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AN INVESTIGATION TO DEFINE

MINIMUM STREAM FLOWS NECESSARY

TO SUSTAIN THE FISH AND WILDLIFE

RESOURCES OF THE UPPER CLARK FORK RIVER

Eutrophication-Related
Influences

Baseline Nutrient, Diel Dissolved Oxygen and Algal Accrual
Studies during 1976-77 and a Review of
Previous Investigations

MONTANA DEPARTMENT OF FISH AND GAME

Ecological Services Division

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and

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April 1978

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CONTENTS

LIST OF TABLES-----	iii
LIST OF FIGURES-----	iv
I. INTRODUCTION-----	1
II. METHODS-----	2
A. Water Quality Sampling-----	2
B. Diel Dissolved Oxygen and Temperature Sampling-----	3
C. Periphyton (Artificial Substrate) Sampling-----	3
III. RESULTS AND DISCUSSION-----	3
A. Water Quality Sampling-----	3
1. USGS Program 1969-1973-----	5
2. EPA Program 1974-----	5
B. Diel Dissolved Oxygen and Temperature Sampling-----	11
1. Montana WQB Survey (Braico) 1973-----	11
2. Optimum Dissolved Oxygen for Growth of Salmonids-----	22
3. Optimum and Lethal Temperature for Salmonids-----	22
C. Periphyton Sampling-----	23
D. Situation Statement-----	25
IV. LITERATURE CITED-----	26
APPENDIX 1. USGS Data, Deer Lodge and Galen-----	27
APPENDIX 2. USGS Data, Garrison and Drummond-----	28
APPENDIX 3. USGS Data, Alberton-----	29
APPENDIX 4. USGS Data, Above Missoula-----	30
APPENDIX 5. USGS Data, Thompson Falls-----	31
APPENDIX 6. USGS Data, Bitterroot River at Maclay Bridge-----	32
APPENDIX 7. USGS Data, Flathead River at Perma-----	33
APPENDIX 8. EPA Data, Upper Clark Fork River 1974-----	34

CONTENTS (CONTINUED)

APPENDIX 9.	Ambient Air Temperature and Precipitation Conditions at Reporting Weather Stations During the Diel Dissolved Oxygen Sampling Periods in 1973, 1976 and 1977-----	37
APPENDIX 10.	Diel Dissolved Oxygen as Percent Saturation Versus Time (Modified from Braico, 1973)-----	38
APPENDIX 11.	Diel Dissolved Oxygen as Percent Saturation Versus Time (Modified from Braico, 1973)-----	39
APPENDIX 12.	Time, Temperature, Dissolved Oxygen and Percent Saturation for 5 Stations on the Clark Fork River 8/2-3/73-----	40
APPENDIX 13.	Selected Streamflow Data (Cubic Feet Per Second) during Diel Dissolved Oxygen Sampling Periods-----	41
APPENDIX 14.	Maximum and Minimum Stream Temperatures Recorded at the Bonita Station on the Clark Fork River during the Summer of 1977-----	42

LIST OF TABLES

TABLE

1.	Water Quality Data for 6 Stations on the Clark Fork River 7/21/77-----	6
2.	Water Quality Data for 6 Stations on the Clark Fork River 8/4/77-----	7
3.	Water Quality Data for 6 Stations on the Clark Fork River 8/18/77-----	8
4.	Water Quality Data for 9 Mainstream Stations and 3 Tributaries of the Clark Fork River 9/13-14/77-----	9
5.	Time, Temperature, Dissolved Oxygen and Percent Saturation for 3 Stations on the Clark Fork River 7/20/76-----	12
6.	Time, Temperature, Dissolved Oxygen and Percent Saturation for 2 Stations on the Clark Fork River 7/20/77-----	13
7.	Time, Temperature, Dissolved Oxygen and Percent Saturation for 3 Stations on the Clark Fork River 8/3/77-----	14
8.	Time, Temperature, Dissolved Oxygen and Percent Saturation for 2 Stations 8/17/77-----	15
9.	Time, Temperature, Dissolved Oxygen and Percent Saturation for the Clark Fork River at Bonita 9/13/77-----	16
10.	Periphyton Biomass as Chlorophyll-a (mg/M ² /day) from Microscope Slides Suspended in Artificial Substrates at 6 Stations on the Clark Fork River-----	24

LIST OF FIGURES

FIGURE

1. Clark Fork River and Tributaries-----4
2. Diel Dissolved Oxygen as Percent
Saturation Versus Time, 7/20/76-----17
3. Diel Dissolved Oxygen as Percent
Saturation Versus Time, 7/20/77-----18
4. Diel Dissolved Oxygen as Percent
Saturation Versus Time, 8/3/77-----19
5. Diel Dissolved Oxygen as Percent
Saturation Versus Time, 8/17/77-----20
6. Diel Dissolved Oxygen as Percent
Saturation Versus Time, 9/13/77-----21

I. INTRODUCTION

During the summers of 1976 and 1977 the Montana Department of Fish & Game conducted diel dissolved oxygen and periphyton productivity studies in the Clark Fork River between Deer Lodge and Huson, Montana. During the summer of 1976 diel dissolved oxygen was monitored only once; however, during the summer of 1977 it was monitored on 4 occasions. Additionally, during the summer of 1977, water samples were collected at six mainstem stations on four dates for common ion and nutrient analyses. Artificial substrates, used to measure periphyton production, were installed and sampled periodically at these same stations. Also, one water sampling run, consisting of twelve stations, was conducted from Deer Lodge to Thompson Falls. Included in this run were analyses for nutrients, common ions and seven heavy metals per station.

The ultimate goal of this study is to determine the correlation between decreased water quantity and quality and relative increases in algal production with subsequent nighttime "sags" of dissolved oxygen. Such predictive information will be formulated after the collection and study of additional data. The data herein, including a review of information from previous studies by other agencies on the Clark Fork River, comprises an initial, baseline report.

Early morning dissolved oxygen levels dipped quite low in the upper Clark Fork River during the July 1977 sampling run. August dissolved oxygen sags were not quite so severe, presumably a result of unseasonably cold and rainy weather.

Periphyton productivity measurements were plagued by vandalism. However, the scattered data that was obtained generally demonstrated that increased

periphyton production was correlated with higher concentrations of macro-nutrients such as phosphate and nitrate.

II. METHODS

A. Water Quality Sampling

The following six mainstem stations were sampled once in late July, twice in August and once in mid September for common ion and nutrient analyses:

<u>STATION</u>	<u>LEGAL DESCRIPTION</u>
Deer Lodge	T8N R9W Sec. 3
Gold Creek	T10N R11W Sec. 26
Bonita	T11N R16W Sec. 10
Turah	T12N R18W Sec. 2
Reserve St. (Missoula)	T13N R19W Sec. 18
* Grove St. (Missoula)	T13N R19W Sec. 19
Huson	T15N R22W Sec. 26

* The Grove Street station was substituted for Reserve Street station starting with the 2nd August sampling run. The Grove Street station was approximately 1000 feet (300 meters) below the City of Missoula waste treatment plant.

In mid September the following additional stations were sampled along with the previously mentioned 6 stations for common ions, nutrients and total recoverable metals:

<u>STATION</u>	<u>LEGAL DESCRIPTION</u>
Blackfoot River above Bonner	T13N R18W Sec. 22
Bitterroot River at Missoula	T13N R20W Sec. 26
Clark Fork at Superior	T17N R26W Sec. 34
Clark Fork above Paradise	T18N R25W Sec. 4
Flathead River below Perma	T18N R24W Sec. 6
Clark Fork at Thompson Falls	T21N R29W Sec. 8

All chemical analyses were performed by the chemistry laboratory of the Department of Health and Environmental Sciences in Helena, Montana. A description of the study area and sampling stations is displayed in Figure 1.

B. Diel Dissolved Oxygen and Temperature Sampling

Diel dissolved oxygen and temperature measurements were made at selected mainstem stations once in July of 1976 and 1977, twice in August of 1977 and once in September of 1977. These measurements were obtained by teaming a Uniloc dissolved oxygen analyser/recorder with a Taylor seven-day recording thermograph. The dissolved oxygen analysers were periodically calibrated with Iodometric titrations (APHA 1975).

C. Periphyton (Artificial Substrate) Sampling

Artificial substrates, consisting of transparent slide trays holding 8 microscope slides suspended below the water surface by floating supports (available from Design Alliance, Cincinnati, Ohio), were placed at the 6 mainstem stations several times during the summer of 1977. As was mentioned earlier, many of these artificial substrates were lost to vandalism. Samples that were collected were preserved for biomass accrual determinations as dry and ash weights and as chlorophyll-A expressed in $\text{mg}/\text{M}^2/\text{day}$, or net productivity (APHA 1975).

III. RESULTS & DISCUSSION

The data from the summers of 1976 and 1977 are only baseline in nature and are not, at this time, predictive. It is anticipated that additional data collection methods, including algal assays, will be utilized in preceeding years. However, some important trends in the data collected thus far can be noted.

A. Water Quality Sampling

Summertime macronutrient concentrations are highest in the upper river in the vicinity of Deer Lodge. Nutrient concentrations gradually decreased

CLARK FORK AND TRIBUTARIES

downstream to very low levels just above Missoula. An increase in nutrient concentrations was obvious just below Missoula while concentrations 60 miles (95 Km) below Missoula at Superior were very low and remained low to Thompson Falls. The samples from the three major tributaries, (The Blackfoot, Bitterroot and Flathead Rivers) were conspicuously low in dissolved salts and nutrients. Only the Bitterroot had detectable levels of orthophosphate or nitrate. Water Quality data is displayed in Tables 1 through 4.

Additionally, a recent review of records at the Montana Department of Health and Environmental Sciences, Water Quality Bureau, revealed that although a considerable amount of water quality data has been collected during recent years in the upper Clark Fork River, the majority of this data has been collected above Gold Creek. The primary emphasis during most of the past collections, in turn, has been towards heavy metal or common ion analyses; very little nutrient information has been accumulated during federal, state or private surveys.

One notable exception is a series of samples collected by the U.S. Geological Survey from 1969-1973. From 1969-1971, monthly samples were collected at five stations - Deer Lodge, Garrison, above Missoula, Alberton, and Thompson Falls. In the remaining two years, all of these stations except Thompson Falls were discontinued, but Galen (above Deer Lodge) and Drummond were added along with the Bitterroot River at Missoula and the Flathead River at Perma. The sampling frequency was also reduced in these latter two years, but the records are still worthy enough to serve as reliable background information. The USGS data for these four years is therefore presented by station in Appendices 1-7.

