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INTERIM REPORT

EFFICIENCY OF EROSION CONTROL PRACTICES OF THE VIRGINIA DEPARTMENT OF HIGHWAYS AND TRANSPORTATION

by

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ABSTRACT

Stream monitoring stations have been installed on eight construction projects under Phase I of this study. Monitoring on four of the projects is complete and monitoring on the remaining four is continuing. On the basis of the limited data, it appears that the amount of suspended sediment transported from a construction project in the Valley and Ridge region, a predominantly clayey soil area, is quite large as compared to that from a project in the Piedmont region, a silty soil area. This trend is especially evident when no erosion control measures are used. It also has been noted that relatively large amounts of sediment are generated during the spring and fall, when the soil generally is most susceptible to erosion.

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INTRODUCTION

Prior to the widespread use of erosion and sediment controls in the early 1970's, a number of studies had documented the sediment levels generated by construction activities (Wolman 1964; Wolman and Shick 1967; Vice et al. 1969; Anderson and McCall 1968; Davis and Brooks 1967; Dawdy 1967; Swerdon and Kountz 1973; Guy 1963; Guy and Ferguson 1962; Yorke and Herb 1976; Keller 1962; Eskelin 1976; and NACRF 1970). The reports on these studies provide excellent data on sediment levels resulting from unprotected construction sites, but provide little insight into the effectiveness of programs subsequently developed to control erosion and sedimentation.

Since the early 1970's, a number of studies have been made in Virginia to evaluate and monitor the effectiveness of specific controls such as straw bale barriers, silt fence barriers, and log check dams. At the Research Council studies have been conducted by Wyant, Sherwood, and Walker (1972), Sherwood and Wyant (1974 and 1976), Wyant (1975, 1976a, 1976b, and 1980), Poche (1975), and Poche and Sherwood (1975). While the reports on these studies contain valuable information on specific controls, none of the studies included continuous monitoring downstream from highway construction projects to evaluate the overall effectiveness of the erosion and sediment control program being used. In fact, these studies did not determine the sediment levels being generated by the construction activities or the effect of the sediment on the biota of an aquatic system.

While it has been well documented that excessive amounts of sediment have a detrimental effect on biotic communities (Cairns 1968; Gammon 1970; Sorensen et al. 1977), to the author's knowledge no one has differentiated between the effects of construction-induced sediment and background sediment on the biotic communities of a stream. It is very difficult to delineate effects of the former on the biotic communities, because many environmental factors, such as the type and amount of sediment, the hydraulic characteristics of the stream, and the intensity and duration of storm events, affect the response of biota. In fact, a search of the literature turned up no study in which there was continuous monitoring of the sediment levels and the biota up- and downstream of a highway construction project. In only one study was there continuous monitoring of the sediment up- and downstream of a highway construction project (Eckhardt 1976).

PURPOSE

This study was undertaken at the request of the Environmental Quality Division to evaluate the erosion and sediment control practices employed by the Department on construction projects. However, because of the myriad factors that must be considered in determining the effectiveness of the practices in use on any given project, it was emphasized that the findings might not be conclusive nor lend themselves to unqualified generalizations. Among the factors to be considered are the nature of the construction; soil type; degree of slope; extent of the drainage area; the amount and intensity of rainfall; the type, spacing, and number of erosion and sediment control structures placed; the number of storm events; the amount of runoff; magnitude and velocity of the stream flow; and the effort expended in maintaining the control structures.

The basic purpose of the research was twofold: (1) to evaluate, on a total project basis, the effectiveness of the erosion and sediment control practices in use by the Department, and (2) to determine what level of erosion and sediment control can be obtained using present methods designed, installed, and maintained at the highest practical level.

SCOPE

To achieve the twofold purpose, the research was divided into two phases designed to proceed simultaneously and independently. In Phase I, a number of the Department's construction sites on which the standard erosion and sediment control measures were in use were to be monitored over several storm events. In Phase II, the highest practical erosion and sediment control measures were to be employed on a single construction site. This site was to be monitored continuously over the life of the project or until such time that sufficient data were collected to allow an evaluation of the effectiveness of the controls.

For Phase I, three to five construction projects located in each of the three major physiographic regions of the state (Coastal Plain, Piedmont, and Valley and Ridge) were to be selected for study. Water samples and flow measurements were to be taken daily and at intervals during and immediately after several storm events. All water samples were to be processed at the Research Council laboratory, where suspended sediment concentrations and total sediment loads were to be determined. Concurrently, periodic sampling and processing of in-stream biota were planned to be carried out by the Environmental Quality Division. It was thought that the total of up to fifteen construction projects throughout the state should yield sufficient data to indicate the effectiveness of the Department's erosion and sediment control program.

For Phase II, a single stream affected by a specially selected construction project was to be monitored continuously for sediment. The project was to receive the best (design, installation, and maintenance) in erosion and sedimentation control consistent with the present state of the art. The erosion and sediment control measures were to be designed to the highest practical level by the Research Council and the Location and Design Disivion, and be installed and maintained by the Research Council. This project was to be located close to the Research Council laboratories in Charlottesville and in very erosive Piedmont soils. It was expected that this phase of the study would provide a determination of the best results that could be expected when taking special care in the design, installation, and maintenance of the presently used erosion and sediment control measures. As in Phase I, data on fish and benthic organisms in the receiving stream were to be generated by the Environmental Quality Division.

APPROACH

Phase I

Various research alternatives were considered in a preliminary "Research Plan" (Wyant 1978) prepared for a task group organized to provide guidance and advice on the conduct of the proposed research. From the task group's consideration of the alternatives presented in the preliminary plan, the two-phase approach was formulated.

For Phase I, it was decided that the construction projects selected would traverse streams at nearly right angles. Sampling stations would be located up- and downstream from the construction site and as near as possible to it to avoid interference from intervening areas.

The task group agreed that the parameters listed in Table 1 would be determined for each station as indicated for the different flow conditions or type of sample. Automatic samplers would be used to obtain samples of total nonfilterable solids (suspended solids), with depth-integrated hand samples to be obtained periodically. The plan stipulates that the samples were to be processed in the laboratory within 7 days of the collection time by the total-suspended-matter (nonfilterable-residue) method (APHA, AWWA, WPCF 1975) using glass fiber filters that remove 99.7% of the particles larger than 0.3 μ.

TABLE 1

Sampling Schedule for Phase I Projects
(All parameters to be determined up- and downstream)

Parameter	Low Flow	High Flow	Benthic Sampling	Fish Survey
Total Nonfilterable Residue (Suspended Solids)	Daily	Every hour	Quarterly	Semiannually
Flow	Continuous	Continuous	Quarterly	Semiannually
Temperature (Air and Water)	Weekly	---	Quarterly	Semiannually
Dissolved Oxygen	Weekly	---	Quarterly	Semiannually
pH	Weekly	---	Quarterly	Semiannually
Alkalinity	Weekly	---	Quarterly	Semiannually
Rainfall	Continuous	Continuous	---	---

At locations having permanent drainage structures at the testing sites and a stream of constant width, the stream depth or flow was to be determined with an automatic flowmeter so that the total suspended solids carried by the stream could be computed. At locations with no permanent structure, the cross section of the stream would be determined periodically. By ascertaining the depth of the water in the known cross section, the stream flow could be determined from a predetermined stage-discharge curve.

Temperature, dissolved oxygen, pH, and alkalinity were to be determined according to the schedule in Table 1 by approved methods (ASTM 1980; APHA, AWWA, WPCF 1975). The amount and intensity of rainfall during each storm were to be measured with an automatic recording rain gage.

Sediment concentrations and total sediment were to be used as indicators of the effectiveness of the erosion and sediment control measures and stream biota were to be studied. The Environmental Quality Division was to conduct benthic and fish surveys as noted in Table 1, with the organisms taken during these surveys being classified and the counts statistically evaluated. These data were to be forwarded to the Research Council for inclusion in the evaluation and the final report.

Phase II

As was noted under the section on SCOPE, for Phase II the Research Council, in cooperation with the Location and Design Division, was to design the sediment and erosion controls, and install and maintain them. The parameters listed in Table 1 were to be determined on the same sampling schedule.

PROBLEMS

Many problems stemming from a variety of causes have been encountered in the study, and most of the major ones are described here. First, finding projects suitably located for monitoring has been extremely difficult. Because of the Department's economic situation, many proposed construction projects have been delayed or have been removed from the advertising schedule just prior to publication. In several instances, projects have been selected for monitoring and the Research

Council has commenced its work only to find later that the project has been delayed for 6 months to a year. Many projects have been found unsuitable for the study because of one or more of the following reasons:

1. Adjacent disturbance or interference, such as plowed fields or cow pastures, between the two monitoring stations.

2. Very flat land in the area, thus no significant amount of drainage into the stream from the construction project and a high risk of flooding the monitoring equipment.

