WASHINGTON STATE DEPARTMENT OF ECOLOGY

Chehalis Best Management Practices Evaluation Project

1996-97 Water Quality Data Report for Bunker Creek and Deep Creek Project Area

Abstract

This report describes the results of four years of dry season water quality monitoring on Bunker Creek and Deep Creek (1994-97) and interim results for the third year of wet season monitoring (1996-97). Pre- and post-BMP monitoring were conducted to determine effectiveness of best management practices (BMPs).

During the wet season, monitoring continued to show high turbidity and high levels of total suspended solids. Turbidity standards were exceeded at two sites on Deep Creek during the wet season.

In Bunker and Deep creeks during the 1997 dry season, water quality standards were exceeded for fecal coliform, dissolved oxygen, and temperature. In 1997 fecal coliform levels at Deep Creek site DCM 2.4 were higher than in 1996, but still lower than 1995. Increases seen in 1997 are most likely due to poor livestock management practices.

In comparing pre- and post-BMP dry season data, statistically significant improvements were seen in water quality. Two sites on Deep Creek showed lower bacterial levels and one site showed lower ammonia-nitrogen levels. Bunker Creek showed improvements in dissolved oxygen levels. Water quality improvements on Deep Creek are most likely due to fencing to exclude livestock from the creek. Further post-BMP monitoring is recommended on Bunker and Deep creeks.

Introduction

This report presents the results for pre- and post-best management practice (BMP) water quality monitoring on Bunker Creek and Deep Creek during the 1994-97 dry season and the 1996-97 wet season. Interim dry and wet season results for 1994-96 are available in two previously published reports (Sargeant; 1996a, 1997a). This project is funded in part by the U. S. Fish & Wildlife Service (USFWS) Chehalis Fisheries Restoration Program (CFRP). The purpose of the monitoring is to gather pre- and post-BMP data on several sites in the Deep Creek basin and the mouth of Bunker Creek, and to follow up on the Upper Chehalis River Dry Season Total Maximum Daily Load (TMDL) Study (Pickett, 1994). Monitoring sites are shown in Figure 1.

by Debby Sargeant
November 1998

Waterbody No. WA-23-1104

Ecology Report #98-333

Methods

All sampling was conducted as described by the Quality Assurance Project Plan (QAPP) and addenda (Sargeant; 1994, 1995, 1996b, 1997b). Dry season sampling events were conducted twice at Bunker Creek in both 1994 and 1995, with an additional sample event on Deep Creek three times in 1996, and three times in 1997. Ten wet season sampling events were conducted in 1996-97.

During the dry season (July through September) field measurements for temperature, pH, and conductivity were made using the methods described in the QAPP. Flows were obtained using a velocity meter and top-set wading rod. Laboratory samples were collected for fecal coliform, nitrite/nitrate nitrogen, ammonia nitrogen, total persulfate nitrogen, and dissolved oxygen. At Bunker Creek, samples for 5-day biochemical oxygen demand (BOD5) were also collected. In 1996 and 1997, samples were also collected for total phosphorus. Samples were analyzed in accordance with the QAPP. Dissolved oxygen samples were preserved on site and were analyzed within 48 hours at the Ecology headquarters laboratory.

During the wet season (November through March) field measurements for temperature, pH, and conductivity were made using the methods described in the QAPP. Flows were obtained using a velocity meter and top-set wading rod, or estimated using a flow curve developed from calibrating flows to gauges placed at the beginning of the wet season. Flows were obtained only for Deep Creek during the wet season, because flow discharge measurements for Bunker Creek at BCM 0.5 could not be safely obtained.

Laboratory samples were collected for turbidity and total suspended solids at all sites. During the wet season an additional upstream site was sampled at Deep Creek mile (CM) 4.5.

All laboratory samples were collected from flowing water by subsurface grab. Immediately following collection, samples were placed in the dark, on ice, and shipped to Ecology's Manchester Environmental laboratory within 24 hours after collection. Samples were analyzed in accordance with the QAPP.

Data Analysis

In order to compare dry and wet season data between stations and years a statistical test for the significance of variation was done using SYSTAT (1991) statistical software. For dry season comparisons between years, the data were grouped as pre-BMP (1995) and post-BMP (1996-97). For site BCM 0.5, 1991, 1992 and 1994 data were available so pre-BMP data included those years. For BCM 0.5, data daily averages were used for data analysis if more than one sample event occurred in a day. Comparisons were made for each parameter using a non-parametric test, the Mann Whitney U statistic or the Kruskal-Wallis one-way analysis of variance. A statistical significance level of $P \leq 0.05$ was used.

To compare wet season watershed moisture conditions the Antecedent Precipitation Index (API) was calculated for each sample event (Linsley et al., 1975). The API was calculated using precipitation data for the 14 days preceding the first day of sampling using an Io of 0, and a k of 0.87.

Results

Best Management Practices

In 1994 and 1995 erosion control BMPs were installed in the upper reaches of Deep Creek. Between 1995 and 1996 summer sampling, the Lewis Conservation District installed a number of agricultural BMPs at several sites in the lower reaches of Deep Creek. As of January 1997 the Conservation District, in cooperation with landowners, will have fenced most of the creek side area where cattle or horses are kept (Brummer, 1996). The BMPs installed were funded in part by USFWS CFRP funds.

The following is a summary of land uses and BMPs installed as of June 1996 and their relation to the water quality monitoring stations:

Upstream of DCM 4.5
In 1994 and 1995 in the upper reaches of Deep Creek, the CFRP and Department of Natural Resources funded BMPs to target erosion control treatment, including: 38 miles of abandoned trail and road restoration; 6 miles of drainage upgrade; erosion control treatments such as culvert replacement and sedimentation traps; and stream bank revegetation (Ireland, 1995). Land use in the upper watershed is primarily forestry.

Upstream of DCM 3.9 and downstream of DCM 4.5
The landowner immediately upstream of DCM 3.9 keeps a herd of cattle. The property alongside the creek has been fenced for a number of years. Upstream of this site there is no known domestic animal access.

Upstream of DCM 3.6 and downstream of DCM 3.9
Three pieces of property received BMP treatments in this stretch of creek. The site just upstream of DCM 3.6 received 1,300 feet of fencing along the south side of the creek, with no animal access points. This piece of property includes Rundoph Creek. Fencing of Rundoph was completed in January 1997. Approximately 11 cow/calf pairs and one steer are kept at this site.

Upstream of DCM 2.4 and downstream of DCM 3.6
One landowner keeps animals between these two stations; the number of animals varies. There were 20 cattle and a few horses in 1995; in early summer of 1996 the herd size was reduced to 12 cattle and a few horses, and in 1997 20 cow/calf pairs and one horse were kept (Amrine, 1998). At this site 4,552 feet of fencing were installed along 3,000 feet of the creek, on both sides. Three pasture pumps were installed and there is one animal access point.

