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MEMORANDUM
July 16, 1979

To: Dave Nunnallee

From: Greg Cloud and Shirley Prescott

Subject: Follow-up Survey on Boise Creek (after removal of Encumclaw STP discharge)

INTRODUCTION

On March 19, 1979 a water quality survey was performed on Boise Creek near Enumclaw (Figure 1). The purpose was to measure any changes in stream quality and biota after the Enumclaw STP discharge was discontinued and rerouted to the White River. This change was made on December 8, 1978. Data collected during the current survey are compared with a similar study conducted on March 21 and 22, 1978 (Yake, W.E. and G. Cloud, 1978) in conjunction with a Class II inspection of the Enumclaw sewage treatment plant (STP).

METHODS

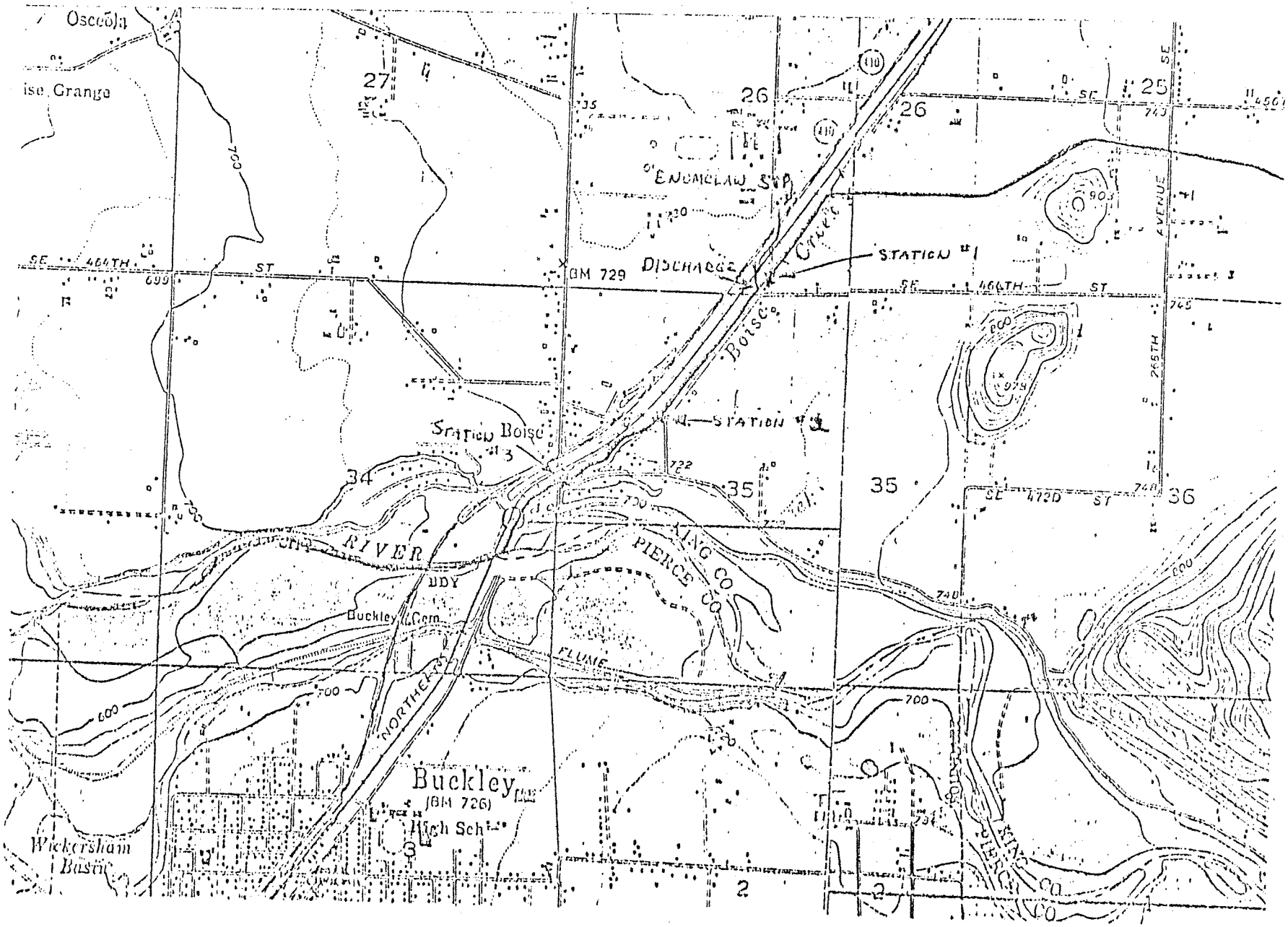
Water quality and biological samples were collected at the same three stations as the survey conducted in March 1978: Station 1, located approximately 200 feet upstream of the STP's former discharge point; Station 2, approximately 0.4 mile downstream near an abandoned highway bridge; Station 3, approximately 0.8 mile below the point of the plant's former discharge (Figure 1).

