WATER QUALITY STATUS REPORT • REPORT NO. 79

LAKE IRRIGATION DISTRICT SURVEY and CASCADE RESERVOIR TRIBUTARY ASSESSMENT

Valley County, Idaho

1986

Prepared by
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Department of Health & Welfare
Division of Environment
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ABSTRACT

The impact of agricultural irrigation practices on surface water quality in the Cascade Reservoir watershed was studied during 1986. Stations located on irrigation ditches above and below cropland and pastureland were monitored for nutrients, sediment and bacteria. Samples were collected every two weeks during the irrigation season. Flood irrigated cropland had the most significant water quality impacts, with increases in total nitrogen, phosphorus, turbidity and suspended solids. Monitoring conducted on sprinkler irrigated cropland showed the least amount of change in water quality. Dissolved orthophosphate increased over 600 percent and total nitrogen increased 180 percent below the flood irrigated pastureland. There was no correlation between the increases in nutrients and the presence or absence of grazing animals. Stations located on tributaries to Cascade Reservoir were monitored for nutrients, bacteria, sediment, flow, chemical oxygen demand, dissolved oxygen and pH. The flow in Mud Creek was found to be highly influenced by irrigation return flows. Mud Creek had slightly higher sediment loadings to Cascade Reservoir during the latter part of the irrigation season. Lake Fork Creek had the highest sediment and phosphorus loadings to the reservoir, but these were directly related to the volume of flow in the creek. Boulder Creek had the most consistent phosphorus loadings to the reservoir over the course of the survey. The tributaries contributed significantly more phosphorus to the reservoir during spring runoff than the McCall sewage treatment plant during the same period. The treatment plant contributed double the amount of phosphorus to Cascade Reservoir as the individual tributaries during August and September. Best management practices which eliminate nutrient and sediment laden water from reaching Cascade Reservoir should be installed on all irrigated cropland and pastureland. The conversion from flood irrigation to sprinkler irrigation is recommended to avoid excessive leaching of nutrients from the soil.

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INTRODUCTION

BACKGROUND

A review of water quality studies conducted on Cascade Reservoir cited nonpoint source runoff from agricultural lands as the most significant source of nutrient loading to the reservoir (Klahr 1986). The review was prepared to assist the planning activities of the Cascade Reservoir Interagency Task Force, a committee of representatives from numerous state and federal agencies responsible for resource management in the reservoir watershed.

The Task Force determined two specific drainages within the watershed were the most impacted by nonpoint source runoff from agricultural lands, and warranted further water quality monitoring. These drainages were:

- Boulder Creek, which drains agricultural lands northeast of the reservoir, and

- Mud Creek, an unstudied tributary of Cascade Reservoir.

As part of the cooperative effort to define and control water quality impacts to the reservoir, the Division of Environment committed to continue monitoring in the watershed during the 1985 water year. The U. S. Soil Conservation Service (SCS) also proposed a study of on-farm use of water in an irrigation district in the reservoir watershed. It was determined that a cooperative study between the Division of Environment and the SCS would generate data useful to both organizations due to the similarities in objectives and locale.

OBJECTIVES

The objectives of this cooperative study between the Division and the SCS were:

1. To generate data linking land use and land management practices in the Lake Irrigation District with water quality impacts.

2. To conduct an initial water quality assessment of the Mud Creek drainage.

An additional goal of this cooperative effort was to initiate the planning process and data acquisition necessary for placing the Valley Soil Conservation District in line for a planning grant through the Idaho Agricultural Pollution Abatement program.

Also, the data generated in this study will be applicable to other irrigation systems in the valley, specifically to the Boulder Creek drainage and irrigation network.

DESCRIPTION OF THE PROJECT AREA

The Lake Irrigation District is located in the northwestern portion of Valley County within the Lake Fork and Mud Creek drainages (Figure 1). Water for the irrigation district is derived from the forested mountains comprising the headwaters of the Lake Fork Creek drainage. Little Payette Lake, and to a lesser extent Brown's Pond, serve as storage basins for the irrigation district. The diversion dam for the Lake Irrigation District Canal is on Lake Fork Creek approximately one river mile below Little Payette Lake outlet (Thomas 1985).

Mud Creek, a tributary to Cascade Reservoir, originates as seeps and overland flow from the Lake Irrigation District Canal. Originally, Mud Creek was a tributary of Lake Fork Creek. After the creation of the reservoir, the confluence of the creeks was flooded and now Mud Creek flows directly into the reservoir, in the "Lake Fork arm" of the reservoir. The Mud Creek watershed area is approximately 20,000 acres. The ditches and streambeds comprising the Mud Creek drainage are water-filled during the irrigation season (May 15 - September 15) and during spring runoff.

The portion of the watershed between Little Payette Lake and the community of Lake Fork consists of gently sloping to strongly sloping terrain characterized by glacial outwash features and moderately well-drained soils (Rasmussen 1981). The lower, or southern half of the drainage, from Lake Fork to Cascade Reservoir, consists primarily of the poorly drained Roseberry soils.

The Lake Irrigation District occupies 8300 acres within the 20,000 acre Mud Creek watershed. Land use within the Lake Irrigation District is summarized in the following table.

TABLE 1. Land use in the Lake Irrigation District (Thomas 1985).

LAND USE		ACREAGE
Pasture and hayland -- irrigated		5350
Pasture and hayland -- nonirrigated		1500
Cropland		800
Residential subdivision		650
	TOTAL	8300*

* Includes non-irrigated pasture not in the Lake Irrigation District. System laterals may flow through these areas.

METHODS AND MATERIALS

STUDY DESIGN

This study was designed to:

1. Link land use and land management in the Lake Irrigation District with water quality impacts (Lake Irrigation District Survey), and to

2. Assess the water quality of Mud Creek and to estimate its nutrient and sediment loading to Cascade Reservoir relative to adjacent tributaries. Stations located on Mud Creek and at the mouths of Boulder Creek and Lake Fork Creek were monitored concurrently for comparative purposes (Mud Creek/Stream Survey).

Two sets of sample stations, one for each survey, were chosen and are outlined below.

Lake Irrigation District Survey

In an attempt to assess the impacts of land use and land management on water quality within the Lake Irrigation District, monitoring stations were located directly on irrigation ditches above and below the following situations:

- Pastureland with flood/sub-irrigation

- Cropland with flood irrigation

- Cropland with sprinkler irrigation

The original study plan called for monitoring stations located above and below sprinkler irrigated pastureland. However, suitable monitoring stations protected from the influence of outside irrigation waters could not be located, and this portion of the study was not conducted.

Mud Creek/Stream Survey

The monitoring stations for the stream survey portion of this study are shown in Figure 2.

Four monitoring stations were selected on Mud Creek: source, two midpoints, and mouth. The source or "headwaters" of Mud Creek, as previously explained, is actually the waters of Lake Fork Creek. Lake Fork Creek is diverted into the Lake Irrigation District Canal, where seeps and overland flow draining from the canal merge to form unnamed tributaries of Mud Creek. Therefore, the headwaters station was located at the Lake Irrigation District Canal gauge station below the diversion dam.

The three lower stations on Mud Creek were located at road crossings. The second station downstream was at Hartzel Bridge Road, just below the confluence of two prominent, yet unnamed tributaries of Mud Creek. This station also serves as the cut-off point for the Lake Irrigation District distribution system.

The third station downstream was below a large, privately owned ranch with its own irrigation diversion and distribution system. Sampling at this point will allow comparisons between the water quality below the Lake Irrigation District and below a single, private operator.

The last station was at the mouth of Mud Creek. Boulder Creek and Lake Fork Creek were also sampled at their mouths.

PARAMETERS

Different sample parameters were selected for each portion of the study. Parameters monitored during the Lake Irrigation District survey are listed in Table 2. Sample parameters for the stream survey are listed in Table 3. Both parameter lists are focused on the known water quality problems of the region, namely suspended sediment and nutrients.

Table 2. Sample parameters for Lake Irrigation district water quality monitoring.

PARAMETER	UNITS	STORET NO.
1. Suspended solids, total	mg/L	00530
2. Phosphorus, total	mg/L	00665
3. Orthophosphate, dissolved	mg/L	00671
4. Kjeldahl nitrogen, total	mg/L	00625
5. Fecal coliform	*/100ml	31616
6. Fecal streptococcus	*/100ml	31679
7. Turbidity	NTU	00076

TABLE 3. Water quality parameters monitored on Mud Creek, Boulder Creek and Lake Fork Creek .

PARAMETER	UNITS	STORET NO.
1. Stream discharge	cfs	00061
2. Water temperature	°C	00010
3. pH	S. U.	00400
4. Dissolved oxygen	mg/L	00299
5. Suspended sediments, total	mg/L	80154
6. Phosphorus, total	mg/L	00665
7. Orthophosphate, dissolved	mg/L	00671
8. Kjeldahl nitrogen, total	mg/L	00625
9. Nitrite and nitrate nitrogen, total	mg/L	00630
10. Ammonia, total	mg/L	00610
11. COD	mg/L	00335
12. Fecal coliform	#/100ml	31616
13. Fecal streptococcus	#/100ml	31679
14. Turbidity	NTU	00076

METHODS

The water quality surveys were conducted every two weeks during the irrigation season, which lasted from mid-May through mid-September. Non-irrigation season monitoring was conducted once in March, twice in April, and once in October.

Chemical and bacterial analyses were conducted by the State of Idaho, Bureau of Laboratories following Standard Methods (American Public Health Association 1985).

Sampling methods for each survey are outlined below.

Lake Irrigation District Survey

Attempts were made to monitor flow in the ditches by installing weirs. However, seepage and loss around the weirs was unavoidable, and numerous ditches were unsuitable for weir placement. Therefore, flow measurements were not calculated for this portion of the study.

The gauge located at the station on the Lake Irrigation Canal was read each sampling period.

Sediment and nutrient grab samples were collected in one-liter cubitainers and preserved to 4° C on ice. Bacterial samples were collected in sterilized 250ml Nalgene bottles and also preserved on ice to 4° C.

Mud Creek Stream Survey

Field parameters were determined with the use of portable meters. Dissolved oxygen and temperature were measured with a Yellow Springs Instrument Company Model 54A meter. The meter was calibrated against a Winkler titration prior to each survey. The pH was determined with an Orion Model 231 digital pH/mV/temperature meter. The meter was calibrated for accuracy at the beginning of each survey.

All chemical samples were collected with a DH-48 suspended sediment sampler. Composite samples were collected into a churn splitter. Two one-liter cubitainers were filled from the churn splitter and preserved at 4° C on ice.

Twenty milliliters of sample was filtered through a Schleicher & Schuell 0.45 micron filter and collected in a vial for dissolved orthophosphate analysis. The sample was cooled on ice until delivery to the laboratory.

Bacterial grab samples were collected into sterile 250ml Nalgene bottles and preserved on ice to 4° C.

Stream flow was measured with a Marsh-McBirney Model 201 portable water current meter. Depth and width measurements were taken at each station for discharge calculations. A bridge board and winch were utilized for flow measurements and sample collection during the high runoff period at the station located on Lake Fork Creek.

QUALITY ASSURANCE

Quality assurance data provides an indication of the reliability of the chemical analyses and, to some extent, the consistency of the monitoring program. Quality assurance samples for estimating precision and accuracy are easily incorporated into a water quality survey design. Precision refers to the reproducibility of a value, and accuracy refers to the agreement between the amount of a parameter measured and the amount actually present (American Public Health Association 1985).

Duplicate samples were collected each time monitoring occurred as a means of measuring precision. The water sample was collected with a hand held DH 48 suspended sediment sampler and composited into a churn splitter. Replicate samples were collected from the churn splitter into cubitainers.

Accuracy was measured with the use of field spiked samples. Two sets of spiked samples for total phosphorus and dissolved orthophosphate were collected during the study. An ampule containing the spike was emptied into a cubitainer containing 900 ml of sample water. The spike quantity is calculated by subtracting the background value, determined from a split sample, from the total amount recovered in the laboratory.

