WATER QUALITY STUDY OF BILLINGSLEY CREEK, IDAHO

EXECUTIVE SUMMARY

The study purpose was to evaluate EPA's proposed trout hatchery permit limits on Billingsley Creek water quality. The proposed permit effluent limits are technology based. Total suspended solids (TSS), settleable solids, nutrients (nitrogen and phosphorus), ammonia, and dissolved oxygen were evaluated. The conclusions of the study are summarized below:

1. TSS levels resulting from the proposed effluent limits will provide a high level of protection for the biota and comply with Idaho WQS.

2. Settleable solids discharged from the hatcheries are a real concern for Billingsley Creek.

   The potential settleable solids load allowed by the proposed effluent limits is quite high. If these proposed loadings were discharged to Billingsley Creek, it would cause unacceptable impacts to the stream.

   However, it is unlikely that the actual settleable solids loading would ever be as high as proposed. Settleable solids are well below effluent limits when the TSS meets the effluent limits. The data from the JRB (1984) study indicated that the hatcheries can achieve trace levels of settleable solids in their effluents. Also, the cleaning effluents which contain the higher solids load are only discharged sporadically. But to ensure that the possible loads under the proposed permit are never discharged, the permit limits should be lowered for cleaning effluents and every effort made to minimize solids discharges.

   RECOMMENDATIONS

   a. Lower the permit limit for cleaning effluents to 0.5 ml/l.

   b. Emphasize the importance of developing operation plans that will minimize the discharge of solids.

   c. Evaluate the effect of settleable solids on the stream after a year and reopen the permit if necessary.

3. Nitrogen and phosphorus levels in Billingsley Creek appear to be excessive. Plant growth in the stream is excessive and contributes to a significant diurnal oxygen swing. However, the late night D.O. sag is short lived because of the short detention time of water in the stream. Further, D.O. never reached dangerous levels. The lowest D.O. recorded was 5.0 mg/l. The effluents contribute both nutrients to the stream system. However, there is evidence that much of the nitrogen (at least the nitrites and nitrates) and some of the phosphorous may be in the spring water before it enters the trout hatcheries.

Phosphorus appears to be contributed to the system by the hatchery operations. However, individual hatchery discharges of phosphorus are at quite low effluent concentrations and may be difficult to remove.

RECOMMENDATIONS

a. Evaluate the effect of nutrients on the stream after a year and reopen the permit if necessary.

b. Emphasize the importance of developing operations plans that minimize the discharge of nutients.

4. The trout hatcheries appear to have little direct impact on dissolved oxygen (DO) in Billingsley Creek. They may contribute indirectly to depressed nighttime DO by discharging nutrients to the stream. At this time there is no evidence that the diurnal dissolved oxygen swing has an adverse effect on the stream. As recommended above the permit can be reopened if impacts are detected. The state has an ongoing study that should document any impacts.

DESCRIPTION OF BILLINGSLEY CREEK

Billingsley Creek originates at Curren Spring in Gooding County, approximately 3 miles from Hagerman, Idaho. The stream flows just over 7.5 miles northwest to its confluence with the Snake River. A number of spring fed streams are tributary to Billingsley Creek. The creek is also fed by irrigation return flows.

Billingsley Creek flows primarily through agricultural lands with row crops, pastures, and confined animal feeding operations. Water is diverted from Billingsley Creek for irrigation at Curren Ditch near the headwaters, and at numerous locations in the downstream reaches.

There are four major trout hatcheries that discharge to Billingsley Creek: Rangen Hatchery, Jones Hatchery, Idaho Springs, and Fisheries Development. Rangen is located at the headwaters and utilizes Billingsley Creek water for all its raceways and ponds. Virtually all the water in the creek immediately below Rangen has passed through the hatchery. During the irrigation season all the water in the creek below Rangen can be diverted for irrigation at Curren Ditch, immediately below the hatchery at river mile 7.0. Jones Hatchery discharges to the creek at river mile 5.7. This hatchery utilizes water from a spring. During the non-irrigation season, flow in the creek roughly doubles at Jones. When water is being diverted at Curren Ditch, nearly all the flow below Jones results from the Jones effluent. The Idaho Springs Hatchery discharges to Billingsley Creek at River miles 3.9 and 3.8. This hatchery withdraws water from Billingsley Creek for its rearing ponds. It utilizes spring water for its raceways. Idaho Springs was not in operation during this study. Fisheries Development discharges to the stream at river mile 2.7, and it utilizes spring water.

The physical habitat and water quality of Billingsley Creek are both indicative of extensive agricultural and aquacultural use. JRB (1984) found Billingsley Creek water quality to be inferior to comparable spring fed streams primarily as a result of high nutrient levels. JRB also reported heavy accumulations of organic material below the trout hatcheries. In addition, they observed extensive macrophyte beds, especially downstream of hatcheries. Overall, JRB concluded that Billingsley Creek exhibits symptoms of a stressed stream system, attributable to the trout hatcheries, feedlot runoff, and grazing.

METHODOLOGY

This study evaluated the impact of the following technology based effluent limits for trout hatcheries on the water quality of Billingsley Creek:

Raceway discharge:

• net 30-day average TSS	5.0 mg/l
• instantaneous maximum TSS	15.0 mg/l
• net average daily settleable solids	0.1 mg/l

Cleaning Waste Treatment Pond

• daily minimum TSS removal efficiency	85 %
• daily maximum TSS	100 mg/l
• daily minimum settleable solids removal efficiency	90%
• daily maximum settleable solids	1.0 ml/l

Billingsley Creek and the four trout hatchery effluents were sampled in January, March, April, May, and June. Field data was collected by the Twin Falls office of the Idaho Department of Health and Welfare, Division of Environment (DOE) and EPA's Environmental Services Division (ESD). ESD gauged the stream in March and June and analyzed water samples in the laboratory for $BOD_{5, 10, 15, 20}$, settleable solids, suspended solids, and nutrients. The ESD BOD data was used for the dissolved oxygen model, but DOE data was used for the rest of the analyses because it was available for all sampling dates. The ESD data was used as a quality assurance check.

The following parameters were measured for each station on each sampling date.

Temperature
pH
Biochemical oxygen demand
Dissolved oxygen
Total residue
Volatile residue
Non-filterable residue (suspended solids)
Total ammonia
Kjeldahl nitrogen
Nitrite & nitrate
Total phosphorus
Ortho phosphate
Turbidity
Conductivity
Alkalinity

The eight stream and seven effluent stations listed below in Table 1 were monitored:

TABLE 1: Billingsley Creek Stations

Number	Descriptions	River Mile	Idaho STORET No.
B1	Above Rangen @ Curren Spgs	7.8	2060047
B2	Below Rangen @ Culvert	7.2	2060162
B3	Above Jones @ Bridge	5.8	2060163
B4	200 yards below Jones	5.6	2060164
B5	Above Idaho Springs	4.0	2060165
B5A	Below Idaho Springs	3.7	
B6	Below Fisheries Development	2.6	2060166
B7	150 below Highway 30	0.6	2060046
F1	Rangen Raceway Effluent	7.3	2060174
F1A	Rangen Settling Pond Effluent	7.4	2060175
F2	Jones Raceway Effluent	5.7	2060176
F2A	Jones Settling Pond Effluent	5.7	2060177
F3	Idaho Springs Raceway Effluent	3.8	2060178
F3A	Idaho Springs Rearing Pond Effluent	3.9	2060179
F4	Fisheries Development Settling Pond Eff.	2.7	2060180

Standard methods were used for all analyses. The effects of the trout hatchery effluents on dissolved oxygen were evaluated using the STREAM water quality model developed by Manhattan College.

All the data collected for this study are listed in the Appendix to this study. The field data for parameters of primary concern in this study are listed in Appendix Tables C and D for the stream stations and Table E for the effluents. Statistical summaries of all the data are presented in Figures 1 and 2 and in Appendix Tables A and B for stream stations and effluents respectively.

EFFLUENT QUALITY

Effluent quality was generally quite good with only the nutrients being at excessive levels. Figure 1 presents a statistical summary of all of the effluent data. Appendix Table A contains the data used to compile the charts shown in Figure 1.

TSS were very low for all the effluents (see Appendix Table A and E). The highest recorded value was 9.8 mg/l from the Fisheries Development settling pond. The mean TSS levels ranged from 3.7 mg/l at the Jones raceway to 7.9 mg/l at the Jones settling pond. Only two settleable solids measurements were taken: 0.1 ml/l at the Rangen raceway and 0.1 ml/l at the Jones settling pond.

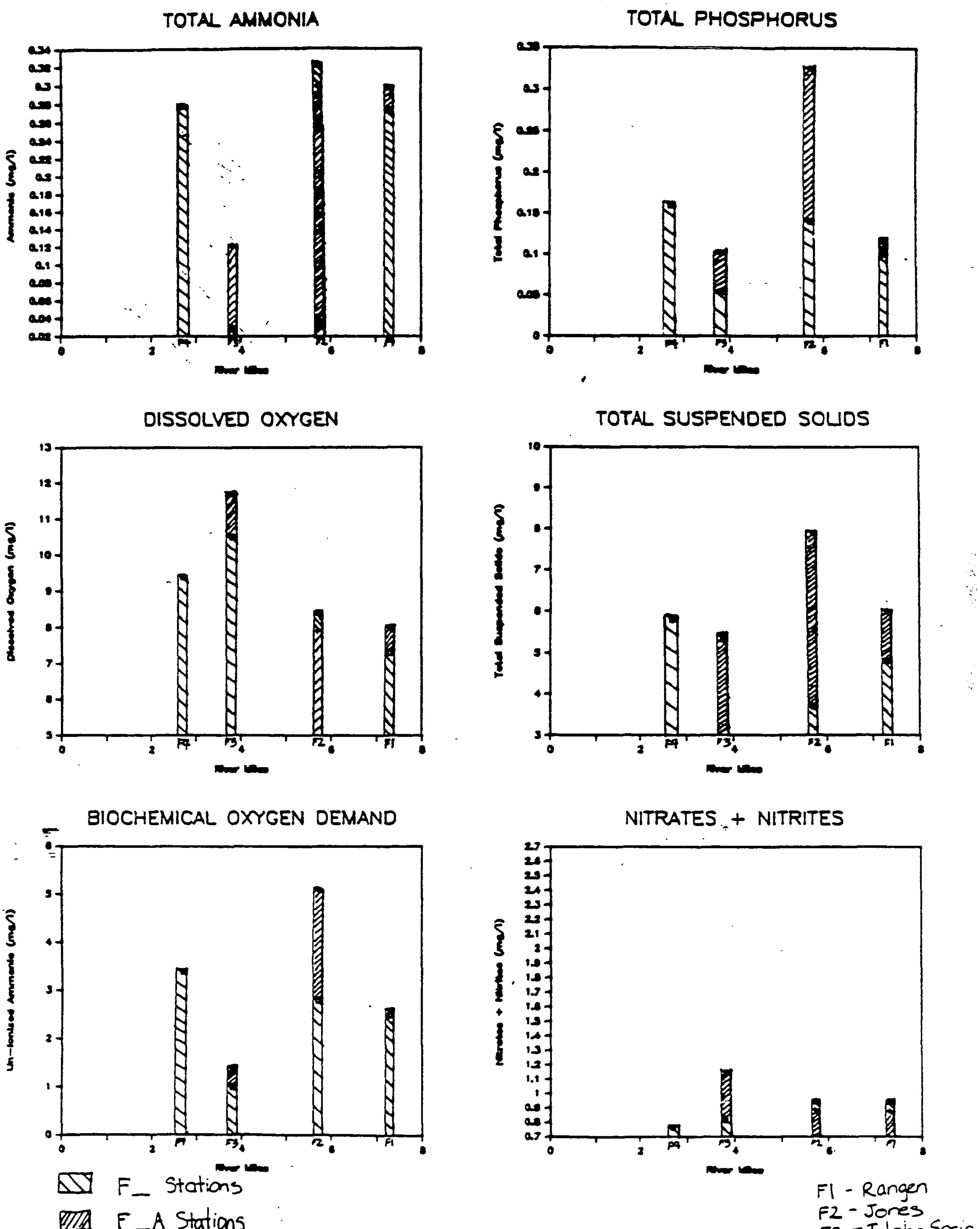


FIGURE 1: Fish Hatchery Effluent Data

The nutrients, phosphorus, and nitrogen were really quite low in the effluents. Phosphorus ranged from 0-0.49 mg/l. The mean phosphorus levels ranged from 0.054 mg/l at the Idaho Springs Raceway to 0.326 at the Jones settling pond. Mean nitrate/nitrite nitrogen levels ranged from 0.763 at the Fisheries Development settling pond to 1.148 at the Idaho Springs Rearing Pond. Mean total ammonia levels ranged from 0.029 mg/l at Idaho Springs raceway to 0.322 mg/l at the Jones raceway. Mean Kjeldahl nitrogen ranged from 0.142 mg/l at Idaho Springs raceway to 0.842 mg/l at Jones settling pond.