A large culvert on Deep Creek washed out during the flooding on February 6, 1996. This culvert has been identified as a cause of bank erosion immediately downstream of the culvert. The culvert was replaced in April of 1996.

Downstream of DCM 2.4
On a site with 2 horses and 10-12 cattle, 2,650 feet of fencing were installed on both sides of the creek. There are two animal crossings at the site. Land use in this area is primarily rural homesteads with some animal keeping.

Precipitation and Flows

Wet Season

Precipitation for the sampling period, November 1996 through March 1997, was 48.62 inches measured at the Olympia Airport NOAA Weather Station. This is higher than the normal average of 35.39 inches (Perrich, 1992) expected for November through March. The preceding 24 and 48 hour rainfall (as of 4:00 a.m.), and the antecedent precipitation index (API) for each sampling day is shown in Table 1.

Table 1. Previous rainfall and API for 1996-97 Bunker Creek/Deep Creek wet season sample trips.

Date	Preceding 24 hour rainfall in inches	Preceding 48 hour rainfall in inches	Antecedent precipitation index in inches
11/13/96	0.42	0.59	1.02
11/25/96	0.40	1.14	1.94
12/03/96	0.66	0.80	2.37
12/09/96	0.18	0.71	2.91
01/07/97	1.04	1.05	4.49
01/28/97	0.60	0.60	1.67
02/12/97	0.72	0.72	1.27
02/19/97	1.09	1.33	1.36
03/03/97	0.54	1.84	2.50
03/10/97	0.20	0.84	2.58
Average	**0.59**	**0.96**	**2.21**

To compare the 1996-97 sample season with previous years, previous rainfall, the average API, and stream discharge from each sample season is presented in Table 2. The table shows mean, median, minimum, and maximum discharge for DCM 2.4, the average 24 and 48 hour rainfall preceding sampling, and the average API for the sampling year.

Table 2. Discharge statistics for each season at DCM 2.4 and previous rainfall.

Sample Season	N=	Mean Discharge cfs	Median Discharge cfs	Minimum Discharge cfs	Maximum Discharge cfs*	Average preceding 24 hour rainfall in inches	Average preceding 48 hour rainfall in inches	Average API in inches
1994-95	10	58	27	5	220	0.54	0.80	2.06
1995-96	10	61	58	7	170	0.55	0.89	2.15
1996-97	10	61	62	19	123	0.59	0.96	2.21

*** Maximum discharge for all years is a field estimate\gauge reading extrapolated from a flow curve.**

Average preceding rainfall and the API were very similar for all wet season sampling years, with increasing rainfall and API from 1994-95 through 1996-97. Flows were similar in 1995-96 and 1996-97, but more variable in 1995-96. Flows in 1994-95 were the most variable and had the lowest median.

Dry Season
The preceding 24 and 48 hour rainfall as measured at the Olympia Airport NOAA Weather Station for each dry season sampling day is shown in Table 3. For all dry season events the previous 48 hour rainfall was less than 0.10".

Table 3. Previous dry season rainfall for 1995-97 Bunker Creek/Deep Creek sample trips.

Date	Preceding 24 hour rainfall in inches	Preceding 48 hour rainfall in inches
7/12/95	0.00	0.00
8/14/95	0.00	0.02
9/13/95	0.00	0.00
7/8/96	0.00	0.00
8/6/96	0.03	0.09
9/11/96	0.00	0.00
7/1/97	0.02	0.04
8/5/97	0.00	0.00
9/8/97	0.00	0.00

Water Quality Characterization

Wet Season
The 1996-97 wet season field and laboratory results for Bunker and Deep creeks are presented in Appendix A. During all sample events, temperature and pH met water quality standards for all sites.

Figures 2 and 3 present turbidity and total suspended solids (TSS) data for each site during the wet season. To determine compliance with the water quality standards for turbidity, standards were applied to each reach in the study by using the station immediately upstream as background. Turbidity standards were not met at DCM 2.4 during six sample events, and during two events at station DCM 3.6. Station DCM 3.9 met turbidity standards for all sample events.

Regressions were done using 1996-97 wet season sampling data from Deep Creek only, with 40 data pairs serving as the basis for correlation. Total suspended solids (TSS) values correlate strongly with turbidity, with a coefficient of determination (r^2) of 0.89. [The coefficient of determination ranges from 0 to 1, and the stronger the relationship between x and y, in this case TSS and turbidity, the higher the r^2.]

Comparing 24 and 48 hour rainfall, the API, and discharge with turbidity and TSS, correlations using linear regression with a single independent variable are weak. Bivariate multiple regressions were done using discharge combined with either API, or 24-hour or 48-hour previous rainfall as the independent variables. The strongest correlation was between TSS (dependent variable) and discharge and API (dependent variables) with an adjusted r^2 of 0.62.

Non-parametric statistical testing showed no significant difference in turbidity or TSS values between wet seasons. Three years of wet season data were compared at each site (n=10). An additional site was added during the 1995-96 wet season at DCM 4.5. Two years of data were compared at this site.

Dry Season

Appendix B presents the 1994-97 dry season field and laboratory results for Bunker and Deep creeks. During all dry season sampling events pH and ammonia met water quality standards for all sites. All the Deep Creek sites met temperature standards; the Bunker Creek site violated temperature standards once on 8/5/97, with a temperature of 18.3 degrees C.

During the dry season none of the sites fully met the D.O. criterion of 8.0 mg/L for Class A waters. Dissolved oxygen levels were the highest in July with most Deep Creek sites meeting the standard, but in August and September none of the sites met the criterion. Dissolved oxygen levels were lowest at the Bunker Creek site, with only one sample event meeting the criterion. Although D.O. was low, BOD5 samples collected in Bunker Creek were below detection limits. Statistical analysis of BCM 0.5 D.O. data from 1991-97 shows an improvement in post-BMP D.O. levels.

Figure 4 presents average dry season nitrogen levels for Bunker and Deep creeks. Total nitrogen was lower in 1996 and 1997 than in 1995 for the Deep Creek sites. This was due to decreases in ammonia and organic nitrogen. At DCM 3.9 decreases in ammonia levels were statistically significant.