Another informative set of data was collected by the U.S. Environmental Protection Agency from August 19-23, 1974 (EPA 1975). Ten mainstem stations

TABLE 1

WATER QUALITY DATA FOR 6 STATIONS
ON THE CLARK FORK RIVER 7-21-77

<u>STATION</u>	HCO ₃	CO ₃	SO ₄	pH	COND.	HARD	ALKA.	TSS	TP	PO ₄	NO ₂ NO ₃
DEER LODGE	201.	0.	232.	7.9	763		165		.078	.060	.11
GOLD CREEK	206.	0.	155.	8.2	639		169		.056	.045	.03
BONITA	222.	0.	151.	8.0	639		182		.021	.010	.07
TURAH	157.	0.	82.	8.2	403		129		.011	.004	.04
RESERVE ST. MISSOULA	155.	0.	43.0	8.2	329		127		.010	.003	.03
HUSON	143.	0.	32.0	8.1	309		122		.023	.017	.07

TABLE 2
WATER QUALITY DATA FOR 6 STATIONS ON THE
CLARK FORK RIVER 8-4-77

STATION	Ca	Mg	Na	HCO ₃	CO ₃	SO ₄	pH	COND.	HARD	ALKA.	TSS	TP	PO ₄	NO ₂ NO ₃
DEER LODGE	105.	20.7	27.9	306.	0.	227	8.2	757.6	348	251		.091	.055	.10
GOLD CREEK	94.	9.7	23.0	202.	4.	164	8.3	666.7	276	172		.063	.035	.01
BONITA	88.	14.3	17.9	212.	0.	14.1	8.2	648.0	279	174		.039	.016	.05
TURAH	56.	14.6	10.5	155.	4.	86.	8.4	420.5	200	133		.021	.009	.04
RESERVE ST. MISSOULA	45.5	13.9	7.20	159.	0.	44.6	8.2	337.5	171	130		.024	.008	.03
HUSON	38.1	11.8	11.0	157.	0.	29.4	7.8	319.1	144	129		.049	.019	.05

TABLE 3

WATER QUALITY DATA FOR 6 STATIONS ON THE
CLARK FORK RIVER 8-18-77

STATION	Ca	Mg	Na	HCO ₃	CO ₃	SO ₄	pH	COND.	HARD	ALKA.	TSS	TP	PO ₄	NO ₂ NO ₃
DEER LODGE	65.	31.5	28.2	167.	8.	167.	8.5	753.	292	150	5.8	.072	.058	.06
GOLD CREEK	80.	19.2	24.	169	5.	154	8.5	654.	279	146	7.8	.048	.029	.01
BONITA	66.	28.9	18	185	11.	145	8.4	665.	285	170	9.4	.027	.012	.03
TURAH	56.	17.7	11.6	92	37.	87	8.4	456	213	136	5.3	.015	.005	.02
GROVE ST. MISSOULA	41.8	14.4	7.00	142	3.	38.5	8.4	337	164	121	7.4	.015	.004	<.01
HUSON	36.8	14.2	11.8	160	3.	25.4	8.4	337	150	136	3.1	.035	.021	.02

TABLE 4

WATER QUALITY DATA FOR 9 MAINSTREAM
STATIONS AND 3 TRIBUTARIES OF THE
CLARK FORK RIVER 9/13 & 9/14 1977

	Ca	Mg	Na	K	HCO ₃	CO ₃	Cl	SO ₄	pH	COND	HARD	ALKA	JTU's
DEER LODGE	95	26	26	7.4	200	0.	15.6	205	8.2	703	344	164	.5
GOLD CREEK	103	19.5	24	6.9	182	4.	12.3	242	8.4	744	350	156	.6
BONITA	93	31	19.5	6.3	209	3.	9.7	193	8.3	685	360	176	.3
TURAH	63	17.6	13.4	4.9	156	6.	5.9	117	8.6	431	157	138	.3
BLACKFOOT RIVER ABOVE BONNER	35.5	13.0	4.0	2.1	162	4.	1.7	7.0	8.5	266	142	139	.2
GROVE ST. MISSOULA	49.6	14.1	11.0	3.9	166	0.	5.7	71	8.1	396	182	136	.3
BITTERFOOT RIVER AT MISSOULA	31.5	5.7	3.6	3.6	132	0.	3.4	7.4	8.1	225	102	103	.7
HUSON	44.0	10.2	12.5	3.6	162	0.	6.4	41.0	8.2	344	152	133	.2
SUPERIOR	41.0	9.1	11.0	3.3	149	2.	5.4	35.0	8.4	321	140	126	.4
FLATHEAD RIVER AT PERMA	28.0	6.3	2.0	1.1	110	0.	1.7	6.5	8.2	180	96	90	.2
PARADISE	38.5	10.7	10.3	3.2	141	3.	4.7	31.0	8.4	307	140	120	.5
THOMPSON FALLS	31.5	5.7	4.9	2.0	120	0	3.2	12.0	8.2	203	102	99	.6

TABLE 4 (Continued)

WATER QUALITY DATA FOR 9 MAINSTREAM
STATIONS AND 3 TRIBUTARIES OF THE
CLARK FORK RIVER 9/13 & 9/14 1977

	TP	PO ₄	NO ₂ NO ₃	Hq	Mn	Zn	Cd	Pb	Fe	Cu
DEER LODGE	.068	.045	.20	<.0002	.06	<.01	<.001	<.05	.07	<.01
GOLD CREEK	.040	.022	<.01	<.0002	.09	.02	<.001	<.05	.10	.01
BONITA	.030	.012	.15	<.0002	.03	.02	<.001	<.05	.14	<.01
TURAH	.020	.004	<.01	<.0002	.03	<.01	.001	<.05	.06	<.01
BLACKFOOT RIVER ABOVE BONNER	.009	<.001	<.01	<.0002	<.01	<.01	<.001	<.05	<.05	<.01
GROVE ST. MISSOULA	.140	.120	.69	<.0002	.03	<.01	<.001	<.05	.07	.01
BITTERROOT RIVER AT MISSOULA	.020	.003	.09	<.0002	.02	<.01	<.001	<.05	.07	<.01
HUSON	.034	.013	.01	<.0002	.06	<.01	<.001	<.05	.09	<.01
SUPERIOR	.018	.004	<.01	<.0002	.03	<.01	<.001	<.05	.11	<.01
FLATHEAD RIVER AT PERMA	.009	<.001	<.01	<.0002	<.01	<.01	<.001	<.05	<.05	<.01
PARADISE	.020	.002	<.01	<.0002	.02	<.01	<.001	<.05	.09	<.01
THOMPSON FALLS	.008	.001	<.01	<.0002	<.01	<.01	<.001	<.05	.09	<.01

from above Deer Lodge to above Missoula and three tributary stations were sampled for nutrients and heavy metals once per day during this five day period. The results of these nutrient analyses, a description of sampling stations and a map of the EPA study area is presented in Appendix 8.

B. Diel Dissolved Oxygen and Temperature Sampling

In 1977, fluctuations in dissolved oxygen concentrations were greatest at the Deer Lodge station, with late afternoon high values over 11.0 mg/l and early morning low values near 6.0 mg/l. The most severe dissolved oxygen sags were observed in late July 1977 when the dissolved oxygen dipped below 6.0 mg/l at Bonita. Relatively low river flows coupled with warm weather allowed algal populations to reach densities that depleted dissolved oxygen concentrations (through respiration) to these low nighttime levels. As was mentioned earlier, more extreme fluctuations in dissolved oxygen concentrations were expected in August but did not materialize presumably as a result of unseasonably cool and rainy weather (Appendix 9). Dissolved oxygen, temperature and percent saturation of dissolved oxygen data are presented in Tables 5 through 9. These same data are displayed graphically as percent saturation of dissolved oxygen versus time in Figures 2 through 6. It can be readily seen that dissolved oxygen fluctuations were much less dramatic when the river was sampled during the summer of 1976, which compared to 1977, was a much higher flow year. Data collected on the Clark Fork River by Braico (1973) was also gathered during a relatively low flow (and much warmer) year. Data from this 1973 study is illustrated in Appendices 10-11. For comparative purposes, these appendices have been prepared in the same format as Figures 2-6. This 1973 d.o. and temp. data is tabulated in Appendix 12. Appendix 13 compares river flow data from selected stream gauging stations for the 1973, 1976 and 1977 study periods.

TABLE 5

TIME, TEMPERATURE, DISSOLVED OXYGEN AND PERCENT
SATURATION FOR 3 STATIONS ON THE CLARK FORK RIVER 7/20/76

<u>STATION - DEER LODGE</u>				<u>DRUMMOND</u>			<u>BONITA</u>		
<u>TIME</u>	<u>TEMP</u>	<u>DO</u>	<u>% SAT.</u>	<u>TEMP</u>	<u>DO</u>	<u>% SAT.</u>	<u>TEMP</u>	<u>DO</u>	<u>% SAT.</u>
1 PM	66.5 ⁰	9.1	114						
2 PM	69								
3 PM	69.5	8.9	117				67.5 ⁰	8.5	105
4 PM	68			67.5 ⁰	8.4	105			
5 PM	68	8.0	103				69	8.5	106
6 PM	67			67.5	8.1	101	68.5	8.4	104
7 PM	68	7.6	97				68	7.9	98
8 PM	69						66.5	7.7	93
9 PM	68	7.6	97	65.5	8.3	102	65.5	7.7	92
10 PM	67.5						65	7.6	90
11 PM	67	8.0	101				65	7.5	89
12 MID	66.5			63	7.8	92	64.5	7.4	88
1 AM	65.5	7.6	95				64	7.4	87
2 AM	65.5			61.5	8.1	95	64	7.4	87
3 AM	65	7.3	91				64	7.4	87
4 AM	65			60	8.1	93	64	7.4	87
5 AM	64.5	7.0	88				63.5	7.4	87
6 AM	64						63.5	7.4	87
7 AM	63.5	6.8	84	59.5	8.3	94	63.5	7.4	87
8 AM	63						63.5	7.5	88
9 AM	63	7.0	86				63.5	7.5	88
10 AM	63.5						63	7.7	91
11 AM	64	7.0	86	60	8.5	93	63	7.9	93
12 NOON	64.5						63.5	8.1	95
1 PM	65	8.3	104				65	8.4	100
2 PM				64.5	9.2	112	66	8.6	104
3 PM							67	8.7	106

TABLE 6

TIME, TEMPERATURE, DISSOLVED OXYGEN AND PERCENT SATURATION
FOR 2 STATIONS ON THE CLARK FORK RIVER 7/20/77

	STATION -		DEER LODGE		BONITA		
	TIME	TEMP	DO	% SAT.	TEMP	DO	% SAT.
7/20	3 PM	69 ⁰	10.0	129	69 ⁰	9.1	114
	4 PM	70	10.0	131	70	8.6	109
	5 PM	71	10.0	132	71	8.4	107
	6 PM	71	9.4	124	71	7.8	100
	7 PM	70.5	8.0	106	70.5	6.9	88
	8 PM	70	7.8	102	70	6.7	85
	9 PM	69.5	7.4	97	69.5	6.6	83
	10 PM	69	6.8	88	69	6.2	77
	11 PM	68	6.4	82	68	6.0	74
	12 MID	67.5	6.0	76	67.5	5.9	73
7/21	1 AM	67	6.0	76	67	5.9	73
	2 AM	66.5	6.0	73	66.5	5.9	71
	3 AM	66	6.0	73	66	5.9	71
	4 AM	65.5	6.0	73	65.5	6.0	73
	5 AM	65	6.2	74	65	6.1	73
	6 AM	64.5	6.4	77	64.5	6.2	74
	7 AM	64	6.6	79	64	6.3	75
	8 AM	63.5	7.0	86	63.5	6.6	78
	9 AM	63	7.7	94	63	7.0	83
	10 AM	62.5	8.5	103	62.5	7.4	87
	11 AM	63.5	9.2	113	63.5	7.6	90
	12 NOON	65.5	9.6	116	65.5	7.9	96
	1 PM	68.5	10.2	132	68.5	8.1	101
	2 PM	70	10.4	136	70	7.5	95
	3 PM	70	10.6	139			