Oxygen levels were generally fairly high in the effluents. The lowest recorded dissolved oxygen level was 7.1 at the Rangen raceway and the Jones settling pond. Five day biochemical oxygen demand was generally very low. The maximum recorded was 8.7 mg/l at the Jones settling pond. The mean BOD at Jones settling pond was only 5.1 mg/l. The highest mean at the other dischargers was 2.8 mg/l at the Jones raceway.

INSTREAM WATER QUALITY

The instream water quality of Billingsley Creek was generally quite good during the study period (Appendix Tables C and D). Only the nutrients, nitrogen, and phosphorus were at concentrations that could cause water quality problems. A statistical summary of this data is presented in Figure 2 and Appendix Table B.

Instream TSS ranged from a high of 24.0 mg/l at Station B7 in January to a low of less than 1.0 mg/l at every station except Station 5 in June (Appendix Table B). Station 5 had 1.0 mg/l in June. The data in Table D indicates that TSS generally decreased at each station with season and with flow. Further, TSS decreased below the hatcheries on each sampling date (see Appendix Figures 1-5).

Instream nutrient levels were fairly high and constant throughout the study. Total phosphorus ranged from 0 to 0.2 mg/l. Nitrate/nitrites ranged from 0.72 to 9.2 mg/l. Total ammonia ranged from .004 to .729 mg/l. Kjeldahl nitrogen ranged from 0.1 to 0.8 mg/l. It is important to note from Appendix Table C that the headwater station (B1) consistently had lower levels of phosphorus, ammonia, and Kjeldahl nitrogen than the rest of the stream, but its nitrate/nitrite levels were in the same range as the rest of the stream.

Un-ionized ammonia was very low at every station on every sampling date. The highest readings were on May 22 at Stations 3 and 4; 0.075 and 0.019 mg/l respectively. The Station 3 level was apparently the result of high pH (9.0) rather than an influx of ammonia because the total ammonia level was only 0.350 mg/l. This is very similar to Station B2 when the total ammonia was 0.337 but the un-ionized was only 0.0071 mg/l The highest un-ionized ammonia level at the other stations was 0.0097 mg/l at Station B6.

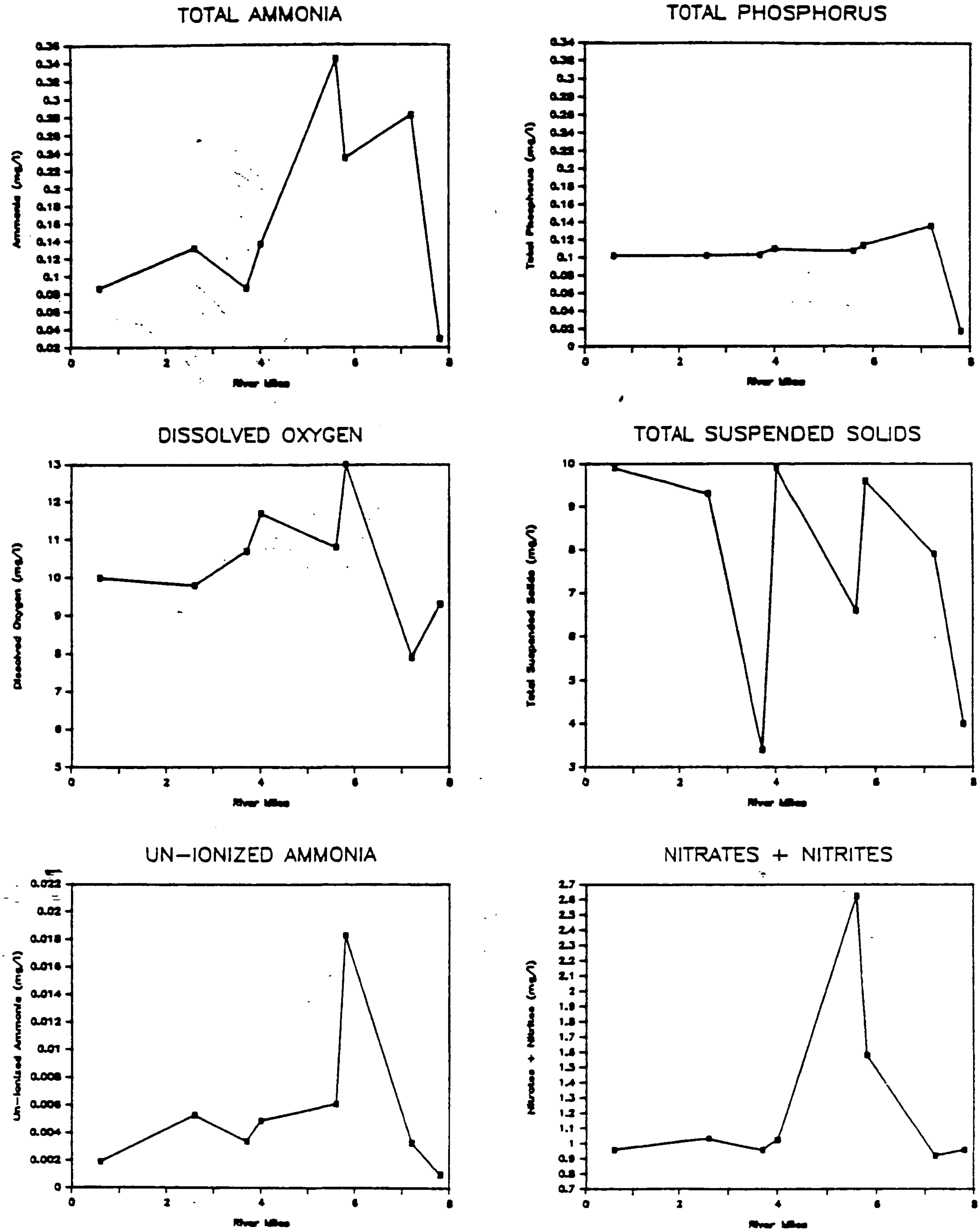


FIGURE 2: Ambient Water Quality Data

Dissolved oxygen was fairly high throughout the study (Appendix Figures 1-5). The lowest value recorded was 6.2 at Station B2 below the Rangen hatchery on March 7, 1984. Dissolved oxygen was supersaturated in much of the stream during May and June. At Station B3 oxygen levels of 19.5 mg/l in May and 14.2 mg/l in June were recorded. At B5 the May concentration was 14.8 and the June level was 12.6, and at B5A the May and June concentrations were 12.0 and 11.2 mg/l respectively.

STUDY RESULTS

The results of this study are summarized in three sections. First, we compare the actual trout hatchery effluents to the EPA established effluent limits for such hatcheries. Second, we summarize the impact of the trout hatchery effluent on instream water quality. Following these summaries, we present a detailed pollutant-by-pollutant analysis of the impact of each pollutant on Billingsley Creek. Graphs are used whenever possible in presenting data. All data collected for this study is compiled in the Appendix.

TSS

It is quite evident that the hatchery effluents had little impact on instream TSS during this study. Appendix Figures 1-5 show that TSS actually decreased below the hatchery effluents (except below Rangen where the stream is entirely effluent).

The greatest effect of the trout hatcheries on Billingsley Creek TSS levels will occur at the lowest flows. To analyze the worst case impact of the proposed effluent limits on Billingsley Creek we assumed all the flow in the Creek was effluent from the trout hatcheries. Further, we assumed that all effluent discharge was at the instantaneous maximum permit levels at the same time. The effluent flows used in the analysis are the mean flows given in Appendix Table A.

Table 2 lists the worst case conditions simulated and the expected Billingsley Creek TSS concentrations below each hatchery. The highest TSS levels in the Creek during this hypothetical worst case would be below Rangen (27.6 mg/l).

TABLE 2: Worst Case Analysis of the Impact of the Proposed Effluent Limits on Billingsley Creek TSS Levels:

	Effluent Flow (cfs)	Effluent TSS (mg/l)	Billingsley Creek TSS (mg/l)
Rangen Settling Pond	4.8	100.0	100.0*
Rangen Raceway	27.6	15.0	27.6
Jones Settling Pond	1.9	100.0	----
Jones Raceway	44.6	15.0	22.6
Idaho Springs Rearing Pond	30.8	15.0	20.4
Idaho Springs Raceway	52.0	15.0	18.6
Fisheries Development Settling Pond	10.9	15.0	18.4

*This high level will be totally on Rangen property and will occur over a stream reach roughly 150 meters long.

Even this worst case for TSS should have little or no impact on fish and aquatic life. According to "Water Quality Criteria," (EPA, 1972) a maximum suspended sediment concentration of 25.0 mg/l provides a high level of protection for aquatic communities while a maximum of 80.0 mg/l provides a moderate level of protection. So even this worst case will provide a relatively high level of protection. The Idaho water quality standards require that point sources not increase the turbidity of receiving waters by more than 5 NTU over background if background is less than 50 NTU. We do not know what turbidity would result from the highest predicted TSS of 27.6 mg/l. However, it can be estimated roughly. Table 3 below tabulates the highest instream and effluent TSS levels and their corresponding turbidities.

TABLE 3: Turbidity vs. TSS in Billingsley Creek and the Trout Hatchery Effluents

	TSS (mg/l)	Turbidity (NTU)
Billingsley Creek	24.0	4.6
	22.0	2.0
	21.0	2.7
	20.0	2.7
	16.0	1.2
Trout Hatcheries	10.8	1.4
	9.8	0.8
	9.6	1.3
	9.0	1.7
	9.0	1.2

Based on the data in Table 3, it appears that the turbidity resulting from 27.6 mg/l TSS will be about, or less than, 5.0 NTU. In light of the fact that 27.6 mg/l is a fairly conservative worst case estimate of the impact of the hatcheries on Billingsley Creek, we feel the permit limits will not violate Idaho water quality standards or adversely impact the aquatic community of Billingsley Creek.

<u>Settleable Solids:</u>

Composite samples were analyzed for settleable solids from the Rangen raceway and Jones settling pond in March. Both samples were 0.1 ml/l. JRB (1984) collected extensive data on settleable solids at the Jones and Rangen Raceways. In 39 samples from Rangen, the TSS ranged from 14 mg/l to less than 0.1 and the settleable solids were all traces (less than 0.1). These data demonstrate that the hatcheries will comply with the 0.1 ml/l raceway effluent limit for settleable solids if they comply with the suspended solids limit. In fact, these effluent limits will result in virtually no discharge of settleable solids from raceways.

Appendix Table F lists all of the TSS and settleable solids data from JRB, 1984 for trout hatchery cleaning effluents. In nine of the samples the TSS exceeded the 100 mg/l effluent limits. But of those nine, only two exceeded the 1 ml/l settleable solids limit. In six of those nine, only "trace" settleable solids (less than 0.1 ml/l) were detectable.

The data in Table F, considered as a whole, indicate that settleable solids will generally be considerably lower than the effluent limits when TSS is equal to the effluent limits. However, the very limited data from Rangen in Table 9 indicates that effluent settleable solids content might vary proportionally with TSS so that 100 mg/l TSS would result in 1.0 ml/l settleable solids. Self monitoring data from Rangen (Appendix Table G) does not totally support this relationship. It shows TSS levels of 14.0, 38.0, 42.8, and 29.8 with corresponding settleable solids all less than 0.1 ml/l

So, the Rangen Hatchery probably follows the trend apparent in Appendix Table F, i.e., settleable solids are less than the effluent limit of 1.0 ml/l when TSS equals the effluent limit of 100 mg/l.

Since TSS is the limiting parameter in the effluent limit, it appears that the proposed limits will result in very little discharge of settleable solids to Billingsley Creek. However, since settleable solids can significantly impact the stream ecosystem, we simulated a hypothetical worst case in which the hatcheries all discharged their maximum allowed limits of 0.1 ml/l from raceway and 1.0 ml/l from settling ponds. We used the mean effluent flows listed in Appendix Table A.