3. Stream too small for sampling or so large as to prevent personnel from working in the stream to obtain cross sections, place the automatic sampling equipment, or obtain biological samples.

4. Difference in the elevations of the sampling equipment and the sampling probe that exceeded the pumping capability of the equipment.

One of the main limitations has been the limited capability of the sampling equipment. The equipment available is built for use in a laboratory and does not perform well under field conditions. For example, it is not constructed to withstand freezing weather, high humidity, nor high flows.

Problems also were encountered in the field storage of the equipment. First, the equipment was placed in 55 gallon (0.21 m^3) metal drums securely fasten by cables to large trees or 3 foot (0.91 m) metal posts driven in the ground. The use of metal drums had to be terminated when moisture from condensation created problems with the electronic equipment. To replace the drums, plywood boxes with vent holes were constructed. These boxes have performed well over the last year or more, even in freezing weather, with some insulation.

Another problem with the equipment resulted from the need to use a DC power source. At the outset 12-volt auto batteries were used. Although these indicate 11.2 volts power, they still would not provide enough power to run a water sampler. Thus, after several rain events, it was determined that they would not suffice and that 12-volt, deep-cycle marine batteries would be needed.

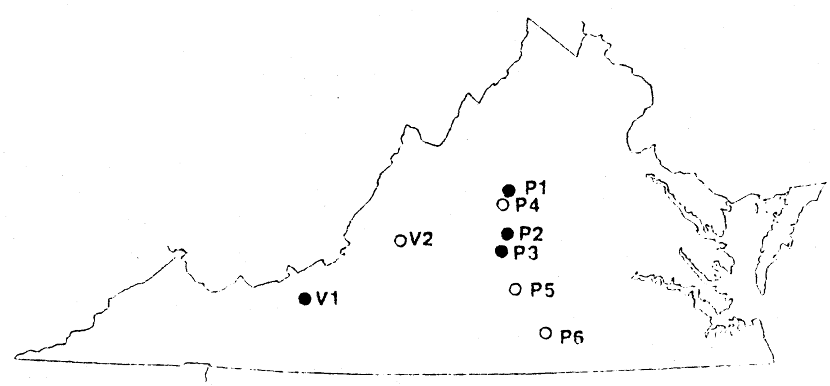
Other mechanical and electrical problems have been encountered because of the severity of the field conditions or the limitations of the water sampling equipment. One major limitation of the equipment is its inability to integrate samples. Therefore, when the suction hose is placed in the stream its elevation must be such as to prevent the sampling of bedload material during high flow conditions and drawing air during low flow periods. In the analysis of the data, this fact must be remembered so as not to draw conclusions from any erroneous results attributable to samples obtained during extreme flow conditions.

Several sets of data from storm events had to be discarded because of flooding in the device holding the water bottles used to collect samples. It was determined that the electronic control in one of the two types of water samplers purchased did not terminate the sampling after the last bottle was filled. The flooding in this type of sampler occurred only when several daily samples had been taken prior to a rain event. When a new sampling time interval was set after several bottles had been filled, the electronic controls would cycle the sampler through the total number of bottles, thus flooding the first several bottles filled at the old time interval.

WORK ACCOMPLISHED

Stream monitoring stations have been installed on eight construction projects under Phase I of this study. On four of these, monitoring has been completed. Three of the four are located in the micaceous silty soil of the Piedmont physiographic area, and the other is located in the Valley and Ridge physiographic area, which is predominately clayey soils (Figure 1). All four were monitored as described in the APPROACH section of this report.

P1 Buck Mt. Creek
P2 Buck Creek
P3 Rockfish River
P4 Mechums River
P5 Wreck Island Creek
P6 Couches Creek
V1 Big Walker Creek
V2 Sinking Creek



● monitoring completed

○ being monitored

Figure 1. Locations of stream monitoring.

On the other four projects, monitoring of the streams is in progress. Three of the four are located in the Piedmont; the fourth in the Valley and Ridge province (Figure 1).

Descriptions of the first four streams monitored, their watershed, and the construction project are given below, along with the results obtained to date. The water quality data obtained by the Research Council are given in Appendix A. The data on water quality and the fish survey and part of the data on the benthic populations collected by the Environmental Quality Division are given in Appendix B. Trends in the data and noteworthy results are discussed in this section.

On the projects still being monitored, data have been collected for several storm events and are being analyzed. Initial benthic sampling has been completed and the analysis of the samples is in progress.

In Phase II of the study, several projects have been reviewed but no suitable one has been found. The search is continuing.

Buck Mountain Creek, P1 (Figure 1)

A single-lane, wooden floor bridge over Buck Mountain Creek in Albemarle County was being replaced with a two-lane, prestressed concrete bridge. The plans called for three piers and the two abutments of the bridge. Under normal flow conditions, one pier was in the edge of the stream and the other two on dry land. The bridge spanned a distance of 130 ft. (39.6 m).

The total project length was 0.863 mi. (1,389 m). Approximately 2,000 ft. (610 m) of roadway on each side of the bridge were relocated and a connector to another secondary road was constructed. The average grades for the relocated sections of roadway were 5.2% and 6.0%. The total excavation on the project was 29,658 yd.^{3} (22,677 m^3) of earth, with 6,002 yd.^{3} (4,589 m^3) being wasted. A total of 1,464 lin. ft. (446 m) of baled straw silt barriers were designed to protect adjoining property and Buck Mountain Creek. In addition, stone was specified to be placed at the end of culverts to control erosion.

The drainage basin above the project is mostly timberland and farmland. The terrain is rolling and drops from a maximum elevation of 3,000 ft. (914 m) to 410 ft. (125 m) at the bridge. The drainage area above the bridge covers 37.4 mi.^{2} (9.7 x 10^7 m^2).

The contractor started earthwork around August 1, 1978, with most of the initial effort being applied to the bridge construction. Clearing and grubbing on both sides of the bridge began on August 10, 1978, and was done in stages until completed around the middle of October. Cofferdams to aid in pier construction in the stream were installed in mid-August and removed in November. Silt created by excavation and dragline operations behind the cofferdams was not visible in the stream.* Baled straw barriers were installed August 7, 1978, along the stream for the bridge construction work. Three days later, the barrier was washed out in spots from a 1.25 in. (3.18 cm) rain event. New barriers were not installed until around the end of October. In mid-September, baled straw barriers were installed along the right-of-way fence to prevent sediment-laden runoff from going onto adjoining properties. As construction progressed, baled straw barriers and erosion control stone were placed as needed in the ditches and at the ends of the culverts. Seeding of denuded areas was conducted in stages to prevent leaving large areas unprotected.

Suspended solids data were collected with a DH-48 integrated hand sampler until automatic samplers were installed March 9, 1979. Water depth data for flow calculations were recorded from a stage height gage installed on September 5, 1978. The stage-discharge curve developed for Buck Mountain Creek is shown in Appendix C. A total rainfall gage was used until an automatic recording gage was installed on March 14, 1979.

Using the suspended solids and discharge data generated during ambient flow and storm events, the instantaneous sediment discharge was determined as

$$Q_s \text{ (pounds per hour)} = 0.225\, Q_w C_s,$$

where

Q_w = water discharge in cubic feet per second; and

C_s = suspended solids concentration in parts per million (modified from Howell et al. 1972).

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*Under Virginia's policy, no channelization work is allowed.

Table 2 lists the mean daily discharge for each month of monitoring and the estimated suspended sediment discharge for Buck Mountain Creek during ambient flow conditions. The daily discharges are normal, except those for January, when some of the largest rain events occurred. In 1979, January had higher than normal temperatures and rainfall, thus Buck Mountain Creek had a higher than normal discharge.

The estimated suspended sediment discharge for January indicates that approximately 2,839 lb./hr. (1,289 kg/hr.) of soil were deposited between the upstream and downstream sampling stations.* The large amounts of sediment transported past the upstream station are mainly due to runoff from large cultivated fields and a housing development on one of the two tributaries. The deposition of soil between the two stations is mainly due to pools where the soil settles out of suspension. In addition, the stream widens between the two stations in several locations, thus its velocity is reduced and the soil settles out.

The suspended sediment discharge for the other months seem normal, except that for December. The author knows of no reason for the high sediment discharge of 1,229 lb./hr. (558 kg/hr.), since the contractor did very little work during this month and the erosion control devices were in place and seemed to be functional.