TABLE 7

TIME, TEMPERATURE, DISSOLVED OXYGEN AND PERCENT SATURATION
FOR 3 STATIONS ON THE CLARK FORK RIVER 8/3/77

	<u>DEER LODGE</u>				<u>BONITA</u>			<u>HUSON</u>		
	<u>TIME</u>	<u>TEMP</u>	<u>DO</u>	<u>% SAT.</u>	<u>TEMP</u>	<u>DO</u>	<u>% SAT.</u>	<u>TEMP</u>	<u>DO</u>	<u>% SAT.</u>
3/3	12 NOON	66 ⁰	10.3	125						
	1 PM	68	10.5	130						
	2 PM	70	11.0	139						
	3 PM	73	11.1	150						
	4 PM	74	11.1	152	74 ⁰	9.6	125			
	5 PM	75	10.6	147	73	9.3	121			
	6 PM	73.5	9.7	127	73	3.6	112			
	7 PM	72	9.3	124	72	3.8	114			
	3 PM	70	3.3	115	71	3.2	105	71 ⁰	10.4	131
	9 PM	63	8.0	102	70	7.5	95	71	9.3	124
	10 PM	67	7.7	97	69	7.0	87	70.5	9.3	116
	11 PM	65.5	7.0	88	68	6.9	85	70	3.9	111
	12 MID	64.5	6.6	87	67	6.8	83	69.5	9.5	106
8/4	1 AM	64	6.5	79	67	6.8	83	69	8.2	101
	2 AM	63	6.4	78	66	6.8	82	69	8.0	99
	3 AM	63	6.4	78	66	6.3	82	68.5	7.8	95
	4 AM	62.5	6.4	78	66	6.8	82	68	7.5	92
	5 AM	62	6.4	77	66	6.9	83	68	7.3	89
	6 AM	61	6.5	77	65	6.9	83	67.5	7.1	86
	7 AM	60.5	6.7	80	65	7.1	85	67	7.1	86
	8 AM	60.5	6.8	81	64	7.6	91	67	7.2	87
	9 AM	61	7.3	87	65	3.1	97	66.5	7.6	91
	10 AM	61.5	3.3	100	66	8.8	114	66	3.1	97
	11 AM	63.5	9.0	110	67	9.1	111	66.5	8.3	99
	12 NOON	66	9.3	123	66	3.9	108	66.5	3.5	102
	1 PM				65	8.7	104	67	8.5	103
	2 PM				66	9.0	109	67.5	3.7	105
	3 PM				67	9.3	114	67	9.0	109
	4 PM				70	9.9	125			

TABLE 3

TIME, TEMPERATURE, DISSOLVED OXYGEN AND PERCENT SATURATION
FOR 2 STATIONS ON THE CLARK FORK RIVER 8/17/77

<u>STATION -</u>		<u>DEER LODGE</u>			<u>BONITA</u>		
	<u>TIME</u>	<u>TEMP</u>	<u>DO</u>	<u>% SAT.</u>	<u>TEMP</u>	<u>DO</u>	<u>% SAT.</u>
8/17	10 AM	59 ⁰	9.7	106			
	11 AM	62	10.0	121			
	12 NOON	64	10.4	129	68 ⁰	9.6	129
	1 PM	66	10.6	133	70	9.8	124
	2 PM	67	10.9	138	71	9.7	124
	3 PM	69	11.2	145	73	9.5	121
	4 PM	71	11.1	147	74	9.4	124
	5 PM	72	10.9	146	74	8.9	118
	6 PM	73	10.6	143	74	8.8	116
	7 PM	74	10.1	138	74	8.2	108
	8 PM	74	9.3	127	73	7.6	99
	9 PM	73	8.2	111	72	6.8	88
8/18	10 PM	72	7.3	98	70	6.5	82
	11 PM	71	6.7	89	69	6.4	80
	12 MID	70	6.4	84	68	6.3	78
	1 AM	69	6.3	81	68	6.3	78
	2 AM	67	6.3	80	67	6.4	78
	3 AM	66	6.2	78	66	6.4	77
	4 AM	65	6.3	78	65.5	6.4	77
	5 AM	64.5	6.4	79	65	6.6	79
	6 AM	64	6.5	80	64	6.7	80
	7 AM	63.5	6.6	81	64	7.0	84
	8 AM	63	6.7	81	63	7.6	89
	9 AM	63	7.1	86	64	8.7	104
	10 AM	63.5	8.0	98	66	9.2	111
	11 AM	65	8.9	110	68	9.6	119
	12 NOON	66	9.5	119	71	10.1	129
	1 PM	68	9.9	127			
	2 PM	69	10.3	133			
	3 PM	72	10.6	142			

TABLE 9

TIME, TEMPERATURE, DISSOLVED OXYGEN, AND PERCENT SATURATION
FOR THE CLARK FORK RIVER AT BONITA 9/13/77

<u>TIME</u>	<u>TEMP</u>	<u>DO</u>	<u>% SAT.</u>
11 AM	57 ⁰	10.0	109
12 NOON	58	10.4	115
1 PM	59	10.5	117
2 PM	60	10.6	120
3 PM	61	10.5	121
4 PM	62	10.0	116
5 PM	62	9.6	111
6 PM	63	9.2	108
7 PM	64	8.4	97
8 PM	63	7.6	89
9 PM	62	7.3	95
10 PM	61	7.2	83
11 PM	60	7.1	81
12 MID	60	7.1	81
9/14 1 AM	59	7.1	79
2 AM	59	7.1	79
3 AM	58	7.1	78
4 AM	58	7.1	78
5 AM	57	7.2	79
6 AM	57	7.4	81
7 AM	56	7.5	81
8 AM	56	8.0	87
9 AM	55	8.8	94
10 AM	56	9.8	106
11 AM	57	10.3	113

FIGURE 2

Clark Fork 7-20-76

DIEL DISSOLVED OXYGEN AS PERCENT
SATURATION VERSUS TIME

△ Deer Lodge
□ Bonita
○ Drummond

5000

FIGURE 3

Clark Fork 7-20-77

DIEL DISSOLVED OXYGEN AS PERCENT
SATURATION VERSUS TIME

△—△ Deer Lodge
□—□ Bonita

FIGURE 4

Clark Fork 8/3/77

DIEL DISSOLVED OXYGEN AS PERCENT
SATURATION VERSUS TIME

FIGURE 5

Clark Fork 8/17/77

DIEL DISSOLVED OXYGEN AS PERCENT
SATURATION VERSUS TIME

△-△ Deer Lodge
□-□ Bonita

FIGURE 6

Clark Fork 9/13/77

DIEL DISSOLVED OXYGEN AS PERCENT
SATURATION VERSUS TIME

□—□ Bonita

It should be noted that violations of the state water quality standard for dissolved oxygen were recorded both at Deer Lodge and Bonita during August of 1973 and during July and August of 1977. In fact, violations occurred at all stations in 1973. The Clark Fork is classified as a C-D₁ stream at Deer Lodge and as a B-D₁ stream at Bonita. For both of these classifications, water quality is to be "Maintained suitable for growth and propagation of salmonid fishes" and Dissolved Oxygen concentration is not to be reduced below 7.0 milligrams per liter."

It is important to maintain sufficient dissolved oxygen concentrations in the Clark Fork River, not only because of the requirements within the State Water Quality Standards, but also because of the needs of fish and other aquatic life. In fact, these standards are based upon the respiratory requirements of fish and aquatic invertebrates. To maintain a highly productive salmonid fishery, the dissolved oxygen must be consistently maintained above 6.0 mg/L, and preferably above 7.0 mg/L (Herman, Warren and Doudoroff 1962; Shumway, Warren and Doudoroff 1964; EPA 1973). Wide diel fluctuations of dissolved oxygen between tolerable but very low and high levels are nearly as harmful to aquatic animals as is continuous exposure to low dissolved oxygen levels (Doudoroff and Shumway 1967).

Elevated stream temperatures when combined with suboptimal dissolved oxygen levels have an additive (or synergetic) impact upon salmonid populations (Garside 1966). The upper maximum average weekly temperature for growth of both rainbow and brook trout is reported to be 19°C (66°F), while 24°C (75°F) is the short term maximum temperature for survival of these species (ERL 1976). These same critical temperature extremes are even lower for brown trout, with the upper limit for growth being 17°C (62.5°F) and 23.5°C (74.5°F) being the upper incipient lethal temperature (EPA 1973).

When dissolved oxygen levels are below those needed for optimum growth of salmonids, which as mentioned above is between 6.0 and 7.0 mg/L, these critical temperature limits are likely to be even lower.

The Region 2 Office of the Montana Department of Fish and Game in Missoula maintained a constant recording thermograph at Bonita during the summer of 1977. Maximum stream temperatures above 74.5°F were recorded on seven separate days from July 22 through August 19. Also, average weekly temperatures exceeded 62.5°F from early July through late August (Appendix 14). The Missoula office has indicated that this thermograph will continue to be operated, since the Clark Fork River immediately above the confluence of Rock Creek is an extremely critical river segment, where summer temperature and/or dissolved oxygen levels could very easily become toxic to salmonid populations. Thermographs will also be maintained at Gold Creek and Bearmouth, which is midway between Bonita and Gold Creek.

C. Periphyton Sampling

Biomass accrual determinations (as dry and ash dry weights) have not yet been completed. However, periphyton biomass as mg/M²/day chlorophyll-a have been calculated for stations where slides were recovered. This data is arranged in Table 10 and is rather spotty as a result of vandalism. However, some trends can be pointed out. Large biomass accumulations seem to occur at stations that had high concentrations of nitrate and phosphate. The Gold Creek station had very low accumulations of algal biomass. This station, however, was dominated by Cladophora, a large perennial algae. During the summer of 1977, conspicuously low nutrient concentrations and biomass accumulations were also found within areas dominated by Cladophora in the Yellowstone River (Knudson, 1977).

TABLE 10

PERIPHYTON BIOMASS AS CHLOROPHYLL-A ($\text{Mg}/\text{M}^2/\text{Day}$) FROM MICROSCOPE SLIDES SUSPENDED IN
ARTIFICIAL SUBSTRATES AT SIX STATIONS ON THE CLARK FORK RIVER. INCUBATION PERIODS
VARIED FROM 7 TO 14 DAYS.

<u>STATION</u>	<u>8/3/77</u>		<u>8/11/77</u>		<u>8/18/77</u>		<u>9/14/77</u>	
	<u># of Slides</u>	<u>$\text{Mg}/\text{M}^2/\text{Day}$</u>	<u># of Slides</u>	<u>$\text{Mg}/\text{M}^2/\text{Day}$</u>	<u># of Slides</u>	<u>$\text{Mg}/\text{M}^2/\text{Day}$</u>	<u># of Slides</u>	<u>$\text{Mg}/\text{M}^2/\text{Day}$</u>
DEER LODGE			3	1.86	2	.97		
2 GOLD CREEK	2	.07	3	.22	2	.05		
BONITA	1	.71			3	.49	3	1.03
TURAH	2	.31					3	.48
GROVE ST.							3	1.56
HUSON	3	2.22						

D. Situation Statement

Additional studies to further explore the nutrient/algae/dissolved oxygen problem are planned for the upper Clark Fork River. These studies are intended to support the need for a reservation of river flow that will adequately protect the fish and wildlife resources of the river. Inherent in any such minimum flow request is the need to understand the impacts of increased nutrient loading, temperature, and dewatering upon algal productivity and subsequently, the dissolved oxygen regime of this segment of the river. Ultimately, of course, these impacts must be related to the salmonid fishery.

Although mining and milling wastes must always be considered as potential threats to the water quality of the Upper Clark Fork River, the pollution control efforts at the Anaconda Company's Butte and Anaconda operations have significantly reduced the heavy metal contamination that had historically depleted the sport fishery in the river above Missoula. The Company's lower settling ponds have also provided nutrient removal (tertiary treatment) for the total of the domestic wastes from these two cities. A continuation of this latter treatment, or a similar type of treatment by the cities themselves, may be necessary to insure the continual recovery of the river. Increased dewatering by agriculture and (potential) fertilizer and petroleum-related developments also present severe threats, as do the nutrient-enriched and/or heated discharges generated by these activities. It would be a lamentable situation if the recently reestablished, and highly successful, salmonid fishery were to be lost again to more insidious, eutrophication-related water quality and quantity problems.