All quality assurance data were analyzed according to Bauer (1986) and Bauer et al. (1986).

RESULTS AND DISCUSSION

The results of this study are most easily understood if the data for each survey (Lake Irrigation District Survey and the Mud Creek/Stream Survey) are analyzed separately, and then compared together to create the overall picture.

The results of the water quality monitoring conducted within the Lake Irrigation District will be examined first.

Lake Irrigation District Study

The results of the Lake Irrigation District study are presented in Tables 4 through 7.

Statistical analysis of the data were not possible because of the inherent differences between the land uses and irrigation systems on each property. Also, the small sample sizes and the time-distribution and water-volume differences for each data set introduced error into the statistical analyses.

Irrigation management practices introduced variability on the sampling program. Monitoring occurred three times on the flood irrigated cropland, five times on the sprinkler irrigated cropland, and six times on the flood irrigated pastureland. The primary reason for these differences in the frequency of monitoring was directly related to whether or not irrigation was occurring. For instance, irrigation began on the sprinkler irrigated cropland over a month before irrigation commenced on the flood irrigated cropland. Often irrigation would not be occurring while we were monitoring, and no samples could be collected. At least once, recent rains resulted in irrigation water being bypassed rather than being diverted onto the fields.

The discussion on the Lake Irrigation District study will be broken down into the various monitoring situations: flood irrigated cropland, sprinkler irrigated cropland, and flood irrigated pastureland.

FLOOD IRRIGATED CROPLAND

The most significant impacts to water quality relative to land use were from the flood irrigated cropland. The flood irrigated cropland, which was planted in potatoes, was sampled three times during the study (Table 4).

The levels of organic nitrogen, phosphorus, turbidity, and suspended solids were significantly elevated below the flood irrigated cropland as compared to samples collected above the cropland.

The most apparent impact to the irrigation water was the increase in turbidity and suspended solids. The average increase in turbidity was 50 times that of the incoming water; the average increase in total suspended solids was 20 times that of the background sample (Figure 3).

Total phosphorus was consistently nondetectable above the cropland. The average value for total phosphorus below the potato field was 0.6mg/l (Figure 4). This correlates with a study conducted by Wendt and Corey (1980) which found the greatest losses of potentially available phosphorus in runoff from recently tilled soils and on row crops.

There was also an increase in dissolved orthophosphate below the flood irrigated cropland. The average concentration of dissolved orthophosphate in the irrigation water was 0.002 mg/L as compared to 0.016 mg/L in the drain water leaving the field. This represents an eightfold increase.

The average value for total nitrogen above the flood irrigated field was 0.35 mg/L whereas the average value for total nitrogen below the field was 1.32 mg/L, for an approximate fourfold increase (Figure 5).

Also, numbers of fecal coliform (FC) and fecal streptococcus (FS) increased below the flood irrigated cropland. The literature indicates an increase in bacteria can be common in irrigation water flowing over fields (Saxton et al. 1983, Jawson et al. 1982a). This is attributed to the warm, nutrient rich soil providing a growth medium for the bacteria.

The increases in nutrients and sediment below flood irrigated cropland are expected and validate data obtained from similar studies. Saxton et al. (1983) found much higher erosion rates from tilled agricultural lands as compared to similar pasturelands. The Rock Creek Rural Clean Water

Program, Idaho, has demonstrated repeatedly that the water quality impacts from irrigated cropland, and specifically from flood irrigated cropland, are more severe than from pastureland or hay fields (Clark 1987). Wendt and Corey (1980) found that sediment losses from cropland were greatest from fields with the least amount of plant cover, and that annual sediment losses from crops were in the following order, least to most: alfalfa < oats < corn < fallow field. McTernan et al. (1987) studied the site specific pollutant yield for similar watersheds subjected to differing crop management practices. They found that less sediment concentration is produced from a no-till corn field as compared to a minimum-till corn field.

SPRINKLER IRRIGATED CROPLAND

The monitoring results for the sprinkler irrigated cropland are contained in Table 5. The sprinkler irrigated cropland, which was planted in oats and alfalfa, was sampled five times during the survey.

There was little change in the water quality of the incoming water versus the drain water leaving the sprinkler irrigated cropland. The levels of nitrogen, sediment, and turbidity did not rise significantly in the irrigation return flow, as compared to the incoming water.

The level of dissolved orthophosphate did show an increase in the return flow from the alfalfa field. The average concentration of dissolved orthophosphate in the irrigation water was 0.006 mg/L compared to an average concentration of 0.018 mg/L in the return flow (Figure 6). Wendt and Corey (1980) found the losses of dissolved orthophosphate were higher in runoff from alfalfa fields as compared to oat and corn fields.

As with the flood irrigated cropland, the numbers of FC and FS did increase in the water samples collected below the sprinkler irrigated cropland.

FLOOD IRRIGATED PASTURE

The most predominant land use within the Lake Irrigation District, and within the Long Valley area, is flood irrigated pastureland. Table 6 contains the results for water quality monitoring conducted on flood irrigated pastureland.

It was difficult to isolate the irrigation return water from the flooded pasture. As a result, our study monitored two drains below the flood irrigated pasture in an effort to capture the entire flow.

There were increases in the levels of total nitrogen and in dissolved orthophosphate below the flood irrigated fields. Total nitrogen increased from a mean value of 0.33 mg/L above the pastureland to 0.62 mg/L below each pasture, nearly doubling the concentration. Dissolved orthophosphate increased from an average concentration of 0.005 mg/L in the incoming irrigation water to an average of 0.046 mg/L below Field *1 and 0.022 mg/L below Field *2 (Figure 8).

The average concentration of total phosphorus did not show a large increase below the flood irrigated pastureland. This was surprising in light of the fact it has been shown cattle produce waste containing 16 kg total phosphorus per head per year, or 20 times that generated by a human (Loveless and Dean 1985). The lack of a significant change in total phosphorus levels below the flood irrigated pastureland can be attributed to several factors. The detection limit for total phosphorus for this survey was 0.1 mg/L. The incoming irrigation water had values below the detection limit 50% of the time. These values could not be assumed to be zero, and therefore were computed into the average concentration at the detection limit of 0.1 mg/L. This weighted the average concentration of total phosphorus for the incoming water, and minimized any differences between the sample locations.

Also, rather that seeing an increase in total phosphorus, there was a significant increase in dissolved orthophosphate below the flood irrigated pasture. This could be attributed to the leaching effect of flood irrigation transporting the more soluble phosphorus constituent from the fields. These findings are similar to results listed in the published literature. Miller et al. (1984) found that the soluble constituents like organics and phosphorus were consistently higher below flood irrigated fields.

Also, total phosphorus tends to be associated with the sediment runoff fraction. Clark and Bauer (1983) found that 50% of the total phosphorus in an agricultural drain in southwest Idaho was associated with sediment. Jawson et al. (1982b) found that increases in the concentrations of total nitrogen and total phosphorus in runoff from animal grazed watersheds in Northern Idaho were associated with sediment loss.

This study did not see an increase in total suspended solids in the ditch water below the flood irrigated pastureland, which could account for the minimal increase in total phosphorus below the pastureland.

Miller et al. (1984) found consistently higher concentrations of nitrogen and phosphorus in surface return flow below pastureland. They found that the levels of nutrients and sediment in surface runoff were correlated with site characteristics and water management as opposed to the presence or absence of grazing animals. This concurs with the results from this study, which did not show any correlation between the concentration of nutrients in irrigation return flows and the presence or absence of grazing animals (Table 7).

There was an increase in the numbers of both FC and FS below the fields. Research has shown that a FC/FS ratio less than 0.7 indicates animal contamination, and a FC/FS ratio greater than 2.0 or 3.0 is attributed to human contamination (Clausen et al. 1977). Any ratio falling in the gray area between these values cannot be classified. The FC/FS ratios below the flood irrigated pastureland strongly indicate contamination from human sources. This may be attributable to the different die-off rates for fecal streptococcus bacteria versus fecal coliform bacteria. Saxton et al. (1983) found that indicator bacteria can persistent from the fall through the winter and into the spring. They found the numbers of FC and FS increased during the wet and warm spring months before grazing began. Similarly, Jawson et al. (1982a) found that the numbers of bacteria appeared to increase in runoff after warm weather in the spring months, long after the animals were removed. Also, they found that FS had greater persistence than FC. This finding suggests that use of the FC/FS ratio as a measure of animal fecal pollution is questionable.

Some authors have suggested that increases in nutrients and sediment in runoff associated with cattle grazing does not have a significant impact on the receiving water due to the low volume of the runoff (Edmundson 1985, Jawson et al. 1982b).

Edmundson (1985) found that cattle grazing may have slightly increased nutrient levels to the receiving waters, but concluded that large increases are not common under normal grazing activities. He concluded these levels should have little impact on the receiving waters, and that the results are consistent with published literature addressing similar situations.

However, Edmundson (1985) did not define "normal grazing activities," nor was the condition of the grazed land assessed. The study did find that the water quality in the upper watershed was considerably better than the quality of water below the grazed area. Finally, although his results may have found consistencies with other published literature, there are numerous publications suggesting cattle grazing does have an impact on water quality and the aquatic environment (Braun 1986, McTernan 1987, Miller et al. 1984, Meehan and Platts 1978, Platts 1978, Platts 1981, Platts 1983).

Jawson et al. (1982) monitored nutrient and sediment deliveries from a grazed and an ungrazed watershed and found strong indications that animal grazing caused increased sediment delivery. Nitrogen and phosphorus losses were approximately 8 to 12 times greater from the grazed watershed as compared to the control watershed. Both Jawson et al. (1982b) and Edmondson (1985) reached the same conclusion, that grazing appeared to cause an increase in nutrients in runoff, but that the quantities would not seem to be a significant threat to downstream water. However, only Jawson et al. (1982b) included an important qualifier. They concluded that phosphorus losses were such that enrichment of some waters could occur, and this would depend on the quality of the downstream water.

This is a very important qualification with regards to surface waters draining to a lake or reservoir. To prevent the development of biological nuisances and to control accelerated or cultural eutrophication, total phosphorus levels should not exceed 0.05 mg/L in any stream at the point where it enters a lake or reservoir (U.S. EPA 1986). Uncontaminated lake watersheds are known to have surface waters that contain from 0.01 to 0.05 mg/L total phosphorus (Wetzel 1975). The total phosphorus concentration in the samples collected below the flood irrigated pastureland was 0.1 mg/L on every occasion except one, when it was 0.2 mg/L. Therefore, the irrigation water contained a level of total phosphorus which would cause accelerated eutrophication on every occasion.

Another very important consideration that was not discussed by either author was the effect of cumulative loading to the receiving water. Although the contribution from a single return flow may not appear to be significant in terms of the receiving water, the combined return flows for a whole drainage can impact the quality of the receiving water and impair the beneficial uses.

Mud Creek/Stream Survey

The mouths of Mud Creek, Boulder Creek, and Lake Fork Creek were sampled twice monthly from mid-April through mid-October to evaluate and compare the impact of each creek on the water quality of Cascade Reservoir. Also, Mud Creek was monitored at three additional stations in the drainage to determine a watershed profile. The results from this survey are contained in Tables 8, 9 and 10.

<u>FLOW</u>

The flow in Mud Creek is controlled by seepage from the Lake Irrigation District Canal, localized storm events and irrigation return flows. Mud Creek reached its peak flow of 33 cfs in mid-April, after which the flow dropped steadily until mid-June. From mid-June to mid-July the flow rose and stabilized. This indicates the influence of irrigation return flows on this drainage. The peak flow in Mud Creek occurred nearly three weeks prior to peak flow in Boulder Creek and over a month prior to peak flow in the higher elevation watershed of Lake Fork Creek.

Boulder Creek peaked a week earlier than Lake Fork Creek at 102 cfs. Its flow dropped rapidly until late-June when it was running 12 cfs.