Table 4 gives the volume of settleable solids that would be discharged in a day from each of the effluents in the worst case situation. The average settling velocity of the suspended sediments from Jones Hatchery is 1.57 cm/sec (JRB, 1984). Billingsley Creek is generally from one to four feet deep below the hatcheries so at a settling velocity of 1.57 cm/sec the material will settle to the bottom between 30-78 seconds after discharge. At current velocities of 1-2 ft/sec, the material should settle out between 30 and 156 feet from the outfalls. After that, it would probably be slowly distributed downstream as bed load.

The volumes listed in Table 4 are clearly unacceptable. They would result in large areas of stream being covered by the fish farm residues. Though these levels are possible under the proposed effluent limits, they are highly unlikely for three reasons. First, TSS is the limiting parameter in the effluent limitation. If the TSS limits are met, settleable solids will be quite low; probably present only as traces. Second, the effluent data collected for this study and the JRB data show that the settling pond discharges almost always discharge concentrations of TSS and settleable solids much less than the permit levels. Third, the higher concentrations of TSS and settleable solids in the settling pond effluents will only occur during cleaning operations; usually a fraction of the day.

TABLE 4

	cfs	Settleable Solids ml/l	Settleable Solids m3 /day
Rangen Settling Pond	4.8	1.0	11.7
Rangen Raceway	27.6	.1	6.7
Jones Settling Pond	1.9	1.0	4.6
Jones Raceway	44.6	1	10.8
Idaho Springs Rearing Pond	30.8	.1	7.4
Idaho Springs Raceway	52.0	.1	12.6
Fisheries Development	10.9	.1	2.6

It is much more likely that virtually no settleable solids will be discharged from the raceways. This conclusion is based on the JRB data discussed above showing that settleable solids from the Jones and Rangen raceways was always less than 0.1 ml/l even though TSS was as high as 24 mg/l. Further, the settling pond effluent loads should be much less than tabulated in Table 4. According to JRB, at Rangen, the large raceways are cleaned every 30-60 days. The small raceways are cleaned everyday, but cleaning effluents flow from each only 3-4 minutes. Also 0.5 ml/l is a more likely, yet conservative estimate of the level of settleable solids discharged from Rangen. Using that concentration and two hours cleaning

time each day, the daily load from Rangen is .48M^3 or 17.2 feet^3. The JRB report states that the Jones settling pond does not, as a rule, discharge to the creek. Therefore, much of the time it will deliver no load to Billingsley Creek.

The daily load of settleable solids possible under the proposed effluent limits is too great. However, the hatcheries are capable of maintaining their settleable solids effluent concentrations much lower than the permit levels. Most of the time settleable solids are less than quantifiable detection limits in both the raceway and settling pond effluents. These "traces" of settleable solids do not adversely affect Billingsley Creek. This excellent performance can be maintained at the hatcheries if an emphasis is placed on managing the solids load. Therefore, EPA and IDHW should work with the hatcheries to develop management plans and O & M plans that will facilitate maximum removal of solids from the effluent.

Nutrients-Nitrogen and Phosphorus:

Appendix Table H lists total nitrogen, total phosphorus, and the nitrogen/phosphorus ratios at Billingsley Creek. Generally, both nutrients are somewhat excessive, potentially leading to nuisance growth of aquatic vegetation. This is confirmed by observations that Billingsley Creek was characterized by dense growth of macrophytes and periphyton in 1983 (JRB, 1984) and 1984 (Mike McMasters, Personal Communication). Overall, phosphorus probably contributes more to the vegetation problems than nitrogen. Total phosphorus concentrations greater than .02 mg/l can lead to eutrophic conditions in lakes. Phosphorus was consistently near 1 mg/l in Billingsley Creek. The nitrogen/phosphorus ratio can be used to estimate which nutrient is limiting plant growth. A ratio greater than 15 indicates that phosphorus is limiting algae growth. A ratio lower than 15 indicates nitrogen is limiting. In Billingsley Creek the ratio is close to 15 most of the time (Appendix Table H). This indicates that nitrogen as well as phosphorus is excessive and that reductions in either nutrient should help lessen plan growth in the stream, especially periphyton. Many of the rooted macrophytes can obtain nutrients from the substrate as well as the water column. Decreases in macrophyte growth will occur slowly.

Table E shows that the hatcheries contribute nitrogen and phosphorus to Billingsley Creek. JRB (1984) and McMasters (Personal Communication) both found vegetation to be denser below the hatcheries than elsewhere, indicating that the hatcheries contribute to plant growth. If at all possible, nutrient loads, especially phosphorus from the hatcheries, should be reduced. Total phosphorus in the hatchery effluents ranged up to 0.49 mg/l, high enough to be excessive in this effluent dominated stream but low enough to be difficult to remove. Nitrogen, especially nitrates and nitrites, are high in the effluents. However, nitrates and nitrites may be fairly high in the influents to the hatcheries as well. Station B1 is at the headwaters of Billingsley Creek and may be indicative of the quality of spring water in the valley. Table I compares nutrients levels at Station B1 and the effluents. Total phosphorus, ammonia, and Kjeldahl nitrogen are all higher in the effluent than at B1, but nitrite/nitrate is about the same in B1 as in the effluents. So while the hatcheries appear to contribute phosphorus, ammonia, and Kjeldahl nitrogen to the stream, they may not contribute significant amounts of nitrate which is the most readily used nutrient form of nitrogen.

High nutrient levels contribute to excessive plant growth in Billingsley Creek. The trout hatcheries contribute nutrients so effort should be made to decrease effluent nutrient levels to the extent possible. However there is no evidence of serious degradation from the plant growth. Though the plants cause depressions in dissolved oxygen levels at night, the lowest recorded levels (5.0 mg/l) are not dangerous to the aquatic community. Further, the hatchery effluent phosphorus concentrations are extremely low. Therefore, EPA and IDHW should work closely with the hatcheries to develop management and O & M plans that minimize the input of nutrients to their water supply and maximize the removal of nutrients before discharging the water to Billingsley Creek.

UN-IONIZED AMMONIA

Un-ionized ammonia (NH_3) data from Billingsley Creek are listed in Appendix Tables D and E. Un-ionized ammonia was extremely low except on May 22, 1984, at Station 3 when it reached 0.075 mg/l and May 22, 1984, at station 4 when it reach 0.0194 mg/l. The state water quality standard for NH_3 is 0.02 mg/l as a 30-day mean. It appears from the data in Appendix Table D that Billingsley Creek complies with that standard.

EPA has recently published draft criteria for NH_3. The criteria include a 30-day average value and a never to be exceeded value that varies as a function of pH and temperature. Appendix Table J lists the criteria for Billingsley Creek using ambient pH and temperature data. Note that the Billingsley Creek grab samples violated the 30-day average criterion only once, on May 22, at station B_3. They never violated the maximum criterion.

At their current discharge rates, the trout hatcheries are not causing NH_3 water quality standards violations. Since the hatcheries discharged right at or slightly less than their TSS limits, no NH_3 problems are expected from the proposed effluent limits.

DISSOLVED OXYGEN

Appendix Figures 1-5 show the dissolved oxygen (DO) concentrations measured in Billingsley Creek. DO was fairly high in the stream throughout the study, with observed values never violating the state water quality standard of 6.0 mg/l.

Starting in April much of the stream was supersaturated with DO when sampled. This is the result of dense vegetation producing DO during the day. DO saturation during the day is usually accompanied by depression of DO levels at night. IDHW monitored DO through a 24-hour period in July (McMasters, Personal Communication). On that day DO fluctuated approximately 9 mg/l from the highest daytime measurement to the lowest nighttime measurement. The lowest DO recorded that day was 5.0 mg/l. The high at that station was 13.2 mg/l.

Carbonaceous biochemical Oxygen demand (CBOD) ranged from 0.4-3.7 mg/l in the creek and 0.2-8.7 mg/l in the effluents. These are very low levels of BOD and would not be expected to affect DO concentrations in shallow fast moving streams like Billingsley Creek. This is confirmed by the DO data discussed above.

In order to confirm that BOD from the hatcheries have little or no effect on stream DO we utilized the stream water quality model to simulate DO in the stream. We checked model accuracy by simulating DO on the March and June sampling dates. Appendix Figures 6 and 7 compare simulated DO to actually measured DO. The model simulated actual DO levels quite well. The underestimates in June are a result of plant caused supersaturation discussed above. The model does not simulate the effects of photosynthesis on DO. The model predicted average DO in the absence of photosynthesis. Photosynthesis can be accounted for by superimposing the measured diurnal DO swing (9.0 mg/l) on the model results. This is done by adding 4.5 mg/l to the DO predictions and subtracting 4.5 from the prediction. The result is a daily DO swing from 4.5 mg/l to 13.5 mg/l in the stream between Jones and Idaho Springs, very close to the measured swing. The model appears to be predicting instream time averaged DO fairly well and can be used to predict DO in the worst case.

The worst case situation simulated assumed all the flow in the stream to be effluent from the hatcheries. The effluent flow rate for each hatchery was set at half the June flow to reduce aeration rates and increase residence time in the stream. The CBOD for all the dischargers was set at the highest level recorded for any effluent during the study (9.0 mg/l). Likewise, dissolved oxygen was set at the lowest level recorded for any discharger (7.1 mg/l).

Appendix Figure 8 illustrates the results of this worst case analysis. DO will not violate the water quality standard of 6.0 mg/l as a result of BOD and DO levels in the effluents. However, very low DO levels could result from plant respiration if there is a 9.0 mg/l daily swing in DO as discussed above. Utilizing the 9.0 mg/l daily swing, the DO below Jones could go down to 3.0 mg/l under these worse case conditions. This low DO would last for a short time because of the short detention time of water in the stream. It is important to note that average instream DO is never lower than effluent DO in the worst case situation. This shows that the low DO is a result of the effluent level of 7.1 mg/l that was assumed. Reference back to Appendix Table E shows that most of the time effluent DO was higher than 7.1. Therefore, we feel that the worst case illustrated in Figure 8 is a very conservative worst case.

0428d

TABLE A: STATISTICAL SUMMARY FOR BILLINGSLEY CREEK***
TROUT HATCHERY EFFLUENT DATA
(FLOW = CFS; OTHER DATA = MG/L)

STATION F1A RANGEN SETTLING POND

	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
MEAN	4.8	8.0	2.6	.297	6.0	.116	.876	.616
STD DEV	1.7	.4	1.3	.175	2.8	.030	.073	.135
STD ERR	.7	.2	.6	.078	1.2	.014	.033	.060
MINIMUM	3.0	7.5	1.1	.179	2.2	.100	.818	.480
MAXIMUM	7.0	8.3	4.3	.594	9.6	.170	.970	.800
RANGE	4.0	.8	3.2	.415	7.4	.070	.152	.320
USED	5	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0	0

STATION F1 RANGEN RACEWAY

	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
AN	27.6	7.3	2.5	.273	4.8	.100	.943	.570
STD DEV	7.9	.2	.7	.037	2.6	.014	.213	.192
STD ERR	3.5	.1	.3	.016	1.2	.006	.095	.086
MINIMUM	21.6	7.1	1.9	.224	1.6	.080	.744	.400
MAXIMUM	41.0	7.6	3.7	.317	7.8	.120	1.260	.900
RANGE	19.4	.5	1.8	.093	6.2	.040	.516	.500
USED	5	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0	0

STATION F2A JONES SETTLING POND

	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
MEAN	1.9	7.9	5.1	.299	7.9	.326	.888	.842
STD DEV	1.4	.6	2.7	.109	1.8	.131	.054	.253
STD ERR	.6	.3	1.2	.049	.8	.058	.024	.113
MINIMUM	.0	7.1	2.4	.138	4.8	.140	.823	.400
MAXIMUM	4.0	8.5	8.7	.404	9.0	.490	.970	1.010
RANGE	4.0	1.4	6.3	.266	4.2	.350	.147	.610
USED	5	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0	0

STATION F2 JONES RACEWAY

	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
MEAN	44.6	8.4	2.8	.322	3.7	.140	.944	.666
STD DEV	9.2	.6	.8	.080	2.5	.057	.111	.169
STD ERR	4.1	.3	.4	.036	1.1	.025	.050	.075
MINIMUM	34.0	7.5	2.1	.221	1.0	.080	.843	.440
MAXIMUM	57.0	9.2	4.1	.416	6.8	.200	1.110	.900
RANGE	23.0	1.7	2.0	.195	5.8	.120	.267	.460
USED	5	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0	0