Table 3 summarizes the data collected during the storm events. Plots of the suspended solids levels, the stream flow, and the rainfall for these events are shown in Appendix C. As indicated in Table 3 and the plots for the first three storm events, larger loads of soil were transported into the monitored area than were carried out. This finding indicates that some of the transported material was deposited between the two monitoring stations, which is consistent with the January ambient flow conditions.

The data for the remaining four storm events indicate that additional sediment was contributed by the construction activities (Table 3). The results indicate that for the first large spring rains (March 23-25 and April 3-5) large amounts of soil were added to the stream. The April 9 storm event was a small one and contributed approximately 0.6 ton (545 kg) of soil to the stream. The last storm event (April 13 and 14), although of great enough magnitude and duration to create substantial runoff and soil loss, did not generate a large amount of soil loss from the construction project, most likely because the events of March 23-25 and April 3-5 had removed the loose soil created by the freezing and thawing weather of the previous months. The project was nearing completion in early 1979 and no additional erosion and sediment controls were installed prior to or between these storm events.

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*See Appendix D for sketches of monitoring stations and control measures.

Table 2

Estimated Suspended Sediment Discharge for Buck Mt. Creek During Ambient Flow Conditions (Construction Commenced on August 1, 1978)

Month	Mean Daily Discharge, cfs.	Suspended Sediment Discharge, lb./hr.		
		Downstream	Upstream	Difference
Sept. '78	72.1	167	77	90
Oct. '78	68.8	189	69	120
Nov. '78	75.4	127	68	59
Dec. '78	83.6	1,324	95	1,229
Jan. '79	580.5	15,529	18,368	-2,839
Feb. '79	No samples — freezing weather			
Mar. '79	123.0	333	314	19
Apr. '79	107.6	367	265	102

Conversion: 1 cfs. = 0.028 m^3/sec

1 lb./hr. = 0.454 kg/hr

Table 3

Estimated Suspended Sediment Discharge for Buck Mt. Creek During Storm Events (Construction Commenced on August 1, 1978)

Date	Total Rainfall, in.	Monitoring Time, hr.	Suspended Sediment Discharge, lb.		
			Downstream	Upstream	Difference
9 Dec. '78	1.12	17	104,507	105,162	- 655
2 Jan. '79	1.70	4	108,289	121,671	- 13,382
24 Jan. '79	1.64	5.5	171,678	282,978	-111,300
23-25 Mar. '79	1.82	39.5	196,643	167,445	29,198
3-5 Apr. '79	1.18	52	59,097	24,317	34,780
9 Apr. '79	0.28	20	6,711	5,473	1,238
13-14 Apr. '79	0.70	27	8,784	3,502	5,282

Conversion: 1 lb. = 0.454 kg

1 in. = 2.54 cm

In summary, the suspended solids data indicate that large amounts of soil were transported by Buck Mountain Creek into the construction limits and deposited during the winter months for ambient flow conditions and significant storm events. This deposition was evident in the area of the new bridge, where the velocity of the stream decreased and allowed the deposition to occur. Also, it should be noted that the erosion control measures had been installed for approximately 5 months, and that, from the results obtained, they appear to have performed their intended function. From the data collected during the early spring storm events, it seems to be critical to have properly installed erosion control measures to prevent the erosion of large amounts of soil into the stream from the construction project.

Buck Creek, P2 (Figure 1)

On Route 29 in Nelson County, 2.8 mi. (4,506 m) of road were being widen from two lanes to four lanes. A four-barrel, 8-foot by 8-foot (2.4-m by 2.4-m) box culvert was constructed under the two additional lanes of Route 29 where the project traversed Buck Creek. The box culvert was 160 ft. (49 m) long and required that approximately 710 ft. (216 m) of channel be changed above and below the structure. Large riprap (16 to 23 in. [0.41 to 0.58 m]) was placed in these channel change areas to a minimum depth of 30 in. (0.76 m). The box culvert required 2,445 $yd.^3$ (1,869 m^3) of excavation.

The design of the project called for log or rock check dams to be installed in areas draining into Buck Creek, and for the use of 426 $yd.^2$ (356 m^2) erosion control riprap on the project. Nine baled straw check dams and 590 lin. ft. (180 m) of baled straw silt barriers were designed for the disturbed areas of Buck Creek. In addition, one drop inlet silt trap and a brush silt barrier were specified on the plans.

The drainage area above Buck Creek is very wooded and steep. The drainage basin drops from an elevation of 1,885 ft. (575 m) to 525 ft. (160 m) at the box culvert. Runoff from 5.4 $mi.^2$ (1.4×10^7 m^2) of the basin passes through the box culvert under Route 29.

Construction near Buck Creek was well under way before the Research Council located the project and commenced stream monitoring. The four-barrel box culvert had been completed, the fills constructed, and the large riprap placed in the channel change areas when the project was selected. Other than the riprap, no erosion and sediment control measures had been installed on this project prior to the initial visit of research personnel at the end of June 1978. In addition, no controls had been placed in the disturbed areas of Buck Creek when stream monitoring was terminated in April 1979.

The suspended solids, flow, and rainfall data were obtained by the same techniques used on Buck Mountain Creek. A stage-discharge curve was developed for Buck Creek and is included in Appendix C.

Using the suspended solids and discharge data generated during ambient flow and storm events, the instantaneous sediment discharge was determined. Tables 4 and 5 give the suspended sediment discharges for ambient flow conditions and storm events, respectively. Plots of the suspended solids levels, stream flow, and rainfall for the storm events are shown in Appendix C.

As indicated in Table 4, the upstream suspended solids level was essentially constant for all the months monitored except August 1978 and April 1979. The reason for this small increase was the additional eroded soil contributed by the fall and spring breakup. However, it should be noted that large amounts of soil (306 and 179 lb./hr. [139 and 81 kg/hr.] were contributed to the stream in June and July 1978. The flow was not excessive for these two months; the erosion resulted from the lack of seeding, erosion control barriers, and protection for the drop inlet, and from soil spilling over the end of the new box culvert into the stream. At the time of the author's first visit to the project (June 1978), soil was backfilled up to the stream's edge in some areas and into the stream in others. In addition, downstream from the upper construction limits the stream was choked with soil from work conducted previously in or near the stream. The increases indicated in Table 4 probably resulted from this streambed material being resuspended.

Table 5 indicates that large amounts of soil were eroded from the project into the stream during several of the monitored storm events (November 17 and 27, 1978, and April 4, 1979). The November 17 and 27 storm events had high suspended solids concentrations (approximately 1,000 ppm) downstream (Appendix C). For the April 4 storm event, the high flow during the suspended sediment peak period created the high sediment discharge.

The April 3 storm event did not generate as large a sediment discharge (481 lb. [218 kg]) as did the spring storms monitored on Buck Mountain Creek, because several earlier storms, which were not monitored and for which some pertinent data are lacking, had washed the loose soil off the slopes and on downstream. One of the partially monitored storm events had occurred on April 2. Appendix C contains the suspended sediment curves for this 0.87-in. (2.2-cm) rain event. The results obtained were not included in Table 5 because the flow equipment malfunctioned. This storm, and others that occurred prior to April and were not monitored, had carried downstream the majority of the soil from the spring breakup.

Table 4

Estimated Suspended Sediment Discharge for Buck Creek During Ambient Flow Conditions (Construction Commenced Prior to June 1978)

Month	Mean Daily Discharge, cfs.	Suspended Sediment Discharge, lb./hr.		
		Downstream	Upstream	Difference
June '78	2.5	311	5	306
July '78	1.6	182	3	179
Aug. '78	1.7	53	12	41
Sept. '78	2.3	99	3	96
Oct. '78	4.2	91	4	87
Nov. '78	2.7	91	2	89
Dec. '78	2.9	16	3	13
Jan, Feb. Mar. '79	No samples — freezing weather			
Apr. '79	3.7	42	21	21

Conversion: 1 cfs. = 0.028 m^3/sec

1 lb./hr. = 0.454 kg./hr.

Table 5

Estimated Suspended Sediment Discharge for Buck Creek During Storm Events (Construction Commenced Prior to June 1978)

Date	Total Rainfall, in.	Monitoring Time, hr.	Suspended Sediment Discharge, lb.		
			Downstream	Upstream	Difference
17 Nov. '78	0.66	9.25	5,150	72	5,078
27 Nov. '78	1.09	3.0	2,317	200	2,117
4 Dec. '78	0.91	2.0	453	46	407
3 Apr. '79	0.73	11.0	1,021	540	481
4 Apr. '79	0.49	8.5	2,274	795	1,479
13 Apr. '79	0.84	17.0	1,154	781	373

Conversion: 1 in. = 2.54 cm.