IV. LITERATURE CITED

- American Public Health Association 1975. Standard Methods for the Examination of Water and Wastewater, 14th ed. APHA. 1193 p.
- Braico, R.D. 1973. Dissolved Oxygen and Temperature Diurnal Variations in the Clark Fork River between Deer Lodge and Superior, Montana for the period August 2-3, 1973. Water Quality Bureau, Environmental Sciences Division, Montana Department of Health and Environmental Sciences, Helena. 33 p.
- Doudoroff, P. and D.L. Shumway, 1967. Dissolved Oxygen Criteria for the Protection of Fish. Trans. Amer. Fish. Soc. Publ. No. 4:13-19.
- Environmental Research Laboratory, 1976. Procedures for Developing Temperature Criteria for Freshwater Fish. Ecological Research Series. ERL, Duluth, Minn. IN: Quality Criteria For Water U.S.EPA, Washington D.C..
- Garside, E.T. 1966. Effect of Oxygen in relation to Temperature on the Development of Embryos of Brook Trout and Rainbow Trout. J. Fish. Res. Bd. Canada. 23: 1121-1134.
- Herrmann, R.B., C.E. Warren and P. Doudoroff, 1962. Influence of Oxygen Concentration on the Growth of Juvenile Coho Salmon. Trans. Amer. Fish. Soc. 91(2): 155-167.
- Knudson, K. 1977. Effects of Decreased Water Quantity and Increased Nutrient Additions on Algal Biomass Accumulation, and subsequently, the Dissolved Oxygen Balance of the Yellowstone River. Montana Dept. of Fish and Game Interim Report to the Bureau of Land Management, Denver, Colorado (Final report to be completed in early 1979).
- Montana Department of Fish and Game, 1977. Thermograph Records, Region 2 files (supplied by Don Peters).
- Shumway, D.L., C.E. Warren and P. Doudoroff, 1964. Influence of Oxygen Concentration and Water Movement on the Growth of Steelhead Trout and Coho Salmon Embryos. Trans. Amer. Fish. Soc. 93(4): 342-356.
- U.S. Department of Commerce, 1978. Temperature and Precipitation Records for Montana. Supplied by the National Weather Service Office in Helena.
- U.S. Environmental Protection Agency, 1973. Water Quality Criteria 1972. Ecological Research Series. EPA R3-73-033. Washington D.C. 594 p.
- U.S. Environmental Protection Agency, 1975. Biological Survey of the Clark Fork River, Montana, August 12-23, 1974. Tech. Invest. Branch, Surv. and Anal. Div. EPA Region 8, Denver, Colorado. SA/TIB-36. 42 p.
- U.S. Environmental Protection Agency, 1976. Quality Criteria for Water. EPA Office of Water Planning and Standards. Washington D.C. 256 p.
- U.S. Geological Survey 1970-1973. Water Resources Data for Montana, Part 2. Water Quality Records (a separate publication for each water year). Dept. of the Interior. USGS. Helena, MT.

Appendix 1 USGS Data Deers Lodge and Galen

DEER LODGE

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	TIME	DISS-CHARGE (CFS)	TEMP-FRATURE (DEG C)	NITRATE (MG/L)	NITRITE (MG/L)	AMMONIA-NITROGEN (MG/L)	ORGANIC-NITROGEN (MG/L)	DISS-SOLVED-NITROGEN (MG/L)	DISS-SOLVED-ORGANIC-NITROGEN (MG/L)	TOTAL-PHOSPHORUS (MG/L)	TOTAL-ORGANIC-CARBON (MG/L)	BIO-CHEMICAL-OXYGEN DEMAND (MG/L)	HARDNESS (MG/L)	ALKALINITY AS CaCO3 (MG/L)
OCT. 17...	0845	259	3.5	.60	.10	.03	.32	--	.08	.11	1.0	1.0	598	126
NOV. 06...	0710	296	3.0	.60	.00	.08	.25	--	.15	.30	6.0	2.3	631	126
DEC. 30...	0930	238	.0	.80	.00	.10	.39	--	.10	.12	2.0	1.7	693	146
JAN. 15...	1700	358	.0	.70	.00	--	1.4	--	.03	.04	2.0	1.9	749	116
FEB. 12...	1115	282	2.5	.60	.00	.09	.28	--	.10	.17	2.0	1.0	696	116
MAR. 19...	0715	282	.5	.59	.00	.15	.10	--	.04	.07	1.0	2.2	659	113
APR. 16...	0815	364	2.0	.58	.00	.24	.69	--	.04	.13	2.0	2.1	691	101
MAY 15...	1510	611	12.5	.40	.00	.00	.28	--	.07	.12	3.0	1.9	572	92
JUNE 11...	0830	816	9.5	.10	.00	.04	.75	--	.03	.13	1.0	0.8	332	61
JULY 13...	0815	298	16.5	.35	.00	.01	.42	.15	.05	.05	2.0	0.9	616	105
AUG. 06...	1200	214	11.0	.30	.00	.04	.25	.06	.07	.08	4.0	1.4	722	120
SEPT. 11...	0715	250	11.0	.48	--	.03	--	.14	.06	.06	--	1.3	--	108

CHEMICAL ANALYSES, OCTOBER 1970 TO JUNE 1971

DATE	TIME	DISS-CHARGE (CFS)	TEMP-ERATURE (DEG C)	NITRATE		NITRITE		AMMONIA-NITROGEN		ORGANIC-NITROGEN		DISS-SOLVED-NITROGEN		DISS-SOLVED-ORGANIC-NITROGEN		TOTAL-PHOSPHORUS (MG/L)	TOTAL-ORGANIC-CARBON (MG/L)	BIO-CHEMICAL-OXYGEN DEMAND (MG/L)	HARD-NESS (MG/L)	ALKALINITY AS CaCO3 (MG/L)
				(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)	(MG/L)							
OCT. 09...	0900	229	4.5																690	126
NOV. 05...	0735	290	3.0	.5	.020	--		.05	.30	.010	.22	.10	9.0	--				--	--	121
DEC. 02...	1630	340	1.0	.6	--	--		.10	--	.030	.08	.050	28	.8				1.7	--	120
JAN. 06...	1530	253	.0	--	.060	.20	.12	--	--	.06	--	3.0	2.3	780	130					92
FEB. 03...	1410	610	1.5	--	--	.50	.31	--	--	.03	.13	130	4.3	--					--	105
MAR. 05...	0900	305	.0	--	--	.20	.58	--	--	.10	.070	11	1.4	--					--	77
APR. 08...	1430	325	8.5	.4	.040	.40	.06	.20	.020	.15	.090	7.0	1.6	730	106					75
MAY 08...	0110	975	10.5	--	--	.40	.21	--	--	.15	.18	7.0	2.0	--					--	
JUNE 04...	1300	582	12.5	--	--	.26	.14	--	--	.12	.10	5.0	1.9	--					--	

GALEN

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DISS-CHARGE ICFS	TEMPER- ATURE IDEG C	O15- SOLVED NITRATE MG/L	O15- SOLVED NITRITE MG/L	O15- SOLVED AMMONIA NITRO- GEN MG/L	O15- SOLVED ORGANIC NITRO- GEN MG/L	TOTAL NITRO- GEN MG/L	TOTAL DISS- SOL- VED NITRO- GEN MG/L	O15- SOLVED ORPHO- PHOS- PHORUS PP MG/L	TOTAL PHOS- PHORUS PP MG/L	TOTAL ORGANIC CARBON IC	BIO- CHEM- ICAL OXYGEN DEMAND MG/L	HARD- NESS ICMG/L	ALKALI- NITY AS CaCO3 MG/L	
OCT. 13...	1300	129	6.4	.38	.40	.19	.19	.78	.38	.12	.000	.14	.0	2.4	790	67
JAN. 05...	1440	109	.0	.54	.55	.68	.92	2.2	1.4	.010	.010	.20	2.0	9.2	1200	80
APR. 16...	1230	221	5.0	.37	.39	.40	.08	.67	.48	.10	.020	.10	.0	2.2	1100	61
JULY 19...	1500	94	11.5	--	.19	--	--	.41	.22	.030	.010	.090	--	1.3	1200	61

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	DISS-CHARGE (CFS)	TEMP-FRATURE (DEG C)	NITRATE (MG/L)	NITRITE (MG/L)	AMMONIA-NITROGEN (MG/L)	ORGANIC-NITROGEN (MG/L)	TOTAL-NITROGEN (MG/L)	TOTAL-DISS-SOLVED-NITROGEN (MG/L)	TOTAL-PHOSPHORUS (MG/L)	TOTAL-ORGANIC-CARBON (MG/L)	BIO-CHEMICAL-OXYGEN DEMAND (MG/L)	HARDNESS (MG/L)	ALKALINITY AS CaCO3 (MG/L)
OCT. 1...	1045	94	6.0	.50	--	.98	.42	.61	.18	.03	1.6	.77	58	
NOV. 1...	1015	131	.5	.45	--	1.8	1.3	.01	.00	.06	5.8	.656	56	
DEC. 19...	1500	94	7.0	.26	.49	.94	.65	.01	.01	.04	3.5	.451	74	
JAN. 23...	1615	91	7.0	.06	.69	.63	.01	.01	.02	.02	2.0	.408	51	
FEB. 16...	1700	212	13.5	.14	.49	.35	.01	.01	.08	.08	2.8	.746	55	

Appendix 2
USGS Data
Garrison & Drummond

GARRISON

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1970

DATE	TIME	DIS- CHARGE (CFS)	TEMP- ERATURE (DEG C)	DISSOLVED NITRATE		DISSOLVED NITRITE		AMMONIA NITRO- GEN (MG/L)	ORGANIC NITRO- GEN (MG/L)	TOTAL NITRO- GEN (MG/L)	DIS- SOLVED PHOS- PHORUS (MG/L)	DIS- SOLVED PHOS- PHORUS (MG/L)	TOTAL PHOS- PHORUS (MG/L)	TOTAL CARBON DEMAND (MG/L)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	HARD- NESS AS CALCIUM (MG/L)	ALKA- LINEITY AS CALCIUM (MG/L)
				(MG/L)	(MG/L)	(MG/L)	(MG/L)										
OCT 13...	1110	197	4.5	.40	.00	.00	.29	.29	.05	.06	.11	6.3	.7	561	129		
OCT 13...	1130	456	4.5	.40	.00	.01	.21	.22	.16	.16	.32	9.0	1.7	512	136		
OCT 13...	1145	108	.0	.70	.00	.10	.12	.22	.14	.16	1.0	2.0	626	123			
OCT 13...	1250	161	.0	.60	.00	1.1	1.9	3.0	.07	.21	2.0	1.5	641	126			
OCT 13...	1300	377	2.5	.60	.00	.07	.19	.26	.08	.16	2.0	1.3	593	135			
OCT 13...	1215	935	2.5	.53	.00	.08	.31	.39	.65	.98	1.0	2.2	535	115			
OCT 13...	1230	496	4.0	.49	.00	.18	.01	.20	.08	.15	1.0	1.7	503	100			
OCT 13...	1745	935	11.0	.28	.00	.01	.21	.22	.08	.09	3.0	1.4	381	85			
OCT 13...	1830	1630	9.5	.01	.00	.01	.66	.67	.01	1.0	1.6	200	123				
OCT 13...	1200	510	15.5	.10	.00	.01	.29	.29	.09	.10	4.0	1.1	376	115			
OCT 13...	1010	126	21.5	.07	.00	.05	.73	.78	.06	.10	2.0	1.9	513	123			
OCT 13...	1030	278	9.5	.34	.00	.02	.00	.36	.12	.21	.0	2.0	.00	123			