STATION F3A IDAHO SPRINGS REARING POND

	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
MEAN	30.8	11.7	1.4	.122	5.3	.100	1.148	.450
STD DEV	22.5	1.7	.5	.045	1.7	.000	.241	.058
STD ERR	11.3	.9	.2	.022	.9	.000	.121	.029
MINIMUM	11.3	9.9	.8	.067	3.6	.100	.960	.400
MAXIMUM	60.0	13.8	2.0	.169	7.4	.100	1.500	.500
RANGE	48.7	3.9	1.2	.102	3.8	.000	.540	.100
USED	4	4	4	4	4	4	4	4
OMITTED	0	0	0	0	0	0	0	0

STATION F3 IDAHO SPRINGS RACEWAY

	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
MEAN	42.0	10.5	1.0	.029	5.4	.054	.813	.142
STD DEV	24.1	.6	.8	.007	3.0	.044	.044	.043
STD ERR	10.8	.3	.4	.003	1.3	.020	.020	.019
MINIMUM	.0	9.9	.2	.021	1.6	.000	.770	.100
MAXIMUM	60.0	11.2	2.0	.039	8.6	.100	.880	.200
RANGE	60.0	1.3	1.8	.018	7.0	.100	.110	.100
USED	5	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0	0

STATION F4 FISHERIES DEVELOPMENT SETTLING POND

	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
MEAN	10.9	9.4	3.4	.278	5.8	.160	.763	.778
STD DEV	3.5	.9	1.9	.190	2.8	.062	.130	.273
STD ERR	1.5	.4	.8	.085	1.2	.028	.058	.122
MINIMUM	7.2	8.5	1.5	.066	2.8	.060	.596	.310
MAXIMUM	15.5	10.8	6.1	.434	9.8	.200	.950	1.000
RANGE	8.3	2.3	4.6	.368	7.0	.140	.354	.690
USED	5	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0	0

TABLE B: STATISTICAL SUMMARY OF BILLINGSLEY CREEK FIELD DATA**
(ALL DATA = MG/L)

STATION B1 ABOVE RANGEN TROUT HATCHERY

	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
MEAN	9.3	.030	4.0	.018	.957	.0010	.114
STD DEV	1.1	.033	3.4	.025	.201	.0014	.019
STD ERR	.5	.015	1.5	.011	.090	.0006	.009
MINIMUM	7.3	.004	.0	.000	.820	.0001	.100
MAXIMUM	10.0	.084	8.8	.050	1.300	.0034	.140
RANGE	2.7	.080	8.8	.050	.480	.0033	.040
USED	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0

STATION B2 BELOW RANGEN TROUT HATCHERY

	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
MEAN	7.9	.282	7.9	.136	.918	.0033	.630
STD DEV	1.1	.044	6.2	.043	.173	.0022	.082
STD ERR	.5	.019	2.8	.019	.077	.0010	.037
MINIMUM	6.2	.232	.0	.100	.814	.0013	.500
MAXIMUM	9.4	.337	16.4	.200	1.220	.0071	.700
RANGE	3.2	.105	16.4	.100	.406	.0058	.200
USED	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0

**LEGEND

D.O. = Dissolved Oxygen
AMMON = Total Ammonia
TSS = Total Suspended Solids
TP = Total Phosphorus
NITRA = Nitrates + Nitrites
NH3 = Un-ionized Ammonia
TKN = Kjeldahl Nitrogen

STATION 83 ABOVE JONES TROUT HATCHERY**

	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
MEAN	13.0	.234	9.6	.114	1.580	.0183	.562
STD DEV	4.0	.136	8.9	.022	.633	.0318	.152
STD ERR	1.8	.061	4.0	.010	.283	.0142	.068
MINIMUM	9.7	.058	.0	.100	1.070	.0015	.400
MAXIMUM	19.5	.391	22.0	.150	2.510	.0750	.800
RANGE	9.8	.333	22.0	.050	1.440	.0735	.400
USED	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0

STATION 84 BELOW JONES TROUT HATCHERY

	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
MEAN	10.8	.344	6.6	.108	2.624	.0061	.638
STD DEV	.7	.223	6.0	.011	3.694	.0077	.091
STD ERR	.3	.100	2.7	.005	1.652	.0034	.041
MINIMUM	10.2	.189	.0	.100	.791	.0007	.500
MAXIMUM	11.6	.729	16.0	.120	9.230	.0194	.700
RANGE	1.4	.540	16.0	.020	8.439	.0187	.200
USED	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0

STATION 85 ABOVE IDAHO SPRINGS TROUT HATCHERIES

	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
MEAN	11.7	.137	9.9	.110	1.024	.0049	.514
STD DEV	2.0	.050	7.8	.017	.191	.0024	.129
STD ERR	.9	.022	3.5	.008	.086	.0011	.058
MINIMUM	10.1	.055	1.0	.100	.721	.0031	.400
MAXIMUM	14.8	.185	20.0	.140	1.170	.0090	.710
RANGE	4.7	.130	19.0	.040	.449	.0059	.310
USED	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0

STATION 85A BELOW IDAHO SPRINGS TROUT HATCHERY**

	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
MEAN	10.7	.087	3.4	.103	.957	.0034	.363
STD DEV	1.1	.042	2.7	.005	.052	.0012	.075
STD ERR	.6	.021	1.3	.002	.026	.0006	.037
MINIMUM	9.6	.036	.0	.100	.908	.0020	.300
MAXIMUM	12.0	.136	6.0	.110	1.020	.0047	.450
RANGE	2.4	.100	6.0	.010	.112	.0027	.150
USED	4	4	4	4	4	4	4
OMITTED	0	0	0	0	0	0	0

STATION 86 BELOW FISHERIES DEVELOPMENT TROUT HATCHERY

	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
MEAN	9.8	.132	9.3	.102	1.032	.0053	.394
STD DEV	.8	.061	7.9	.004	.123	.0026	.056
STD ERR	.4	.027	3.5	.002	.055	.0012	.025
MINIMUM	8.9	.070	.0	.100	.960	.0031	.300
MAXIMUM	11.0	.231	21.0	.110	1.250	.0097	.450
RANGE	2.1	.161	21.0	.010	.290	.0066	.150
USED	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0

STATION 87 BELOW HIGHWAY 30

	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
MEAN	10.0	.086	9.9	.102	.958	.0019	.368
STD DEV	.4	.025	8.9	.018	.040	.0008	.089
STD ERR	.2	.011	4.0	.008	.018	.0004	.040
MINIMUM	9.6	.049	.0	.080	.920	.0012	.300
MAXIMUM	10.7	.117	24.0	.130	1.020	.0030	.510
RANGE	1.1	.068	24.0	.050	.100	.0018	.210
USED	5	5	5	5	5	5	5
OMITTED	0	0	0	0	0	0	0

**LEGEND

D.O. = Dissolved Oxygen
TSS = Total Suspended Solids
NITRA = Nitrates + Nitrites
TKN = Kjeldahl Nitrogen

AMMON = Total Ammonia
TP = Total Phosphorus
NH3 = Un-ionized Ammonia

TABLE C: BILLINGSLEY CREEK FIELD DATA SORTED BY DATE**
(FLOW = CFS; OTHER DATA = MG/L)

FIELD DATA COLLECTED JANUARY 31, 1984

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
81	7.8	01/31/84	.0	9.3	.004	8.8	.040	1.300	.0001	.130
82	7.2	01/31/84	44.0	7.8	.254	11.2	.120	1.220	.0025	.690
83	5.8	01/31/84	57.0	10.2	.196	22.0	.120	1.180	.0021	.500
84	5.6	01/31/84	121.0	10.2	.189	16.0	.120	1.080	.0027	.500
85	4.0	01/31/84	136.0	10.1	.145	20.0	.110	1.120	.0031	.560
86	2.6	01/31/84	.0	9.3	.130	21.0	.110	1.010	.0038	.420
87	.6	01/31/84	213.0	10.0	.117	24.0	.130	1.020	.0015	.510

FIELD DATA COLLECTED MARCH 6 AND 7, 1984

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
81	7.8	03/07/84	.0	7.3	.039	2.8	.050	.970	.0005	.140
82	7.2	03/07/84	31.0	6.2	.271	16.4	.160	.910	.0027	.66[illegible]
83	5.8	03/06/84	47.0	9.7	.173	15.2	.150	1.070	.0040	.6[illegible]
84	5.6	03/06/84	99.0	10.2	.199	7.8	.120	.970	.0016	.5[illegible]
85	4.0	03/06/84	119.0	10.6	.166	14.0	.140	1.160	.0052	.710
85A	3.7	03/06/84	179.6	9.6	.101	6.0	.110	.978	.0031	.450
86	2.6	03/06/84	211.0	8.9	.099	11.0	.100	.960	.0031	.450
87	.6	03/06/84	201.0	9.7	.081	7.4	.080	.950	.0014	.330

FIELD DATA COLLECTED APRIL 24, 1984

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
81	7.8	04/24/84	.0	9.9	.008	5.8	.000	.820	.0002	.100
82	7.2	04/24/84	28.0	8.1	.316	6.6	.100	.820	.0027	.600
83	5.8	04/24/84	40.0	11.3	.391	6.8	.100	1.170	.0090	.800
84	5.6	04/24/84	82.0	11.4	.264	5.6	.100	9.230	.0063	.700
85	4.0	04/24/84	108.0	10.5	.185	11.2	.100	.950	.0034	.500
85A	3.7	04/24/84	153.0	10.0	.136	5.0	.100	.908	.0047	.400
86	2.6	04/24/84	183.0	9.8	.231	9.6	.100	1.250	.0051	.400
87	.6	04/24/84	158.0	9.6	.099	11.8	.100	.920	.0026	.400

**LEGEND

D.O. = Dissolved Oxygen
TSS = Total Suspended Solids
NITRA = Nitrates + Nitrites
TKN = Kjeldahl Nitrogen
AMMON = Total Ammonia
TP = Total Phosphorus
NH3 = Un-ionized Ammonia

FIELD DATA COLLECTED MAY 22, 1984**

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
81	7.8	05/22/84	.0	10.0	.014	2.8	.000	.825	.0034	.100
82	7.2	05/22/84	27.0	7.8	.337	5.1	.200	.828	.0071	.700
83	5.8	05/22/84	4.0	19.5	.350	3.8	.100	2.510	.0750	.400
84	5.6	05/22/84	42.0	11.6	.729	3.4	.100	.791	.0194	.700
85	4.0	05/22/84	45.0	14.8	.055	3.4	.100	.721	.0090	.400
85A	3.7	05/22/84	112.0	12.0	.036	2.6	.100	.922	.0039	.300
86	2.6	05/22/84	121.0	11.0	.070	4.8	.100	.970	.0097	.400
87	.6	05/22/84	.0	10.7	.049	6.4	.100	.930	.0012	.300

FIELD DATA COLLECTED JUNE 12, 1984

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
81	7.8	06/12/84	.0	9.9	.084	.0	.000	.872	.0006	.100
82	7.2	06/12/84	35.5	9.4	.232	.0	.100	.814	.0013	.500
83	5.8	06/12/84	5.0	14.2	.058	.0	.100	1.970	.0015	.500
84	5.6	06/12/84	50.8	10.4	.338	.0	.100	1.050	.0007	.700
85	4.0	06/12/84	54.0	12.6	.136	1.0	.100	1.170	.0038	.400
[illegible]	3.7	06/12/84	120.0	11.2	.075	.0	.100	1.020	.0020	.300
[illegible]	2.6	06/12/84	141.0	10.1	.129	.0	.100	.969	.0048	.300
87	.6	06/12/84	143.0	9.9	.084	.0	.100	.972	.0030	.300

**<u>LEGEND</u>

D.O. = Dissolved Oxygen
TSS = Total Suspended Solids
NITRA = Nitrates + Nitrites
TKN = Kjeldahl Nitrogen
AMMON = Total Ammonia
TP = Total Phosphorus
NH3 = Un-ionized Ammonia

TABLE D: BILLINGSLEY CREEK FIELD DATA SORTED BY STATION **
(FLOW = CFS; OTHER DATA = MG/L)

