual forbs, such as Psoralea lanceolata, and Bromus tectorum will exhibit a burst of growth during the fall before the first frost occurs and winter dormancy begins. The cold wet winters will support the growth of some species at least on an intermittent basis.

Daubenmire (1970) divided the Columbia Basin shrub steppe region into nine zonal associations based upon climax vegetation. These zones have differentiated in response to various climatic and edaphic conditions including temperature, precipitation, soil type, etc. WNP-2 is located within the driest of the nine zones known as the Artemisia-Agropyron association. The region occupies the central portion of the Columbia Basin and extends west to the foothills of the cascade range (Figure 7-2). The zone includes four distinct layers of vegetation: (1) a layer of shrubs dominated by Artemisia tridentata, Purshia tridentata, Chrysothamnus nauseosus and C. viscidiflorus with a few other shrubs occasionally present; (2) a layer of caespitose perennial grasses dominated by Agropyron spicatum, Sitanion hystrix, Stipa comata and Agropyron dasystachum; (3) a layer of herbaceous annual and perennial forbs extending to approximately 15 cm from the soil surface. These include such species as Bromus tectorum, Festuca octoflora, Poa sandbergii, Astragalus sclerocarpus, Brodiaea douglasii, Descurainia pinnata, Phlox longifolia, and Plantago pategonica; (4) a crustose layer of lichens and mosses including Tortula brevipes, Aloina rigida, Bryum argenteum and Candelaria vitellina.

Epiphytic lichens (e.g., Candelaria concolor, Physcia grisea and Letharia vulpina) as well as mosses (e.g., Tortula ruralis) are common on the stems of Artemisia and Purshia.

Structural and successional changes in Artemisia-Agropyron community structure have been associated with grazing, farming and periodic fires. Grazing was probably of only minor importance in this region prior to the arrival of European settlers as only deer, elk, and antelope were present in large numbers prior to the introduction of the horse. It appears that buffalo were never a major grazing factor in this region as they were in the great plains (Galbraith and Anderson 1971).

When cattle were introduced in 1834 (Daubenmire 1970) their numbers increased rapidly to an estimated 200,000 by 1855 (Cotton 1904). The result of the grazing pressure created by large herds of cattle, sheep and horses was to reduce the presence of the large perennial grasses and to increase the presence of certain alien species which were well adapted to the steppe, most notably Bromus tectorum.

It appears that fire was not a major factor in the development of steppe vegetation climaxes prior to the introduction of cattle. Daubenmire (1970) indicated that steppe aborigines would have had little use for controlled fires since few game animals could be harvested through its use. Bromus tectorum was introduced into the state in about 1890 (Klemmedson and Smith 1964). Today it has become ubiquitous throughout the Artemisia-Agropyron zone. It is the most common plant to move into an area which has been grazed excessively, burned or abandoned after cultivation. Even though B. tectorum may be preceded by other aggressive annuals such as Sisymbrium altissimum or Salsola kali, they generally will be reduced to a minor role in a few seasons. Once established, it appears that Bromus tectorum seldom gives up its claim to overgrazed or abandoned soils. Bromus communities appear to remove sufficient soil moisture so as to prevent recolonization by native perennial grasses such as Agropyron (Daubenmire 1970). Also, the early development of the Bromus seedling which occurs in the fall at the beginning of the rainy season and the continued development of its root system during the winter (Harris 1967) help to assure the success of this alien species by permitting maximum usage of available soil moisture during the spring months. Also, its root system is capable of extending beyond two meters. (Hulbert 1955)

Although Bromus tectorum is highly palatable to livestock in its early stages of development, its introduction has markedly and irreversibly degraded the steppe vegetation by displacing native perennial grasses following disturbances. In addition, its high yearly variation in productivity and high flammability increase its undesirability as a permanent member of the steppe vegetation.

Sampling was conducted at each of nine permanent sites, four grassland sites, G01-G04, and five shrub sites, S01-S05. Figure 7-1 shows the location of each site. The orientation of the various components including transects and productivity plots within each community are depicted in Figure 7-3. Sites G01, G02, and G03 are extensively disturbed grassland areas dominated by annuals within close proximity to the plant. They are devoid of shrubs and consist largely of introduced Eurasian species including Bromus tectorum, Draba verna, Sisymbrium altissimum, Microsteris gracilis var. humilior, Holosteum umbellatum, Descurainia pinnata, Salsola kali, Franseria acanthicarpa, and Amsinckia lycopsoides. Site G04, located approximately 3 km south of WNP-2, was at one time severely disturbed by overgrazing, but appears to be in a relatively advanced stage of recovery as evidenced by the high cover values exhibited by the perennial grasses Stipa comata and Poa sandbergii.

Sites S01 and S03 are highly disturbed sites located approximately 2 km from WNP-2. They are mixed shrub sites characterized by the presence of Artemisia tridentata, Purshia tridentata, Chrysothamnus nauseous, C. viscidiflorus, Opuntia polyacantha, and Eriogonum niveum together with a variety of bunch grasses, Bromus tectorum, and a variety of annual and perennial forbs. Site S05 lies approximately 8 km southeast of WNP-2. The site was a mixed shrub community, however, a fire in 1981 destroyed most of the shrubs reducing the cover to less than 1%. Site S02 lies on the periphery of a series of sand dune clusters which occur sporadically in west central Benton County along the Columbia River. The S02 sampling plot occurs within a stabilized area well below the average height of the dunes. It supports a population of Purshia tridentata, Chrysothamnus nauseosus, and C. viscidiflorus. Beneath the shrub canopy is usually an abundance of litter and a dense population of Bromus tectorum. Well represented between shrubs are Poa sanbergii, Agropyron spicatum, Achillea millefolium, Cymopteris terebinthinus, Draba verna, Holosteum umbellatum and Microsteris gracilis var. humilior. On the leeward side of adjacent large dunes are found populations of Agropyron dasystachyum and Rumex venosus while the windward sides contain chiefly Psoralea lanceaolata and Elymus flavescens. On some of the more stabilized dune surfaces occur Koeleria cristata, Oryzopsis hymenoides, Stipa comata, Penstemon acuminatus, Arenaria franklinii, Cryptantha leucophaea and Fritillaria Pudica. Also observed near the S02 boundary was a mature population of Leptodactylon pungens.

Given the low precipitation level of the region, operation of the cooling towers should increase the concentration of some components of the cooling water matrix in the local soil profile. In time, these concentrations could reach levels which would inhibit the growth of native or cultivated vegetation living within the drift zone. The nature and extent of these effects can only be determined by monitoring such parameters as productivity, vegetation cover and frequency, and soil chemistry over time and comparing the data with preoperational baseline studies.

Extrapolating predictive dose-response data on salt drift damage to vegetation in a natural situation is difficult, if not impossible. Using predictive models and a variety of assumptions the salt deposition rates presented in Table 7-1 were estimated as part of required preoperational monitoring and environmental impact analysis. Since salt drift transport is largely determined by local meteorology, predictive models and laboratory situations may not be representative of cooling tower drift under actual plant operating conditions.

Predicted isopleths of salt drift deposition from the operation of the mechanical draft cooling towers of WNP-2, based on conservative assumptions, are presented in Figures 7-4 and 7-5. It is evident that if all the salt were to be confined to the soil profile, values as high as 16,000 pounds per acre could be realized over the 40 year operating life of the plant. The most commonly used parameter for estimating the overall quantity of salt present within a soil is the electrical conductivity of a saturation extract or water leachate from the soil sample. It appears that little or nothing is known of the salt tolerance of most of the plant species living within the shrub steppe region surrounding WNP-2. However, much data exists relating cultivated plant productivity and soil conductivity. Table 7-2 summarizes some data relating soil conductivity to three levels of yield reductions in several species of cultivated plants (Carter 1975).

7.2 MATERIALS AND METHODS

Fifty microplots (20 cm x 50 cm) were placed at 1-m intervals on alternate sides of the herbaceous transect (Figure 7-3). Canopy cover was estimated for each species occurring within a microplot using Daubenmire's (1968) cover classes. Data were recorded on standard data sheets.

Quality assurance was accomplished by twice sampling three randomly selected microplots on each herbaceous transect. The entire transect was resampled if cover estimates for any major species (> 50 percent frequency) differed by more than one cover class.

7.2.1 Herbaceous Phytomass

Phytomass sampling was conducted concurrently with cover sampling. Phytomass sampling plots were randomly located within an area adjacent to the permanent transects or plots (Figure 7-3). At each study site, all live herbaceous vegetation rooted in five randomly located microplots (20 x 50 cm) was clipped to ground level and placed in paper bags. Each bag was stapled shut and labeled with site code, plot number, date and personnel.

Sample bags were transported to the laboratory, opened, and placed in a drying oven at 50°C for 24 hours. Following drying, the bags were removed singly from the oven and their contents immediately weighed to the nearest 0.1 g. Laboratory quality assurance consisted of independently reworking 10 percent of the phytomass samples to assess data validity and reliability.

7.2.2 Shrub Canopy Cover

Five 50-m lines were used to measure shrub canopy cover in each of the five shrub plots (Figure 7-3). Whenever a shrub was crossed by a tape stretched between the end posts, its species and the distance (cm) at which it intercepted the line were recorded. For each shrub plot, intercept distances of each species along all five lines were summed to give a total intercept distance. From this, a shrub canopy cover value (percent) was obtained by dividing total intercept distance by total line length.

Quality assurance procedures consisted of twice sampling one major species along a randomly selected shrub transect. Resampling was conducted if intercept lengths differed by more than 10 percent.

7.2.3 Shrub Density

Individual live shrubs were counted and recorded by species within each of the four strips delineated by shrub intercept transects (Figure 7-3). Numbers per strip were summed to obtain shrub density by species for the entire 1000 m^2 plot. Sampling was concurrent with cover sampling.

Quality assurance consisted of resampling one randomly selected species within one strip. Resampling was conducted if the count difference exceeded one individual.

7.2.4 Soil Chemistry

At each of the nine grassland and shrub sites, five 500 ml soil samples were collected from the top 15 cm of soil with a clean stainless steel trowel. The sample was placed in two 250-ml sterile plastic cups with lids, labeled and refrigerated at 4°C. Eighteen parameters were analyzed in each sample including pH, bicarbonate, carbonate, conductivity, sulfate, chloride, fluoride, copper, zinc, nickel, cadmium, lead, mercury, chromium, calcium, magnesium, sodium and potassium. Samples were analyzed for pH, bicarbonate, carbonate, sulfate, chloride and conductivity according to Methods of Soil Analysis (1965). Samples for zinc, calcium, magnesium, sodium and potassium were analyzed by flame atomic absorption spectroscopy according to Methods For Chemical Analysis of Water and Wastes (USEPA 1983). Mercury was analyzed by cold vapor atomic absorption spectroscopy according to (USEPA 1983). Samples for copper, cadmium, lead, nickel and chromium were analyzed by graphite furnace atomic absorption spectroscopy according to EPA (USEPA 1983). Fluoride samples were analyzed by specific ion electrode utilizing a sodium carbonate fusion analysis developed at AM Test Laboratories Inc., Seattle, Washington (Appendix B). Aliquots of soil for trace metal analyses were digested according to Procedures for Handling and Chemical Analysis of Sediment and Water Samples (Plumb 1981). Preservation times and conditions, when utilized, were according to USEPA (1983).

Laboratory quality control comprised approximately 20% of the sample analysis load. National Bureau of Standards river sediment samples were digested and analyzed along with each batch of soil samples. Routine quality assurance analyses included internal laboratory standards, externally prepared EPA controls, reagent blanks and yearly blind EPA performance samples.

7.2.5 Vegetation Chemistry

Samples of *Bromus tectorum*, *Poa sandbergii*, *Artemisia tridentata* and *Purshia tridentata* were collected at each site. Two species were substituted at some of the sites due to absence of one or more of those listed above. Substitute species were *Phlox longifolia* and *Sisymbrium altissimum*. Samples were collected at the same time as soil samples and as close to the soil sampling site as possible. Sufficient quantities of leafy material of each species were collected to yield at least five grams of dry weight. The clipped material was sealed in a plastic bag, labeled and refrigerated at 4 degrees C until analyzed.

In the laboratory, the clipped plant tissue was oven dried to a constant weight, ground in a Wiley mill and digested according to Plumb (1981). Sulfate was analyzed by nephalometry and chloride by mercuric chloride titration according to USEPA (1983). Copper was analyzed by graphite furnace atomic spectroscopy according to USEPA (1983).

7.3 RESULTS AND DISCUSSION

During the 1985 season, 58 plant taxa were observed in the study area. These are presented in Table 7-3. Table 7-4 lists by year the species of vascular plants observed during field activities from 1975-1985.

7.3.1 Herbaceous Cover

Herbaceous cover data for 1985 are contained in the appendix and summarized in Table 7-5. Figures 7-6, 7-7, 7-8 and 7-9 provide a comparison with the data of previous years.

On August 11th and 12th of 1984 a fire burned approximately 300,000 acres of rangeland within the Columbia Basin, most of which was on the Hanford Reservation. The fire destroyed most of the vegetation on Sites G01, G02, S01, S02 and S04 and exerted a marked effect on the herbaceous and shrub cover produced during the 1985 season.

Total herbaceous cover averaged 32.45% in the study area. At grassland sites average herbaceous cover was 43.48% and at shrub sites it was 30.12%. *Bromus tectorum* continued to dominate herbaceous vegetation in the study area, accounting for 10.12% of total herbaceous cover.

Annual grasses averaged 10.27%, down from the 43.21% observed in 1984. The dominant annual grass observed at all stations was Bromus tectorum. Festuca octoflora was present only at Site S04 (1.35%) and was down in cover from 1984 (2.4%).

Mean herbaceous cover was markedly reduced in 1985 from 1984 (32.45% vs. 64.42%). Although annual precipitation was lower in 1985 than in 1984 (5.10 vs. 7.27 inches) it is likely the fire exerted the greatest influence upon 1985 cover. Many other factors other than fire and precipitation can influence the yearly fluctuations in cover values. These include other climatic and edaphic factors, the cyclic production of seed (Hulbert 1955) and litter thickness.

Perennial grasses averaged 8.86% or 27.30% of the total in comparison to 6.82% and 10.75% in 1984. Poa sandbergii was the most abundant perennial grass at all sites except G03 and S05 where it did not occur. As in 1984, perennial grasses were absent at Site G03. The dominant perennial grass at Site S05 was Agropyron spicatum.

Annual forb cover averaged 11.91% as opposed to 11.73% in 1984 and still lower in 1983 and 1982. The most abundant annual forbs were Draba verna (4.02%), Holosteum umbellatum (2.27%), Tragopogon dubius (1.70%) and Microsteris gracilis (0.91%).

Perennial forb cover for 1985 averaged 1.41% which approximates the 1.65% measured in 1984. Overall, there has been little fluctuation since 1975 in the perennial forb cover, which would be expected since perennials are less susceptible to short-term climatic fluctuations than annuals.

Species composition in 1985 was similar to 1984. Site G02 had the greatest variety of annual forbs present while Site S03 had the greatest variety of perennials. Sites S04 and S05 were reduced considerably in species frequency from 1984, while site G02 increased. Species frequencies for 1985 are presented in Table 7-6.

7.3.2 Herbaceous Phytomass

Mean production of herbaceous phytomass in 1985 was 27.9 g/m^2 dry weight. Production varied widely among sites, from 1.4 g/m^2 at site S02 to 70.1 g/m^2 at site G01 (Figure 7-10). In 1985, grassland sites averaged higher herbaceous phytomass than shrub sites (36.4 vs. 21.2) and Site G01 had the highest phytomass production of all sites.

Mean herbaceous phytomass production at grassland sites and at shrub sites is shown graphically in Figure 7-11. The grassland sites show considerably more variability from year to year than do the shrub sites. Table 7-7 presents mean phytomass values for each site in each year, while Figure 7-9 presents mean herbaceous cover values at grassland and shrub sites since 1975, for comparison with the phytomass data presented in Figure 7-10.

7.3.3 Shrub Cover and Density

Shrub cover and density data for 1985 are included in Appendix B. Table 7-8 summarizes shrub cover data for 1985. There are four shrub species present in the study area: *Artemisia tridentata*, *Purshia tridentata*, *Chrysothamnus nauseosus*, and *Chrysothamnus viscidiflorus*. *Eriogonum niveum* (a subshrub) and *Opuntia polyacantha* (a cactus) are also present. *Leptodactylon pungens* was observed near Site S02 in 1984 but does not occur within the sampling plot.

During the August range fire all viable shrubs were completely destroyed at Site S04, while the only individuals surviving at site S01, were isolated clumps of low growing Eriogonum niveum. All mature shrubs were destroyed at Site S02 with only a few juvenile seedlings present in 1985. Shrub density at Site S03 was nearly identical to that observed in 1984. Site S05, which was burned in 1981, continued to show signs of recovery with an increase in juvenile forms of Purshia tridentata and Eriogonum niveum.

Shrub cover values reflected the August 1984 fire. Total shrub cover was reduced to zero at Sites S01, S02 and S04 while a slight increase was observed at Sites S03 (7.05 vs. 6.69) and S05 (2.18 vs. 1.61). Mean total shrub cover was reduced from 12.86% in 1984 to 5.00% in 1985.

Figure 7-12 presents the mean shrub cover values measured from 1975 through 1985.

Shrub cover and density at the five sample sites in 1985 are shown in Figure 7-13. Figure 7-14 shows the values for shrub density at each site for 1980 through 1985.

7.3.4 Soil Chemistry

The results of the 1985 soil chemical analyses are presented in Table 7-9 and are shown graphically in Figures 7-15 to 7-31. Soils at all sample sites range from sandy to sandy loam and contain a low percentage of clay.

Trace metal analyses for cadmium, mercury, lead, copper, chromium, nickel and zinc are within the ranges experienced in preoperational studies.

Values for sodium, potassium, calcium, magnesium, fluoride, chloride and sulfate were at the lower end of the ranges reported during preoperational studies.

Soil pH values ranged from 6.83 at Site G01 to 7.83 at Site S02. A slight decrease in pH was evident at Sites G01, G02 and G03.

Soil bicarbonate values were within the ranges experienced in previous studies.

Conductivity values exhibited a marked increase at Sites G01, G02 and G03 in comparison to data acquired in previous studies. Site G04 and all of the shrub sites were within the ranges of previous studies for conductivity.

After one year of plant operation, soils present at the nine sites sampled surrounding WNP-2 are within the ranges experienced in previous preoperational studies (1980-1984) with respect to seventeen chemical parameters. However, at Sites G01, G02 and G03, those sites closest to the cooling towers, a marked increase in conductivity, and a slight decrease in pH was evident. Continued inflation of these or other values should be readily apparent in future studies should it occur.

7.3.5 Vegetation Chemistry

The results of the 1985 vegetation chemical analyses are presented in Table 7-10 and shown graphically in Figures 7-32 through 7-34. Copper and chloride concentrations in *Bromus tectorum* and *Poa sandbergii* are presented in Figures 7-35 through 7-38.

Sulfate concentrations from 1980 to 1985 were very low for all species except *Sisymbrium altissimum*, as has been observed in previous years.

Extractable chloride concentrations ranged from 0.09% to 0.82% in 1985 and were similar to values reported for all species in previous years.

Copper concentrations ranged from 3.26 ug/gm to 10.98 ug/gm for all species examined and were also similar to concentrations observed in previous studies.

In summary, sulfate, chloride and copper concentrations in the six species of plant tissues examined in 1985 were relatively consistent and tended to cluster around the mean values reported in previous years. No correlations between soil and vegetation chemical concentrations were apparent.

7.4 SUMMARY AND CONCLUSIONS

7.4.1 Herbaceous Cover

The August 1985 fire markedly reduced the herbaceous cover at Sites G01, G02, S01, S02 and S04. Overall average cover was reduced from 63.42% in 1984 to 32.45% in 1985. Most of the reductions in cover occurred within the annual grass component of vegetation.

7.4.2 Herbaceous Phytomass

The fire also reduced 1985 average phytomass production. Mean herbaceous phytomass in 1985 was 27.9 g/m^2m down from the 89.2 g/m^2 observed in 1984. As in 1984, grassland sites averaged higher herbaceous phytomass production than did shrub sites.

7.4.3 Shrub Cover and Density

Nearly all mature shrubs were destroyed at Sites S01, S02, and S04 by the fire. Site S05 continued to show signs of recovery from the 1981 fire, while Site S03 demonstrated a slight increase in shrub cover. Mean total 1985 shrub cover was 5.00%.

7.4.4 Soil and Vegetation Chemistry

Trace metal analyses of soil and vegetation samples collected in May 1985 showed study area soils and vegetation to be within ranges reported in previous studies. Mean sulfate, chloride, bicarbonate and fluoride levels also tended to cluster about the values reported in previous studies. Soils collected at Sites G01, G02 and G03, sites closest to the cooling towers, exhibited increases in conductivity over those reported in previous years. A slight decrease in pH was also evident. Further changes in these or other parameters should be readily apparent in future studies.

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Table 7-1. Estimates of Salt Deposition Rates Versus Distance From Cooling Towers

Distance from Tower (miles)	Salt Deposition (lb/acre yr) Equal Direction Frequency	9%(1) from Single Direction	20% (1) from Single Direction
0 to 0.22	nil	nil	nil
0.22 to 0.28	271.0	390.0	867.0
0.28 to 0.33	166.0	239.0	531.0
0.33 to 0.6	0.4	0.6	1.3
0.6 to 3	0.7	1.0	2.2
3	0.7	1.0	2.2

(1)16-point compass presumed. Maximum wind direction frequency observed at WNP-2 site was 9%. Measurement elevation was 23 ft.

(2)16-point compass presumed. Maximum wind direction frequency observed at HMS site was 20%. Measurement elevation was 400 ft.

Table 7-2. Electrical Conductivity (millisiemens/cm) at Which 10%, 25%, and 50%, Yield Reductions Can Be Expected for Various Agricultural Crops

	Percent Yield Reduction		
	10	25	50
Field Crops	EC	EC	EC
Barley	11.9	15.8	17.5
Sugarbeets	10.0	13.0	16.0
Cotton	9.9	11.9	16.0
Safflower	7.0	11.0	14.0
Wheat	7.1	10.0	14.0
Sorghum	5.9	9.0	11.9
Soybean	5.2	6.9	9.0
Sesbania	3.8	5.7	9.0
Rice	5.1	5.9	8.0
Corn	5.1	5.9	7.0
Broadbean	3.1	4.2	6.2
Flax	2.9	4.2	6.2
Beans	1.1	2.1	3.0
Vegetable Crops			
Beets	8.0	9.7	11.7
Spinach	5.7	6.9	8.0
Tomato	4.0	6.6	8.0
Broccoli	4.0	5.9	8.0
Cabbage	2.5	4.0	7.0
Potato	2.5	4.0	6.0
Corn	2.5	4.0	6.0
Sweetpotato	2.5	3.7	6.0
Lettuce	2.0	3.0	4.8
Bellpepper	2.0	3.0	4.8
Onion	2.0	3.4	4.0
Carrot	1.3	2.5	4.2
Beans	1.3	2.0	3.2
Forage Crops			
Bermudagrass	13.0	15.9	18.1
Tall wheatgrass	10.9	15.1	18.1
Crested wheatgrass	5.9	11.0	18.1
Tall fescue	6.8	10.4	14.7
Barley hay	8.2	11.0	13.5
Perennial rye	7.9	10.0	13.0
Hardinggrass	7.9	10.0	13.0
Birdsfoot trefoil	5.9	8.1	10.0
Beardless wildrye	3.9	7.0	10.8
Alfalfa	3.0	4.9	8.2
Orchardgrass	2.7	4.6	8.1
Meadow foxtail	2.1	5.5	6.4
Clovers, alsike and red	2.1	2.5	4.2

Table 7-3. Vascular Plants Observed During 1985 Field Work

	Common Name
APIACEAE	Parsley Family
Cymopterus terebinthinus (Hook.) T.&G. var. terebinthinus	Turpentine cymopterus
Lomatium macrocarpum (Nutt.) Coult & Rose	Large-fruit lomatium
ASTERACEAE	Aster Family
Achillea millefolium L.	Yarrow
Antennaria dimorpha (Nutt.) T&G	Low pussy-toes
Artemisia tridentata Nutt.	Big sagebrush
Balsamorhiza careyana Gray	Carey's balsamroot
Chrysothamnus nauseosus (Pall.) Britt	Gray rabbitbrush
Chrysothamnus viscidiflorus (Hook.) Nutt	Green rabbitbrush
Crepis atrabarba Heller	Slender hawksbeard
Franseria acanthicarpa Hook.	Bur ragweed
Layia glandulosa (Hook.) H&A	White daisy tidytips
Tragopogon dubius Scop.	Yellow salsify
Aster canescens (Pursh)	Hoary Aster
BORAGINACEAE	Borage Family
Amsinckia lycopsoides Lehm.	Tarweed fiddleneck
Cryptantha circumscissa (H&A) Johnst.	Matted cryptantha
Cryptantha leucophaea (Dougl.) Pays.	Gray cryptantha
Cryptantha pterocarya (Torr.) Greene	Winged cryptantha
BRASSICACEAE	Mustard Family
Descurainia pinnata (Walt.) Britt.	Western tansymustard
Draba verna L.	Spring draba
Erysimum asperum (Nutt.) DC.	Prairie rocket
Sisymbrium altissimum L.	Tumblemustard
CACTACEAE	Cactus Family
Opuntia polyacantha Haw.	Starvation cactus
CARYOPHYLLACEAE	Pink Family
Arenaria franklinii Dougl. var. franklinii	Franklin's sandwort
Holosteum umbellatum L.	Jagged chickweed
CHENOPODIACEAE	Chenopod Family
Salsola kali L.	Russian thistle

Table 7-3 (cont.). Vascular Plants Observed During 1985 Field Work

	Common Name
FABACEAE	Pea Family
Astragalus purshii Dougl.	Wooly-pod milk-vetch
Astragalus sclerocarpus Gray	Stalked-pod milk-vetch
Psoralea lanceolata Pursh	Lance-leaf scurf-pea
HYDROPHYLLACEAE	Waterleaf Family
Phacelia hastata Dougl.	Whiteleaf phacelia
Phacelia linearis (Pursh) Holz.	Threadleaf phacelia
LILIACEAE	Lily Family
Brodiaea douglasii Wats.	Douglas' brodiaea
Fritillaria pudica	Chocolate lily
LOASACEAE	Blazing-star Family
Mentzelia albicaulis Dougl.	White-stemmed mentzelia
MALVACEAE	Mallow Family
Sphaeralcea munroana (Dougl.) Spach	White-stemmed globe-mallow
ONAGRACEAE	Evening-primrose Family
Oenothera pallida Lindl. var. *pallida*	White-stemmed evening-primrose
PLANTAGINACEAE	Plantain Family
Plantago patagonica Jacq.	Indian-wheat
POACEAE	Grass Family
Agropyron cristatum (L.) Gaertn.	Crested wheatgrass
Agropyron dasystachyum (Hoak.) Scribn.	Thick-spiked wheatgrass
Agropyron spicatum (Pursh) Scribn. & Smith	Bluebunch wheatgrass
Bromus tectorum L.	Cheatgrass
Festuca octoflora Walt.	Six-weeks fescue
Koeleria cristata Pers.	Prairie Junegrass
Oryzopsis hymenoides (R&S) Ricker	Indian ricegrass

Table 7-3 (cont.). Vascular Plants Observed During 1985 Field Work

	Common Name
Poa sandbergii Vasey	Sandberg's bluegrass
Sitanion hystrix (Nutt.) Smith	Bottlebrush squirreltail
Stipa comata Trin & Rupr.	Needle-and-thread
POLEMONIACEAE	Phlox Family
Gilia minutiflora Benth.	Gilia
Gilia sinuata Dougl.	Shy gilia
Microsteris gracilis (Hook.) Greene var. *humilior* (Hook.) Cronq.	Pink microsteris
Phlox longifolia	Long-leaf phlox
POLYGONACEAE	Buckwheat Family
Eriogonum niveum Dougl.	Snow buckwheat
Rumex venosus Pursh	Wild begonia
RANUNCULACEAE	Buttercup Family
Delphinium nuttallianum Pritz. ex Walpers	Larkspur
ROSACEAE	Rose Family
Purshia tridentata (Pursh) DC.	Antelope bitterbursh
SANTALACEAE	Sandalwood Family
Comandra umbellata (L.) Nutt.	Bastard toad-flax
SAXIFRAGACEAE	
Ribes aureum Pursh	Golden current
SCROPHULARIACEAE	Figwort Family
Penstemon acuminatus Dougl.	Sand-dune penstemon
VALERIANACEAE	Valerian Family
Plectritis macrocera T&G	Longhorn plectritis

Table 7-4. Vascular Plants Observed During 1975 - 1985 Field Activities

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Annual Grasses											
Bromus tectorum	X	X	X	X	X	X	X	X	X	X	X
Festuca octoflora	X					X	X	X	X	X	X
Festuca sp.		X		X							
Perennial Grasses											
Agropyron cristatum							X	X	X	X	X
Agropyron dasystachyum				X			X	X	X	X	X
Agropyron spicatum						X	X	X	X	X	X
Koeleria cristata				X		X	X	X	X	X	X
Oryzopsis hymenoides	X	X	X	X	X	X	X	X	X	X	X
Poa sandbergii							X	X	X	X	X
Poa Scabrella							X	X	X	X	
Sitanion hystrix						X		X	X	X	X
Stipa comata		X		X	X	X	X	X	X	X	X
Stipa thurberiana					X						

Tables 7-4 (cont.). Vascular Plants Observed During 1975 - 1985 Field Activities

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Annual Forbs											
Franseria acanthicarpa	X		X	X	X			X	X	X	X
Amsinckia lycopsoides	X	X	X	X	X	X	X	X	X	X	X
Amsinckia menziesii							X	X			
Chenopodium leptophyllum			X								
Cryptantha pterocarya		X		X		X	X	X	X	X	X
Cryptantha circumscissa	X	X	X	X	X	X	X	X	X	X	X
Descurainia pinnata	X	X	X	X	X	X	X	X	X	X	X
Draba verna	X	X		X	X	X	X	X	X	X	X
Epilobium paniculatum	X	X	X	X	X						
Erysimum asperum							X	X	X	X	X
Gilia minutiflora					X				X		X
Gilia sinuata						X		X	X	X	X
Holosteum umbellatum	X	X		X	X	X	X	X	X	X	X
Lagophylla ramosissima						X					
Layia glandulosa			X		X			X	X	X	X
Mentzelia albicaulis			X		X			X	X	X	X
Microsteris gracilis	X	X	X	X	X	X	X	X	X	X	X
Phacelia hastata							X	X	X	X	X
Phacelia linearis				X		X	X	X	X	X	X
Phacelia sp.		X									
Plantago patagonica	X	X		X	X	X	X	X	X	X	X
Plectritis macrocera		X							X		X

Table 7-4 (cont.). Vascular Plants Observed During 1975 - 1985 Field Activities

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Polemonium micranthum	X			X							
Salsola kali	X	X	X	X	X	X	X	X	X	X	X
Sisymbrium altissimum	X	X	X	X	X	X	X	X	X	X	X
Tragopogon dubius				X			X	X	X	X	X
Perennial Forbs											
Achillea millefolium	X	X	X			X	X	X	X	X	X
Antennaria dimorpha						X	X	X	X	X	X
Arenaria franklinii var. *franklinii*						X	X	X	X	X	X
Aster canescens (*Machaeranthera canescens*)		X			X				X	X	X
Astragalus lyallii			X								
Astragalus purshii	X	X				X	X	X	X	X	X
Astragalus sclerocarpus						X	X	X	X	X	X
Astragalus sp.				X							
Balsamorhiza careyanna	X	X		X	X	X	X	X	X	X	X
Brodiaea douglasii	X	X		X	X	X	X	X	X	X	X
Brodiaea howellii				X							
Calochortus macrocarpus	X				X						
Comandra umbellata	X		X	X	X	X	X	X	X	X	X
Crepis atrabarba		X	X	X	X	X	X	X	X	X	X
Cryptantha leucophaea						X	X	X	X		X

Table 7-4 (cont.). Vascular Plants Observed During 1975 - 1985 Field Activities

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Cymopterus terebinthinus	X			X		X	X	X	X	X	X
Delphinium sp.				X					X	X	X
Erigeron divergens							X				
Fritillaria pudica									X	X	X
Lomatium macrocarpum	X		X		X	X	X	X	X	X	X
Lomatium sp.				X							
Oenothera pallida	X	X	X	X	X	X	X	X	X	X	X
Penstemon acuminatus							X	X	X	X	X
Penstemon sp.						X					
Phlox longifolia	X	X	X	X	X	X	X	X	X	X	X
Psoralea lanceolata	X	X	X	X	X		X	X	X	X	X
Rumex venosus				X		X	X	X	X	X	X
Sphaeralcea munroana								X	X		X
Shrubs, subshrubs, cacti											
Artemisia tridentata	X	X	X	X	X	X	X	X	X	X	X
Chrysothamnus nauseosus	X	X	X	X	X	X	X	X	X	X	X
Chrysothamnus viscidiflorus	X	X	X	X		X	X	X	X	X	X
Eriogonum niveum	X	X	X	X	X	X	X	X	X	X	X
Leptodactylon pungens									X	X	
Opuntia polyacantha	X			X		X	X	X	X	X	X
Purshia tridentata	X	X	X	X	X	X	X	X	X	X	X
Ribes aureum*											X

*Species sighted for the first time during 1985 field activities.

Table 7-5. Mean Herbaceous Cover Values (%) By Species For Each 1985 Sampling Site

	G01	G02	G03	G04	S01	S02	S03	S04	S05	Average
Annual Grasses										
Bromus tectorum	8.00	8.10	18.30	7.25	2.10	2.15	14.60	3.60	27.0	10.12
Festuca octoflora								1.35		.15
Total Annual Grass Cover	8.00	8.10	18.30	7.25	2.10	2.15	14.60	4.95	27.0	10.27
Perennial Grasses										
Agropyron spicatum						0.40			1.85	0.25
Poa sandbergii	9.20	17.95		13.90	1.05	4.30	17.85	2.40		7.41
Stipa comata				10.30		0.55				1.21
Total Perennial Grass Cover	9.20	17.95		24.20	1.05	5.25	17.85	2.40	1.85	8.86
Annual Forbs										
Amsinckia lycopsoides		0.05								0.01
Cryptantha pterocarya		0.05						0.05		0.01
Cryptantha circumscissa		0.05			0.05					0.01
Descurainia pinnata	0.10	1.00			0.40	0.45		1.70	0.35	0.44
Draba verna	7.45	8.40	9.95	2.20		2.55	3.00	0.25	2.40	4.02
Franseria acanthicarpa		0.05	3.55	0.95	0.05			0.35	0.95	0.66
Gilia sinuata										
Holosteum umbellatum	7.70	3.35	3.30	1.75		0.50	3.15		0.70	2.27
Layia glandulosa										
Mentzelia albicaulis					0.15	1.75				0.21
Microsteris gracilis	0.40	2.90	2.90		0.25		0.65	0.45	0.65	0.91
Phacelia linearis						0.35				0.04
Plantago patagonica	0.05			0.70			5.05		0.80	0.73
Salsola kali				1.10	0.55		0.05	0.05	0.10	0.21
Sisymbrium altissimum	2.50	0.75	0.25	0.05			0.50		2.25	0.70
Tragopogon dubius	8.10	7.20								1.70
Total Annual Forb Cover	26.30	23.80	19.95	6.75	1.35	5.60	12.40	2.85	8.20	11.91
Perennial Forbs										
Achillea millefolium				0.10				0.05		0.02
Astragalus sclerocarpus							0.05	2.75		0.31
Balsamorhiza careyana								2.95	0.05	0.33
Brodiaea douglasii			2.35				0.10			0.27
Crepis atrabarba							0.85			0.09
Cymopteris terebinthinus	0.40	0.10				1.35				0.21
Oenothera pallida				0.05					0.10	0.02
Phlox longifolia				0.75			0.20		0.10	0.12
Rumex venosus	0.40									0.04
Total Perennial Forb Cover	0.80	0.10	2.35	0.90		1.35	1.20	5.75	0.25	1.41
TOTAL HERBACEOUS COVER	44.30	49.95	40.60	39.10	4.50	14.35	46.05	15.95	37.30	32.45

Table 7-6. Mean Frequency Values (%) By Species For Each 1985 Sampling Site

	G01	G02	G03	G04	S01	S02	S03	S04	S05
Annual Grasses									
Bromus tectorum	86	90	100	86	64	38	100	64	100
Festuca octoflora								44	
Perennial Grasses									
Agropyron spicatum						6			8
Poa sandbergii	92	98		94	12	36	100	46	
Stipa comata				68		12			
Annual Forbs									
Amsinckia lycopsoides		2							
Cryptantha circumscissa		2			2				
Cryptantha pterocarya		2						2	
Descurainia pinnata	4	10			6	8		28	4
Draba verna	98	98	100	88		26	100	10	96
Franseria acanthicarpa		2	52	38	2			4	28
Gilia sinuata									
Holosteum umbellatum		84	92	60		20	96		28
Layia glandulosa									
Mentzelia albicaulis					6	20			
Microsteris gracilis	16	56	96		10		26	18	26
Phacelia linearis						14			
Plantago pategonica	2			28			82		32
Salsola kali			34	22		2	2	4	
Sisymbrium altissimum	42	20	10	2			10		22
Tragopogon dubius	48	32							
Perennial Forbs									
Achillea millefolium			4					2	
Aster canescens				10					
Astragalus sclerocarpus							2	14	
Balsamorhiza careyana								12	2
Brodiaea douglasii	34						4		
Crepis atrabarba							6		
Cymopteris terebinthinus	6	4				6			
Oenothera pallida			2						4
Phlox longifolia			10				8		4
Rumex venosus	6								
TOTAL SPECIES PER SITE	11	13	10	10	7	11	12	12	12

Table 7-7. Comparison of Herbaceous Phytomass for 1975 - 1985

	Mean Dry Weight (g/m^2)										
Site	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
G01	359	108	21	166	64	160	200	90	77	94	70
G02	302	258	11	162	37	68	255	60	137	116	27
G03	-	-	-	-	-	53	261	62	64	133	12
G04	-	-	-	-	-	79	159	113	82	67	37
S01	126	137	4	173	21	36	180	98	171	104	5
S02	144	98	7	128	28	63	115	24	232	57	1
S03	88	177	7	115	16	43	31	22	54	95	27
S04	-	-	-	-	-	78	52	39	68	93	11
S05	-	-	-	-	-	71	81	184	136	43	61

Table 7-8. Summary of Shrub Cover at Five Study Sites for 1985

SHRUBS	S01	S02	S03	S04	S05	X
Artemisia tridentata	-	-	5.95	-	-	1.19
Chrysothamnus nauseosus	-	-	1.09	-	-	0.22
Chrysothamnus viscidiflorus	-	-	-	-	0.29	0.06
Purshia tridentata	-	-	-	-	-	-
TOTAL SHRUB COVER	0.00	0.00	7.04	0.00	0.29	1.50
SUBSHRUB						
Eriogonum niveum	-	-	0.01	-	0.95	0.19
CACTUS						
Opuntia polyacantha	-	-	-	-	0.94	0.19
TOTAL COVER	0.00	0.00	7.05	0.00	2.18	5.00

Table 7-9. Summary of Soil Chemistry for May 1985

	G01	G02	G03	G04	S01	S02	S03	S04	S05
pH (1:2 soil to water)	6.83	6.73	7.12	7.32	7.12	7.83	7.26	7.44	6.86
Conductivity (1:2 soil to water) umhos/cm	69.9	97.2	98.0	15.3	56.6	42.5	18.3	38.6	25.9
Sulfate ug/gm	3.38	2.80	30.26	0.44	1.48	1.68	0.44	3.08	0.88
Chloride ug/gm	6.95	4.62	4.40	1.60	3.04	2.56	2.32	2.88	2.40
Copper ug/gm	14.61	12.13	12.59	10.90	11.30	10.38	11.55	11.96	10.87
Lead ug/gm	3.37	3.53	2.90	2.17	3.06	2.16	2.22	2.32	3.38
Cadmium ug/gm	0.08	0.05	0.06	0.05	0.04	0.04	0.06	0.05	0.09
Chromium ug/gm	10.56	5.14	7.48	4.57	5.89	6.21	6.00	6.78	5.98
Nickel ug/gm	14.30	13.32	12.83	10.34	11.78	12.18	11.06	12.62	11.20
Zinc ug/gm	62.57	55.27	54.29	51.29	52.67	35.48	57.06	50.98	52.08
Sodium %	0.030	0.029	0.019	0.017	0.023	0.019	0.019	0.020	0.017
Potassium %	0.33	0.23	0.18	0.13	0.16	0.09	0.17	0.18	0.13
Calcium %	0.29	0.27	0.24	0.25	0.26	0.28	0.29	0.28	0.23
Mercury ug/gm	0.004	0.003	0.008	0.008	0.005	0.002	0.004	0.006	0.004
Fluoride ug/gm	163.0	194.0	208.0	186.0	219.0	204.0	286.0	191.0	236.0
Bicarbonate (meq/HCO3/gm)	0.0015	0.0027	0.0032	0.0011	0.0020	0.0030	0.0012	0.0012	0.0017
Magnesium %	0.51	0.44	0.43	0.40	0.46	0.37	0.41	0.43	0.41

Table 7-10. Summary of 1985 Vegetation Chemistry

	Site	POSA(1)	BRTE(1)	SIAL(1)	PHLO(1)	PUTR(1)	ARTR(1)
Copper (ug/g)	G01	4.39	7.22	5.07	4.66		
	G02	3.88	4.75	4.79	4.87		
	G03	6.96	9.65	5.59	5.53		
	G04	3.83	5.04	4.24	3.26		
	S01	5.50	4.97	4.28	5.17		
	S02	3.39	5.49		4.80	3.69	
	S03	3.26	5.36		4.32		10.98
	S04	6.20	9.49	7.62	8.10		
	S05	3.78	4.29			5.15	9.04
Extractable Sulfate (%)	G01	0.011	0.090	0.527	0.017		
	G02	0.010	0.022	0.490	0.062		
	G03	0.077	0.177	0.593	0.059		
	G04	0.024	0.048	0.343	0.000		
	S01	0.019	0.062	0.454	0.031		
	S02	0.000	0.101		0.060	0.013	
	S03	0.025	0.020		0.028		0.021
	S04	0.029	0.160	0.602	0.195		
	S05	0.027	0.000			0.000	0.021
Extractable Chloride (%)	G01	0.32	0.38	0.63	0.13		
	G02	0.20	0.23	0.50	0.13		
	G03	0.20	0.36	0.54	0.10		
	G04	0.21	0.17	0.49	0.12		
	S01	0.18	0.16	0.56	0.13		
	S02	0.25	0.23		0.10	0.09	
	S03	0.18	0.22		0.11		0.82
	S04	0.20	0.55	0.80	0.14		
	S05	0.24	0.10			0.10	0.53

(1) POSA = *Poa Sandbergii*
BRTE = *Bromus tectorum*
SIAL = *Sisymbrium altissimum*
PHLO = *Phlox longifolia*
PUTR = *Purshia tridentata*
ARTR = *Artemisia tridentata*

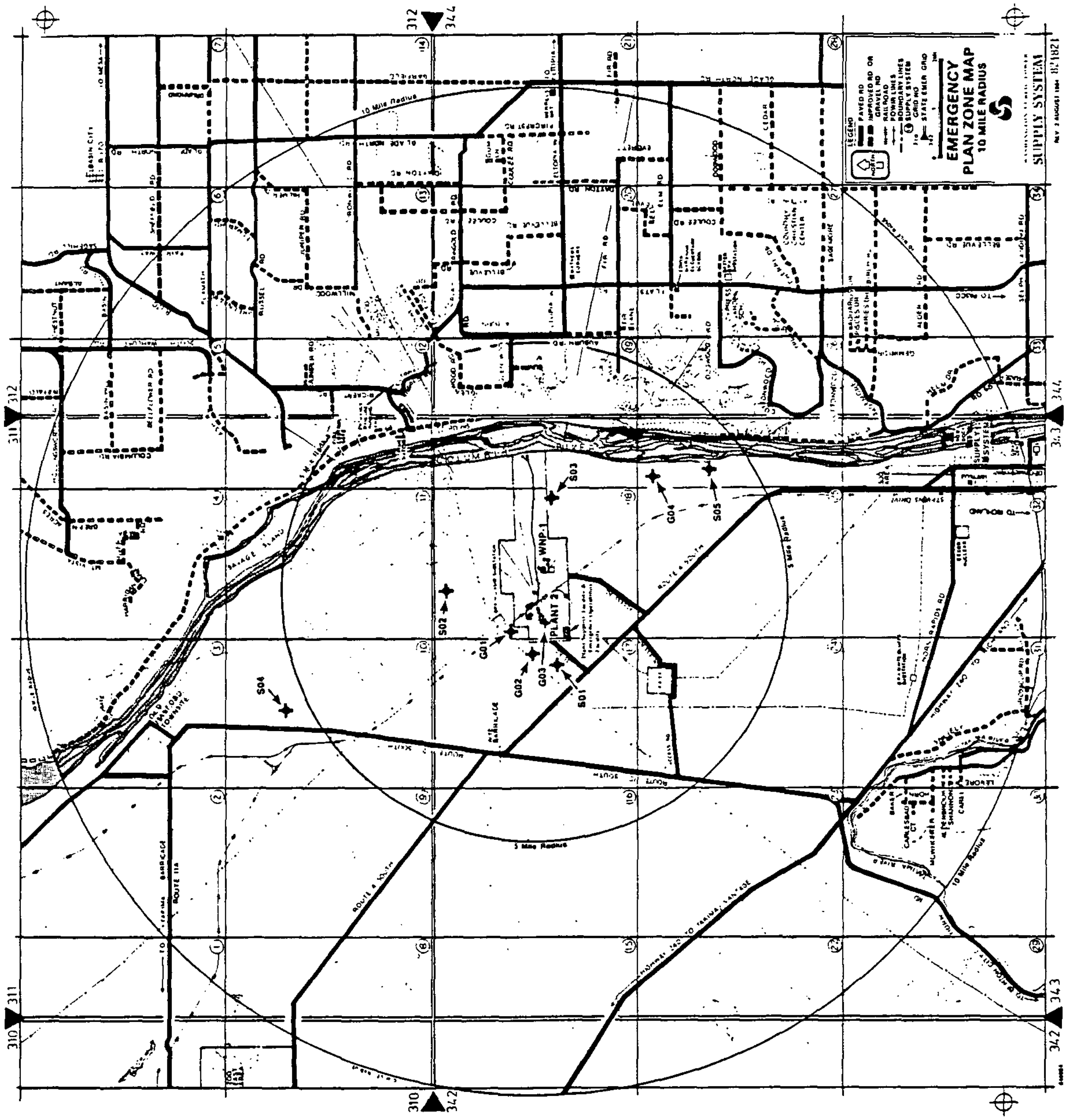


Figure 7-1. Soil and Vegetation Sampling Location Map

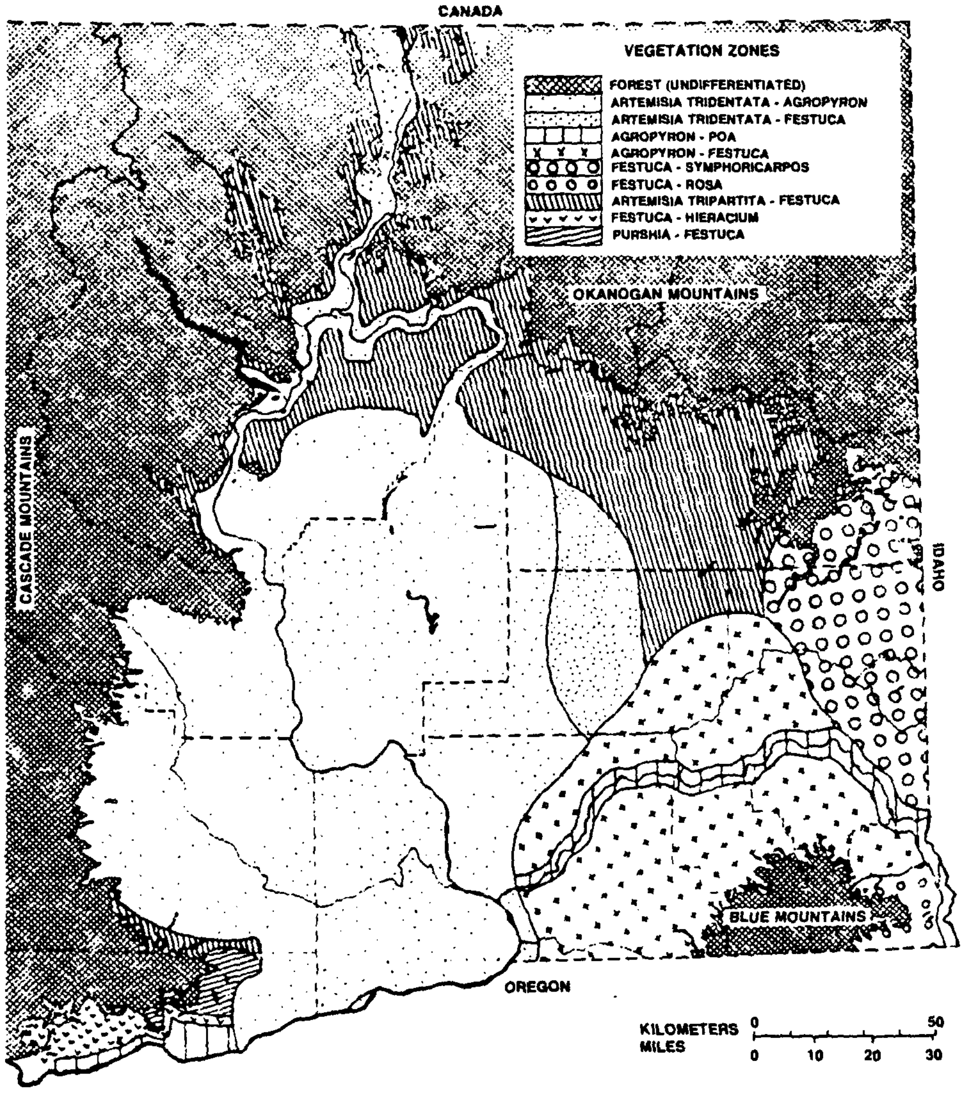


Figure 7-2. Columbia Basin Floristic Zones

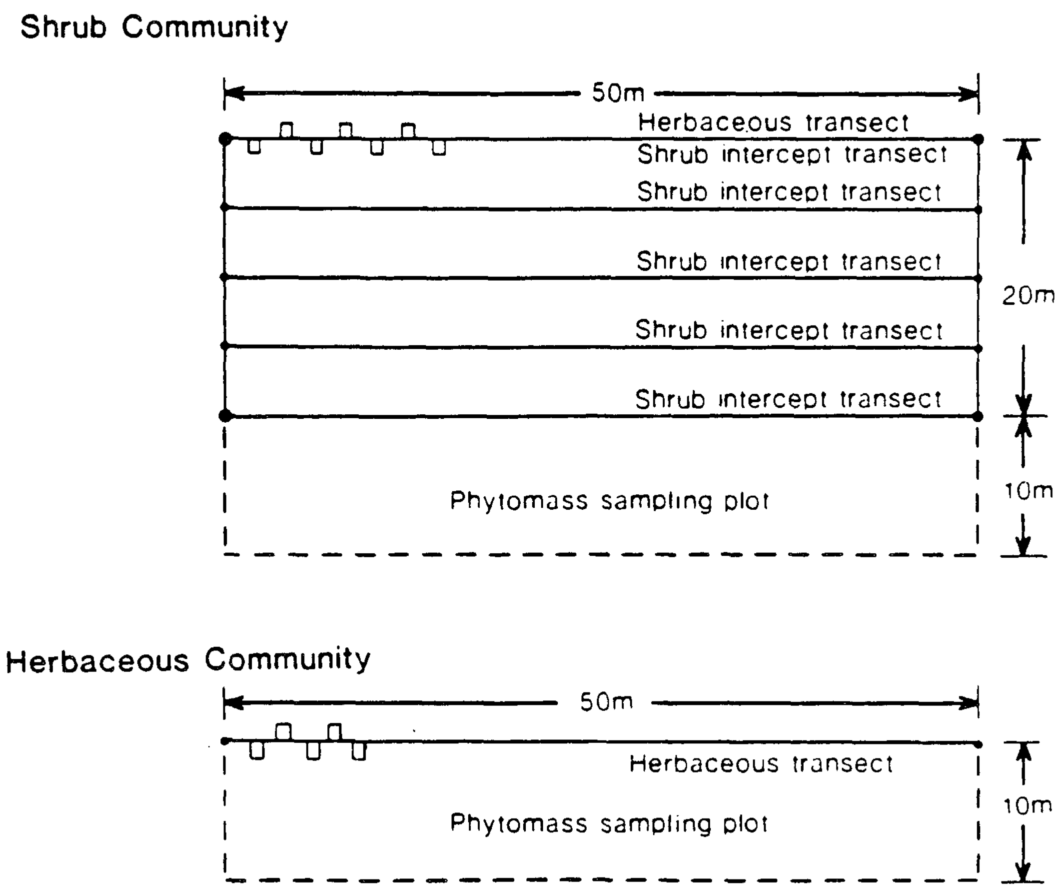


Figure 7-3. Layout of Vegetation and Soil Sampling Plots

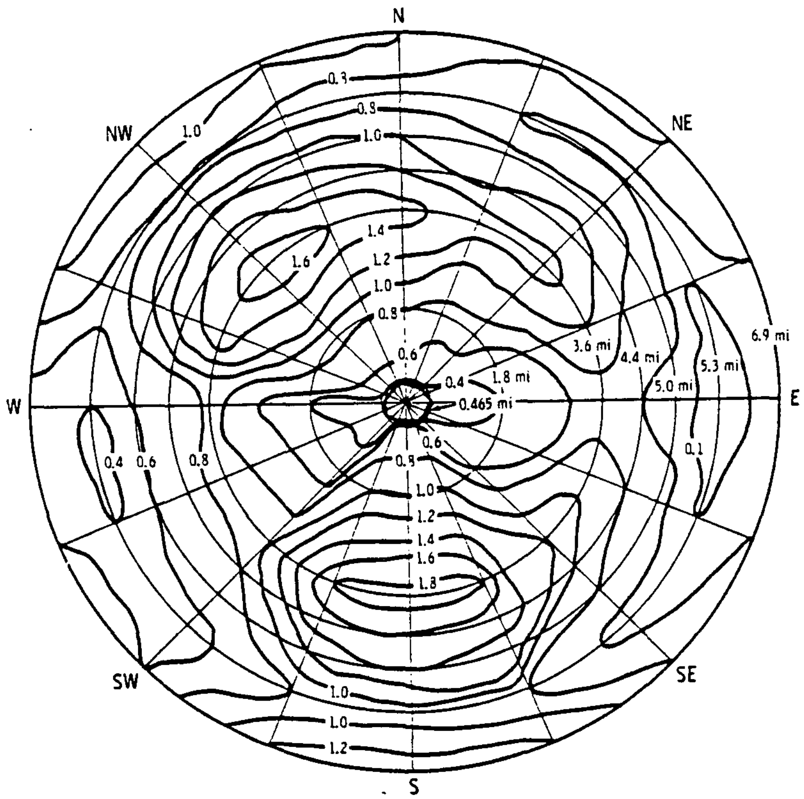


Figure 7-4. Predicted Isopleth of Salt Drift Deposition from WNP-2 Mechanical Draft Cooling Towers