Four parameters were measured in situ: temperature (°C), pH, dissolved oxygen, and specific conductivity. In addition, samples were collected and packed in ice, then transported to the DOE Tumwater Laboratory for the following 14 analyses:

1. Turbidity (NTU)
2. Chemical Oxygen Demand (mg/l)
3. Biological Oxygen Demand (mg/l)
4. Total Coliform (Col./100 ml)
5. Fecal Coliform (Col./100 ml)
6. Nitrate-N (mg/l)
7. Nitrite-N (mg/l)
8. Ammonia-N (mg/l)
9. Ortho-Phosphate-P (mg/l)
10. Total Phosphate-P (mg/l)
11. Total Solids (mg/l)
12. Total Non-Volatile Solids (mg/l)
13. Total Suspended Solids (mg/l)
14. Total Susp. Non-Vol. Solids (mg/l)

All of the laboratory analyses were performed as per Standard Methods for the Examination of Water and Wastewater (American Public Health Association, *et al.*, 1976).

Figure 1. Boise Creek Study Area



For the biological sampling, macroinvertebrate samples were collected and analyzed as per the March 1978 survey. Rocks of approximately equal size were selected, then removed and placed in a fine mesh net. All of the attached material was removed by hand or rinsing and the contents placed in sample bottles containing 70 percent ethyl alcohol. The longest two right angle axes of the rock were then measured to estimate surface area. All organisms collected were taken to the DOE laboratory, keyed to genera or species, if possible, and Shannon diversity index computed. Although not included in the 1978 survey, Brillouin indices were computed on both 1978 and 1979 data.

RESULTS

Data for the physical and chemical parameters are presented in Table 1. For comparison, this table also includes results from the 1978 survey. A discussion of the findings follows.

Physical and Chemical

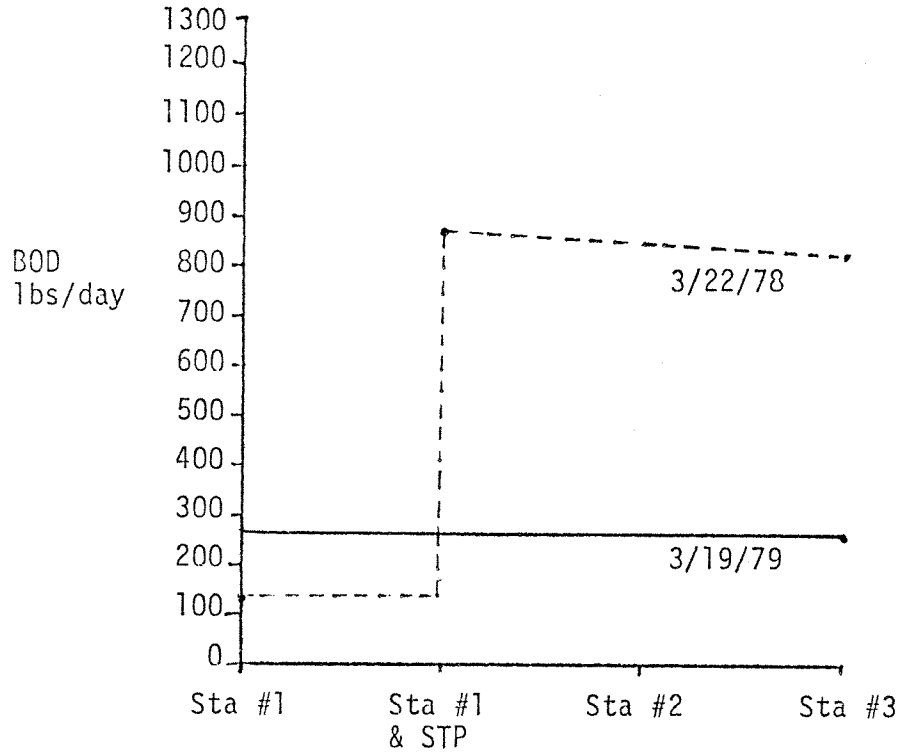
Stream flow on March 19, 1979 was about the same as the stream and STP combined during the 1978 survey, and therefore a comparison of stream loadings was possible for the lower stations (2 and 3). Substantial reductions in COD and O-PO_4-P were evident at these stations (Figure 2).