The peak flow measured on Lake Fork Creek was 984 cfs, which occurred during the last week in May. This flow dropped rapidly until four weeks later, in late June, the flow at the mouth was 23 cfs. Water from the creek was turned into the Lake Irrigation Canal on May 20, prior to the measured peak discharge. The low flow at the mouth of Lake Fork Creek by late June is attributed somewhat to an early runoff, but more to the diversion by the Lake Irrigation District Canal.

The most unusual aspect of the hydrology of these three drainages is that as Lake Fork Creek and Boulder Creek dropped, the flow in Mud Creek rose (Figure 9). At peak flow Lake Fork Creek carried 30 times the flow that Mud Creek carried, but by the first week in July, Mud Creek carried twice the flow of either Lake Fork Creek or Boulder Creek.

Hydrologically, there are two periods to examine for water quality influences from these drainages on Cascade Reservoir. First, there is the peak runoff period when the majority of sediment and nutrients are transported. In terms of total loadings to the reservoir, this time period far and above outweighs any other event. Lake Fork Creek, with its significantly higher flows than the other two tributaries, contributed the most in total loadings to the reservoir during this time period.

The second hydrologic period to consider is the low flows of mid-summer. There are several reasons why this period is critical to water quality in Cascade Reservoir. During the summer the majority of inflow water is irrigation return flows. The waters of Lake Fork Creek, Boulder Creek and Gold Fork Creek are diverted into canals and run across fields or pastures before entering the reservoir. Releases from the reservoir are slowed to the minimum, which is 200 cfs for the North Fork Payette River below Cascade Reservoir, to conserve water for late season irrigation. The downstream releases for irrigation begin in approximately July of each year. Finally, as the reservoir warms the impacts of the incoming irrigation return flow water could be more severe as opposed to the cold spring runoff inflows.

SEDIMENT

The average concentration for total suspended sediment was very similar for all three creeks. However, when total suspended sediment loadings are compared, the highest volume creek, Lake Fork Creek, contributed the most sediment to the reservoir, especially during the spring runoff period (Figure 10).

Mud Creek tended to have higher suspended sediment loadings to the reservoir during the latter part of the irrigation season, and especially during September and October (Figure 11). Mud Creek had a slightly higher concentration of suspended sediment and on several occasions it had higher flows, which resulted in higher loadings to the reservoir. Following the spring runoff period, Mud Creek had consistently higher sediment loadings to Cascade Reservoir than Boulder Creek.

TURBIDITY

No significant differences in turbidity were observed between these streams. No individual reading exceeded 10 NTU. The average turbidity values for each stream were within 2 points of each other.

TOTAL PHOSPHORUS

Boulder Creek had the most consistently detectable level of total phosphorus. Phosphorus was detected in the water sample on every survey date except for two occasions. On the other hand, phosphorus levels in Lake Fork Creek were below the detection limit on every sampling date except once in late May. Mud Creek had erratic levels of phosphorus ranging from nondetectable readings on two thirds of the sampling dates to 0.3 mg/L on a single occasion in May.

Total phosphorus loadings were difficult to calculate due to the nondetectable levels of total phosphorus for many of the sampling dates. Overall, Boulder Creek had the most consistent phosphorus loadings to the reservoir.

Table 11 is a comparison of the phosphorus loadings to Cascade Reservoir from the three creeks and the McCall Sewage Treatment Plant (STP) during the summer of 1986. The loading values for the McCall STP were calculated from flow and total phosphorus data obtained from the discharge monitoring reports. The loading value represents a mean monthly average and is presented in the table on the last survey data for that month. The loading values for the creeks were obtained from data collected on that survey date. During spring runoff in May, Lake Fork Creek contributed 530.5 lbs/day of phosphorus to Cascade Reservoir. This is the highest loading rate and, in fact, is greater than all other loading rates summed together. Throughout spring runoff the streams contributed significantly more phosphorus to Cascade Reservoir than the McCall STP. However, towards the end of the summer, the STP had much higher loading rates than the creeks.

It has been shown that the cost of phosphorus reductions from farming is considerably higher that the cost of phosphorus reductions from domestic sewage treatment (Kramer et al. 1984). Therefore, all alternative methods of reducing phosphorus loading to the reservoir need to be identified and evaluated.

DISSOLVED ORTHOPHOSPHATE

Boulder Creek had the highest average concentration of dissolved orthophosphate as compared to the other streams. The average concentration of dissolved orthophosphate in Boulder Creek was 0.032 mg/L, compared to 0.006 mg/L in Lake Fork Creek, and 0.01 mg/L in Mud Creek.

Dissolved orthophosphate is biologically available phosphorus that can be readily assimilated by algae for growth. In terms of impact on Cascade Reservoir, this is a nutrient of great concern. The levels found in Boulder Creek were consistently higher than the concentrations found in the other creeks, and often were three and four times as concentrated.

BACTERIA

Boulder Creek contained the highest average concentration of fecal coliform bacteria as compared to the other streams. The Idaho Water Quality Standards and Wastewater Treatment Requirements (1985) state that waters designated for primary contact recreation should not exceed 500/100 ml at any time. Boulder Creek exceeded this value on three occasions and was the only creek to exceed this standard. Boulder Creek also had a FC/FS ratio that indicated pollution from human sources, especially during the first half of the study. The Central District Health Department indicated there were several homes along the creek that had inadequate sewage treatment. These homes were brought into compliance with sewage treatment requirements during the course of this study (Lappin 1986). This could account for the high FC/FS ratios at the beginning of the study that dropped over the course of the summer.

Lake Fork Creek had the lowest total numbers for fecal coliform and fecal streptococcus. The FC/FS ratio for this drainage indicated contamination from animal sources almost consistently throughout the course of the study.

Mud Creek had the highest average concentration for fecal streptococcus at 304/100ml. The individual sample counts exceeded 1000 organisms/100ml on several occasions. The FC/FS ratio fluctuated over the course of the study, but indicated contamination from animal origin over most of the irrigation season.

TOTAL NITROGEN

Total kjeldahl nitrogen values were relatively consistent between the three drainages. Lake Fork Creek had the lowest average concentration of 0.24 mg/L.

QUALITY ASSURANCE

The precision, expressed as the average relative range (ARR), varied greatly for this survey. Total phosphorus had the lowest average relative range of 1.0 percent. This indicates that an individual sample for total phosphorus is expected to be within 1.0 percent of a duplicate sample. However, the nondetectable levels of phosphorus were computed into this statistic at their detection limit of 1.0 mg/L, and therefore this average relative range is not meaningful.

Precision was good for chemical oxygen demand (ARR=9.6%), conductivity (ARR=7.2%), and total kjeldahl nitrogen (ARR=13.6%). Precision values falling into a poor range include ammonia (ARR=35.2%), nitrite-nitrate (ARR=49.6%), and total suspended sediment (ARR=47.0%).

Dissolved orthophosphate had the worst precision with an average relative range of 51.1 percent. This average relative range is much greater than values reported by Clark (1986).

Accuracy, expressed as the average percent recovery of the spike, was excellent for this survey. Total phosphorus had an average percent recovery of 105 ± 3.9, and dissolved orthophosphate had an average percent recovery of 98.6 ± 5.4.

Overall, the quality assurance data indicate a high accuracy for sample analyses, but erratic results regarding reproducibility. For example, dissolved orthophosphate had a high accuracy with regards to spiked sample analysis, but had a poor precision with duplicate samples. Bauer et al. (1986) indicate that the most obvious source of error contributing to poor precision is improper sample splitting. Examination of the suspended sediment results, which are most susceptible to improper sample mixing, indicate this could be the source of error in this survey. The average relative range for suspended sediment was 47.0 percent, indicating a poor agreement between duplicate samples.

CONCLUSIONS

LAKE IRRIGATION DISTRICT SURVEY

The irrigation return flows from the flood irrigated cropland and the flood irrigated pastureland exceeded 0.05 mg/L total phosphorus, the level which results in accelerated eutrophication in lakes and reservoirs, 100% of the time. The irrigation return water from the sprinkler irrigated cropland exceeded this level on about 50% of the survey dates.

The flood irrigated cropland had the most severe water quality impacts detected between the upper and lower sampling points. Nutrients and sediment were dramatically increased below the flood irrigated cropland. These results are consistent with data obtained from similar studies.

The least impact to water quality was detected below sprinkler irrigated cropland. The levels of nitrogen, sediment, and turbidity did not change significantly below sprinkler irrigated cropland. There was an increase in the level of dissolved orthophosphate below the sprinkler irrigated cropland, but the increase was 30 times less than the increase detected below flood irrigated cropland.

The water quality monitoring results from the flood irrigated pastureland showed an average increase of over 600% in dissolved orthophosphate and an increase of 180% in total nitrogen.. The increases in the dissolved orthophosphate concentrations and the total nitrogen levels below the flood irrigated pastureland are attributed to the leaching affect of this type of irrigation practice on the soluble nutrients. Total phosphorus levels did not show a significant increase below the flooded pastureland, which is correlated to a lack of accelerated sediment runoff. There was not a significant increase in turbidity or total suspended solids below the irrigated pastureland. Although there was an increase in nutrients below the flood irrigated pastureland, this was not correlated with the presence or absence of grazing animals.

The average concentration of total phosphorus in surface waters in the Cascade Reservoir watershed, as determined by this survey, was near 0.10 mg/L, or between five and ten times the amount of an uncontaminated watershed. However, a detection limit of 0.1mg/L total phosphorus was not precise enough to allow differentiation between many of the sampling stations. A detection limit lower than 0.1mg/L for total phosphorus is necessary to accurately predict water quality impacts, especially with respect to Cascade Reservoir.

MUD CREEK/STREAM SURVEY

Boulder Creek exceeded the nuisance phosphorus level of 0.05 mg/L on 82% of the survey dates, Mud Creek on 33% of the survey dates and Lake Fork Creek on 9% of the survey dates.

A comparison of the total phosphorus loadings indicates that Boulder Creek was the most consistent contributor of phosphorus to Cascade Reservoir. The McCall Sewage Treatment Plant (STP) contributed significantly less phosphorus to Cascade Reservoir during the spring runoff period as compared to the three tributaries. During July the contribution from the McCall STP was roughly equal to the amount of phosphorus contributed by Mud Creek, while during the late summer months the McCall STP contributed twice the amount of phosphorus to the reservoir as the creeks.

The tributaries were all a source of sediment to Cascade Reservoir. The average concentration of suspended sediment was very similar for all three tributaries. Lake Fork Creek had the highest suspended sediment loadings to the reservoir during spring runoff. Following the spring runoff period, Mud Creek tended to have higher sediment loadings. The different loading rates were directly related to flow levels.

In summary, these tributaries contribute sediment and nutrients in varying quantities to Cascade Reservoir. The contributions are relatively similar with respect to concentration, however the total loadings differ based on flow variations. The cumulative impacts of these tributaries on the reservoir are resulting in nutrient levels exceeding the recommended criteria for avoiding accelerated eutrophication.

RECOMMENDATIONS

Flood irrigated cropland within the Lake Irrigation District needs to be identified. Best management practices (BMPs) which eliminate nutrient and sediment laden water from reaching surface waters should be installed on all flood irrigated cropland. Examples of these BMPs include: conservation tillage, filter strips, sediment basins, I slots, buried pipe, gated pipeline, contour plowing and land leveling.

The levels of nutrients in runoff from the flood irrigated pastureland can be attributed to site characteristics and water management in the Lake Irrigation District. Excessive irrigation is resulting in the leaching of nutrients from the fields. Irrigation management practices need to be evaluated with regards to frequency, rate and duration of water application to eliminate the leaching characteristics of this form of irrigation. Irrigation systems needs to be evaluated and modified to allow application of the least amount of water necessary to achieve full irrigation of the land.

Sprinkler irrigation systems appear to result in the least amount of nutrients and sediment being transported from the fields to surface waters. This type of irrigation should be considered as a replacement for flood irrigation whenever possible.

A survey of the Lake Irrigation District distribution system was conducted by the Soil Conservation Service during 1986. Recommendations from the survey should be implemented as soon as they are available.