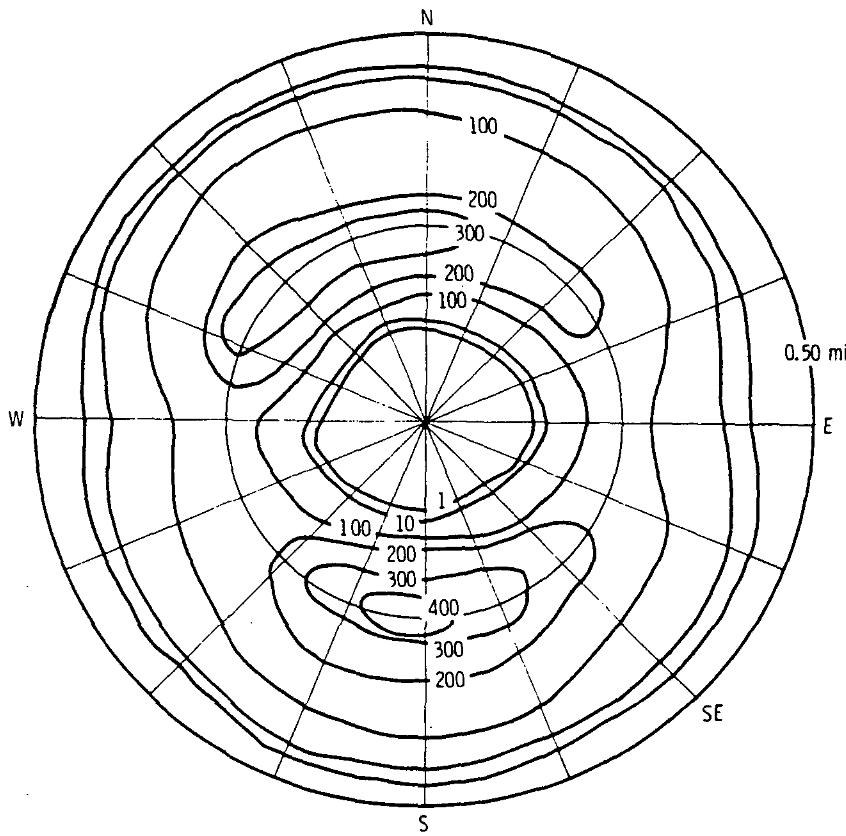
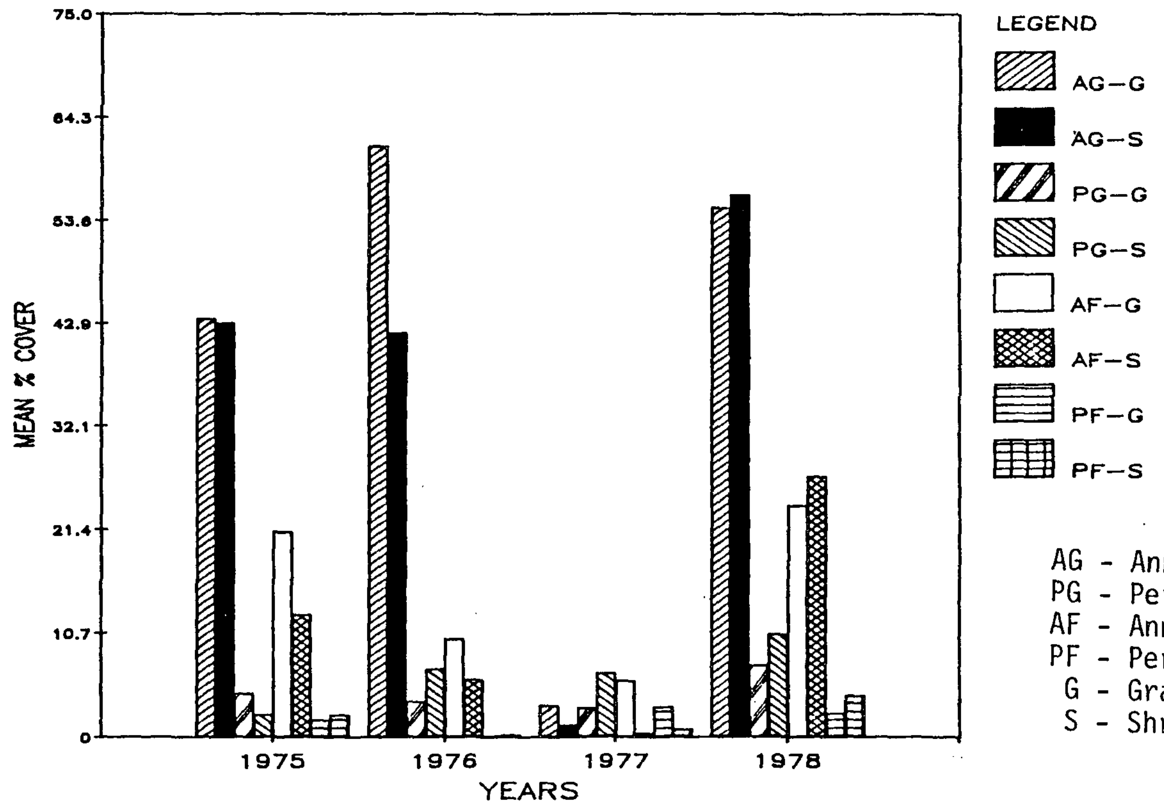


Figure 7-5. Predicted Isopleth of Salt Drift Deposition from WNP-2 Mechanical Draft Cooling Towers



AG - Annual Grass
PG - Perennial Grass
AF - Annual Forb
PF - Perennial Forb
G - Grassland Site
S - Shrub Site

Figure 7-6. Mean Herbaceous Cover for 1975 - 1978

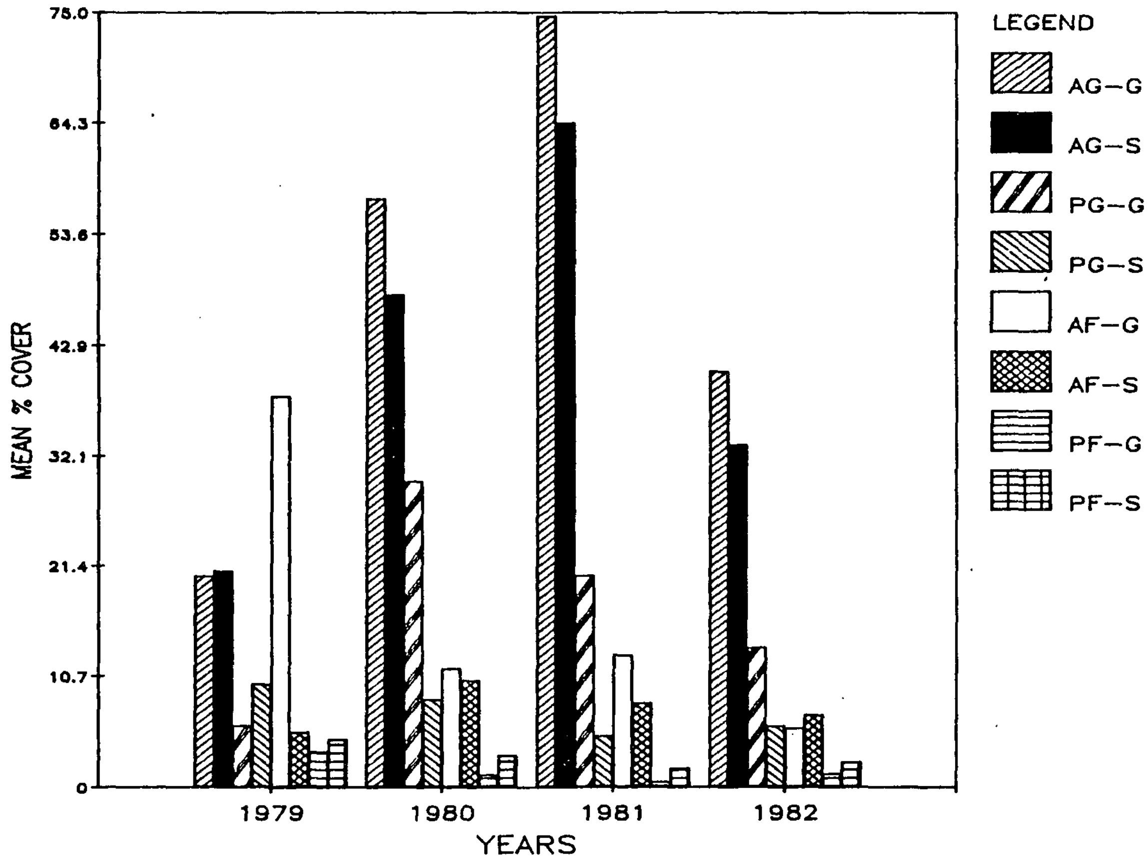


Figure 7-7. Mean Herbaceous Cover for 1979 - 1982

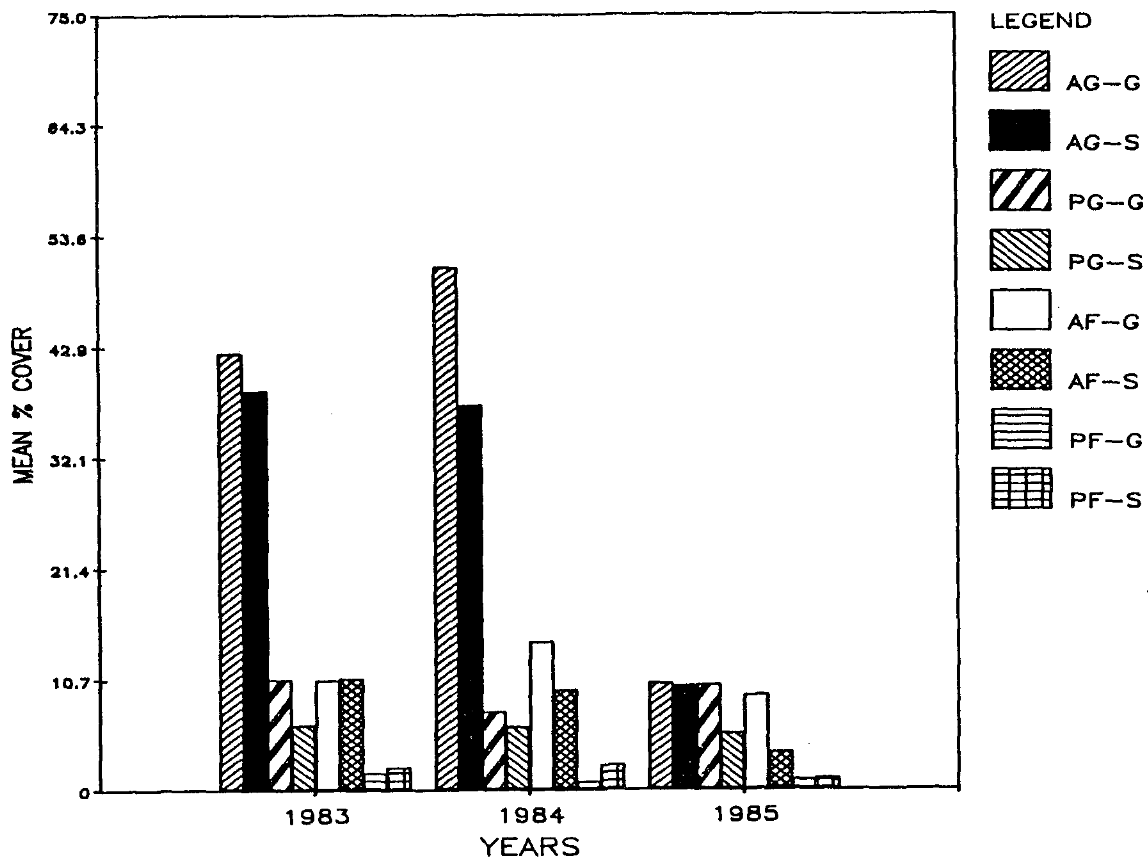


Figure 7-8. Mean Herbaceous Cover for 1983 - 1985

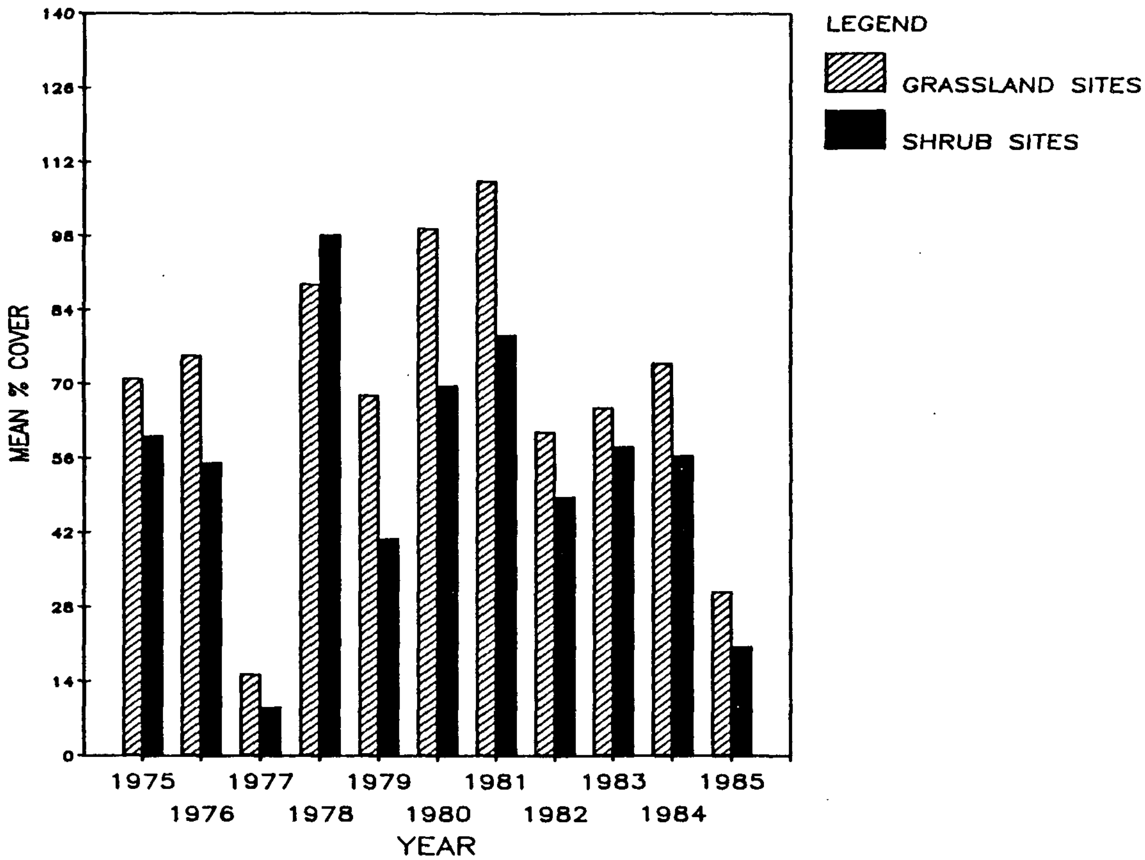


Figure 7-9. Mean Herbaceous Cover - Grassland and Shrub Sites for 1975 - 1985

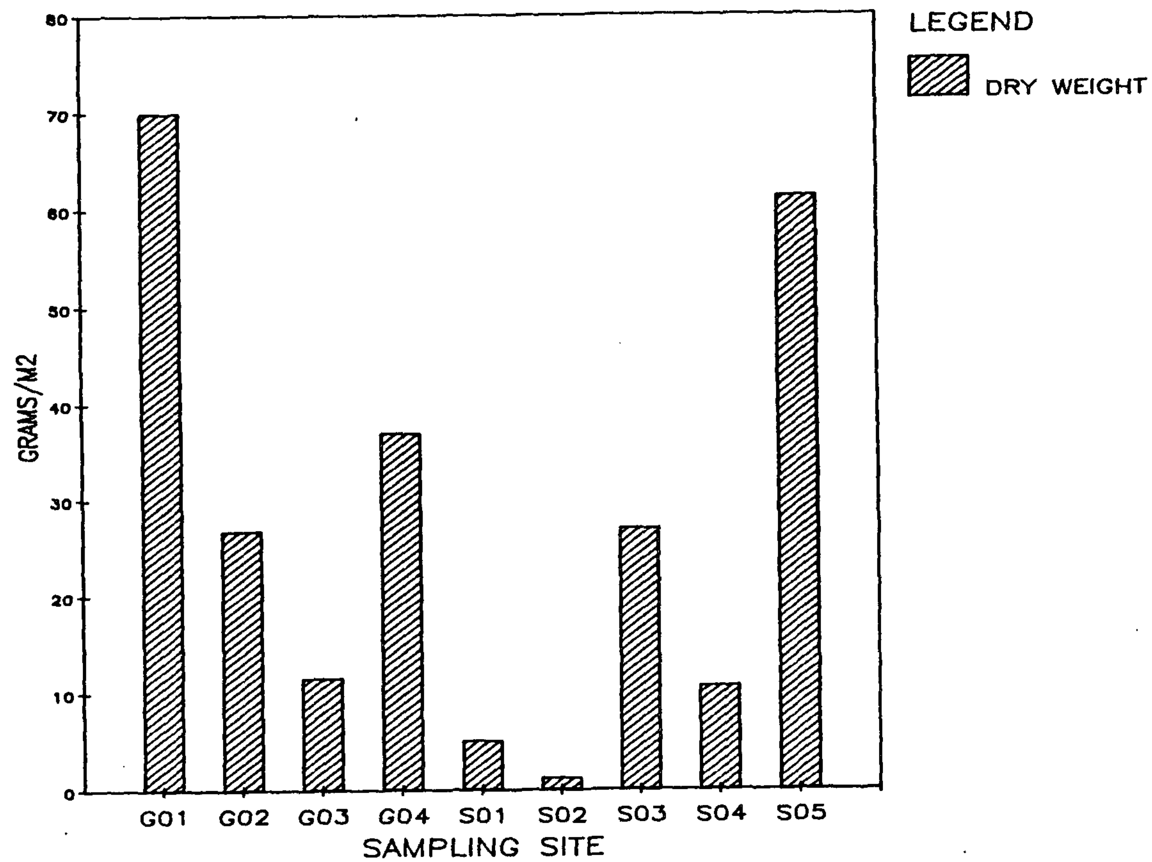


Figure 7-10. Mean Herbaceous Phytomass for May 1985

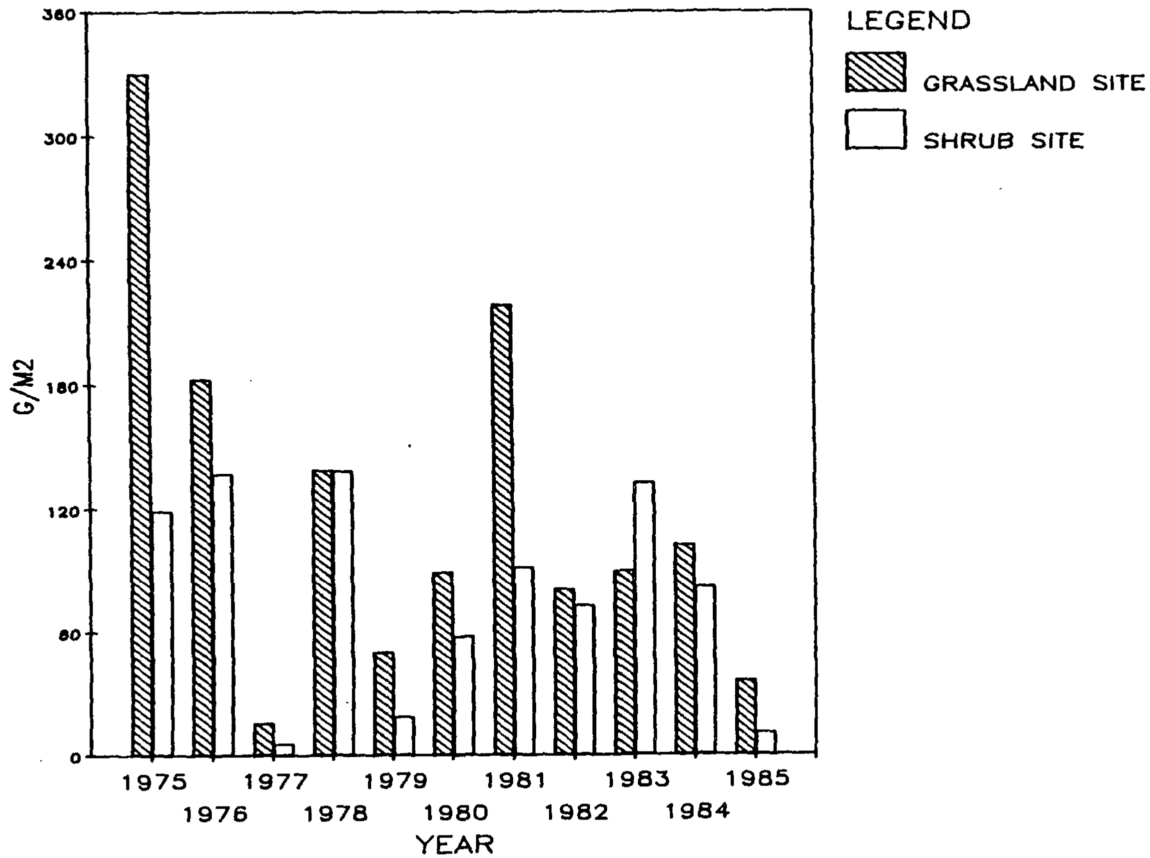


Figure 7-11. Mean Herbaceous Phytomass at Grassland and Shrub Sites for 1975 - 1985

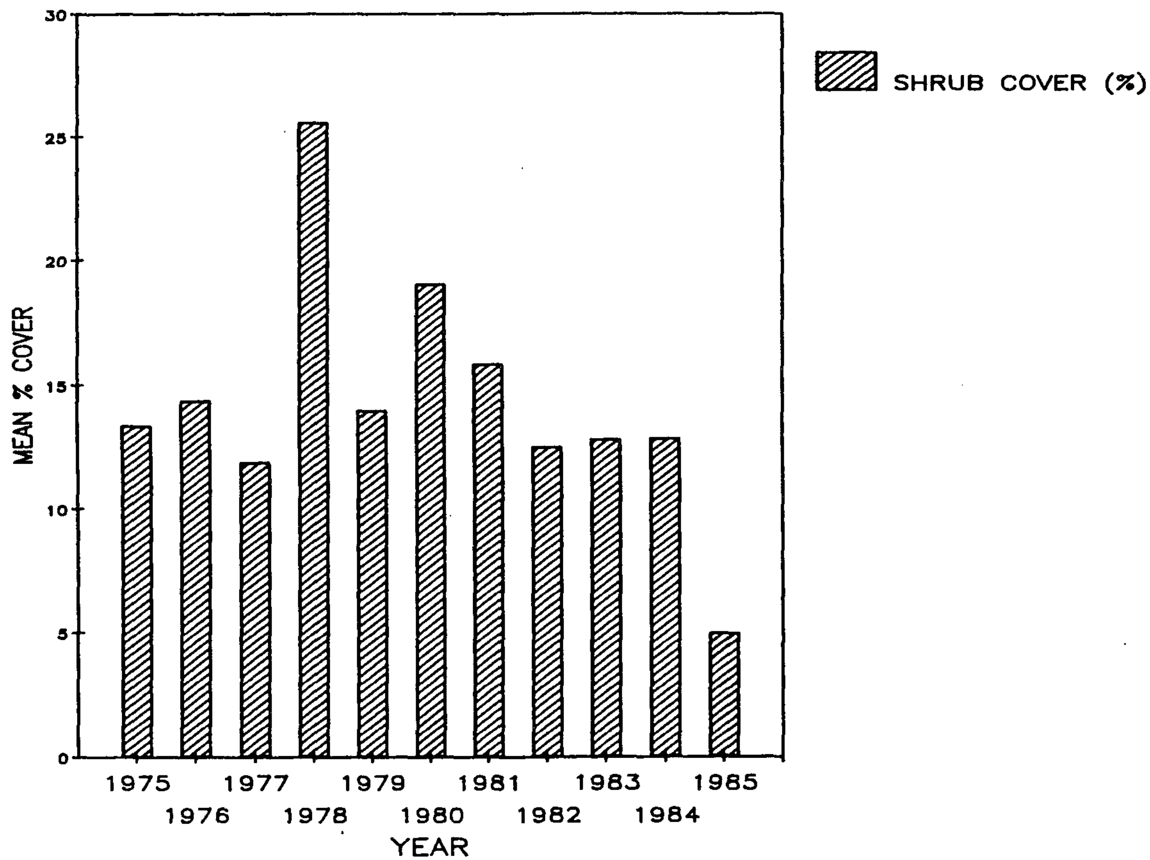


Figure 7-12. Mean Total Shrub Cover for 1975 - 1985

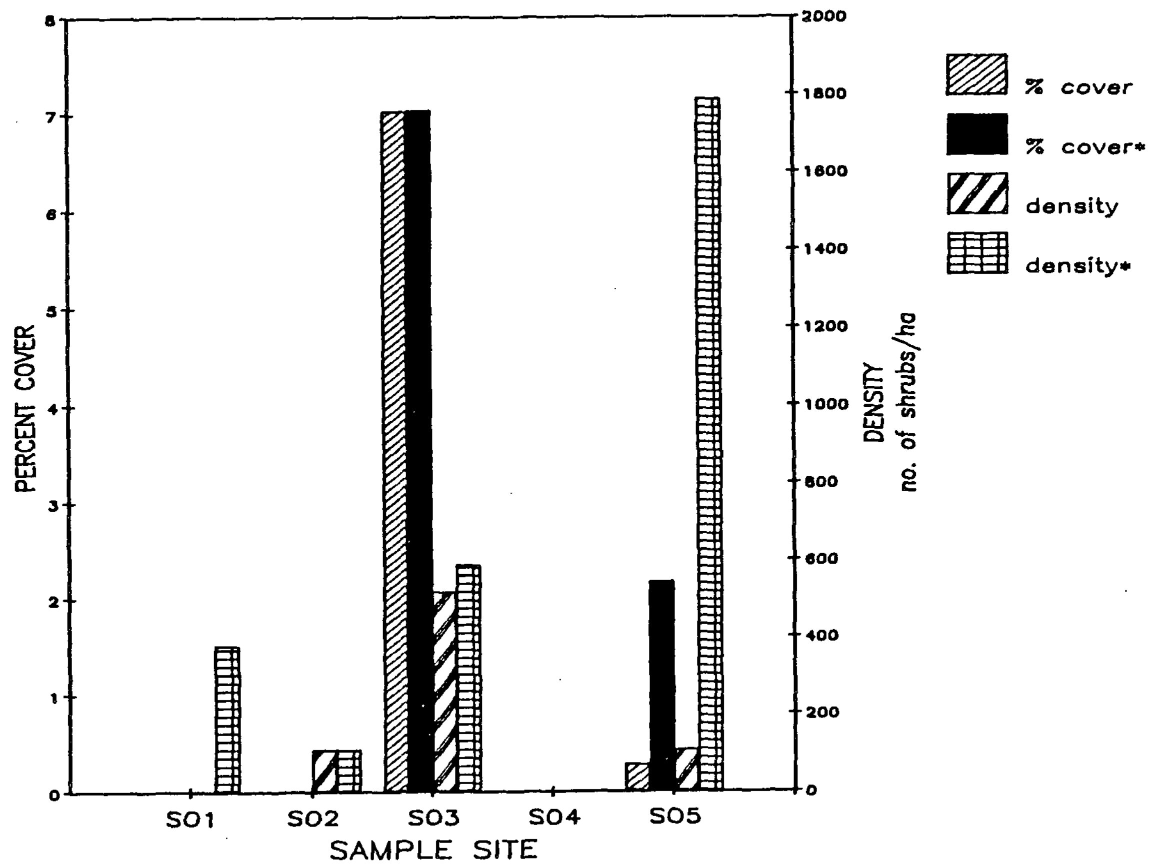


Figure 7-13. Shrub Cover and Shrub Density for May 1985

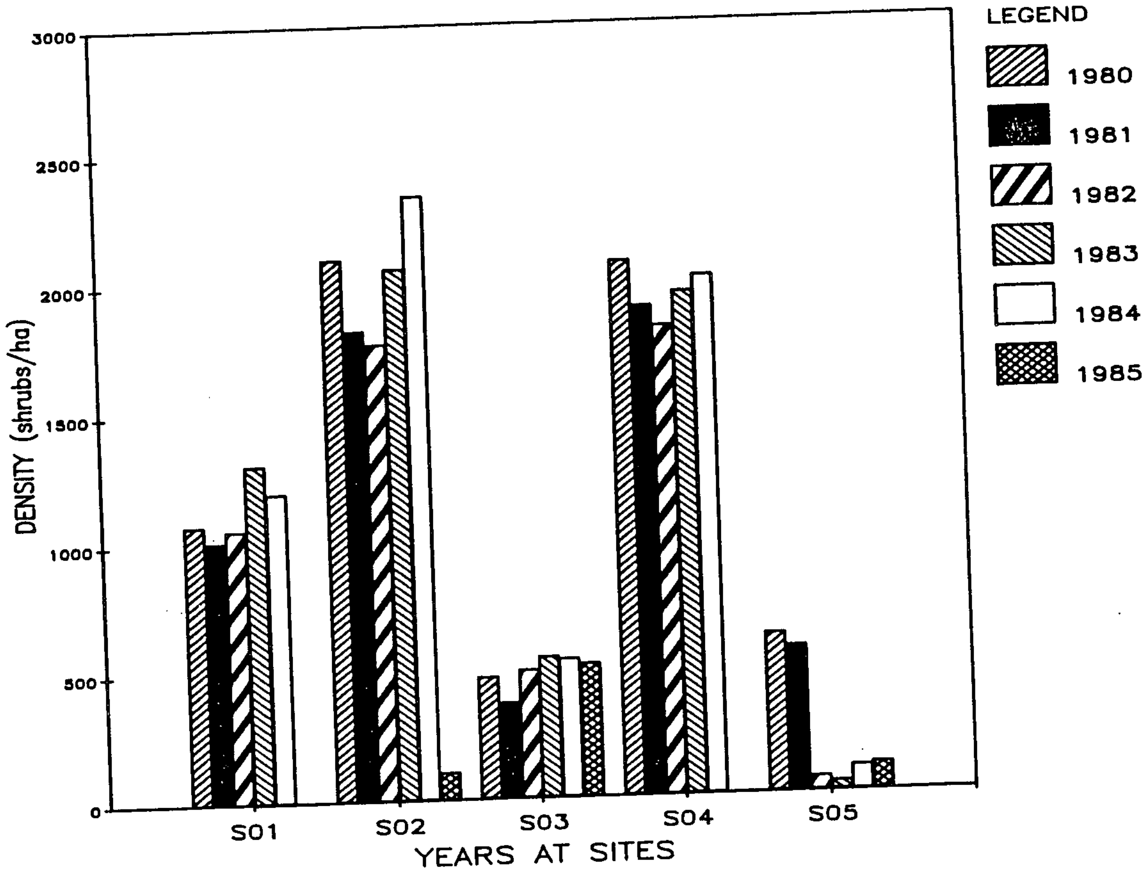


Figure 7-14. Shrub Density at Five Sites for 1980 - 1985

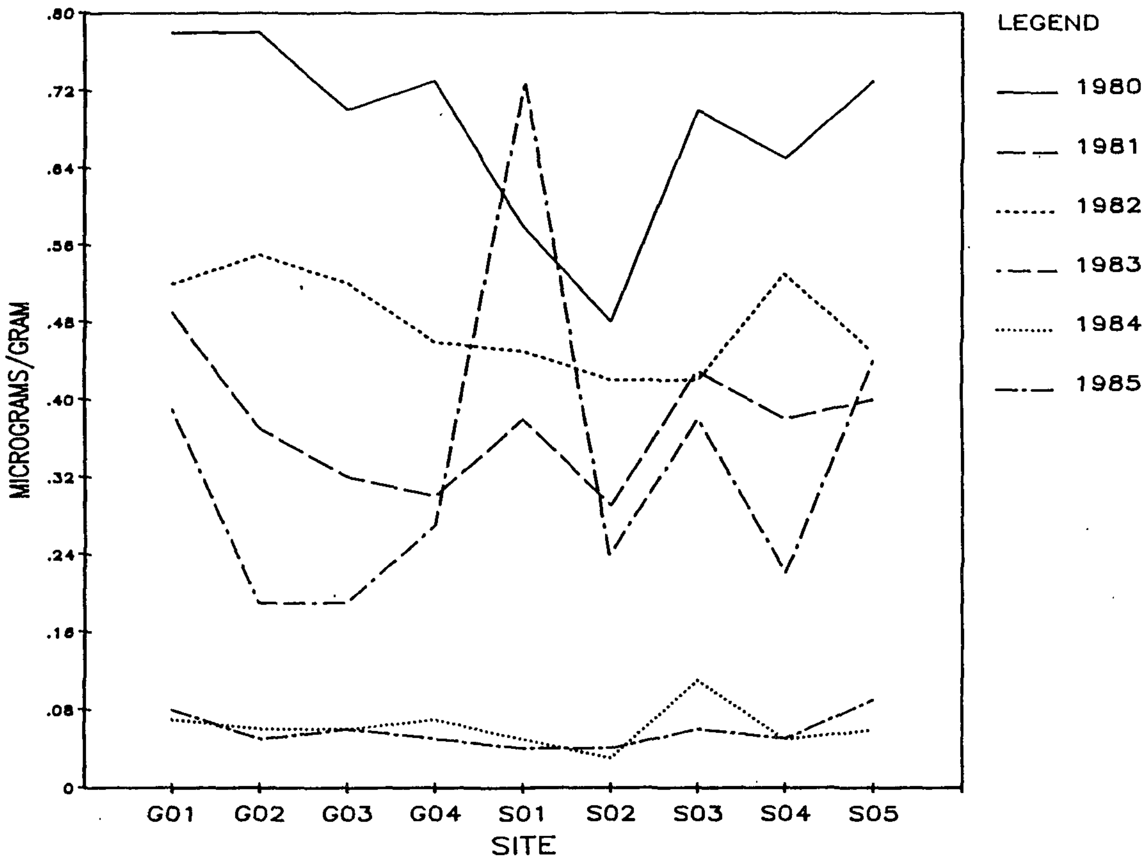


Figure 7-15. Soil Cadmium for 1980 - 1985

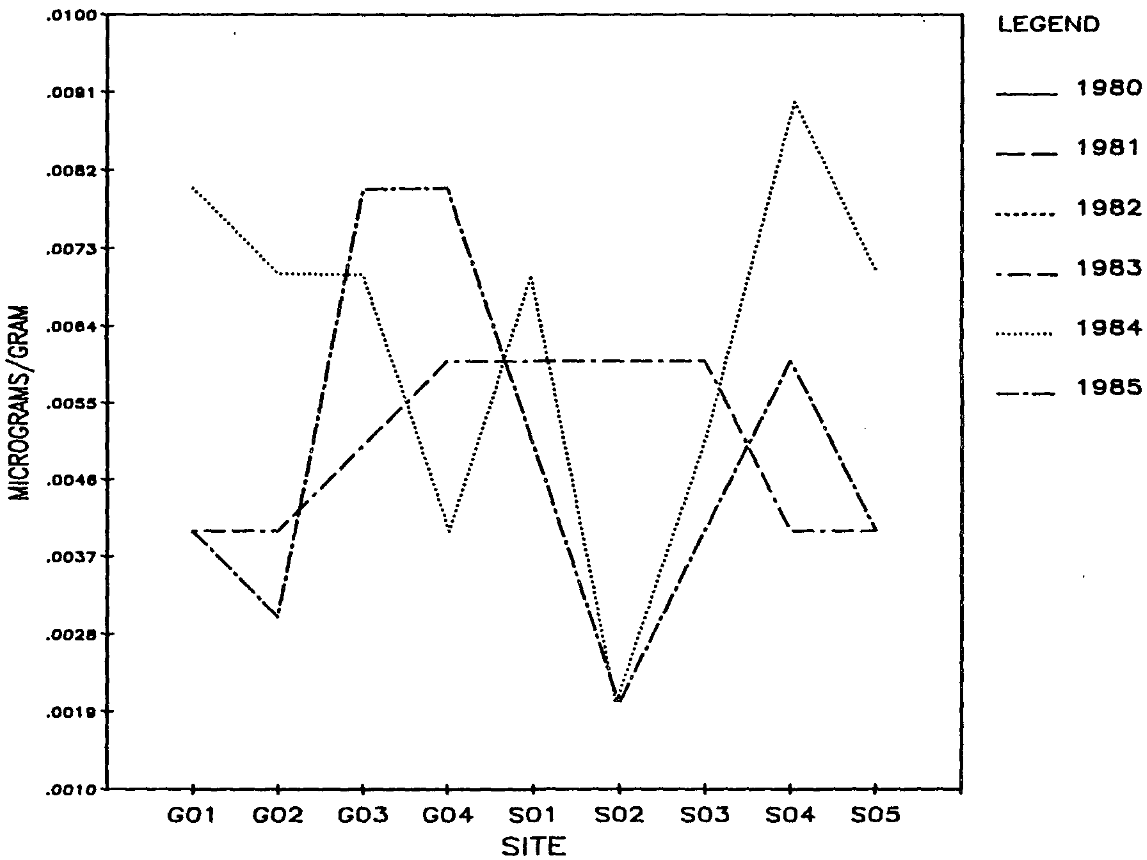


Figure 7-16. Soil Mercury for 1980 - 1985*

* Data for 1980 - 1982 below detection level.