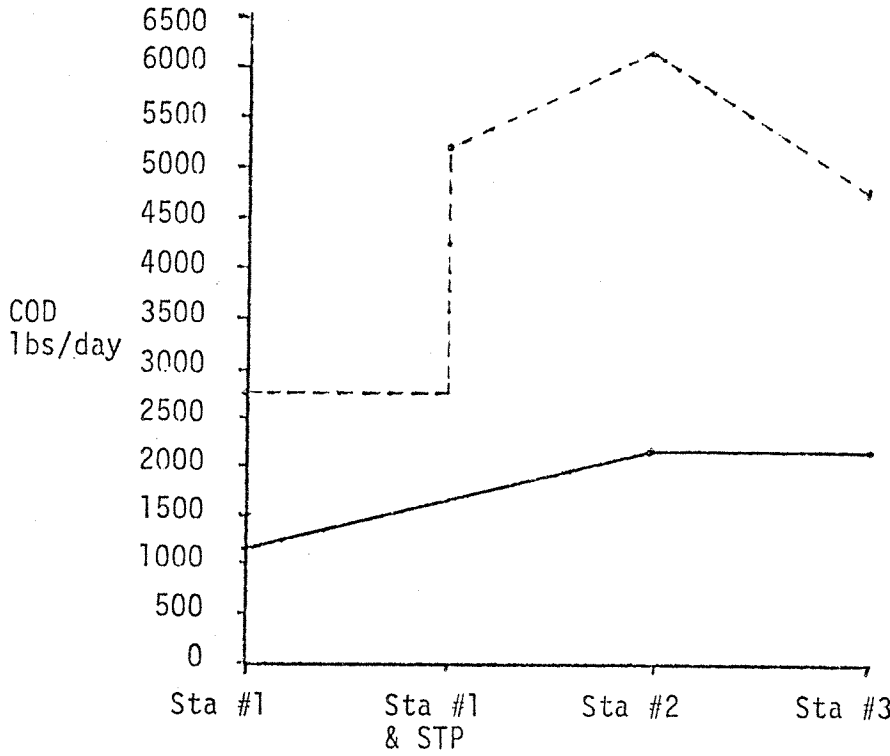
During the 1978 survey, the nutrient levels at stations 2 and 3 were great enough to promote periphyton enrichment. Nutrient levels generally decreased at stations 2 and 3 after removal of the STP discharge. Algal bloom potential has been lowered near the threshold limits of 0.3 mg/l NO_3-N and 0.01 O-PO_4-P. These limits are defined by Klein (1959) as the levels necessary for potential algal bloom conditions. Table 1 shows phosphate loadings in Boise Creek have declined by approximately 80 percent at stations below the former STP discharge. The previously high nutrient levels apparently fostered periphyton growth downstream from the STP discharge. However the NO_3-N concentration (.66 mg/l) was still high at control station (#1). High nitrate values could be attributable to agricultural runoff from drainage ditches and fields upstream from station 1.