1 lb. = 0.454 kg.

Although the results for the monitored storm events on this project (Table 5) did not indicate more sediment than the results from Buck Mountain Creek (Table 3), they should have. This project was in similar soil, but lacked the attention given to erosion and siltation control at Buck Mountain Creek. Consequently, the data should reflect conditions far worse than those at Buck Mountain Creek, but they do not. These results point out some of the problems with the suspended sediment monitoring program that were discussed earlier in this report. Since most of the eroded soil was deposited on the streambed, the benthic monitoring program may reflect the effect on the stream ecology.

Rockfish River, P3 (Figure 1)

The third stream monitored in the Piedmont physiographic area was the Rockfish River at the Route 29 crossing in Nelson County, where 2.8 mi. (4,506 m) of Route 29 were being widened from two lanes to four lanes. This construction project was the same one that traversed Buck Creek. A two-lane, six-span concrete deck bridge was constructed over the Rockfish River. In addition, small repairs were made on the existing two-lane concrete bridge. The total length of the bridge was 377 ft. (115 m).

The drainage area of the Rockfish River above this bridge is 105 mi.^{2} (2.7 x 10^8 m^2). Most of the area is very steep and wooded, with some houses and small farms. The drainage basin drops from a maximum elevation of approximately 1,925 ft. (587 m) to 510 ft. (155 m) at the bridge.

For the area being disturbed by construction, the plans call for two silt traps to provide protection around drop inlets, one straw check dam, and erosion control riprap in seven locations. In addition, protection of the stream was required during the construction of the piers. During the monitoring period, neither the straw check dam nor the silt traps were in place.

Construction had begun prior to the selection of the project for study in June 1978. Excavating for the bridge piers commenced around September 1. An earth retaining berm and a causeway were constructed with a bulldozer and drag-line equipment around September 22. A straw bale berm was constructed on September 29 to filter sediment-laden water pumped from the pier footings. During the early part of October, front end loaders were operated in the Rockfish River to construct channel changes. Earthwork activities were conducted in or near the Rockfish River through December 1978.

A tributary, Davis Creek, that enters the Rockfish River between the locations for the two monitoring stations established was also monitored so the effects of the construction could be determined. The stage-discharge curve and suspended solids data on Davis Creek are included in Appendix C. As with the previous projects, instantaneous sediment discharges were determined for both ambient flow conditions and different storm events. Tables 6 and 7 are the suspended sediment discharges for ambient flow conditions and storm events, respectively. Plots of the suspended solids levels and stream flow for the Rockfish River are shown in Appendix C, along with the rainfall for the monitored storm events. The stage-discharge curve developed for the Rockfish River is included in Appendix C.

Table 6 indicates that during ambient flow conditions the suspended sediment discharge was essentially the same for all the months monitored. Except for October 1978, July 1979, and August 1979, sediment settled out between the two monitoring stations, as indicated by the negative values in Table 6.

Table 7 lists the data for the storm events monitored. Other storm events were monitored, but these are not included because complete data were not obtained due to equipment malfunctions or human error. As indicated in Table 7, large amounts of sediment were generated during the August and September 1979 storm events. However, only a small amount (3,927 lb. [1,783 kg]) was contributed to the river during the August 30-31 storm. Conversely, the September 1979 storm contributed approximately 18 tons (16,330 kg) of sediment to the Rockfish River. No apparent reason for the difference was evident, unless it was due to the duration of the rain. The two storm events in 1978 during active construction and periods when erosion ordinarily is low contributed only small amounts (579 and 914 lb. [263 and 415 kg]) of sediment.

In summary, no storm event was monitored during the early spring breakup on this project. However, two storm events were monitored during the early fall when ground conditions promote erosion. The data for both events indicated that large loads of sediment were generated, but only one event took large amounts of sediment from the construction project. The two events during November and December created insignificant increases in the sediment load in the river.

Table 6

Estimated Suspended Sediment Discharge for the Rockfish River During Ambient Flow Conditions (Construction Commenced September 1, 1978)

Month	Mean Daily Discharge, cfs.	Suspended Sediment Discharge, lb./hr.		
		Downstream	Upstream	Difference
July '78	101	239	249	- 10
Aug. '78	101	455	484	- 29
Sept. '78	42	285	395	-110
Oct. '78	14	26	16	10
Nov. '78	17	120	125	- 5
Dec. '78	14	15	19	- 4
June '79	185	683	734	- 51
July '79	108	834	779	55
Aug. '79	86	62	60	2
Sept. '79	143	460	553	- 93

Conversion: 1 cfs. = 0.028 m^3/sec.

1 lb./hr. = 0.454 kg./hr.

2328

Table 7

Estimated Suspended Sediment Discharge for Rockfish River
During Storm Events (Construction Commenced September 1, 1978)

Date	Total Rainfall, in.	Monitoring Time, hr.	Suspended Sediment Discharge, lb.		
			Downstream	Upstream	Difference
Nov. 17, '78	0.66	9.0	10,284	9,370	914
Dec. 9, '78	0.99	2.3	4,054	3,475	579
Aug. 30-31, '79	0.72	8.0	69,035	65,108	3,927
Sept. 13-14, '79	1.00	21.0	82,052	46,358	35,694

Conversion: 1 lb. = 0.454 kg.

1 in. = 2.54 cm.

Big Walker Creek, V1 (Figure 1)

Route 667, a secondary road in Giles County, was being relocated and improved for approximately 0.2 mi. (322 m). A two-lane, 152-ft. (46 m) long concrete bridge was to replace a single-lane, steel-truss bridge. Approximately 600 ft. (183 m) of the new roadway drained into Big Walker Creek on the northern end of the project, while about 400 ft. (122 m) contributed runoff from the southern end.

The drainage basin of Big Walker Creek above the project is 191 $mi.^2$ ($4.9 \times 10^8\ m^2$). Most of the land is mountainous and steep. The drainage basin drops approximately 1,350 ft. (411 m) from the top of the highest mountain (3,280 ft. [1,000 m]) to the bridge (1,930 ft. [588 m]).

The plans specified that six straw bale silt barriers and approximately 420 ft. (128 m) of brush silt barriers be constructed on the project. During the monitoring period of October 1979 through March 1980 no controls were in place. To the author's knowledge, no controls had been installed prior to this period. During the clearing and grubbing operation brush was spread near the right-of-way in several locations, but was not placed properly to form a brush silt barrier.

Construction had begun before the Research Council selected the project and initiated water monitoring. When the water monitoring equipment was installed on October 10, 1979, the clearing and grubbing operation had been completed, 80% of the earthwork had been done, the deck of the bridge was being formed, and the disturbed areas had not been seeded. The remaining earthwork and the seeding of the entire project were performed in the spring of 1980.

As had been done on the other projects, instantaneous sediment discharges were determined for both ambient flow conditions and storm events. Tables 8 and 9 give the suspended sediment discharges for ambient flow conditions and storm events, respectively. Plots of the suspended solids levels, stream flow, and rainfall for the events are shown in Appendix C along with the stage-discharge curve developed for Big Walker Creek.

Table 8 indicates that during the spring breakup in March, when a large number of rain events usually occur, the flow was high and much sediment was transported. Without any erosion control measures on the project and resuspension of bedload material between the two monitoring stations, 94 tons/hr. (85,277 kg/hr.) of soil were contributed to Big Walker Creek between the two monitoring stations. Data for the other months indicate that very little sediment was contributed by the construction project, even when the flow was high in January.

Table 8

Estimated Suspended Sediment Discharge
for Big Walker Creek During Ambient Flow Conditions
(Construction Commenced Prior to October 1979)

Month	Mean Daily Discharge, cfs.	Suspended Sediment Discharge, tons/hr.		
		Downstream	Upstream	Difference
Nov. '79	54.5	0.07	0.04	0.03
Dec. '79	51.6	0.06	0.01	0.05
Jan. '80	35,715.0	51.00	50.00	1.00
Feb. '80	3,067.0	1.00	1.10	-0.10
Mar. '80	716,570.0	822.00	728.00	94.00

Conversion: 1 cfs. = 0.028 m^3/sec.

1 ton/hr. = 907.2 kg/hr.

Table 9

Estimated Suspended Sediment Discharge for Big Walker Creek During Storm Events
(Construction Commenced Prior to October 1979)

Date	Total Rainfall, in.	Monitoring Time, hr.	Suspended Sediment Discharge, tons		
			Downstream	Upstream	Difference
Nov. 9-10, '79	0.78	27	68.0	29.0	39.0
Nov. 10-11, '79	0.24	27	20,723.0	5,586.0	15,137.0
Dec. 13-14, '79	0.27	26	2.8	0.7	2.1
Jan. 19-20, '80	0.54	22	10,409.0	7,221.0	3,188.0
Mar. 8, '80	0.21	18	46,661.0	14,602.0	32,059.0

Conversion: 1 ton = 907.2 kg.