At the mouth of Bunker Creek ammonia levels averaged 0.079 mg/L in 1995, 0.039 mg/L in 1996, and 0.027 mg/L in 1997. While ammonia levels at all sites met water quality standards, they did not meet the Bunker Creek dry season ammonia target of <0.010 mg/L, as recommended in the Upper Chehalis River Dry Season Total Maximum Daily Load Study (Pickett, 1994). The elevated ammonia and organic nitrogen levels may be partially responsible for low D.O. at this site. Also, the increase in D.O. levels at this site could be related to the decrease in ammonia and organic nitrogen levels at this site (Figure 4). There has been no significant change in temperature, which effects D.O. levels.

In 1996 and 1997 total phosphorus levels were measured at all sites. Figure 5 presents average dry season total phosphorus levels by year and station. Phosphorus concentrations above 0.10 mg/L in flowing waters may stimulate algal growth (EPA, 1986). On September 8, 1997 all sites had values around 0.10 mg/L, but other than that all sample dates had total phosphorus levels less than 0.10 mg/L.

Figure 6 presents the geometric mean fecal coliform level for each site by year. In 1995 there were violations in the fecal coliform standard at stations DCM 3.6 and DCM 2.4. In 1996 all stations met the standard. In 1997 only one station DCM 3.6 met the standard. Table 5 summarizes the fecal coliform results by station and year.

Table 5. Dry season fecal coliform results for Bunker Creek/Deep Creek.

Station	Year	N	Geometric mean (GM) below #100/100 mL?	10% or less of all samples for calculating GM exceed #200/100 mL?
DCM 3.9	1995	2	YES (GM=70)	YES
	1996	3	YES (GM=55)	YES
	1997	3	NO (GM=110)	NO, 1 out of 3 samples exceed 200
DCM 3.6	1995	3	NO (GM=200)	NO, 2 out of 3 samples exceed 200
	1996	3	YES (GM=89)	YES
	1997	3	YES (GM=62)	YES
DCM 2.4	1995	3	NO (GM=2000)	NO, 3 out of 3 samples exceed 200
	1996	3	YES (GM=69)	YES
	1997	3	NO (GM=320)	NO, 2 out of 3 samples exceed 200
BCM 0.5	1994	2	YES (GM=100)	YES
	1995	2	YES (GM=80)	YES
	1996	3	YES (GM=80)	YES
	1997	3	NO (GM=110)	NO, 1 out of 3 samples exceed 200

For statistical testing, data were grouped into pre-BMP and post-BMP sets. Statistically significant improvements in fecal coliform levels were noted for DCM 2.4 and 3.6. Figure 6 illustrates the steady decline in fecal coliform levels at DCM 3.6. While fecal coliform levels improved dramatically at DCM 2.4 from 1995 to 1996 an increase in fecal coliform was noted in 1997. Improvements in both DCM 3.6 and 2.4 can be attributed to fencing BMPs. It is worthwhile to note that during the 1997 dry season a break in the fence along the riparian corridor allowed animals access to the creek just upstream of DCM 2.4. This could account for the increase in fecal coliform levels seen in 1997. Increase in herd size could also contribute to higher bacterial levels.

Conclusions

DCM 3.9

There were dry season violations in the D.O. criteria and fecal coliform standard.

DCM 3.6

There were high TSS values and violations in the turbidity standard during 1996-97 wet season monitoring. Dry season violations were seen in the D.O. criteria, but statistically significant post-BMP improvements seen in fecal coliform and ammonia-nitrogen values. Dry season improvements are most likely due improvements in animal keeping practices, including fencing to exclude livestock from the creek.

DCM 2.4

There were high TSS values and violations in the turbidity standard during 1996-97 wet season monitoring and dry season violations in D.O. criteria. Statistically significant post-BMP improvements were seen in fecal coliform levels. But, fecal coliform levels in 1997 increased from 1996 at this site, though fecal coliform values were much less than in 1995. Increases seen in 1997 are most likely due to a break in the fence line allowing animals access to the riparian corridor and creek.

BCM 0.5

There were dry season violations in D.O. and temperature standards, and post-BMP improvements seen in ammonia-nitrogen and D.O. levels.

Recommendations

- Conduct post-BMP wet season monitoring on Bunker and Deep creeks.
- Conduct two 1998 dry season monitoring events on Bunker and Deep creeks to further monitor effects of BMP implementation and to determine if BMPs are being maintained.
- Follow-up on BMP maintenance in Deep Creek and implement BMP practices on Bunker Creek.

References

Amrine, B., 1998. Personal communication. Lewis Conservation District, Chehalis, WA.

Brummer, S., 1996. Personal communication. Lewis Conservation District, Chehalis, WA.

EPA, 1986. Quality Criteria for Water 1986. EPA 440/5-86-001. U. S. Environmental Protection Agency, Region 10, Washington, DC.

Ireland, R., 1995. The Deep Creek Restoration Project, #W95-17. Chehalis Basin Fisheries Task Force, Aberdeen, WA.

Linsley, R., M. Kohler and J. Paulhus. 1975. Hydrology for Engineers, Third edition. McGraw-Hill Book Company, New York, NY.

Perrich, J., 1992. The ESE National Precipitation Databook. Cahners Publishing, Danville, CA.

Pickett, P., 1994. Upper Chehalis River Dry Season Total Maximum Daily Load Study. Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, WA.

Sargeant, D., 1994. Chehalis River Basin Best Management Practices Evaluation Project Quality Assurance Project Plan. Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, WA.

-----------, 1995. Addendum to Quality Assurance Project Plan for the Chehalis River Basin Best Management Practices Evaluation Project. Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, WA.

-----------, 1996a. Bunker/Deep Creek Water Quality Data report, 1994-95. Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, WA.

-----------, 1996b. *1996-97 Chehalis Best Management Practices monitoring*. Memorandum to Mike Kelly (USFWS) and Kahle Jennings (Ecology), July 2, 1996. Environmental Investigations and laboratory Services Program, Washington State Department of Ecology, Olympia, WA.

-----------, 1997a. Chehalis River Best Management Practices Evaluation Project, 1995-96 Water Quality Data Report for Bunker/Deep Creek Project Area. Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, WA.

-----------, 1997b. *QAPP Addendum for 1997-98 Chehalis BMP Monitoring*. Memorandum to Mike Kelly (USFWS) and Kahle Jennings (Ecology) dated October 2, 1997. Environmental Investigations and Laboratory Services Program, Washington State Department of Ecology, Olympia, WA.

SYSTAT, 1991. SYSTAT version 5.0 SYSTAT, Inc., April 1991.

Contacts

Debby Sargeant/	Washington State Department of Ecology
Paul Pickett	Environmental Investigations and Laboratory Services Program
	(360) 407-6684/(360) 407-6685

If you have special accommodation needs, please contact Shirley Rollins at (360) 407-6696 (voice). Ecology's telecommunication device for the deaf (TDD) number at Ecology Headquarters is (360) 407-6006.