CHEMICAL ANALYSES, OCTOBER 1970 TO JUNE 1971

DISCHARGE				NITRATE			AMMONIA			ORGANIC			TOTAL			BIOCHEMICAL			ALKALINITY		
	TIME	DISCHARGE (CFS)	TEMPERATURE (DEG C)	NITRATE (MG/L)	NITRITE (MG/L)	NITROGEN (MG/L)	NITRATE (MG/L)	NITRITE (MG/L)	NITROGEN (MG/L)	PHOSPHORUS (MG/L)	PHOSPHORUS (MG/L)	TOTAL (MG/L)	CARBON (MG/L)	DEMAND (MG/L)	HARDNESS (MG/L)	MEQ/L	AS CALCIUM (MG/L)	AS CALCIUM (MG/L)			
DATE																					
OCT 13	1145	318	4.5	.4	.010	--	.01	.21	.080	.15	.080	.17	--	--	540	106					
OCT 13	1000	379	5.0	.6	--	--	.04	--	.050	.12	.080	.12	.0	--	--	131					
OCT 13	0800	381	.0	.7	--	--	.18	--	.040	.01	.070	5.0	2.7	--	--	129					
OCT 13	1030	370	.0	--	.050	.10	.20	.30	.00	--	.00	--	.0	2.7	720	148					
OCT 13	1115	640	.5	--	--	.20	.32	.52	.00	.10	.10	11	4.2	--	97	97					
OCT 13	1200	610	.0	--	--	.10	.43	.53	.00	.10	.10	3.0	1.1	--	114	114					
OCT 13	1000	.00	5.0	.9	--	--	.00	--	--	.04	--	3.0	1.9	510	106	106					
OCT 13	0015	1170	9.0	--	--	.30	.00	--	.12	.12	.24	5.0	2.0	--	77	77					
OCT 13	1230	1460	10.0	--	--	.14	.11	--	.15	.10	.25	4.0	1.2	--	81	81					

DRUMMOND

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS- CHARGE (CFS)	TEMPER- ATURE (DEG C)	DISSOLVED	DISSOLVED	DISSOLVED	DISSOLVED	TOTAL	DISSOLVED	DISSOLVED	TOTAL	TOTAL	BIO- CHEM- ICAL	ALKA- LINEITY
				NITRATE (MG/L)	NITRITE (MG/L)	AMMONIA NITRO- GEN (MG/L)	ORGANIC NITRO- GEN (MG/L)	TOTAL NITRO- GEN (MG/L)	PHOS- PHORUS (MG/L)	PHOS- PHORUS (MG/L)	PHOS- PHORUS (MG/L)	CARBON (MG/L)	OXYGEN DEMAND (MG/L)	HARD- NESS (MG/L)
OCT 13...	1810	556	8.5	.00	.00	.07	.14	.21	.21	.070	.080	.090	.0	2.0
JAN 13...	1510	455	.0	.70	.70	.17	.30	.47	.040	.010	.050	4.0	1.7	450
APR 13...	0930	989	1.5	.11	.11	.03	.33	.47	.16	.010	.170	.090	3.6	2.3
JUL 13...	1200	540	12.0	.00	.00	.00	.00	.00	.14	.10	.24	.17	.00	1.8

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

		DISCHARGE				TOTAL NITROGEN				DISSOLVED NITROGEN				TOTAL PHOSPHORUS				BIOCHEMICAL OXYGEN DEMAND				ALKALINITY	
		DISCHARGE		TOTAL		DISSOLVED		TOTAL		DISSOLVED		TOTAL		DISSOLVED		TOTAL		BOD		ALKALINITY			
		CFS		MG/L		MG/L		MG/L		MG/L		MG/L		MG/L		MG/L		MG/L		MG/L			
DATE	TIME	DISCHARGE	TEMPERATURE	DISSOLVED NITRATE	DISSOLVED NITRITE	AMMONIA NITROGEN	ORGANIC NITROGEN	TOTAL NITROGEN	DISSOLVED PHOSPHORUS	DISSOLVED PHOSPHORUS	TOTAL PHOSPHORUS	TOTAL CARBON	BIOCHEMICAL OXYGEN DEMAND	HARDNESS AS CALCIUM	ALKALINITY AS CALCIUM								
OCT 13	1615	614	7.5	.04	.00	.29	.25	.54	.10	.04	.14	1.6	3.0	145									
OCT 13	1630	460	.0	.45	.00	1.1	.65	1.75	.12	.21	.33	3.0	1.35										
OCT 13	1615	465	8.5	.04	.11	.52	.39	.91	.00	.06	.06	3.5	2.0	140									
OCT 13	0915	105	12.5	.01	.02	.41	.36	.77	.05	.08	.13	1.6	1.0	208									

Appendix 3
USGS Data
Alberton

ALBERTON

CHEMICAL ANALYSES, WATER YEAR BEGINNING 1974 TO SEPTEMBER 1970

DATE	TIME	DISS- CHARGE (CGS)	TEMP- ERATURE (DEG C)	NITRATE (NI) (MG/L)	NITRITE (NI) (MG/L)	AMMONIA NITRI- GEN (NI) (MG/L)	ORGANIC NITRO- GEN (NI) (MG/L)	DIS- SOLVED PHOS- PHATE (PI) (MG/L)	DIS- SOLVED PHOS- PHORUS (PI) (MG/L)	TOTAL PHOS- PHORUS (PI) (MG/L)	INITIAL ORGANIC CARBON (CI) (MG/L)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	HARD- NESS (CA, MG) (MG/L)	ALKAL- INITY AS CA(CO) (MG/L)
OCT.														
10...	1640	3200	5.0	.10	.00	.00	.12	--	.02	.17	7.0	1.0	173	126
NOV.														
12...	1640	2700	7.0	.00	.00	.01	.00	--	.17	.52	8.0	1.6	167	123
DEC.														
01...	1640	2450	1.5	.20	.00	.01	.09	--	.05	.16	2.0	1.1	198	121
JAN.														
15...	0900	2800	.0	.30	.00	.04	.43	--	.07	.12	3.0	1.7	180	110
FEB.														
11...	0945	2400	2.0	.20	.00	.12	.29	--	.05	.06	2.0	1.2	187	112
MAR.														
17...	1710	2850	5.0	.10	.00	.04	.26	--	.05	.07	3.0	2.5	180	107
APR.														
15...	1340	1500	6.0	.12	.00	.09	.18	--	.05	.06	2.0	1.3	162	100
MAY														
13...	1615	11400	8.0	.07	.00	.00	.20	--	.04	.08	5.0	2.3	90	71
JUNE														
09...	1750	26100	12.5	.06	.00	.46	1.3	--	.01	.16	2.0	1.3	60	46
JULY														
11...	1115	7900	17.5	.01	.00	.01	.19	.02	.01	.06	19	1.0	111	79
AUG.														
04...	1945	3953	21.0	.01	.00	.04	.10	.01	.02	.11	49	1.7	146	102
SEPT.														
09...	1200	2500	13.0	.03	--	.01	--	.04	.02	.03	11	1.5	--	120

CHEMICAL ANALYSES, OCTOBER 1970 TO JUNE 1971

DATE	TIME	DISS- CHARGE (CGS)	TEMP- ERATURE (DEG C)	NITRATE (NI) (MG/L)	NITRITE (NI) (MG/L)	NITRATE (NI) (MG/L)	AMMONIA NITRO- GEN (NI) (MG/L)	ORGANIC NITRO- GEN (NI) (MG/L)	DIS- SOLVED PHOS- PHATE (PI) (MG/L)	DIS- SOLVED PHOS- PHORUS (PI) (MG/L)	TOTAL PHOS- PHORUS (PI) (MG/L)	INITIAL ORGANIC CARBON (CI) (MG/L)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	HARD- NESS (CA, MG) (MG/L)	ALKAL- INITY AS CA(CO) (MG/L)
OCT.															
04...	1230	2880	10.5	.00	.010	--	.02	.22	.020	.04	.040	7.0	--	180	116
NOV.															
03...	1200	2900	3.5	.5	--	--	.01	--	.020	.03	.020	54	1.6	--	116
DEC.															
01...	1610	3230	3.0	.1	--	--	.01	--	.030	.04	.080	.0	1.5	--	92
JAN.															
01...	0940	1510	1.5	--	.020	.10	.06	.02	--	.01	--	20	.8	180	121
FEB.															
17...	1700	12100	2.5	--	--	.50	.00	--	--	.23	.20	4.0	3.0	--	49
MAR.															
03...	1300	1540	1.5	--	--	.10	.05	--	--	.10	.010	.0	.8	--	97
APR.															
07...	1245	4170	8.5	.1	.030	.10	.27	.20	.020	.17	.20	7.0	1.2	150	80
MAY															
04...	1100	26500	10.0	--	--	.10	.08	--	--	.12	.20	4.0	2.4	--	63
JUNE															
01...	0930	29200	10.5	--	--	.01	.01	--	--	.12	.070	.0	.9	--	51

Appendix 4
USGS Data
Above Missoula

ABOVE MISSOULA

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1969 TO SEPTEMBER 1970

DATE	TIME	DIS- CHARGE (CFS)	TEMP- EMALUPT 100C-61	NITRATE (N) MG/L	NITRITE (N) MG/L	AMMONIA NITRO- GEN (N) MG/L	ORGANIC NITRO- GEN (N) MG/L	DIS- SIL- WET PHOS- PHATE (P) MG/L	DIS- SIL- WET PHOS- PHATE (P) MG/L	TOTAL PHOS- PHORUS (P) MG/L	TOTAL ORGANIC CARBON (C) MG/L	BIO- CHEM- ICAL OXYGEN DEMAND (O) MG/L	HAZ- NESS (CA, MG) MG/L	ALBA- MINITY AS CACOS MG/L
OCT...														
16...	1930	1010	3.5	.16	.00	.00	.00	--	.02	.97	6.0	.8	260	144
NOV...														
13...	0810	1690	5.0	.00	.00	.01	.14	--	.18	.24	7.0	.9	248	136
DEC...														
18...	1730	1450	.5	.20	.00	.00	.10	--	.08	.12	2.0	.8	280	133
JAN...														
15...	1145	1600	.0	.30	.00	.01	.47	--	.00	.04	4.0	1.1	277	128
FEB...														
11...	1230	1180	1.0	.20	.00	.07	.16	--	.02	.03	2.0	1.4	290	120
MAR...														
18...	0810	1580	3.0	.11	.00	.01	.36	--	.08	.08	4.0	2.4	247	128
APR...														
15...	1630	2010	5.0	.14	.00	.00	.20	--	.05	.16	8.0	1.2	234	120
MAY...														
13...	2000	7190	8.0	.04	.00	.06	.47	--	.05	.10	5.0	2.8	121	80
JUNE...														
10...	0840	15300	10.5	.09	.00	.00	.26	--	.05	.21	1.0	1.6	90	69
JULY...														
12...	0915	3810	17.0	.01	.00	.01	.16	.12	.05	.03	5.0	.9	163	116
AUG...														
05...	1445	2240	18.0	.00	.00	.02	.08	.01	.02	.14	3.0	.5	187	115
SEPT...														
10...	0930	1400	12.5	.02	--	.00	--	.06	.03	.11	1.0	1.2	--	130