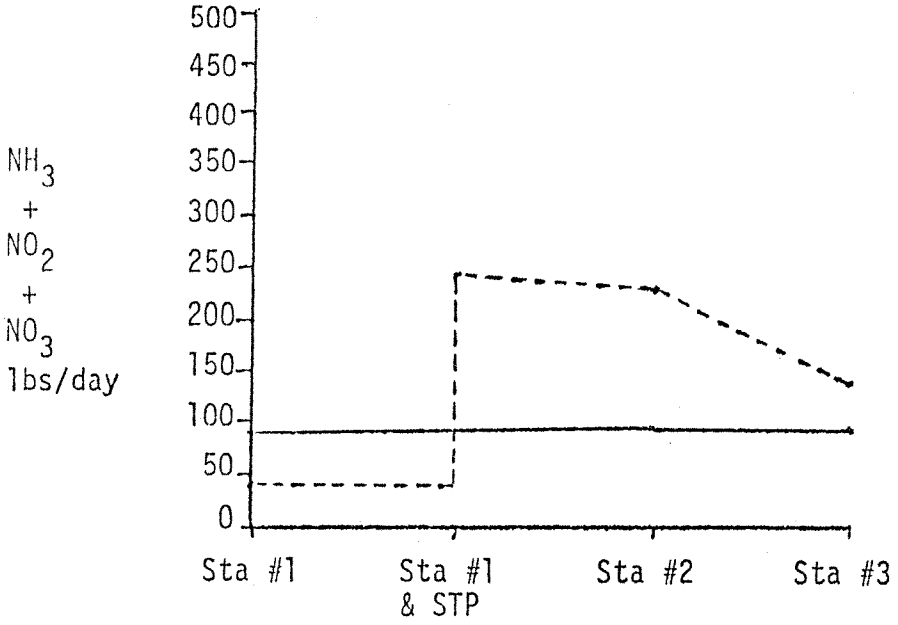
Bacteriological

Removal of the STP discharge appeared to make little difference in fecal bacteria levels in the creek (Table 1). This is to be expected since the STP was achieving good effluent disinfection during the 1978 survey. Remaining fecal coliforms could originate from several causes. Weyerhaeuser Corporation has a sawmill several miles upstream that could be

Figure 2. Mass Loadings on Boise Creek, March 19, 1979







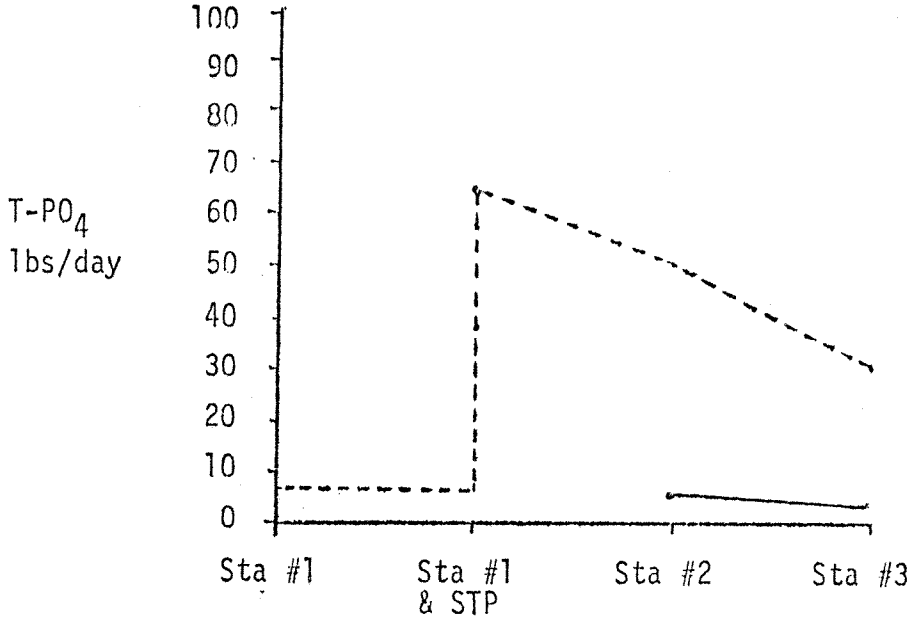


Table 1

Analytical Results: Boise Creek (with and without Enumclaw STP Discharge)

Parameter	Station 1			Station 2			Station 3		
	1978		1979	1978		1979	1978		1979
	3/21	3/22	3/19	3/21*	3/22*	3/19**	3/21*	3/22*	3/19**
Flow (cfs)	18.6	12.1	26.2	26.5	----	----	22.4	22.8	----
Dissolved O_2 (mg/l)	11.4	11.2	13.8	10.8	10.7	12.1	10.5	10.8	11.7
Dissolved O_2 % Sat.	98.4	98.6	115.2	99	95.8	100.9	99.4	96.2	101.2
COD (mg/l)	27	23	8	43	27	15	39	27	15
BOD_5 (mg/l)	----	2	<2	----	5	<2	----	7	2
Turbidity (NTU's)	10	6	3	8	7	4	8	8	2
pH	6.8	6.7	7.3	7.6	7.2	7.1	7.8	7.3	7.4
Spec. Cond. (µmhos/cm)	63	75	81	110	110	78	95	100	85
Temp (°C)	7.8	8.6	6.1	10.4	9.4	6.5	11.8	9.2	8.0
Total Colif. (#/100 ml)	4200	6100	4700	1200	3200	2800	2200	3500	4600
Fecal Colif. (#/100 ml)	600	490	420	220	290	330	160	430	330
NH_3-N (mg/l)	.02	.02	.03	1.2	.72	.03	.80	.62	.03
NO_2-N (mg/l)	<.02	<.02	<.01	<.02	<.02	<.01	<.02	.02	<.01
NO_3-N (mg/l)	.38	.38	.66	.42	.42	.67	.43	.44	.67
O-PO_4-P (mg/l)	.04	.02	.07	.32	.23	.02	.22	.37	.04
T-OPO_4-P (mg/l)	.06	.04	***	.36	.26	.05	.27	.28	.04
Total Solids (mg/l)	94	70	55	90	94	58	97	92	63
T. Non-Vol. Solids (mg/l)	69	50	30	65	65	36	59	63	33
T. Sus. Solids (mg/l)	32	8	5	10	10	5	11	11	5
TNVSS (mg/l)	20	1	2	2	3	2	2	4	2