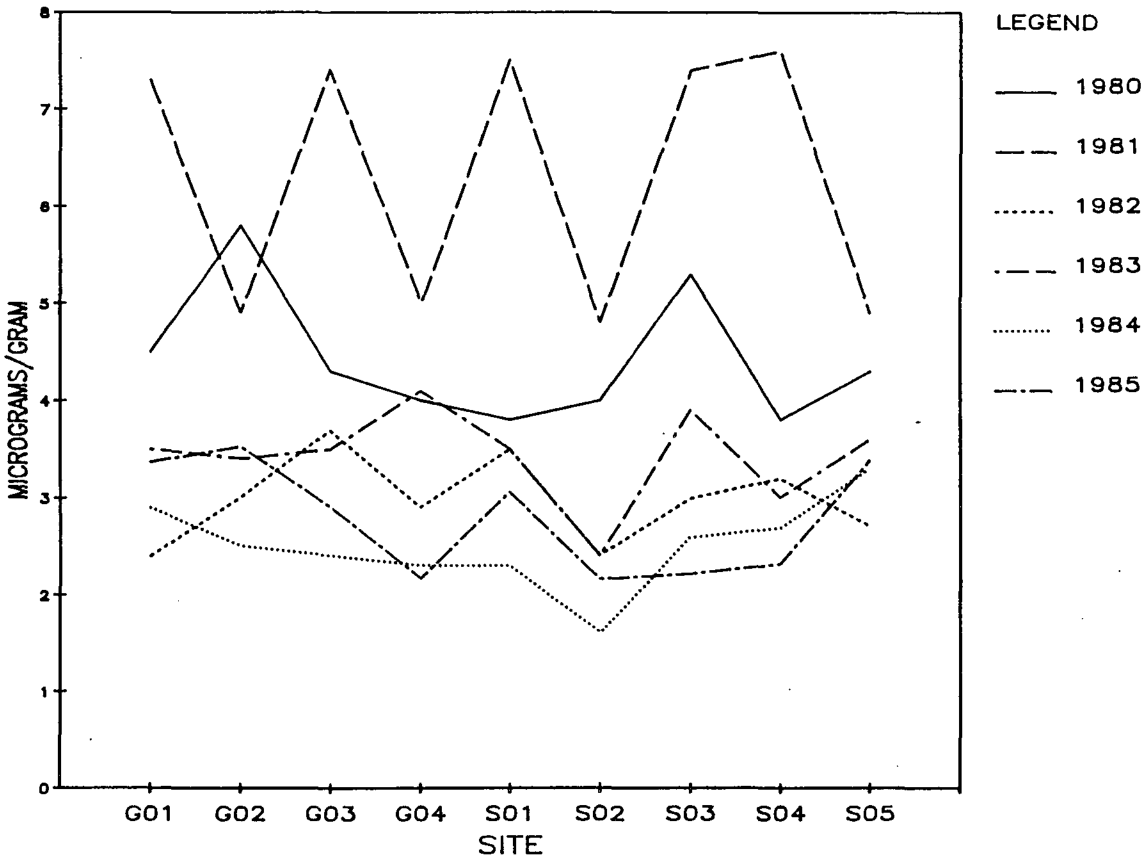


Figure 7-17. Soil Lead for 1980 - 1985

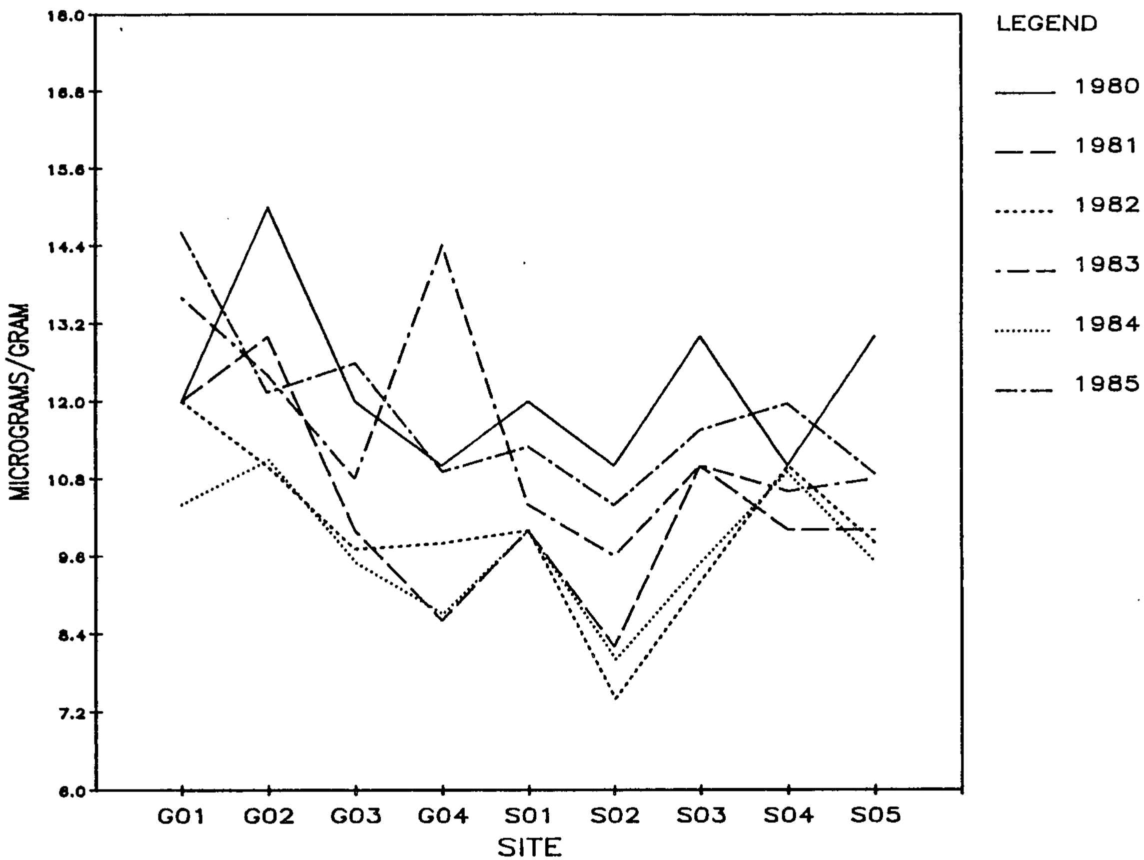


Figure 7-18. Soil Copper for 1980 - 1985

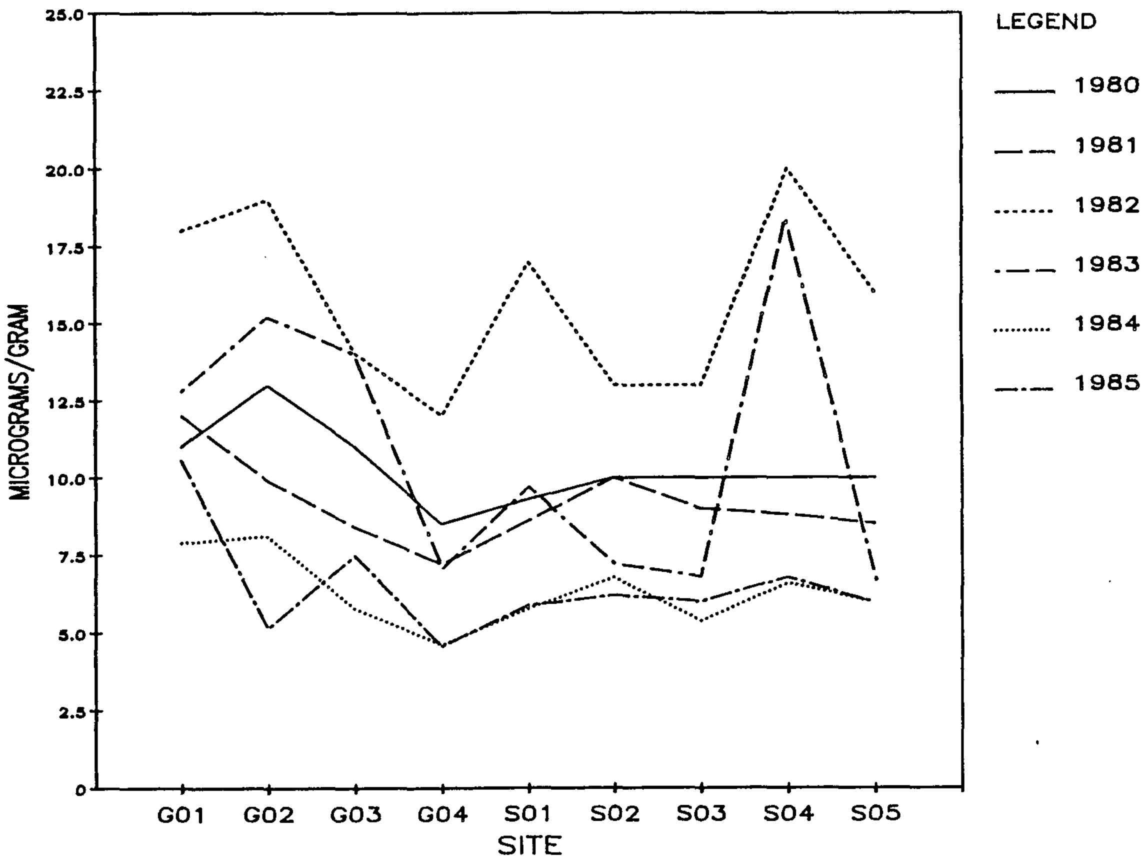


Figure 7-19. Soil Chromium for 1980 - 1985

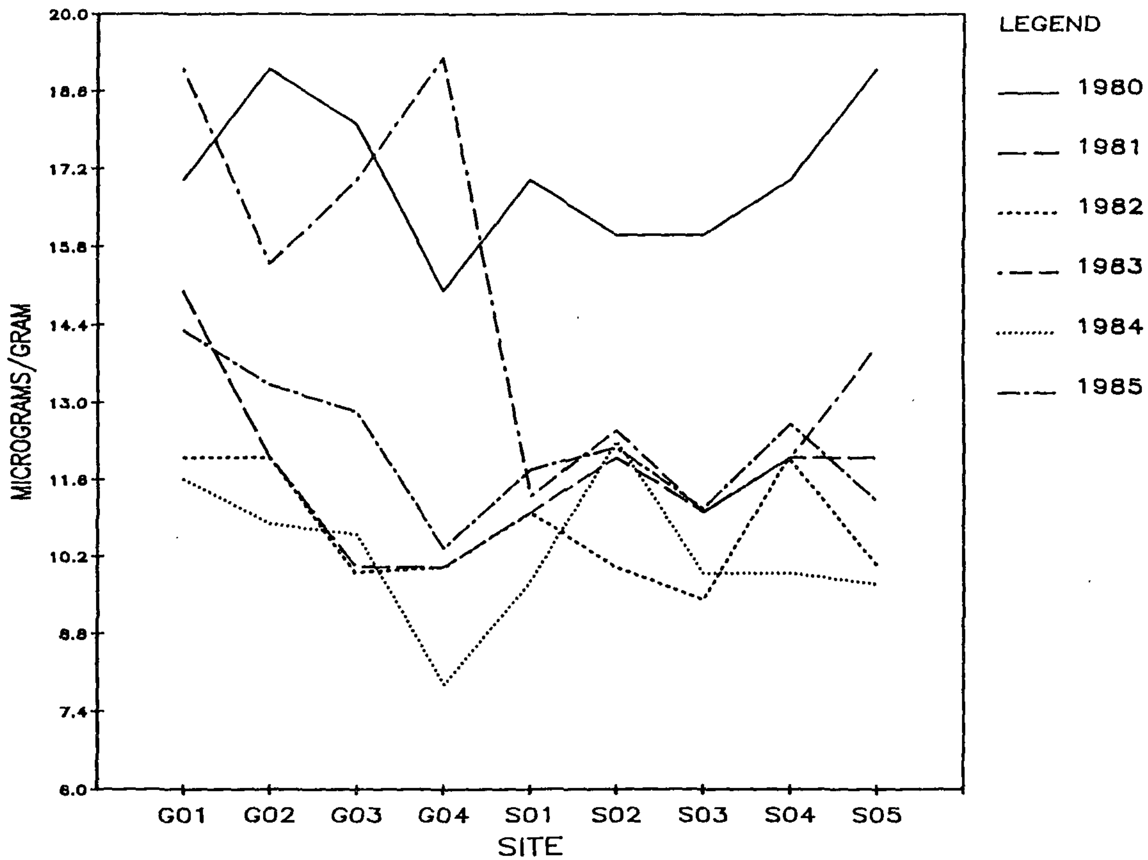


Figure 7-20. Soil Nickel for 1980 - 1985

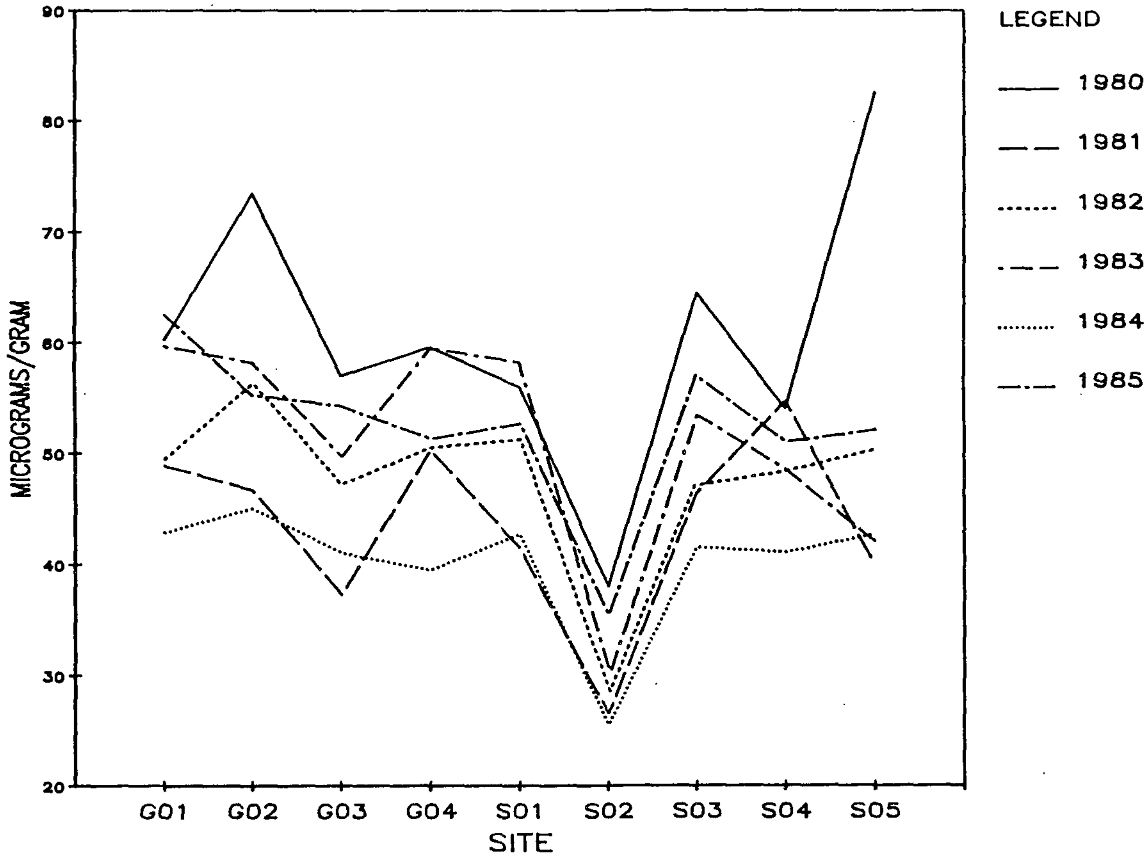


Figure 7-21. Soil Zinc for 1980 - 1985

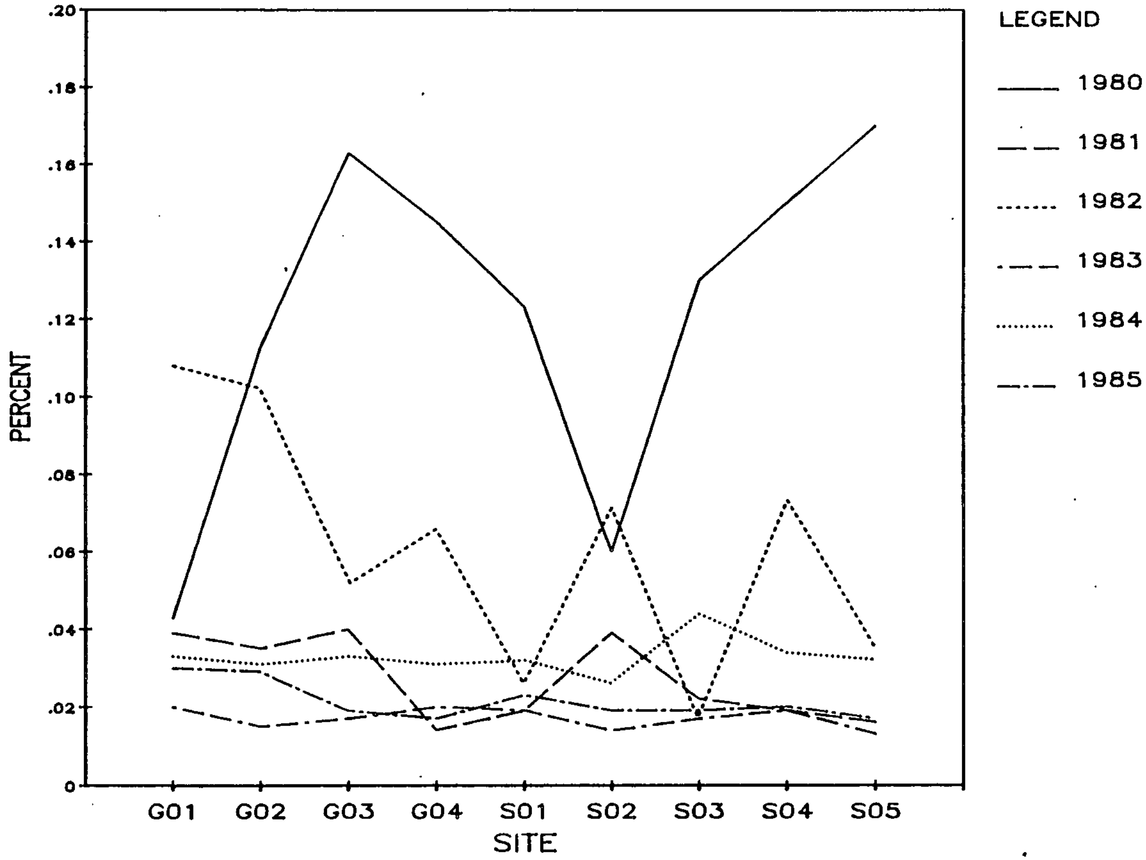


Figure 7-22. Soil Sodium for 1980 - 1985

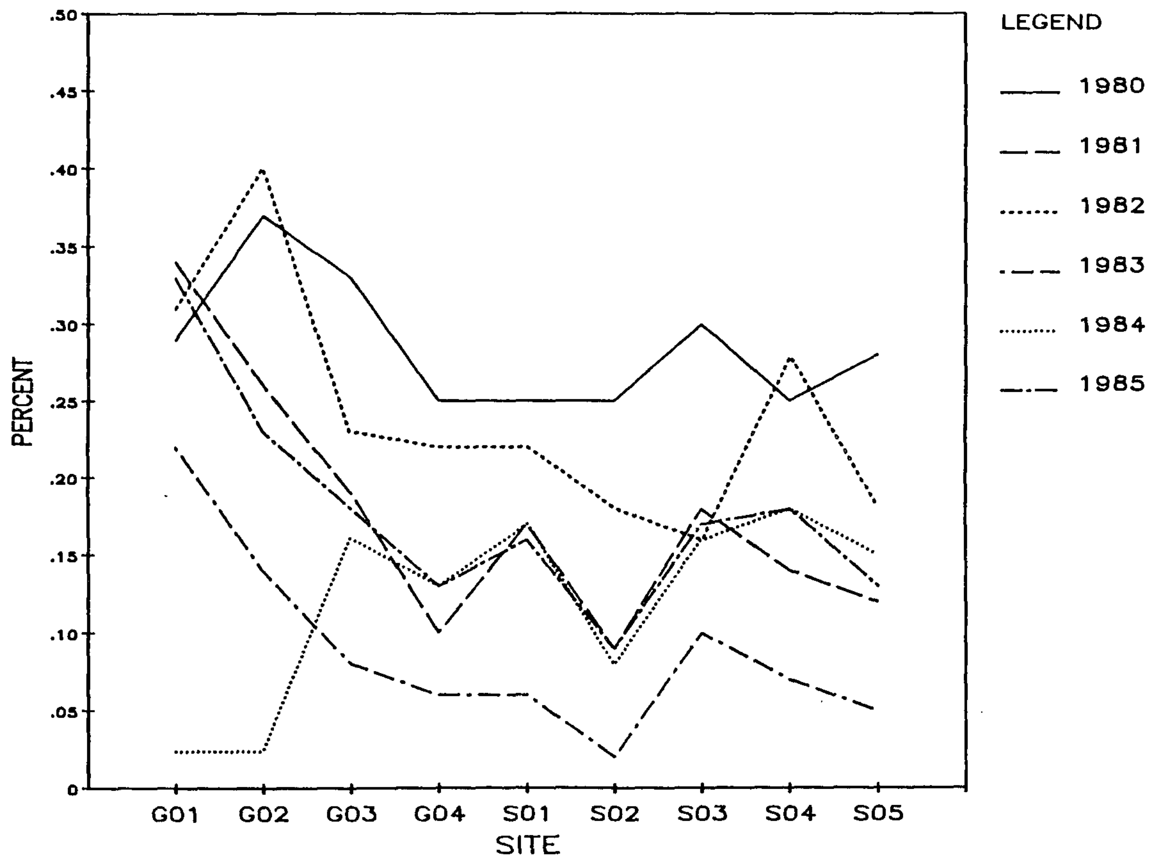


Figure 7-23. Soil Potassium for 1980 - 1985

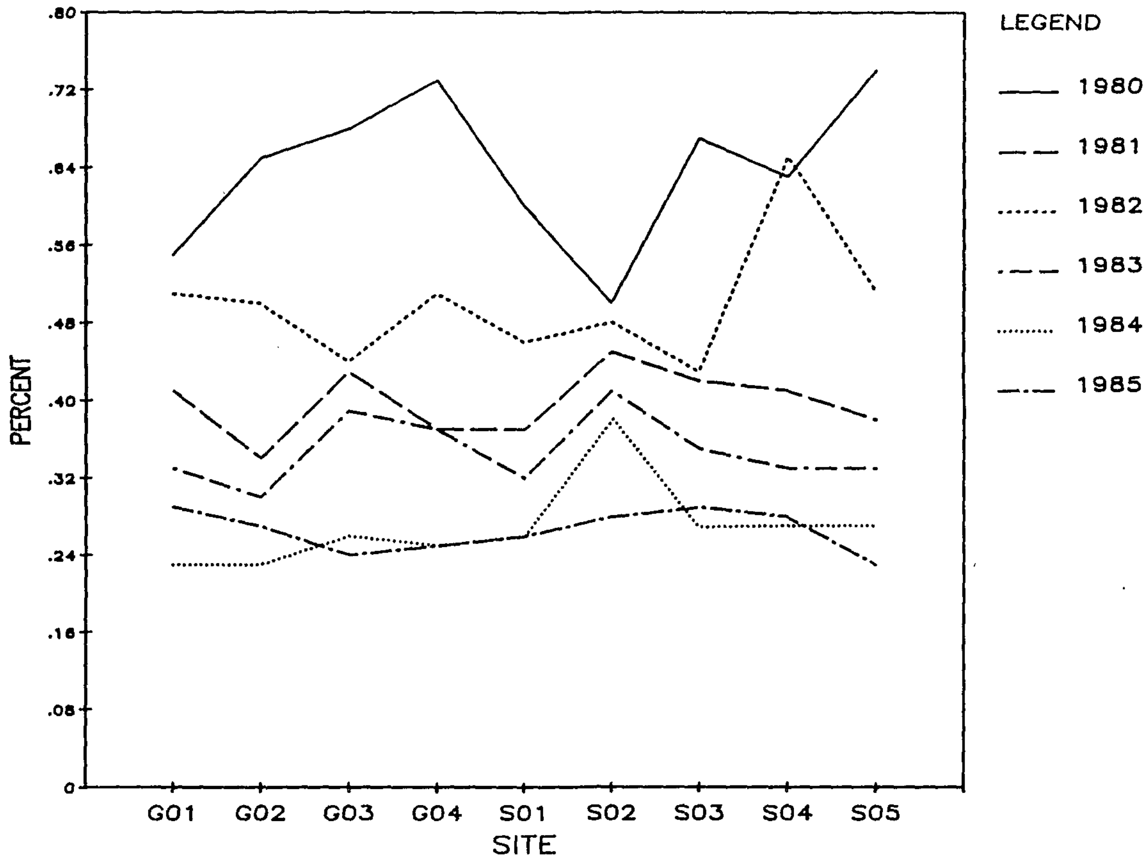


Figure 7-24. Soil Calcium for 1980 - 1985

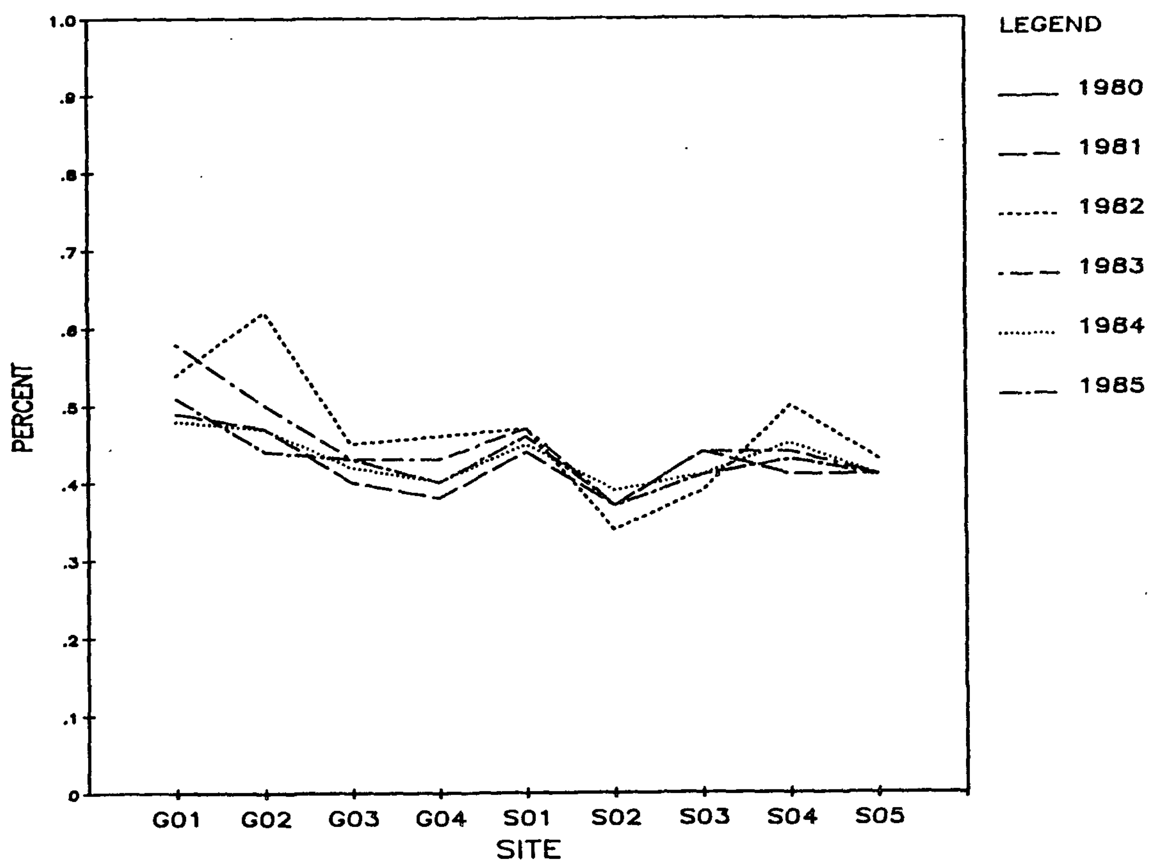


Figure 7-25. Soil Magnesium for 1980 - 1985

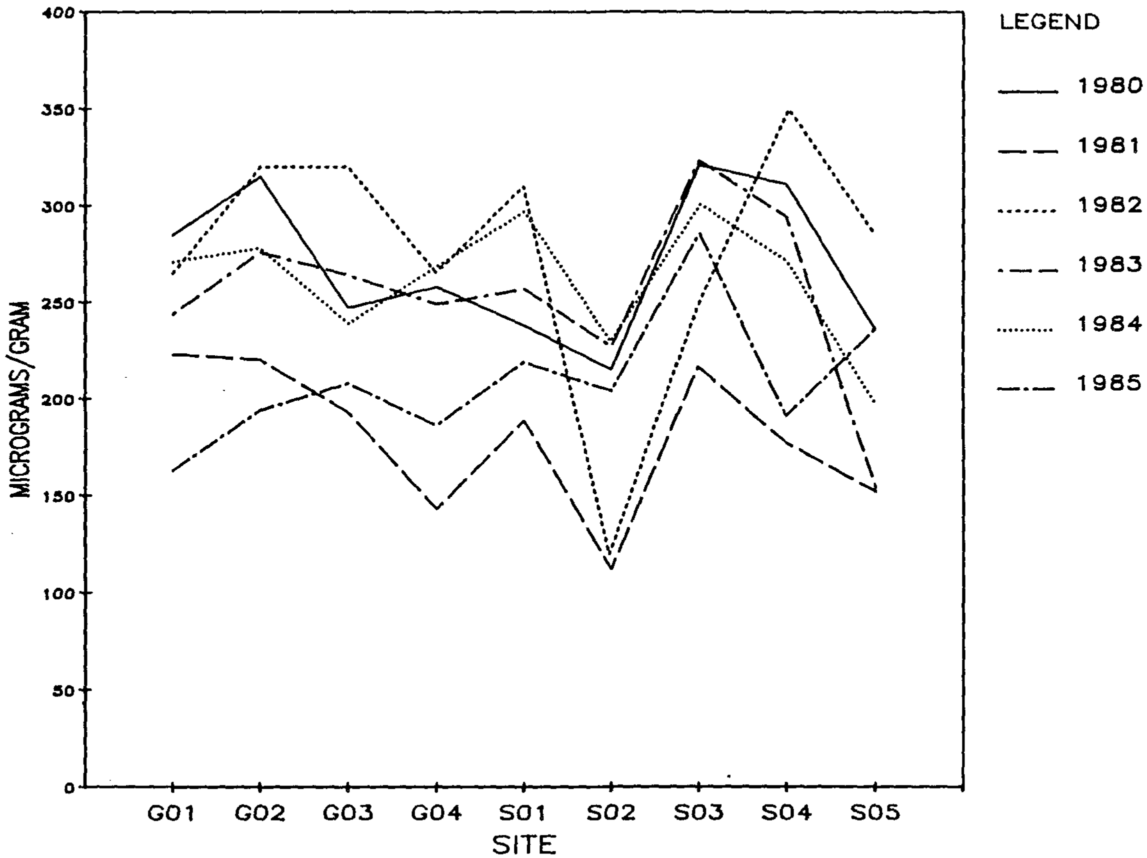


Figure 7-26. Soil Fluoride for 1980 - 1985

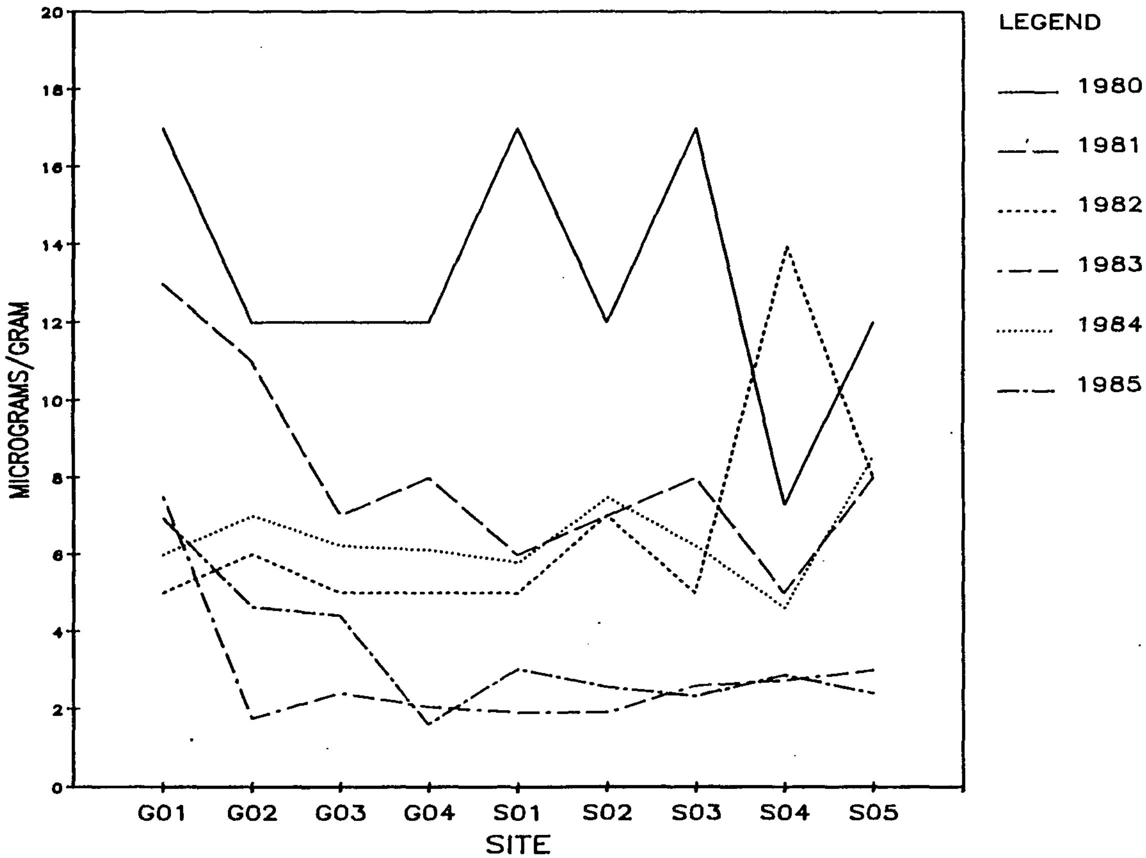


Figure 7-27. Soil Chloride for 1980 - 1985

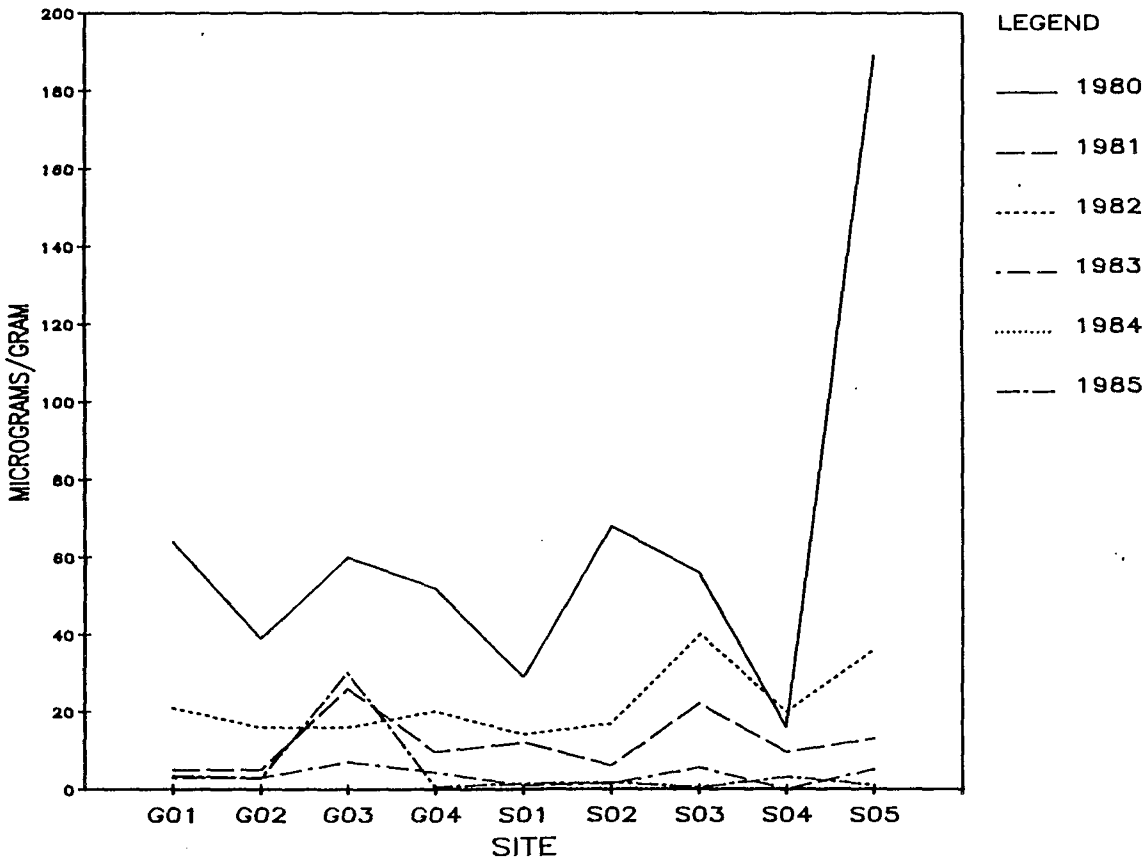


Figure 7-28. Soil Sulfate for 1980 - 1985

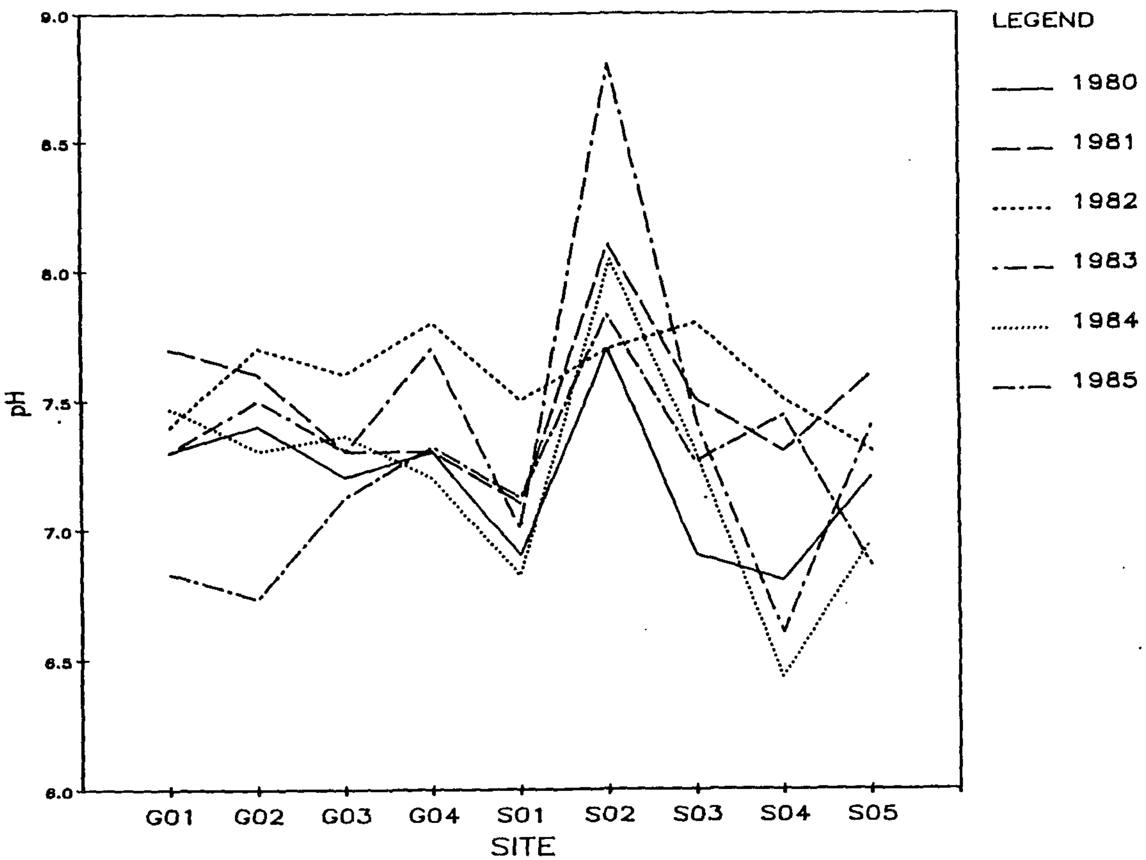


Figure 7-29. Soil pH for 1980 - 1985

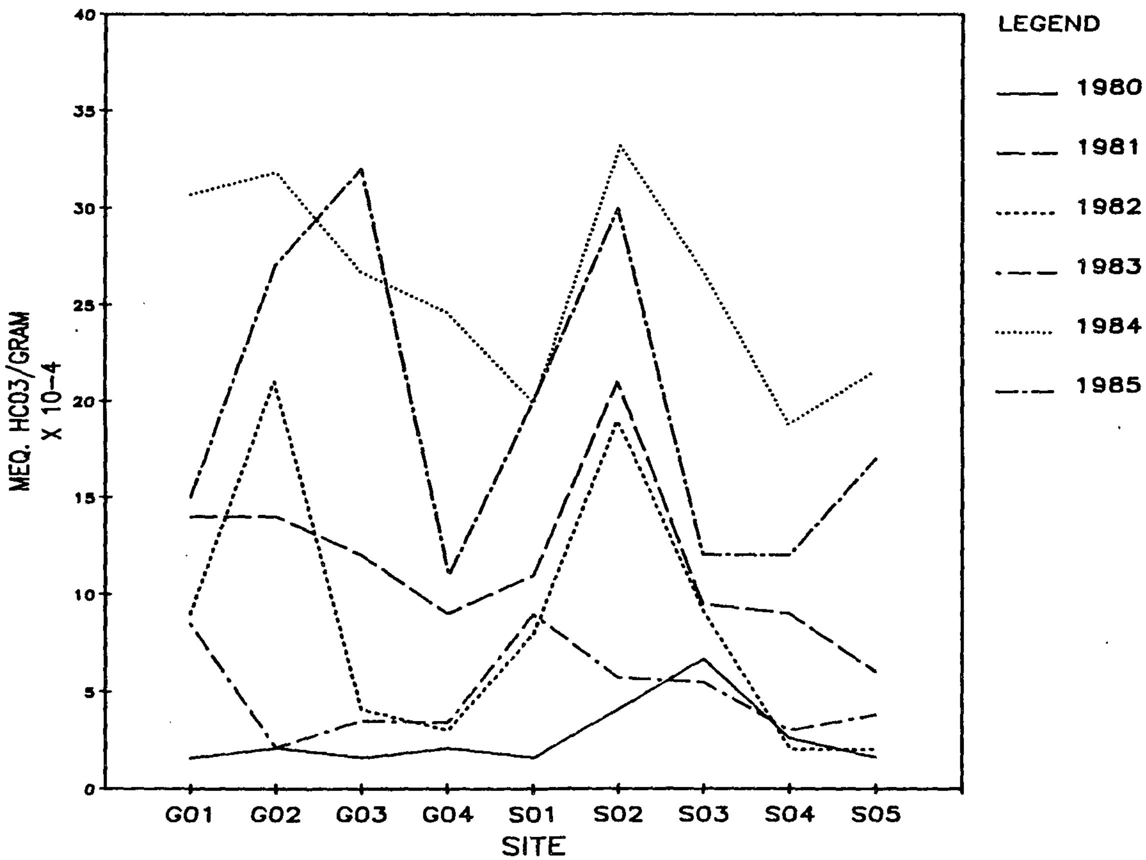


Figure 7-30. Soil Bicarbonate for 1980 - 1985

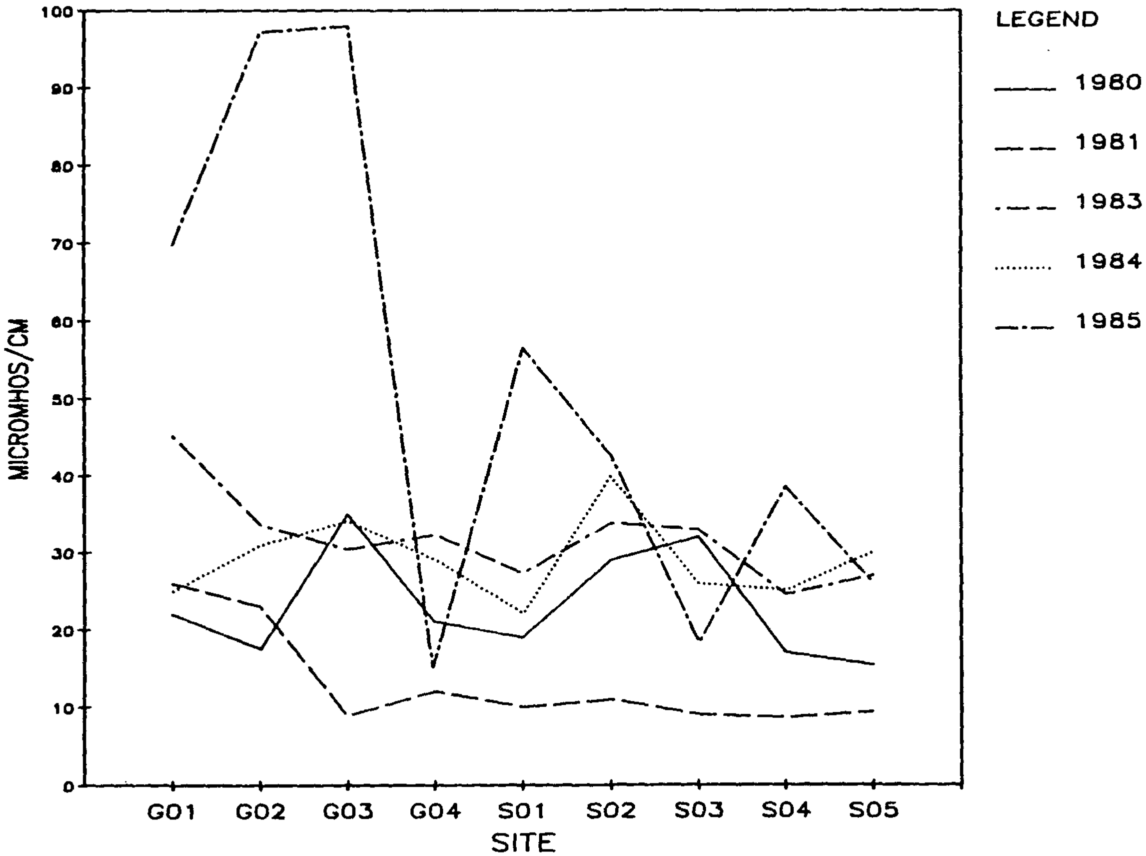


Figure 7-31. Soil Conductivity for 1980 - 1985

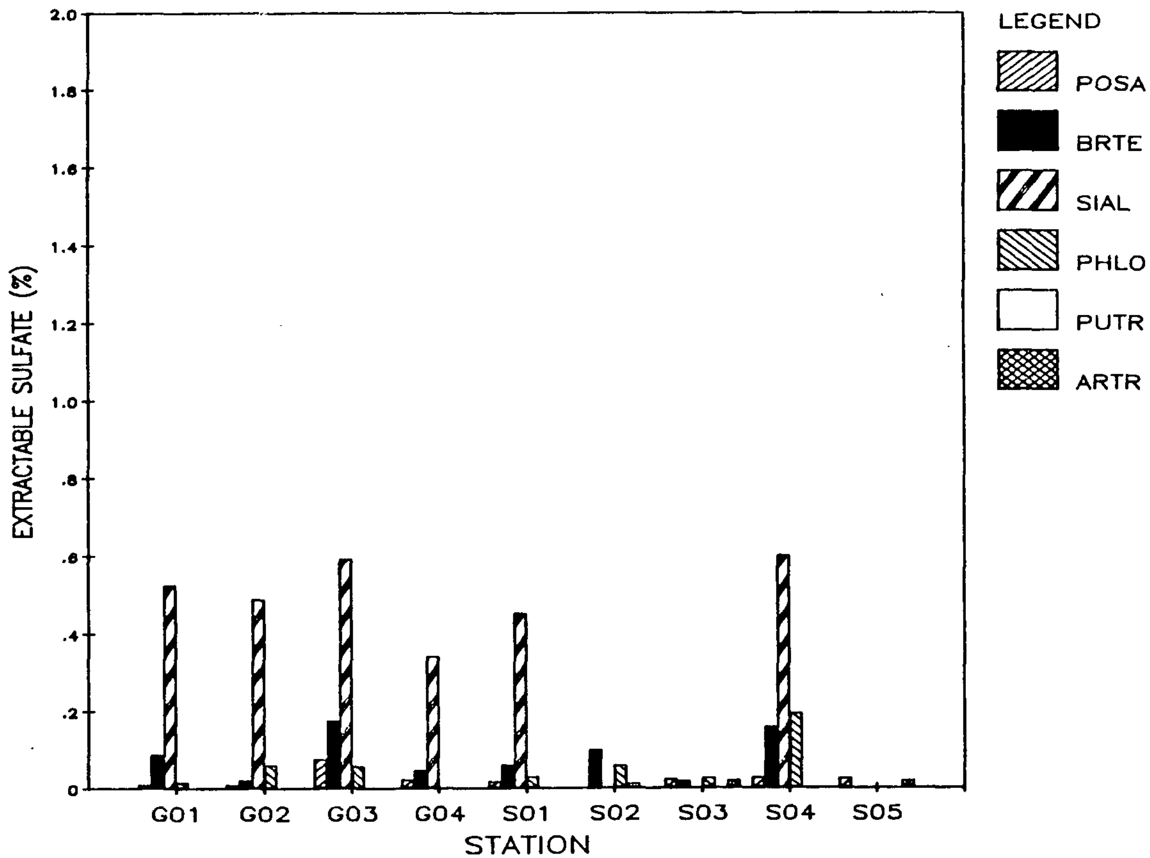


Figure 7-32. Total Vegetation Sulfate for 1985

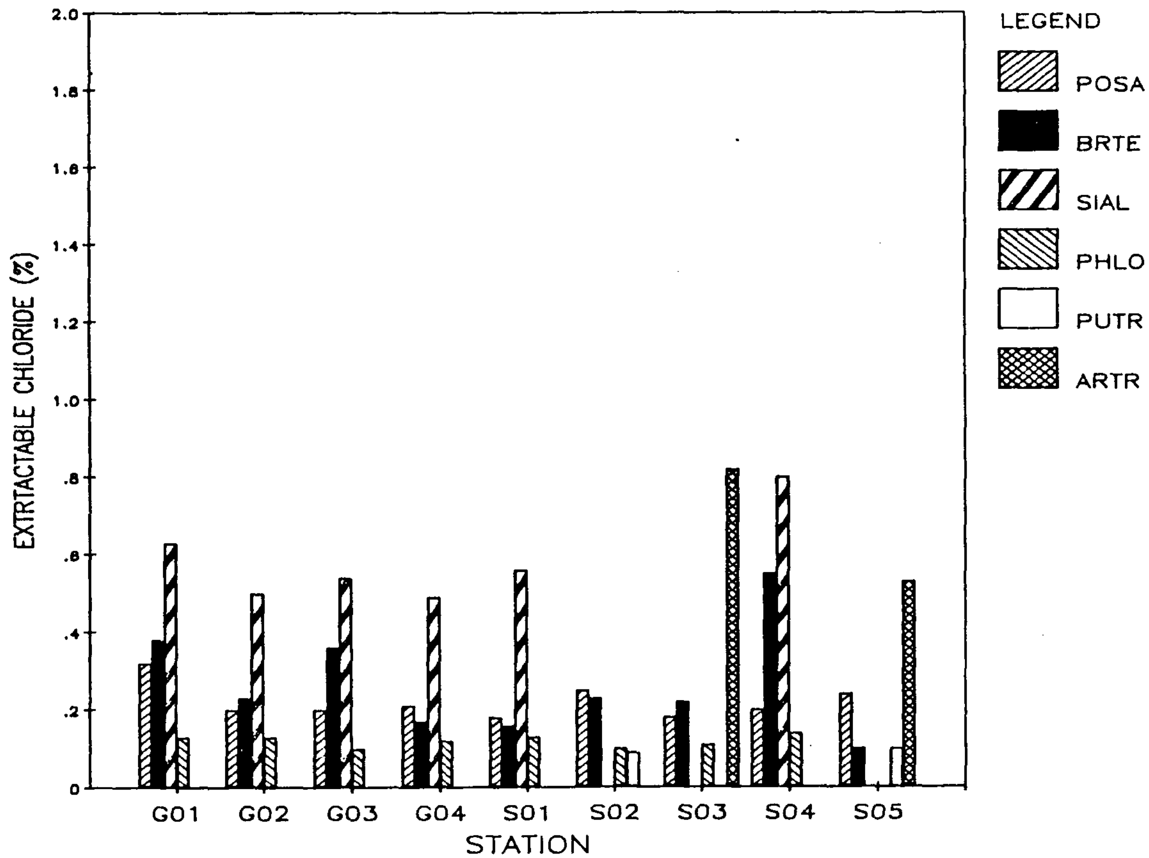


Figure 7-33. Total Vegetation Chloride for 1985

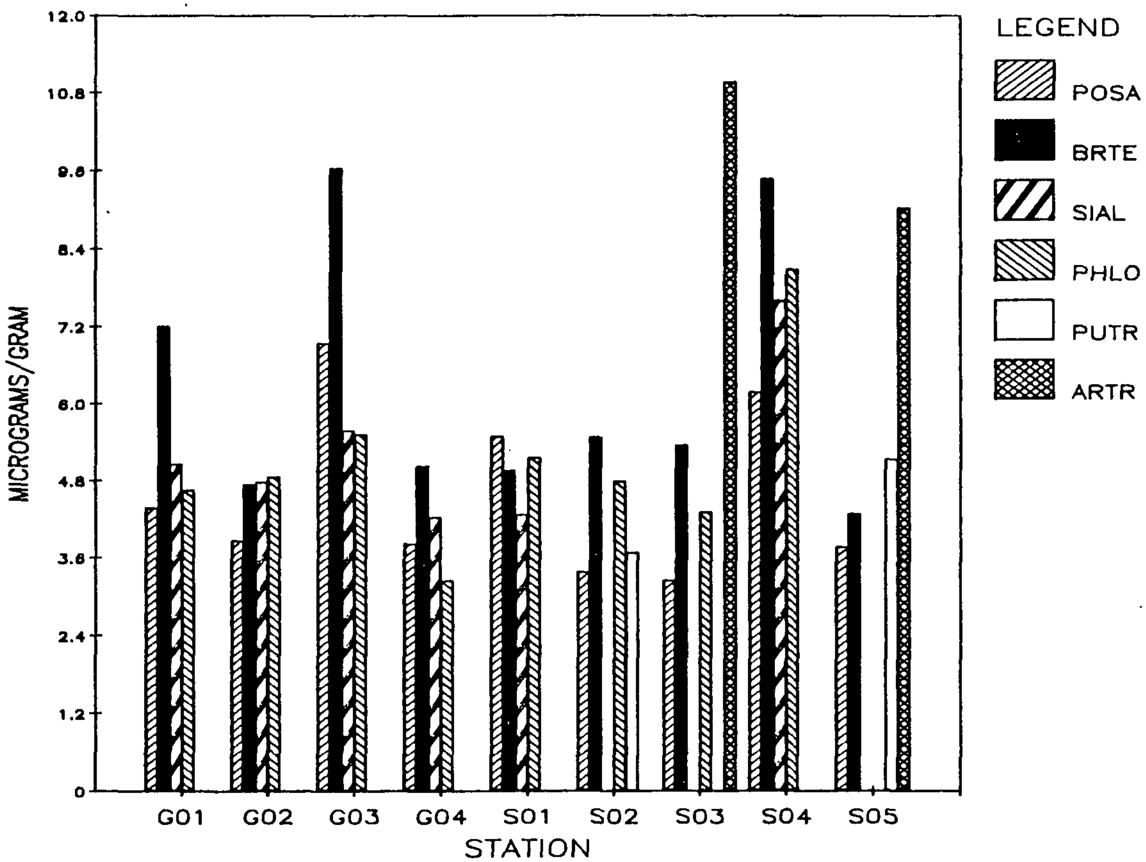


Figure 7-34. Total Vegetation Copper for 1985

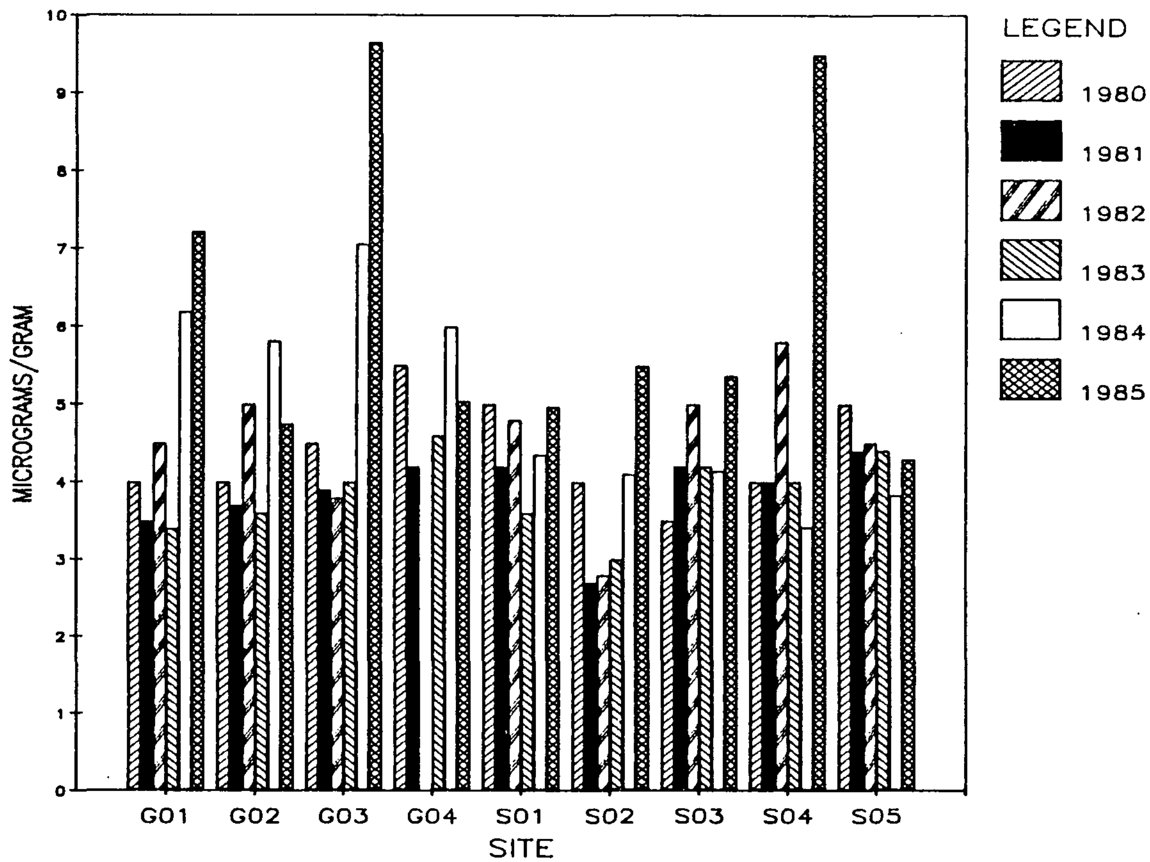


Figure 7-35. Copper Concentrations in Bromus tectorum for 1980 - 1985

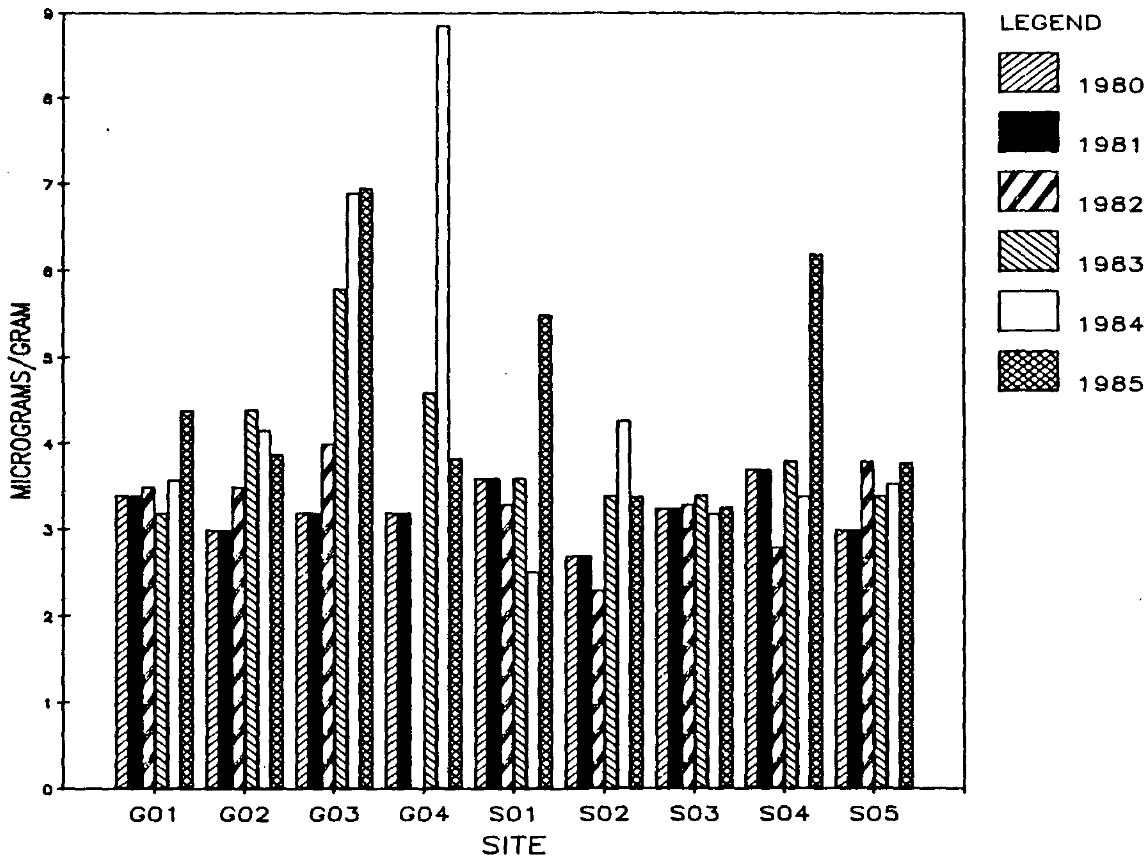


Figure 7-36. Copper Concentrations in *Poa sandbergii* for 1980 - 1985

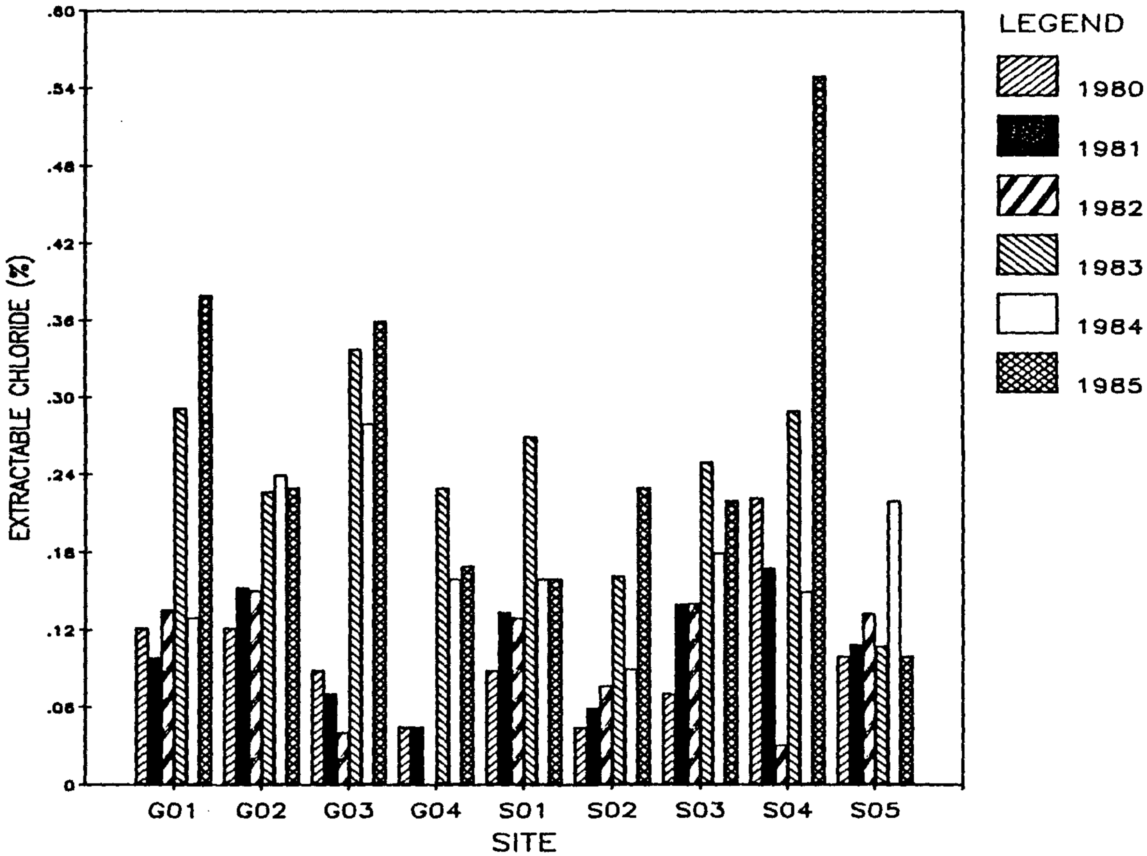


Figure 7-37. Chloride Concentrations in Bromus tectorum for 1980 - 1985

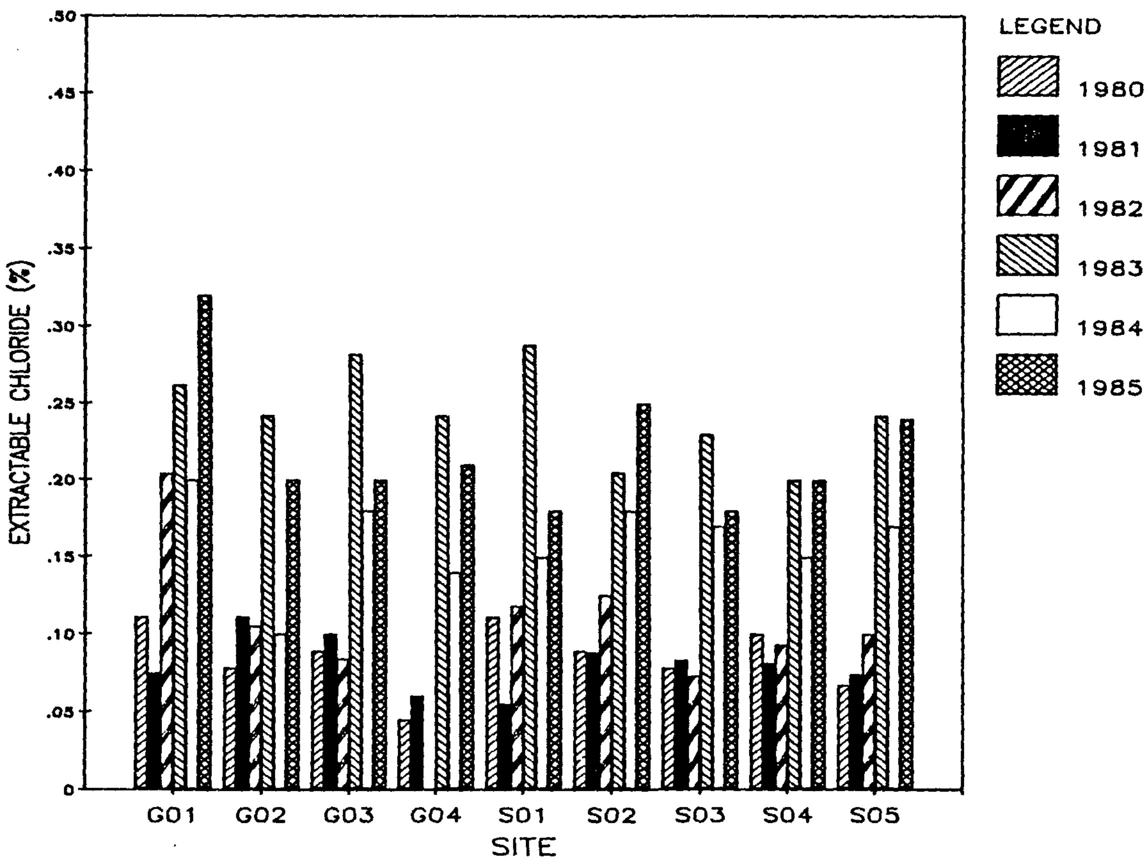


Figure 7-38. Chloride Concentrations in Poa sandbergii for 1980 - 1985

8.0 TERRESTRIAL - ANIMAL

8.1 INTRODUCTION

The habitat found in the vicinity of WNP-1 and WNP-2 supports avian, deer and rabbit communities that may be affected by plant construction and operation. Direct effects such as physical disturbances and noise as well as indirect effects brought about through changes in the abundance of food items, are potentially related to plant construction and operation activities. The objectives of the bird, deer, and rabbit census programs are to document the presence or absence of plant related impacts and to define the temporal and spatial limits of natural population changes in these communities during WNP-2 operation. These surveys fulfill requirements imposed by the Energy Facility Site Evaluation Council Resolution Nos. 194 and 195 dated May 26, 1981.

As a result of an August 1984 range fire, EFSEC allowed the Supply System to terminate sampling in the three plots which were disturbed by the fire (EFSEC Resolution No. 223 dated October 29, 1985). The 1985 survey program was limited to three plots in the southeast quadrant.

8.2 MATERIALS AND METHODS

8.2.1 Birds

The 1985 spring and fall surveys of bird communities were conducted May 9, 10, 14-17 and October 17, 18, 23-25, and 29. The surveys were conducted on two 20-acre plots located south of the WNP-1 and WNP-2 sites (Figure 8-1). The plots are located in two different biomes, riparian (river) and shrub-steppe. All the surveys were started at sunrise. By rotating which plot (and biome) was surveyed first each day, each plot was observed at different times of the morning.

The investigator traveled approximately the same route each day within each plot. The starting and ending time, distance walked, and weather were noted. Each bird encountered within the plot was noted as well as those birds observed within one kilometer of the plot.

8.2.2 Deer and Rabbit

The 1985 census was conducted within 75 circular 25 m^2 plots. The spring and fall counts were performed during the May 9, 10, and 14 and October 23, 25, and 29 time periods, respectively. The sample areas are located in bitterbrush-sagebrush, riparian, and burned habitats south of the WNP-1 and WNP-2 site. There are 25 circular plots for each of the three different sample areas (Figure 8-1). The pellet-group/pellet-count technique (Bennett et. al. 1940) is used as an index to calculate deer and rabbit population size based on the density of fecal pellet groups or fecal pellets, the deposition period and regional defecation rate. The investigator proceeds to the monitoring location and the date, time, and weather conditions are noted. The plots are searched for pellets by placing the looped end of a 2.825 meter rope over a nail on a stake that is in the center of each plot. Using the 1 meter and 2 meter marks on the rope, the investigator searches around the stake at each of these intervals and at the edge of the plot. The pellet groups are recorded and then removed from the plot. Rabbit pellets are counted individually.

Using the total number of deer and rabbit pellet groups or pellets found in each plot during the semi-annual census, the mean density of deer or rabbits can be calculated per square kilometer for each sample area. The deer and rabbit density for each sample area was calculated by using the formulas:

$$\text{Number of rabbits} = \frac{(\frac{a}{b}) \times 10^6}{(c \times d)}$$

a = number of pellets
b = size of plot
c = days between sample collection
d = deposition rate/day (530 pellets/day per rabbit)

$$\text{Number of deer} = \frac{(\frac{a}{b}) \times 10^6}{(c \times d)}$$

a = pellet groups
b = size of plot
c = days between sample collection
d = deposition rate (13 pellet groups/day per deer)

8.3 RESULTS AND DISCUSSION

8.3.1 Birds

Tables 8-1 and 8-2 present the 1985 spring and fall data, which includes the number of bird species sighted and their frequencies within and outside the plots. Twenty-two different species were observed within the south riparian biome during the spring survey and nine species were observed within the south shrub biome. During the fall survey the south riparian biome again had the largest number of species with thirteen within the plot and two outside. The total number of species sighted during the previous five years are listed in Table 8-3.

The number of sightings was used to calculated density per acre. However, to calculate density, only low-flying and perching birds were counted. Because of their transient behavior, flocks that were noted as passing through the plots were not included in the density calculations. Tables 8-4 and 8-5 show the spring and fall density figures. Spring and fall percent composition data are presented in Tables 8-6 and 8-7, respectively. Percentages were calculated utilizing only those birds appearing within the sample plots.

Western meadow larks, brown headed cow birds, white-crowned sparrows, and black-billed magpies comprised 47.23 percent of the birds observed in 1985 (Table 8-7). Waterfowl and shorebirds observed were: ducks, geese, gulls, loons, killdeer, herons and curlews. Only three species of raptors were observed in 1985: loggerhead shrike, red-tailed hawk, and northern harrier. The game birds observed during the survey include the Canada goose, cinnamon teal, mallard duck, California quail, morning dove, and ring-necked pheasant. Table 8-9 lists all bird species observed during the 1981 through 1985 surveys.

During the 1985 surveys, a total of 42 different species were recorded as compared to 39, 43, and 48 during the 1984, 1983 and 1982 surveys. Twenty-five of the species recorded during 1985 were also recorded during the 1981-1984 studies. Species not recorded in all years were generally low in abundance. Yellow-headed blackbirds and Audubon's warblers which were first sighted in the 1983 survey, were sighted again in the 1984 and 1985 surveys. The yellow warbler, seen for the first time in the 1984 survey, was also sighted in 1985 as well as a Traill's flycatcher. All four species were sighted in the south riparian biome. In general the seasonal trends in total sightings and species numbers observed in the 1981 census were evident in the 1982 - 1985 censes.

8.3.2 Deer and Rabbits

The number of deer and rabbit pellet groups per plot recorded during the spring and fall surveys are presented in Tables 8-10 and 8-11, respectively. Deer and rabbit densities per sample area recorded during the spring and fall 1985 surveys are presented in Tables 8-12 and 8-13, respectively.

Deer densities (deer/km^2) were highest in the south shrub and south riparian sample biomes during the spring and fall census periods (Table 8-10). The south grass biomes had relatively low density values. The south shrub biome had the highest densities recorded during the five year sampling period while the 1982 density values were the highest observed during the five years (Table 8-10). It appears that deer densities near WNP-1 and WNP-2 are low compared to other areas sampled both inside and outside Washington state (Bennett et. al. 1940, Eberhardt et. al. 1956, Pickens 1976, Zeigler 1978).

The highest rabbit densities (rabbits/km^2) observed were in the south shrub biome during the 1981-1985 sampling periods (Table 8-11). The south riparian and south grass biome had relatively low density values. The results of this study are in good agreement with those reported by others (Beak 1979, Cochran et. al. 1961, Larrison 1970).

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Table 8-1. Spring Bird Survey of May 9-17, 1985

SPRING SURVEY 1985

Species List	South Riparian														South Riparian													
	On Plot							Off Plot							On Plot							Off Plot						
(1)	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total
American coot									2					2														
Audubon's warbler	1						1		2					2														
Bank swallow			2				2			3			10	13														
Barn swallow						1	1												1		1							
Black-billed magpie	3	5	3	5	4	1	21		2		2			4								1	3	1	2			7
Brewer's blackbird															1						1							
Brown-head cowbird	4	8	8	22	24	16	82	4	14				7	25														
Bullock's oriole	3	4	1	5	1	1	15																					
California quail																	2				2			1	4			5
Canada goose								2	2		12			16								2						2
Cinnamon teal										2				2														
Common loon									3	1				4														
Common merganizer		2					2		2				2	4														
Common raven								1						1														
Eastern kingbird	1	4	1	3		1	10	1	1					2														
Foster tern												2		2														
Great blue heron													3	3														
Herring gull		1					1																					
Killdeer								1						1														
Lark sparrow																1					1							
Long-billed curlew																				2	2							
Mallard	2	2					4		1				4	5														
Morning dove		1			1		2	1	2			4		7													2	2
Northern harrier																1					1							
Red-winged blackbird	6	5	9	7	2	12	41	5			2	3		10		2		11	1		14				3	1		4
Ring-necked pheasant					1		1																					
Sage Sparrow		1	1	1		1	4																					
Savannah sparrow	2			1			3													1	1							
Traills flycatcher					1		1																					
Tree sparrow					1		1																					
Western kingbird	4	3	5	6	8	4	30					3		3														
Western meadow lark	10	6	9	6	5	4	40	4		4	4	2	5	19	13	6	8	13	4	7	51	10	5	5	17	6	12	55
White-crown sparrow	1	1			2		4																					
Yellow warbler					1		1																					
Yellowhead blackbird		4				4	8																					
Unidentified blackbird		1					1															1					4	5
Unidentified gull		3				1	4	3	8	18	15	1	23	68		1					1	5	1	6	7	2	3	24
Unidentified sparrow					1		1													2	2				1		2	3
	Total Species						22	Total Sightings						275	Total Species						9	Total Sightings						74

(1) Dates of Surveys
1 - May 9, 1985 3 - May 14, 1985 5 - May 16, 1985
2 - May 10, 1985 4 - May 15, 1985 6 - May 17, 1985

Table 8-2. Fall Bird Survey of October 17-22, 1985

FALL SURVEY 1985

South Riparian

Species	On Plot (1) 1	2	3	4	5	6	Total	Off Plot 1	2	3	4	5	6	Totals
Audubon's warbler					3		3							
Blackbilled magpie	3	2		3	1	1	10	1	2					3
California quail		8			10	7	25		13					13
Canada goose														
Common merganser				2			2							
Great blue heron		1			1		2	5		1	2			8
Loggerhead shrike														
Mallard								2	4			7	100	113
Oregon junco	1	1			6	1	9							
Red-shafted flicker		1	1		1	1	4							
Red-tailed hawk					2	2	4							
Red-winged blackbird														
Ring-necked pheasant		2	2	2			6							
Savannah sparrow		1					1							
Song sparrow					1		1							
Starling														
Western grebe											2		2	4
Western meadowlark		2				2	4		1				3	4
White-crowned sparrow	14	12	5	9	7	12	59			2				2
Unidentified blackbird			1				1							
Unidentified gull		3					3				4	1	13	18
Unidentified sparrow		1				1	2				1			1
	Total Species						13	Total Sightings						130

South Shrub

Species	On Plot 1	2	3	4	5	6	Total	Off Plot 1	2	3	4	5	6	Totals
Audubon's warbler														
Blackbilled magpie				1			1	2						2
California quail								10	2					12
Canada goose										50			2	52
Common merganser														
Great blue heron								1						1
Loggerhead shrike						1	1							
Mallard										3	20			23
Oregon junco														
Red-shafted flicker										1				1
Red-tailed hawk														
Red-winged blackbird						2	2							
Ring-necked pheasant														
Savannah sparrow														
Song sparrow														
Starling										50				50
Western grebe														
Western meadowlark		7	5		1	5	18	6	12		3	2	7	30
White-crowned sparrow						1	1	8					2	10
Unidentified blackbird														
Unidentified gull									3				3	6
Unidentified sparrow		1	1				2	2	10	1		1		14
	Total Species						5	Total Sightings						26

(1) Dates of Surveys
- 1 - October 17, 1985
- 2 - October 18, 1985
- 3 - October 23, 1985
- 4 - October 24, 1985
- 5 - October 25, 1985
- 6 - October 29, 1985

Table 8-3. Total Number of Species Sighted 1981 Thru 1985

Year	Spring	Fall
1985	35	20
1984	29	15
1983	35	21
1982	41	24
1981	32	26

Table 8-4. Spring Bird Survey Densities for 1985

Species	N(1) South Shrub	N/A(2)	N South Riparian	N/A
American robin			1	.05
Bank swallow			2	.1
Barn swallow	1	.05	1	.05
Black-billed magpie			21	1.05
Brewer's blackbird	1	.05		
Brownhead cowbird			82	4.1
Bullock's oriole			15	.75
California quail	2	.1		
Common merganzer			2	.1
Eastern kingbird			10	.5
Herring gull			1	.05
Lark sparrow	1	.05		
Long-billed curlew	2	.1		
Mallard			4	.1
Morning dove			2	.1
Northern harrier	1	.05		
Red-winged blackbird	14	.7	41	2.05
Ring-necked pheasant			1	.05
Sage sparrow			4	.2
Savannah sparrow	1	.05	3	.15
Traills flycatcher			1	.05
Tree sparrow			1	.05
Western kingbird			30	1.5
Western meadowlark	51	2.55	40	2.0
White-crowned sparrow			4	.2
Yellow warbler			1	.05
Yellow-head blackbird			8	.4

(1) N = Number of birds observed

(2) N/A = Number of birds per acre

Table 8-5. Fall Bird Survey Densities for 1985

Species	N[1] South Shrub	N/A[2]	N South Riparian	N/A
Audubon's warbler			3	.15
Black-billed magpie	1	.05	10	.5
California quail			25	1.25
Common merganzer			2	.1
Great blue heron			2	.1
Loggerhead shrike	1	.05		
Oregon junco			9	.45
Red-shafted flicker			4	.2
Red-sailed hawk			4	.2
Red-wing blackbird	2	.1		
Ring-necked pheasant			6	.3
Sage sparrow			1	.05
Savannah sparrow			1	.05
Western meadow lark	18	.9	4	.2
White-crown sparrow	1	.05	59	2.95

(1)N = Number of birds observed

(2)N/A = Number of birds per acre

Table 8-6. Spring Bird Survey Percentages for 1985

Species	#Sightings North Shrub	Percent Composition	#Sightings Within North Riparian	Percent Composition
Audubon's warbler			1	.3
Bank swallow			2	.7