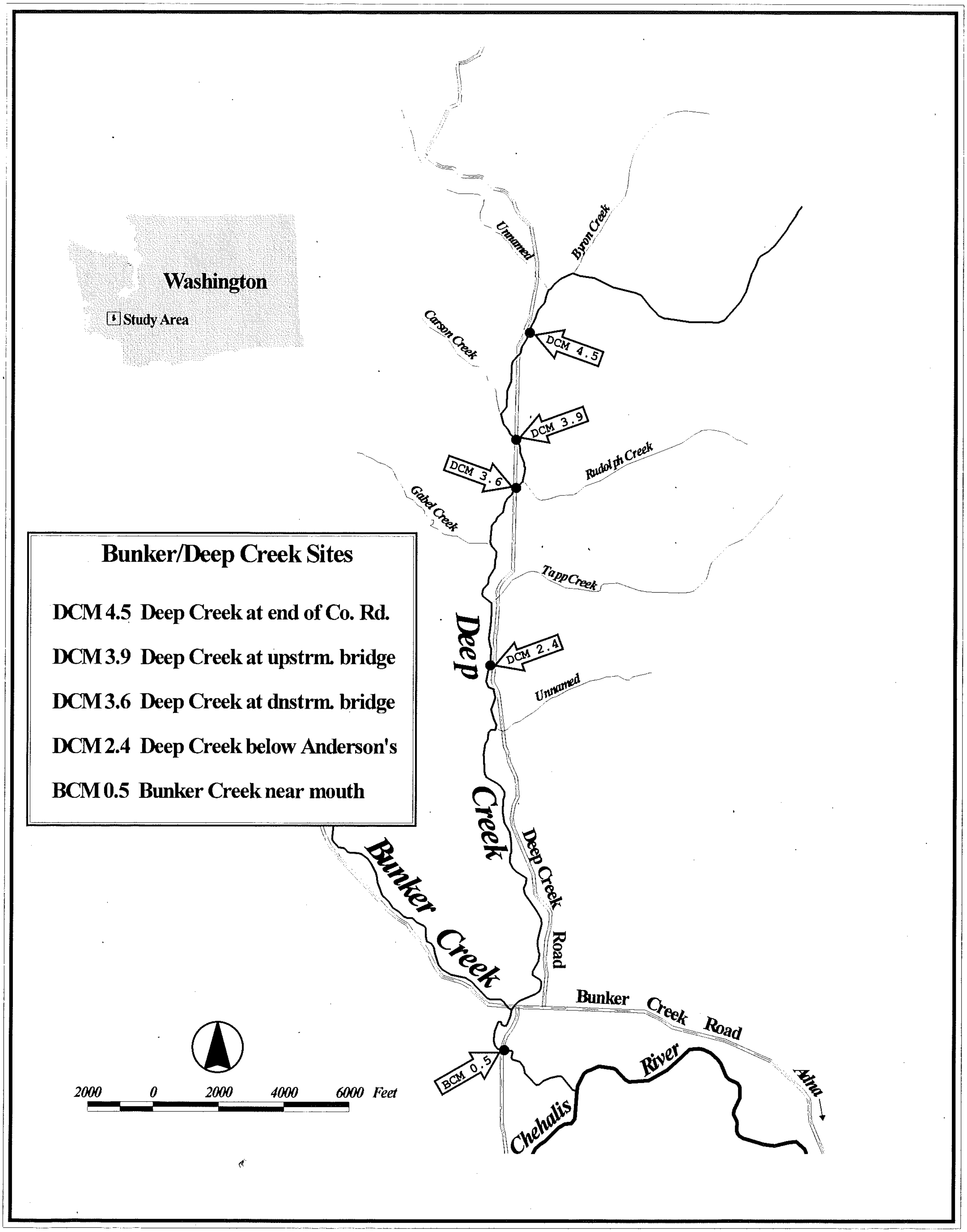


Figure 1. Bunker and Deep Creek Sampling Sites

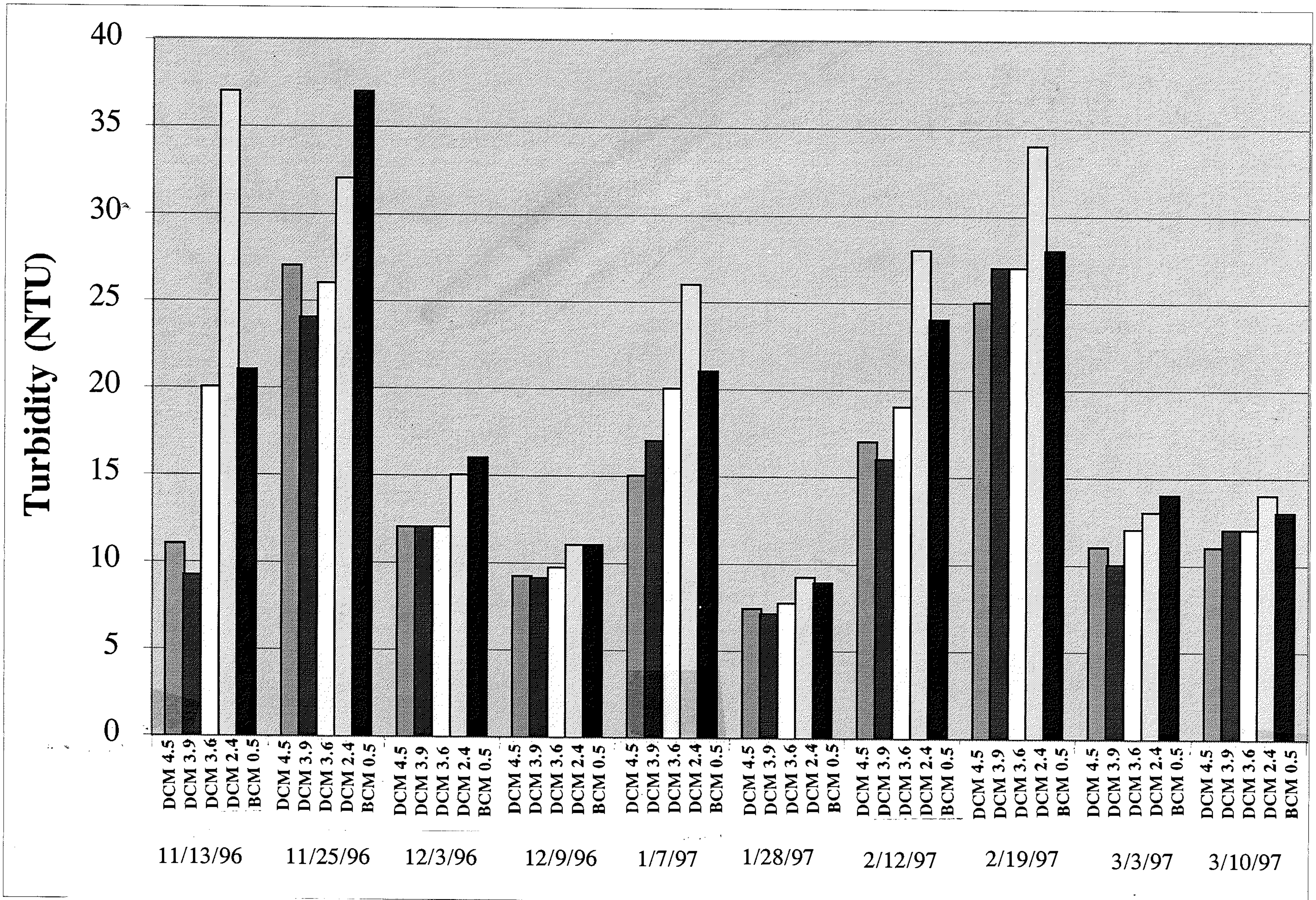