CHEMICAL ANALYSES, OCTOBER 1970 TO JUNE 1971

DATE	TIME	DIS- CHARGE (CFS)	TEMP- EMALUPT 100C-61	NITRATE (N) MG/L	NITRITE (N) MG/L	AMMONIA NITRO- GEN (N) MG/L	ORGANIC NITRO- GEN (N) MG/L	DIS- SIL- WET PHOS- PHATE (P) MG/L	DIS- SIL- WET PHOS- PHATE (P) MG/L	TOTAL PHOS- PHORUS (P) MG/L	TOTAL ORGANIC CARBON (C) MG/L	BIO- CHEM- ICAL OXYGEN DEMAND (O) MG/L	HAZ- NESS (CA, MG) MG/L	ALBA- MINITY AS CACOS MG/L
OCT...														
07...	0830	1890	7.0	.00	.010	--	.03	.22	.090	.09	.060	.25	--	220
NOV...														
06...	0730	1610	2.0	.1	--	--	.02	--	.010	.01	.020	.0	.8	--
DEC...														
07...	0900	1440	2.0	.2	--	--	.01	--	.010	.01	.020	.40	.8	--
JAN...														
04...	1000	1000	.5	--	.020	.10	.00	.02	--	.00	--	.0	1.1	270
FEB...														
02...	1445	5100		--	--	.40	.08	--	--	.23	.20	.40	3.2	--
MAR...														
03...	1730	2000	.5	--	--	.10	.05	--	--	.10	.050	2.0	.9	--
APR...														
04...	1730	2630	8.0	.00	.010	.00	.26	.20	.020	.06	.090	1.0	1.0	230
MAY...														
04...	1720	10800	10.5	--	--	.10	.00	--	--	.09	.060	7.0	1.7	--
JUNE...														
02...	1700	13900	11.0	--	--	.05	.08	--	--	.12	.090	.48	.8	--

THOMPSON FALLS

Appendix 5 USGS Data Thompson Falls

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1968 TO SEPTEMBER 1970

Thompson Falls														
DATE	TIME	DIS-CHARGE (CFS)	TEMPERATURE (DEG C)	NITRATE (MG/L)	NITRITE (MG/L)	AMMONIA NITROGEN (MG/L)	ORGANIC NITROGEN (MG/L)	DISSOLVED ORTHOPHOSPHATE (MG/L)	DISSOLVED PHOSPHORUS (MG/L)	TOTAL PHOSPHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	BIO-CHEMICAL OXYGEN DEMAND (MG/L)	HARDNESS 1CA, MG/L	ALKALINITY AS CA(OH)2 (MG/L)
OCT. 15...	1600	15400	7.0	.00	.00	.01	.18	--	.07	.12	5.0	1.0	107	99
NOV. 12...	0715	8600	6.0	.00	.00	.01	.11	--	.08	.28	5.0	.8	148	107
OCT. 18...	0915	15800	2.0	.00	.00	.01	--	--	.00	.03	2.0	.9	111	97
JAN. 14...	1040	17100	.0	.10	.00	.01	.18	--	.03	.17	2.0	1.0	108	93
FEB. 16...	1300	8400	3.0	.00	.00	.09	.12	--	.02	.02	2.0	.7	120	104
MAR. 11...	1100	10300	5.0	.03	.00	.04	.12	--	.07	.12	1.0	1.2	115	100
APR. 15...	0640	15800	6.5	.04	.00	.00	.14	--	.02	.04	2.0	.8	105	90
MAY 11...	0830	31900	7.5	.10	.00	.00	.16	--	.08	.09	3.0	1.3	80	75
JUNE 09...	1039	90000	14.5	.07	.01	.07	.37	--	.00	.10	.0	1.3	88	62
JULY 22...	1200	14500	22.0	.01	.00	.02	.08	.06	.00	.04	5.0	1.2	96	94
AUG. 16...	1300	1800	19.4	.09	.00	.01	.06	.01	.01	.02	10	1.0	104	107
SEPT. 15...	0930	15000	11.5	.00	--	.01	--	.08	.04	.04	7.0	.8	--	100

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1971

DATE	TIME	DIS- CHARGE (CFS)	TEMP- ERATURE (DEG C)	NITRATE (MG/L)	NITRITE (MG/L)	AMMONIA NITRO- GEN (MG/L)	ORGANIC NITRO- GEN (MG/L)	DISSOLV- ED ORTH- PHOS- PHORUS (MG/L)	DISSOLV- ED PHOS- PHORUS (MG/L)	TOTAL PHOS- PHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	HARD- NESS 1CA, MG/L	ALKAL- INITY AS CA(OH) (MG/L)	
OCT...	0900	17600	4.0	.60	.000	--	.10	.15	.07	.040	1.0	.9	110	99	
NOV...	1030	9030	5.0	.00	--	--	.01	--	.01	.640	4.0	.9	--	105	
DEC...	1800	12600	2.0	.00	--	--	.05	--	--	.02	.010	13	1.2	--	103
JAN...	0900	17500	.0	--	.070	.00	.00	.09	.010	.02	--	1.0	2.2	91	80
FEB...	0700	14000	4.0	--	--	.20	.14	--	.020	.02	.030	1.0	1.1	--	81
MAR...	0900	14600	4.0	--	--	.10	.11	--	.010	.01	.040	8.0	2.0	94	82
APR...	0900	20500	4.5	.1	.000	.10	.14	.40	.020	.01	.040	8.0	2.0	74	82
MAY...	0730	11000	8.0	--	--	.00	.07	--	--	.17	.10	2.0	.9	--	66
JUNE...	0800	83100	11.0	--	--	.01	.05	--	--	.06	.050	5.0	1.1	--	88
JULY...	0900	21400	21.0	.4	.000	.08	.11	--	.030	.00	.050	8.0	1.2	90	80
AUG...	0830	10400	21.5	--	--	--	--	--	--	--	--	--	1.1	--	84
SEPT...	0900	11400	14.5	--	--	--	--	--	--	--	--	--	.8	--	93

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS- CHARGE (CFS)	TEMPER- ATURE (DEG C)	DIS- SOLV- ED ORTH- PHOS- PHORUS (MG/L)		DIS- SOLV- ED METRO- CHEM (MG/L)		TOTAL PHOS- PHORUS (MG/L)		TOTAL ORGANIC CARBON (MG/L)		HARD- NESS 1CA, MG/L	ALKAL- INITY AS CA(OH) (MG/L)		
				DIS- SOLV- ED (MG/L)	ORTH- PHOS- PHORUS (MG/L)	DIS- SOLV- ED (MG/L)	METRO- CHEM (MG/L)	TOTAL PHOS- PHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)						
OCT. 11..	0810	10700	11.5	.00	.01	.01	.18	.18	.17	.070	.010	.000	2.0	110	95
JAN. 11..	0810	17500	.0	.05	.05	.06	.36	.47	.42	.010	.000	.020	2.0	100	90
APR. 11..	0810	31500	5.5	.00	.00	.10	.07	.17	.17	.010	.000	.040	.0	95	80
JUNE 11..	0930	34070	16.0	--	.01	--	--	.09	.08	.020	.000	.020	--	77	75

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

		DIS- CHARGE (CFS)		TEMP- ERATURE (DEG C)	DIS- SOLV- ED ORTH- PHOS- PHORUS (MG/L)	DIS- SOLV- ED PHOS- PHORUS (MG/L)	TOTAL PHOS- PHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	HARD- NESS 1CA, MG/L	ALKAL- INITY AS CA(OH) (MG/L)		
DATE	TIME	DIS- CHARGE (CFS)	TEMP- ERATURE (DEG C)	DIS- SOLV- ED ORTH- PHOS- PHORUS (MG/L)	DIS- SOLV- ED PHOS- PHORUS (MG/L)	TOTAL PHOS- PHORUS (MG/L)	TOTAL ORGANIC CARBON (MG/L)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	HARD- NESS 1CA, MG/L	ALKAL- INITY AS CA(OH) (MG/L)			
MAY...	1030	13000	6.0	.01	--	.18	.04	.00	.08	.04	1.8	1.4	85
JUN...	1030	12800	.5	.00	--	.25	.19	.00	.08	.05	1.8	.8	91
MAY...	1000	11400	8.8	.00	.08	.14	.08	.01	.03	1.4	.9	106	
JUN...	1130	12000	14.8	--	--	--	--	--	--	1.0	.4	81	
JULY...	1230	21200	14.5	--	--	--	--	--	--	.9	.8	86	
AUG...	1400	14400	20.0	.00	.00	.20	.20	.00	.01	1.8	.4	96	
SEP...	1430	6180	20.5	.00	.00	.08	.08	.01	.00	.03	.1	.47	91

Appendix 6
USGS Data
Bitterroot River

BITTERROOT RIVER AT MACLAY BRIDGE

CHEMICAL ANALYSES, JULY TO SEPTEMBER 1970

DATE	TIME	DIS- CHARGE (CFS)	TEMP- ERATURE (DEG C)	NITRATE NIT (MG/L)	NITRITE NIT (MG/L)	AMMONIA NITRO- GEN (MG/L)	ORGANIC NITRO- GEN (MG/L)	DIS- SOLVED NITRO- GEN (MG/L)	DIS- SOLVED PHOS- PHORUS (MG/L)	TOTAL PHOS- PHORUS (MG/L)	ORGANIC CARBON IC (MG/L)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	HARD- NESS CAL-MG (MG/L)	ALKAL- INITY AS CACO3 (MG/L)
JULY														
11...	1500	7630	18.0	.04	.00	.01	.20	.25	.09	.09	1.0	.8	45	44
AUG.														
05...	1100	1290	19.0	.07	.00	.03	.15	.00	.01	.06	3.0	.2	75	78
SEP.														
04...	1530	950	15.0	.05	.00	.00	.31	.03	.03	.02	5.0	2.0	--	100

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS- CHARGE (CFS)	TEMP- ERATURE (DEG C)	DIS- SOLVED NITRATE NIT (MG/L)	DIS- SOLVED NITRITE NIT (MG/L)	DIS- SOLVED AMMONIA NITRO- GEN (MG/L)	ORGANIC NITRO- GEN (MG/L)	TOTAL NITRO- GEN (MG/L)	TOTAL KJL- OXY- GEN (MG/L)	DIS- SOL- VED PHOS- PHORUS PP (MG/L)	DIS- SOLVED PHOS- PHORUS PP (MG/L)	TOTAL PHOS- PHORUS PP (MG/L)	TOTAL ORGANIC CARBON IC (MG/L)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	HARD- NESS CAL-MG (MG/L)	ALKAL- INITY AS CACO3 (MG/L)
OCT.																
14...	0945	810	8.0	.10	.08	.07	.12	.27	.14	.050	.040	.090	.3	2.3	90	94
NOV.																
09...	0910	880	4.5	--	--	--	--	--	--	--	--	--	--	2.1	--	86
DEC.																
06...	1200	820	.0	--	--	--	--	--	--	--	--	--	--	1.3	--	84
JAN.																
06...	0900	400	.0	.17	.17	.06	.26	.49	.32	.020	.010	.040	2.0	1.9	77	85
FEB.																
15...	1700	980	2.5	--	--	--	--	--	--	--	--	--	--	1.5	--	76
MAR.																
21...	0810	3950	5.0	--	--	--	--	--	--	--	--	--	--	1.1	--	42
APR.																
17...	1700	7660	6.5	.01	.01	.03	.18	.22	.21	.000	.000	.050	1.0	1.6	53	51
MAY																
16...	1510	12000	10.0	--	.08	--	--	--	--	.020	.000	--	--	2.1	21	20
JUNE																
13...	1530	21500	11.0	--	--	--	--	--	--	--	--	--	--	1.2	--	25
JULY																
20...	0915	364	10.5	--	.02	--	--	.13	.11	.010	.000	.040	--	1.4	22	41
AUG.																
24...	0912	1030	14.5	--	--	--	--	--	--	--	--	--	--	1.5	83	75
SEP.																
20...	1845	1070	12.5	--	--	--	--	--	--	--	--	--	--	1.4	86	79