Barn swallow			1	.3
Black-billed magpie			21	7.7
Brewing blackbird	1	1.3		
Brownhead cow bird			82	30.2
Bullock's oriole			15	5.5
California quail	2	2.7		
Common merganzer			2	.7
Eastern kingbird			10	3.6
Herring gull			1	.3
Lark sparrow	1	1.3		
Long-billed curlew	2	2.7		
Mallard			4	1.4
Morning dove			2	.7
Northern harrier	1	1.3		
Red-winged blackbird	14	18.9	41	15.1
Ring-necked pheasant			1	.3
Sage sparrow			4	1.4
Savannah sparrow	1	1.3	3	1.1
Traill's flycatcher			1	.3
Tree sparrow			1	.3
Western kingbird			30	11.0
Western meadow lark	51	68.9	40	14.7
White-crowned sparrow			1	1.4
Yellow warbler			1	.3
Yellow-head blackbird			8	2.9
Total Sightings	74		271	

Table 8-7. Fall Bird Survey Percentages for 1985

Species	#Sightings South Shrub	Percent Composition	#Sightings Within South Riparian	Percent Composition
Audubon's warbler			3	2.3
Black-billed magpie	1	3.8	10	7.6
California quail			25	19.2
Common merganzer			2	1.5
Great blue heron			2	1.5
Loggerhead shrike	1	3.8		
Oregon junco			9	6.9
Red-shafted flicker			4	3.0
Red-tailed hawk			4	3.0
Red-winged blackbird	2	7.6		
Ring-necked pheasant			6	4.6
Sage sparrow	1	3.8		
Savannah sparrow			1	.7
Song sparrow			1	.7
Western meadowlark	18	69	4	3.0
White-crowned sparrow	1	3.8	59	45.3
Total Sightings	26		130	

Table 8-8. List of Ten (10) Most Sighted Birds and Percentage Compositions for 1985

	Species	Sighted	[1]Percent Composition
1.	Western meadow larks	103	20.98
2.	Brown-Read cow bird	82	16.70
3.	White-crown sparrow	64	13.03
4.	Black-billed magpie	32	6.52
5.	Western kingbird	27	5.50
6.	California quail	30	6.11
7.	Bullock's oriole	15	3.05
8.	Eastern kingbird	10	2.04
9.	Oregon junco	9	1.83
10.	Yellowhead blackbird	8	1.63
			77.39

[1]Percentages are derived from total identified birds sighted inside the plots for 1985.

[1]Total birds sighted within plots 491.

Table 8-9. Bird Species List for 1985

	Identified	Spring 1981-1985	Fall 1981-1985	Previous Studies(1)
1.	American coot	X	X	
2.	American goldfinch	X		
3.	American kestrel	X	X	X
4.	American robin	X	X	
5.	Audubon's warbler		X	
6.	Bald eagle		X	
7.	Bank swallow	X		
8.	Barn swallow	X	X	X
9.	Black-billed magpie	X	X	X
10.	Blue-wing teal	X		
11.	Brewer's blackbird	X		
12.	Brownhead cowbird	X		
13.	Bullock's oriole	X		
14.	Burrowing owl		X	X
15.	California quail	X	X	
16.	Canada goose	X	X	
17.	Cinnamon teal	X		
18.	Cliff swallow	X		X
19.	Common crow	X	X	
20.	Common loon	X	X	
21.	Common merganser	X		
22.	Common nighthawk	X		X
23.	Common raven	X	X	X
24.	Common tern	X		
25.	Eared grebe		X	
26.	Eastern kingbird	X		
27.	Ferruginous hawk			X

Table 8-9 (cont.). Bird Species List for 1985

	Identified	Spring 1981-1985	Fall 1981-1985	Previous Studies(1)
28.	Foster tern	X		
29.	Golden eagle			X
30.	Great blue heron	X	X	
31.	Green-wing teal	X		
32.	Herring gull	X		
33.	Horned lark	X	X	X
34.	Killdeer	X	X	X
35.	Lark sparrow	X		
36.	Loggerhead shrike	X	X	X
37.	Long-billed curlew	X		X
38.	Mallard	X	X	
39.	Marsh hawk (harrier)	X	X	X
40.	Morning dove	X		X
41.	Oregon junco		X	X
42.	Prairie falcon			X
43.	Red-headed duck	X		
44.	Red-shafted flicker		X	X
45.	Red-tailed hawk	X	X	X
46.	Red-wing blackbird	X	X	
47.	Ring-necked pheasant	X	X	
48.	Rock dove (domestic pigeon)	X		
49.	Rough-legged hawk		X	X
50.	Sage sparrow	X	X	X
51.	Savannah sparrow	X	X	X
52.	Say's phoebe	X		
53.	Song sparrow	X		
54.	Spotted sandpiper	X		
55.	Starling	X	X	X

Table 8-9 (cont.). Bird Species List for 1985

	Identified	Spring 1981-1985	Fall 1981-1985	Previous Studies(1)
56.	Swainson's hawk		X	
57.	Traill's flycatcher	X		
58.	Tree sparrow	X	X	
59.	Water pipit		X	
60.	Western kingbird	X		
61.	Western meadowlark	X	X	X
62.	Western sandpiper		X	
63.	Western gull	X		
64.	Whistling swan		X	
65.	White-crowned sparrow	X	X	X
66.	Wilson's warbler	X		
67.	Yellow warbler	X		
68.	Yellow head blackbird	X		

(1) Previous studies were performed for the Washington Public Power Supply System by Battelle Pacific Northwest Laboratories (Battelle, 1976, 1977, 1979a, 1979b).

Table 8-10. Deer Pellet Census: Densities Spring 1985

Sample area	Total Pellet Group					Densities (No. of Deer/km^2)				
	1981	1982	1983	1984	1985	1981	1982	1983	1984	1985
North Shrub	--[1]	3	0	2	--[2]	--	1.74	0	1.01	--
South Shrub	--	137	35	25	15	--	77.31	19.3	14.0	8.8
North Riparian	--	11	27	28	--	--	6.26	14.9	14.9	--
South Riparian	--	3	5	5	15	--	1.83	2.7	2.6	8.5
North Grass	--	3	4	0	--	--	1.82	2.1	0	--
South Grass	--	6	14	27	17	--	3.63	7.49	14.7	9.5

[1] Plots initially cleared of pellets.

[2] North plots were not sampled because of range fire (EFSEC Resolution No. 223, October 29, 1984).

Table 8-10 (cont.). Deer Pellet Census: Densities
Fall 1985

Sample area	Total Pellet Group					Densities (No. of Deer/km^2)				
	1981	1982	1983	1984	1985	1981	1982	1983	1984	1985
North Shrub	4	8	1	--[1]	--	2.91	7.57	0.89	--	--
South Shrub	35	79	40	28	8	28.53	72.56	35.6	23.6	5.7
North Riparian	17	18	19	--	--	12.92	17.44	16.7	--	--
South Riparian	1	2	6	7	9	0.76	2.21	5.3	6.1	6.6
North Grass	1	1	4	--	--	0.76	1.13	3.5	--	--
South Grass	1	6	10	7	3	0.78	6.65	9.1	5.9	2.3

(1) North plots were not sampled because of range fire on August 11-12, 1984.
(EFSEC Resolution No. 223, October 1984)

Table 8-11. Rabbit Pellet Census: Densities
Fall 1985

Sample area	Total Pellets					Densities (No. of Rabbit/km^2)				
	1981	1982	1983	1984	1985	1981	1982	1983	1984	1985
North Shrub	4,680	2,743	1,549	--[1]	--	83.60	63.69	33.8	--[1]	--
South Shrub	720	2,717	886	1,337	590	14.39	61.21	19.1	26.6	12.7
North Riparian	120	433	740	--	--	2.24	10.29	15.9	--	--
South Riparian	0	0	2	23	3	0	0	.44	.49	.05
North Grass	120	0	0	--	--	2.32	0		--	--
South Grass	0	0	0	2	0	0	0	0	.004	0

[1] North plots were not sampled because of range fire on August 11-12, 1984.
(EFSEC Resolution No. 223, October 1984)

Table 8-12. Deer Pellet Census for 1985: Number of Pellet Groups Spring 1985

Plot No.(1)	South Shrub May 10	South Riparian May 9	South Grass May 14
1	0	0	0
2	1	0	0
3	0	2	0
4	0	0	0
5	0	0	0
6	1	0	0
7	1	0	0
8	0	0	3
9	1	0	3
10	0	0	4
11	1	2	0
12	1	2	0
13	1	1	1
14	2	1	0
15	3	1	0
16	0	0	0
17	0	1	0
18	2	1	1
19	0	1	0
20	0	0	1
21	0	1	0
22	0	0	1
23	0	0	1
24	0	1	1
25	1	1	1
Total Pellet Groups	15	15	17

(1) North plots were not sample because of range fire on August 11-12, 1984.

Table 8-12 (cont.). Deer Pellet Census for 1985:
Number of Pellet Groups
Fall 1985

Plot No.(1)	South Shrub Oct 29	South Riparian Oct 23	South Grass Oct 25
1	1	0	0
2	0	0	0
3	0	3	0
4	0	0	0
5	0	0	0
6	1	0	0
7	0	0	0
8	1	0	1
9	0	0	0
10	0	0	1
11	0	1	0
12	1	0	0
13	0	1	0
14	1	2	0
15	1	0	0
16	0	0	0
17	1	0	1
18	1	0	0
19	1	0	0
20	0	0	0
21	0	0	0
22	0	0	0
23	0	0	0
24	0	0	0
25	0	3	0
Total Pellet Groups	9	9	3

(1) North plots were not sample because of range fire on August 11-12, 1984.

Plot No.[1]	South Shrub May 14	South Riparian May 9	South Grass May 10
1	49	0	0
2	27	0	0
3	55	0	0
4	19	0	0
5	21	0	0
6	151	0	0
7	36	0	0
8	39	0	0
9	96	0	0
10	36	0	0
11	21	0	0
12	20	0	0
13	44	0	0
14	52	0	0
15	12	0	0
16	11	0	0
17	30	0	0
18	6	0	0
19	41	0	0
20	9	0	0
21	51	0	0
22	8	0	0
23	10	0	0
24	26	0	0
25	16	0	0
Total Pellets	886	0	0

(1) North plots were not sampled because of range fire on August 11-12, 1984.

Table 8-13 (cont.). Rabbit Pellet Census for 1985: Number of Pellets Fall 1985

Plot No.[1]	South Shrub Oct 29	South Riparian Oct 23	South Grass Oct 25
1	17	0	0
2	11	0	0
3	3	3	0
4	7	0	0
5	4	0	0
6	54	0	0
7	21	0	0
8	48	0	0
9	18	0	0
10	26	0	0
11	37	0	0
12	63	0	0
13	43	0	0
14	48	0	0
15	26	0	0
16	39	0	0
17	18	0	0
18	7	0	0
19	31	0	0
20	15	0	0
21	22	0	0
22	0	0	0
23	4	0	0
24	18	0	0
25	10	0	0
Total Pellets	590	3	0

(1) North plots were not sampled because of range fire on August 11-12, 1984.

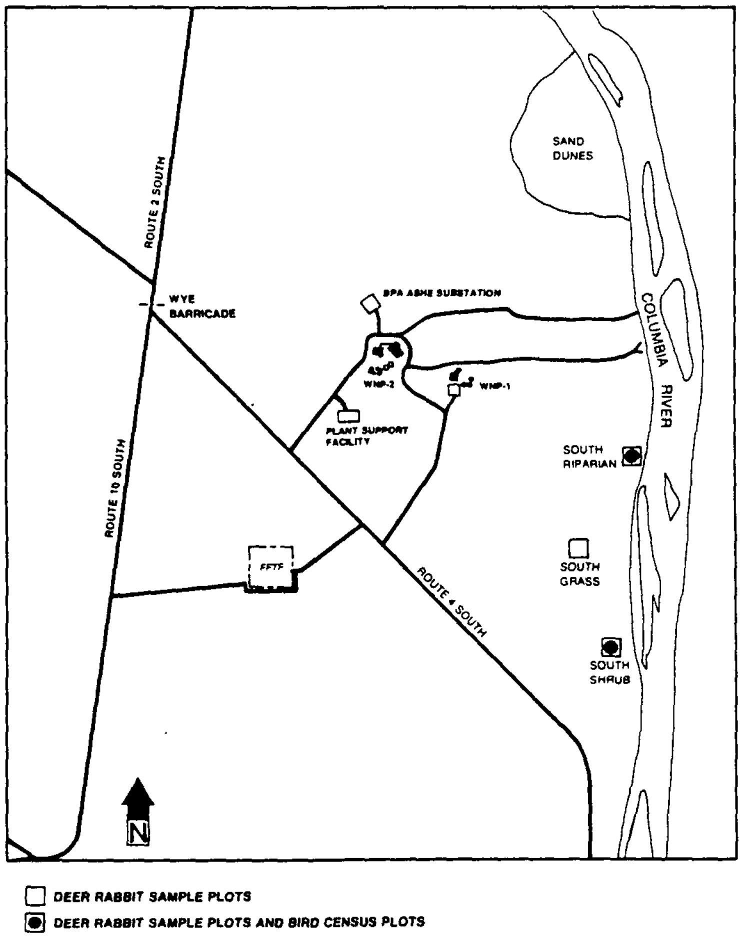


Figure 8-1. Deer, Rabbit, and Bird Plots in the Vicinity of WNP-1 and WNP-2

9.0 FISH BIOASSAY

9.1 INTRODUCTION

To evaluate the effect of the cooling tower blowdown effluent on Columbia River salmonids, four 96-hr static bioassays were conducted between October 1984 and November 1985. The bioassays, which were specifically required by Condition G34 of the WNP-2 NPDES Permit, used various concentrations of the recirculating cooling water. The first bioassay (October 1984) was discussed in the 1984 annual report (Supply System 1985) and the results are included here to provide complete information on the bioassays.

9.2 METHODS AND MATERIALS

The bioassays generally adhered to the procedures set forth by the Washington State Department of Ecology (1980). Specific methodology is provided in Environmental Programs Instruction, EPI 13-2.11 entitled "WNP-2 Aquatic Bioassays" (Washington Public Power Supply System 1983).

A total of four bioassay tests were conducted: two with chinook salmon and two with steelhead trout. All fish were provided by the State of Washington from the Ringold Hatchery (River Mile 355). Fish were acclimatized, in a 2000-liter capacity holding tank, for at least two weeks prior to testing. A commercial fish food (i.e., Oregon Moist) was utilized, with food size and feeding rates as used at the Ringold Hatchery. Fish were not fed for 48 hours prior to the start of, or during acute (i.e., 96 hours) bioassays.

Fish acclimatization and control aquaria water was drawn from the Columbia River via the WNP-2 makeup water pumphouse.

Static tests were conducted in 132.5 liter capacity glass aquaria containing a volume of approximately 114 liters. The bioassay system (Figure 9-1) consisted of twelve aquaria placed in a water bath (temperature modifying) table. The water bath table maintained aquaria water temperature close to river temperature during the test. Six different concentrations were tested in duplicate. The six concentrations represented the following percentage of WNP-2 cooling tower blowdown water: 0, 30, 50, 65, 80 and 100. Test water was taken directly from the WNP-2 cooling towers and distributed to the aquaria.

At the beginning of each test, fish were distributed in a stratified random manner to the aquaria. The loading factor varied from approximately 0.3 grams/liter in Test 3 to 5 grams/liter in Test 2 (Table 9-1). Aeration was used to maintain adequate dissolved oxygen (DO) concentrations in the test solutions. Checks for dead fish were made at least twice daily.

Fork lengths and wet weights were determined by anesthetizing and measuring representative fish before the test and all survivors at the end of the test. All fish surviving the tests were released to the Columbia River.

Table 9-1 identifies dates, species, sizes, and numbers of fish utilized in each of the bioassays.

Temperature, DO, pH and conductivity were measured daily in each aquaria. Grab samples were collected at the beginning and end of each bioassay in each aquaria and analyzed for total copper, total iron, total zinc, total cadmium, total lead, and total mercury.

At the beginning and end of the bioassay grab water samples were collected from a control, high, medium and low concentration aquaria and analyzed for hardness, alkalinity, chloride, total calcium, total magnesium, orthophosphorus, sulfate, and ammonia. Total residual chlorine analyses were performed in the same aquaria at the beginning of the bioassay.

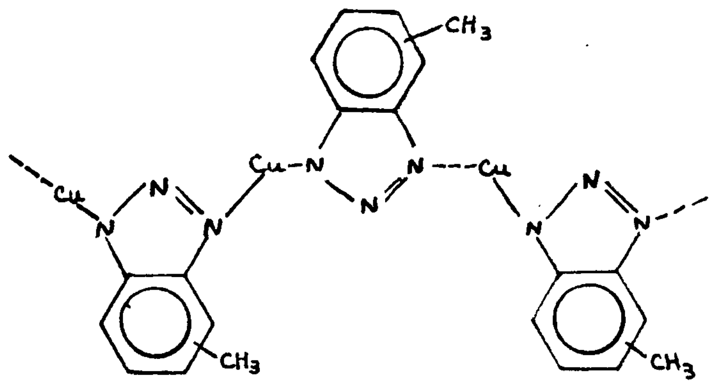
In addition to the above, total nickel, total chromium, total sodium, and total potassium were collected during the first and last bioassays. During the second bioassay, dissolved and labile copper were measured.

Water samples were collected, stored and analyzed per USEPA (1983). Instrumentation and quality control were the same as described in Section 4.0.

9.3 RESULTS AND DISCUSSION

No fish mortalities were observed at any concentration during any of the bioassays. Our results are in good agreement with those reported for the Trojan Nuclear Plant which is located downstream on the Columbia River at River Mile 72.5 (Beak, 1979) and the Centralia Power Station on the Skookumchuck River (Mulvihill and Kruger, 1976). It is interesting that there were no mortalities considering the high concentration of some metals in the cooling tower water (e.g., copper, Table 9-4; zinc, Table 9-6 and iron, Table 9-7). Possible explanations for no mortality are: (1) the majority of the metal is in the particulate form which is non-toxic; (2) the high hardness of the cooling tower water (Table 9-3) reduces the toxic effect; and/or (3) the corrosion inhibitor added to the cooling tower water binds the toxic metal forms.

Table 9-5 presents copper speciation data collected during the second bioassay (March 1985). Clearly, most of the copper is in solution and is not electroactive. WNP-2 plant engineering personnel presently add Calgon PCl 8125 to the circulating water systems to inhibit corrosion of the admiralty brass condensor tubes. The product contains a mixture of 4 and 5 methyl benzotriazole which forms a protective film on the surface of the tubes (Poling 1979). In addition to reacting at the metal surface, tolytriazole reacts with the free cupric ions in a 1:2 molar ratio, $Cu^{++} + 2TT \rightarrow Cu(TT)_2$, to form a soluble non-toxic complex:



Differential pulse anodic stripping voltammetry studies performed in our laboratory have demonstrated that these soluble complexes are electrochemically nonlabile between pH 7 and 8 and thus unavailable for interaction at the gill surface of salmonids.

One of the funtions of the corrosion inhibitor is to chemically bind copper. This data indicates that the copper is bound and, therefore, non-toxic.

A review of the basic water quality parameters (Table 9-2) shows that temperature, pH and DO between aquaria and the river were very similar. The number of cycles of concentration of cooling tower water over Columbia River water was approximately 4.5, 5.1, 6.9, and 8.2 for Tests 1-4, respectively, based on calcium concentration at the beginning of the test. Conductivity and hardness reflect the cycles of concentration (Tables 9-2 and 9-3). Sulfate, chloride and orthophosphate values were highest in the aquaria with the greatest percentage of discharge water (Table 9-3). The addition of chlorine, sulfuric acid, and a corrosion inhibitor to the cooling tower water probably explains the increases. Ammonia-nitrogen values increased in all tanks within a test to similar values by the end of the test. This undoubtedly was a consequence of the bioassays being static. Total residual chlorine values in all aquaria at the beginning of the test were low (1-13 ug/l: Table 9-3).

Tables 9-4 through 9-12 present most of the results of metal analyses. The metal concentrations in river water during our bioassay were comparable to those previously reported for the Columbia River near WNP-2 (Supply System 1982, Cushing and Rancitelli 1972, Silker 1964). The concentrations of mercury, cadmium, chromium, and nickel were always less than or equal to 0.5 ppb, 1 ppb, 2 ppb, and 5 ppb respectively.

Copper, zinc, and iron concentrations in the 100 percent discharge water aquaria were consistently much higher than would be estimated by simply concentrating river water by factor of five or more. Mercury and potassium concentrations were also higher than estimated in the first bioassy but not the fourth. The higher levels may be attributable to a number of factors such as residual within the plant pipes and the products of pipe corrosion. Mercury levels in the 100 percent discharge water aquaria are high compared to the river but the actual concentrations are still low. Mercury is not added to the WNP-2 discharge via chemical treatment processes. Lead, and cadmium concentrations were at levels close to ambient. Nickel, calcium, magnesium and sodium levels were close to what would be expected through evaporation and resultant concentration in the cooling towers.