Figure 2. 1996-97 Wet Season Monitoring Results for Turbidity.

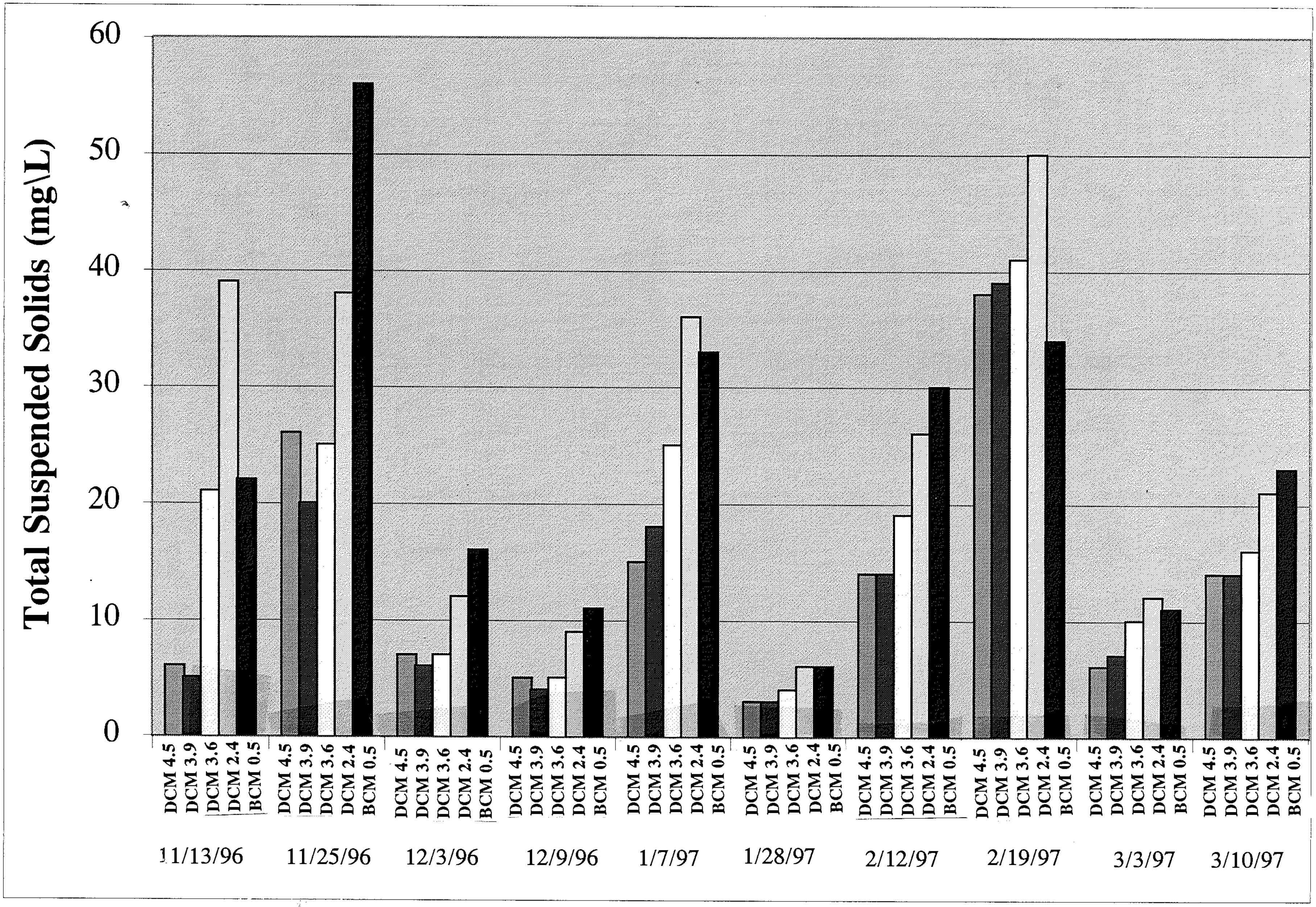


Figure 3. 1996-97 Wet Season Results for Total Suspended Solids.