1 in. = 2.54 cm.

The data for suspended sediment discharges during storm events, Table 9, indicate similar results. The small storm event in March (0.21 in. [0.5 cm] of rainfall) contributed more than 32,000 tons (2.9×10^7 kg) of suspended sediment to the stream in a short period of time. During the December 13-14 storm event, which produced almost as much total rainfall, a very small amount of soil was carried from the construction project, probably because the soil was frozen and not susceptible to excessive erosion.

Another fact of interest in Table 9 is the large amount of soil eroded during the small storm event of November 10-11 as compared to the amount eroded during the two previous days. The heavier erosion resulted from soil becoming saturated, a condition that promotes runoff and lessens infiltration.

In summary, large amounts of soil were carried from this construction project into the stream during periods of high erosion potential and flow. The results indicate how a small construction project not protected against erosion and sedimentation can adversely affect a large stream.

SUMMARY

The four streams on which monitoring has been completed are quite different in many ways. First, the sizes of the drainage basins vary from 5.4 mi.^{2} ($1,4 \times 10^7$ m^2) on Buck Creek to 191 mi.^{2} (4.9×10^8 m^2) on Big Walker Creek. In addition, the size of the streams varies tremendously. The type of soil varies from project to project and, more generally, from physiographic region to physiographic region.

However, considering all the variables and the limited data in Tables 2-9, the following trends are evident. First, the amount of suspended sediment transported from a construction project in the Valley and Ridge region is rather large as compared to that from a project in the Piedmont. This trend is especially evident when no erosion control measures are used.

Another observarion that should be noted is that relatively large amounts of sediment are generated during the spring and fall when the soil is generally most susceptible to erosion. Therefore, it seems to be imperative that all the necessary erosion control measures be installed properly prior to these times of the year. In addition to the soils being highly erodible, frequent and sometimes large storm events occur during these seasons.

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APPENDIX A

WATER QUALITY DATA COLLECTED BY RESEARCH COUNCIL

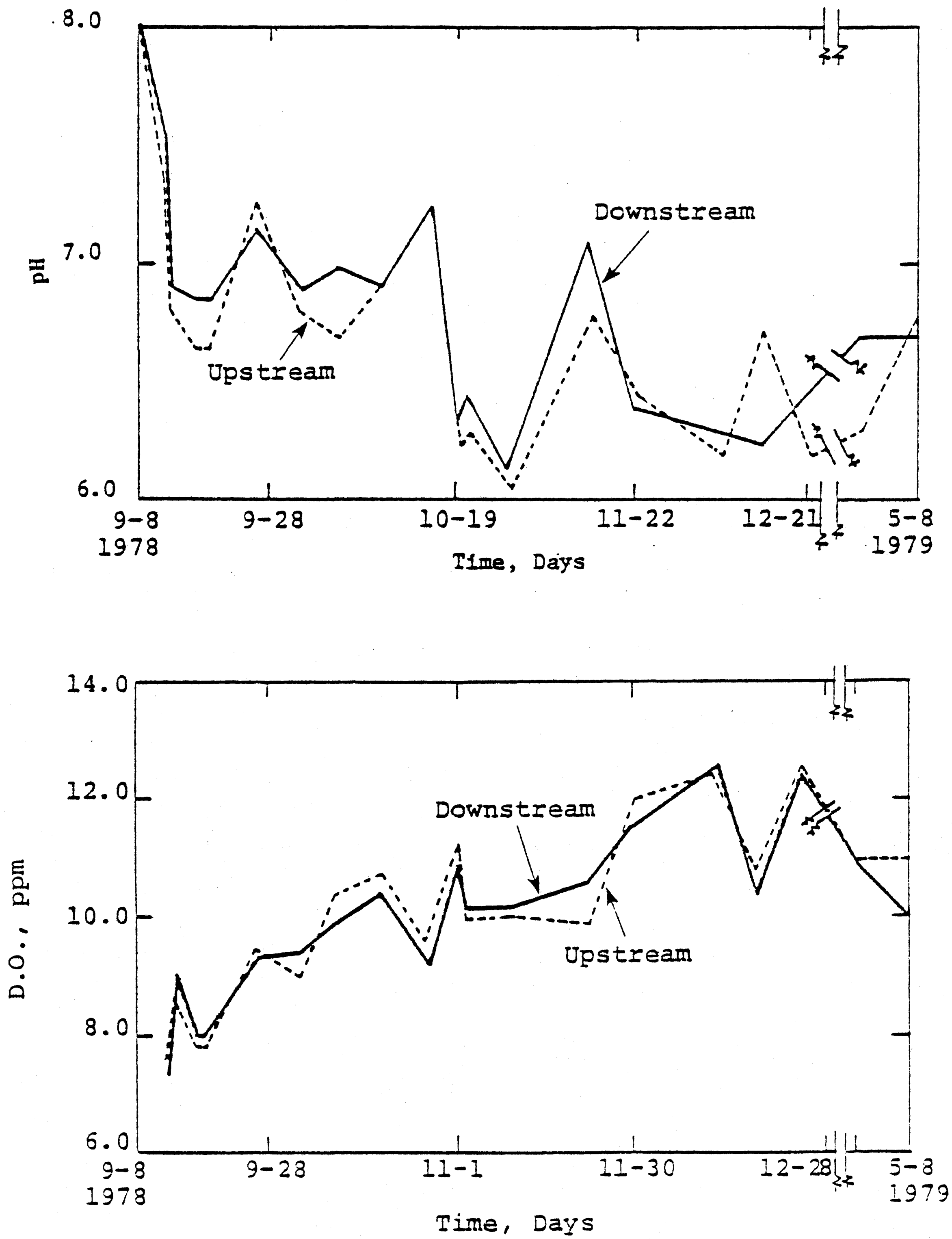


Figure A-1. pH (top) and dissolved oxygen data (bottom) for Buck Mt. Creek.

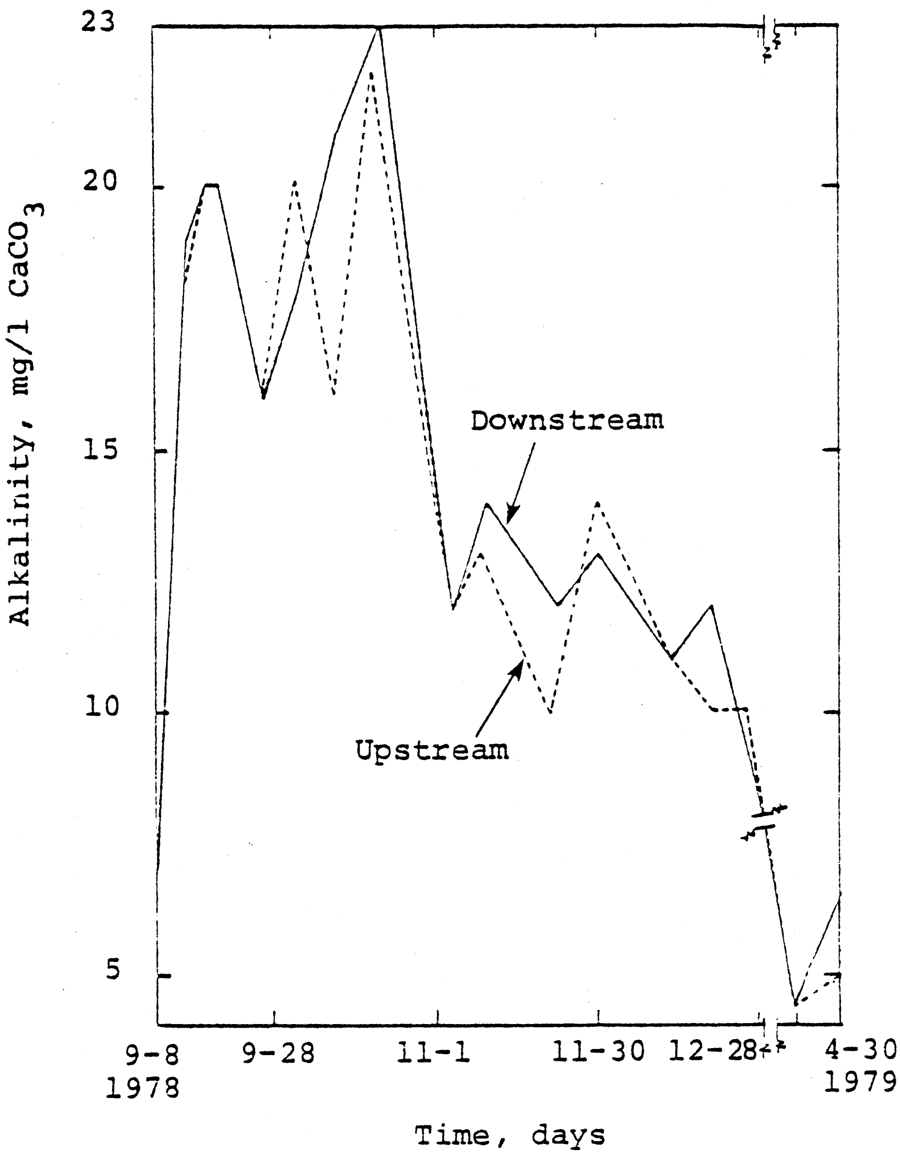


Figure A-2. Alkalinity for Buck Mt. Creek.