FIELD DATA FROM STATION 81

STA	MILE	DATE	FLOW*	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
81	7.8	01/31/84	.0	9.3	.004	8.8	.040	1.300	.0001	.130
81	7.8	03/07/84	.0	7.3	.039	2.8	.050	.970	.0005	.140
81	7.8	04/24/84	.0	9.9	.008	5.8	.000	.820	.0002	.100
81	7.8	05/22/84	.0	10.0	.014	2.8	.000	.825	.0034	.100
81	7.8	06/12/84	.0	9.9	.084	.0	.000	.872	.0006	.100

* FLOW WAS NOT MEASURED

FIELD DATA FROM STATION 82

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
82	7.2	01/31/84	44.0	7.8	.254	11.2	.120	1.220	.0025	.690
82	7.2	03/07/84	31.0	6.2	.271	16.4	.160	.910	.0027	.660
82	7.2	04/24/84	28.0	8.1	.316	6.6	.100	.820	.0027	.600
82	7.2	05/22/84	27.0	7.8	.337	5.1	.200	.828	.0071	.700
82	7.2	06/12/84	35.5	9.4	.232	.0	.100	.814	.0013	.500

FIELD DATA FROM STATION 83

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
83	5.8	01/31/84	57.0	10.2	.196	22.0	.120	1.180	.0021	.500
83	5.8	03/06/84	47.0	9.7	.173	15.2	.150	1.070	.0040	.610
83	5.8	04/24/84	40.0	11.3	.391	6.8	.100	1.170	.0090	.800
83	5.8	05/22/84	4.0	19.5	.350	3.8	.100	2.510	.0750	.400
83	5.8	06/12/84	5.0	14.2	.058	.0	.100	1.970	.0015	.500

FIELD DATA FROM STATION 84

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
84	5.6	01/31/84	121.0	10.2	.189	16.0	.120	1.080	.0027	.500
84	5.6	03/06/84	99.0	10.2	.199	7.8	.120	.970	.0016	.590
84	5.6	04/24/84	82.0	11.4	.264	5.6	.100	9.230	.0063	.700
84	5.6	05/22/84	42.0	11.6	.729	3.4	.100	.791	.0194	.700
84	5.6	06/12/84	50.8	10.4	.338	.0	.100	1.050	.0007	.700

FIELD DATA FROM STATION 85**

	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
85	4.0	01/31/84	136.0	10.1	.145	20.0	.110	1.120	.0031	.560
85	4.0	03/06/84	119.0	10.6	.166	14.0	.140	1.160	.0052	.710
85	4.0	04/24/84	108.0	10.5	.185	11.2	.100	.950	.0034	.500
85	4.0	05/22/84	45.0	14.8	.055	3.4	.100	.721	.0090	.400
85	4.0	06/12/84	54.0	12.6	.136	1.0	.100	1.170	.0038	.400

FIELD DATA FROM STATION 85A

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
85A	3.7	03/06/84	179.6	9.6	.101	6.0	.110	.978	.0031	.450
85A	3.7	04/24/84	153.0	10.0	.136	5.0	.100	.908	.0047	.400
85A	3.7	05/22/84	112.0	12.0	.036	2.6	.100	.922	.0039	.300
85A	3.7	06/12/84	120.0	11.2	.075	.0	.100	1.020	.0020	.300

FIELD DATA FROM STATION 6

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
86	2.6	01/31/84	.0	9.3	.130	21.0	.110	1.010	.0038	.420
86	2.6	03/06/84	211.0	8.9	.099	11.0	.100	.960	.0031	.450
86	2.6	04/24/84	183.0	9.8	.231	9.6	.100	1.250	.0051	.400
86	2.6	05/22/84	121.0	11.0	.070	4.8	.100	.970	.0097	.400
86	2.6	06/12/84	141.0	10.1	.129	.0	.100	.969	.0048	.300

FIELD DATA FROM STATION 87

STA	MILE	DATE	FLOW	D.O.	AMMON	TSS	TP	NITRA	NH3	TKN
87	.6	01/31/84	213.0	10.0	.117	24.0	.130	1.020	.0015	.510
87	.6	03/06/84	201.0	9.7	.081	7.4	.080	.950	.0014	.330
87	.6	04/24/84	158.0	9.6	.099	11.8	.100	.920	.0026	.400
87	.6	05/22/84	.0	10.7	.049	6.4	.100	.930	.0012	.300
	.6	06/12/84	143.0	9.9	.084	.0	.100	.972	.0030	.300

TABLE E: BILLINGSLEY CREEK TROUT HATCHERY EFFLUENT [illegible]
(FLOW = CFS; OTHER DATA = MG/L)

STA	NAME	MILE	DATE	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
F1A	RANGEN SETTLING POND EFFLUENT	7.4	01/31/84	3.0	8.3	3.4	.179	9.6	.170	.940	.480
F1A	RANGEN SETTLING POND EFFLUENT	7.4	03/07/84	7.0	8.0	1.7	.198	4.6	.110	.970	.700
F1A	RANGEN SETTLING POND EFFLUENT	7.4	04/24/84	5.0	8.3	4.3	.315	6.8	.100	.820	.800
F1A	RANGEN SETTLING POND EFFLUENT	7.4	05/22/84	5.7	7.5	1.1	.199	7.0	.100	.818	.600
F1A	RANGEN SETTLING POND EFFLUENT	7.4	06/12/84	3.3	7.7	2.4	.594	2.2	.100	.834	.500
STA	NAME	MILE	DATE	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
F1	RANGEN RACEWAY EFFLUENT	7.3	01/31/84	41.0	7.5	1.9	.248	6.6	.080	1.260	.540
F1	RANGEN RACEWAY EFFLUENT	7.3	03/07/84	24.0	7.2	2.6	.288	1.6	.120	1.020	.510
F1	RANGEN RACEWAY EFFLUENT	7.3	04/24/84	23.0	7.1	3.7	.317	5.4	.100	.940	.500
F1	RANGEN RACEWAY EFFLUENT	7.3	05/22/84	21.6	7.6	2.0	.287	7.8	.100	.753	.400
F1	RANGEN RACEWAY EFFLUENT	7.3	06/12/84	28.5	7.1	2.2	.224	2.7	.100	.744	.900
STA	NAME	MILE	DATE	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
F2A	JONES SETTLING POND EFFLUENT	5.7	01/31/84	4.0	8.4	2.8	.138	8.6	.140	.970	.400
F2A	JONES SETTLING POND EFFLUENT	5.7	03/06/84	2.0	7.1	6.9	.269	8.0	.490	.900	1.010
F2A	JONES SETTLING POND EFFLUENT	5.7	04/24/84	2.0	8.5	8.7	.286	9.0	.400	.860	1.000
F2A	JONES SETTLING POND EFFLUENT	5.7	05/22/84	.0	8.0	2.4	.397	9.0	.300	.823	.900
F2A	JONES SETTLING POND EFFLUENT	5.7	06/12/84	1.4	7.6	4.6	.404	4.8	.300	.886	.900
STA	NAME	MILE	DATE	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
F2	JONES RACEWAY EFFLUENT	5.7	01/31/84	57.0	8.6	3.1	.221	6.8	.080	1.110	.440
F2	JONES RACEWAY EFFLUENT	5.7	03/06/84	51.0	8.0	2.4	.257	1.4	.120	1.000	.590
F2	JONES RACEWAY EFFLUENT	5.7	04/24/84	40.0	7.5	4.1	.361	4.2	.200	.860	.900
F2	JONES RACEWAY EFFLUENT	5.7	05/22/84	34.0	9.2	2.1	.355	5.2	.200	.843	.700
F2	JONES RACEWAY EFFLUENT	5.7	06/12/84	41.1	8.6	2.4	.416	1.0	.100	.908	.700
STA	NAME	MILE	DATE	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
F3A	IDAHO SPRINGS REARING POND EFF	3.9	03/06/84	40.0	9.9	1.4	.144	5.8	.100	1.090	.500
F3A	IDAHO SPRINGS REARING POND EFF	3.9	04/24/84	37.0	10.8	2.0	.169	4.2	.100	.960	.500
F3A	IDAHO SPRINGS REARING POND EFF	3.9	05/22/84	15.0	13.8	.8	.067	3.6	.100	1.040	.400
F3A	IDAHO SPRINGS REARING POND EFF	3.9	06/12/84	11.3	12.2	1.4	.106	7.4	.100	1.500	.400

**LEGEND

D.O. = Dissolved Oxygen
AMMON = Total Ammonia
TSS = Total Suspended Solids
TKN = Kjeldahl Nitrogen
TP = Total Phosphorus
NITRA= Nitrates + Nitrites
NH3 = Un-ionized Ammonia
B.O.D. = 5 day Biochemical Oxygen Demand

STA	NAME	MILE	DATE	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
F3	IDAHO SPRINGS RACEWAY EFFLUENT	3.8	01/31/84	.0	10.0	1.6	.026	3.2	.030	.880	.160
F3	IDAHO SPRINGS RACEWAY EFFLUENT	3.8	03/06/84	55.0	9.9	.8	.021	1.6	.040	.820	.150
F3	IDAHO SPRINGS RACEWAY EFFLUENT	3.8	04/24/84	45.0	10.3	2.0	.029	8.6	.100	.770	.200
F3	IDAHO SPRINGS RACEWAY EFFLUENT	3.8	05/22/84	50.0	11.1	.2	.039	5.6	.100	.777	.100
F3	IDAHO SPRINGS RACEWAY EFFLUENT	3.8	06/12/84	60.0	11.2	.2	.030	7.8	.000	.810	.100

STA	NAME	MILE	DATE	FLOW	D.O.	B.O.D.	AMMONIA	TSS	TP	NITRA	TKN
F4	FISH DEV SETTLING POND EFFLUEN	2.7	01/31/84	11.0	8.5	6.1	.387	9.8	.140	.952	.780
F4	FISH DEV SETTLING POND EFFLUEN	2.7	03/06/84	13.0	10.8	1.5	.076	2.8	.060	.810	.310
F4	FISH DEV SETTLING POND EFFLUEN	2.7	04/24/84	8.0	9.1	4.4	.427	7.2	.200	.730	.900
F4	FISH DEV SETTLING POND EFFLUEN	2.7	05/22/84	7.2	9.4	2.4	.434	5.4	.200	.728	1.009
F4	FISH DEV SETTLING POND EFFLUEN	2.7	06/12/84	15.5	9.2	2.4	.066	4.0	.200	.596	.900

LEGEND

D.O. = Dissolved Oxygen
AMMON = Total Ammonia
TSS = Total Suspended Solids
TP = Total Phosphorus
NITRA = Nitrates + Nitrites
NH3 = Un-ionized Ammonia
TKN = Kjeldahl Nitrogen
B.O.D. = 5 day Biochemical Oxygen Demand

Table F: TSS and Settleable Solids in Cleaning Effluents of Trout Hatcheries

Date	Effluent TSS (mg/l)	Effluent Set. Slds. (ml/l)
Crystal Springs Hatchery		
5/20/83	264	2.5
5/22/83	142	0.5
5/23/83	186	11.0
5/24/83	128	Trace
6/08/83	124	Trace
6/09/83	22	Trace
Rim View Hatchery		
6/01/83	42	Trace
Pisces Hatchery		
5/12/83	132	Trace
5/13/83	110	Trace
5/14/83	92	Trace
5/15/83	103	Trace
5/16/83	150	Trace
Fish Breeders		
5/19/83	33	Trace
5/20/83	25	Trace
5/21/83	30	Trace
5/22/83	22	Trace
5/23/83	36	Trace
5/24/83	25	Trace
5/25/83	24	Trace
6/08/83	37	Trace
6/09/83	23	Trace
6/10/83	35	Trace
Hagerman Hatchery		
5/16/83	13	Trace
5/17/83	6	Trace
5/18/83	11	Trace
5/19/83	4	Trace
5/20/83	5	Trace
5/21/83	6	Trace
Rangen Hatchery		
5/29/83	8	0.1
5/30/83	9	Trace
6/01/83	34	0.3
6/03/83	8	Trace
6/04/83	22	0.2
Jones Hatchery		
6/02/83	13	--
6/07/83	49	Trace

Table G : Rangen Self Monitoring Data

Date	TSS mg/l	Settleable Solids ml/l
01/83	4.0	less than .1
02/83	29.0	less than .3
01/84	14.0	less than .1
02/84	38.0	less than .1
03/84	42.75	less than .1
05/84	29.8	less than .1

Table H : Total Nitrogen, Total Phosphorus
and the N/P Ratio at Billingsley Creek