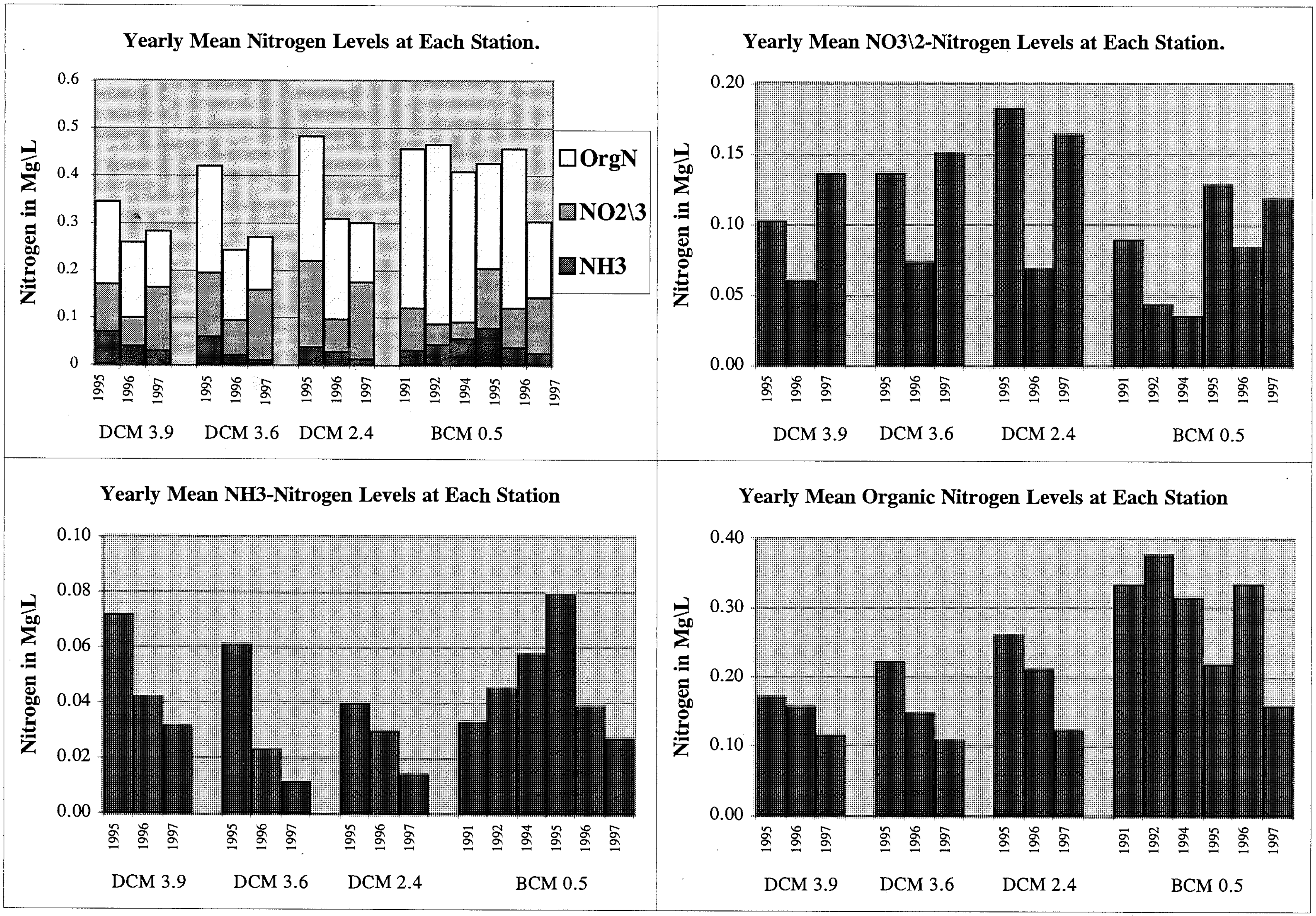


Figure 4. Average Dry Season Nitrogen Levels by Station.

* 1991-92 BCM 0.5 data from Upper Chehalis River Dry Season TMDL (Pickett, 1994).

Figure 5. Average Dry Season Total Phosphorus Levels at Each Station

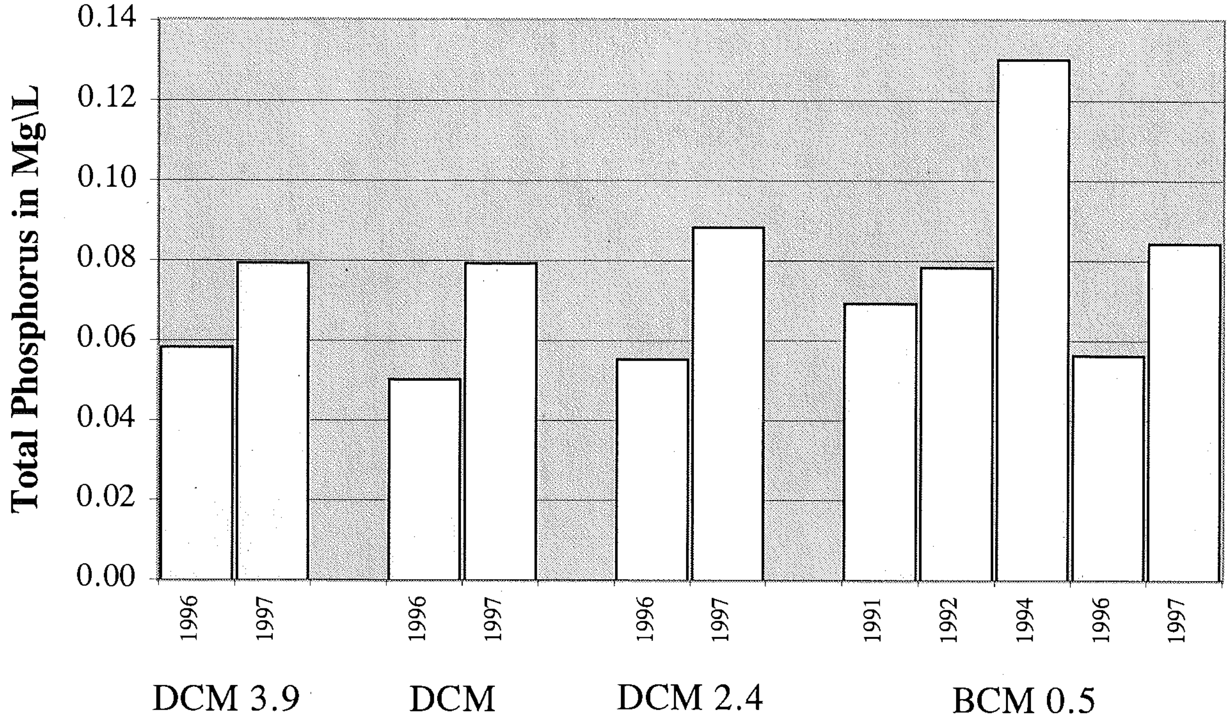
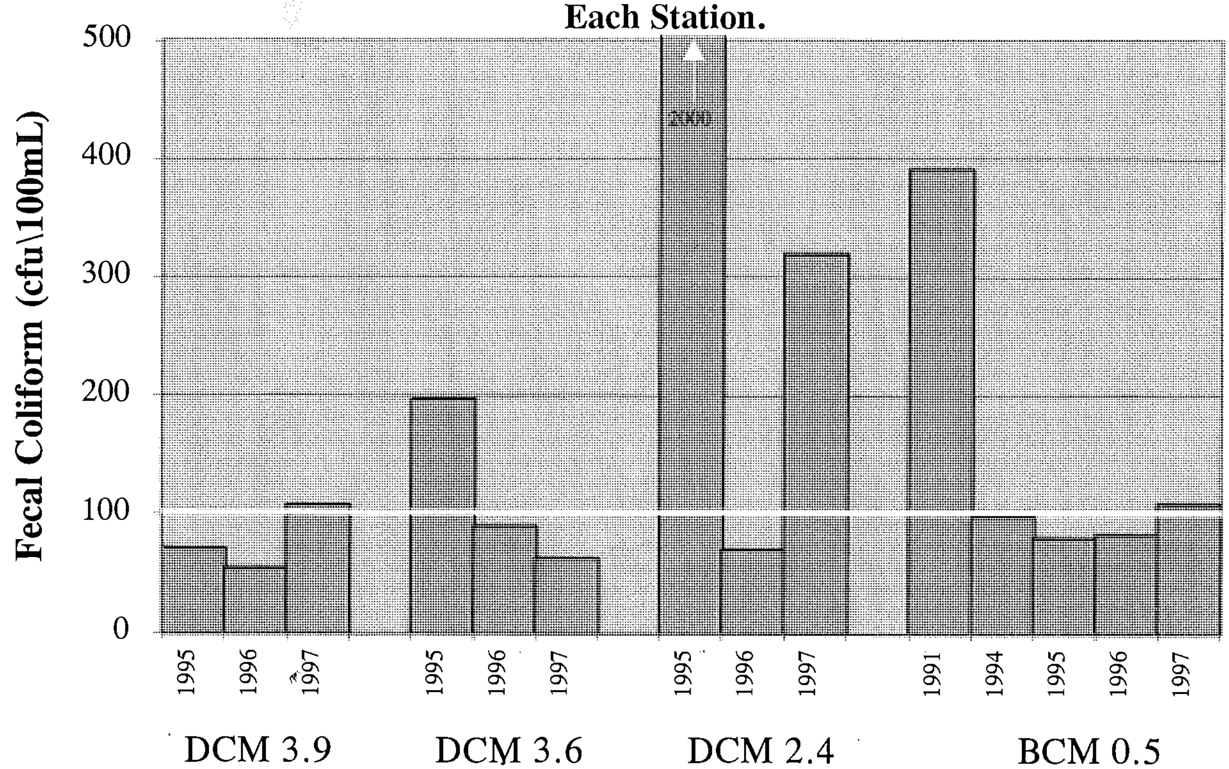