Nonpoint source impacts to Cascade Reservoir were apparent in all the tributaries monitored during this study. The McCall sewage treatment plant was a source of phosphorus to the reservoir, as were the tributaries. A means of reducing phosphorus contributions from the McCall STP should be evaluated in conjunction with other BMP implementation. The most cost effective and efficient methods of phosphorus reduction need to be implemented. A comprehensive plan addressing the cumulative impacts of all nonpoint source and point source contributions to the reservoir is needed.

LITERATURE CITED

American Public Health Association. 1985. Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D. C. 16th Edition. 1,134 pp.

Bauer, S. B. 1986. Pilot study of quality assurance sample procedures. Idaho Dept. Health and Welfare, Div. of Environment, Boise, ID. 40pp.

Bauer, S. B., W. H. Clark, and J. A. Dodds. 1986. Quality assurance sample procedures for water quality surveys. Journal of the Idaho Academy Science 22 (2): 47-55.

Braun, R. H. 1986. Emerging limits on federal land management discretion: livestock, riparian ecosystems, and the Clean Water Law. Environmental Law 17:43-79.

Clark, W. H. 1986. Rock Creek Rural Clean Water Program comprehensive water quality monitoring report, 1981-1986. Idaho Dept. Health and Welfare, Div. of Environment, Boise, ID. 147pp.

Clark, W. H. 1987. Personnal communication. Idaho Dept. Health and Welfare, Div. of Environment, Boise, ID.

Clark, W. H. and S. B. Bauer. 1983. Water quality status report, Lower Boise River Drains, Canyon County, Idaho. Water Quality Series 50. Idaho Dept. Health and Welfare, Div. of Environment, Boise, ID. 101pp.

Clausen, E. M., B. L. Green, and W. Litsky. 1977. Fecal streptococci: indicators of pollution IN: A. W. Hoadley and B. J. Dutka, Eds. Bacterial indicators/health hazards associated with water. American Society Testing Materials No. 635:247-264.

Edmundson, E. 1985. Water quality characteristics of the Little Salmon River near New Meadows, Idaho. Boise State University, Boise, ID. 27 pp.

Idaho Department of Health and Welfare. 1985. Idaho Water Quality Standards and Wastewater Treatment Requirements. Idaho Dept. Health and Welfare, Div. of Environment, Boise, Idaho. 72 pp.

Jawson, M. D., L. F. Elliott, K. E. Saxton, and D. H. Fortier. 1982a. The effect of cattle grazing on indicator bacteria in runoff from a Pacific Northwest Watershed. Journal Environmental Quality 11: 621-627.

Jawson, M. D., L. F. Elliott, K. E. Saxton, and D. H. Fortier. 1982b. The effect of cattle grazing on nutrient losses in a Pacific Northwest setting. Journal Environmental Quality 11: 628-631.

Klahr, P. C. 1986. Cascade Reservoir literature review. Idaho Dept. Health and Welfare, Div. of Environment, Boise, ID 26pp.

Kramer, R. A., W. T. McSweeny, W. R. Kerns, and R. W. Stavros. 1984. An evaluation of alternative policies for controlling agricultural nonpoint source pollution. Water Resources Bulletin 20: 841-846.

Lappin, J. L. 1986. Personnel communication. Central District Health Dept., McCall, ID

Loveless, R. and R. Dean. 1985. Water quality progress report, Snake Creek, Utah. Monitoring and Data Support Division, U. S. Environmental Protection Agency, Washington, D.C.

McTernan, W. F., B. L. Weand, and T. J. Grizzard. 1987. Evaluation of management practices to control agricultural pollutants. Water Resources Bulletin 23 (4): 691-699.

Meehan, W. R. and W. S. Platts. 1978. Livestock grazing and the aquatic environment. Journal Soil Water Conservation 33(6): 274-278.

Miller, W. W., J. C. Guitjens, and C. N. Mahannah. 1984. Water quality of irrigation and surface return flows from flood-irrigated pasture and alfalfa hay. Journal Environmental Quality 13:543-548.

Platts, W. S. 1978. Livestock interactions with fish and aquatic environments: problems in evaluation. Trans. 43nd N. American Wildlife and Nat. Resour. Conf., Wildlife Management Institute, Washington, D. C.

Platts, W. S. 1981. Effects of livestock grazing. Series 7 In: W. R. Meehan, technical editor. Influence of forest and rangeland management on anadramous fish habitat in western North America. U. S. Forest Service, Pacific NW Forest and Range Exp. Station, General Technical Report PNW-124, Portland, OR. 25pp.

Platts, W. S. and W. R. Meehan. 1983. Livestock grazing and fish environments: situation and needs. In: J. Menke, ed. Symposium on livestock interactions with wildlife, fisheries and their environments, Sparks, NV, May 1977. USDA Pac. SW For. and Range Exp. Sta., Berkeley, CA.

Rasmussen, L. M. 1981. Soil survey of Valley area, Idaho. U. S. Department of Agriculture, Soil Conservation Service, Boise, ID 146pp.

Saxton, K. E., L. F. Elliot, R. I. Papendick, M. D. Jawson, and D. H. Fortier. 1983. Effect of animal grazing on water quality on nonpoint runoff in the Pacific Northwest. EPA-600/S2-83-071. U. S. Environmental Protection Agency, Ada, OK.

Thomas, M. 1985. Initial Assessment Lake Irrigation District. U. S. Department of Agriculture, Soil Conservation Service, Donnelly, ID.

U. S. Environmental Proctection Agency. 1986. Quality criteria for water. EPA 44/5-85-001. Washington, D.C.

Wendt, R. C. and R. B. Corey. 1980. Phosphorus variations in surface runoff from agricultural lands as a function of land use. Journal Environmental Qual. 9:130-136.

Wetzel, R. G. 1975. Limnology. W. B. Saunders Company, Philadelphia, PA. 743pp.

Table 4. Water quality monitoring results from flood irrigated cropland.

Lateral above flood irrigated cropland

DATE	Tot. K. Nit. (mg/l)	Tot. Phos (mg/l)	Diss. Ortho P (mg/l)	Turbidity (NTU)	Tot. Susp. Solids(mg/L)	Fecal Coli. #/100ml	Fecal Strep #/100ml	FC/FS Ratio
7/23/86	0.43	<0.1	<0.001	2	14	250	400	0.6
8/11/86	0.29	<0.1	0.003	2	16	150	930	0.2
8/21/86	0.34	<0.1	0.001	2	2	100	600	0.2
MEAN	0.35	<0.1	0.002	2	10.7	167	643	0.3
STAND. DEV	0.07	0.0	0.001	0	7.6	76	268	0.3

Drain below flood irrigated cropland

DATE	Tot. K. Nit. (mg/l)	Tot. Phos (mg/l)	Diss. Ortho P (mg/l)	Turbidity (NTU)	Tot. Susp. Solids(mg/L)	Fecal Coli. #/100ml	Fecal Strep #/100ml	FC/FS Ratio
7/23/86	1.49	0.8	0.012	102	258	320	2900	0.1
8/11/86	1.80	0.8	0.022	100	332	4000	3500	1.1
8/21/86	0.66	0.2	0.015	10	52	300	2500	0.1
MEAN	1.32	0.6	0.016	70.7	214.0	1540	2967	0.5
STAND. DEV.	0.59	0.3	0.005	52.5	145.1	2130	503	0.6

Table 5. Water quality monitoring data from the sprinkler irrigated cropland.

Lateral above sprinkler irrigated cropland

DATE	Tot. K Nit. (mg/l)	Tot. Phos. (mg/l)	Diss. Ortho P (mg/l)	Turbidity (NTU)	Tot. Susp. Solids (mg/l)	Fecal Coli. #/100ml	Fecal Strep #/100ml	FC/FS Ratio
6/11/86								
6/24/86	0.24	<0.1	0.002	2	18	80	90	0.9
7/23/86	0.10	<0.1	0.001	1	20	60	160	0.4
8/11/86	0.44	<0.1	0.016	1	18	600	600	1.0
8/21/86	0.32	<0.1	0.003	2	16	380	1400	0.3
MEAN	0.28	<0.1	0.006	1.5	18.0	280	563	0.7
STAND. DEV.	0.14	0.0	0.007	0.6	1.6	259	602	0.4

Drain below sprinkler irrigated cropland

DATE	Tot. K Nit. (mg/l)	Tot. Phos (mg/l)	Diss. Ortho P (mg/l)	Turbidity (NTU)	Tot. Susp. Solids(mg/l)	Fecal Colif. #/100ml	Fecal Strep #/100ml	FC/FS Ratio
6/11/86	0.29	0.1	0.023	2	10	170	700	0.2
6/24/86	0.25	<0.1	0.011	1	4	70	300	0.2
7/23/86	0.15	<0.1	0.009	2	8	330	1200	0.3
8/11/86	0.40	0.1	0.026	3	66	250	1000	0.3
8/21/86	0.40	0.1	0.019	1	10	2000	3200	0.6
MEAN	0.30	0.10	0.018	1.8	19.6	564	1280	0.3
STAND. DEV.	0.11	0.00	0.007	0.8	26.1	809	1126	0.2

Table 6. Water quality monitoring results from flood irrigated pastureland.

Lateral above flood irrigated pasture

DATE	Tot. K Nit. (mg/l)	Tot. Phos. (mg/l)	Diss. Ortho P. (mg/L)	Turbidity (NTU)	Total Susp. Solids(mg/L)	Fecal Coli. #/100ml	Fecal Strep #/100ml	FC/FS Ratio
6/11/86	0.27	0.1	0.001	10	26	900	110	8.2
6/24/86	0.42	0.1	0.005	9	30	1500	1200	1.3
7/9/86	0.43	<0.1	0.003	4	2	320	170	1.9
7/23/86	0.17	<0.1	0.001	5	8	330	290	1.1
8/11/86	0.36	0.1	0.014	8	30	900	800	1.1
8/21/86	0.32	<0.1	0.008	4	4	1200	2600	0.5
MEAN	0.33	0.1	0.005	6.7	16.7	858	862	2.3
STAND. DEV.	0.10	0.0	0.005	2.7	13.4	469	950	2.9

Drain below flood irrigated FIELD #1 (Bold indiactes animals present)

DATE	Tot. K Nit. (mg/l)	Tot. Phos (mg/l)	Diss. Ortho P (mg/l)	Turbidity (NTU)	Total Susp. Solids(mg/L)	Fecal Coli. #/100ml	Fecal Strep #/100ml	FC/FS Ratio
6/11/86	1.28	0.2	0.050	7.5	10	13000	310	41.9
6/24/86	0.45	0.1	0.067	2	4	520	1300	0.4
7/9/86	**0.57**	**0.1**	**0.026**	**3**	**4**	**360**	**200**	**1.8**
7/23/86	**0.34**	**0.1**	**0.041**	**2**	**8**	**200**	**200**	**1.0**
8/11/86	**0.42**	**0.1**	**0.048**	**1**	**22**	**160**	**460**	**0.3**
8/21/86	0.65	0.1	0.043	2	<2	700	1800	0.4
MEAN	0.62	0.1	0.046	2.9	9.6	2490	712	7.6
STAND. DEV.	0.31	0.0	0.012	2.1	6.6	4704	616	15.3

Table 6. Continued

Drain below flood irrigated FIELD #2 (Bold indicates animals present).

DATE	Tot. K Nit. (mg/l)	Tot. Phos. (mg/l)	Diss. Ortho. P (mg/l)	Turbidity (NTU)	Total Susp. Solids(mg/L)	Fecal Coli. #/100ml	Fecal Strep #/100ml	FC/FS Ratio
6/11/86								
6/24/86	0.45	0.1	0.027	6	10	6700	2200	3.0
7/9/86	0.41	0.1	0.022	3	8	300	100	3.0
7/23/86	0.23	0.1	0.019	2	12	210	30	7.0
8/11/86	0.57	0.1	0.037	8	34	470	200	2.4
8/21/86	**1.43**	**0.1**	**0.003**	**2**	**2**	**1100**	**2500**	**0.4**
MEAN	0.62	0.1	0.022	4.2	13.2	1756	1006	3.2
STAND. DEV.	0.47	0.0	0.012	2.7	12.2	2786	1233	2.4

Table 7. Summary of water quality data for flood irrigated pastureland with and without animals present.