9.4 REFERENCES

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Table 9-1. Size and Number of Fish Used in WNP-2 Bioassay Tests

Bioassay Reference Number	Dates	Species	Number	Fork Length (cm) Average	Fork Length (cm) Range	Weight (g) Average	Weight (g) Range
1	October 22-26, 1984	Chinook	10	12.2	10.4 - 14.9	20.0	11.6 - 36.6
2	March 18-22, 1985	Steelhead	10	18.1	15.0 - 20.5	57.3	31.4 - 79.7
3	April 29-May 3, 1985	Chinook	20	5.8	4.9 - 6.5	1.8	1.0 - 2.7
4	November 11-15, 1985	Steelhead	10	16.0	13.2 - 18.9	44.7	25.4 - 74.0

Table 9-2. Basic Water Quality Parameters

Parameter Bioassay No.	Columbia River		Control Aquaria		100% Discharge Aquaria	
	Average	Range	Average	Range	Average	Range
Temperature (°C)						
1	13.1	12.9-13.4	14.3	13.9-14.6	14.3	13.9-14.6
2	4.0	3.6-4.8	5.2	5.0-5.5	5.1	4.9-5.5
3	8.8	8.2-9.1	9.8	9.2-10.5	9.8	9.1-10.5
4	9.6	9.2-10.1	10.3	9.7-12.5	10.3	9.7-12.4
Dissolved Oxygen (mg/l)						
1	10.4	10.0-11.0	8.7	8.5-9.2	8.8	8.1-9.2
2	14.2	13.6-14.8	10.7	10.2-11.0	9.3	7.9-9.9
3	13.8	13.0-14.6	11.2	10.8-11.8	10.6	9.0-11.3
4	9.7	8.7-11.1	9.6	8.3-10.8	9.7	7.5-10.5
pH						
1	8.1	8.1-8.4	7.7	7.6-7.9	7.8	7.6-7.8
2	8.4	8.3-8.6	7.7	7.7-7.8	7.5	7.5-7.7
3	8.2	8.1-8.5	8.1	8.0-8.2	8.1	8.1-8.2
4	7.7	7.6-8.0	7.7	7.5-80	8.1	7.9-8.4
Conductivity (umhos/cm)						
1	104	103-107	117	111-124	596	590-600
2	90	88-95	98	94-105	434	406-503(1)
3	110	107-113	113	109-116	709	697-724
4	98	90-102	104	100-110	799	780-830

(1)Suspect Value

Table 9-3. Basic Water Chemistry Parameters

Parameter	River		0 (Control)		30		65		100	
			Percent Cooling Tower Water in Aquaria							
Bioassay No.	S[1]	E	S	E	S	E	S	E	S	E
Total Residual Chlorine										
1	.002		.002		.005		.012		.013	
2	.002		.002		.002		.002		.002	
3	.002		.002		.002		.002		.002	
4	.002		.002		.002		.002		.002	
Sulfate										
1	12	11	12	11	107	98	185	181	273	251
2	13	13	12	14	92	105	178	196	267	290
3	15	15	15	15	157	160	311	312	493	475
4	31	33	31	31	42	40	90	91	120	130
Chloride										
1	1.2	1.2	0.9	0.9	6.2	5.8	11.9	11.0	18.4	17.7
2	0.7	0.8	0.9	0.8	3.1	3.2	6.1	6.3	9.4	9.2
3	1.2	1.2	1.3	1.7	7.1	7.1	14.8	13.2	18.0	19.0
4	1.5	1.2	1.2	1.9	10.1	10.2	21.6	21.7	31.3	31.3

(1) S = Start of test
E = End of test

Table 9-3 (cont.). Basic Water Chemistry Parameters

Parameter	River		Percent Cooling Tower Water in Aquaria: 0 (Control)		30		65		100	
Bioassay No.	S	E	S	E	S	E	S	E	S	E
Alkalinity										
1	56	58	55	60	61	66	67	73	73	76
2	65	65	65	68	66	69	69	73	72	75
3	70	69	68	69	86	83	101	100	117	117
4	56	57	55	60	83	88	115	121	147	152
Hardness										
1	64	65	64	64	144	145	246	235	330	333
2	73	74	73	73	152	152	243	248	335	329
3	79	78	82	76	211	211	366	366	525	520
4	63	66	63	63	203	203	363	377	526	542
Orthophosphate										
1	0.02	0.03	0.03	0.10	0.47	0.59	0.99	1.08	1.20	1.25
2	0.02	0.01	0.01	0.11	0.30	0.42	0.64	0.76	0.96	1.06
3	0.02	0.02	0.02	0.01	0.37	0.41	0.77	0.84	1.14	1.13
4	0.02	0.03	0.02	0.24	0.53	0.71	1.25	1.39	1.54	1.77
Ammonia Nitrogen										
1	<0.01	<0.01	<0.01	0.56	0.06	0.56	0.09	0.61	0.40	0.58
2	<0.01	<0.01	<0.01	0.76	<0.01	0.79	0.09	0.91	0.15	0.71
3	<0.01	<0.01	<0.01	0.14	<0.01	0.17	0.03	0.19	0.06	0.22
4	<0.01	<0.01	0.05	1.10	0.07	0.96	0.08	0.87	0.14	0.96

Table 9-4. Total Copper Concentrations (ppb)

Percent Discharge Concentration	Bioassay Dates: October 22-26, 1984		March 18-22, 1985		April 29-May 3, 1985		November 11-15, 1985	
	S[1]	E	S	E	S	E	S	E
River	3	1	1	2	2	4	4	4
0[2]	2	3	2	2	2	6	5	3
0	1	2	2	2	2	2	6	4
30	210	209	121	119	495	454	222	216
30	208	215	123	117	405	425	222	215
50	352	343	215	204	781	736	360	358
50	331	332	187	189	742	685	383	368
65	457	451	284	291	933	949	473	462
65	437	453	277	277	962	975	488	477
80	557	557	348	340	1162	1166	584	565
80	543	552	355	342	1216	1390	718	721
100	697	714	440	440	1380	1390	718	721
100	681	696	443	430	1399	1406	745	727

(1) S = Start of test
E = End of test
(2) Duplicate aquaria

Table 9-5. Comparison of Copper Forms (ppb) in the March 18-22, 1985, Bioassay

Percent Discharge Concentration	Total Copper S	Total Copper E	Dissolved Copper S	Dissolved Copper E	Labile Copper S	Labile Copper E
0	1.8	1.7	1.9(1)	1.7	0	0
30	123	119	120	119	0	0
65	277	291	257	265	0	0
100	443	440	410	412	0	0
River	1.3	1.5	1.6(1)	1.9(1)	0	0

S Start of test
E End of test
(1) Contamination suspected

Table 9-6. Total Zinc Concentrations (ppb)

Percent Discharge Concentration	Bioassay Dates: October 22-26, 1984		March 18-22, 1985		April 29-May 3, 1985		November 11-15, 1985	
	S(1)	E	S	E	S	E	S	E
River	2	6	8	9	2	4	14	10
0(2)	86	44	12	50	2	6	14	25
0	73	201	14	20	2	2	15	19
30	234	327	93	116	495	454	154	151
30	172	266	90	-	405	425	150	147
50	339	262	144	-	781	736	274	266
50	273	387	136	-	742	685	214	206
65	401	-	185	184	933	949	267	259
65	364	391	173	182	962	975	276	268
80	412	413	223	237	1162	1166	340	325
80	406	545	222	226	1216	1216	356	348
100	504	502	286	284	1380	1390	394	389
100	588	665	298	-	1399	1406	406	394

(1) S = Start of test
    E = End of test
(2) Duplicate aquaria

Table 9-7. Total Iron Concentrations (ppb)

Percent Discharge Concentration	Bioassay Dates: October 22-26, 1984		March 18-22, 1985		April 29-May 3, 1985		November 11-15, 1985	
	S(1)	E	S	E	S	E	S	E
River	6	73	39	43	56	75	60	57
0(2)	28	34	55	43	46	29	15	50
0	19	30	68	44	34	34	29	44
30	90	173	154	93	157	93	121	223
30	87	217	204	216	110	96	121	248
50	133	212	248	158	166	130	182	259
50	181	189	232	191	140	135	151	315
65	178	268	324	348	165	173	230	427
65	161	366	282	265	187	152	182	350
80	216	352	344	379	227	184	271	456
80	185	492	-	247	200	176	279	531
100	248	572	376	344	234	208	309	410
100	245	537	411	428	250	293	283	647

(1) S = Start of test
E = End of test
(2) Duplicate aquaria

Table 9-8. Total Lead Concentrations (ppb)

Percent Discharge Concentration	Bioassay Dates: October 22-26, 1984		March 18-22, 1985		April 29-May 3, 1985		November 11-15, 1985	
	S(1)	E	S	E	S	E	S	E
River	3	3	<1	<1	<1	1	1	1
0(2)	1	1	<1	1	1	<1	1	1
0	<1	1	1	1	<1	<1	1	1
30	3	3	2	2	2	2	2	1
30	5	4	1	2	1	1	2	1
50	4	6	2	1	2	1	2	1
50	4	4	1	2	1	1	3	2
65	3	4	2	3	1	2	3	1
65	6	5	2	3	<1	1	3	2
80	8	9	2	2	2	1	3	2
80	5	7	2	3	2	1	3	2
100	6	8	4	3	4	2	4	2
100	11	8	3	3	2	2	5	2

(1) S = Start of test
E = End of test
(2) Duplicate aquaria

Table 9-9. Total Calcium Concentrations (ppm)

Percent Discharge Concentration	Bioassay Dates: October 22-26, 1984		March 18-22, 1985		April 29-May 3, 1985		November 11-15, 1985	
	S(1)	E	S	E	S	E	S	E
River	22	23	21	21	24	24	18	17
0(2)	22	23	21	22	24	24	20	20
0	23	22	22	22	24	24	17	19
30	48	47	46	45	63	60	61	55
30	47	48	45	46	61	64	62	62
50	63	63	63	60	93	88	83	81
50	61	62	62	59	89	89	85	94
65	73	76	75	74	112	111	98	107
65	72	72	73	71	130	113	102	115
80	85	85	86	87	130	137	111	123
80	84	85	88	87	136	134	116	125
100	100	98	106	103	164	168	150	119
100	98	99	108	103	166	168	146	163

(1) S = Start of test
E = End of test
(2) Duplicate aquaria

Table 9-10. Total Magnesium Concentrations (ppm)

Percent Discharge Concentration	Bioassay Dates: October 22-26, 1984		March 18-22, 1985		April 29-May 3, 1985		November 11-15, 1985	
	S(1)	E	S	E	S	E	S	E
River	4	4	5	6	6	6	3	3
0(2)	4	4	5	5	6	6	3	3
0	4	4	5	5	6	6	3	3
30	9	9	11	11	15	15	11	12
30	9	9	11	11	15	15	10	11
50	13	13	16	14	22	21	15	17
50	13	13	14	14	20	20	17	18
65	15	15	17	17	25	24	19	21
65	15	15	16	17	27	25	21	22
80	18	18	19	20	29	29	22	26
80	17	18	19	20	30	30	22	23
100	21	21	23	23	35	35	32	26
100	20	20	22	23	35	35	28	33

(1) S = Start of test
E = End of test
(2) Duplicate aquaria

Table 9-11. Total Sodium Concentrations (ppm)

Percent Discharge Concentration	Bioassay Dates			
	October 22-26, 1984		November 11-15, 1985	
	S(1)	E	S	E
River	7	6	3	2
0(2)	6	7	5	4
0	7	6	2	1
30	15	11	10	15
30	11	11	12	14
50	15	15	14	22
50	14	15	19	23
65	17	18	21	27
65	14	15	24	31
80	19	19	26	32
80	19	19	27	33
100	22	22	34	33
100	22	23	33	44

(1) S = Start of test
E = End of test
(2) Duplicate aquaria

Table 9-12. Total Potassium Concentrations (ppm)

Percent Discharge Concentration	Bioassay Dates			
	October 22-26, 1984		November 11-15, 1985	
	S(1)	E	S	E
River	1	1	1	1
0(2)	1	2	1	1
0	1	1	1	1
30	7	6	2	3
30	7	7	2	2
50	10	10	3	3
50	9	10	3	3
65	13	13	4	3
65	12	12	4	3
80	16	16	4	4
80	15	14	4	4
100	19	19	6	5
100	18	19	6	5

(1) S = Start of test
E = End of test
(2) Duplicate aquaria

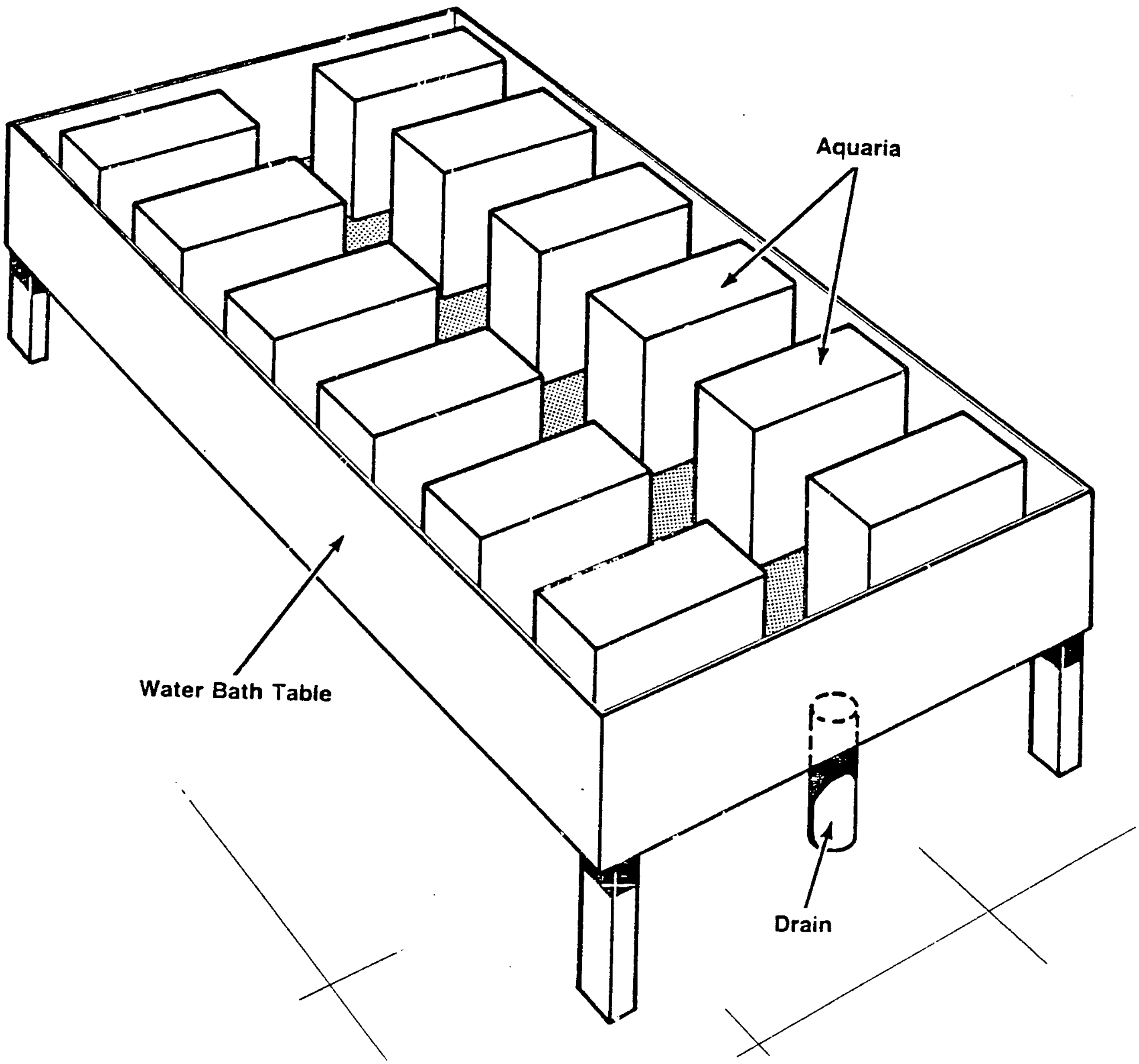


Figure 9-1. Static Bioassay System

10.0 THERMAL PLUME

10.1 INTRODUCTION

Thermal discharges to the river are from the cold leg of the recirculating cooling water system (i.e., after heat rejection in the cooling towers). No numerical temperature limits are imposed on the discharge except through the indirect requirement of conformance to State water quality standards (WDOE 1977) outside the boundaries of a mixing zone (NPDES permit condition G3). The boundaries of this mixing zone are:

1. Surface to riverbed
2. 50 feet upstream to 300 feet downstream of the discharge, and
3. 100 feet wide (centerline not specified).

State water quality standards require that the maximum increase in river temperature be 0.3°C (0.5°F) anytime the ambient temperature exceeds 20°C (68°F). For river temperatures below 20°C, the allowable increase is calculated by the following formula expressed in degrees C.

$$\text{Allowable increase} = \frac{34}{\text{Ambient Tempertaure} + 9}$$

The Supply System performed three dimensional mapping of the discharge plume on four occasions to document compliance with water quality standards.

10.2 MATERIALS AND METHODS

Two parallel rows of six buoys were deployed in the mixing zone approximately 20 feet either side of the plume centerline. The downstream distances were approximately 50, 100, 150, 200, 250, and 300 feet below the discharge. A marked rope tied to the discharge and to the bow of the boat was used to maneuver within the buoy field and provided a second measurement of downstream distance. By swinging an arc on the rope tied to the discharge and measuring lateral distance from the buoys with a long marked rod, it was possible to position the boat fairly accurately relative to the discharge (approximately $\pm$ 5 feet). Usually 300 feet was the maximum downstream distance at which temperature measurements were made. On April 1, 1985, however, measurements were made to 500 feet downstream with lateral distances estimated by lining up the six upstream buoys.

Temperature measurements were made utilizing a Yellow Springs Instrument Model 2100 Tele-Thermometer. This instrument simultaneously displays the temperature from two thermisters to 0.1°C. Four thermisters, each on a 25-ft lead, were attached at various positions on a cable carried underwater with a 100 lb lead downrigger. A switch was utilized so that the temperature readout could instantly be changed from one pair of thermisters to the other. Response time of the thermisters to temperature changes was approximately 2-3 seconds.

Centerline temperature was determined by locating the highest temperature at a given downstream distance. Temperatures at other locations represent a fixed grid position relative to the discharge and buoys.

At 100% reactor power the design temperature for cooling tower outlet is 76°F (24.4°C). When reactor power is less than 100% it is still possible to simulate conditions in the blowdown at 100% by securing cooling tower fans to reduce efficiency. Provided plant power is greater than 50%, circulating water flow is independent of power level. During all four of the tests reported in this document, the plant was either at 100% power or the condition was simulated by reducing cooling tower performance. In addition, the tower make-up (TMU) crosstie, which dilutes discharge water with Columbia River water, was closed. By closing this valve, the maximum discharge temperature was achieved.

The data for discharge flow and temperature is reported as "Approximately" in the tables because there is roughly a two hour time lag between when the measurements are made in the WNP-2 control room and when the water reaches the river. Due to thermal mass, little temperature change occurs during this time, but temperatures do fluctuate and an exact discharge temperature and flow is not ascertainable.

Likewise, we must utilize informed judgement to estimate flow of the Columbia because the nearest gaging station is at Priest Rapids Dam 45 miles upstream.

10.3 RESULTS AND DISCUSSION

All raw data collected during the four tests (March 14, April 1, August 26, and November 19, 1985) are presented in Tables 10-1 through 10-4. A graphical presentation of centerline temperatures at the four depths is presented in Figures 10-1 through 10-4.

The most significant observation from the studies is that, during the observation periods, the WNP-2 discharges were clearly in compliance with State of Washington water quality standards (WDOE 1977). Beyond that, it can be seen that there is very little temperature rise in the Columbia River.

The extent to which the plume was measurable was a function of ambient temperature. On August 26, 1985 when the Columbia River was close to regulated low flow and it's temperature was near the annual maximum, the maximum temperature rise at any location (except the discharge) was only 0.2°C. The effect of the jet can clearly be seen in Table 10-3 where there was no rise in temperature at centerline or 20 ft east of centerline but there was a 0.1 to 0.2°C rise 10 ft east of centerline.

The other extreme condition took place on March 14, 1985, when the ambient water temperature was only 3.4°C and the discharge temperature was approximately 26°C. In this case, the plume was clearly measurable, however, the maximum temperature rise was still only 0.8°C on the surface (100' downstream) when 2.7°C was the regulatory limit at 300'.

On April 1, 1985, measurements were made as far as 500 ft below the discharge. At 500 ft the centerline temperature rise was still 0.4°C and the 0.1° isotherm was slightly more than 40 ft wide. Thus, there is a long, narrow, low incremental temperature plume which results from the plant discharge.

10.4 BIBLIOGRAPHY

Washington Department of Ecology. 1977. Washington State water quality standards. Water Quality Planning Office of Water Programs, Olympia, WA.

Table 10-1. Thermal Plume Test Conducted March 14, 1985

Power Level: 100%
Discharge Temperature: Approximately 26°C
Discharge Flow Rate: Approximately 7000 gpm
Estimated River Flow: 106,000 cfs
Allowable Temperature Rise Outside Mixing Zone: 2.7°C

Highest Temperature Observed at Surface

Downstream Distance (Feet)	20 Ft West	10 Ft West	Centerline	10 Ft East	20 Ft East
Ambient			3.4		
0					
10			3.4		
50	3.4		3.4		
100	3.4		4.2		3.4
150	3.5		3.9		3.5
200	3.5		3.8		3.5
250					
300	3.4	3.7	3.7		3.5

Highest Temperature Observed at 2 Ft

Downstream Distance (Feet)	20 Ft West	10 Ft West	Centerline	10 Ft East	20 Ft East
Ambient			3.4		
0					
10			3.4		
50	3.4		3.9		
100	3.4		4		3.4
150	3.5		3.8		3.4
200	3.5		3.8		3.4
250					
300	3.4	3.7	3.7		3.4

Table 10-1 (cont.). Thermal Plume Test Conducted March 14, 1985

Highest Temperature Observed at 6 Ft

Downstream Distance (Feet)	20 Ft West	10 Ft West	Centerline	10 Ft East	20 Ft East
Ambient			3.3		
0					
10			3.3		
50	3.3		4.4		
100	3.4		3.9		3.3
150	3.4		3.6		3.4
200	3.4		3.7		3.4
250					
300	3.3	3.4	3.7		3.4

Highest Temperature Observed at 9 Ft (1 Ft Above Bottom)

Downstream Distance (Feet)	20 Ft West	10 Ft West	Centerline	10 Ft East	20 Ft East
Ambient			3.3		
0					
10			9.2		
50	3.3		4.2		
100	3.4		3.8		3.3
150	3.4		3.6		3.4
200	3.4		3.6		3.4
250					
300	3.4	3.4	3.7		3.4

Table 10-2. Thermal Plume Test Conducted April 1, 1985

Power Level: 100%
Discharge Temperature: Approximately 27°C
Discharge Flow Rate: Approximately 7000 gpm
Estimated River Flow: 68,000 cfs
Allowable Temperature Rise Outside Mixing Zone: 2.4°C

Highest Temperature Observed at Surface

Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East	30 Ft East
Ambient			4.9			
0			4.8			
12			4.8			
22			6.1			
32			6.6			
42			6.8			
50	4.9	4.9	6.2	4.9	4.9	
100	4.9	5.0	6.0	5.9	4.9	
150	4.9	5.0	5.8	5.7	5.0	4.9
200	4.9	4.9	5.7	5.5	4.9	4.9
250	4.9	5.1	5.4	5.4	5.0	4.9
300	4.9	5.4	5.5	5.4	4.9	4.9
350	5.0		5.4		5.0	
400	5.0		5.4		5.1	
450	5.1		5.3		5.2	
500	5.3		5.4		5.3	

Table 10-2 (cont.). Thermal Plume Test Conducted April 1, 1985

	Highest Temperature Observed at 2 Ft					
Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East	30 Ft East
Ambient			5.0			
0			4.9			
12			8.3			
22			7.2			
32			6.8			
42			6.5			
50	4.9	4.9	6.5	4.9	5.0	
100	5.0	5.0	6.1	5.2	5.0	
150	5.0	5.0	5.8	5.7	5.1	5.0
200	5.0	5.0	5.7	5.5	5.2	5.0
250	5.0	5.2	5.6	5.5	5.1	5.0
300	5.0	5.5	5.6	5.4	5.0	5.0
350	5.1		5.5		5.0	
400	5.1		5.4		5.1	
450	5.2		5.4		5.1	
500	5.3		5.4		5.1	

Table 10-2 (cont.). Thermal Plume Test Conducted April 1, 1985

Highest Temperature Observed at 3 Ft						
Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East	30 Ft East
Ambient			5.0			
0			5.0			
12			7.9			
22			7.4			
32			7.4			
42			6.8			
50	4.9	5.0	6.1	5.0	5.0	
100	5.0	5.1	6.0	6.1	5.0	
150	5.0	5.0	5.7	5.7	5.3	5.0
200	5.0	5.2	5.6	5.7	5.1	5.0
250	5.0	5.2	5.7	5.5	5.4	5.0
300	5.0	5.3	5.4	5.5	5.1	5.0
350	5.1		5.4		5.0	
400	5.2		5.5		5.1	
450	5.3		5.3		5.2	
500	5.2		5.3		5.1	

Table 10-2 (cont.). Thermal Plume Test Conducted April 1, 1985

Highest Temperature Observed at 6 Ft (1 Ft Above Bottom)						
Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East	30 Ft East
Ambient			4.9			
0			22.3			
12			9.4			
22			6.4			
32			5.9			
42			5.7			
50	4.9	4.9	6.1	4.9	4.9	
100	4.9	4.9	5.4	5.3	4.9	
150	4.9	5.0	5.2	5.5	5.2	4.9
200	4.9	4.9	5.4	5.3	5.0	4.9
250	4.9	5.0	5.4	5.2	5.0	4.9
300	4.9	5.2	5.3	5.3	4.9	4.9
350	5.0		5.3		4.9	
400	5.0		5.4		5.0	
450	5.1		5.2		5.1	
500	5.1		5.2		5.0	

Table 10-3. Thermal Plume Test Conducted August 26, 1985

Power Level: 72%
Discharge Temperature: Approximately 24°C
Discharge Flow Rate: Approximately 7450 gpm
Estimated River Flow: 52,000 cfs
Allowable Temperature Rise Outside Mixing Zone: 1.2°C

Highest Temperature Observed at Surface

Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East
Ambient			19.4		
0			19.4		
50	19.4	19.4	19.6	19.6	19.3
100	19.4	19.4	19.4	19.5	19.3
150	19.4	19.4	19.4	19.5	19.3
200	19.4	19.4	19.4	19.5	19.3
250	19.4	19.4	19.4	19.4	19.3
300	19.4	19.4	19.4	19.5	19.3

Highest Temperature Observed at 2 Ft

Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East
Ambient			19.4		
0			19.4		
50	19.4	19.4	19.6	19.5	19.3
100	19.4	19.4	19.4	19.5	19.3
150	19.4	19.4	19.5	19.5	19.3
200	19.4	19.4	19.4	19.5	19.3
250	19.4	19.4	19.4	19.4	19.3
300	19.4	19.4	19.4	19.5	19.4

Table 10-3 (cont.). Thermal Plume Test Conducted August 26, 1985

Highest Temperature Observed at 5 Ft

Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East
Ambient			19.3		
0			20.4		
50	19.3	19.3	19.4	19.4	19.3
100	19.3	19.3	19.3	19.4	19.3
150	19.3	19.3	19.3	19.4	19.3
200	19.3	19.3	19.3	19.3	19.3
250	19.3	19.3	19.3	19.4	19.3
300	19.3	19.3	19.3	19.3	19.3

Highest Temperature Observed at 7 Ft (1 Ft Above Bottom)

Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East
Ambient			19.3		
0			19.4		
50	19.3	19.3	19.3	19.4	19.3
100	19.3	19.3	19.3	19.4	19.3
150	19.3	19.3	19.3	19.3	19.3
200	19.3	19.3	19.3	19.4	19.3
250	19.3	19.3	19.3	19.4	19.3
300	19.3	19.3	19.3	19.3	19.3

Table 10.4. Thermal Plume Test Conducted November 19, 1985

Power Level: 69%
Discharge Temperature: Approximately 25°C
Discharge Flow Rate: Approximately 6500 gpm
Estimated River Flow: 110,000 cfs
Allowable Temperature Rise Outside Mixing Zone: 2.0°C

Highest Temperature Observed at Surface

Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East
Ambient			8.0		
0			8.0		
50	7.9	8.0	8.1	8.0	8.0
100	7.9	8.0	8.2	8.0	8.0
150	7.9	8.0	8.3	8.1	8.0
200	7.9	8.0	8.3	8.1	8.0
250	7.9	7.9	8.0	8.0	8.0
300	7.9	8.0	8.2	8.1	8.0

Highest Temperature Observed at 2

Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East
Ambient			8.0		
0			8.0		
50	8.0	8.0	8.6	8.0	8.0
100	8.0	8.0	8.4	8.0	8.0
150	7.9	8.0	8.4	8.1	8.0
200	8.0	8.0	8.4	8.1	8.0
250	8.0	8.0	8.3	8.0	8.0
300	8.0	8.0	8.2	8.1	8.0

Table 10-4 (cont.). Thermal Plume Test Conducted November 19, 1985

Highest Temperature Observed at 7 Ft

Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East
Ambient			7.9		
0			8.0		
50	7.9	8.1	8.7	7.9	7.9
100	7.9	7.9	8.3	7.9	7.9
150	7.9	7.9	8.3	7.9	7.9
200	7.9	7.9	8.3	8.0	7.9
250	7.9	7.9	8.1	8.2	7.9
300	7.9	7.9	8.2	8.0	7.9

Highest Temperature Observed at 12 Ft (Bottom = 13 Ft)

Downstream Distance (Feet)	20 Ft West	10 Ft West	Center-line	10 Ft East	20 Ft East
Ambient			8.0		
0			23.1		
50	8.0	7.9	8.7	8.1	8.0
100	8.0	8.1	8.6	8.3	8.0
150	8.0	8.0	8.4	8.0	8.0
200	8.0	8.1	8.4	8.1	8.0
250	8.0	8.0	8.2	8.3	8.1
300	8.0	8.0	8.3	8.1	8.0

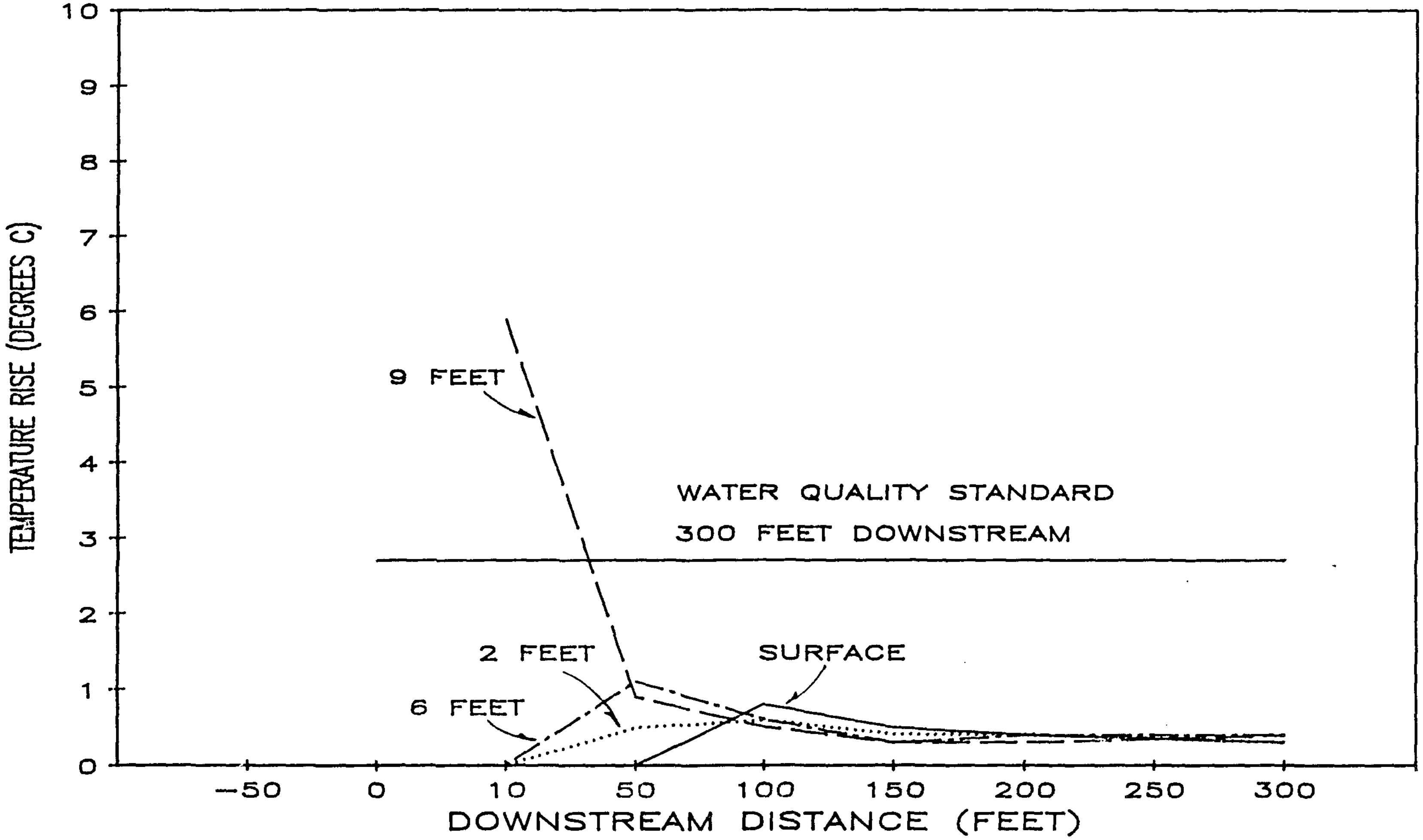


Figure 10-1. Temperature Rise in the Columbia River at the Centerline of WNP-2's Discharge Plume at Various Depths and Downstream Distances on March 14, 1985

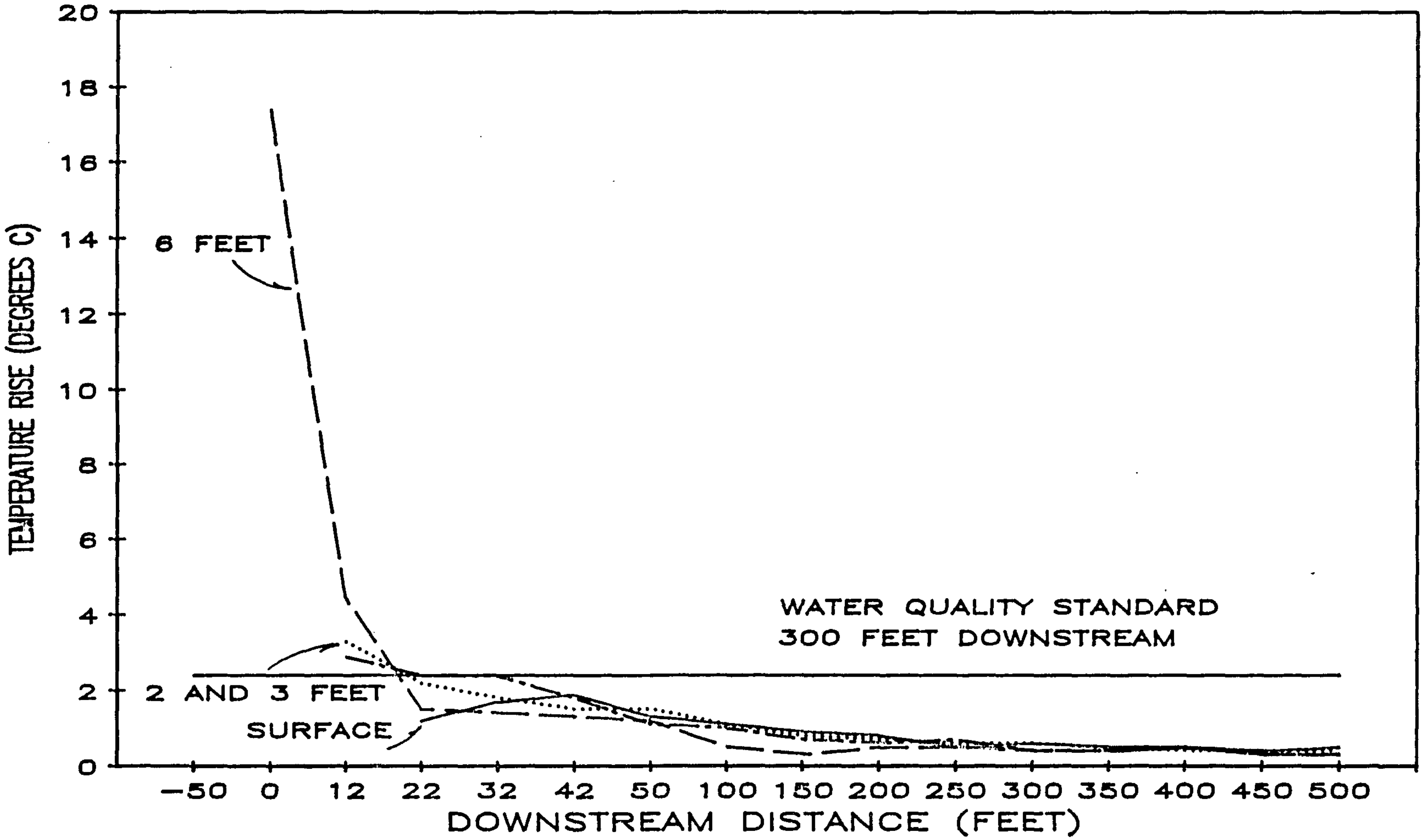


Figure 10-2. Temperature Rise in the Columbia River at the Centerline of WNP-2's Discharge Plume at Various Depths and Downstream Distances on April 1, 1985

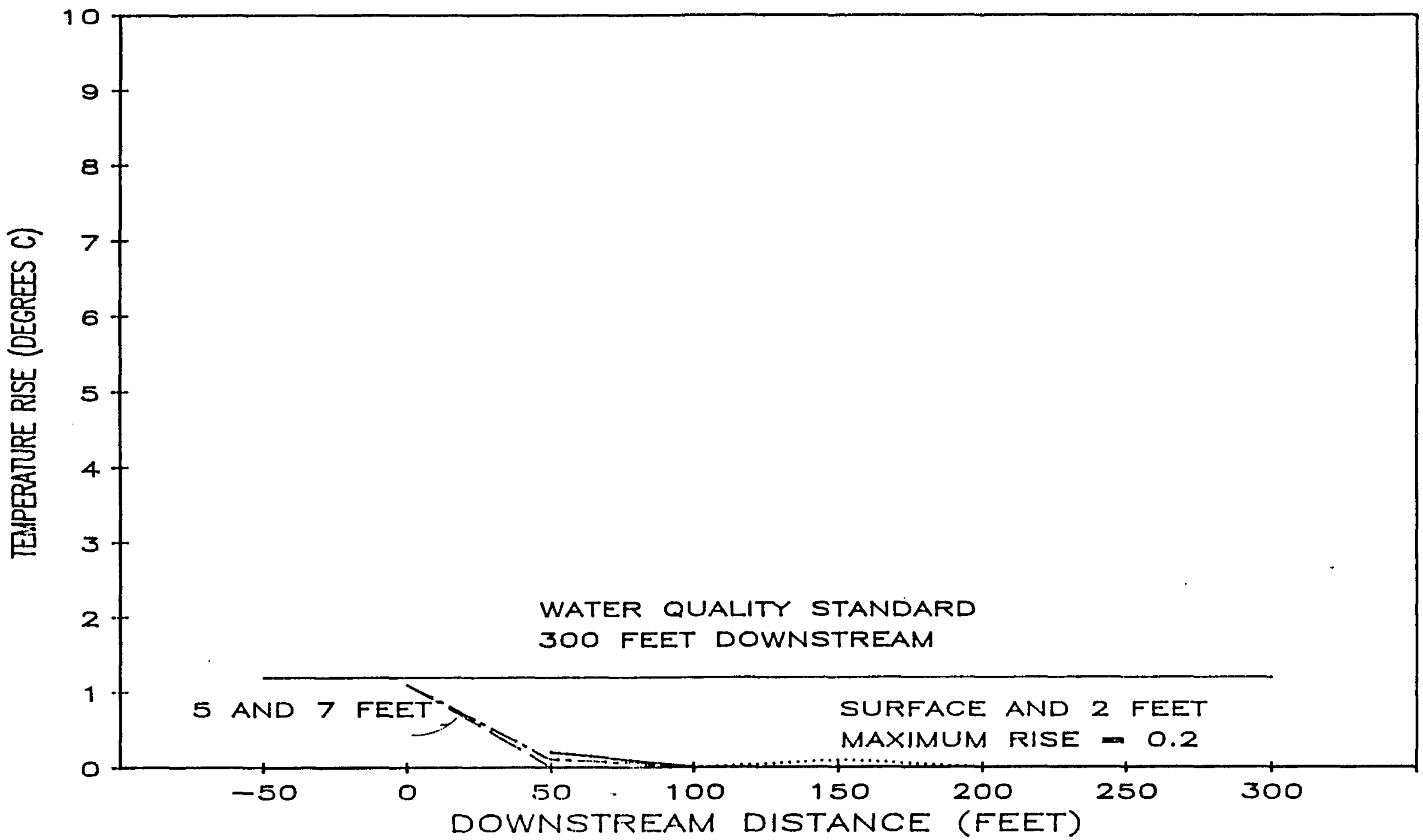


Figure 10-3. Temperature Rise in the Columbia River at the Centerline of WNP-2 Discharge Plume at Various Depths and Downstream Distances on August 26, 1985

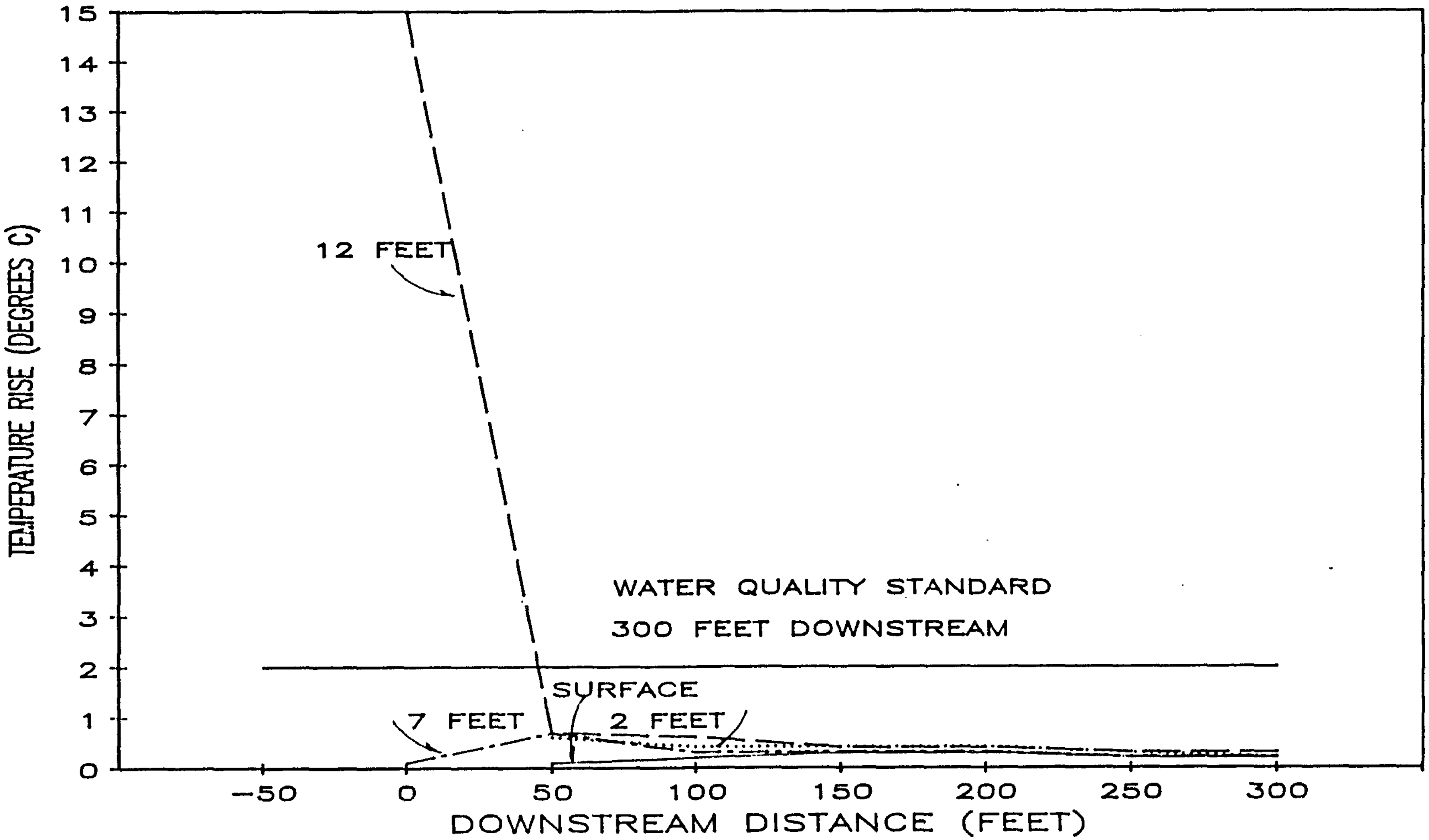


Figure 10-4. Temperature Rise in the Columbia River at the Centerline of WNP-2's Discharge Plume at Various Depths and Downstream Distances on November 19, 1985

11.0 FISH DRIFT TESTS

11.1 INTRODUCTION

The WNP-2 fish drift study program was designed to evaluate the impact of cooling tower blowdown on Columbia River salmonids passing through the thermal plume. It was established to comply with the requirements of EFSEC Resolution No. 214, which called for tests to be performed twice in the spring and once during the summer/fall period after the plant reached at least 75% thermal load.

A preliminary fish drift experiment was conducted on November 9-11, 1983. Approximately 80 age +1 steelhead trout were used in the study. No fish mortalities were observed (Stables, 1983).

11.2 MATERIALS AND METHODS

Drift tests were performed on two separate occasions during 1985; March 28 to April 2 using steelhead trout (mean length 18.0 cm; mean weight 69.0g), and April 30 to May 6 using chinook salmon (mean length 5.71 cm; mean weight 1.67 g). The fish were obtained from the Washington Department of Game Ringold Hatchery. Fish were acclimatized in a holding tank for fourteen days prior to testing. The same food, food size and feeding rates as used at the hatchery were employed. Fish were not fed 48 hours prior to testing.

Each test was an in-situ bioassay method in which caged fish (20/group) were floated either through the thermal plume (treatment group) or on a parallel course, but outside the plume (control group) (Figure 11-1). The cage was constructed of nylon netting (2'x2'x2' size; 1/4" stretch mesh) suspended in a frame made of acrylonitrile butadiene styrene (ABS) pipe. Each test consisted of four separate drifts; two treatment and two control. Following a drift test, the four separate groups of fish were held in individual 44-gallon flow through containers and observed for an additional 120 hours. The containers provided a minimum of 1 liter of water for each 10 grams of fish, and a flow-through rate of 1.44 liters per gram of fish per day. Water used for the holding tank and test containers was drawn from the Columbia River via the make-up water pumphouse. Aeration was used to maintain adequate dissolved oxygen (DO) concentrations during transporting and holding of fish between the laboratory and test location. Fish were not fed during the post-drift holding period.

A Fluke Model 2190A Thermometer and associated scanner and printer were used to measure the temperature of the Columbia River during the drift portion of each test. The system involved use of two temperature sensitive electrodes; one placed inside the drift cage (Probe 1), and one outside (Probe 2). Readings from both electrodes were recorded one time every six seconds. The electrodes were positioned at an approximate depth of two feet. Temperature was recorded to within 0.1°C. The instrument was calibrated against an NBS-traceable thermometer.

Daily during the post-drift holding period, temperature, DO, pH and conductivity were measured in each holding container. Checks for dead fish were made twice daily. All fish were released to the Columbia River following testing. Instrument calibration and quality control were the same as described in Section 4.0.

A procedure implemented by plant operations personnel provided blowdown temperatures of 23.9°C or higher and maximum blowdown flow rates during the test periods.

11.3 RESULTS AND DISCUSSION

There were no fish mortalities observed for the drift studies performed during 1985.

Columbia River temperatures recorded during the drift portion of the testing periods are presented in Table 11-1. The mean maximum temperature differential observed between the river and the discharge mixing zone was 1.1°C for the March 28, 1985 drift (T1). Temperatures for control group drifts remained basically at ambient levels for all testing periods. Insignificant changes during practice and test (treatment) drifts during the April 30 study resulted in only two tests (one treatment, one control) being performed. Forty fish per drift were used.

The basic water quality parameters for the post drift holding period are shown in Tables 11-2 and 11-3. No significant differences were observed.

The normal plant operating maximum blowdown rate and maximum discharge temperature is 14.5 cfs and 28°C, respectively (Mudge et al. 1982). Blowdown flow rate and temperature for the March 28 and April 30 tests averaged 16.0 cfs (7200 gpm) and 24.4°C (76°F), and 15.4 cfs (6900 gpm) and 25.4°C (77.7°F), respectively. At average river velocities of 1.38 mps (4.5 fps), the test groups were subjected to the thermal mixing zone (see section 10.1) for approximately 146 seconds or 2.4 minutes.

Insignificant changes in surface temperatures recorded during performance of a thermal plume study (see Table 10-3, Section 10.0), coupled with the results of the spring drift studies, influenced the decision to cancel the fall period test scheduled for November 19, 1985. As mentioned earlier, a preliminary drift test conducted in November, 1983 resulted in no fish mortalities.

In conclusion, drift studies performed during 1985 indicate no measurable impact on Columbia River salmonids exposed to surface level thermal discharges at 75% or greater thermal loads.

11.4 BIBLIOGRAPHY

Mudge, J.E., T.B. Stables, W. Davis III, 1982. Technical review of the aquatic monitoring program of WNP-2. Washington Public Power Supply System, Richland, WA.

Stables, T.B., December 16, 1983, Washington Public Power Supply System, Internal correspondence, preliminary fish drift tests (November 1983).

Table 11-1. Summarized Fish Drift Test Data for March 28 and April 30, 1985

	River Temperature (°C)			Discharge		River	
	(1)	Maximum		Rate	Temp	Flow	
Date	Group	Ambient	Probe 1	Probe 2	(cfs)	(°C)	(cfs)
3/28	T1	4.00	5.2	5.0	16.0	24.4	118,000
	C1	3.80	4.1	4.0			
	T2	4.05	4.6	4.6			
	C2	4.05	4.1	4.0			
4/30	T1(2)	8.55	8.6	8.6	15.4	25.4	140,000
	C1	8.45	8.6	8.5			
	PT1	8.30	8.5	8.5			
	PT2	8.20	8.3	8.4			

(1) T = Treatment, C = Control, PT = Practice Treatment

(2) Temperature monitoring instrument malfunctioned - data incomplete.

Table 11-2. Summarized Data for Post Drift Holding Period for March 28 through April 1, 1985

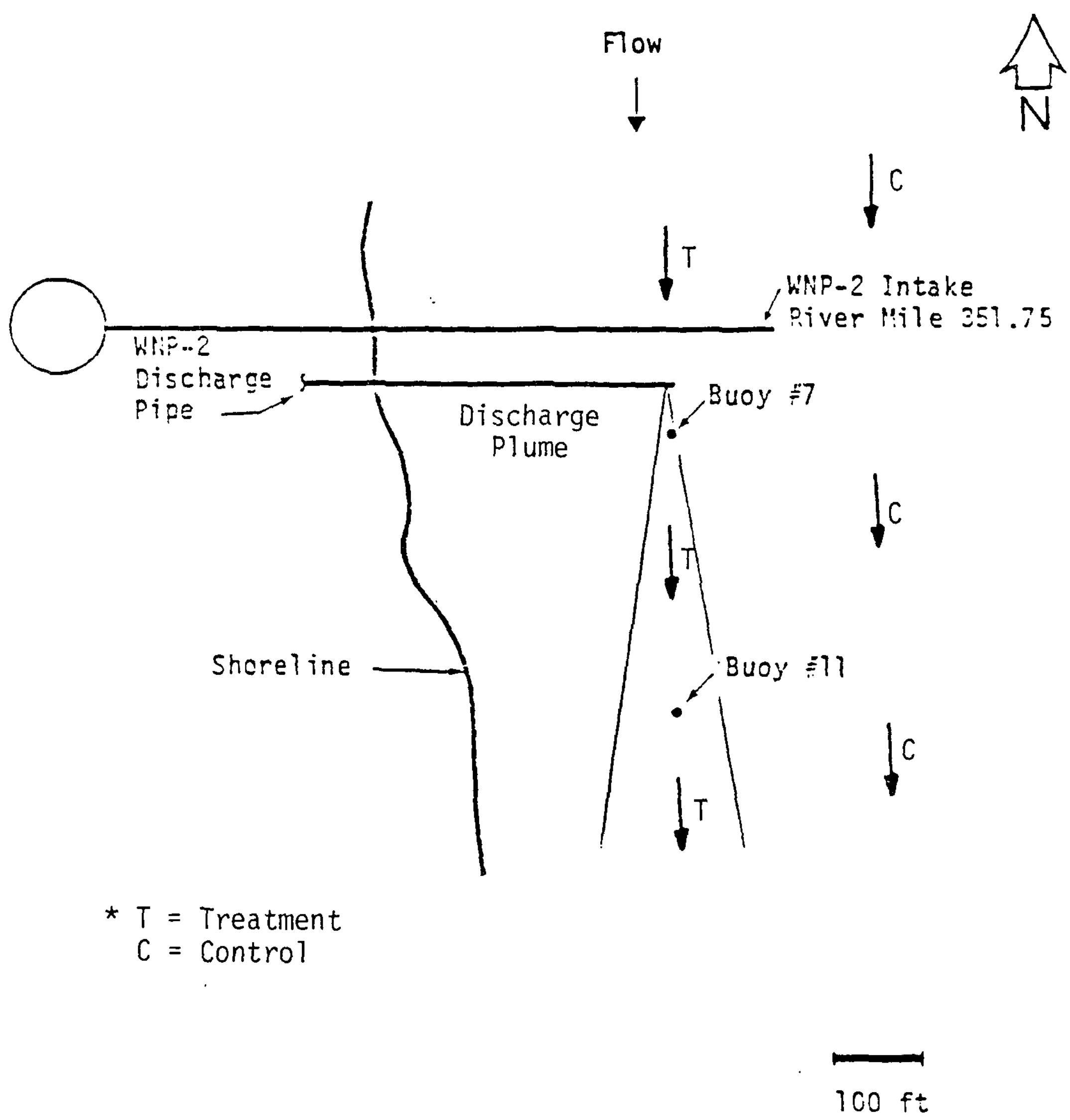
Date	Group (1)	Temp. (°C)	DO (mg/l)	pH	Conductivity (us/cm)
3/28	T1	5.1	13.6	8.37	94.3
	C1	5.0	13.9	8.46	93.1
	T2	5.0	13.9	8.44	92.4
	C2	5.0	13.8	8.22	95.4
3/29	T1	6.0	12.2	--	--
	C1	5.7	12.5	--	--
	T2	5.5	13.0	--	--
	C2	5.5	12.6	--	--
3/30	T1	4.9	13.0	--	--
	C1	5.0	12.9	--	--
	T2	5.1	13.0	--	--
	C2	5.2	12.8	--	--
3/31	T1	5.9	13.0	--	--
	C1	6.0	12.8	--	--
	T2	6.5	11.8	--	--
	C2	5.5	13.4	--	--
4/1	T1	6.5	12.9	--	--
	C1	6.5	12.9	--	--
	T2	6.4	12.9	--	--
	C2	6.3	13.2	--	--
4/1	T1	6.5	13.4	--	--
	C1	6.9	12.7	--	--
	T2	6.3	13.5	--	--
	C2	6.4	13.8	--	--

(1) T = Treatment, C = Control

Table 11-3. Summarized Data for Post Drift Holding Period for April 30 through May 6, 1985

Date	Group (1)	Temp. (°C)	DO (mg/l)	pH	Conductivity (us/cm)
4/30	C	--	--	--	--
	T	--	--	--	--
5/1	C	8.8	13.6	8.26	111.4
	T	8.8	13.6	8.25	111.4
5/2	C	9.2	13.0	8.21	115.0
	T	9.2	12.9	8.23	114.0
5/3	C	9.4	12.8	8.14	112.9
	T	9.4	12.8	8.15	112.4
5/5	C	9.2	12.8	8.13	110.0
	T	9.2	12.7	8.15	111.0
5/6	C	9.4	12.8	8.04	111.0
	T	9.4	12.8	8.10	110.1

(1) T = Treatment, C = Control



Figures 11-1. Relative Location of Fish Drift Test Treatment and Control Pathways

12.0 FISH ENTRAINMENT

12.1 INTRODUCTION

The Hanford Reach of the Columbia River represents one of the few remaining free-flowing stretches supporting natural spawning and rearing of chinook salmon and steelhead trout. The intake structure for Washington Public Power Supply System Nuclear Project No. 2 (WNP-2) is located within the Hanford Reach at River Mile 352. Withdrawal of river water for cooling tower makeup may entrain fish through the 1-cm (3/8-in) holes in the intake screens. Of particular concern are the naturally spawned salmon juveniles, primarily chinook salmon, which are present in the river system as out-migrants during spring and summer periods.