* = Station with STP Discharge
** = Station Without STP Discharge
*** = Interference

contributing coliforms (Yake, 1978). This mill could also be contributing moderate COD loadings to the stream. Non-point sources associated with agriculture and livestock are also likely contributors to coliform populations in Boise Creek. Many farms containing domestic animals are situated along the length of the stream after it reaches the Enumclaw Valley. Throughout this farm area, drainage ditches connect to Boise Creek and both total and fecal coliform organisms would be expected to be high in these waterways.

Biological

The biological sampling showed fewer macroinvertebrate organisms were present during 1979 than in 1978. It is possible that the much colder weather during winter, 1979, and consequently the colder water temperatures are primarily responsible. The Ephemeroptera (may flies) were quite immature as compared to those same organisms sampled in March 1978. This low level of maturity, coupled with the fact that stations 2 and 3 have had a very short recovery period (3-1/2 months) since the removal of the STP discharge, probably were responsible for the lower numbers of macroinvertebrate found at the downstream stations (Table 2). In the study of March 1978, many leeches were observed in the warmer, stagnent waters at station 3. These were not part of the random sampling as the leeches inhabited areas not conducive to the majority of the benthic population. During this study (March 1979), very few leeches were found near station 3. It is probable that decreased nutrient loading and lack of decaying detritis induced by the removal of the STP discharge contributed to a decline in the leech population.

Diversity indices were computed using two methods; the Shannon Index and the Brillouin Index. Both of these indices show the same basic trends at the three stations. It should be noted that the Brillouin Index more accurately reflects the true diversity as it is more sensitive with lower organism total counts than the Shannon Index. Table 3, below, gives comparisons of indices and stations. The supplemental appendix contains the detailed information concerning these.

Table 3

	Station 1	Station 2	Station 3
1978 Shannon Index	1.53	0.77	0.94
1978 Brillouin Index	1.48	0.74	0.90
1979 Shannon Index	2.32	1.52	0.76
1979 Brillouin Index	2.18	1.37	0.65

Table 2

Macroinvertebrate Populations in Boise Creek - March 1979

Phylum Family Genus species	Station 1		Station 2		Station 3	
	count	d *	count	d *	count	d *
Diptera						
Tendipedidae						
unidentified species (larbal)	150	83.33	46	27.05	53	37.85
Blephariceridae						
unidentified species	1	0.56				
Simulidae						
unidentified species	4	2.22				
Tipulidae						
Prinocera sp.	1	0.56				
Unidentified Family						
unidentified species	5	2.78				
Trichoptera						
Rhyacophilidae						
Rhyacophila sp.	13	7.22	1	0.59	1	0.71
Glossosoma sp.	64	35.56				
Ephemeroptera						
Heptageniidae						
Rhithrogena decora	2	1.11			1	0.71
Baetidae						
Baetis sp.	5	2.78	12	7.06	1	0.71
Plecoptera						
Nemouridae						
unidentified species	3	1.67	1	0.59	1	0.71
Oligochaeta						
unidentified species	28	15.56	11	6.47	5	3.57
Malacostraca						
Gammaridae						
Gammarus lacustris	4	2.22	1	0.59		
Total Count	290		72		61	
Total Density		155.57		42.35		44.27
Species Diversity (Shannon)	2.32		1.52		0.76	
Species Diversity (Brillouin Index)	2.18		1.37		0.65	

The lack of marked improvement in the diversity of aquatic invertebrates at the lower stations is again probably due to the short recovery period and the relatively cold water temperatures.