		TN	TP	N/P
B1	11/31/84	1.4	.04	35
	3/07/84	1.1	.05	22
	4/24/84	.9	0	
	5/22/84	.9	0	
	6/12/84	1.0	0	
B2	1/31/84	1.9	.12	16
	3/07/84	1.6	.16	10
	4/24/84	1.4	.1	14
	5/22/84	1.5	.2	7.5
	6/12/84	1.3	.1	13
B3	1/31/84	1.7	.12	14
	3/06/84	1.7	.15	11
	4/24/84	2.0	.1	20
	5/22/84	2.9	.1	29
	6/12/84	2.5	.1	25
B4	1/31/84	1.6	.12	13
	3/06/84	1.6	.12	13
	4/24/84	9.9	.1	99
	5/22/84	1.5	.1	15
	6/12/84	1.8	.1	18
B5	1/31/84	1.7	.11	15
	3/06/84	1.9	.14	14
	4/24/84	1.5	.1	15
	5/22/84	1.1	.1	11
	6/12	1.6	.1	16
B5A	3/06	1.4	.11	13
	4/24	1.3	.1	13
	5/22	1.2	.1	12
	6/12	1.3	.1	13
	1/31	1.4	.11	13
B6	3/06	1.4	.1	14
	4/24	1.7	.1	17
	5/28	1.4	.1	14
	6/12	1.3	.1	13
	1/31	1.5	.13	12
	3/06	1.3	.08	16
	4/24	1.3	.1	13
	5/22	1.2	.1	12
	6/12	1.3	.1	13

TABLE I: Comparison of Nutrient Levels at Station B1 With Nutrient Levels In The Hatchery Effluents

	B1	Rangen		Jones		Idaho Springs		Fisheries Develop.
		Raceway	Settling Pond	Raceway	Settling Pond	Raceway	Settling Pond	Settling Pond
TP	0-0.05	0.08-0.12	0.1-0.17	0.08-0.2	0.14-0.49	0-0.1	0.1	0.06-0.2
Ammonia	0.004-0.084	0.224-0.317	0.179-0.594	0.221-0.416	0.138-0.404	0.21-0.39	0.067-0.169	0.066-0.434
Kjeldahl-N	0.1-0.14	0.4-0.9	0.48-0.8	0.44-0.90	0.4-1.01	0.1-0.2	0.4-0.5	0.310-1.0
Nitrite/ Nitrate	0.82-1.3	0.744-1.26	0.818-0.97	0.843-1.11	0.823-0.97	0.77-0.88	0.96-1.5	0.596-0.950

0405d

TABLE J.: BILLINGSLEY CREEK NH3 CRITERIA AND ACTUAL NH3 CONCENTRATION DURING THE 1984 FIELD STUDY

STATION #	DATE	TEMP (C)	PH(SU)	30-DAY CRITERIA MG/L NH3-N	MAXIMUM CRITERIA MG/L NH3-N	ACTUAL NH3 MG/L NH3-
B1	1/31/84	14.00	7.90	0.025	0.098	.0001
B1	3/7/84	14.2	8.1	0.025	0.107	.0005
B1	4/24/84	14.8	8	0.025	0.103	.0002
B1	5/22/84	14.2	8	0.025	0.103	.0034
B1	6/12/84	14.5	8.1	0.025	0.107	.0006
B2	1/31/84	13.8	7.6	0.021	0.081	.0025
B2	3/7/84	14	7.6	0.021	0.081	.0027
B2	4/24/84	14.8	7.5	0.018	0.075	.0027
B2	5/22/84	15	7.9	0.025	0.098	.0071
B2	6/12/84	14.9	7.3	0.013	0.060	.0013
B3	1/31/84	12.1	7.7	0.025	0.088	.0021
B3	3/6/84	14	8	0.025	0.103	.0040
B3	4/24/84	16.1	7.9	0.025	0.098	.0090
B3	5/22/84	15	9	0.025	0.121	.0750
B3	6/12/84	15	8	0.025	0.103	.0015
B4	1/31/84	13	7.8	0.025	0.093	.0027
B4	3/6/84	14.2	7.5	0.018	0.075	.0016
B4	4/24/84	16.6	7.9	0.025	0.098	.0063
B4	5/22/84	15.1	8	0.025	0.103	.0194
B4	6/12/84	15	6.9	0.007	0.033	.0007
B5	1/31/84	12	8	0.025	0.103	.0031
B5	3/6/84	14.3	8.1	0.025	0.107	.0052
B5	4/24/84	16	7.8	0.025	0.093	.0034
B5	5/22/84	16.9	8.5	0.025	0.120	.0090
B5	6/12/84	15.5	8	0.025	0.103	.0038
B5A	3/6/84	14	8.1	0.025	0.107	.0031
B5A	4/24/84	15.6	8.1	0.025	0.107	.0047
B5A	5/22/84	16.6	8.6	0.025	0.118	.0039
B5A	6/12/84	15.8	8	0.025	0.103	.0020
B6	1/31/84	13.2	8.1	0.025	0.107	.0038
B6	3/6/84	14.2	8.1	0.025	0.107	.0031
B6	4/24/84	15.5	7.9	0.025	0.098	.0051
B6	5/22/84	17	8.7	0.025	0.119	.0097
B6	6/12/84	16.5	8.1	0.025	0.107	.0048
B7	1/31/84	11.6	7.8	0.025	0.093	.0015
B7	3/6/84	12.5	7.9	0.025	0.098	.0014
B7	4/24/84	14.9	8	0.025	0.103	.0026
B7	5/22/84	16	8.6	0.025	0.118	.0012
B7	6/12/84	16	8.1	0.025	0.107	.0030

FIGURE 1: DISSOLVED OXYGEN (O) AND TSS (S) IN MG/L VERSUS RIVER MILE ON JANUARY 31, 1984.

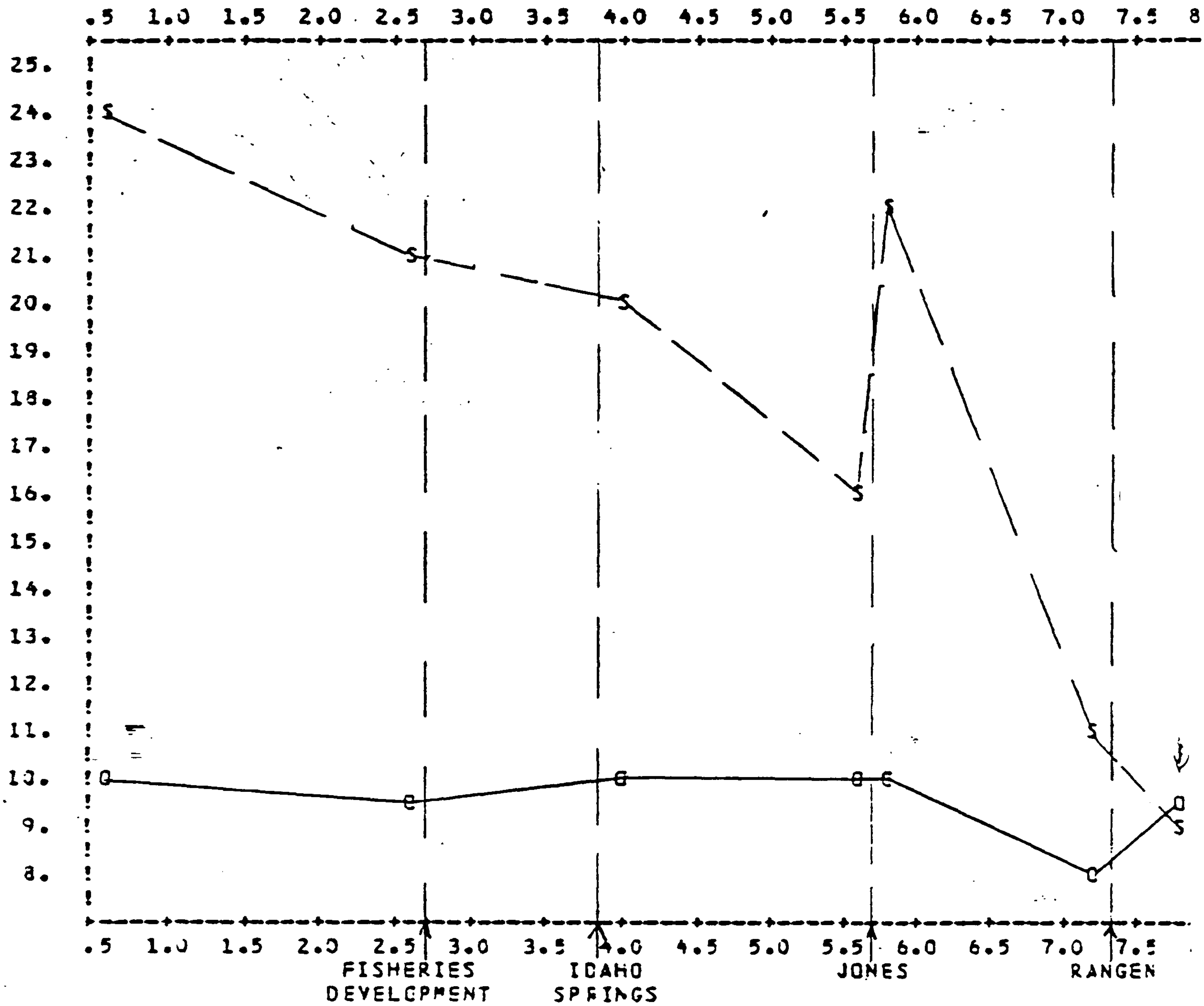


FIGURE 2: DISSOLVED OXYGEN (O) AND TSS (S) IN MG/L VERSUS RIVER MILE ON MARCH 6-7, 1984.

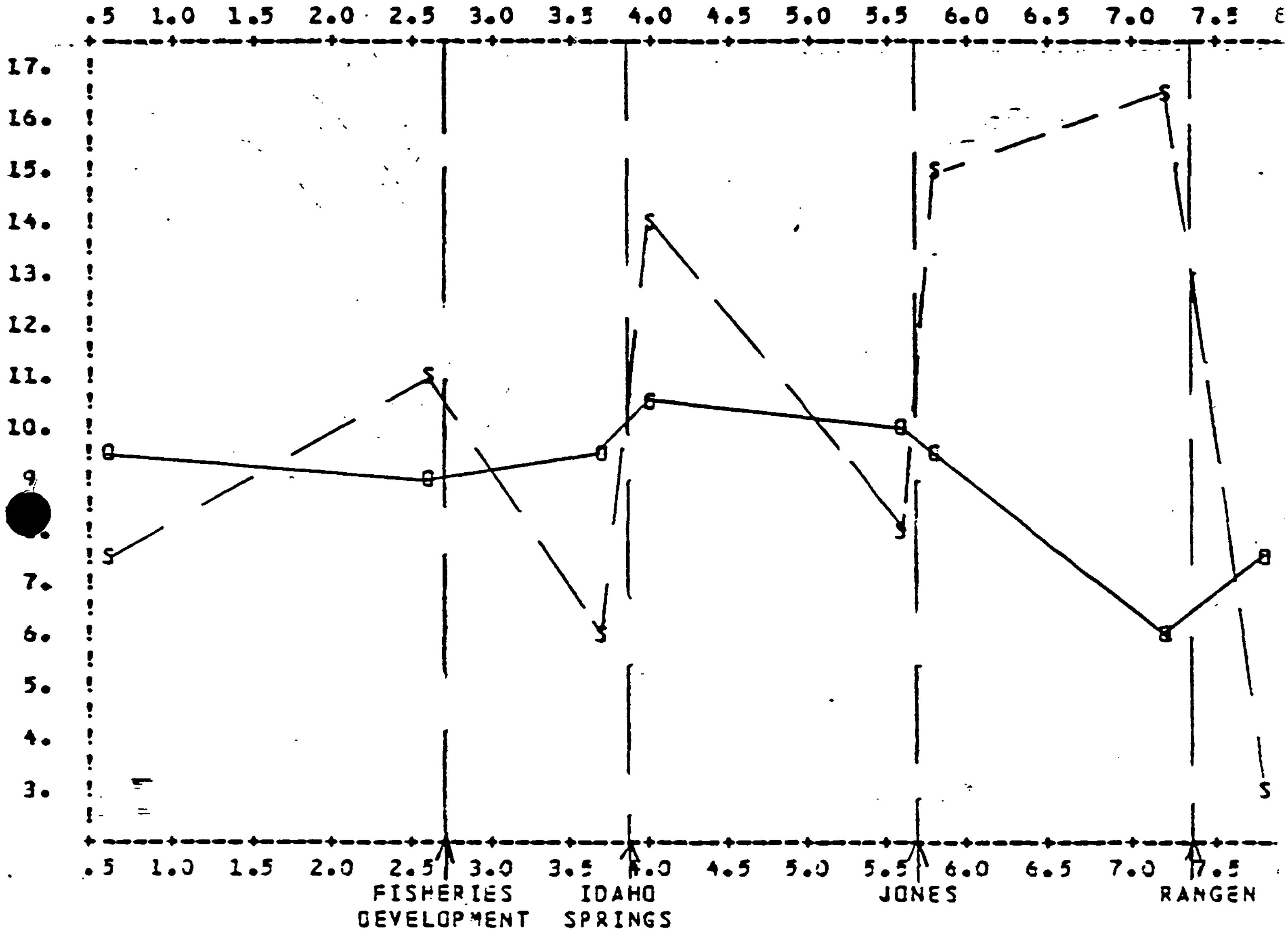


FIGURE 3: DISSOLVED OXYGEN (O) AND TSS (S) IN MG/L
VERSUS RIVER MILE ON APRIL 24,1984.