Initial entrainment studies were conducted from May 1979 to May 1980 by Beak Consultants Incorporated as part of the Preoperational Environmental Monitoring Program for WNP-2 (Beak 1980). In November, 1982, the Operational Environmental Monitoring Program was approved by the Energy Facility Site Evaluation Council and presented in EFSEC Resolution No. 214. In part, Resolution No. 214 states that entrainment studies will be performed during one spring out-migration period (April, May, June) while the plant is at or above 75% power load.

In January 1983, the National Marine Fisheries Service (NMFS) presented the Supply System with comments/concerns regarding the entrainment study portion of the Operational Environmental Monitoring Program (Evans, 1983). In response to NMFS concerns, entrainment sampling was increased to cover the period from July 15 to September 15, during one summer/full time period when the plant has reached at least 75% load (Sorensen 1983).

WNP-2 reached approximately 75 percent thermal load in November, 1984. The entrainment studies conducted in 1985 were designed to fulfill the requirements set forth in EFSEC Resolution No. 214 and to address the concerns of NMFS.

12.2 MATERIALS AND METHODS

Routine monitoring involved inspection of sampling cages in the make-up water pumphouse (Figure 12-1) which were designed to collect small organisms entrained in the WNP-2 intake structures. Two sampling cages were available, each 1.75 m (5.8 ft) long, 1.52 m (5 ft) high and 1.07 m (3.5 ft) wide. Each cage has a 1.07 m^2 door. The cage has an aluminum frame and door, while the remainder is made of woven stainless steel wire mesh with 2.0-mm square openings. The cages were lowered approximately 35 feet into the pumphouse sump to the sampling position in direct alignment with the openings of the 36-inch inlet pipes. The cage door automatically opened as it neared the inlet pipe, and upon cage retrieval the door closed shortly after cage lift began (Mudge et. al, 1981).

Sampling efficiency tests conducted in May and June 1979 concluded that a 12-hour sampling interval using the sampling cages was sufficient to measure entrainment (Beak, 1980).

Twenty-four hour entrainment samples were collected weekly from April 3 to May 2 and July 23 to September 11, 1985. With the exception of the test conducted on June 10, 1985, there was no entrainment sampling during the May 6 to July 1 plant outage. Normal sampling was from 0730 to 1930 hours and 1930 to 0730 hours. Each sampling interval utilized a different cage (north or south), which was subjected to continuous flow. At the end of each interval, the cage was inspected for fish or fish parts, rinsed with water to remove scum, and reinspected. Information, including pumphouse flow rates, river level elevation, and number of fish entrained were recorded.

Each entrainment test required implementation of a plant test procedure to provide near-maximum pumphouse flow rates (1.451 m^3/s was desired) for the duration of the sampling period. In addition, each test was conducted with both intake pipe gates in the open position; therefore, actual volume sampled was approximately one-half of the total pumphouse flow.

Beach seine catches were used to document the presence of newly emerged chinook salmon fry in the area of the WNP-2 intake structures. Samples were taken at each of two sites (Figure 12-2), once per week (April - June), and in conjunction with entrainment sampling. The seine measured 9.1 m x 1.2 m (30 ft x 4 ft) and was constructed of 6.4 mm (1/4 in) stretch mesh heat set braided nylon (delta pattern). Sampling routine consisted of walking the seine through the shallows, in the direction of river flow, and parallel to shore for approximately 9.1 m (30 ft) (Beak, 1980). The seine was then bagged and the number and lengths of chinook salmon fry recorded. Beach seining was not performed during the July 23 to September 11 sampling period.

12.3 RESULTS AND DISCUSSION

Entrainment samples were collected on 25 occasions from April 1985 through September 1985 and contained no fish, fish eggs, or larvae. Over 294 hours of sampling was performed with an average sampling period of just under 12 hours (Table 12-1).

Five separate beach seine operations were performed between April 11 and June 11, 1985. A total of 101 chinook salmon juveniles were collected, 43 of which averaged 43 mm in length. Maximum and minimum lengths were 62 mm and 36 mm, respectively (Table 12-2). The study confirms the presence of chinook salmon juveniles near the intake structures during the period of entrainment sampling.

Under normal plant operating conditions the water withdrawal rate is approximately 0.946 m^3/s (33.4 cfs) to 1.262 m^3/s (44.6 cfs), with the maximum attainable rate being 1.451 m^3/s (51.2 cfs). For the period of entrainment sampling in 1985, withdrawal rate averaged 1.104 m^3/s (39.0 cfs), and ranged from a mean low of 0.715 m^3/s (25.2 cfs) to a mean high of 1.451 m^3/s (51.2 cfs).

It is estimated that the maximum river water withdrawal would be less than 0.15% of the river volume, at the lowest regulated flow of 36,000 cfs (Mudge et. al, 1982). During the 1985 study, the lowest river flow encountered during entrainment sampling was 54,500 cfs on September 10. Mean intake flow for this date was 1.250 m^3/s (44.125 cfs), which is approximately 0.08% of the river volume.

Sixty-nine entrainment samples collected from May 1979 through May 1980 revealed no fish, fish eggs or larvae (Beak, 1980). Including these studies, over 976 hours of entrainment sampling has been performed on the WNP-2 intake structures.

In summary, entrainment sampling during 1985 at water withdrawal rates associated with thermal loads of 75% or greater indicates no apparent impact on Columbia River salmonid populations.

12.4 BIBLIOGRAPHY

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Mudge, J.E., T.B. Stables, W. Davis III. 1982. Technical review of the aquatic monitoring program of WNP-2. Washington Public Power Supply System, Richland, WA.

Sorensen, G.C., May 9, 1983, Washington Public Power Supply System, Letter to D.R. Evans, Supply System Project No. 2 Aquatic Operational Monitoring Program.

Table 12-1. Summarized Entrainment Sample Data, April 1985 through September 1985

Date	Duration (hr)	Mean Intake Flow (m^3/s)	Intake/Sample Vol (m^3)	Vol (m^3)	River Flow (cfs)	Results
4/11/85	11.083	1.136	45,320	22,660	62,500	*
4/11-4/12	13.000	1.136	53,159	26,580	62,700	*
4/17	11.750	1.073	45,383	22,692	129,000	*
4/17-4/18	12.617	1.325	60,177	30,089	123,000	*
4/23	4.333	1.451	22,633	11,317	139,000	*
4/23-4/24	13.500	0.873	42,423	21,212	135,000	*
5/2	4.000	1.451	20,892	10,446	135,000	*
5/2-5/3	12.817	0.789	36,402	18,201	134,000	*
6/10-6/11	18.000	0.715	46,332	23,166	98,600	*
7/23	12.000	1.410	60,905	30,453	98,400	*
7/23-7/24	12.050	0.946	41,033	20,517	89,600	*
7/30	11.500	1.325	54,849	27,425	60,000	*
7/30-7/31	14.000	1.281	64,556	32,278	66,100	*
8/8	11.500	1.276	52,826	26,413	81,900	*
8/8-8/9	12.250	1.300	57,309	28,655	73,900	*
8/13	11.500	1.276	52,821	26,411	81,900	*
8/13-8/14	12.317	1.304	57,810	28,905	91,100	*
8/22	11.917	1.241	53,226	26,613	59,900	*
8/22-8/23	12.083	1.276	55,490	27,745	56,900	*
8/27	11.617	1.320	55,200	27,600	89,500	*
8/27-8/28	12.233	1.221	53,746	26,873	63,800	*
9/5	11.950	1.204	51,772	25,886	63,800	*
9/5-9/6	12.167	1.301	56,990	28,495	65,400	*
9/10	11.917	1.250	53,627	26,814	54,500	*
9/10-9/11	12.083	1.262	54,881	27,441	56,200	*

*No fish or fish eggs entrained.

Table 12-2. Beach Seine Sample Data, April 1985 through June 1985

Date	Location	Number Chinook Caught	Length (mm) Min	Max	Mean
4/11/85	Site 1	35	-	-	-
	Site 2	0	-	-	-
4/18/85	Site 1	6	36	57	43
	Site 2	0	-	-	-
4/23/85	Site 1	0	-	-	-
	Site 2	0	-	-	-
5/2/85	Site 1	3	-	-	-
	Site 2	22	37	49	41
6/11/85	Site 1	20	-	-	-
	Site 2	15	36	62	46

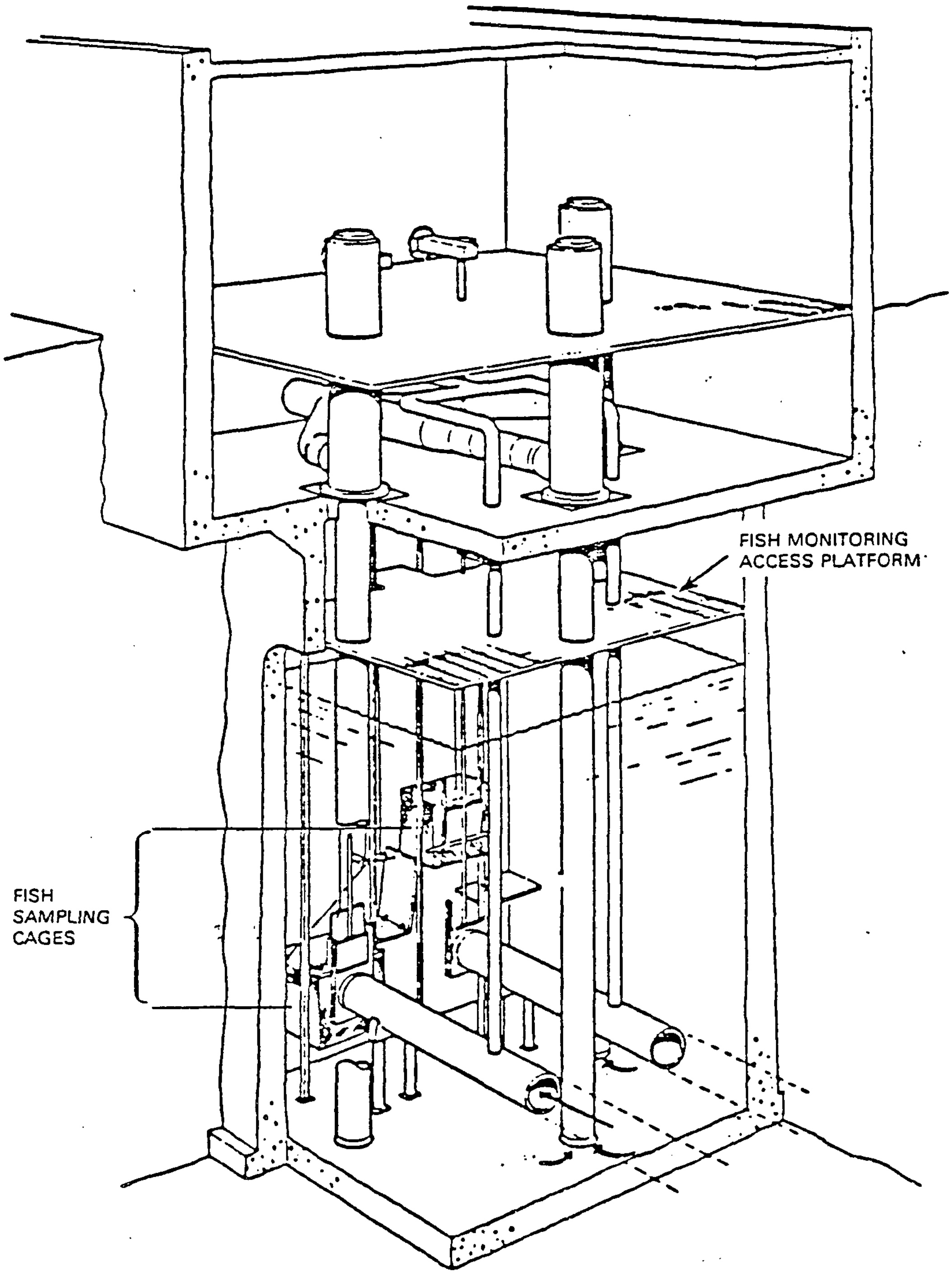

Figure 12-1. WNP-2 Make-Up Water Pumphouse Fish Monitoring Facilities

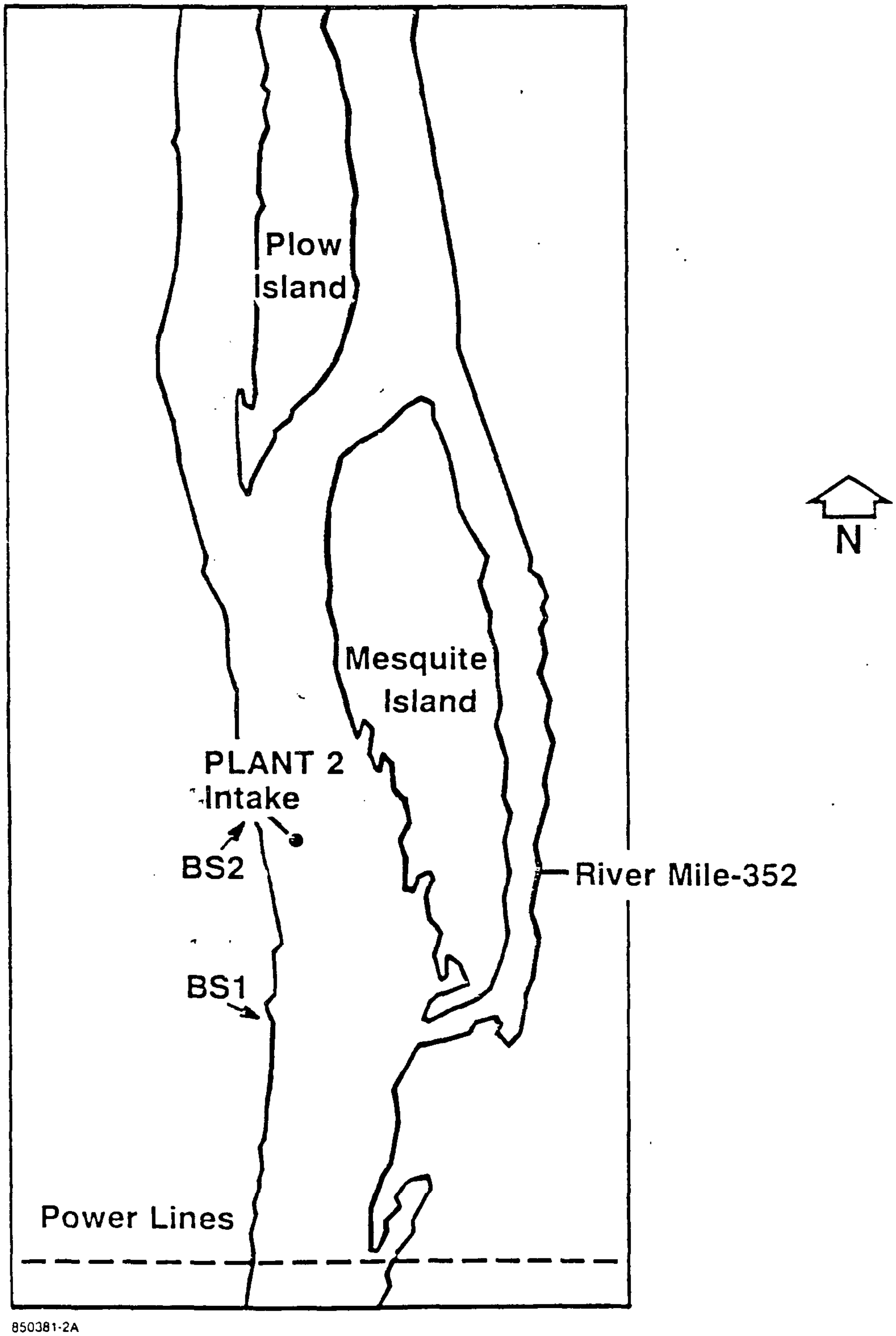

Figure 12-2. Beach Seine Sample Station Locations

APPENDIX A

TABLE A-1

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
SEPT-DEC 84	1	CADDISFLY-HYDROPSYCHIDAE, LARVAE	40003.37	76.09	9868.41	141.23	96.70	31.27
SEPT-DEC 84	1	MIDGES-CHIRONOMIDAE, LARVAE	10067.43	19.15	4091.11	.34	.23	.23
SEPT-DEC 84	1	CADDISFLY-LEFTOCERIDAE, LARVAE	767.00	1.46	286.91	2.02	1.39	.73
SEPT-DEC 84	1	MAYFLY-EPHEMERELLIDAE, NYMPH	508.60	.97	121.10	.08	.06	.03
SEPT-DEC 84	1	CADDISFLY-HYDROPTILIDAE, LARVAE	484.40	.92	145.30	.09	.06	.02
SEPT-DEC 84	1	MIDGES-CHIRONOMIDAE, PUPAE	209.90	.40	133.40	.08	.05	.06
SEPT-DEC 84	1	MAYFLY-GENERAL, NYMPH	161.50	.31	77.85	.02	.01	.01
SEPT-DEC 84	1	CADDISFLY-PSYCHOMYIIDAE, LARVAE	121.07	.23	83.89	.04	.03	.03
SEPT-DEC 84	1	MAYFLY-BAETIDAE, NYMPH	80.73	.15	65.04	.01	.01	.01
SEPT-DEC 84	1	SNAIL-FLUMINICOLA, ADULT	40.37	.08	50.43	.88	.60	1.44
SEPT-DEC 84	1	CLAM-BIVALVIA, ADULT	32.30	.06	55.95	.02	.01	.03
SEPT-DEC 84	1	OLIGOCHAETE, ADULT	32.30	.06	37.02	.00	.00	.00
SEPT-DEC 84	1	SNAIL-FISHEROLA, ADULT	16.13	.03	27.94	.67	.46	1.16
SEPT-DEC 84	1	CADDISFLY-HYDROPSYCHIDAE, PUPAE	16.13	.03	27.94	.19	.13	.33
SEPT-DEC 84	1	SNAIL-PARAPHOLYX, ADULT	8.07	.02	13.97	.31	.21	.54
SEPT-DEC 84	1	BLACKFLY-SIMULIDAE, LARVAE	8.07	.02	13.97	.06	.04	.10
SEPT-DEC 84	1	MOTH-PYRALIDAE, LARVAE	8.07	.02	13.97	.00	.00	.01
SEPT-DEC 84	1	CADDISFLY-RHYACOPHILIDAE, LARVAE	8.07	.02	13.97	.00	.00	.01
SEPT-DEC 84	1	ROUND-WORM, ADULT	.	.	.	.	.	.
SEPT-DEC 84	7W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	30509.13	75.81	2507.93	121.55	65.18	29.19
SEPT-DEC 84	7W	MIDGES-CHIRONOMIDAE, LARVAE	4133.53	10.27	330.60	.72	.39	.11
SEPT-DEC 84	7W	SNAIL-FLUMINICOLA, ADULT	3253.37	8.08	911.85	46.77	25.08	4.57
SEPT-DEC 84	7W	CADDISFLY-LEPTOCERIDAE, LARVAE	1033.40	2.57	604.18	2.17	1.17	1.42
SEPT-DEC 84	7W	SNAIL-FISHEROLA, ADULT	371.37	.92	217.07	9.46	5.07	4.20
SEPT-DEC 84	7W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	226.03	.56	275.42	.13	.07	.16
SEPT-DEC 84	7W	MIDGES-CHIRONOMIDAE, PUPAE	185.67	.46	28.00	.07	.04	.02
SEPT-DEC 84	7W	CADDISFLY-HYDROPTILIDAE, LARVAE	137.27	.34	50.43	.02	.01	.02
SEPT-DEC 84	7W	MAYFLY-EPHEMERELLIDAE, NYMPH	96.87	.24	87.31	.01	.01	.01
SEPT-DEC 84	7W	BLACKFLY-SIMULIDAE, LARVAE	88.80	.22	91.73	.09	.05	.04
SEPT-DEC 84	7W	MAYFLY-BAETIDAE, NYMPH	56.53	.14	50.43	.05	.03	.04
SEPT-DEC 84	7W	MOTH-PYRALIDAE, LARVAE	48.43	.12	24.25	.21	.11	.14
SEPT-DEC 84	7W	SNAIL-PHYSA, ADULT	32.30	.08	37.02	1.21	.65	1.63
SEPT-DEC 84	7W	SNAIL-PARAPHOLYX, ADULT	32.27	.08	27.94	.58	.31	.50
SEPT-DEC 84	7W	CLAM-BIVALVIA, ADULT	32.27	.08	13.97	.01	.01	.01
SEPT-DEC 84	7W	BLACKFLY-SIMULIDAE, PUPAE	8.07	.02	13.97	.01	.00	.02
SEPT-DEC 84	7W	UNIDENTIFIED	.	.	.	3.42	1.83	.46
SEPT-DEC 84	7W	ROUND-WORM, ADULT	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
SEPT-DEC 84	7M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	47874.87	83.23	13578.70	293.30	87.04	210.11
SEPT-DEC 84	7M	MIDGES-CHIRONOMIDAE, LARVAE	5417.23	9.42	1610.44	1.09	.32	.64
SEPT-DEC 84	7M	SNAIL-FLUMINICOLA, ADULT	1235.23	2.15	707.39	24.64	7.31	14.97
SEPT-DEC 84	7M	CADDISFLY-LEPTOCERIDAE, LARVAE	1202.93	2.09	197.27	3.10	.92	1.06
SEPT-DEC 84	7M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	363.30	.63	471.48	.27	.08	.35
SEPT-DEC 84	7M	SNAIL-FISHEROLA, ADULT	274.50	.48	392.28	8.64	2.56	11.77
SEPT-DEC 84	7M	MAYFLY-EPHEMERELLIDAE, NYMPH	258.37	.45	164.84	.05	.01	.04
SEPT-DEC 84	7M	MIDGES-CHIRONOMIDAE, PUPAE	242.20	.42	158.79	.28	.08	.29
SEPT-DEC 84	7M	CADDISFLY-HYDROPTILIDAE, LARVAE	201.83	.35	69.92	.04	.01	.02
SEPT-DEC 84	7M	MAYFLY-BAETIDAE, NYMPH	169.53	.29	96.85	.22	.07	.14
SEPT-DEC 84	7M	BLACKFLY-SIMULIDAE, LARVAE	88.77	.15	69.92	.23	.07	.20
SEPT-DEC 84	7M	MAYFLY-GENERAL, NYMPH	32.30	.06	55.95	.02	.01	.03
SEPT-DEC 84	7M	OLIGOCHAETE, ADULT	24.23	.04	41.97	.00	.00	.00
SEPT-DEC 84	7M	CLAM-BIVALVIA, ADULT	24.20	.04	24.20	.02	.01	.02
SEPT-DEC 84	7M	MIDGES-CHIRONOMIDAE, ADULT	24.20	.04	24.20	.00	.00	.00
SEPT-DEC 84	7M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	24.20	.04	24.20	.14	.04	.14
SEPT-DEC 84	7M	SNAIL-PHYSA, ADULT	16.13	.03	27.94	1.09	.32	1.89
SEPT-DEC 84	7M	MAYFLY-BAETIDAE, ADULT	16.13	.03	27.94	.03	.01	.06
SEPT-DEC 84	7M	MITES-GENERAL, ADULT	8.07	.01	13.97	.00	.00	.01
SEPT-DEC 84	7M	BLACKFLY-SIMULIDAE, PUPAE	8.07	.01	13.97	.04	.01	.07
SEPT-DEC 84	7M	MOTH-PYRALIDAE, LARVAE	8.07	.01	13.97	.05	.02	.09
SEPT-DEC 84	7M	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.01	13.97	.00	.00	.01
SEPT-DEC 84	7M	UNIDENTIFIED	.	.	.	3.70	1.10	1.29
SEPT-DEC 84	7M	ROUND-WORM, ADULT	.	.	.	.	.	.
SEPT-DEC 84	7E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	26738.90	71.18	2375.03	94.07	57.74	11.32
SEPT-DEC 84	7E	MIDGES-CHIRONOMIDAE, LARVAE	4989.30	13.28	1927.11	.89	.55	.54
SEPT-DEC 84	7E	SNAIL-FLUMINICOLA, ADULT	3035.57	8.08	898.88	47.76	29.31	13.71
SEPT-DEC 84	7E	CADDISFLY-LEPTOCERIDAE, LARVAE	1154.30	3.07	311.40	2.77	1.70	.69
SEPT-DEC 84	7E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	484.40	1.29	96.90	.37	.23	.23
SEPT-DEC 84	7E	SNAIL-FISHEROLA, ADULT	363.30	.97	211.14	12.41	7.62	7.32
SEPT-DEC 84	7E	MAYFLY-EPHEMERELLIDAE, NYMPH	153.43	.41	69.92	.03	.02	.01
SEPT-DEC 84	7E	MAYFLY-BAETIDAE, NYMPH	145.[illegible]3	.39	48.45	.11	.07	.08
SEPT-DEC 84	7E	MIDGES-CHIRONOMIDAE, PUPAE	137.23	.37	36.97	.09	.06	.07
SEPT-DEC 84	7E	CADDISFLY-HYDROPTILIDAE, LARVAE	137.23	.37	27.94	.02	.01	.00
SEPT-DEC 84	7E	BLACKFLY-SIMULIDAE, LARVAE	56.50	.15	77.85	.09	.05	.10
SEPT-DEC 84	7E	SNAIL-PARAPHOLYX, ADULT	48.43	.13	48.45	1.00	.62	.91
SEPT-DEC 84	7E	MIDGES-CHIRONOMIDAE, ADULT	24.23	.06	41.97	.00	.00	.01
SEPT-DEC 84	7E	SNAIL-PHYSA, ADULT	24.20	.06	24.20	.68	.42	.82
SEPT-DEC 84	7E	MOTH-PYRALIDAE, LARVAE	24.20	.06	0.0	.04	.02	.03
SEPT-DEC 84	7E	CLAM-BIVALVIA, ADULT	16.13	.04	13.97	.01	.01	.01
SEPT-DEC 84	7E	SNAIL-LYMNAEA, ADULT	16.13	.04	27.94	.97	.59	1.67
SEPT-DEC 84	7E	OLIGOCHAETE, ADULT	16.13	.04	13.97	.00	.00	.00
SEPT-DEC 84	7E	UNIDENTIFIED	.	.	.	1.62	.99	1.25
SEPT-DEC 84	7E	ROUND-WORM, ADULT	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
SEPT-DEC 84	11W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	49788.23	72.45	10315.60	219.89	77.11	168.10
SEPT-DEC 84	11W	MIDGES-CHIRONOMIDAE, LARVAE	12473.30	18.15	4425.75	1.98	.70	.84
SEPT-DEC 84	11W	SNAIL-FLUMINICOLA, ADULT	2405.83	3.50	402.59	51.61	18.10	7.18
SEPT-DEC 84	11W	CADDISFLY-LEPTOCERIDAE, LARVAE	1299.80	1.89	513.97	3.66	1.28	1.99
SEPT-DEC 84	11W	MAYFLY-EPHEMERELLIDAE, NYMPH	1025.30	1.49	195.72	.15	.05	.05
SEPT-DEC 84	11W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	645.90	.94	171.84	.43	.15	.14
SEPT-DEC 84	11W	CADDISFLY-HYDROPTILIDAE, LARVAE	411.73	.60	96.85	.12	.04	.04
SEPT-DEC 84	11W	MIDGES-CHIRONOMIDAE, PUPAE	185.70	.27	37.02	.14	.05	.06
SEPT-DEC 84	11W	MOTH-PYRALIDAE, LARVAE	80.73	.12	50.43	.17	.06	.19
SEPT-DEC 84	11W	CLAM-BIVALVIA, ADULT	72.67	.11	48.45	.02	.01	.01
SEPT-DEC 84	11W	SNAIL-FISHEROLA, ADULT	64.57	.09	73.99	2.09	.73	2.80
SEPT-DEC 84	11W	MAYFLY-BAETIDAE, NYMPH	56.50	.08	37.02	.07	.02	.05
SEPT-DEC 84	11W	BLACKFLY-SIMULIDAE, LARVAE	40.37	.06	28.00	.06	.03	.05
SEPT-DEC 84	11W	OLIGOCHAETE, ADULT	40.33	.06	13.97	.00	.00	.00
SEPT-DEC 84	11W	MAYFLY-HEPTAGENIIDAE, NYMPH	24.23	.04	41.97	.00	.00	.00
SEPT-DEC 84	11W	SNAIL-PHYSA, ADULT	16.13	.02	27.94	.53	.19	.92
SEPT-DEC 84	11W	SNAIL-PARAPHOLYX, ADULT	16.13	.02	13.97	.26	.09	.29
SEPT-DEC 84	11W	BLACKFLY-SIMULIDAE, PUPAE	16.13	.02	13.97	.02	.01	.04
SEPT-DEC 84	11W	MAYFLY-GENERAL, NYMPH	16.13	.02	27.94	.01	.00	.02
SEPT-DEC 84	11W	SNAIL-LYMNAEA, ADULT	8.07	.01	13.97	.80	.28	1.38
SEPT-DEC 84	11W	MIDGES-CHIRONOMIDAE, ADULT	8.07	.01	13.97	.00	.00	.00
SEPT-DEC 84	11W	CADDISFLY-HYDROPTILIDAE, PUPAE	8.07	.01	13.97	0.0	0.0	0.0
SEPT-DEC 84	11W	CADDISFLY-HYDROPSYCHIDAE, PUPAE	8.07	.01	13.97	.09	.03	.16
SEPT-DEC 84	11W	MAYFLY-GENERAL, ADULT	8.07	.01	.	.01	.00	.
SEPT-DEC 84	11W	UNIDENTIFIED	0.0	0.0	.	3.03	1.06	1.55
SEPT-DEC 84	11W	ROUND-WORM, ADULT	.	.	.	.	.	.
SEPT-DEC 84	11M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	40600.80	77.73	2314.57	234.85	87.38	36.82
SEPT-DEC 84	11M	MIDGES-CHIRONOMIDAE, LARVAE	8864.50	16.97	1156.74	1.11	.41	.27
SEPT-DEC 84	11M	SNAIL-FLUMINICOLA, ADULT	637.77	1.22	316.10	19.09	7.10	10.66
SEPT-DEC 84	11M	CADDISFLY-LEPTOCERIDAE, LARVAE	516.70	.99	330.59	1.34	.50	1.00
SEPT-DEC 84	11M	MAYFLY-EPHEMERELLIDAE, NYMPH	347.17	.66	85.09	.04	.01	.00
SEPT-DEC 84	11M	MIDGES-CHIRONOMIDAE, PUPAE	322.93	.62	141.91	.15	.06	.03
SEPT-DEC 84	11M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	314.83	.60	64.08	.14	.05	.07
SEPT-DEC 84	11M	SNAIL-FISHEROLA, ADULT	209.90	.40	175.18	8.44	3.14	5.76
SEPT-DEC 84	11M	CADDISFLY-HYDROPTILIDAE, LARVAE	113.03	.22	27.94	.03	.01	.02
SEPT-DEC 84	11M	MAYFLY-BAETIDAE, NYMPH	88.80	.17	50.42	.10	.04	.10
SEPT-DEC 84	11M	BLACKFLY-SIMULIDAE, LARVAE	72.67	.14	24.25	.19	.07	.10
SEPT-DEC 84	11M	MOTH-PYRALIDAE, LARVAE	32.27	.06	13.97	.08	.03	.06
SEPT-DEC 84	11M	OLIGOCHAETE, ADULT	24.23	.05	41.97	.00	.00	.00
SEPT-DEC 84	11M	CLAM-BIVALVIA, ADULT	24.20	.05	24.20	.01	.00	.01
SEPT-DEC 84	11M	SNAIL-PHYSA, ADULT	24.20	.05	24.20	2.05	.76	2.38
SEPT-DEC 84	11M	MITES-GENERAL, ADULT	16.13	.03	13.97	.00	.00	.01
SEPT-DEC 84	11M	SNAIL-PARAPHOLYX, ADULT	8.07	.02	13.97	.25	.09	.43
SEPT-DEC 84	11M	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.02	13.97	.01	.00	.01
SEPT-DEC 84	11M	MAYFLY-TRICORYTHIDAE, NYMPH	8.07	.02	13.97	.00	.00	.00
SEPT-DEC 84	11M	UNIDENTIFIED	0.0	0.0	0.0	.88	.33	1.53
SEPT-DEC 84	11M	ROUND-WORM, ADULT	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
SEPT-DEC 84	11E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	31865.47	75.98	6770.09	217.82	75.72	105.80
SEPT-DEC 84	11E	MIDGES-CHIRONOMIDAE, LARVAE	4480.70	10.68	1833.82	.64	.22	.22
SEPT-DEC 84	11E	SNAIL-FLUMINICOLA, ADULT	3067.83	7.31	1778.22	59.08	20.54	23.02
SEPT-DEC 84	11E	CADDISFLY-LEPTOCERIDAE, LARVAE	847.73	2.02	666.38	2.45	.85	1.71
SEPT-DEC 84	11E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	411.73	.98	303.48	.49	.17	.40
SEPT-DEC 84	11E	MAYFLY-EPHEMERELLIDAE, NYMPH	395.60	.94	178.49	.10	.03	.07
SEPT-DEC 84	11E	CADDISFLY-HYDROPTILIDAE, LARVAE	242.20	.58	41.92	.05	.02	.02
SEPT-DEC 84	11E	MAYFLY-BAETIDAE, NYMPH	153.40	.37	77.85	.18	.06	.16
SEPT-DEC 84	11E	MIDGES-CHIRONOMIDAE, PUPAE	145.30	.35	24.20	.06	.02	.01
SEPT-DEC 84	11E	SNAIL-FISHEROLA, ADULT	121.10	.29	87.35	4.21	1.46	2.55
SEPT-DEC 84	11E	CLAM-BIVALVIA, ADULT	48.47	.12	41.97	.01	.00	.01
SEPT-DEC 84	11E	MAYFLY-GENERAL, NYMPH	48.43	.12	83.89	.03	.01	.06
SEPT-DEC 84	11E	BLACKFLY-SIMULIDAE, LARVAE	32.27	.08	13.97	.09	.03	.11
SEPT-DEC 84	11E	MOTH-PYRALIDAE, LARVAE	24.20	.06	0.0	.06	.02	.02
SEPT-DEC 84	11E	SNAIL-PARAPHOLYX, ADULT	8.07	.02	13.97	.05	.02	.09
SEPT-DEC 84	11E	MITES-GENERAL, ADULT	8.07	.02	13.97	.00	.00	.01
SEPT-DEC 84	11E	MIDGES-CHIRONOMIDAE, ADULT	8.07	.02	13.97	.00	.00	.00
SEPT-DEC 84	11E	BLACKFLY-SIMULIDAE, PUPAE	8.07	.02	13.97	.06	.02	.10
SEPT-DEC 84	11E	CADDISFLY-HYDROPTILIDAE, PUPAE	8.07	.02	13.97	.00	.00	.01
SEPT-DEC 84	11E	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.02	13.97	.00	.00	.01
SEPT-DEC 84	11E	OLIGOCHAETE, ADULT	8.07	.02	13.97	.00	.00	.00
SEPT-DEC 84	11E	UNIDENTIFIED	.	.	.	2.25	.78	1.02
SEPT-DEC 84	11E	ROUND-WORM, ADULT	.	.	.	.	.	.
SEPT-DEC 84	8	CADDISFLY-HYDROPSYCHIDAE, LARVAE	52186.03	59.44	3647.66	237.23	92.51	133.41
SEPT-DEC 84	8	MIDGES-CHIRONOMIDAE, LARVAE	25011.20	28.49	21023.05	3.80	1.48	3.46
SEPT-DEC 84	8	CADDISFLY-HYDROPTILIDAE, LARVAE	5150.77	5.87	1788.71	1.58	.62	.42
SEPT-DEC 84	8	MAYFLY-EPHEMERELLIDAE, NYMPH	1356.30	1.54	553.87	.26	.10	.11
SEPT-DEC 84	8	CADDISFLY-LEPTOCERIDAE, LARVAE	1307.90	1.49	361.65	3.63	1.42	.58
SEPT-DEC 84	8	CADDISFLY-PSYCHOMYIIDAE, LARVAE	1154.50	1.31	1127.31	.81	.32	.75
SEPT-DEC 84	8	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	637.80	.73	940.64	.43	.17	.64
SEPT-DEC 84	8	MAYFLY-HEPTAGENIIDAE, NYMPH	314.87	.36	24.25	.12	.05	.04
SEPT-DEC 84	8	MIDGES-CHIRONOMIDAE, PUPAE	242.20	.28	111.00	.14	.06	.04
SEPT-DEC 84	8	MOTH-PYRALIDAE, LARVAE	113.03	.13	50.38	.28	.11	.07
SEPT-DEC 84	8	SNAIL-FLUMINICOLA, ADULT	64.60	.07	14.03	1.51	.59	.64
SEPT-DEC 84	8	MAYFLY-BAETIDAE, NYMPH	40.37	.05	28.00	.05	.02	.06
SEPT-DEC 84	8	CLAM-BIVALVIA, ADULT	32.30	.04	37.02	.02	.01	.02
SEPT-DEC 84	8	SNAIL-LYMNAEA, ADULT	32.30	.04	37.02	3.97	1.55	4.18
SEPT-DEC 84	8	MAYFLY-TRICORYTHIDAE, NYMPH	24.23	.03	41.97	.00	.00	.01
SEPT-DEC 84	8	MAYFLY-GENERAL, NYMPH	36.35	.03	51.41	.02	.01	.04
SEPT-DEC 84	8	SNAIL-PARAPHOLYX, ADULT	24.20	.03	24.20	.39	.15	.35
SEPT-DEC 84	8	SNAIL-FISHEROLA, ADULT	24.20	.03	24.20	.52	.20	.46
SEPT-DEC 84	8	MITES-GENERAL, ADULT	16.13	.02	27.94	.00	.00	.01
SEPT-DEC 84	8	MIDGES-CHIRONOMIDAE, ADULT	16.13	.02	13.97	.01	.00	.01
SEPT-DEC 84	8	BLACKFLY-SIMULIDAE, ADULT	8.07	.01	13.97	.01	.01	.02
SEPT-DEC 84	8	OLIGOCHAETE, ADULT	8.07	.01	13.97	.00	.00	.00
SEPT-DEC 84	8	FLAT-WORM, ADULT	8.07	.01	13.97	.01	.00	.01
SEPT-DEC 84	8	UNIDENTIFIED	0.0	0.0	.	1.62	.63	1.20
SEPT-DEC 84	8	ROUND-WORM, ADULT	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
DEC-MAR 85	1	CADDISFLY-HYDROPSYCHIDAE, LARVAE	347.13	32.33	225.01	2.21	55.38	1.18
DEC-MAR 85	1	MIDGES-CHIRONOMIDAE, LARVAE	331.00	30.83	195.76	.52	13.11	.20
DEC-MAR 85	1	MIDGES-CHIRONOMIDAE, PUPAE	121.10	11.28	0.0	.16	3.95	.04
DEC-MAR 85	1	BLACKFLY-SIMULIDAE, LARVAE	113.03	10.53	85.09	.29	7.31	.18
DEC-MAR 85	1	CADDISFLY-LEPTOCERIDAE, LARVAE	56.50	5.26	60.95	.16	3.89	.18
DEC-MAR 85	1	MAYFLY-EPHEMERELLIDAE, NYMPH	40.37	3.76	28.00	.02	.38	.01
DEC-MAR 85	1	SNAIL-FLUMINICOLA, ADULT	32.30	3.01	55.95	.57	14.42	1.00
DEC-MAR 85	1	CADDISFLY-HYDROPTILIDAE, LARVAE	16.13	1.50	13.97	.00	.06	.00
DEC-MAR 85	1	CADDISFLY-PSYCHOMYIIDAE, LARVAE	8.07	.75	13.97	.00	.02	.00
DEC-MAR 85	1	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	8.07	.75	13.97	.00	.12	.01
DEC-MAR 85	1	UNIDENTIFIED	0.0	0.0	0.0	.05	1.36	.09
DEC-MAR 85	7W	MIDGES-CHIRONOMIDAE, LARVAE	1009.17	28.15	668.32	2.04	5.05	1.44
DEC-MAR 85	7W	SNAIL-FLUMINICOLA, ADULT	831.57	23.20	636.36	23.55	58.33	16.55
DEC-MAR 85	7W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	637.80	17.79	350.45	7.94	19.66	5.65
DEC-MAR 85	7W	MIDGES-CHIRONOMIDAE, PUPAE	419.80	11.71	148.02	.82	2.04	.14
DEC-MAR 85	7W	CADDISFLY-LEPTOCERIDAE, LARVAE	137.23	3.83	97.90	.38	.93	.25
DEC-MAR 85	7W	BLACKFLY-SIMULIDAE, LARVAE	121.10	3.38	105.58	.37	.91	.35
DEC-MAR 85	7W	MAYFLY-EPHEMERELLIDAE, NYMPH	104.97	2.93	109.22	.04	.09	.05
DEC-MAR 85	7W	CADDISFLY-HYDROPTILIDAE, LARVAE	96.87	2.70	128.17	.03	.08	.05
DEC-MAR 85	7W	SNAIL-FISHEROLA, ADULT	80.73	2.25	139.83	4.28	10.59	7.41
DEC-MAR 85	7W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	64.57	1.80	28.00	.02	.05	.01
DEC-MAR 85	7W	MOLLUSC, ADULT	32.30	.90	55.95	.39	.97	.68
DEC-MAR 85	7W	MIDGES-CHIRONOMIDAE, ADULT	16.13	.45	13.97	.02	.05	.02
DEC-MAR 85	7W	MAYFLY-HEPTAGENIIDAE, NYMPH	16.13	.45	13.97	.01	.02	.01
DEC-MAR 85	7W	BLACKFLY-SIMULIDAE, PUPAE	8.07	.23	13.97	.02	.06	.04
DEC-MAR 85	7W	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	8.07	.23	13.97	.10	.24	.17
DEC-MAR 85	7W	ROUND-WORM, ADULT	0.0	0.0	.	0.0	0.0	.
DEC-MAR 85	7W	UNIDENTIFIED	.	.	.	.37	.93	.51
DEC-MAR 85	7M	MIDGES-CHIRONOMIDAE, LARVAE	831.53	37.18	346.23	1.44	14.51	.69
DEC-MAR 85	7M	MIDGES-CHIRONOMIDAE, PUPAE	419.83	18.77	247.39	.66	6.63	.43
DEC-MAR 85	7M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	403.67	18.05	205.97	2.44	24.64	2.50
DEC-MAR 85	7M	BLACKFLY-SIMULIDAE, LARVAE	250.27	11.19	330.60	.84	8.48	1.21
DEC-MAR 85	7M	SNAIL-FLUMINICOLA, ADULT	153.37	6.86	225.03	4.27	43.16	6.30
DEC-MAR 85	7M	MAYFLY-EPHEMERELLIDAE, NYMPH	80.73	3.61	50.43	.04	.36	.02
DEC-MAR 85	7M	CADDISFLY-HYDROPTILIDAE, LARVAE	40.37	1.81	28.00	.01	.15	.01
DEC-MAR 85	7M	MIDGES-CHIRONOMIDAE, ADULT	32.30	1.44	37.02	.04	.45	.06
DEC-MAR 85	7M	BLACKFLY-SIMULIDAE, PUPAE	16.13	.72	13.97	.10	1.00	.09
DEC-MAR 85	7M	CADDISFLY-LEPTOCERIDAE, LARVAE	8.07	.36	13.97	.02	.20	.03
DEC-MAR 85	7M	UNIDENTIFIED	0.0	0.0	0.0	.04	.43	.07

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
DEC-MAR 85	7E	MIDGES-CHIRONOMIDAE, LARVAE	1219.07	33.78	532.98	2.66	7.70	1.18
DEC-MAR 85	7E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	629.73	17.45	569.58	2.30	6.65	2.55
DEC-MAR 85	7E	MIDGES-CHIRONOMIDAE, PUPAE	549.00	15.21	137.72	1.10	3.20	.41
DEC-MAR 85	7E	SNAIL-FLUMINICOLA, ADULT	548.97	15.21	406.23	13.22	38.27	8.96
DEC-MAR 85	7E	SNAIL-FISHEROLA, ADULT	145.33	4.03	128.17	11.26	32.60	10.41
DEC-MAR 85	7E	MAYFLY-EPHEMERELLIDAE, NYMPH	96.90	2.69	111.00	.02	.07	.02
DEC-MAR 85	7E	BLACKFLY-SIMULIDAE, LARVAE	96.87	2.68	87.31	.26	.77	.23
DEC-MAR 85	7E	CADDISFLY-LEPTOCERIDAE, LARVAE	72.63	2.01	41.97	.20	.59	.15
DEC-MAR 85	7E	CADDISFLY-HYDROPTILIDAE, LARVAE	64.60	1.79	37.02	.02	.05	.01
DEC-MAR 85	7E	MIDGES-CHIRONOMIDAE, ADULT	48.43	1.34	24.25	.10	.28	.09
DEC-MAR 85	7E	SNAIL-PHYSA, ADULT	32.30	.90	55.95	1.13	3.28	1.96
DEC-MAR 85	7E	OLIGOCHAETE, ADULT	32.30	.90	37.02	.04	.11	.06
DEC-MAR 85	7E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	16.13	.45	27.94	.21	.61	.36
DEC-MAR 85	7E	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	16.13	.45	27.94	.20	.59	.35
DEC-MAR 85	7E	SNAIL-PARAPHOLYX, ADULT	8.07	.22	13.97	.48	1.39	.83
DEC-MAR 85	7E	SNAIL-LYMNAEA, ADULT	8.07	.22	13.97	1.17	3.38	2.02
DEC-MAR 85	7E	BLACKFLY-SIMULIDAE, PUPAE	8.07	.22	13.97	.02	.07	.04
DEC-MAR 85	7E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	8.07	.22	13.97	.00	.00	.00
DEC-MAR 85	7E	MAYFLY-TRICORYTHIDAE, NYMPH	8.07	.22	13.97	.01	.03	.02
DEC-MAR 85	7E	UNIDENTIFIED	0.0	0.0	.	.13	.37	.12
DEC-MAR 85	11W	MIDGES-CHIRONOMIDAE, LARVAE	960.73	30.51	513.99	1.72	8.53	.62
DEC-MAR 85	11W	SNAIL-FLUMINICOLA, ADULT	645.87	20.51	228.94	14.06	69.63	6.27
DEC-MAR 85	11W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	637.80	20.26	55.95	2.27	11.27	.51
DEC-MAR 85	11W	MIDGES-CHIRONOMIDAE, PUPAE	355.23	11.28	91.71	.77	3.81	.15
DEC-MAR 85	11W	BLACKFLY-SIMULIDAE, LARVAE	201.87	6.41	13.97	.63	3.12	.13
DEC-MAR 85	11W	CADDISFLY-LEPTOCERIDAE, LARVAE	104.97	3.33	13.97	.30	1.49	.05
DEC-MAR 85	11W	CADDISFLY-HYDROPTILIDAE, LARVAE	96.87	3.08	48.45	.03	.15	.02
DEC-MAR 85	11W	OLIGOCHAETE, ADULT	40.37	1.28	37.01	.01	.05	.01
DEC-MAR 85	11W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	32.27	1.02	13.97	.02	.12	.01
DEC-MAR 85	11W	MAYFLY-EPHEMERELLIDAE, NYMPH	32.27	1.02	13.97	.01	.05	.00
DEC-MAR 85	11W	MIDGES-CHIRONOMIDAE, ADULT	16.13	.51	13.97	.02	.12	.02
DEC-MAR 85	11W	CLAM-BIVALVIA, ADULT	8.07	.26	13.97	.00	.02	.01
DEC-MAR 85	11W	SNAIL-LYMNAEA, ADULT	8.07	.26	13.97	.17	.82	.29
DEC-MAR 85	11W	MOLLUSC, ADULT	8.07	.26	13.97	.08	.37	.13
DEC-MAR 85	11W	UNIDENTIFIED	.	.	.	.09	.46	.06
DEC-MAR 85	11M	MIDGES-CHIRONOMIDAE, LARVAE	452.10	32.18	60.95	.55	14.31	.29
DEC-MAR 85	11M	BLACKFLY-SIMULIDAE, LARVAE	387.53	27.59	64.08	.90	23.52	.50
DEC-MAR 85	11M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	347.17	24.71	219.76	2.09	54.49	1.63
DEC-MAR 85	11M	MIDGES-CHIRONOMIDAE, PUPAE	145.33	10.35	64.08	.23	6.05	.18
DEC-MAR 85	11M	CADDISFLY-HYDROPTILIDAE, LARVAE	48.43	3.45	24.25	.01	.19	.00
DEC-MAR 85	11M	MAYFLY-EPHEMERELLIDAE, NYMPH	24.23	1.73	41.97	.01	.38	.03
DEC-MAR 85	11M	UNIDENTIFIED	0.0	0.0	0.0	.04	1.05	.07