Figure6 Dry Season Geometric Mean Fecal Coliform Levels at Each Station.



* 1991-92 data from Upper Chehalis River Dry Sesaon TMDL (Pickett, 1994).

Appendix A.
Bunker\Deep Creek Wet Season Field and Laboratory Data
(paired values are field replicates)

Site Location	Date	Temperature ° C	pH	Conductivity umho/cm*	Discharge cfs	Turbidity NTU		Total Suspended Solids mg/L	
DCM 4.5	11/7/95	8.3	6.8	72	23	28		16	
DCM 4.5	12/4/95	8.0	6.6	57	34	13	12	14	15
DCM 4.5	12/11/95	8.5	6.5	56	45	23		24	
DCM 4.5	1/3/96	8.4	7.5	64	24	10		6	
DCM 4.5	1/22/96	6.8	7.8	57	53	17		16	
DCM 4.5	2/6/96	5.8	7.5	49	80	110		191	
DCM 4.5	2/20/96	7.6	7.6	55	33	60		52	
DCM 4.5	3/4/96	6.5	6.6	60	8	12		5	
DCM 4.5	3/11/96	8.8	6.7	58	13	16		10	
DCM 4.5	4/1/96	7.4	6.7	65	5	8.3		3	
DCM 3.9	11/7/95	8.2	6.8	70	31	32	32	17	
DCM 3.9	12/4/95	8.2	6.5	56	48	14		16	
DCM 3.9	12/11/95	8.5	6.9	56	59	23		23	
DCM 3.9	1/3/96	8.4	7.4	63	28	10		6	
DCM 3.9	1/22/96	6.7	7.8	58	71	17		18	19
DCM 3.9	2/6/96	5.9	7.6	51	117	130		240	
DCM 3.9	2/20/96	7.4	7.7	55	41	50		38	
DCM 3.9	3/4/96	6.8	6.6	56	E 6	12	11	4	
DCM 3.9	3/11/96	8.9	6.7	62	15	15		9	
DCM 3.9	4/1/96	7.6	6.8	62	5	7.4		2	
DCM 3.6	11/7/95	8.2	6.8	71	34	35		28	
DCM 3.6	12/4/95	8.2	6.4	56	51	16		24	
DCM 3.6	12/11/95	8.5	6.7	65	60	27		31	
DCM 3.6	1/3/96	8.4	7.4	64	28	11	11	8	
DCM 3.6	1/22/96	6.8	7.9	62	77	18		24	
DCM 3.6	2/6/96	6.0	7.7	50	E 142	190		360	332
DCM 3.6	2/20/96	7.5	7.8	55	42	50		42	
DCM 3.6	3/4/96	6.8	6.6	60	10	11		5	
DCM 3.6	3/11/96	9.2	6.7	60	17	15		9	
DCM 3.6	4/1/96	7.8	6.8	65	6	8.0		3	
DCM 2.4	11/7/95	8.2	6.8	73	56	60		69	
DCM 2.4	12/4/95	8.1	6.7	59	60	22		36	
DCM 2.4	12/11/95	8.6	6.9	79	82	30		41	
DCM 2.4	1/3/96	8.4	7.3	63	39	15		14	11
DCM 2.4	1/22/96	6.8	8.1	59	97	26		39	
DCM 2.4	2/6/96	6.0	7.7	51	E 170	190		335	
DCM 2.4	2/20/96	7.5	7.6	58	59	55		55	
DCM 2.4	3/4/96	6.8	6.6	60	16	13		7	
DCM 2.4	3/11/96	9.2	6.8	66	23	16	17	12	
DCM 2.4	4/1/96	7.9	6.9	70	7	9.1		4	
BCM 0.5	11/7/95	7.7	7.0	60	~	85		138	
BCM 0.5	12/4/95	7.9	7.0	51	~	16	17	22	
BCM 0.5	12/11/95	8.4	6.8	72	~	25		34	
BCM 0.5	1/3/96	8.5	6.8	76	~	13		16	
BCM 0.5	1/22/96	6.4	7.9	52	~	21		32	
BCM 0.5	2/6/96	5.4	7.7	46	~	80		130	
BCM 0.5	2/20/96	7.3	7.7	60	~	35		39	
BCM 0.5	3/4/96	6.8	6.6	54	~	12	12	7	
BCM 0.5	3/11/96	9.4	6.8	55	~	13		10	
BCM 0.5	4/1/96	8.2	7.1	63	~	12		6	6

* Specific conductance at 25° C
E Field estimate\gauge reading.
~ Wet season flows were not obtained at BCM 0.5

Appendix B.