Summary

The general water quality at Boise Creek has shown definate improvement during the 3-1/2 month period since the Enumclaw STP discontinued its discharge. Esthetically, the stream improved in color and clarity and there is little evidence of the slime and dark color observed at the time of the first survey. The study area is basically rural in nature and it appears that a combination of small farms, livestock, and possibly septic tanks in the area could be responsible for some of the coliform organisms and nutrients in the stream.

GC:SP:cp

Attachments

STA #1

March 1978

TOTAL NUMBER OF INDIVIDUALS = 404
NUMBER OF SPECIES = 10
NUMBER OF INDIVIDUALS FOR EACH SPECIES
1 -- 288
2 -- 1
3 -- 2
4 -- 13
5 -- 47
6 -- 1
7 -- 13
8 -- 27
9 -- 1
10 -- 11

BRILLOUIN INDEX

H = 1.475
Hmax = 3.29
Hmin = .193

RELATIVE EVENNESS FOR BRILLOUIN INDEX

0 < .414 < 1.0

SHANNON INDEX

S = 1.533
Smax = .385
Smin = .026

EQUIBILITY FOR SHANNON INDEX

.026 < .177 < .385

STA #2

March 1978

TOTAL NUMBER OF INDIVIDUALS = 298
NUMBER OF SPECIES = 3
NUMBER OF INDIVIDUALS FOR EACH SPECIES
1 -- 249
2 -- 39
3 -- 10

BRILLOUIN INDEX

H = .742
Hmax = 1.579
Hmin = .055

RELATIVE EVENNESS FOR BRILLOUIN INDEX

0 < .451 < 1.0

SHANNON INDEX

S = .765
Smax = .193
Smin = .008

EQUIBILITY FOR SHANNON INDEX

.008 < .093 < .193

STA #3

March 1978

TOTAL NUMBER OF INDIVIDUALS = 243
NUMBER OF SPECIES = 5
NUMBER OF INDIVIDUALS FOR EACH SPECIES
1 -- 197
2 -- 12
3 -- 30
4 -- 3
5 -- 1

BRILLOUIN INDEX

H = .901
Hmax = 2.328
Hmin = .13

RELATIVE EVENNESS FOR BRILLOUIN INDEX

0 < .351 < 1.0

SHANNON INDEX

S = .943
Smax = .295
Smin = .019

EQUIBILITY FOR SHANNON INDEX

.019 < .119 < .295

STA #1

March 1979

TOTAL NUMBER OF INDIVIDUALS = 290
NUMBER OF SPECIES = 12
NUMBER OF INDIVIDUALS FOR EACH SPECIES
1 -- 150
2 -- 1
3 -- 4
4 -- 5
5 -- 1
6 -- 13
7 -- 64
8 -- 3
9 -- 28
10 -- 2
11 -- 5
12 -- 4

BRILLOUIN INDEX

H = 2.184
Hmax = 3.485
Hmin = .309

RELATIVE EVENNESS FOR BRILLOUIN INDEX

0 < .59 < 1.0

SHANNON INDEX

S = 2.328
Smax = .439
Smin = .044

EQUIBILITY FOR SHANNON INDEX

.044 < .285 < .439

STA #2

March 1979

TOTAL NUMBER OF INDIVIDUALS = 72
NUMBER OF SPECIES = 6
NUMBER OF INDIVIDUALS FOR EACH SPECIES
1 -- 46
2 -- 1
3 -- 1
4 -- 11
5 -- 12
6 -- 1

BRILLOUIN INDEX

H = 1.373
Hmax = 2.386
Hmin = .426

RELATIVE EVENNESS FOR BRILLOUIN INDEX

0 < .483 < 1.0

SHANNON INDEX

S = 1.515
Smax = .419
Smin = .085

EQUIBILITY FOR SHANNON INDEX

.085 < .246 < .419

STA #3

March 1979

TOTAL NUMBER OF INDIVIDUALS = 61
NUMBER OF SPECIES = 6
NUMBER OF INDIVIDUALS FOR EACH SPECIES
1 -- 53
2 -- 1
3 -- 1
4 -- 5
5 -- 1
6 -- 1

BRILLOUIN INDEX

H = .653
Hmax = 2.415
Hmin = .482

RELATIVE EVENNESS FOR BRILLOUIN INDEX

0 < .088 < 1.0

SHANNON INDEX

S = .764
Smax = .439
Smin = .101

EQUIBILITY FOR SHANNON INDEX

.101 < .129 < .439

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