With Animals

DATE	Tot. K Nit. (mg/l)	Tot. Phos. (mg/l)	Diss. Ortho P (mg/l)	Turbidity (NTU)	Total Susp. Solids(mg/L)	Fecal coli. #/100ml	Fecal Strep #/100ml	FC/FS Ratio
7/9/86	0.57	0.1	0.026	3	4	360	200	1.8
7/23/86	0.34	0.1	0.041	2	8	200	200	1.0
8/11/86	0.42	0.1	0.048	1	22	160	460	0.3
8/21/86	1.43	0.1	0.003	2	2	1100	2500	0.4
MEAN	0.69	0.1	0.030	2.0	9.0	455	840	0.9
STAND. DEV.	0.50	0.0	0.020	0.8	9.0	439	1113	0.7

Without Animals

DATE	Tot. K Nit. (mg/l)	Tot. Phos (mg/l)	Diss. Ortho P (mg/L)	Turbidity (NTU)	Total Susp. Solids (mg/L)	Fecal Coli. #/100ml	Fecal Strep #/100ml	FC/FS Ratio
6/11/86	1.28	0.2	0.050	7.5	10	13000	310	41.9
6/24/86	0.45	0.1	0.067	2	4	520	1300	0.4
8/21/86	0.65	0.1	0.043	2	<2	700	1800	0.4
6/24/86	0.45	0.1	0.027	6	10	6700	2200	3.0
7/9/86	0.41	0.1	0.022	3	8	300	100	3.0
7/23/86	0.23	0.1	0.019	2	12	210	30	7.0
8/11/86	0.57	0.1	0.037	8	34	470	200	2.4
MEAN	0.58	0.1	0.038	4.4	13.0	3129	849	8.3
STAND.DEV.	0.31	0.0	0.016	2.5	9.7	4575	835	13.9

Table 8. Summary of water quality monitoring data from the mouth of Boulder Creek.

Date	Flow (cfs)	TSS (mg/L)	Turbidity (NTU)	T. K. Nit. (mg/L)	Tot. Phos. (mg/L)	Diss. Ortho. Phos.(mg/L)	Fecal Coli. # /100ml	Fecal Strep #/100ml	FC/FS Ratio	COD mg/L
4/22/86	85.1	12	7.8	0.43	0.1	0.018				15.7
5/7/86	102.4	36	3.8	0.18	<0.1	0.007	30	10	3.0	13.2
5/28/86	79.5	8	4.5	0.38	0.1	0.012	500	120	4.2	14.8
6/11/86	52.2	10	3.3	0.30	0.1	0.023	43	63.5	0.7	13.6
6/24/86	12.4	10	2.0	0.66	0.1	0.045	780	325	2.5	48.0
7/9/86	10.5	2	3.0	0.51	0.1	0.086	200	200	1.0	5.3
7/23/86	7.1	14	2.0	0.42	0.1	0.035	110	40	2.8	18.4
8/11/86	5.1	26	2.0	0.47	0.1	0.048	145	190	0.8	13.3
8/21/86	7.0	<2	2.0	0.59	0.1	0.043	500	1000	0.5	23.7
9/17/86	14.7	18	3.0	0.54	0.1	0.020	120	140	0.9	15.6
10/8/86	16.5	8	2.0	0.22	<0.1	0.016	10	50	0.2	10.7
AVERAGE	35.7	14	3.2	0.43	0.1	0.032	244	214	1.6	17.5
STD. DEV.	35.2	9	1.7	0.14	0.0	0.022	246	277	1.3	10.6

Table 9. Summary of water quality monitoring data from the mouth of Mud Creek.

Date	Flow (cfs)	TSS (mg/L)	Turbidity (NTU)	T. K. Nit. (mg/L)	T. Phos. (mg/L)	Diss. Ortho. Phos.(mg/L)	Fecal Coli. # /100ML	Fecal Strep. # /100ML	FC/FS Ratio	COD (mg/L)
3/19/86			2.9	0.74	<0.1		2	2	1.0	17.5
4/16/86	33.7	22	4.1	0.39	<0.1	0.012				22
5/7/86	17.5	34	2.5	0.43	<0.1	0.004	40	30	1.3	11.5
5/28/86	5.4	6	1.1	0.40	0.3	0.036	5	5	1.0	10.8
6/11/86	9.0	12	2	0.38	<0.1	0.005	180	320	0.6	12.8
6/24/86	18.9	12	2	0.49	<0.1	0.008	80	190	0.4	44
7/9/86	21.3	4	4	0.48	0.1	0.013	100	220	0.5	11.4
7/23/86	13.8	24	3.5	0.37	0.1	0.006	65	115	0.6	15.4
8/11/86	5.7	26	1	0.47	0.1	0.006	220	1050	0.2	10.5
8/21/86	6.4	2	<1.0	0.51	<0.1	0.006	400	1300	0.3	12.2
9/17/86	19.4	14	2	0.37	<0.1	0.007	80	100	0.8	11.1
10/8/86	13.6	24	1.5	0.35	<0.1	0.008	16	9	1.8	9.8
AVERAGE	15.0	16	2.4	0.45	0.1	0.010	108	304	0.8	15.8
STD. DEV.	8.1	10	1.0	0.10	0.1	0.009	113	425	0.5	9.2

Table 10. Summary of water quality monitoring data from the mouth of Lake Fork Creek.

Date	Flow (cfs)	TSS (mg/L)	Turbidity (NTU)	T. K. Nit. (mg/L)	T. Phos. (mg/L)	Diss. Ortho Phos.(mg/L)	Fecal Coli. # /100ML	Fecal Strep. # /100ML	FC/FS Ratio	COD (mg/L)
4/22/86	339.3	26	4.0	0.47	<0.1	0.008				9.7
5/7/86	424.3	32	1.3	0.10	<0.1	0.003	<1	3		6.4
5/28/86	984.2	10	2.5	0.35	0.10	0.007	80	180	0.4	14.8
6/11/86	301.3	4	1.0	0.18	<0.1	<0.003	2	6	0.3	9.0
6/24/86	22.9	<2	1.0	0.19	<0.1	0.005	5	20	0.3	40.0
7/9/86	9.1	4	<1.0	0.27	<0.1	<0.001	18	35	0.5	5.7
7/23/86	7.8	52	2.0	0.23	<0.1	<0.001	11	116	0.1	19.3
8/11/86	10.6	22	1.0	0.26	<0.1	0.003	8	22	0.4	6.1
8/21/86	9.8	<2	<1.0	0.26	<0.1	0.012	62	58	1.1	9.7
9/17/86	30.8	6	1.0	0.16	<0.1	0.003	11	25	0.4	6.6
10/8/86	14	6	1.0	0.21	<0.1	0.008	1	5	0.2	6.6
AVERAGE	195.8	18	1.6	0.24	0.1	0.006	22	47	0.4	12.2
STD.DEV	305.7	16	1.0	0.10		0.003	29	58	0.3	10.1

Table 11. Summary of total phosphorus loadings in pounds per day to Cascade Reservoir from Boulder Creek, Mud Creek, Lake Fork Creek, and the McCall Sewage Treatment Plant, April through October, 1986.

PHOSPHORUS LOADINGS (lbs/day)

Date	BOULDER CK	MUD CK	LAKE FK CK	MCCALL STP
4/22	45.9	ND	ND	9.6
5/28	42.9	7.3	530.5	0.5
6/11	28.1	ND	ND	
6/24	6.7	ND	ND	17.0
7/9	5.7	11.5	ND	
7/23	3.8	7.4	ND	6.5
8/11	2.7	3.1	ND	
8/21	3.8	ND	ND	36.8
9/17	7.9	ND	ND	26.3
10/8	ND	ND	ND	12.1

ND = None detectable

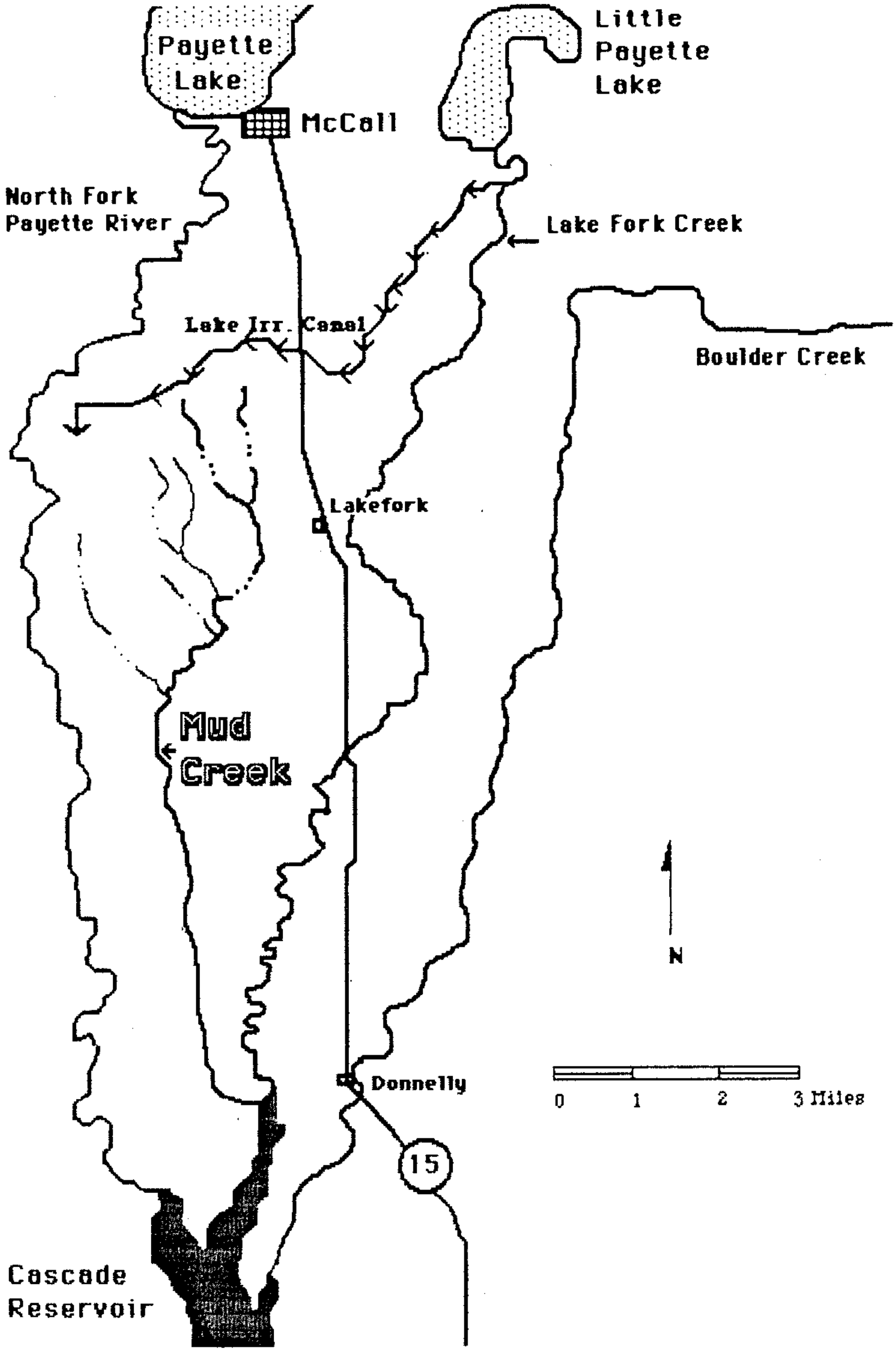

Figure 1. Vicinity map of the study area, Valley County, Idaho.