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
DEC-MAR 85	11E	MIDGES-CHIRONOMIDAE, LARVAE	1211.00	38.96	339.06	2.02	5.81	.71
DEC-MAR 85	11E	SNAIL-FLUMINICOLA, ADULT	984.97	31.69	790.14	27.63	79.67	23.80
DEC-MAR 85	11E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	266.43	8.57	125.80	.93	2.67	.19
DEC-MAR 85	11E	MIDGES-CHIRONOMIDAE, PUPAE	266.40	8.57	128.15	.43	1.25	.30
DEC-MAR 85	11E	MAYFLY-EPHEMERELLIDAE, NYMPH	104.93	3.38	73.99	.03	.10	.03
DEC-MAR 85	11E	BLACKFLY-SIMULIDAE, LARVAE	88.80	2.86	50.42	.36	1.04	.36
DEC-MAR 85	11E	SNAIL-FISHEROLA, ADULT	56.50	1.82	14.03	2.63	7.58	1.92
DEC-MAR 85	11E	CADDISFLY-LEPTOCERIDAE, LARVAE	48.43	1.56	64.08	.11	.33	.14
DEC-MAR 85	11E	MIDGES-CHIRONOMIDAE, ADULT	40.37	1.30	28.00	.04	.12	.02
DEC-MAR 85	11E	CADDISFLY-HYDROPTILIDAE, LARVAE	8.07	.26	13.97	.00	.01	.01
DEC-MAR 85	11E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	8.07	.26	13.97	.01	.02	.01
DEC-MAR 85	11E	MAYFLY-GENERAL, NYMPH	8.07	.26	13.97	.00	.00	.00
DEC-MAR 85	11E	OLIGOCHAETE, ADULT	8.07	.26	13.97	.00	.00	.00
DEC-MAR 85	11E	FLAT-WORM, ADULT	8.07	.26	13.97	.01	.02	.01
DEC-MAR 85	11E	UNIDENTIFIED	0.0	0.0	.	.47	1.36	.50
DEC-MAR 85	8	MIDGES-CHIRONOMIDAE, LARVAE	1501.63	43.06	729.43	2.10	35.90	.96
DEC-MAR 85	8	MIDGES-CHIRONOMIDAE, PUPAE	694.30	19.91	137.72	1.83	31.20	.25
DEC-MAR 85	8	CADDISFLY-HYDROPTILIDAE, LARVAE	565.13	16.20	170.13	.20	3.42	.06
DEC-MAR 85	8	CADDISFLY-HYDROPSYCHIDAE, LARVAE	331.00	9.49	119.43	.69	11.74	.84
DEC-MAR 85	8	OLIGOCHAETE, ADULT	137.23	3.93	109.22	.05	.79	.04
DEC-MAR 85	8	CADDISFLY-LEPTOCERIDAE, LARVAE	56.53	1.62	50.43	.19	3.20	.17
DEC-MAR 85	8	BLACKFLY-SIMULIDAE, LARVAE	56.50	1.62	77.85	.15	2.50	.16
DEC-MAR 85	8	CADDISFLY-PSYCHOMYIIDAE, LARVAE	56.50	1.62	55.95	.04	.61	.05
DEC-MAR 85	8	MAYFLY-EPHEMERELLIDAE, NYMPH	40.37	1.16	50.43	.01	.21	.02
DEC-MAR 85	8	MIDGES-CHIRONOMIDAE, ADULT	32.30	.93	55.95	.06	.95	.10
DEC-MAR 85	8	SNAIL-FISHEROLA, ADULT	8.07	.23	13.97	.44	7.44	.75
DEC-MAR 85	8	MOTH-PYRALIDAE, LARVAE	8.07	.23	13.97	.01	.15	.02
DEC-MAR 85	8	UNIDENTIFIED	.	.	.	.11	1.89	.09

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
MARCH-JUNE 85	1	CADDISFLY-HYDROPSYCHIDAE, LARVAE	5376.83	32.02	3502.14	91.20	63.96	56.15
MARCH-JUNE 85	1	MAYFLY-EPHEMERELLIDAE, NYMPH	2397.80	14.28	428.50	12.77	8.96	1.92
MARCH-JUNE 85	1	BLACKFLY-SIMULIDAE, LARVAE	1864.93	11.11	2735.44	5.88	4.13	8.91
MARCH-JUNE 85	1	BLACKFLY-SIMULIDAE, PUPAE	1760.00	10.48	2552.35	6.39	4.48	10.01
MARCH-JUNE 85	1	MIDGES-CHIRONOMIDAE, PUPAE	1655.03	9.86	957.93	.92	.65	.55
MARCH-JUNE 85	1	MIDGES-CHIRONOMIDAE, LARVAE	1259.47	7.50	614.14	.58	.41	.30
MARCH-JUNE 85	1	CADDISFLY-HYDROPSYCHIDAE, PUPAE	823.50	4.90	1028.44	14.78	10.37	19.34
MARCH-JUNE 85	1	MAYFLY-BAETIDAE, NYMPH	581.30	3.46	96.90	.46	.32	.24
MARCH-JUNE 85	1	MAYFLY-GENERAL, NYMPH	330.97	1.97	139.83	.32	.22	.07
MARCH-JUNE 85	1	OLIGOCHAETE, ADULT	193.77	1.15	128.17	.02	.01	.01
MARCH-JUNE 85	1	MIDGES-CHIRONOMIDAE, ADULT	137.27	.82	60.95	.36	.25	.56
MARCH-JUNE 85	1	CADDISFLY-LEPTOCERIDAE, LARVAE	129.17	.77	52.31	1.11	.78	.68
MARCH-JUNE 85	1	SNAIL-FLUMINICOLA, ADULT	64.57	.38	91.68	1.37	.96	2.15
MARCH-JUNE 85	1	CADDISFLY-GENERAL, PUPAE	56.50	.34	97.86	.35	.24	.60
MARCH-JUNE 85	1	CADDISFLY-HYDROPTILIDAE, LARVAE	40.37	.24	50.43	.03	.02	.03
MARCH-JUNE 85	1	SNAIL-FISHEROLA, ADULT	32.27	.19	13.97	3.27	2.30	1.33
MARCH-JUNE 85	1	CADDISFLY-HYDROPSYCHIDAE, ADULT	24.23	.14	41.97	.38	.27	.66
MARCH-JUNE 85	1	CLAM-BIVALVIA, ADULT	16.13	.10	27.94	.22	.16	.38
MARCH-JUNE 85	1	SNAIL-PARAPHOLYX, ADULT	16.13	.10	27.94	1.14	.80	1.97
MARCH-JUNE 85	1	MOTH-PYRALIDAE, LARVAE	16.13	.10	13.97	.02	.02	.03
MARCH-JUNE 85	1	MITES-GENERAL, ADULT	8.07	.05	13.97	.00	.00	.00
MARCH-JUNE 85	1	CADDISFLY-PSYCHOMYIIDAE, LARVAE	8.07	.05	13.97	.04	.03	.06
MARCH-JUNE 85	1	UNIDENTIFIED	.	.	.	.97	.68	.57
MARCH-JUNE 85	1	ROUND-WORM, ADULT	.	.	.	.	.	.
MARCH-JUNE 85	7W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	3406.93	22.91	923.00	51.96	27.96	14.15
MARCH-JUNE 85	7W	SNAIL-FLUMINICOLA, ADULT	2300.90	15.47	636.67	67.28	36.21	18.86
MARCH-JUNE 85	7W	MIDGES-CHIRONOMIDAE, PUPAE	1695.40	11.40	563.34	1.35	.73	.40
MARCH-JUNE 85	7W	MIDGES-CHIRONOMIDAE, LARVAE	1356.33	9.12	404.57	.91	.49	.17
MARCH-JUNE 85	7W	MAYFLY-EPHEMERELLIDAE, NYMPH	1097.97	7.38	243.81	3.37	1.81	.24
MARCH-JUNE 85	7W	MAYFLY-BAETIDAE, NYMPH	847.70	5.70	441.95	.81	.44	.47
MARCH-JUNE 85	7W	BLACKFLY-SIMULIDAE, PUPAE	823.50	5.54	420.20	2.22	1.19	.96
MARCH-JUNE 85	7W	OLIGOCHAETE, ADULT	791.17	5.32	874.71	.71	.38	1.17
MARCH-JUNE 85	7W	BLACKFLY-SIMULIDAE, LARVAE	742.77	4.99	295.98	1.81	.97	.96
MARCH-JUNE 85	7W	SNAIL-FISHEROLA, ADULT	411.77	2.77	87.31	30.50	16.41	5.33
MARCH-JUNE 85	7W	CADDISFLY-HYDROPSYCHIDAE, PUPAE	411.73	2.77	443.94	7.96	4.28	9.55
MARCH-JUNE 85	7W	CADDISFLY-LEPTOCERIDAE, LARVAE	250.30	1.68	55.95	2.27	1.22	.45
MARCH-JUNE 85	7W	CADDISFLY-HYDROPTILIDAE, LARVAE	201.83	1.36	73.99	.08	.04	.04
MARCH-JUNE 85	7W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	137.23	.92	109.22	.40	.22	.37
MARCH-JUNE 85	7W	SNAIL-PARAPHOLYX, ADULT	129.17	.87	27.94	6.90	3.71	2.37
MARCH-JUNE 85	7W	CADDISFLY-HYDROPTILIDAE, PUPAE	80.77	.54	13.97	.03	.02	.00
MARCH-JUNE 85	7W	MIDGES-CHIRONOMIDAE, ADULT	56.53	.38	50.43	.01	.01	.01
MARCH-JUNE 85	7W	SNAIL-PHYSA, ADULT	56.50	.38	37.02	4.15	2.23	4.26
MARCH-JUNE 85	7W	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	32.30	.22	37.02	.04	.02	.06
MARCH-JUNE 85	7W	MOLLUSC, ADULT	16.13	.11	27.94	.18	.10	.31
MARCH-JUNE 85	7W	MITES-GENERAL, ADULT	16.13	.11	13.97	.01	.00	.01
MARCH-JUNE 85	7W	SNAIL-LYMNAEA, ADULT	8.07	.05	13.97	1.73	.93	3.00
MARCH-JUNE 85	7W	MAYFLY-GENERAL, NYMPH	0.0	0.0	0.0	.46	.25	.80
MARCH-JUNE 85	7W	MAYFLY-GENERAL	0.0	0.0	.	.14	.07	.29
MARCH-JUNE 85	7W	UNIDENTIFIED	.	.	.	.40	.22	.16
MARCH-JUNE 85	7W	MAYFLY-GENERAL, ADULT	.	.	.	.12	.07	.
MARCH-JUNE 85	7W	ROUND-WORM, ADULT	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
MARCH-JUNE 85	7M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	3156.67	23.80	832.81	38.21	40.94	6.37
MARCH-JUNE 85	7M	MIDGES-CHIRONOMIDAE, PUPAE	1945.67	14.67	568.17	.90	.96	.34
MARCH-JUNE 85	7M	MIDGES-CHIRONOMIDAE, LARVAE	1606.60	12.11	366.77	.56	.60	.17
MARCH-JUNE 85	7M	MAYFLY-BAETIDAE, NYMPH	1574.30	11.87	351.82	1.88	2.01	1.08
MARCH-JUNE 85	7M	MAYFLY-EPHEMERELLIDAE, NYMPH	1533.93	11.56	119.49	3.18	3.41	2.00
MARCH-JUNE 85	7M	SNAIL-FLUMINICOLA, ADULT	1025.30	7.73	861.59	33.68	36.08	27.83
MARCH-JUNE 85	7M	BLACKFLY-SIMULIDAE, PUPAE	597.43	4.50	406.99	1.18	1.26	.69
MARCH-JUNE 85	7M	BLACKFLY-SIMULIDAE, LARVAE	468.23	3.53	211.64	.94	1.00	.48
MARCH-JUNE 85	7M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	411.73	3.10	422.26	7.06	7.56	6.05
MARCH-JUNE 85	7M	OLIGOCHAETE, ADULT	379.43	2.86	387.75	.02	.02	.02
MARCH-JUNE 85	7M	CADDISFLY-LEPTOCERIDAE, LARVAE	185.70	1.40	153.81	1.90	2.03	1.74
MARCH-JUNE 85	7M	CADDISFLY-HYDROPTILIDAE, LARVAE	145.33	1.10	64.08	.04	.04	.02
MARCH-JUNE 85	7M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	96.87	.73	48.45	.29	.31	.18
MARCH-JUNE 85	7M	MIDGES-CHIRONOMIDAE, ADULT	32.27	.24	13.97	.01	.01	.00
MARCH-JUNE 85	7M	MITES-GENERAL, ADULT	24.20	.18	24.20	.01	.01	.01
MARCH-JUNE 85	7M	CADDISFLY-HYDROPTILIDAE, PUPAE	24.20	.18	24.20	.01	.01	.01
MARCH-JUNE 85	7M	CLAM-BIVALVIA, ADULT	8.07	.06	13.97	.00	.00	.01
MARCH-JUNE 85	7M	SNAIL-PHYSA, ADULT	8.07	.06	13.97	.58	.62	1.00
MARCH-JUNE 85	7M	SNAIL-PARAPHOLYX, ADULT	8.07	.06	13.97	.44	.48	.77
MARCH-JUNE 85	7M	SNAIL-LYMNAEA, ADULT	8.07	.06	13.97	.64	.69	1.12
MARCH-JUNE 85	7M	MOTH-PYRALIDAE, LARVAE	8.07	.06	13.97	.01	.01	.02
MARCH-JUNE 85	7M	CADDISFLY-PSYCHOMYIIDAE, PUPAE	8.07	.06	13.97	.03	.03	.05
MARCH-JUNE 85	7M	SCUDS/SHRIMPS, ADULT	8.07	.06	13.97	.00	.01	.01
MARCH-JUNE 85	7M	ROUND-WORM, ADULT	0.0	0.0	.	0.0	0.0	.
MARCH-JUNE 85	7M	UNIDENTIFIED	.	.	.	1.78	1.91	.31
MARCH-JUNE 85	7E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	3124.40	24.40	1497.91	36.21	18.84	17.68
MARCH-JUNE 85	7E	SNAIL-FLUMINICOLA, ADULT	1864.93	14.56	1550.05	56.34	29.31	43.91
MARCH-JUNE 85	7E	MIDGES-CHIRONOMIDAE, PUPAE	1832.67	14.31	595.39	.75	.39	.29
MARCH-JUNE 85	7E	MIDGES-CHIRONOMIDAE, LARVAE	1380.57	10.78	486.19	.51	.26	.24
MARCH-JUNE 85	7E	MAYFLY-BAETIDAE, NYMPH	1130.27	8.83	797.53	.79	.41	.58
MARCH-JUNE 85	7E	MAYFLY-EPHEMERELLIDAE, NYMPH	1122.20	8.76	111.89	2.96	1.54	.12
MARCH-JUNE 85	7E	BLACKFLY-SIMULIDAE, LARVAE	557.07	4.35	500.48	1.18	.61	1.13
MARCH-JUNE 85	7E	SNAIL-FISHEROLA, ADULT	395.60	3.09	77.85	32.60	16.96	8.33
MARCH-JUNE 85	7E	BLACKFLY-SIMULIDAE, PUPAE	387.50	3.03	24.20	.80	.42	.03
MARCH-JUNE 85	7E	OLIGOCHAETE, ADULT	234.13	1.83	232.74	.00	.00	0.0
MARCH-JUNE 85	7E	BLACKFLY-SIMULIDAE, ADULT	145.33	1.14	251.72	.28	.15	.49
MARCH-JUNE 85	7E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	145.30	1.13	145.30	2.94	1.53	3.31
MARCH-JUNE 85	7E	CADDISFLY-LEPTOCERIDAE, LARVAE	137.23	1.07	13.97	1.20	.62	.31
MARCH-JUNE 85	7E	CADDISFLY-HYDROPTILIDAE, LARVAE	121.10	.95	96.90	.04	.02	.04
MARCH-JUNE 85	7E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	113.07	.88	69.92	.27	.14	.17
MARCH-JUNE 85	7E	MIDGES-CHIRONOMIDAE, ADULT	56.50	.44	14.03	.02	.01	.00
MARCH-JUNE 85	7E	MITES-GENERAL, ADULT	24.20	.19	24.20	.01	.01	.01
MARCH-JUNE 85	7E	SNAIL-PARAPHOLYX, ADULT	16.13	.13	13.97	53.95	28.07	91.72
MARCH-JUNE 85	7E	MOTH-PYRALIDAE, LARVAE	16.13	.13	13.97	.03	.02	.04
MARCH-JUNE 85	7E	UNIDENTIFIED	.	.	.	1.33	.69	.45

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
MARCH-JUNE 85	11W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	4335.37	19.75	1066.53	72.32	38.86	24.78
MARCH-JUNE 85	11W	MAYFLY-BAETIDAE, NYMPH	2817.57	12.84	752.51	3.91	2.10	1.86
MARCH-JUNE 85	11W	MAYFLY-EPHEMERELLIDAE, NYMPH	2341.27	10.67	1461.75	11.28	6.06	11.28
MARCH-JUNE 85	11W	MIDGES-CHIRONOMIDAE, LARVAE	2252.47	10.26	192.23	1.17	.63	.23
MARCH-JUNE 85	11W	MIDGES-CHIRONOMIDAE, PUPAE	1969.87	8.97	351.27	1.40	.75	.29
MARCH-JUNE 85	11W	SNAIL-FLUMINICOLA, ADULT	1961.83	8.94	862.10	56.72	30.48	25.39
MARCH-JUNE 85	11W	OLIGOCHAETE, ADULT	1655.00	7.54	359.52	.23	.12	.17
MARCH-JUNE 85	11W	BLACKFLY-SIMULIDAE, PUPAE	1574.33	7.17	356.79	4.25	2.29	1.09
MARCH-JUNE 85	11W	BLACKFLY-SIMULIDAE, LARVAE	1356.33	6.18	437.96	3.40	1.83	1.06
MARCH-JUNE 85	11W	CADDISFLY-HYDROPSYCHIDAE, PUPAE	427.90	1.95	335.92	8.79	4.72	6.68
MARCH-JUNE 85	11W	MITES-GENERAL, ADULT	242.20	1.10	72.70	.11	.06	.03
MARCH-JUNE 85	11W	CADDISFLY-LEPTOCERIDAE, LARVAE	226.03	1.03	69.92	2.19	1.17	.60
MARCH-JUNE 85	11W	CADDISFLY-HYDROPTILIDAE, LARVAE	209.90	.96	55.95	.08	.05	.04
MARCH-JUNE 85	11W	SNAIL-FISHEROLA, ADULT	145.33	.66	174.66	10.56	5.68	11.79
MARCH-JUNE 85	11W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	129.20	.59	60.95	.31	.17	.12
MARCH-JUNE 85	11W	MIDGES-CHIRONOMIDAE, ADULT	72.67	.33	24.25	.03	.02	.02
MARCH-JUNE 85	11W	CADDISFLY-HYDROPTILIDAE, PUPAE	56.50	.26	37.02	.03	.02	.02
MARCH-JUNE 85	11W	SNAIL-PARAPHOLYX, ADULT	48.43	.22	24.25	2.61	1.40	1.42
MARCH-JUNE 85	11W	SNAIL-FISHEROLA, PUPAE	32.30	.15	55.95	2.33	1.25	4.03
MARCH-JUNE 85	11W	MOTH-PYRALIDAE, LARVAE	32.30	.15	37.02	.07	.04	.10
MARCH-JUNE 85	11W	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	32.27	.15	13.97	.07	.04	.02
MARCH-JUNE 85	11W	SNAIL-PHYSA, ADULT	16.13	.07	27.94	1.13	.61	1.96
MARCH-JUNE 85	11W	CLAM-BIVALVIA, ADULT	8.07	.04	13.97	.00	.00	.01
MARCH-JUNE 85	11W	SNAIL-LYMNAEA, ADULT	8.07	.04	13.97	1.38	.74	2.40
MARCH-JUNE 85	11W	UNIDENTIFIED	.	.	.	1.01	.54	.33
MARCH-JUNE 85	11W	MAYFLY-GENERAL, NYMPH	.	.	.	.69	.37	.23
MARCH-JUNE 85	11W	ROUND-WORM, ADULT	.	.	.	.	.	.
MARCH-JUNE 85	11M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	2987.13	18.99	750.92	39.02	40.11	7.93
MARCH-JUNE 85	11M	MIDGES-CHIRONOMIDAE, PUPAE	2591.53	16.48	377.53	1.67	1.72	.77
MARCH-JUNE 85	11M	BLACKFLY-SIMULIDAE, PUPAE	1937.63	12.32	753.15	5.40	5.55	2.90
MARCH-JUNE 85	11M	BLACKFLY-SIMULIDAE, LARVAE	1719.63	10.93	541.06	4.44	4.57	1.80
MARCH-JUNE 85	11M	MIDGES-CHIRONOMIDAE, LARVAE	1437.03	9.14	386.24	.68	.70	.06
MARCH-JUNE 85	11M	MAYFLY-BAETIDAE, NYMPH	1211.00	7.70	563.34	1.01	1.04	.69
MARCH-JUNE 85	11M	MAYFLY-EPHEMERELLIDAE, NYMPH	1049.53	6.67	194.26	2.73	2.80	.66
MARCH-JUNE 85	11M	OLIGOCHAETE, ADULT	1025.30	6.52	839.81	.03	.03	.01
MARCH-JUNE 85	11M	SNAIL-FLUMINICOLA, ADULT	726.60	4.62	302.52	30.79	31.64	12.41
MARCH-JUNE 85	11M	CADDISFLY-LEPTOCERIDAE, LARVAE	298.73	1.90	218.40	2.82	2.90	2.09
MARCH-JUNE 85	11M	MIDGES-CHIRONOMIDAE, ADULT	169.57	1.08	125.86	.05	.06	.05
MARCH-JUNE 85	11M	CLAM-BIVALVIA, ADULT	113.03	.72	175.24	.02	.02	.03
MARCH-JUNE 85	11M	MITES-GENERAL, ADULT	113.03	.72	109.22	.04	.04	.04
MARCH-JUNE 85	11M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	80.73	.51	100.86	.18	.19	.25
MARCH-JUNE 85	11M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	72.67	.46	24.25	.92	.94	.21
MARCH-JUNE 85	11M	CADDISFLY-HYDROPTILIDAE, LARVAE	64.57	.41	73.99	.02	.02	.03
MARCH-JUNE 85	11M	CADDISFLY-HYDROPTILIDAE, PUPAE	48.43	.31	64.08	.02	.02	.02
MARCH-JUNE 85	11M	SNAIL-FISHEROLA, ADULT	40.33	.26	13.97	3.98	4.09	1.24
MARCH-JUNE 85	11M	BLACKFLY-SIMULIDAE, ADULT	24.20	.15	24.20	.04	.05	.05
MARCH-JUNE 85	11M	SNAIL-PARAPHOLYX, ADULT	8.07	.05	13.97	.69	.71	1.20
MARCH-JUNE 85	11M	SNAIL-LYMNAEA, ADULT	8.07	.05	13.97	1.49	1.53	2.58
MARCH-JUNE 85	11M	UNIDENTIFIED	0.0	0.0	.	.37	.39	.49
MARCH-JUNE 85	11M	FLY-GENERAL, LARVAE	0.0	0.0	0.0	.01	.01	.01
MARCH-JUNE 85	11M	MAYFLY-GENERAL, NYMPH	0.0	0.0	.	.76	.78	1.28
MARCH-JUNE 85	11M	MAYFLY-GENERAL	0.0	0.0	0.0	.12	.12	.21
MARCH-JUNE 85	11M	ROUND-WORM, ADULT	0.0	0.0	.	0.0	0.0	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY			BIOMASS		
			NO./M2	% STA	S.D.	G/M2	% STA	S.D.
MARCH-JUNE 85	11E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	2648.03	17.68	619.54	46.31	34.29	11.33
MARCH-JUNE 85	11E	BLACKFLY-SIMULIDAE, PUPAE	1921.43	12.83	2160.09	6.72	4.98	8.95
MARCH-JUNE 85	11E	MAYFLY-BAETIDAE, NYMPH	1897.23	12.67	798.29	1.63	1.20	.59
MARCH-JUNE 85	11E	BLACKFLY-SIMULIDAE, LARVAE	1816.50	12.13	1869.98	5.11	3.78	5.63
MARCH-JUNE 85	11E	MAYFLY-EPHEMERELLIDAE, NYMPH	1509.70	10.08	472.30	4.87	3.60	1.01
MARCH-JUNE 85	11E	MIDGES-CHIRONOMIDAE, PUPAE	1493.57	9.97	50.43	.94	.70	.07
MARCH-JUNE 85	11E	SNAIL-FLUMINICOLA, ADULT	1485.50	9.92	1162.11	44.26	32.77	33.29
MARCH-JUNE 85	11E	MIDGES-CHIRONOMIDAE, LARVAE	1106.07	7.39	247.39	.56	.41	.13
MARCH-JUNE 85	11E	OLIGOCHAETE, ADULT	314.87	2.10	174.66	.06	.05	.09
MARCH-JUNE 85	11E	SNAIL-FISHEROLA, ADULT	242.20	1.62	245.80	17.65	13.07	17.13
MARCH-JUNE 85	11E	CADDISFLY-HYDROPTILIDAE, LARVAE	137.27	.92	97.92	.05	.03	.03
MARCH-JUNE 85	11E	CADDISFLY-LEPTOCERIDAE, LARVAE	121.10	.81	105.58	.96	.71	.90
MARCH-JUNE 85	11E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	96.87	.65	105.60	2.13	1.58	2.45
MARCH-JUNE 85	11E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	80.73	.54	97.92	.13	.10	.14
MARCH-JUNE 85	11E	SNAIL-PARAPHOLYX, ADULT	32.30	.22	37.02	2.39	1.77	2.55
MARCH-JUNE 85	11E	CLAM-BIVALVIA, ADULT	16.13	.11	13.97	.01	.00	.01
MARCH-JUNE 85	11E	MITES-GENERAL, ADULT	16.13	.11	13.97	.01	.01	.01
MARCH-JUNE 85	11E	MOTH-PYRALIDAE, LARVAE	16.13	.11	13.97	.10	.08	.13
MARCH-JUNE 85	11E	CADDISFLY-HYDROPTILIDAE, PUPAE	16.13	.11	27.94	.01	.01	.01
MARCH-JUNE 85	11E	MIDGES-CHIRONOMIDAE, ADULT	8.07	.05	13.97	.00	.00	.01
MARCH-JUNE 85	11E	UNIDENTIFIED	.	.	.	.60	.44	.08
MARCH-JUNE 85	11E	MAYFLY-GENERAL	.	.	.	.55	.41	.06
MARCH-JUNE 85	11E	ROUND-WORM, ADULT	.	.	.	.	.	.
MARCH-JUNE 85	8	OLIGOCHAETE, ADULT	9583.07	33.17	7356.23	.71	.68	.41
MARCH-JUNE 85	8	CADDISFLY-HYDROPSYCHIDAE, LARVAE	4811.73	16.65	2435.34	54.15	51.76	26.88
MARCH-JUNE 85	8	MIDGES-CHIRONOMIDAE, LARVAE	2841.80	9.84	744.70	1.50	1.43	.72
MARCH-JUNE 85	8	MAYFLY-BAETIDAE, NYMPH	2631.90	9.11	1208.66	4.56	4.36	3.77
MARCH-JUNE 85	8	MIDGES-CHIRONOMIDAE, PUPAE	2510.80	8.69	799.40	1.75	1.67	1.25
MARCH-JUNE 85	8	MAYFLY-EPHEMERELLIDAE, NYMPH	1735.80	6.01	685.20	7.94	7.59	4.48
MARCH-JUNE 85	8	CADDISFLY-HYDROPTILIDAE, LARVAE	896.13	3.10	413.88	.47	.45	.23
MARCH-JUNE 85	8	CADDISFLY-HYDROPSYCHIDAE, PUPAE	621.67	2.15	370.74	7.61	7.27	4.32
MARCH-JUNE 85	8	MITES-GENERAL, ADULT	589.37	2.04	394.54	.29	.28	.21
MARCH-JUNE 85	8	CADDISFLY-LEPTOCERIDAE, LARVAE	500.53	1.73	316.14	4.29	4.10	2.21
MARCH-JUNE 85	8	BLACKFLY-SIMULIDAE, PUPAE	427.90	1.48	340.20	.99	.95	.87
MARCH-JUNE 85	8	CADDISFLY-PSYCHOMYIIDAE, LARVAE	387.53	1.34	413.88	.98	.94	1.20
MARCH-JUNE 85	8	CADDISFLY-HYDROPTILIDAE, PUPAE	266.40	.92	128.15	.13	.13	.08
MARCH-JUNE 85	8	BLACKFLY-SIMULIDAE, LARVAE	234.13	.81	206.02	.55	.53	.45
MARCH-JUNE 85	8	SNAIL-FLUMINICOLA, ADULT	201.80	.70	188.12	8.11	7.75	6.68
MARCH-JUNE 85	8	MIDGES-CHIRONOMIDAE, ADULT	185.70	.64	238.96	.11	.11	.18
MARCH-JUNE 85	8	CLAM-BIVALVIA, ADULT	129.17	.45	181.81	.03	.03	.04
MARCH-JUNE 85	8	SNAIL-PARAPHOLYX, ADULT	113.03	.39	97.90	6.18	5.91	4.99
MARCH-JUNE 85	8	CADDISFLY-PSYCHOMYIIDAE, ADULT	56.50	.20	97.86	.16	.16	.28
MARCH-JUNE 85	8	MOTH-PYRALIDAE, LARVAE	48.43	.17	48.45	.29	.27	.27
MARCH-JUNE 85	8	MITES-GENERAL, LARVAE	40.37	.14	37.01	.00	.00	.00
MARCH-JUNE 85	8	SNAIL-FISHEROLA, ADULT	32.27	.11	27.94	1.91	1.83	1.66
MARCH-JUNE 85	8	MAYFLY-HEPTAGENIIDAE, NYMPH	24.23	.08	41.97	.03	.03	.05
MARCH-JUNE 85	8	CADDISFLY-PSYCHOMYIIDAE, PUPAE	16.13	.06	27.94	.03	.03	.06
MARCH-JUNE 85	8	MAYFLY-TRICORYTHIDAE, NYMPH	8.07	.03	13.97	.00	.00	.01
MARCH-JUNE 85	8	UNIDENTIFIED	0.0	0.0	.	1.27	1.21	1.19
MARCH-JUNE 85	8	MAYFLY-GENERAL, NYMPH	0.0	0.0	.	.55	.52	.73
MARCH-JUNE 85	8	ROUND-WORM, ADULT	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
JUNE-SEPT 85	1	MIDGES-CHIRONOMIDAE, LARVAE	57805.07	44.06	10510.20	16.29	9.00	9.74
JUNE-SEPT 85	1	MIDGES-CHIRONOMIDAE, PUPAE	38967.27	29.70	10872.75	17.96	9.92	14.41
JUNE-SEPT 85	1	CADDISFLY-HYDROPSYCHIDAE, LARVAE	24812.03	18.91	10500.69	116.17	64.17	82.63
JUNE-SEPT 85	1	CADDISFLY-LEPTOCERIDAE, LARVAE	3810.63	2.90	504.75	2.50	1.38	.62
JUNE-SEPT 85	1	OLIGOCHAETE, ADULT	2260.53	1.72	1636.67	.04	.02	.04
JUNE-SEPT 85	1	CADDISFLY-HYDROPSYCHIDAE, PUPAE	1856.87	1.42	930.61	19.72	10.89	14.44
JUNE-SEPT 85	1	MAYFLY-BAETIDAE, NYMPH	766.93	.58	375.46	.40	.22	.26
JUNE-SEPT 85	1	SNAIL-PARAPHOLYX, ADULT	363.30	.28	231.05	2.59	1.43	1.25
JUNE-SEPT 85	1	CADDISFLY-HYDROPTILIDAE, LARVAE	104.93	.08	50.43	.02	.01	.01
JUNE-SEPT 85	1	CADDISFLY-PSYCHOMYIIDAE, LARVAE	64.57	.05	69.92	.01	.01	.00
JUNE-SEPT 85	1	SNAIL-FLUMINICOLA, ADULT	56.53	.04	28.00	.54	.30	.51
JUNE-SEPT 85	1	CADDISFLY-HYDROPTILIDAE, PUPAE	56.53	.04	50.43	.02	.01	.02
JUNE-SEPT 85	1	MOLLUSC, ADULT	48.43	.04	48.45	.04	.02	.04
JUNE-SEPT 85	1	MAYFLY-TRICORYTHIDAE, NYMPH	32.30	.02	37.02	.06	.03	.08
JUNE-SEPT 85	1	SNAIL-LYMNAEA, ADULT	32.27	.02	13.97	3.20	1.77	2.12
JUNE-SEPT 85	1	MITES-GENERAL, ADULT	32.27	.02	13.97	.00	.00	.00
JUNE-SEPT 85	1	MAYFLY-HEPTAGENIIDAE, NYMPH	32.27	.02	13.97	.01	.01	.01
JUNE-SEPT 85	1	CLAM-BIVALVIA, ADULT	16.13	.01	13.97	.01	.01	.01
JUNE-SEPT 85	1	SNAIL-PHYSA, ADULT	16.13	.01	27.94	1.21	.67	2.09
JUNE-SEPT 85	1	MITES-GENERAL, LARVAE	16.13	.01	27.94	.00	.00	.00
JUNE-SEPT 85	1	SNAIL-FISHEROLA, ADULT	8.07	.01	13.97	.03	.02	.05
JUNE-SEPT 85	1	BLACKFLY-SIMULIIDAE, LARVAE	8.07	.01	13.97	.02	.01	.03
JUNE-SEPT 85	1	CADDISFLY-GLOSSOSOMATIIDAE, PUPAE	8.07	.01	13.97	.05	.03	.09
JUNE-SEPT 85	1	CADDISFLY-GLOSSOSOMATIIDAE, LARVAE	8.07	.01	13.97	.00	.00	.00
JUNE-SEPT 85	1	MAYFLY-EPHEMERELLIDAE, NYMPH	8.07	.01	13.97	.00	.00	.00
JUNE-SEPT 85	1	MAYFLY-GENERAL, NYMPH	8.07	.01	13.97	.01	.00	.01
JUNE-SEPT 85	1	UNIDENTIFIED	0.0	0.0	.	.16	.09	.15
JUNE-SEPT 85	1	ROUND-WORM, ADULT	.	.	.	.	.	.
JUNE-SEPT 85	7W	MIDGES-CHIRONOMIDAE, LARVAE	49354.97	36.57	9054.16	20.17	7.03	4.27
JUNE-SEPT 85	7W	MIDGES-CHIRONOMIDAE, PUPAE	37675.57	27.92	5170.26	25.73	8.97	2.32
JUNE-SEPT 85	7W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	35092.07	26.01	652.54	156.97	54.71	34.29
JUNE-SEPT 85	7W	OLIGOCHAETE, ADULT	2736.87	2.03	663.75	.10	.03	.05
JUNE-SEPT 85	7W	MAYFLY-BAETIDAE, NYMPH	2720.70	2.02	298.93	2.54	.89	.41
JUNE-SEPT 85	7W	SNAIL-FLUMINICOLA, ADULT	2535.07	1.88	1339.42	51.39	17.91	31.71
JUNE-SEPT 85	7W	CADDISFLY-HYDROPSYCHIDAE, PUPAE	1219.07	.90	782.67	15.72	5.48	10.26
JUNE-SEPT 85	7W	CADDISFLY-LEPTOCERIDAE, LARVAE	1146.40	.85	352.96	.73	.26	.21
JUNE-SEPT 85	7W	SNAIL-PARAPHOLYX, ADULT	791.20	.59	311.40	3.32	1.16	1.36
JUNE-SEPT 85	7W	SNAIL-FISHEROLA, ADULT	629.70	.47	231.05	5.06	1.76	1.53
JUNE-SEPT 85	7W	CADDISFLY-HYDROPTILIDAE, LARVAE	217.97	.16	64.06	.08	.03	.03
JUNE-SEPT 85	7W	MAYFLY-TRICORYTHIDAE, NYMPH	153.40	.11	50.42	.16	.06	.03
JUNE-SEPT 85	7W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	137.23	.10	109.22	.08	.03	.08
JUNE-SEPT 85	7W	CADDISFLY-HYDROPTILIDAE, PUPAE	129.17	.10	13.97	.05	.02	.01
JUNE-SEPT 85	7W	MITES-GENERAL, ADULT	80.73	.06	37.01	.04	.01	.01
JUNE-SEPT 85	7W	CADDISFLY-GLOSSOSOMATIIDAE, LARVAE	56.53	.04	50.43	.07	.03	.07
JUNE-SEPT 85	7W	MOTH-PYRALIDAE, LARVAE	48.43	.04	48.45	.04	.01	.04
JUNE-SEPT 85	7W	CLAM-BIVALVIA, ADULT	40.37	.03	37.01	.05	.02	.05
JUNE-SEPT 85	7W	BLACKFLY-SIMULIIDAE, LARVAE	40.37	.03	50.43	.13	.04	.17
JUNE-SEPT 85	7W	FLAT-WORM, ADULT	32.30	.02	37.02	.01	.00	.01
JUNE-SEPT 85	7W	MOLLUSC, ADULT	24.20	.02	24.20	.24	.08	.34
JUNE-SEPT 85	7W	CADDISFLY-PSYCHOMYIIDAE, PUPAE	24.20	.02	24.20	.04	.01	.04
JUNE-SEPT 85	7W	BLACKFLY-SIMULIIDAE, PUPAE	16.13	.01	13.97	.03	.01	.03
JUNE-SEPT 85	7W	SNAIL-PHYSA, ADULT	8.07	.01	13.97	.21	.07	.36
JUNE-SEPT 85	7W	SNAIL-LYMNAEA, ADULT	8.07	.01	13.97	.98	.34	1.71
JUNE-SEPT 85	7W	MIDGES-CHIRONOMIDAE, ADULT	8.07	.01	13.97	.00	.00	.01
JUNE-SEPT 85	7W	CADDISFLY-HYDROPSYCHIDAE, ADULT	8.07	.01	13.97	.17	.06	.30
JUNE-SEPT 85	7W	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.01	13.97	.01	.00	.01
JUNE-SEPT 85	7W	UNIDENTIFIED	.	.	.	2.49	.87	.43
JUNE-SEPT 85	7W	MAYFLY-GENERAL, NYMPH	.	.	.	.29	.10	.04
JUNE-SEPT 85	7W	ROUND-WORM, ADULT	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
JUNE-SEPT 85	7M	MIDGES-CHIRONOMIDAE, LARVAE	66524.27	41.53	24671.68	20.28	6.77	17.21
JUNE-SEPT 85	7M	MIDGES-CHIRONOMIDAE, PUPAE	43972.73	27.45	14407.97	22.49	7.51	17.88
JUNE-SEPT 85	7M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	37406.43	23.35	19154.27	182.03	60.78	150.64
JUNE-SEPT 85	7M	OLIGOCHAETE, ADULT	4077.03	2.55	4210.14	.16	.05	.24
JUNE-SEPT 85	7M	MAYFLY-BAETIDAE, NYMPH	1873.00	1.17	1511.65	1.11	.37	1.08
JUNE-SEPT 85	7M	SNAIL-FLUMINICOLA, ADULT	1663.10	1.04	559.89	46.35	15.48	2.50
JUNE-SEPT 85	7M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	1501.63	.94	547.51	16.99	5.67	10.60
JUNE-SEPT 85	7M	CADDISFLY-LEPTOCERIDAE, LARVAE	1340.17	.84	786.39	.59	.20	.39
JUNE-SEPT 85	7M	SNAIL-PARAPHOLYX, ADULT	516.67	.32	552.48	2.03	.68	1.70
JUNE-SEPT 85	7M	CADDISFLY-HYDROPTILIDAE, LARVAE	274.50	.17	266.80	.09	.03	.10
JUNE-SEPT 85	7M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	234.10	.15	181.79	.11	.04	.09
JUNE-SEPT 85	7M	SNAIL-FISHEROLA, ADULT	137.23	.09	145.97	1.15	.38	1.04
JUNE-SEPT 85	7M	MOLLUSC, ADULT	113.03	.07	137.70	.67	.22	.78
JUNE-SEPT 85	7M	MAYFLY-TRICORYTHIDAE, NYMPH	104.97	.07	36.97	.07	.02	.04
JUNE-SEPT 85	7M	CADDISFLY-HYDROPTILIDAE, PUPAE	96.87	.06	48.45	.03	.01	.02
JUNE-SEPT 85	7M	MITES-GENERAL, ADULT	56.50	.04	60.95	.03	.01	.04
JUNE-SEPT 85	7M	CADDISFLY-PSYCHOMYIIDAE, PUPAE	56.50	.04	77.85	.05	.02	.07
JUNE-SEPT 85	7M	FLAT-WORM, ADULT	48.43	.03	64.08	.03	.01	.05
JUNE-SEPT 85	7M	BLACKFLY-SIMULIDAE, LARVAE	40.37	.03	50.43	.05	.02	.04
JUNE-SEPT 85	7M	MOTH-PYRALIDAE, LARVAE	40.37	.03	37.01	.08	.03	.07
JUNE-SEPT 85	7M	SNAIL-LYMNAEA, ADULT	32.30	.02	37.02	2.32	.77	2.16
JUNE-SEPT 85	7M	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	24.23	.02	41.97	.00	.00	.01
JUNE-SEPT 85	7M	CLAM-BIVALVIA, ADULT	16.13	.01	13.97	.01	.00	.01
JUNE-SEPT 85	7M	SNAIL-PHYSA, ADULT	16.13	.01	27.94	.84	.28	1.46
JUNE-SEPT 85	7M	CADDISFLY-HYDROPSYCHIDAE, ADULT	8.07	.01	13.97	.06	.02	.11
JUNE-SEPT 85	7M	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.01	13.97	.00	.00	.00
JUNE-SEPT 85	7M	MAYFLY-GENERAL, NYMPH	0.0	0.0	.	.08	.03	.07
JUNE-SEPT 85	7M	UNIDENTIFIED	.	.	.	1.80	.60	1.15
JUNE-SEPT 85	7M	ROUND-WORM, ADULT	.	.	.	.	.	.
JUNE-SEPT 85	7E	MIDGES-CHIRONOMIDAE, LARVAE	37137.33	37.99	11809.16	11.58	5.90	7.55
JUNE-SEPT 85	7E	MIDGES-CHIRONOMIDAE, PUPAE	26534.33	27.14	15840.49	12.66	6.44	8.07
JUNE-SEPT 85	7E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	21475.07	21.97	6026.43	90.31	45.97	17.78
JUNE-SEPT 85	7E	SNAIL-FLUMINICOLA, ADULT	3019.43	3.09	770.58	44.41	22.61	23.30
JUNE-SEPT 85	7E	OLIGOCHAETE, ADULT	1840.70	1.88	1131.12	.31	.16	.34
JUNE-SEPT 85	7E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	1582.37	1.62	932.53	16.21	8.25	8.07
JUNE-SEPT 85	7E	MAYFLY-BAETIDAE, NYMPH	1582.37	1.62	1072.36	1.02	.52	.74
JUNE-SEPT 85	7E	CADDISFLY-LEPTOCERIDAE, LARVAE	1558.13	1.59	567.67	.99	.51	.36
JUNE-SEPT 85	7E	SNAIL-FISHEROLA, ADULT	1380.53	1.41	411.75	8.04	4.09	2.33
JUNE-SEPT 85	7E	SNAIL-PARAPHOLYX, ADULT	993.03	1.02	596.67	4.14	2.11	2.03
JUNE-SEPT 85	7E	CADDISFLY-HYDROPTILIDAE, PUPAE	88.80	.09	50.42	.03	.02	.02
JUNE-SEPT 85	7E	CADDISFLY-HYDROPTILIDAE, LARVAE	80.73	.08	73.99	.03	.01	.03
JUNE-SEPT 85	7E	MAYFLY-TRICORYTHIDAE, NYMPH	64.60	.07	55.95	.02	.01	.03
JUNE-SEPT 85	7E	FLAT-WORM, ADULT	64.60	.07	111.89	.10	.05	.18
JUNE-SEPT 85	7E	SNAIL-PHYSA, ADULT	56.53	.06	28.00	1.30	.66	.96
JUNE-SEPT 85	7E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	56.53	.06	50.43	.01	.00	.01
JUNE-SEPT 85	7E	CLAM-BIVALVIA, ADULT	56.50	.06	77.85	2.19	1.11	3.77
JUNE-SEPT 85	7E	MITES-GENERAL, ADULT	56.50	.06	55.95	.02	.01	.02
JUNE-SEPT 85	7E	SNAIL-LYMNAEA, ADULT	40.37	.04	37.01	2.49	1.27	2.20
JUNE-SEPT 85	7E	CADDISFLY-PSYCHOMYIIDAE, PUPAE	24.20	.02	24.20	.02	.01	.02
JUNE-SEPT 85	7E	MOLLUSC, ADULT	16.13	.02	27.94	.05	.03	.09
JUNE-SEPT 85	7E	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	16.13	.02	27.94	.00	.00	.00
JUNE-SEPT 85	7E	SCUDS/SHRIMPS, ADULT	16.13	.02	27.94	.02	.01	.03
JUNE-SEPT 85	7E	BLACKFLY-SIMULIDAE, LARVAE	8.07	.01	13.97	.03	.01	.04
JUNE-SEPT 85	7E	CADDISFLY-GLOSSOSOMATIDAE, PUPAE	8.07	.01	13.97	.03	.02	.06
JUNE-SEPT 85	7E	MAYFLY-HEPTAGENIIDAE, NYMPH	8.07	.01	13.97	.00	.00	.00
JUNE-SEPT 85	7E	UNIDENTIFIED	0.0	0.0	0.0	.32	.16	.55
JUNE-SEPT 85	7E	MAYFLY-GENERAL, NYMPH	.	.	.	.11	.06	.03
JUNE-SEPT 85	7E	ROUND-WORM, ADULT	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	% STA	S.D.	BIOMASS G/M2	% STA	S.D.
JUNE-SEPT 85	11W	MIDGES-CHIRONOMIDAE, LARVAE	46825.33	34.48	12694.40	17.77	5.74	4.41
JUNE-SEPT 85	11W	CADDISFLY-HYDROPSYCHIDAE, LARVAE	42304.23	31.15	5313.70	172.63	55.73	58.98
JUNE-SEPT 85	11W	MIDGES-CHIRONOMIDAE, PUPAE	32939.20	24.26	3496.82	23.29	7.52	5.38
JUNE-SEPT 85	11W	OLIGOCHAETE, ADULT	2946.80	2.17	1447.21	.10	.03	.07
JUNE-SEPT 85	11W	SNAIL-FLUMINICOLA, ADULT	2631.90	1.94	779.72	66.37	21.43	25.68
JUNE-SEPT 85	11W	CADDISFLY-LEPTOCERIDAE, LARVAE	2195.93	1.62	513.99	1.52	.49	.56
JUNE-SEPT 85	11W	MAYFLY-BAETIDAE, NYMPH	2026.40	1.49	712.08	1.54	.50	.48
JUNE-SEPT 85	11W	CADDISFLY-HYDROPSYCHIDAE, PUPAE	1364.40	1.00	137.72	15.34	4.95	1.74
JUNE-SEPT 85	11W	SNAIL-PARAPHOLYX, ADULT	500.53	.37	218.45	2.16	.70	.26
JUNE-SEPT 85	11W	CADDISFLY-PSYCHOMYIIDAE, LARVAE	355.20	.26	77.85	.25	.08	.10
JUNE-SEPT 85	11W	CADDISFLY-HYDROPTILIDAE, LARVAE	314.83	.23	125.86	.10	.03	.03
JUNE-SEPT 85	11W	MAYFLY-TRICORYTHIDAE, NYMPH	290.63	.21	134.85	.45	.15	.20
JUNE-SEPT 85	11W	SNAIL-FISHEROLA, ADULT	274.50	.20	85.04	1.79	.58	.22
JUNE-SEPT 85	11W	MITES-GENERAL, ADULT	274.50	.20	183.39	.15	.05	.10
JUNE-SEPT 85	11W	CADDISFLY-HYDROPTILIDAE, PUPAE	242.20	.18	48.40	.10	.03	.03
JUNE-SEPT 85	11W	MOTH-PYRALIDAE, LARVAE	64.60	.05	55.95	.18	.06	.16
JUNE-SEPT 85	11W	MOLLUSC, ADULT	48.47	.04	41.97	.11	.04	.10
JUNE-SEPT 85	11W	CLAM-BIVALVIA, ADULT	40.37	.03	28.00	.57	.19	.94
JUNE-SEPT 85	11W	BLACKFLY-SIMULIDAE, LARVAE	32.30	.02	37.02	.04	.01	.06
JUNE-SEPT 85	11W	CADDISFLY-PSYCHOMYIIDAE, PUPAE	32.27	.02	13.97	.05	.02	.01
JUNE-SEPT 85	11W	SNAIL-PHYSA, ADULT	16.13	.01	13.97	.78	.25	.67
JUNE-SEPT 85	11W	SNAIL-LYMNAEA, ADULT	16.13	.01	13.97	.39	.13	.44
JUNE-SEPT 85	11W	MAYFLY-HEPTAGENIIDAE, NYMPH	16.13	.01	13.97	.01	.00	.01
JUNE-SEPT 85	11W	MIDGES-CHIRONOMIDAE, ADULT	8.07	.01	13.97	.00	.00	.00
JUNE-SEPT 85	11W	BLACKFLY-SIMULIDAE, PUPAE	8.07	.01	13.97	.02	.01	.04
JUNE-SEPT 85	11W	CADDISFLY-HYDROPSYCHIDAE, ADULT	8.07	.01	13.97	.09	.03	.15
JUNE-SEPT 85	11W	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	8.07	.01	13.97	.01	.00	.01
JUNE-SEPT 85	11W	MAYFLY-EPHEMERELLIDAE, NYMPH	8.07	.01	13.97	.03	.01	.05
JUNE-SEPT 85	11W	CADDISFLY-GENERAL, PUPAE	0.0	0.0	.	.54	.18	.48
JUNE-SEPT 85	11W	UNIDENTIFIED	.	.	.	3.16	1.02	.68
JUNE-SEPT 85	11W	MAYFLY-GENERAL, NYMPH	.	.	.	.22	.07	.07
JUNE-SEPT 85	11W	ROUND-WORM, ADULT	.	.	.	.	.	.
JUNE-SEPT 85	11M	MIDGES-CHIRONOMIDAE, LARVAE	77396.37	40.15	19314.94	30.85	9.58	16.00
JUNE-SEPT 85	11M	MIDGES-CHIRONOMIDAE, PUPAE	56513.33	29.32	6000.43	62.44	19.39	33.92
JUNE-SEPT 85	11M	CADDISFLY-HYDROPSYCHIDAE, LARVAE	36706.73	19.04	5365.76	177.89	55.25	50.51
JUNE-SEPT 85	11M	MAYFLY-GENERAL, NYMPH	11988.90	4.15	16954.86	.07	.02	.06
JUNE-SEPT 85	11M	OLIGOCHAETE, ADULT	7516.27	3.90	6012.08	.29	.09	.28
JUNE-SEPT 85	11M	MAYFLY-BAETIDAE, NYMPH	2034.50	1.06	460.16	1.27	.40	.49
JUNE-SEPT 85	11M	CADDISFLY-HYDROPSYCHIDAE, PUPAE	1162.57	.60	169.55	12.86	3.99	3.14
JUNE-SEPT 85	11M	SNAIL-FLUMINICOLA, ADULT	1098.00	.57	306.68	29.45	9.15	12.80
JUNE-SEPT 85	11M	CADDISFLY-LEPTOCERIDAE, LARVAE	589.37	.31	623.33	.43	.13	.54
JUNE-SEPT 85	11M	MAYFLY-TRICORYTHIDAE, NYMPH	331.00	.17	133.40	.35	.11	.25
JUNE-SEPT 85	11M	CADDISFLY-HYDROPTILIDAE, LARVAE	217.97	.11	87.31	.05	.02	.01
JUNE-SEPT 85	11M	CADDISFLY-PSYCHOMYIIDAE, LARVAE	209.90	.11	114.46	.15	.05	.08
JUNE-SEPT 85	11M	SNAIL-PARAPHOLYX, ADULT	185.70	.10	137.72	.45	.14	.35
JUNE-SEPT 85	11M	SNAIL-FISHEROLA, ADULT	145.30	.08	134.84	1.24	.39	1.08
JUNE-SEPT 85	11M	FLAT-WORM, ADULT	145.30	.08	128.15	.10	.03	.08
JUNE-SEPT 85	11M	MITES-GENERAL, ADULT	129.20	.07	55.95	.06	.02	.04
JUNE-SEPT 85	11M	CADDISFLY-HYDROPTILIDAE, PUPAE	121.10	.06	87.35	.06	.02	.05
JUNE-SEPT 85	11M	MOTH-PYRALIDAE, LARVAE	64.57	.03	28.00	.05	.01	.04
JUNE-SEPT 85	11M	MIDGES-CHIRONOMIDAE, ADULT	40.37	.02	37.01	.01	.00	.01
JUNE-SEPT 85	11M	BLACKFLY-SIMULIDAE, PUPAE	40.33	.02	13.97	.10	.03	.06
JUNE-SEPT 85	11M	CLAM-BIVALVIA, ADULT	24.23	.01	41.97	.01	.00	.01
JUNE-SEPT 85	11M	BLACKFLY-SIMULIDAE, LARVAE	24.20	.01	0.0	.07	.02	.02
JUNE-SEPT 85	11M	CADDISFLY-GLOSSOSOMATIDAE, LARVAE	24.20	.01	24.20	.00	.00	.00
JUNE-SEPT 85	11M	CADDISFLY-PSYCHOMYIIDAE, PUPAE	16.13	.01	13.97	.01	.00	.01
JUNE-SEPT 85	11M	SNAIL-PHYSA, ADULT	8.07	.00	13.97	.36	.11	.63
JUNE-SEPT 85	11M	SNAIL-LYMNAEA, ADULT	8.07	.00	13.97	.09	.03	.15
JUNE-SEPT 85	11M	MOLLUSC, ADULT	8.07	.00	13.97	.00	.00	.00
JUNE-SEPT 85	11M	BLACKFLY-SIMULIDAE, ADULT	8.07	.00	13.97	.01	.00	.01
JUNE-SEPT 85	11M	UNIDENTIFIED	.	.	.	3.26	1.01	.80
JUNE-SEPT 85	11M	ROUND-WORM, ADULT	.	.	.	.	.	.