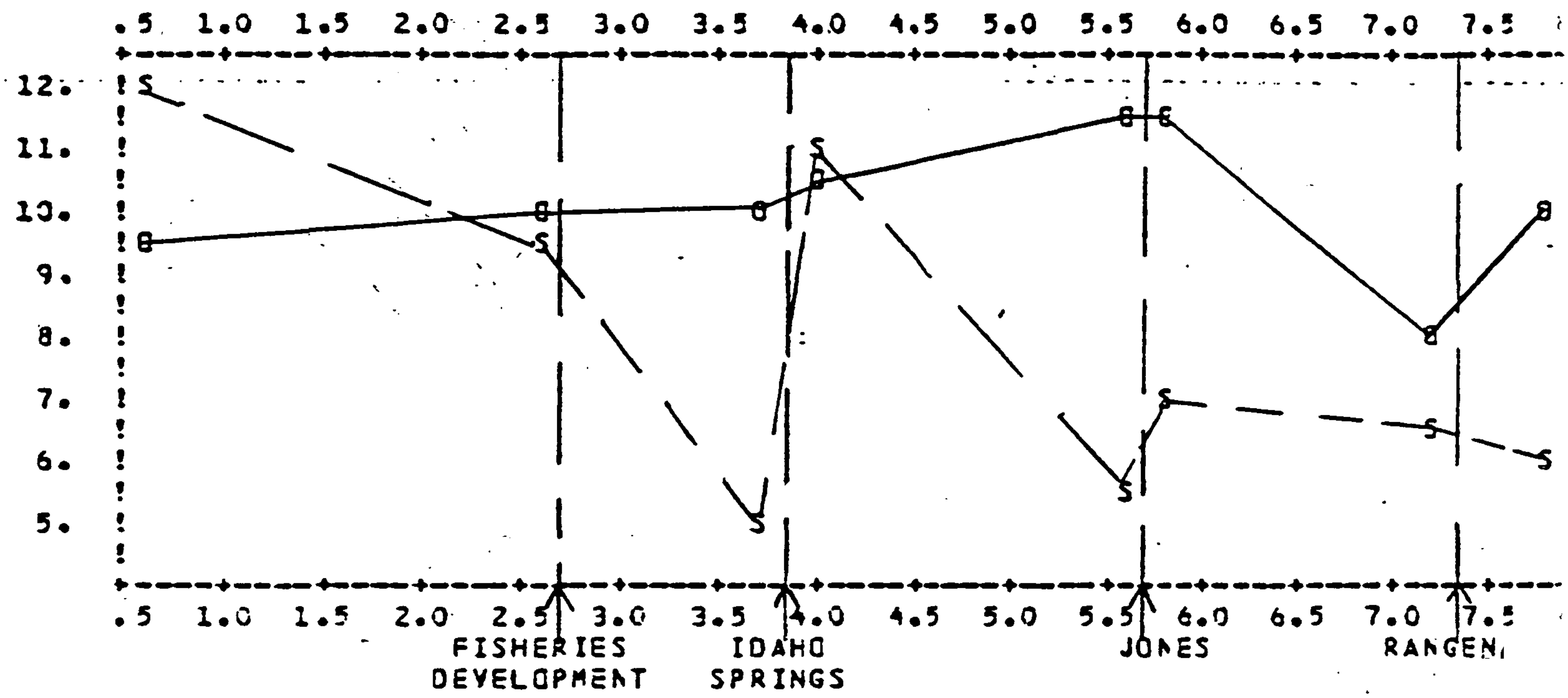


FIGURE 4: DISSOLVED OXYGEN (O) AND TSS (S) IN MG/L
VERSUSS RIVER MILE ON MAY 22, 1984.

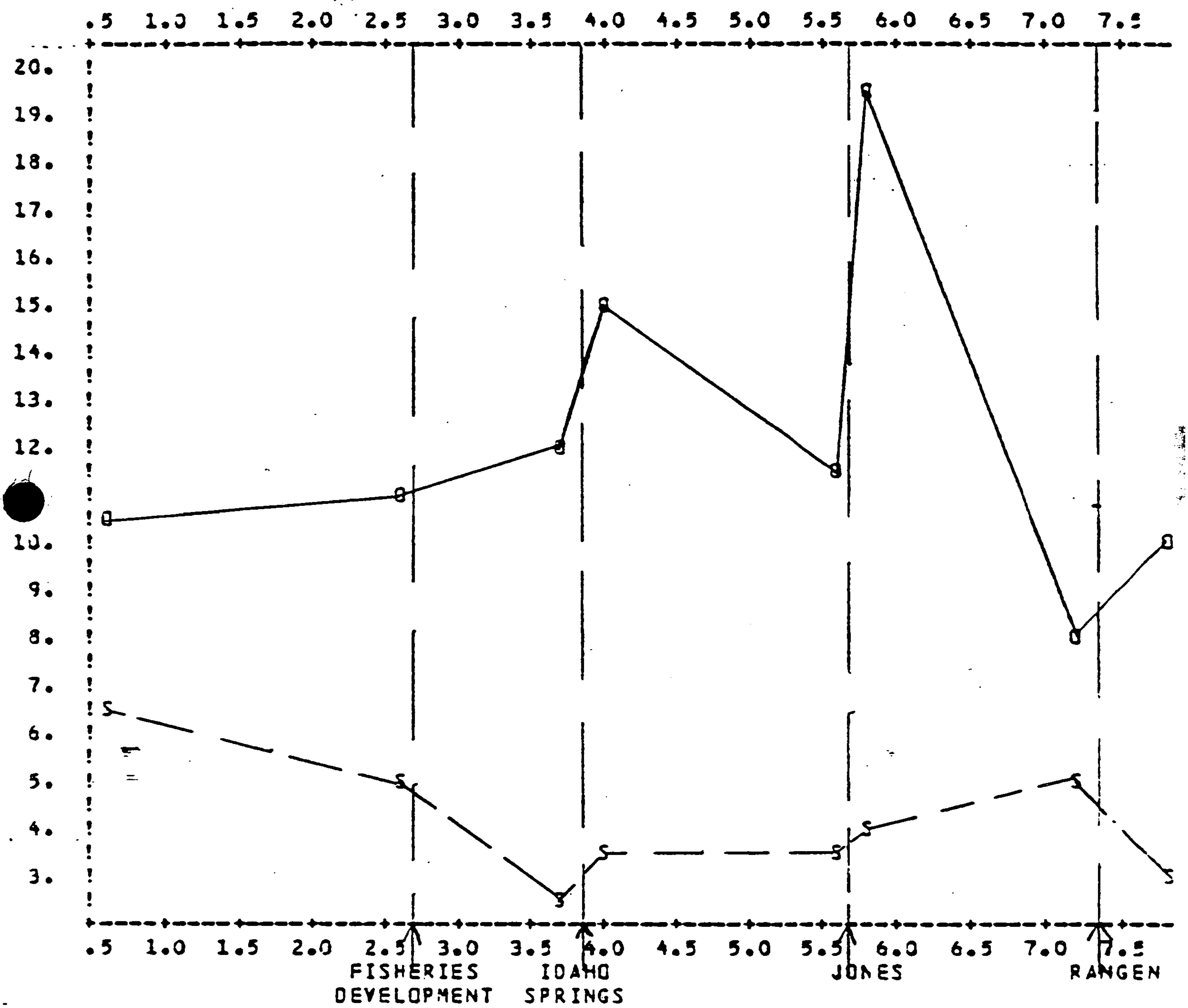


FIGURE 5: DISSOLVED OXYGEN (O) AND TSS (S) IN MG/L VERSUS RIVER MILE ON JUNE 12, 1984.