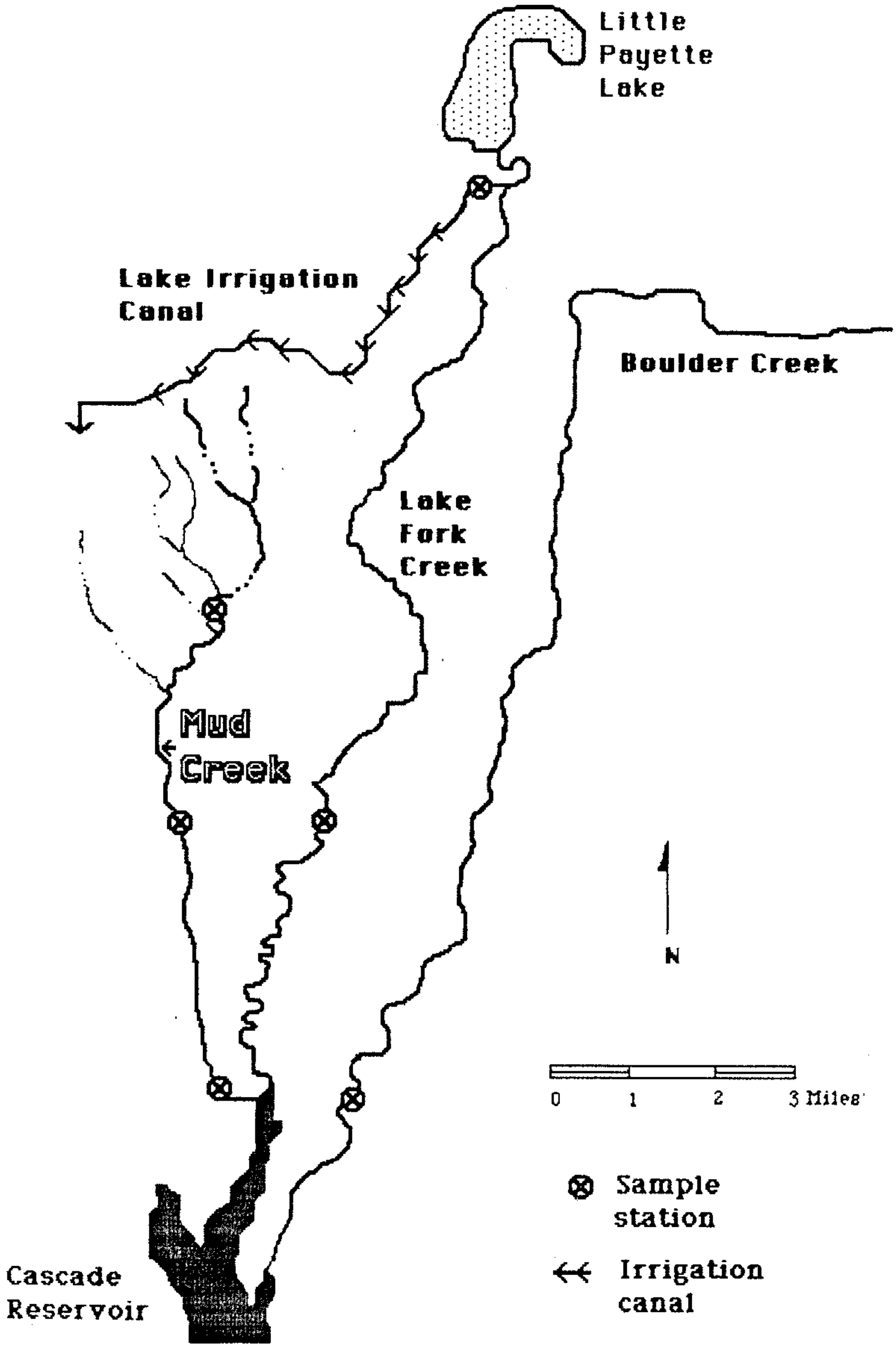

Figure 2. Map of water quality monitoring stations.

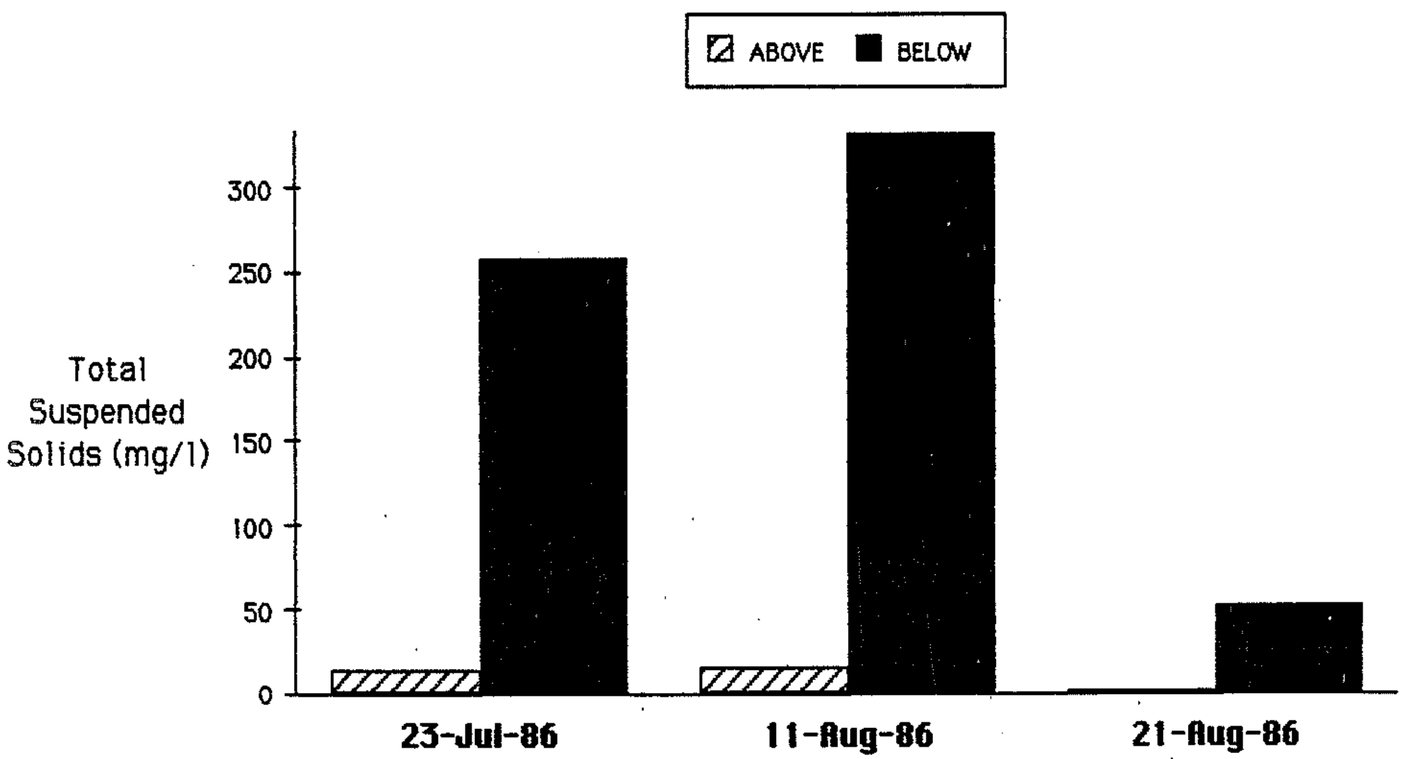

Figure 3. Total suspended solids above and below flood irrigated cropland.

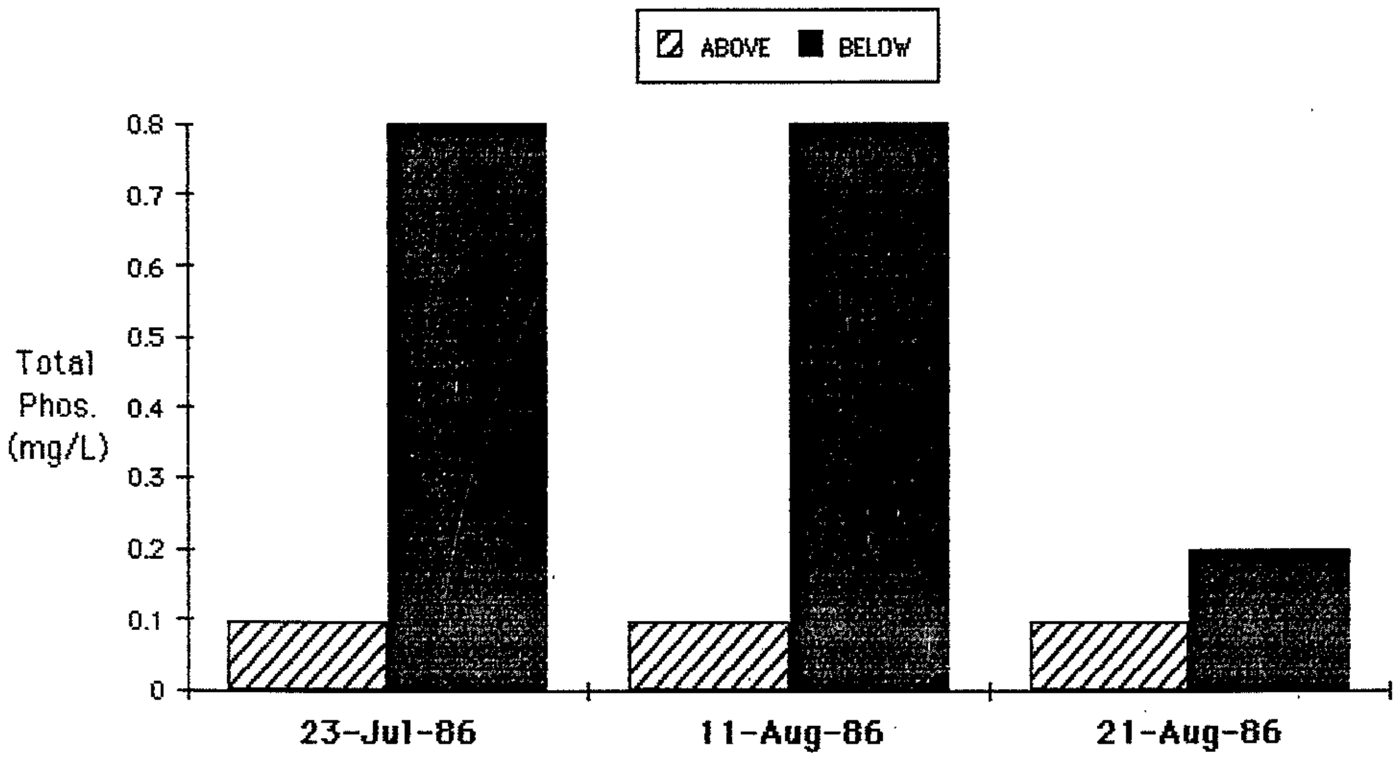

Figure 4. Total phosphorus values above and below flood irrigated cropland.