CHEMICAL ANALYSES, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DATE	TIME	DIS- CHARGE (CFS)	TEMP- ERATURE (DEG C)	DIS- SOLVED NITRATE NIT (MG/L)	TOTAL NITRATE NIT (MG/L)	DIS- SOLVED NITRITE NIT (MG/L)	TOTAL NITRITE NIT (MG/L)	DIS- SOLVED AMMONIA NITRO- GEN (MG/L)	TOTAL AMMONIA NITRO- GEN (MG/L)	DIS- SOLVED PHOS- PHORUS PP (MG/L)	TOTAL PHOS- PHORUS PP (MG/L)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	ALKAL- INITY AS CACO3 (MG/L)
OCT.													
11...	1715	1115	4.5	.85	--	.18	.13	.01	.00	.03	.7	79	70
NOV.													
15...	1530	920	5.5	--	--	--	--	--	--	--	.8	78	82
DEC.													
21...	0910	930	2.5	--	--	--	--	--	--	--	1.6	66	71
JAN.													
17...	1540	1130	.0	.19	--	.42	.23	.03	.00	.06	1.1	72	70
FEB.													
22...	1015	760	2.8	--	--	--	--	--	--	1.5	73	83	83
MAR.													
01...	1645	740	6.0	--	--	--	--	--	--	--	1.6	72	70
APR.													
9...	0930	1760	8.0	.03	.04	.23	.19	.00	.01	.02	2.7	60	62
MAY													
10...	1030	5150	11.0	--	--	--	--	--	--	--	2.0	25	66
JUNE													
05...	1700	3200	16.0	--	--	--	--	--	--	1.0	44	45	45
JULY													
08...	1640	800	19.5	.06	.09	.24	.15	.08	.01	.03	1.5	78	104
AUG.													
27...	1300	460	16.5	.08	.08	.08	.30	.01	.02	.00	1.3	115	110

FLATHEAD RIVER AT PERMA

CHEMICAL ANALYSIS, WATER YEAR OCTOBER 1971 TO SEPTEMBER 1972

DATE	TIME	DIS-CHARGE (CPS)	TEMPER- ATURE (DEG C)	DIS-SOLVED NITRIF		DIS-SOLVED AMMONIA NITRO-		ORGANIC GEN (MG/L)	TOTAL NITRO- GEN (MG/L)	TOTAL NITRO- GEN (MG/L)	DIS- SOL- VED PHOS- PHORUS (MG/L)	DIS- SOL- VED ORPHO- PHOS- PHORUS (MG/L)	TOTAL PHOS- PHORUS (MG/L)	TOTAL ORGANIC CARBON (C)	BIO- CHEM- ICAL OXYGEN DEMAND (MG/L)	HARD- NESS ICAR-MG/L	ALKAL- INITY (MG/L)
				PLUS NITRATE (MG/L)	PLUS NITRATE (MG/L)	PLUS NITRATE (MG/L)	PLUS NITRATE (MG/L)										
OCT. 13...	1200	7160	11.5	.21	.21	.02	.15	.38	.17	.050	.000	.080	.0	1.0	90	91	
NOV. 10...	1130	11100	4.5	--	--	--	--	--	--	--	--	--	--	--	1.6	--	88
DEC. 19...	1230	13700	.5	--	--	--	--	--	--	--	--	--	--	--	1.3	--	90
JAN. 07...	1230	13800	1.0	.02	.02	.06	.26	.34	.32	.010	.000	.020	1.0	1.2	88	88	88
FEB. 10...	1230	13000	.0	--	--	--	--	--	--	--	--	--	--	--	1.2	--	87
MAR. 15...	1200	14400	4.5	--	--	--	--	--	--	--	--	--	--	--	1.1	--	87
APR. 13...	1200	20400	4.5	.00	.00	.08	.01	.09	.09	.010	.000	.020	.0	1.3	97	87	87
MAY 03...	1100	18100	7.0	--	--	--	--	--	--	--	--	--	--	--	1.0	--	85
JUNE 09...	1200	50300	15.0	--	--	--	--	--	--	--	--	--	--	--	.8	--	85
JULY 11...	1230	18800	17.5	--	.00	--	--	--	.11	.11	.020	.000	.020	--	.9	82	84
AUG. 17...	1310	8100	21.0	--	--	--	--	--	--	--	--	--	--	--	2.0	87	77
SEP. 20...	1500	7160	14.0	--	--	--	--	--	--	--	--	--	--	--	1.5	89	79

CLINICAL ANALYSIS, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

[illegible]

Appendix 3

RESULTS OF ANALYSIS

UPPER CLARK FORK RIVER -- MONTANA

(From EPA, 1975)

1974

Station No.	Date Yr/Mo/Day	Time M/Ly	Temp. Cent.	pH SU	DO mg/l	Cond. μ mho	Flow c.f.s.	Total-N mg/l	Total-P mg/l	Nitrate-N mg/l	NH ₄ -N mg/l	O ₂
CF-1	74/8/19	0900	12.5	7.7	8.9	-	-	0.64	0.018	0.14	0.01	C
	74/8/20	1130	13.9	8.0	9.1	850	-	0.52	0.035	0.22	0.03	C
	74/8/21	1115	13.3	8.0	10.0	900	70	0.77	0.038	0.26	0.02	C
	74/8/22	1145	15.0	7.8	9.8	915	-	0.50	0.031	0.14	0.04	C
	74/8/23	0810	12.0	7.6	8.2	920	-	0.58	0.028	0.17	0.01	C
CF-1A	74/8/19	0940	13.0	7.9	9.2	-	-	0.53	0.021	0.23	0.01	C
	74/8/20	1115	12.8	8.0	8.8	830	-	0.60	0.040	0.22	0.04	C
	74/8/21	1100	12.8	7.9	9.8	900	140	0.66	0.034	0.28	0.03	C
	74/8/22	1115	14.4	7.8	9.9	860	-	0.54	0.030	0.21	0.03	C
	74/8/23	0830	12.8	7.6	8.2	875	-	0.53	0.039	0.22	0.01	C
CF-2	74/8/19	1015	14.0	8.0	10.6	-	-	0.53	0.080	0.10	0.02	C
	74/8/20	1030	12.8	8.0	8.6	740	-	0.68	0.098	0.08	0.03	C
	74/8/21	1035	12.2	7.9	10.3	850	150	0.70	0.088	0.26	0.03	C
	74/8/22	1045	14.4	7.9	10.0	810	-	0.64	0.082	0.18	0.03	C
	74/8/23	0850	13.3	7.7	8.6	825	-	0.69	0.090	0.17	<0.01	C
LB-1	74/8/19	1040	13.0	8.1	10.3	-	-	0.16	0.042	0.01	0.02	C
	74/8/20	1015	12.2	7.9	8.7	290	-	0.22	0.045	0.02	0.02	C
	74/8/21	1020	12.2	7.8	9.6	320	80	0.20	0.047	0.01	0.02	C
	74/8/22	1025	13.3	7.8	9.0	320	-	0.20	0.043	0.01	0.03	C
	74/8/23	0910	12.8	7.7	8.7	320	-	0.42	0.043	0.02	0.01	C
CF-3	74/8/19	1200	14.5	8.3	10.7	-	-	0.39	0.056	0.01	0.01	C
	74/8/20	1000	12.8	7.9	8.6	650	-	0.52	0.073	0.04	0.02	C
	74/8/21	1000	11.7	7.9	10.2	700	230*	0.57	0.080	0.12	0.02	C
	74/8/22	1015	13.9	8.1	9.9	695	-	0.50	0.068	0.05	0.03	C
	74/8/23	1420	17.0	8.1	11.0	700	-	0.44	0.060	0.04	0.01	C
CF-4	74/8/19	1220	14.0	8.2	10.5	-	-	0.34	0.042	<0.01	0.01	C
	74/8/20	0945	12.8	7.8	8.5	650	-	0.45	0.187	0.02	0.02	C
	74/8/21	0940	11.7	7.9	10.4	690	240*	0.66	0.086	0.06	0.02	C
	74/8/22	1000	13.3	8.0	9.5	690	-	0.50	0.065	0.02	0.03	C
	74/8/23	1400	16.5	8.0	10.3	700	-	0.40	0.063	<0.01	0.01	C
CF-5	74/8/19	1305	14.0	8.3	10.6	-	-	0.34	0.041	<0.01	0.01	C
	74/8/20	0915	12.8	8.1	8.7	600	-	0.70	0.350	0.04	0.04	C
	74/8/21	0915	11.7	8.0	9.6	650	260*	0.45	0.089	0.01	0.03	C
	74/8/22	0940	13.3	8.2	9.2	655	-	0.42	0.068	0.01	0.03	C
	74/8/23	1340	16.5	8.0	9.8	660	-	0.48	0.057	0.01	0.03	C
CF-6	74/8/19	1340	14.0	8.2	9.8	-	-	0.28	0.040	<0.01	0.01	C
	74/8/20	0930	12.0	7.9	8.5	600	-	0.36	0.070	<0.01	0.01	C
	74/8/21	0925	12.0	8.4	9.1	640	270	0.40	0.073	<0.01	0.02	C
	74/8/22	0920	13.9	8.1	8.8	680	-	0.49	0.069	<0.01	0.02	C
	74/8/23	1320	16.0	7.8	9.5	660	-	1.01	0.062	0.01	0.03	C
FC-1	74/8/19	1440	13.5	8.3	9.9	-	-	0.32	0.074	0.02	0.01	C
	74/8/20	1005	11.0	7.8	9.8	520	-	0.46	0.096	0.08	0.03	C
	74/8/21	1025	10.5	8.4	10.5	480	90	0.30	0.088	0.08	0.02	C
	74/8/22	0950	11.0	8.2	-	500	-	0.32	0.082	0.07	0.03	C
	74/8/23	1240	14.4	7.6	9.6	490	-	0.42	0.086	0.06	0.01	C
CF-7	74/8/19	1505	14.5	8.1	10.0	-	-	0.36	0.047	<0.01	0.01	C
	74/8/20	1030	11.5	8.0	8.8	670	-	0.40	0.067	0.01	0.02	C
	74/8/21	1000	10.5	8.2	9.6	620	400	0.42	0.073	<0.01	0.01	C
	74/8/22	0920	12.5	8.1	-	650	-	0.38	0.083	0.02	0.03	C
	74/8/23	1255	15.0	7.4	9.6	680	-	0.44	0.072	0.01	0.01	C
CF-8	74/8/19	1650	16.0	8.5	10.6	-	-	0.30	0.035	<0.01	0.01	C
	74/8/20	1225	13.0	8.1	9.7	660	-	0.32	0.039	0.01	0.02	C
	74/8/21	1240	15.0	8.6	10.5	660	450*	0.34	0.050	<0.01	0.01	C
	74/8/22	1130	15.0	8.4	-	620	-	0.28	0.046	<0.01	0.02	C
	74/8/23	1130	15.6	7.7	9.4	700	-	0.46	0.046	<0.01	<0.01	C
WC-1	74/8/19	1715	14.0	8.4	9.7	-	-	0.10	0.015	<0.01	0.01	C
	74/8/20	1250	11.0	7.1	10.5	125	-	0.12	0.015	<0.01	0.01	C
	74/8/21	1315	13.0	8.2	10.7	155	420	0.14	0.017	<0.01	0.03	C
	74/8/22	1200	12.0	8.3	-	145	-	0.32	0.020	<0.01	0.03	C
	74/8/23	1145	13.3	7.5	10.0	155	-	0.17	0.027	<0.01	<0.01	C
CF-9	74/8/19	1615	15.0	8.5	10.0	-	-	0.12	0.022	<0.01	0.01	C
	74/8/20	1135	12.0	7.6	9.5	410	-	0.18	0.026	<0.01	0.02	C
	74/8/21	1200	13.5	8.4	10.3	420	870*	0.18	0.028	<0.01	0.02	C
	74/8/22	1050	13.0	8.3	-	425	-	0.20	0.030	<0.01	0.03	C
	74/8/23	1100	14.4	7.5	9.5	460	-	0.47	0.032	<0.01	0.01	C