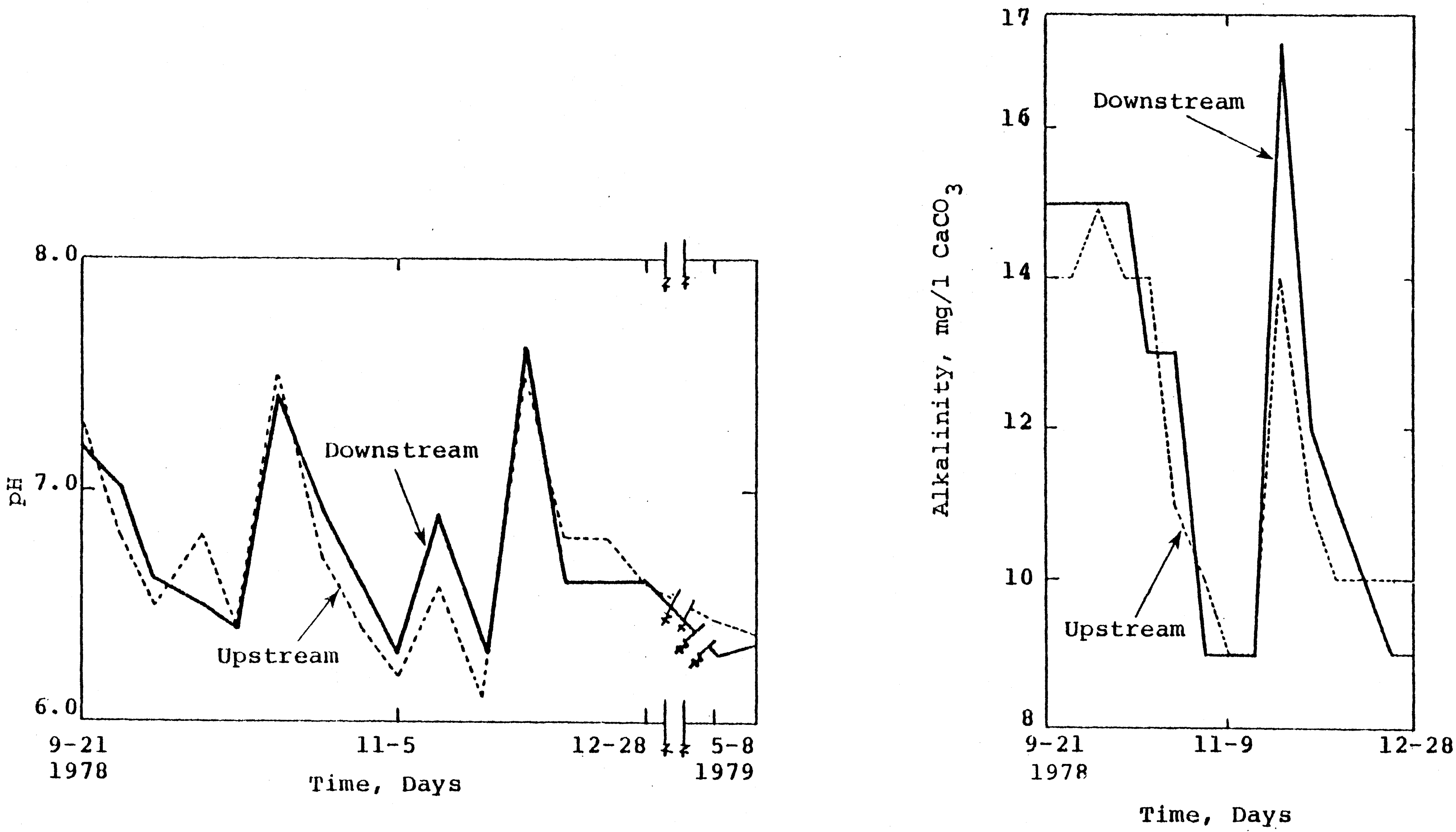


Figure A-3. pH (left) and alkalinity (right) for Buck Creek.

2339

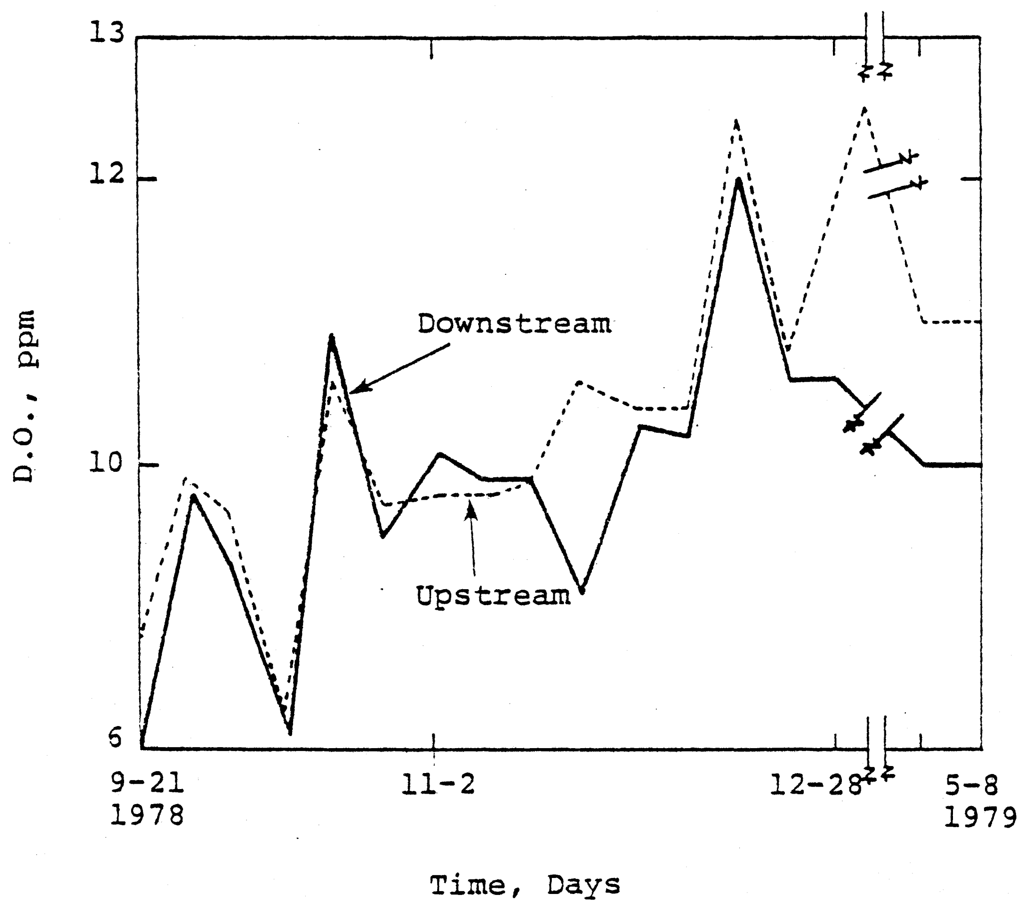
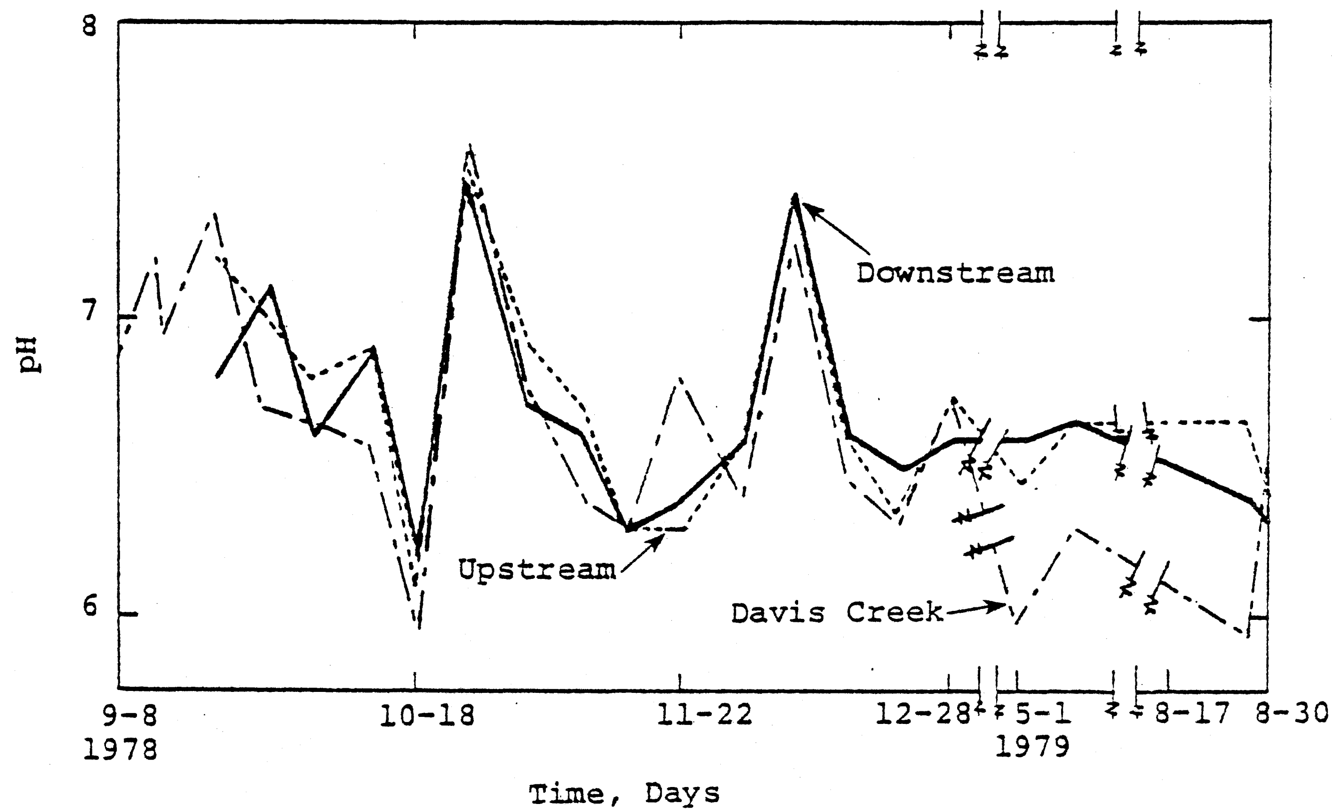