1994-97 Bunker\Deep Creek Dry Season Field and Laboratory Data

(paired values are field replicates)

Site Location	Date	Time	Temp. °C	pH	Conductivity umho/cm*	Discharge cfs	Dissolved Oxygen mg\L**		Dissolved Oxygen % Saturation	BOD5 mg/L		Nitrite\nitrate nitrogen mg/L		Ammonia Nitrogen mg/L		Total Persulfate Nitrogen mg/L		Total Phosphorus mg/L		Fecal Coliform cfu/100 mL	
DCM 3.9	7/12/95	12:55	14.2	6.6	103	0.3	8.1	8.2	79%			0.182		0.069		0.463				55	61
DCM 3.9	8/14/95	10:40	12.5	7.4	114	0.1	6.6	6.7	62%			0.022		0.074		0.224				85	
DCM 3.9	7/8/96	12:00	15.0	7.5	60	0.3	7.7	7.8	77%			0.084		0.028		0.256		0.022		36	
DCM 3.9	8/6/96	10:30	14.4	7.2	&	0.8	5.7		56%			0.054		0.035		0.257		0.063		90	79
DCM 3.9	9/11/96	12:22	12.7	7.3	110	0.1	5.8		55%			0.042		0.062				0.090		48	57
DCM 3.9	7/1/97	12:55	12.9	7.4	83	1.9	9.0	9.0	85%			0.206		< 0.010		0.368		0.057		25	26
DCM 3.9	8/5/97	10:30	15.4	7.7	86	0.3	6.2	6.1	62%			0.161		0.050		0.312		0.078		180	
DCM 3.9	9/8/97	11:10	13.0	7.3	112	< 0.2	5.4	5.5	52%			0.040		0.034		0.164		0.101		270	
DCM 3.6	7/12/95	12:20	13.8	6.7	110	0.3	9.1	9.1	88%			0.250	0.254	0.038	0.047	0.577	0.464			220	260
DCM 3.6	8/14/95	11:30	12.4	7.7	117	0.1	7.5	7.5	70%			0.020		0.079		0.317				210	
DCM 3.6	7/8/96	12:45	15.1	7.5	61	0.7	8.8		87%			0.104		0.048		0.262		0.026		22	26
DCM 3.6	8/6/96	11:00	14.4	7.4	&	0.5	7.7	7.7	75%			0.078		< 0.010		0.270		0.054		170	
DCM 3.6	9/11/96	12:56	13.0	7.2	123	0.0	6.0	5.9	56%			0.037		< 0.010				0.069		170	
DCM 3.6	7/1/97	13:30	13.1	7.5	86	2.6	9.5	9.4	90%			0.222		0.012		0.353		0.072		43	
DCM 3.6	8/5/97	11:30	15.6	7.5	88	0.3	7.9	7.9	79%			0.110		< 0.010		0.225		0.066		61	
DCM 3.6	9/8/97	11:50	13.4	7.8	119	< 0.2	7.5	7.4	71%			0.126	0.112	< 0.010	0.011	0.234	0.224	0.098	0.102	96	84
DCM 2.7T	9/13/95	11:00																		200	220
DCM 2.7	9/13/95	11:00																		150	
DCM 2.4	7/12/95	11:45	13.7	6.8	118	0.8	9.1	9.2	88%			0.326		0.051		0.644				J 5600	
DCM 2.4	8/14/95	12:15	13.1	7.7	141	0.1	7.2	7.2	67%			0.039	0.037	0.028	0.027	0.306	0.332			1200	1500
DCM 2.4	9/13/95	10:20				0.2														930	1200
DCM 2.4	7/8/96	13:25	15.6	7.5	73	0.6	8.6		86%			0.125	0.128	0.020	0.021	0.370	0.309	0.031	0.037	84	
DCM 2.4	8/6/96	9:55	14.5	7.2	&	0.8	6.8		67%			0.052		< 0.010		0.290		0.053		55	
DCM 2.4	9/11/96	13:15	13.4	7.3	155	0.1	6.4		61%			0.026		0.057				0.079		72	
DCM 2.4	7/1/97	14:00	13.6	7.6	94	2.5	9.6	9.7	93%			0.264		0.013		0.450		0.068		100	
DCM 2.4	8/5/97	12:20	16.3	7.6	100	0.5	7.8	7.8	80%			0.146		0.012		0.236		0.095		420	430
DCM 2.4	9/8/97	12:30	13.5	7.7	143	0.2	7.4	7.5	72%			0.081		0.016		0.211		0.100		J 760	
BCM 0.5	8/30/94	16:50	18.6	7.0	145	0.1	4.2		45%	< 2		0.036		0.043		0.318	0.129			130	
BCM 0.5	8/31/94	10:45	16.3		147	0.1	4.5	4.5	46%	< 2	< 2	0.043		0.042		0.435					
BCM 0.5	9/14/94	8:27	14.9	7.0	137	0.2	3.1		31%	< 2		0.031		0.096		0.511	0.129				
BCM 0.5	9/14/94	13:35	15.9	6.9	136	0.2	4.0		41%	< 2		0.029		0.049		0.364	0.129			88	61
BCM 0.5	7/12/95	10:45	14.8	6.6	115	2.9	7.5	7.5	74%	< 3	< 3	0.201		0.058		0.507				130	
BCM 0.5	8/14/95	9:15	14.8	7.3	118	0.7	5.2	5.2	51%	< 3	< 3	0.054		0.102	0.097	0.342				57	39
BCM 0.5	7/8/96	11:40	15.9	7.5	85	2.8	7.4		75%	< 3		0.116		0.035		0.496		0.031		200	
BCM 0.5	8/6/96	9:00	15.8	6.8	&	2.3	5.5		55%	< 3	< 3	0.078		0.036		0.436		0.052		69	
BCM 0.5	9/11/96	13:35	15.4	7.3	110	0.5	4.8		48%	< 3		0.055	0.056	0.046	0.044			0.083	0.088	33	48
BCM 0.5	7/1/97	14:35	14.7	7.7	92	11.1	9.0	9.0	89%	< 4		0.183		0.013		0.405		0.070		75	
BCM 0.5	8/5/97	13:15	18.3	7.5	103	1.3	5.8	5.8	62%	< 4	< 4	0.091		0.030		0.234		0.077		64	
BCM 0.5	9/8/97	13:15	15.4	7.5	131	0.9	6.0	6.1	61%	< 4		0.081		0.038		0.267		0.106		260	

* Specific conductance at 25° C

** D.O. determined by using the azide-modified Winkler titration method.

& Conductivity meter not functioning

J An estimated count; signifies greater than 150 fecal colonies on the plate. The "true" results could be greater than or equal to the reported result.

< Less than the reported result