Note: * signifies an estimated measurement

Appendix 3 (Continued)

UPPER CLARK FORK RIVER STUDYBIOLOGICAL AND WATER QUALITY SAMPLING STATION LOCATIONS

Station No.	Approx. Dist. From Dempsey Creek		Description
	Miles	km	
CF-1	0	0	Clark Fork River upstream of its confluence with Dempsey Creek
CF-1A	6 1/4	10.1	Clark Fork River upstream of Deerlodge and the Montana Hwy. 10A bridge
CF-2	15 5/8	25.2	Clark Fork River downstream of Deerlodge and upstream of the bridge to the Rock Creek Cattle Co.
LB-1	22 7/8	36.9	Little Blackfoot River upstream of the U.S. 90, Mont. St. 10 bridge, 1/2 mi. from Clark Fork R. confluence
CF-3	23 1/8	37.2	Clark Fork River at Garrison downstream of the service road bridge
CF-4	25 5/8	41.3	Clark Fork River downstream of Garrison where river nears the service road at Warm Springs Creek
CF-5	28 3/4	46.3	Clark Fork River upstream of the Gold Creek exit bridge and downstream of the Gold Creek confluence
CF-6	35	56.4	Clark Fork River downstream of the Jens exit bridge
FC-1	52 1/4	84.1	Flint Creek downstream of the bridge on the improved dirt road to the cemetery
CF-7	53 1/8	85.5	Clark Fork River at Drummond downstream of the railroad bridge
CF-8	86 7/8	139.9	Clark Fork River upstream of its confluence with Rock Creek at the old Rock Creek Bridge
RC-1	87 7/8	141.5	Rock Creek where it first approaches the improved dirt road about 3 miles up the canyon
CF-9	94 3/8	151.9	Clark Fork River upstream of Clinton at the Schwartz Creek bridge

Appendix 9.1 Ambient Air Temperature and Precipitation
Conditions at Reporting Weather Stations During the Diel
Dissolved Oxygen Sampling Periods in 1973, 1976 and 1977
(Temp. in °F, Precip. in inches).

DAILY CONDITIONS

MONTHLY CONDITIONS

<u>STATION</u>	<u>DATE</u>	<u>AVE. TEMP.</u>	<u>AVE. MAX.</u>	<u>AVE. MIN.</u>	<u>GENERAL COND.</u>	<u>MONTH</u>	<u>AVE. TEMP.</u>	<u>AVE. MAX.</u>	<u>AVE. MIN.</u>	<u>TOTAL PRECIP.</u>
Deer Lodge	8/2-3/73	72.3	89.0	55.5	Clear	8/73	63.5	82.5	44.5	0.67
	7/20-21/76	62.0	80.0	44.0	Rain	7/76	62.5	82.1	42.8	1.27
	7/20-21/77	65.5	85.0	46.0	Rain	7/77	60.5	78.4	42.5	1.68
	8/3-4/77	66.8	86.0	47.5	Cldy.	8/77	59.8	78.3	41.2	0.89
	8/18-19/77	67.0	90.0	44.0	Clear					
	9/13-14/77	57.0	81.0	33.0	Clear	9/77	51.7	68.3	35.1	2.71
Drummond	8/2-3/78	68.5	90.5	46.5	Clear	8/73	64.4	84.8	44.0	0.48
	7/20-21/76	63.5	78.5	48.5	Rain	7/76	66.0	85.0	46.9	0.74
	7/20-21/77	65.0	83.0	47.0	Rain	7/77	63.1	80.9	45.2	1.15
	8/3-4/77	70.0	88.5	51.5	Cldy.	8/77	62.7	81.1	44.2	0.84
	8/18-19/77	68.3	93.0	43.5	Clear					
	9/13-14/77	56.8	80.5	33.0	Clear	9/77	54.1	70.0	38.1	1.27
Missoula	8/2-3/73	73.3	93.0	53.5	Clear	8/73	67.4	85.2	49.5	0.41
	7/20-21/76	67.8	82.5	53.0	Cldy.	7/76	66.8	83.7	49.9	1.20
	7/20-21/77	69.0	89.0	49.0	Rain	7/77	65.8	81.5	50.1	0.72
	8/3-4/77	71.8	84.5	59.0	Cldy.	8/77	67.6	83.3	51.9	1.28
	8/18-19/77	75.0	97.0	53.0	Clear					
	9/13-14/77	59.5	79.5	39.5	Clear	9/77	54.6	67.6	41.5	1.67

1 U.S. Dept. of Commerce, National Weather Service Records

Appendix 10. Diel Dissolved Oxygen As Percent Saturation
Versus Time (Modified from Braico, 1973)

Appendix 11. Diel Dissolved Oxygen As Percent Saturation
Versus Time (Modified from Braico, 1973)

Clark Fork 8/2/73

○—○ Six Mile
○—○ Drummond
△—△ Deer Lodge

APPENDIX 12. Time, Temperature, Dissolved
Oxygen and Percent Saturation for 5
Stations on the Clark Fork River
8/2-3/73 (From Braico 1973)

DEER LODGE

	<u>Time</u>	<u>Temp.</u>	<u>D.O.</u>	<u>% Sat.</u>
8/2	1030	61	7.8	93
	1200	63	8.4	104
	1630	66	8.4	106
	1800	68	8.7	112
	2230	64	6.7	83
8/3	0030	64	6.3	78
	0500	61	5.9	71
	0630	61	6.0	72
	1030	61	7.5	89

TURAH

	<u>Time</u>	<u>Temp.</u>	<u>D.O.</u>	<u>% Sat.</u>
8/2	0730	61	6.2	71
	1000	64	8.1	96
	1330	68	8.3	102
	1630	72	8.0	103
8/3	2000	69	7.5	93
	0015	67	6.0	73
	0300	64	6.4	76

DRUMMOND

	<u>Time</u>	<u>Temp.</u>	<u>D.O.</u>	<u>% Sat.</u>
8/2	0900	52	7.3	77
	1330	68	8.2	103
	1500	70	8.2	105
	1930	72	7.2	95
	2100	70	6.4	82
	0130	63	6.0	72
8/3	0300	63	6.0	72
	0730	59	6.6	75
	0730	59	7.0	79
	0900	59	7.0	79

HUSON

	<u>Time</u>	<u>Temp.</u>	<u>D.O.</u>	<u>% Sat.</u>
8/2	1030	57	7.5	81
	1430	61	8.8	101
	1700	64	9.3	110
	2100	63	8.8	102
	2330	63	7.8	90
	0330	61	7.0	79
8/3	0700	57	6.5	70
	0900	57	6.7	72

BONITA

	<u>Time</u>	<u>Temp.</u>	<u>D.O.</u>	<u>% Sat.</u>
8/2	0700	63	6.7	79
	1000	64	7.7	92
	1300	71	9.0	115
	1600	76	8.7	116
	1930	76	7.4	99
	2230	71	5.2	66
	0245	67	5.3	65

Appendix 13. Selected Streamflow Data (Cubic Feet Per Second)
During Diel Dissolved Oxygen Sampling Periods
Actual Flows

STATION NAME	USGS STATION NUMBER	<u>MEAN FLOW FOR SAMPLING DATES</u>					
		<u>8/2-3/73</u>	<u>7/20-21/76</u>	<u>7/20-21/77</u>	<u>8/3-4/77</u>	<u>8/18-19/77</u>	<u>9/13-14/77</u>
Clark Fork at Drummond	12331600	89	1120	215	133	108	275
Rock Creek near Clinton	12334510	226	1080	308	217	119	162
Blackfoot River near Bonner	12340000	502	1805	524	429	404	390
Clark Fork above Missoula	12340500	905	4175	1155	888	680	845
Clark Fork below Missoula	12353000	1285	7405	1680	1550	1120	1380

Measured, Calculated, Estimated or Gauged Flows for Selected Sampling Stations

STATION NAME	<u>Flow During Sampling Dates</u>					
	<u>8/2-3/73</u>	<u>7/20-21/76</u>	<u>7/20-21/77</u>	<u>8/3-4/77</u>	<u>8/18-19/77</u>	<u>9/13-14/77</u>
Deer Lodge ¹	50	615	120	75*	60*	150
Gold Creek ²	90	1120	215	125*	110*	275
Bonita ³	180	1290	320	225*	145	290
Turah ⁴	405	2370	630	460	275	450
Missoula ⁵	905	4175	1155	890	680	845
Huson ⁶	1285	7505	1680	1550	1120	1380

1 Fish and Game Measurement* or calculated as 0.55 x Drummond flow

2 Fish and Game Measurement* or estimated to be equal to Drummond flow

3 Fish and Game Measurement* or estimated to be equal to above Missoula - (Blackfoot & Rock Creek) flows

4 Estimated to be equal to above Missoula - Blackfoot flow

5 Gauged (Above Missoula)

6 Gauged (Below Missoula)

Appendix 14. Maximum and Minimum Stream Temperatures Recorded at the Bonita (above Rock Creek) Station on the Clark Fork River During the Summer of 1977. Note That From July 7 Through August 23 the Average Temperature Exceeded 62.5°F (Montana Department of Fish and Game, 1977)

Day	July		Aug.		Sept.	
	Min.	Max.	Min.	Max.	Min.	Max.
1	60.0	69.5	61.5	72.5	54.0	63.0
2	57.5	70.0	63.0	74.5	55.5	62.0
3	55.5	61.0	64.0	73.5	57.0	62.0
4	55.0	65.0	64.0	75.0	57.0	66.0
5	56.0	69.0	61.0	70.0	60.5	67.0
6	56.0	64.5	60.0	71.0	59.5	68.0
7	55.0	70.5	64.0	72.0	58.5	62.0
8	61.0	73.0	63.5	73.5	53.0	61.5
9	63.0	69.0	63.0	73.0	55.5	61.5
10	62.0	68.0	61.5	72.0	54.0	63.0
11	60.0	70.0	61.0	73.0	55.0	63.0
12	62.5	73.5	62.0	74.0	54.5	62.5
13	60.0	66.5	64.0	75.0	55.0	64.5
14	59.0	71.5	64.0	71.0	55.0	62.5
15	62.0	73.5	61.0	70.0	55.0	59.0
16	63.5	74.5	61.5	73.5	54.5	58.0
17	64.0	69.0	63.0	74.0	52.0	55.0
18	62.5	65.5	63.5	75.0	50.0	56.0
19	63.0	71.0	64.0	75.0	52.0	56.5
20	62.5	72.0	64.0	73.5	53.0	56.5
21	64.0	71.0	63.0	74.0		
22	63.5	75.5	60.5	69.5		
23	67.0	77.5	60.0	69.5		
24	67.5	71.0	58.5	64.5		
25	64.5	68.0	58.5	63.5		
26	63.0	68.5	55.5	61.0		
27	62.0	74.0	55.0	61.0		
28	64.0	72.5	55.5	59.5		
29	61.5	70.0	56.0	59.0		
30	60.0	71.0	52.0	55.5		
31	—	—	51.5	60.0		