Figure A-4. Dissolved oxygen data for Buck Creek.



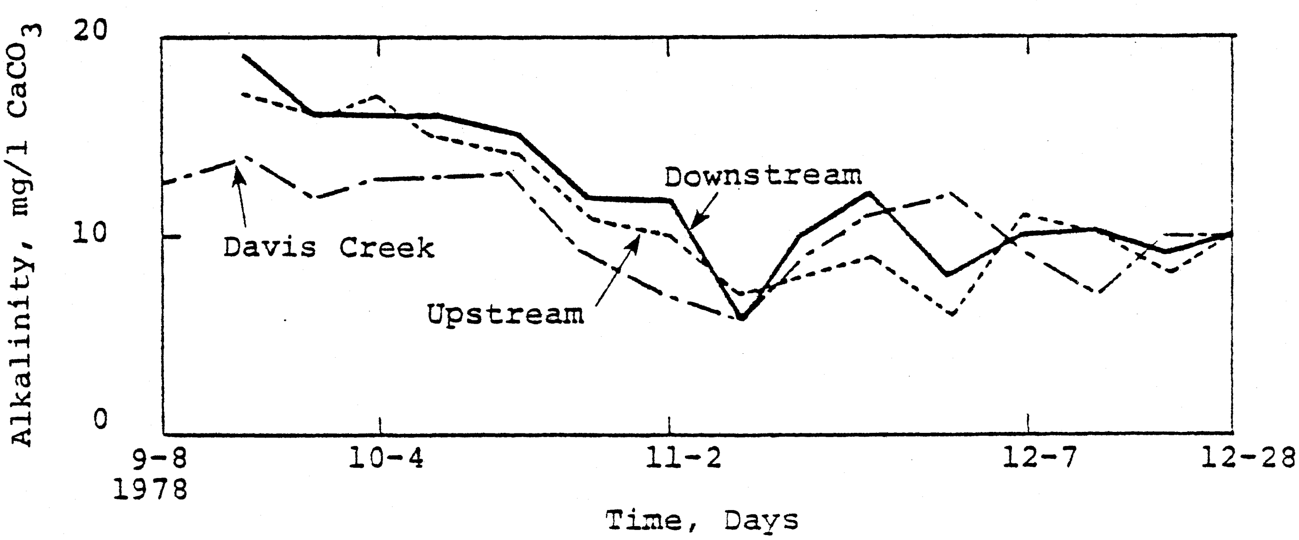


Figure A-5. pH (top) and alkalinity data (bottom) for Rockfish River and Davis Creek.

2342

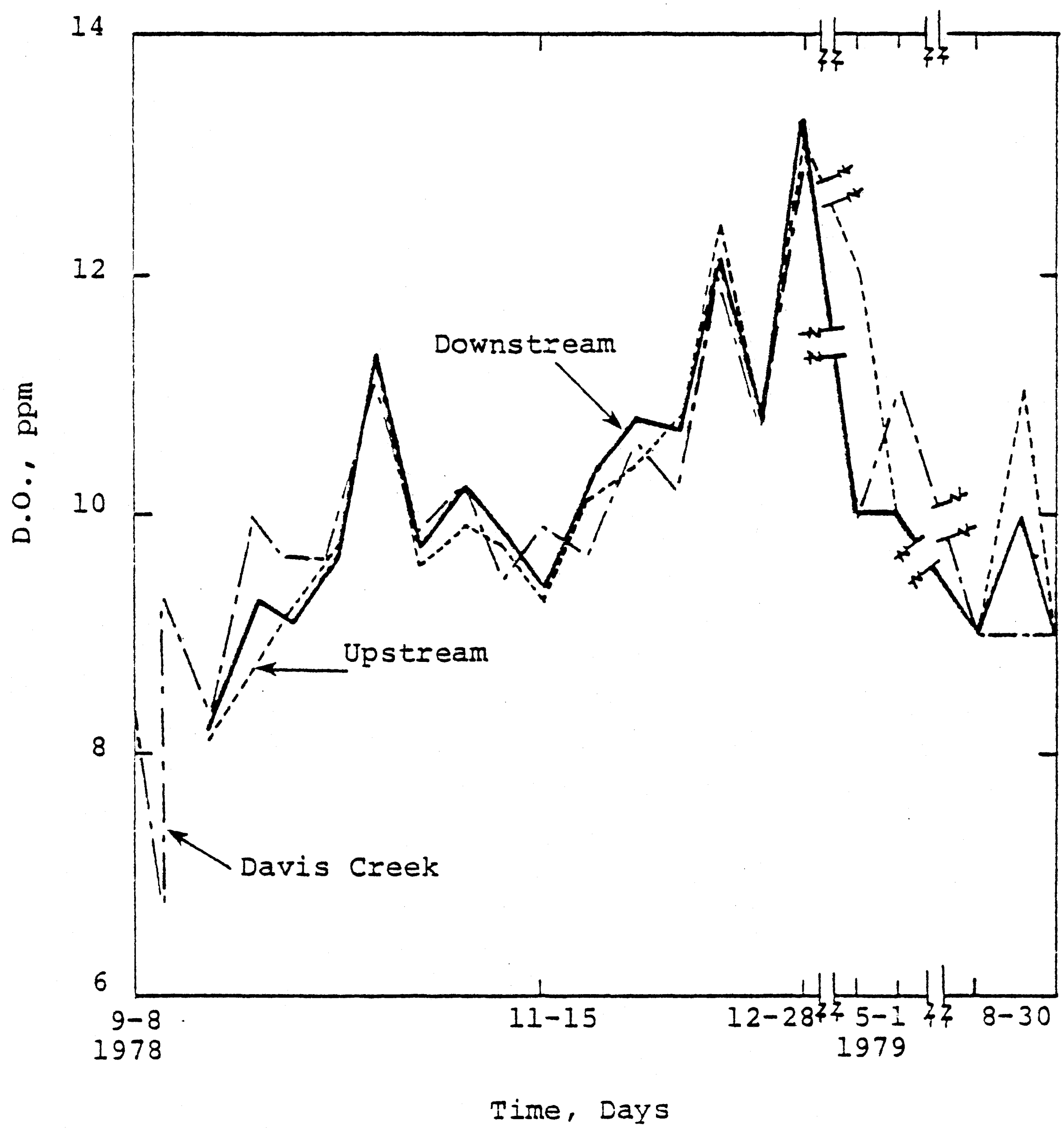


Figure A-6. Dissolved oxygen data for Rockfish River and Davis Creek.