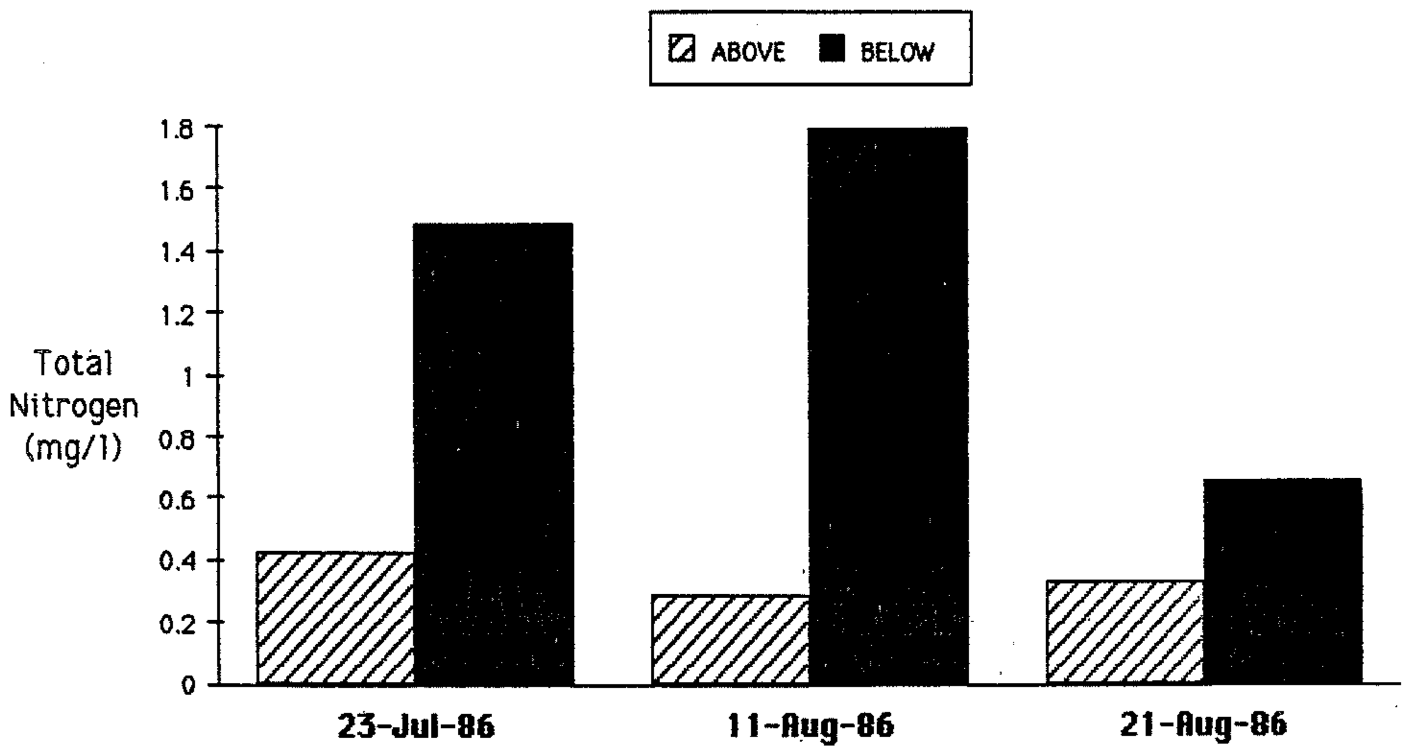

Figure 5. Total nitrogen values above and below flood irrigated cropland.

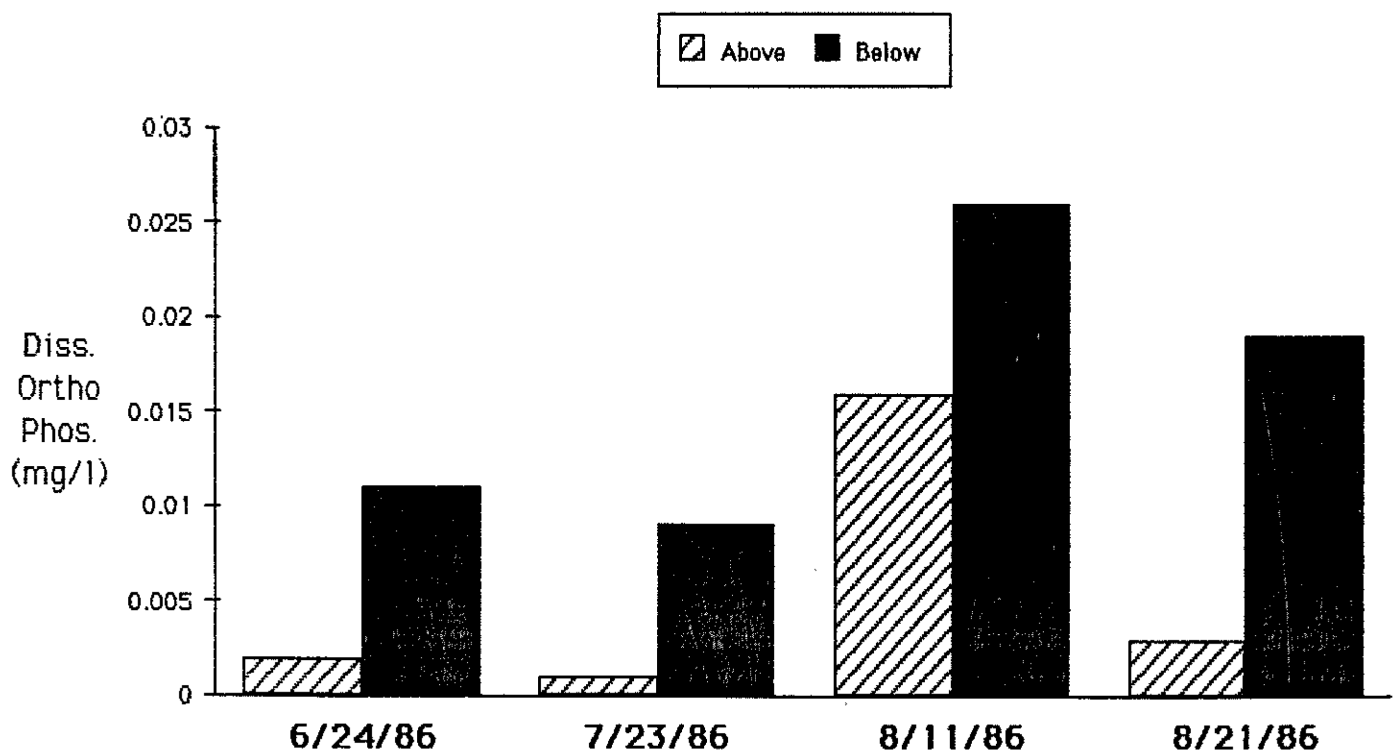

Figure 6. Dissolved orthophosphorus values above and below sprinkler irrigated croplar

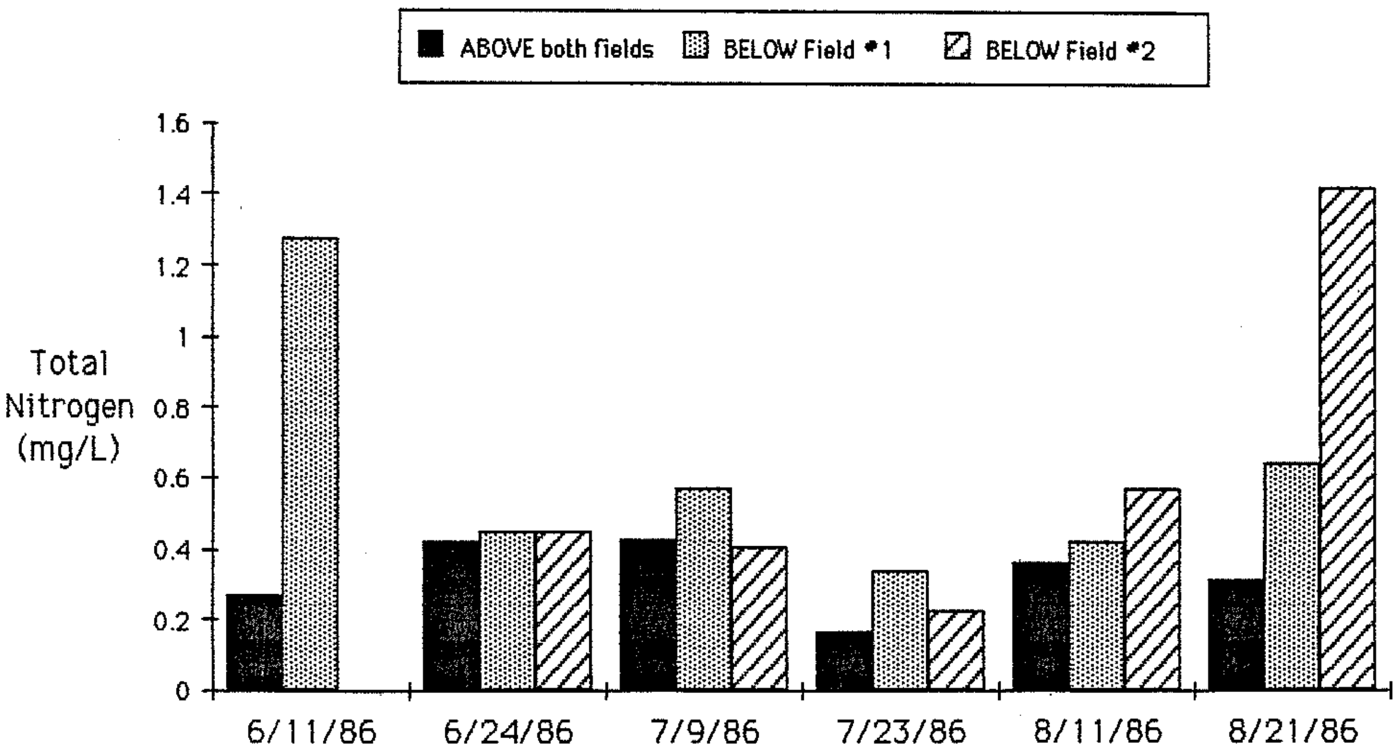

Figure 7. Total nitrogen values above and below flood irrigated pastureland.

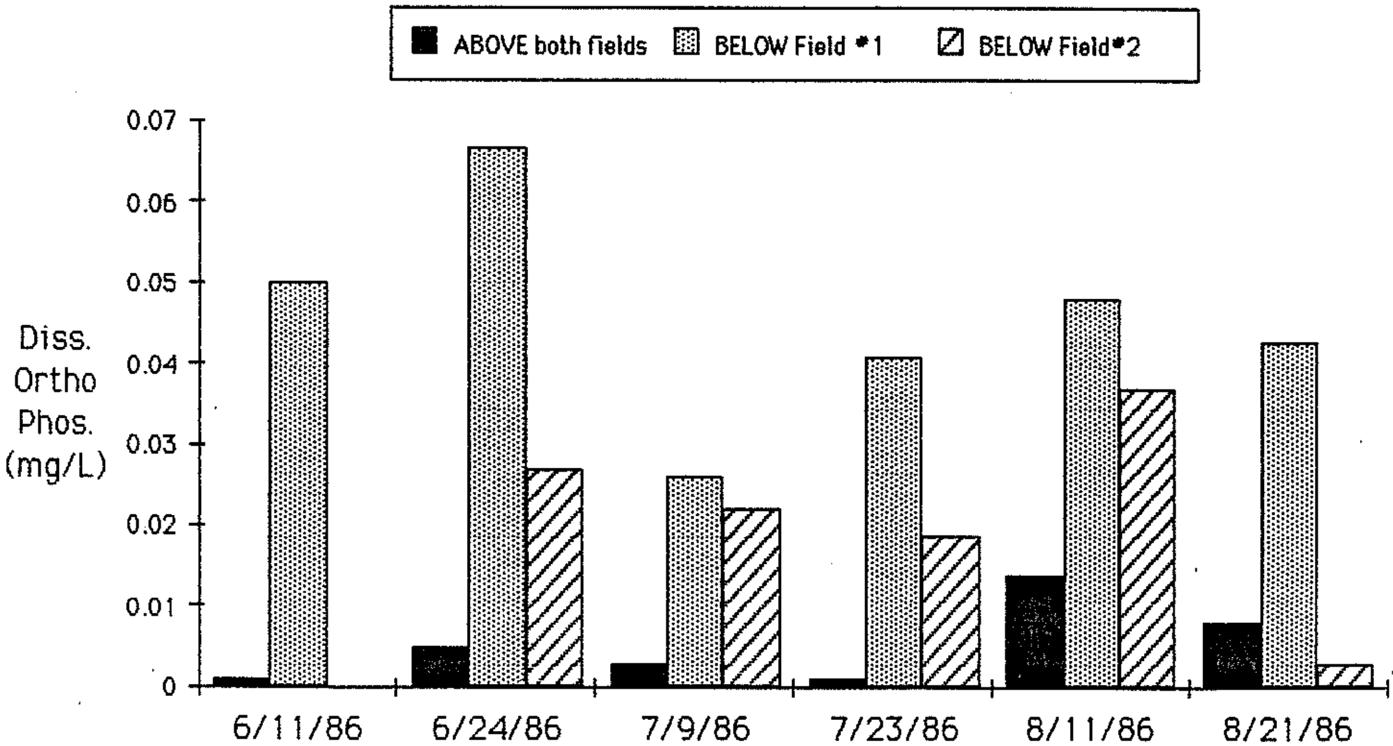

Figure 8. Dissolved orthophosphorus values above and below flood irrigated pastureland.