TABLE A-1 (CONTINUED)

MACROBENTHOS DATA SUMMARY

DATE	STA	TAXONOMIC GROUP AND LIFE STAGE	DENSITY NO./M2	DENSITY % STA	DENSITY S.D.	BIOMASS G/M2	BIOMASS % STA	BIOMASS S.D.
JUNE-SEPT 85	11E	MIDGES-CHIRONOMIDAE, LARVAE	51669.33	43.16	11131.84	13.65	6.67	3.64
JUNE-SEPT 85	11E	MIDGES-CHIRONOMIDAE, PUPAE	38429.07	32.10	4926.71	16.07	7.84	5.48
JUNE-SEPT 85	11E	CADDISFLY-HYDROPSYCHIDAE, LARVAE	22443.87	18.75	5868.57	97.48	47.59	27.65
JUNE-SEPT 85	11E	MAYFLY-BAETIDAE, NYMPH	1655.03	1.38	434.18	.97	.47	.13
JUNE-SEPT 85	11E	SNAIL-FLUMINICOLA, ADULT	1283.67	1.07	872.96	27.14	13.25	22.87
JUNE-SEPT 85	11E	OLIGOCHAETE, ADULT	1194.87	1.00	1179.19	.01	.00	.01
JUNE-SEPT 85	11E	CADDISFLY-HYDROPSYCHIDAE, PUPAE	718.57	.60	304.76	8.07	3.94	3.92
JUNE-SEPT 85	11E	CADDISFLY-LEPTOCERIDAE, LARVAE	653.93	.55	356.79	.32	.16	.10
JUNE-SEPT 85	11E	SNAIL-FISHEROLA, ADULT	645.87	.54	155.73	4.95	2.42	2.10
JUNE-SEPT 85	11E	SNAIL-PARAPHOLYX, ADULT	266.40	.22	158.79	1.10	.54	.76
JUNE-SEPT 85	11E	CADDISFLY-HYDROPTILIDAE, LARVAE	234.13	.20	91.71	.08	.04	.03
JUNE-SEPT 85	11E	MAYFLY-TRICORYTHIDAE, NYMPH	121.10	.10	105.58	.12	.06	.03
JUNE-SEPT 85	11E	CADDISFLY-PSYCHOMYIIDAE, LARVAE	113.03	.09	36.97	.07	.03	.04
JUNE-SEPT 85	11E	CADDISFLY-HYDROPTILIDAE, PUPAE	88.83	.07	13.97	.03	.02	.01
JUNE-SEPT 85	11E	MITES-GENERAL, ADULT	48.43	.04	48.45	.02	.01	.02
JUNE-SEPT 85	11E	CLAM-BIVALVIA, ADULT	32.30	.03	55.95	.02	.01	.04
JUNE-SEPT 85	11E	MIDGES-CHIRONOMIDAE, ADULT	32.30	.03	37.02	.00	.00	.00
JUNE-SEPT 85	11E	MOTH-PYRALIDAE, LARVAE	24.20	.02	24.20	.03	.01	.05
JUNE-SEPT 85	11E	CADDISFLY-PSYCHOMYIIDAE, PUPAE	24.20	.02	24.20	.03	.01	.03
JUNE-SEPT 85	11E	SNAIL-PHYSA, ADULT	8.07	.01	13.97	.49	.24	.85
JUNE-SEPT 85	11E	SNAIL-LYMNAEA, ADULT	8.07	.01	13.97	32.70	15.96	56.63
JUNE-SEPT 85	11E	BLACKFLY-SIMULIDAE, LARVAE	8.07	.01	13.97	.03	.02	.06
JUNE-SEPT 85	11E	MAYFLY-EPHEMERELLIDAE, NYMPH	8.07	.01	13.97	.00	.00	.01
JUNE-SEPT 85	11E	MAYFLY-GENERAL, NYMPH	8.07	.01	13.97	.01	.00	.01
JUNE-SEPT 85	11E	UNIDENTIFIED	.	.	.	1.43	.70	.14
JUNE-SEPT 85	11E	ROUND-WORM, ADULT	.	.	.	.	.	.
JUNE-SEPT 85	8	MIDGES-CHIRONOMIDAE, LARVAE	16738.73	33.01	6507.93	2.78	4.09	.90
JUNE-SEPT 85	8	CADDISFLY-HYDROPSYCHIDAE, LARVAE	14693.47	28.97	1255.96	36.31	53.40	6.22
JUNE-SEPT 85	8	MIDGES-CHIRONOMIDAE, PUPAE	11625.60	22.93	913.44	3.16	4.65	.43
JUNE-SEPT 85	8	SNAIL-PARAPHOLYX, ADULT	1977.97	3.90	462.38	11.63	17.11	4.56
JUNE-SEPT 85	8	CADDISFLY-LEPTOCERIDAE, LARVAE	1178.70	2.32	68.52	.54	.79	.03
JUNE-SEPT 85	8	CADDISFLY-HYDROPTILIDAE, LARVAE	879.97	1.74	85.63	.25	.37	.05
JUNE-SEPT 85	8	CADDISFLY-PSYCHOMYIIDAE, LARVAE	831.57	1.64	51.41	.74	1.09	.20
JUNE-SEPT 85	8	CADDISFLY-HYDROPSYCHIDAE, PUPAE	605.50	1.19	119.85	4.09	6.02	.59
JUNE-SEPT 85	8	CADDISFLY-HYDROPTILIDAE, PUPAE	460.20	.91	154.15	.17	.26	.03
JUNE-SEPT 85	8	MITES-GENERAL, ADULT	419.80	.83	342.52	.17	.25	.14
JUNE-SEPT 85	8	OLIGOCHAETE, ADULT	387.50	.76	274.00	.01	.02	.02
JUNE-SEPT 85	8	MAYFLY-TRICORYTHIDAE, NYMPH	177.60	.35	34.22	.19	.28	.05
JUNE-SEPT 85	8	SNAIL-FLUMINICOLA, ADULT	153.40	.30	119.93	1.47	2.16	.81
JUNE-SEPT 85	8	MAYFLY-HEPTAGENIIDAE, NYMPH	145.30	.29	68.52	.06	.09	.04
JUNE-SEPT 85	8	MOTH-PYRALIDAE, LARVAE	137.23	.27	85.63	.18	.26	.24
JUNE-SEPT 85	8	SNAIL-FISHEROLA, ADULT	96.87	.19	137.04	.54	.79	.87
JUNE-SEPT 85	8	CADDISFLY-PSYCHOMYIIDAE, PUPAE	64.60	.13	34.22	.09	.13	.07
JUNE-SEPT 85	8	SNAIL-LYMNAEA, ADULT	48.43	.10	102.74	2.88	4.23	6.10
JUNE-SEPT 85	8	MAYFLY-BAETIDAE, NYMPH	40.37	.08	85.63	.02	.03	.04
JUNE-SEPT 85	8	SNAIL-PHYSA, ADULT	16.13	.03	0.0	.23	.34	.34
JUNE-SEPT 85	8	MIDGES-CHIRONOMIDAE, ADULT	16.13	.03	34.22	.00	.00	.00
JUNE-SEPT 85	8	CLAM-BIVALVIA, ADULT	8.07	.02	17.11	.00	.00	.01
JUNE-SEPT 85	8	MITES-GENERAL, LARVAE	8.07	.02	17.11	.00	.00	.01
JUNE-SEPT 85	8	UNIDENTIFIED	.	.	.	2.46	3.61	.24
JUNE-SEPT 85	8	ROUND-WORM, ADULT	.	.	.	.	.	.

APPENDIX B

1985 SHRUB DENSITY

Site	Species*	1	2	3	4	Total	S/Ha	S/a
S01	ARTR	0	0	0	0	0	0	0
	CHNA	0	0	0	0	0	0	0
	CHVI	0	0	0	0	0	0	0
	PUTR	0	0	0	0	0	0	0
	ERNI	22	6	3	7	38	380	154
						38	380	154
S02	ARTR	0	0	0	0	0	0	0
	CHNA	0	0	0	0	0	0	0
	CHVI	0	0	0	0	0	0	0
	PUTR	0	0	1	10	11	110	45
						11	110	45
S03	ARTR	5	8	10	18	41	410	166
	CHNA	5	2	3	1	11	110	45
	CHVI	0	0	0	0	0	0	0
	PUTR	0	0	1	0	0	0	0
						52	520	211
	ERNI	0	0	0	5	5	50	20
	OPPO	0	0	0	2	2	20	8
						59	590	239
S04	ARTR	0	0	0	0	0	0	0
	CHNA	0	0	0	0	0	0	0
	CHVI	0	0	0	0	0	0	0
	PUTR	0	0	0	0	0	0	0
						0	0	0
S05	ARTR	0	0	0	0	0	0	0
	CHNA	0	0	1	1	2	20	8
	CHVI	0	0	0	1	1	10	4
	PUTR	1	3	4	0	8	80	32
						11	110	44
	ERNI	90	20	3	0	113	1130	457
	OPPO	16	10	25	4	55	550	223
						179	1790	725

*ARTR = *Artemisia tridentata*
CHNA = *Chrysothamnus nauseosus*
CHVI = *Chrysothamnus viscidiflorus*
ERNI = *Eriogonum niveum*
OPPO = *Opuntia polyacantha*
PUTR = *Purshia tridentata*

1985 SHRUB COVER DATA (%)

Site	Transect	ARTR*	PUTR*	CHNA*	CHVI*
S01	1	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00
	5	0.00	0.00	0.00	0.00
	$\bar{X}$	0.00	0.00	0.00	0.00
	SD	0.00	0.00	0.00	0.00
S02	1	0.00	2.30	0.00	0.00
	2	9.52	1.50	0.00	0.00
	3	15.80	0.00	0.00	0.00
	4	0.16	0.00	0.00	0.00
	5	4.26	1.64	0.00	0.00
	$\bar{X}$	5.95	1.09	0.00	0.00
	SD	6.74	1.04	0.00	0.00
S03	1	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00
	5	0.00	0.00	0.00	0.00
	$\bar{X}$	0.00	0.00	0.00	0.00
	SD	0.00	0.00	0.00	0.00
S04	1	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00
	5	0.00	0.00	0.00	0.00
	$\bar{X}$	0.00	0.00	0.00	0.00
	SD	0.00	0.00	0.00	0.00
S05	1	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.66
	5	0.00	0.00	0.00	0.78
	$\bar{X}$	0.00	0.00	0.00	0.29
	SD	0.00	0.00	0.00	0.40

1985 PHYTOMASS SAMPLE WEIGHTS

Site	Plot	Dry Weight (g)	Site	Plot	Dry Weight (g)
G01	07-06	8.91	S01	44-01	1.02
	07-05	19.34		46-06	0.03
	09-01	3.40		19-02	0.65
	41-10	1.31		22-01	0.27
	28-00	2.07		25-01	0.62
	$\bar{X}$	7.01		$\bar{X}$	0.52
G02	07-06	3.07	S02	44-01	0.09
	07-05	5.25		46-06	0.27
	09-01	1.30		19-02	0.10
	41-10	2.40		22-01	0.22
	28-00	1.41		25-01	0.00
	$\bar{X}$	2.69		$\bar{X}$	0.14
G03	07-06	0.43	S03	44-01	1.65
	07-05	0.42		46-06	4.33
	09-01	2.05		19-02	3.72
	41-10	0.48		22-01	1.95
	28-00	2.44		25-01	1.89
	$\bar{X}$	1.16		$\bar{X}$	2.71
G04	07-06	2.22	S04	44-01	1.22
	07-05	3.21		46-06	0.48
	09-01	8.72		19-02	2.87
	41-10	2.00		22-01	0.83
	28-00	2.37		25-01	0.00
	$\bar{X}$	3.70		$\bar{X}$	1.08
			S05	44-01	5.72
				46-06	9.34
				19-02	7.09
				22-01	4.85
				25-01	3.70
				$\bar{X}$	6.14

SOIL FLUORIDE PROTOCOL

REAGENTS:

1. Na_2CO_3: KNO_3 FLUX (1:1) - Sift together equal weights of Na_2CO_3 and KNO_3 and store in a dry place.
2. Citric Acid 10% (W/V) - Dissolve 100 g Citric Acid in one liter distilled water.
3. T.I.S.A.B. Buffer - Add 57 mls concentrated Acetic Acid, 50g NaCl, 12g sodium citrate dihydrate to 500 mls water. Adjust pH to 5.2 with 6 N NaOH and bring to 100 mls.

PROCEDURE:

NOTE: Samples are dried for 24 hours at 105°C and ground to a fine powder on a Wiley mill.

1. Weigh a 1.00g sample and transfer to a 130 ml nickel crucible.
2. Add 4 grams of the Na_2CO_3: KNO_3 flux and place in muffle furnace at 700°C for 30 minutes.
3. After cooling, add 10 mls of citric acid to the crucible and heat gently until melt dissolves.
4. Bring solution to 100 mls in a volumetric flask and allow to settle.

NOTE: Standards are prepared by adding aqueous NaF to the crucibles and carrying these through the fusion process. A blank must also be carried through each run.

5. Pipette 25.0 mls of standards and samples into 50 ml plastic beakers and adjust pH to 5.5 with 10% citric acid.

6. Add 25.0 mls of TISAB buffer.

7. Using the prepared standards set, the fluoride meter to read in direct concentration and measure samples against these.

Recovery of fluoride in spiked samples as well as NBS River Sediment was 95 - 100%.

Parameters and methods for soil and vegetation sample analyses.

PARAMETER	METHOD	REFERENCE
Soils		
pH	Glass Electrode (1:2 soil to water ratio)	(1) Methods for Soil Analysis, p. 922
Bicarbonate/ Carbonate	Water leach (1:5 soil to water ratio), Acid titration	(1) Methods for Soil Analysis, p. 945
Conductivity	Conductivity cell (1:2 soil to water ratio)	(1) Methods for Soil Analysis, p. 936
Sulfate (soluble)	Water leach (1:5 soil to water ratio), Turbidimetric detection	(1) Methods for Soil Analysis, p. 935 (2) EPA, 375.4
Chloride	Water leach (1:5 soil to water ratio), Mercuric nitrate titration for detection	(1) Methods for Soil Analysis, p. 935 (2) EPA, 325.3
Fluoride (Total)	Fusion, Specific Ion Electrode detection	(2) EPA, 340.2
Mercury	Acid Digestion, Cold Vapor AA detection	(2) EPA, 245.5
Copper, Lead, Cadmium, Chromium, Nickel, Zinc, Sodium, Potassium, Calcium, Magnesium	$HNO_3/HClO_4/HF$ Digestion, AA detection	(2) EPA, 213.1, 220.1, 218.1, 215.1, 239.1, 249.1, 289.1, 273.1, 258.
Vegetation		
Sulfate (Extractable)	Water leach (1:50 vegetation to water ratio), Turbidimetric detection	(2) EPA, 375.4
Chloride (Extractable)	Water leach (1:50 vegetation to water ratio), Mercuric nitrate detection	(2) EPA, 325.3
Copper (Total)	$HNO_3/HClO_4$ digestion, Flame AA detection	(2) EPA, 220.1

STATION : s01
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	98	64.30	3.993
depi	0	0.00	0.000
houm	48	4.65	1.420
loma	4	0.35	0.303
misrh	24	0.60	0.153
phlo	0	0.00	0.000
posa3	84	28.30	3.772
sial	50	2.00	0.500

STATION : s02
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	77.85	2.615
depi	0	0.00	0.000
houm	20	1.25	0.511
misrh	74	3.60	0.674
phlo	0	0.00	0.000
posa3	100	64.05	3.423
sial	0	0.00	0.000

STATION : s03
SAMPLING DATE : 050980

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	73.75	3.197
depi	4	0.10	0.070
houm	96	15.40	2.380
misrh	82	12.65	2.398
phlo	0	0.00	0.000
posa3	4	0.10	0.070
sial	14	0.60	0.316

STATION : s04
SAMPLING DATE : 050680

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.10	0.070
brte	100	12.25	1.731
chvi	2	0.05	0.050
crci	2	0.05	0.050
depi	4	0.10	0.070
houm	18	0.70	0.320
orhy	4	2.00	1.950
phli	2	0.05	0.050
phlo	24	4.45	1.402
plpa	20	1.45	0.802
posa3	88	22.95	2.563
sial	74	2.35	0.400
stco2	16	1.60	0.847

STATION : s01
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	4	0.35	0.303
artr	2	0.05	0.050
brte	100	50.40	4.232
coum	2	0.05	0.050
depi	62	3.70	1.100
eras	4	0.10	0.070
houm	20	1.50	0.580
lasl	2	0.05	0.050
misrh	40	1.75	0.506
oepap	16	0.65	0.318
phlo	6	1.35	0.849
posa3	10	1.00	0.510
sial	0	0.00	0.000

STATION : s02
SAMPLING DATE : 050980

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	8	1.20	0.581
assp	4	1.50	1.050
amly	10	0.25	0.107
brte	92	51.75	4.511
crpt	10	0.25	0.107
cytet	8	0.95	0.510
depi	38	1.95	0.573
sisi	4	0.35	0.303
houm	18	2.15	1.303
lasl	12	0.80	0.425
misrh	18	1.45	0.581
orhy	2	0.05	0.050
phli	40	3.45	1.002
phlo	0	0.00	0.000
posa3	24	5.60	2.311
sial	6	0.15	0.085

STATION : s03
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	16	0.65	0.318
baca	6	0.85	0.751
brte	100	24.25	3.538
crat	4	0.10	0.070
depi	2	0.05	0.050
houm	68	5.15	1.393
lasl	8	0.20	0.097
lara	2	0.05	0.050
misrh	42	2.75	0.910
phlo	34	3.80	1.060
plpa	80	11.65	1.740
posa3	88	23.30	3.012
sial	46	1.65	0.426

STATION : s04
SAMPLING DATE : 050880

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	8	0.70	0.423
assc2	8	0.45	0.309
baca	10	3.35	1.642
brte	98	39.85	4.945
depi	44	1.35	0.329
feoc2	86	16.25	3.008
misrh	44	1.60	0.427
phli	2	0.05	0.050
phlo	0	0.00	0.000
posa3	28	10.90	3.408
sial	12	0.30	0.116

STATION : s05
SAMPLING DATE : 050680

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	6	1.80	1.083
agsp	2	0.05	0.050
amly	22	0.55	0.148
brte	100	56.40	4.528
crci	2	0.05	0.050
depi	10	0.50	0.311
eras	2	0.05	0.050
gisi	2	0.05	0.050
houm	54	4.95	1.631
migrh	2	0.05	0.050
phlo	0	0.00	0.000
plpa	48	4.80	1.638
posa3	0	0.00	0.000
sial	60	2.75	0.607

STATION : s01
SAMPLING DATE : 050481

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	77.40	3.339
depi	0	0.00	0.000
drve2	88	4.45	0.715
houm	96	7.10	1.046
loma	2	0.05	0.050
migrh	14	0.35	0.124
phlo	0	0.00	0.000
posa3	76	19.55	3.019
ruve	4	0.10	0.070
sial	66	3.85	0.943

STATION : s02
SAMPLING DATE : 050481

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	84.00	2.150
depi	0	0.00	0.000
drve2	86	4.85	0.957
houm	54	4.50	1.193
misrh	36	1.15	0.329
phlo	0	0.00	0.000
posa3	94	25.85	3.255
sial	20	1.25	0.511

STATION : s03
SAMPLING DATE : 050681

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	88.40	2.011
depi	4	0.10	0.070
drve2	12	0.55	0.314
houm	88	14.40	2.831
misrh	10	0.25	0.107
phlo	0	0.00	0.000
posa3	0	0.00	0.000
sial	8	2.10	1.443

STATION : s04
SAMPLING DATE : 050781

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.80	0.751
brte	100	48.85	5.098
depi	2	0.05	0.050
drve2	28	0.70	0.160
houm	56	1.65	0.324
mifo	2	0.05	0.050
oepap	14	0.35	0.124
phlo	6	0.65	0.421
plpa	12	0.80	0.425
posa3	92	18.70	2.936
sial	36	2.60	1.296
stco2	56	18.00	3.588

STATION : s01
SAMPLING DATE : 050681

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	74.75	3.315
depi	16	0.40	0.131
drve2	64	1.60	0.171
erni	44	6.60	2.103
houm	44	2.10	0.569
misrh	36	0.90	0.171
phlo	0	0.00	0.000
posa3	2	0.05	0.050
sial	2	0.30	0.300

STATION : s02
SAMPLING DATE : 050681

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	14	2.00	1.081
assp	8	0.95	0.510
amly	4	0.10	0.070
aspu	2	0.05	0.050
brte	100	54.00	4.675
crci	2	0.05	0.050
cytet	4	0.60	0.420
depi	10	0.25	0.107
drve2	30	1.50	0.510
feoc2	12	0.55	0.314
houm	28	1.20	0.430
mifo	14	0.35	0.124
misrh	8	0.20	0.097
oepap	8	0.45	0.309
orhy	2	1.25	1.250
phli	2	0.05	0.050
phlo	0	0.00	0.000
posa3	24	2.30	0.923
sial	0	0.00	0.000
stco2	2	0.05	0.050

STATION : s03
SAMPLING DATE : 050781

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
baca	2	0.05	0.050
brte	100	66.50	4.277
coum	2	0.05	0.050
crat	2	0.30	0.300
depi	2	0.05	0.050
drve2	80	2.75	0.464
houm	86	6.30	1.506
misrh	12	0.30	0.116
oppo	2	0.30	0.300
phlo	8	0.20	0.097
plpa	78	5.95	0.898
posa3	74	14.30	2.702
sial	38	2.65	0.913

STATION : s04
SAMPLING DATE : 050581

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	6	0.85	0.751
assc2	14	1.80	0.889
baca	12	2.20	1.113
brte	100	45.55	4.713
depi	24	0.60	0.153
drve2	4	0.10	0.070
feoc2	90	4.20	0.879
misrh	18	0.45	0.137
phlo	4	0.10	0.070
posa3	14	5.80	2.570

STATION : s05
SAMPLING DATE : 050781

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.35	0.303
amly	2	0.05	0.050
brte	100	72.20	4.051
depi	0	0.00	0.000
drve2	40	1.00	0.175
erni	8	5.65	2.889
houm	82	3.80	0.659
mifo	4	0.10	0.070
misrh	2	0.05	0.050
oepap	4	0.10	0.070
oppo	6	1.80	1.699
phlo	0	0.00	0.000
plpa	36	2.85	0.948
posa3	0	0.00	0.000
sial	50	4.60	1.339

STATION : s01
SAMPLING DATE : 051882

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	42.20	3.517
drve2	70	2.00	0.311
houm	98	6.85	1.175
mifo	22	0.55	0.148
misrh	2	0.05	0.050
posa3	80	11.20	2.107
ruve	2	0.30	0.300
saka	8	0.20	0.097
sial	20	0.50	0.143

STATION : s02
SAMPLING DATE : 051882

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	45.45	3.323
drve2	74	1.85	0.157
houm	60	1.50	0.175
misrh	36	0.90	0.171
posa3	94	11.60	1.511
saka	8	0.20	0.097
sial	2	0.05	0.050

STATION : s03
SAMPLING DATE : 052082

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	2	0.05	0.050
brte	100	51.00	3.685
depi	2	0.30	0.300
drve2	20	0.50	0.143
houm	80	2.00	0.143
mifo	28	0.70	0.160
misrh	42	1.05	0.176
oepap	12	1.30	0.581
posa3	2	0.05	0.050
saka	18	0.45	0.137
sial	2	0.05	0.050

STATION : s04
SAMPLING DATE : 051782

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.10	0.070
brte	98	22.85	3.976
depi	2	0.05	0.050
drve2	36	0.90	0.171
houm	66	2.15	0.410
mifo	26	0.65	0.157
oepap	38	3.40	1.004
phlo	10	0.25	0.107
plpa	16	0.65	0.318
posa3	96	15.80	2.124
sial	6	0.15	0.085
stco2	56	15.50	3.210

STATION : s01
SAMPLING DATE : 052082

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	51.50	3.567
drve2	68	1.70	0.167
houm	54	1.35	0.178
mifo	2	0.05	0.050
migrh	56	1.40	0.177
oepap	6	0.15	0.085
posa3	6	0.40	0.306
sial	2	0.05	0.050

STATION : s02
SAMPLING DATE : 051882

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	14	1.75	1.048
agda	8	0.20	0.097
amly	2	0.30	0.300
astra	2	0.05	0.050
brte	96	25.55	3.394
crpt	6	0.15	0.085
cytet	8	2.10	1.719
depi	6	0.15	0.085
drve2	26	1.15	0.430
feoc2	8	0.20	0.097
gisi	2	0.05	0.050
houm	26	1.40	0.511
lagl	2	0.05	0.050
meal2	4	0.10	0.070
mifo	6	0.15	0.085
migrh	10	0.25	0.107
oepap	10	0.25	0.107
orhy	4	1.30	1.250
posa3	26	4.50	1.674
sial	2	0.30	0.300
stco2	4	0.35	0.303

STATION : s03
SAMPLING DATE : 051782

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	36.60	4.307
crat	12	0.55	0.314
drve2	88	2.45	0.281
houm	80	3.00	0.525
mifo	18	0.45	0.137
phlo	4	0.10	0.070
plpa	80	2.00	0.143
posa3	92	17.90	1.824

STATION : s04
SAMPLING DATE : 051882

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.10	0.070
assc2	20	2.45	0.960
baca	8	3.55	2.114
brte	100	30.55	3.747
crpt	2	0.05	0.050
depi	32	0.80	0.167
drve2	2	0.05	0.050
feoc2	82	2.05	0.137
mifo	14	0.35	0.124
misrh	22	0.55	0.148
posa3	26	4.25	1.660

STATION : s05
SAMPLING DATE : 052082

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	2	0.30	0.300
assp	2	0.75	0.750
amly	16	1.60	0.847
brte	98	19.95	2.704
depi	16	1.15	0.511
drve2	48	1.20	0.178
sisi	6	0.15	0.085
houm	90	3.75	0.603
lasl	2	0.05	0.050
meal2	8	0.45	0.309
mifo	20	0.75	0.321
misrh	6	0.15	0.085
oepap	16	0.65	0.318
plpa	34	1.10	0.329
saka	2	0.05	0.050
sial	44	7.30	2.197

STATION : s01
SAMPLING DATE : 050683

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	49.50	2.583
cytet	4	0.35	0.303
depi	2	0.05	0.050
drve2	92	3.25	0.750
houm	100	9.00	0.892
mifo	16	0.40	0.131
misrh	24	0.60	0.153
posa3	54	2.10	0.497
ruve	2	0.30	0.300
saka	70	1.75	0.164
sial	2	0.05	0.050
trdu	4	0.35	0.303

STATION : s02
SAMPLING DATE : 050683

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	39.55	2.739
cytet	2	0.05	0.050
depi	2	0.05	0.050
drve2	94	2.60	0.267
houm	52	1.30	0.178
mifo	26	0.65	0.157
misrh	94	2.85	0.364
posa3	100	15.75	1.735
saka	76	1.90	0.153
sial	6	0.15	0.085

STATION : s03
SAMPLING DATE : 050483

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	2	0.30	0.300
brte	100	62.70	3.348
depi	2	0.05	0.050
depi	8	0.45	0.309
drve2	36	0.90	0.171
feoc2	2	0.05	0.050
houm	92	3.30	0.502
mifo	36	0.90	0.171
misrh	70	2.00	0.311
oepap	34	2.10	0.632
saka	60	1.50	0.175
sial	6	0.15	0.085

STATION : s04
SAMPLING DATE : 050483

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	2	0.05	0.050
brdo	2	0.05	0.050
brte	100	17.55	3.611
depi	2	0.05	0.050
drve2	76	1.90	0.153
houm	82	2.05	0.137
mifo	30	1.00	0.327
oepap	62	3.55	0.732
phlo	14	0.35	0.124
plpa	18	0.70	0.320
posa3	90	10.95	1.644
saka	44	1.80	0.749
sial	6	0.15	0.085
stco2	64	14.55	2.700

STATION : s01
SAMPLING DATE : 050583

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	53.80	3.769
depi	32	1.05	0.328
drve2	80	2.75	0.464
houm	74	2.35	0.400
mifo	18	0.45	0.137
misrh	82	2.05	0.137
oepap	8	0.70	0.423
posa3	10	2.15	1.113

STATION : s02
SAMPLING DATE : 050383

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	16	1.15	0.511
agsp	8	0.70	0.423
amly	10	0.25	0.107
brte	98	37.15	4.149
crci	2	0.05	0.050
crpt	4	0.10	0.070
cytet	10	1.45	0.848
depi	50	2.00	0.500
drve2	42	1.30	0.329
eras	2	0.30	0.300
feoc2	18	0.45	0.137
gimi	4	0.10	0.070
gisi	6	0.15	0.085
houm	40	1.25	0.329
lagl	6	0.15	0.085
meal2	6	0.15	0.085
mifo	8	0.20	0.097
migrh	36	1.15	0.329
oepap	4	0.35	0.303
phli	26	0.90	0.325
phlo	6	0.15	0.085
posa3	30	7.10	1.962
stco2	4	0.60	0.420

STATION : s03
SAMPLING DATE : 050383

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	2	0.05	0.050
brdo	2	0.05	0.050
brte	100	33.65	4.538
crat	8	0.45	0.309
depi	2	0.05	0.050
drve2	96	2.65	0.262
houm	94	2.60	0.267
mifo	8	0.20	0.097
migrh	70	1.75	0.164
phlo	12	0.55	0.314
plma	2	0.05	0.050
plpa	86	2.65	0.381
posa3	96	14.40	1.841
saka	56	1.90	0.420
sial	34	0.85	0.169
sihy	2	0.05	0.050

STATION : s04
SAMPLING DATE : 050383

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	4	0.10	0.070
assc2	16	1.60	0.847
baca	10	2.65	1.487
brte	100	34.05	4.477
crci	2	0.05	0.050
crpt	2	0.05	0.050
depi	54	1.35	0.178
drve2	28	0.70	0.160
feoc2	88	2.70	0.377
houm	2	0.05	0.050
mifo	38	0.95	0.173
misrh	50	1.25	0.179
oepap	2	0.05	0.050
posa3	28	6.40	2.001

STATION : s05
SAMPLING DATE : 050283

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
assp	2	0.30	0.300
amly	16	0.40	0.131
brte	100	31.85	3.646
crci	12	0.30	0.116
depi	38	1.45	0.429
drve2	94	2.60	0.267
sisi	8	0.20	0.097
houm	100	14.20	1.456
lasl	20	0.50	0.143
meal2	4	0.10	0.070
mifo	56	1.40	0.177
misrh	12	0.30	0.116
oepap	28	1.95	0.636
phli	2	0.05	0.050
plpa	40	1.00	0.175
sial	40	1.25	0.329
stco2	4	1.29	0.327

OK,

STATION : s01
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brdo	2	0.05	0.05
brte	100	60.85	2.54
cytet	6	0.15	0.08
drve2	80	2.00	0.14
houm	100	16.60	1.45
mifo	26	0.65	0.16
misrh	22	0.55	0.15
posa3	48	1.20	0.18
ruve	10	0.50	0.31
saka	26	0.65	0.16
sial	34	0.85	0.17
trdu	12	0.30	0.12

STATION : s02
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brdo	6	0.15	0.08
brte	100	71.30	2.10
cytet	2	0.05	0.05
drve2	100	2.75	0.25
houm	80	4.00	0.70
mifo	36	0.90	0.17
misrh	88	2.20	0.12
posa3	90	4.45	0.90
saka	14	0.35	0.12
sial	16	0.40	0.13

STATION : s03
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
amly	2	0.05	0.05
brdo	40	1.00	0.17
brte	100	60.85	3.54
depi	4	0.10	0.07
drve2	82	2.05	0.14
houm	100	13.85	1.11
mifo	26	0.65	0.16
misrh	74	1.85	0.16
oepap	4	0.10	0.07
saka	56	1.40	0.18
sial	6	0.15	0.08

STATION : s04
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	2	0.05	0.05
brdo	16	0.40	0.13
brte	94	9.60	2.03
drve2	92	2.30	0.10
houm	96	3.65	0.54
mifo	10	0.25	0.11
misrh	2	0.05	0.05
phlo	12	0.80	0.43
plpa	28	0.95	0.33
posa3	88	12.85	1.67
saka	28	0.70	0.16
sial	12	0.30	0.12
stco2	76	12.15	2.19

STATION : s01
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brte	100	41.50	3.49
depi	6	0.15	0.08
drve2	72	2.55	0.48
houm	86	7.85	1.10
misrh	68	1.70	0.17
phlo	2	0.30	0.30
posa3	14	1.85	0.70
saka	4	0.10	0.07

STATION : s02
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	10	1.00	0.51
assp	4	0.60	0.42
assc2	0	0.00	0.00
brte	98	32.45	3.42
crci	4	0.10	0.07
crpt	4	0.10	0.07
cytet	14	3.00	1.99
depi	10	0.25	0.11
drve2	44	1.10	0.18
feoc2	12	0.30	0.12
gisi	4	0.10	0.07
houm	54	4.75	1.21
lagl	2	0.05	0.05
meal2	6	0.15	0.08
mifo	22	0.55	0.15
migrh	26	0.65	0.16
phli	22	0.80	0.32
posa3	48	8.20	1.91
saka	2	0.05	0.05

STATION : s03
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
brdo	2	0.05	0.05
brte	100	39.35	4.11
crat	12	0.55	0.31
drve2	96	2.40	0.07
houm	100	3.50	0.48
mifo	16	0.40	0.13
migrh	60	1.50	0.17
phlo	6	0.15	0.08
plpa	86	2.90	0.45
posa3	100	11.55	1.39
saka	28	0.70	0.16
sial	4	0.10	0.07

STATION : s04
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
acmi	6	0.15	0.08
amac	2	0.05	0.05
assc2	4	2.00	1.44
baca	12	4.35	2.40
brdo	2	0.05	0.05
brte	100	33.90	4.00
crci	4	0.10	0.07
crpt	2	0.05	0.05
depi	28	0.70	0.16
drve2	48	1.20	0.18
feoc2	86	2.40	0.29
houm	14	0.35	0.12
mifo	18	0.45	0.14
misrh	62	1.55	0.17
posa3	46	8.55	2.61
trdu	2	0.05	0.05

STATION : s05
SAMPLING DATE : 05 84

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
assp	2	0.05	0.05
amly	36	1.15	0.33
brte	100	36.50	3.41
crci	12	0.30	0.12
depi	8	0.20	0.10
drve2	96	2.90	0.36
erni	22	1.30	0.51
sisi	2	0.05	0.05
houm	100	3.75	0.54
lasl	12	0.30	0.12
meal2	4	0.10	0.07
mifo	52	1.55	0.33
misrh	36	0.90	0.17
oepap	26	0.65	0.16
oppo	8	1.40	0.85
phli	4	0.10	0.07
plpa	48	1.95	0.50
saka	16	0.40	0.13
sial	32	1.30	0.43
stco2	4	0.35	0.30

OK,

STATION : G01
SAMPLING DATE : MAY 85

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
BRTE	86	8.00	1.36
CYTET	6	0.40	0.31
DEPI	4	0.10	0.07
DRVE2	98	7.45	0.88
HOUM	100	7.70	1.05
MIFO	16	0.40	0.13
MIGRH	16	0.40	0.13
PLPA	2	0.05	0.05
POSA3	92	9.20	1.22
RUVE	6	0.40	0.31
SIAL	42	2.50	0.87
TRDU	48	8.10	1.85

STATION : G02
SAMPLING DATE : MAY 85

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
AMLY	2	0.05	0.05
BRTE	90	8.10	1.35
CRCI	2	0.05	0.05
CRPT	2	0.05	0.05
CYTET	4	0.10	0.07
DEPI	10	1.00	0.51
FRAC	2	0.05	0.05
HOUM	84	3.35	0.57
MIGRH	56	2.90	0.66
POSA3	98	17.95	1.52
SIAL	20	0.75	0.32
TRDU	32	7.20	2.09
DRVE	98	8.40	1.06

STATION : G03
SAMPLING DATE : MAY 85

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
BRDO	34	2,35	0,68
BRTE	100	18,30	1,35
DRVE	100	9,95	1,04
FRAC	52	3,55	0,78
HOUM	92	3.30	0,50
MIFO	6	0,15	0,08
MIGRH	96	2,90	0,36
SAKA	34	1,10	0,33
SIAL	10	0,25	0,11

STATION : G04
SAMPLING DATE : MAY 85

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
ACMI	4	0,10	0,07
ASCA	10	0,75	0,42
BRTE	86	7,25	1,88
DRVE	88	2,20	0,12
FRAC	38	0,95	0,17
HOUM	60	1,75	0,32
MIFO	6	0,15	0,08
OEPAP	2	0,05	0,05
PHLO	10	0,75	0,42
POSA3	94	13,90	1,79
SAKA	22	0,55	0,15
SIAL	2	0,05	0,05
STCO	68	10,30	1,89
PLPA	28	0,70	0,16

STATION : S01
SAMPLING DATE : MAY 85

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
BRTE	64	2,10	0,41
CRCI	2	0,05	0,05
DEPI	6	0,40	0,31
FRAC	2	0,05	0,05
MEAL	6	0,15	0,08
MIGRH	10	0,25	0,11
POSA3	12	1,05	0,51

STATION : S02
SAMPLING DATE : MAY 85

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
AGSP	6	0,40	0,31
BRTE	38	2,15	0,84
CYTET	6	1,35	1,25
DEPI	8	0,45	0,31
DRVE	26	2,55	1,71
HOUM	20	0,50	0,14
MEAL	20	1,75	0,64
PHLI	14	0,35	0,12
POSA3	36	4,30	1,24
STCO	12	0,55	0,31
SAKA	2	0,05	0,05

STATION : S03
SAMPLING DATE : MAY 85

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
ASSC	2	0.05	0.05
BRDO	4	0.10	0.07
BRTE	100	14.60	1.63
CRAT	6	0.85	0.75
DRVE	100	3.00	0.35
HOUM	96	3.15	0.43
MIGRH	26	0.65	0.16
PHLO	8	0.20	0.10
PLPA	82	5.05	0.81
POSA3	100	17.85	1.81
SAKA	2	0.05	0.05
SIAL	10	0.50	0.31
MIFO	18	0.45	0.14

STATION : S04
SAMPLING DATE : MAY 85

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
ACMI	2	0.05	0.05
ASSC	14	2.75	1.75
BACA	12	2.95	1.77
BRTE	64	3.60	0.73
CRPT	2	0.05	0.05
DEPI	28	1.70	0.58
DRVE	10	0.25	0.11
FEOC2	44	1.35	0.33
FRAC	4	0.35	0.30
MIFO	6	0.15	0.08
MIGRH	18	0.45	0.14
POSA3	46	2.40	0.62
SAKA	4	0.10	0.07

STATION : S05
SAMPLING DATE : MAY 85

SPECIES CODE	FREQ (%)	MEAN COVER (%)	STANDARD ERROR
AGSP	8	1,85	1,08
BACA	2	0,05	0,05
BRTE	100	27,05	3,05
DEPI	4	0,35	0,30
DRVE	96	2,40	0,07
FRAC	28	0,95	0,33
HOUM	28	0,70	0,16
MIFO	2	0,05	0,05
MIGRH	26	0,65	0,16
OEPAP	4	0,10	0,07
PHLO	4	0,10	0,07
PLPA	32	0,80	0,17
SIAL	22	2,25	1,30
SIAL	20	4,45	1,79

SUMMARY OF HERBACEOUS COVER FOR 1975 - 1985

CLASS	YEAR	S01	S02	S03	S04	S05	XS	G01	G02	G03	G04	XG	XSG
AG	1975	49.90	35.30	43.80			43.00	43.90	43.00			43.45	43.18
PG	1975	0.60	2.00	4.50			2.37	3.70	5.50			4.60	3.26
AF	1975	14.60	11.70	11.70			12.67	29.50	13.00			21.25	16.10
PF	1975	4.30	0.90	1.80			2.33	1.50	2.10			1.80	2.12
all	1975	69.40	49.90	61.80			60.37	78.60	63.60			71.10	64.66
AG	1976	50.70	40.90	34.30			41.97	71.20	51.60			61.40	49.74
PG	1976	0.40	10.50	10.30			7.07	4.40	3.10			3.75	5.74
AF	1976	5.50	5.30	7.20			6.00	11.90	8.50			10.20	7.68
PF	1976	0.00	0.50	0.20			0.23	0.00	0.20			0.10	0.18
all	1976	56.60	57.20	52.00			55.27	87.50	63.40			75.45	63.34
AG	1977	1.35	0.65	1.90			1.30	5.20	1.45			3.33	2.11
PG	1977	0.35	11.30	8.28			6.64	3.25	2.90			3.08	5.22
AF	1977	0.25	0.05	0.90			0.40	2.40	9.35			5.88	2.59
PF	1977	0.55	0.60	1.42			0.86	0.05	6.30			3.18	1.78
all	1977	2.50	12.60	12.50			9.20	10.90	20.00			15.45	11.70
AG	1978	51.00	67.00	51.00			56.33	68.00	42.00			55.00	55.80
PG	1978	3.00	18.00	11.00			10.67	8.00	7.00			7.50	9.40
AF	1978	38.00	10.00	33.00			27.00	23.00	25.00			24.00	25.80
PF	1978	8.00	0.00	5.00			4.33	2.00	3.00			2.50	3.60
all	1978	100.00	95.00	100.00			98.33	101.00	77.00			89.00	94.60
AG	1979	25.00	29.00	9.00			21.00	31.00	10.00			20.50	20.80
PG	1979	1.00	18.00	11.00			10.00	7.00	5.00			6.00	8.40
AF	1979	2.00	4.00	10.00			5.33	43.00	33.00			38.00	18.40
PF	1979	11.00	0.00	3.00			4.67	0.00	7.00			3.50	4.20
all	1979	39.00	51.00	33.00			41.00	81.00	55.00			68.00	51.80
AG	1980	50.40	51.80	24.30	56.20	56.40	47.82	64.30	77.80	73.80	12.30	57.05	51.72
PG	1980	1.00	7.20	23.30	10.90	0.10	8.50	28.30	64.00	0.10	26.60	29.75	17.94
AF	1980	7.60	4.20	22.50	3.40	14.10	10.36	7.30	5.00	28.70	4.90	11.48	10.86
PF	1980	2.20	2.20	4.70	4.60	1.80	3.10	0.40	0.00	0.00	4.60	1.25	2.28
all	1980	61.20	65.40	74.80	75.10	72.40	69.78	100.30	146.80	102.60	48.40	99.53	83.00
AG	1981	74.80	54.60	66.50	49.80	76.20	64.38	77.40	84.00	88.40	48.90	74.68	68.96
PG	1981	0.10	4.70	14.30	5.80	0.00	4.98	19.60	25.90	0.00	36.70	20.55	11.90
AF	1981	5.30	3.50	18.20	1.20	12.50	8.14	15.90	11.90	17.50	5.90	12.80	10.21
PF	1981	0.00	3.20	0.70	4.90	0.50	1.86	0.20	0.00	0.00	1.90	0.53	1.27
all	1981	80.20	66.00	99.70	61.70	89.20	79.36	113.10	121.80	105.90	93.40	108.55	92.33
AG	1982	51.50	25.80	36.60	32.70	20.00	33.32	42.20	45.50	51.00	22.90	40.40	36.47
PG	1982	0.40	6.40	17.90	4.30	0.80	5.96	11.20	11.60	0.10	31.30	13.55	9.33
AF	1982	4.60	4.20	7.50	1.60	17.30	7.04	9.70	4.60	4.60	4.10	5.75	6.47
PF	1982	0.20	4.30	0.70	6.20	1.00	2.48	0.30	0.00	1.30	3.80	1.35	1.98
all	1982	56.70	40.70	62.70	44.80	39.10	48.80	63.40	61.70	57.00	62.10	61.05	54.24
AG	1983	53.80	37.60	33.65	36.75	31.85	38.73	49.50	39.55	62.75	17.55	42.34	40.33
PG	1983	2.15	7.70	14.45	6.40	1.29	6.40	2.10	15.75	0.00	25.50	10.84	8.37
AF	1983	8.20	7.85	12.55	3.45	22.35	10.88	18.70	8.85	8.65	6.65	10.71	10.81
PF	1983	0.70	3.10	1.05	4.40	1.95	2.24	0.65	0.05	2.10	4.00	1.70	2.00
all	1983	64.85	56.25	61.70	51.00	57.44	58.25	70.95	64.20	73.50	53.70	65.59	61.51
AG	1984	41.50	32.75	39.35	36.30	36.50	37.28	60.85	71.30	60.85	9.60	50.65	43.22

SUMMARY OF HERBACEOUS COVER FOR 1975 - 1985 (CONTINUED)

PG	1984	1.85	8.80	11.55	8.55	0.40	6.23	1.20	4.45		25.00	10.22	6.87
AF	1984	12.35	8.10	11.10	4.00	13.40	9.79	20.65	9.70	19.45	7.95	14.44	11.86
PF	1984	0.30	4.00	0.75	6.55	0.65	2.45	0.70	0.20	1.10	1.25	0.81	1.72
all	1984	56.00	53.65	62.75	55.40	50.95	55.75	83.40	85.65	81.40	43.80	73.56	63.67
AG	1985	2.10	2.15	14.60	4.95	27.05	10.17	8.00	8.10	18.30	7.25	10.41	10.28
PG	1985	1.05	4.70	17.85	2.40	1.85	5.57	9.20	17.95	0.00	13.90	10.26	7.66
AF	1985	0.70	1.35	9.40	2.30	4.75	3.70	18.20	8.15	7.55	3.05	9.24	6.16
PF	1985	0.00	1.35	1.15	3.00	0.25	1.15	0.80	0.10	2.35	0.90	1.04	1.10
all	1985	3.85	9.55	43.00	12.65	33.90	20.59	36.20	34.30	28.20	25.10	30.95	25.19