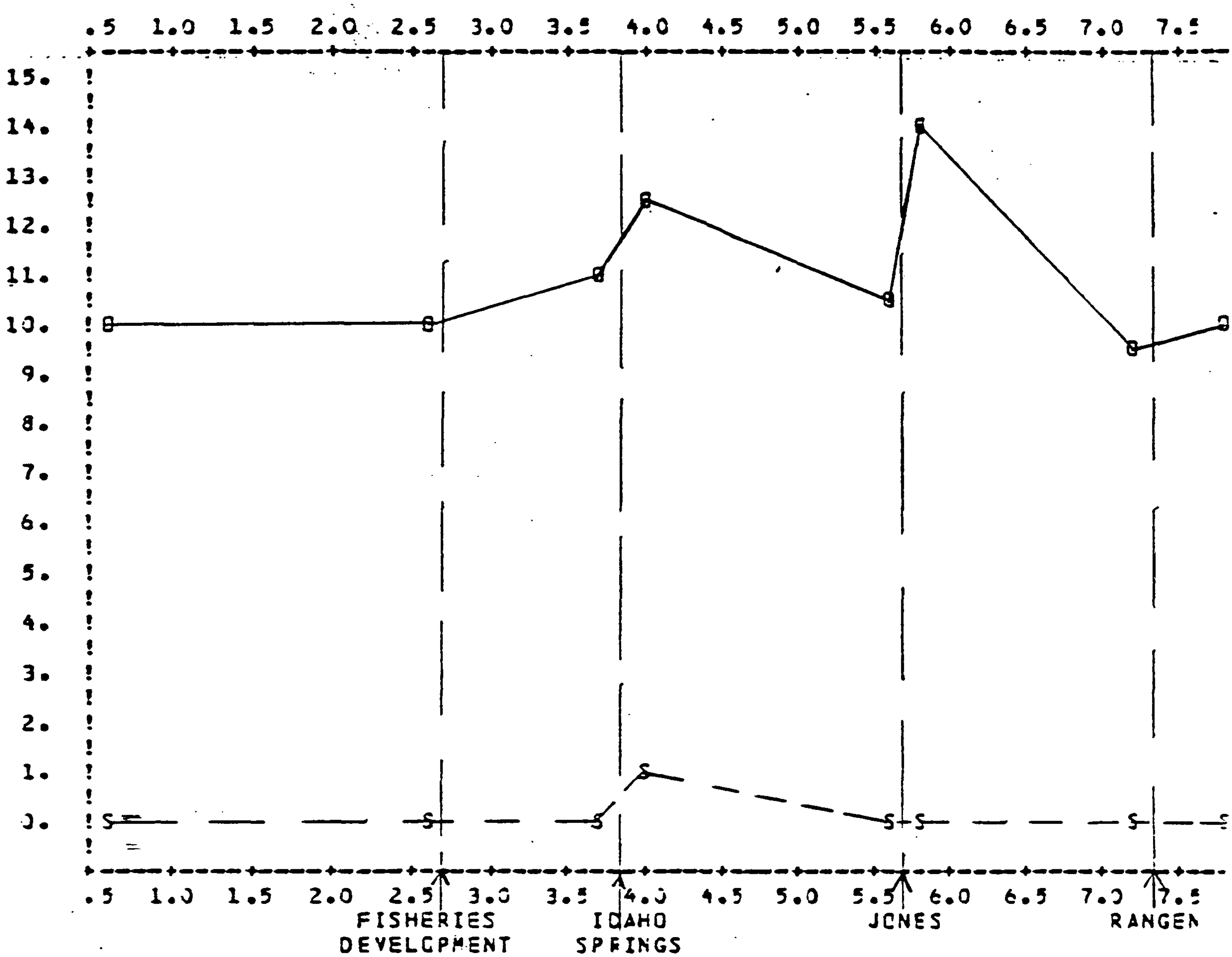
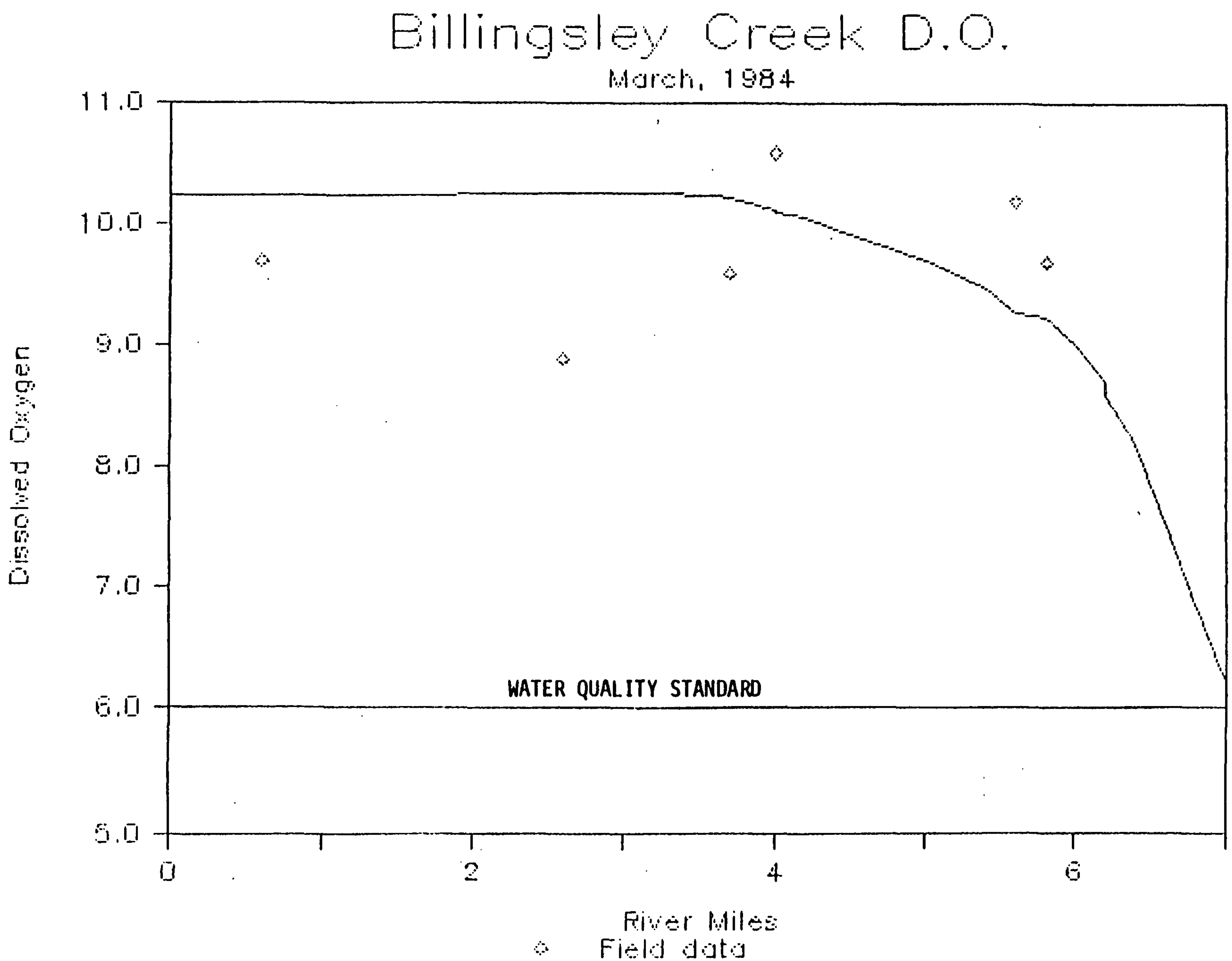


FIGURE 6



Billingsley Creek D.O.
March, 1984
11.0
10.0
9.0
8.0
7.0
6.0
5.0
Dissolved Oxygen
WATER QUALITY STANDARD
0
2
4
6
River Miles
Field data

FIGURE 7

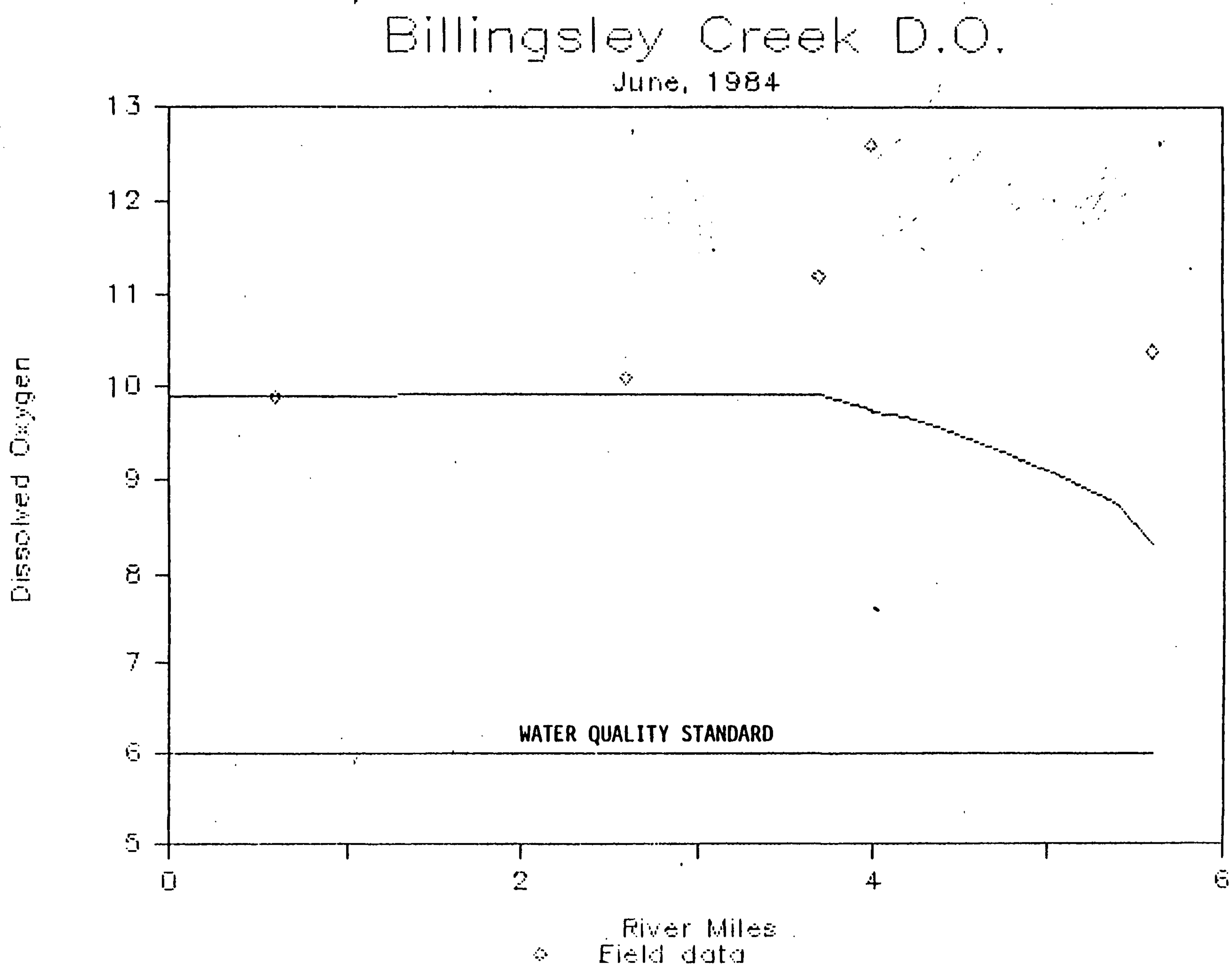
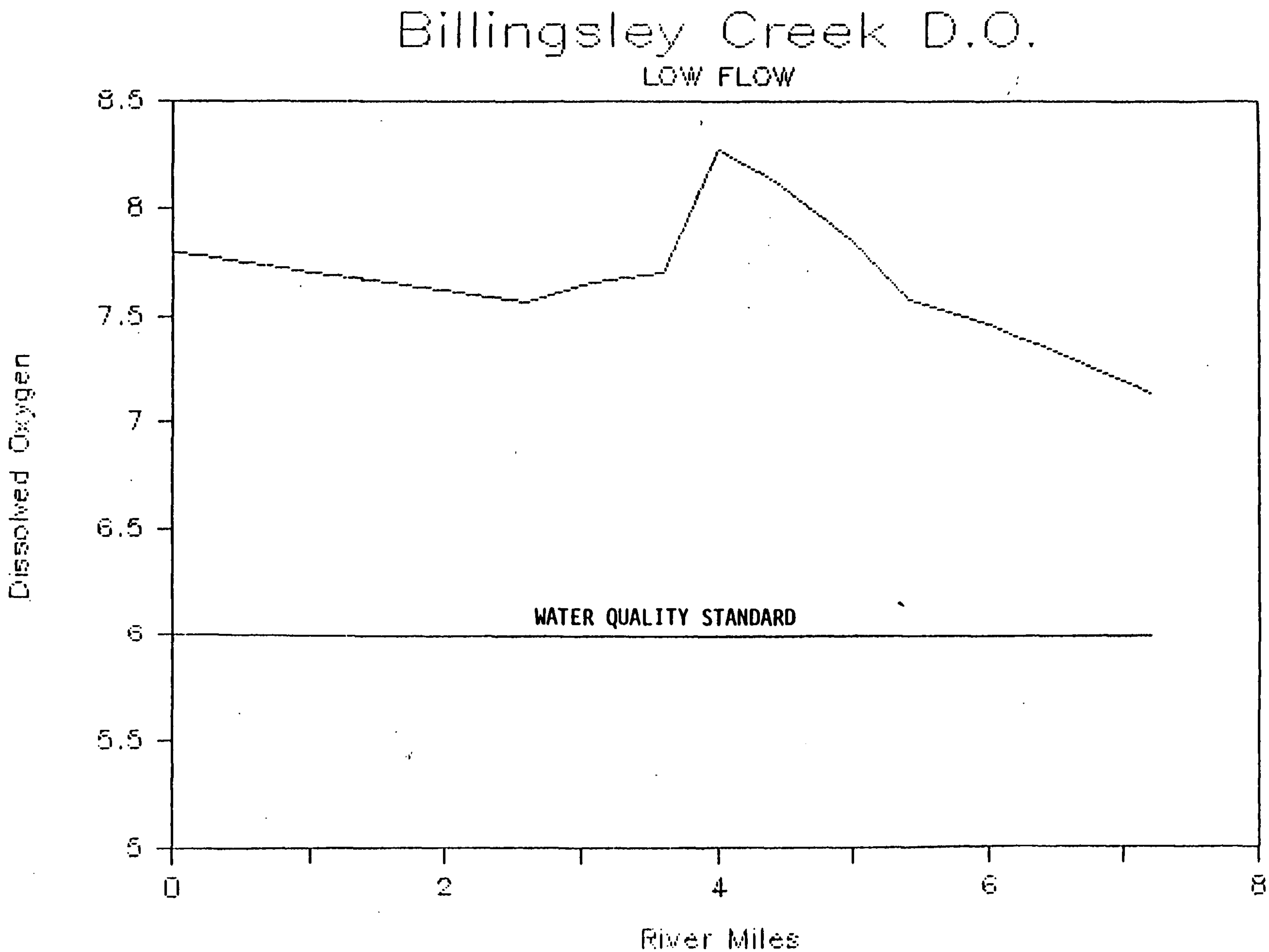

Billingsley Creek D.O.
June, 1984
Dissolved Oxygen
13
12
11
10
9
8
7
6
5
WATER QUALITY STANDARD
0
2
4
6
River Miles
Field data

FIGURE 8


Billingsley Creek D.O.
LOW FLOW
8.5
8
7.5
7
6.5
6
5.5
5
Dissolved Oxygen
WATER QUALITY STANDARD
0
2
4
6
8
River Miles