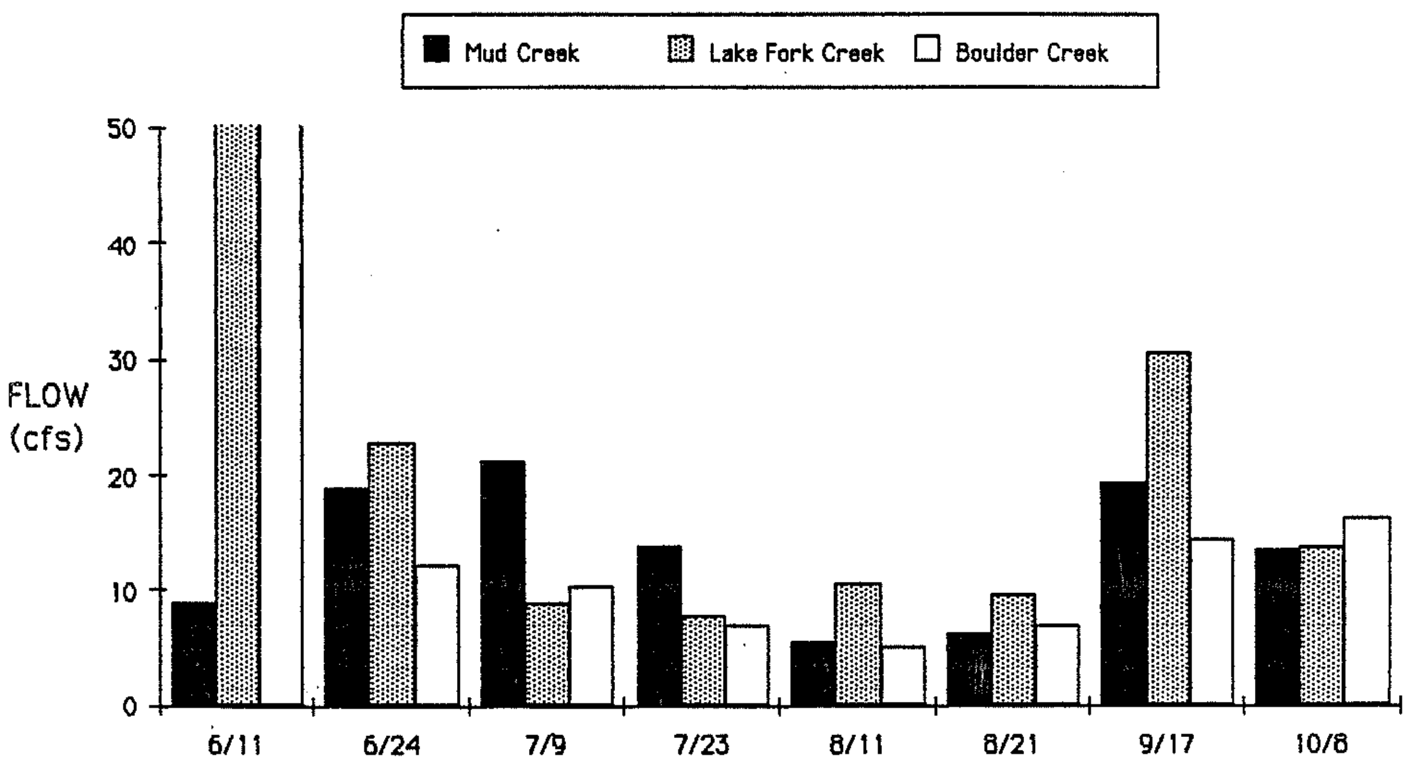

Figure 9. Summer flows for Lake Fork Creek, Mud Creek and Boulder Creek during 1986.

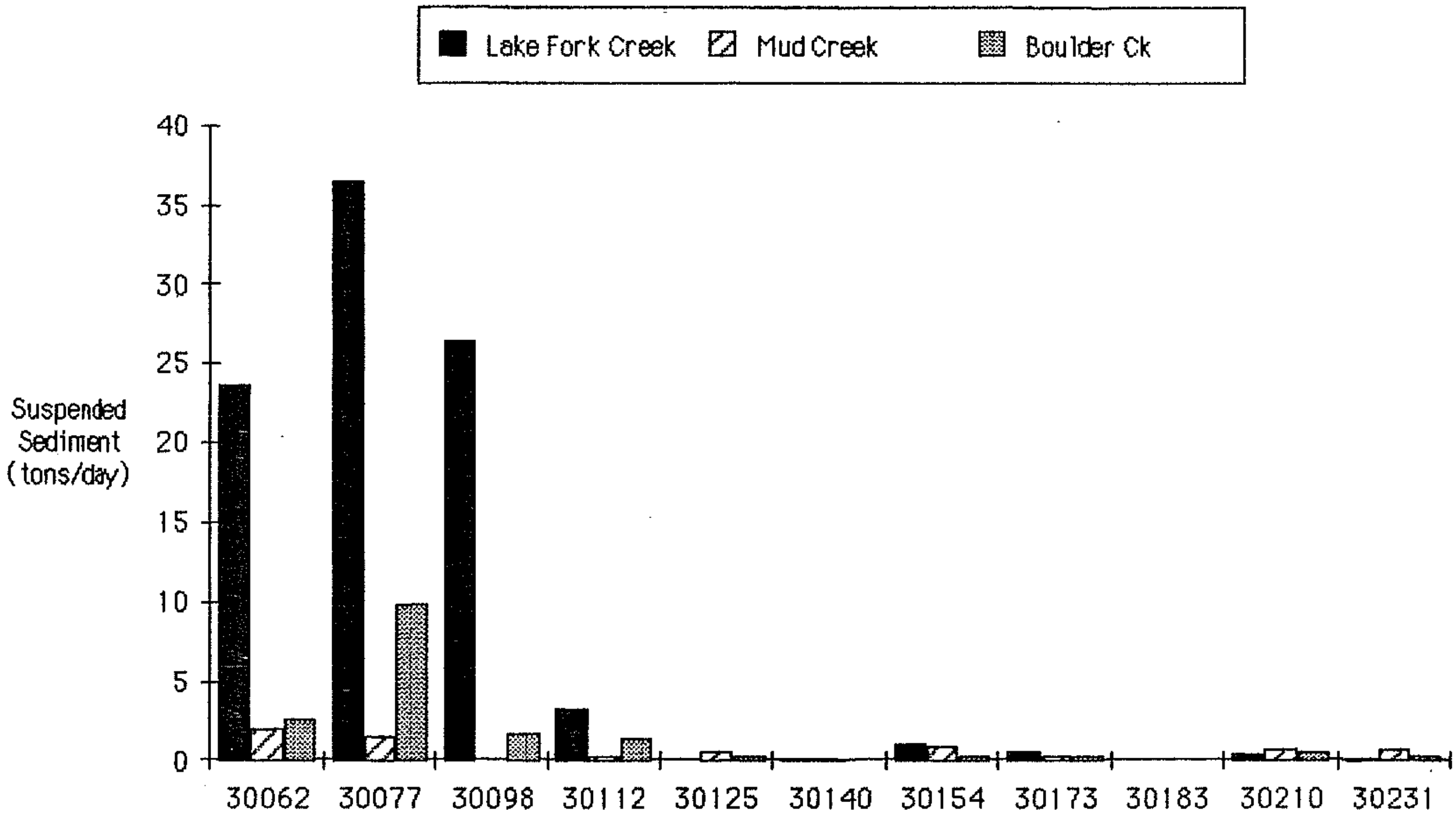

Figure 10. Suspended sediment loadings to Cacade Reservoir from Lake Fork, Mud, and Boulder Creeks.

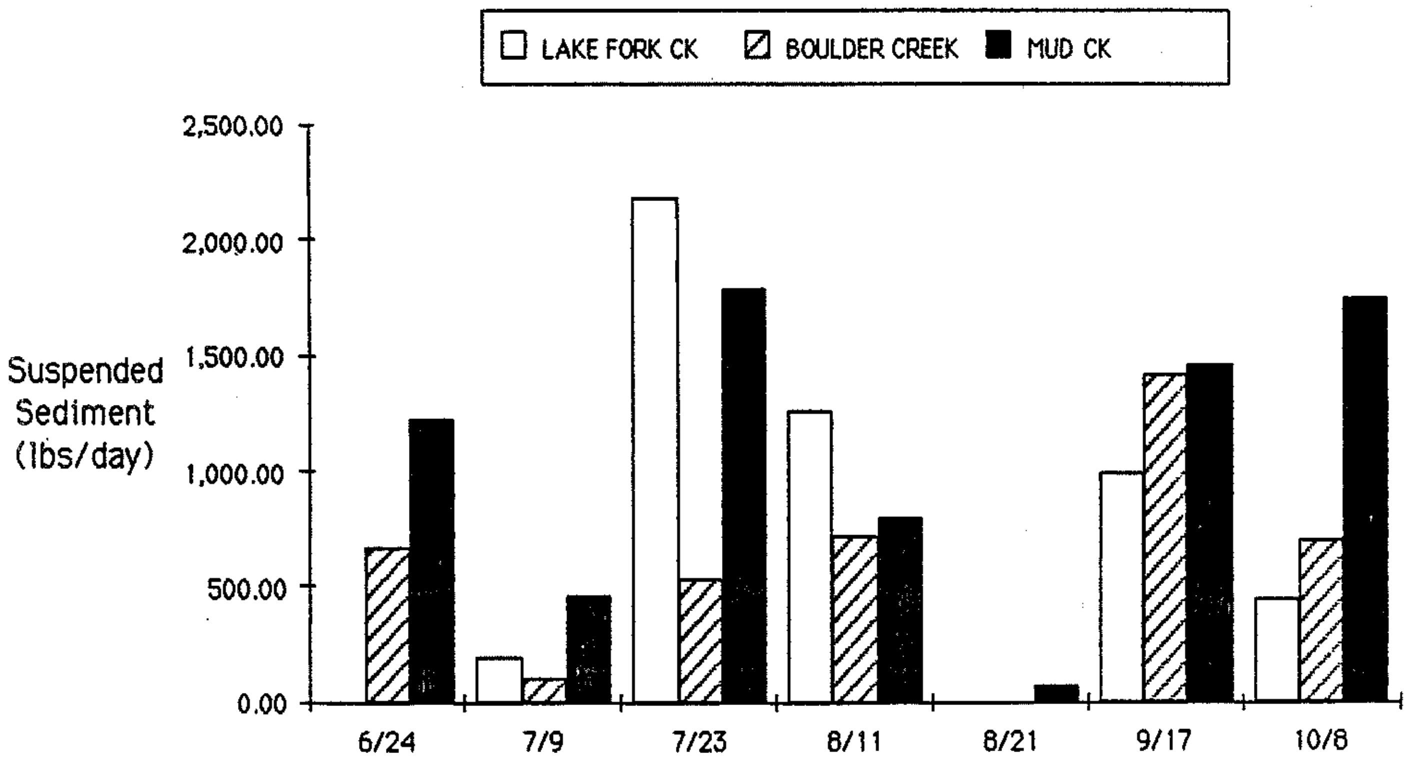

Figure 11. Suspended sediment loadings to Cascade Reservoir under summer flow conditions.