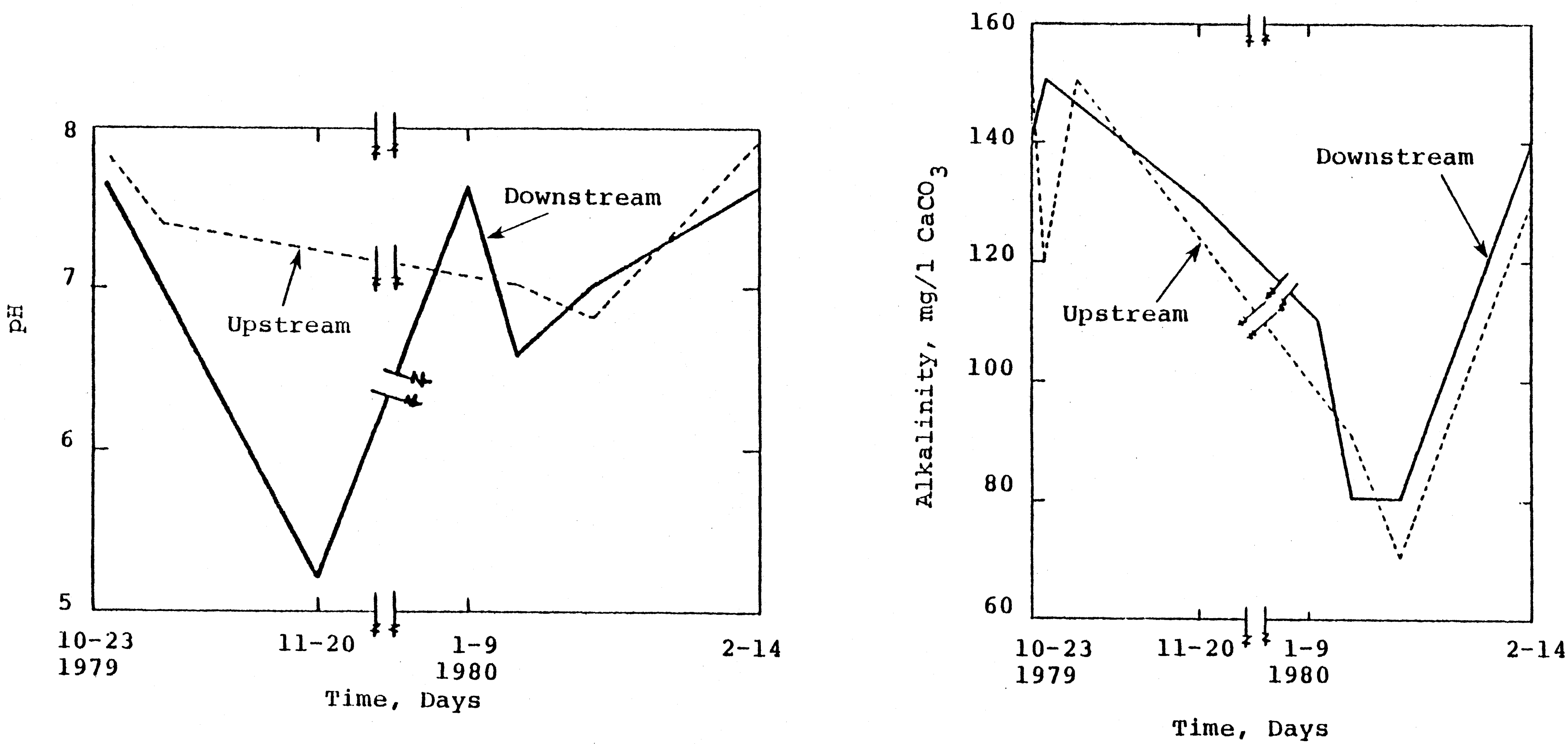


Figure A-7. pH (left) and alkalinity data (right) for Big Walker Creek.

2343

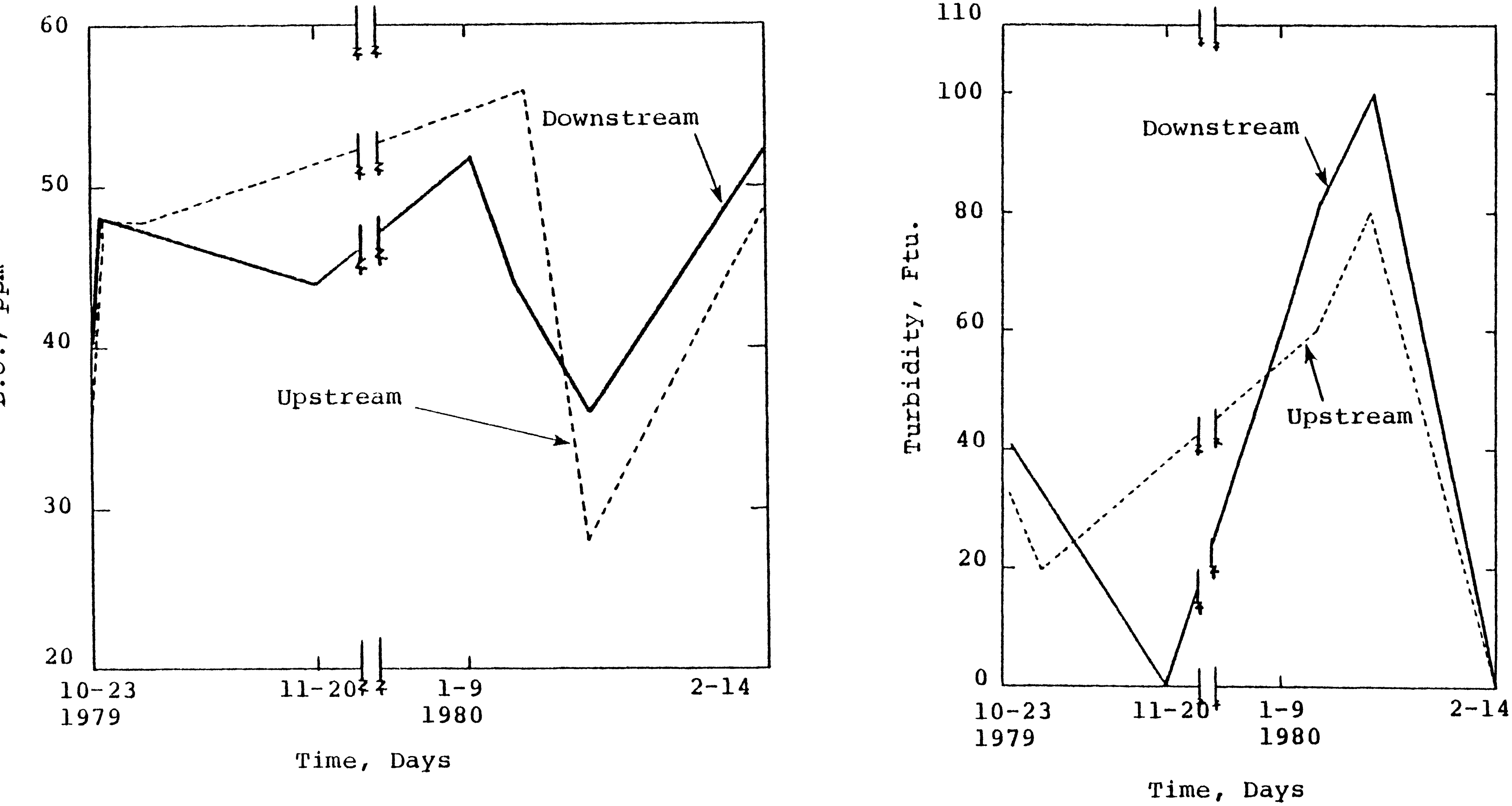


Figure A-8. Dissolved oxygen (left) and turbidity data (right) for Big Walker Creek.

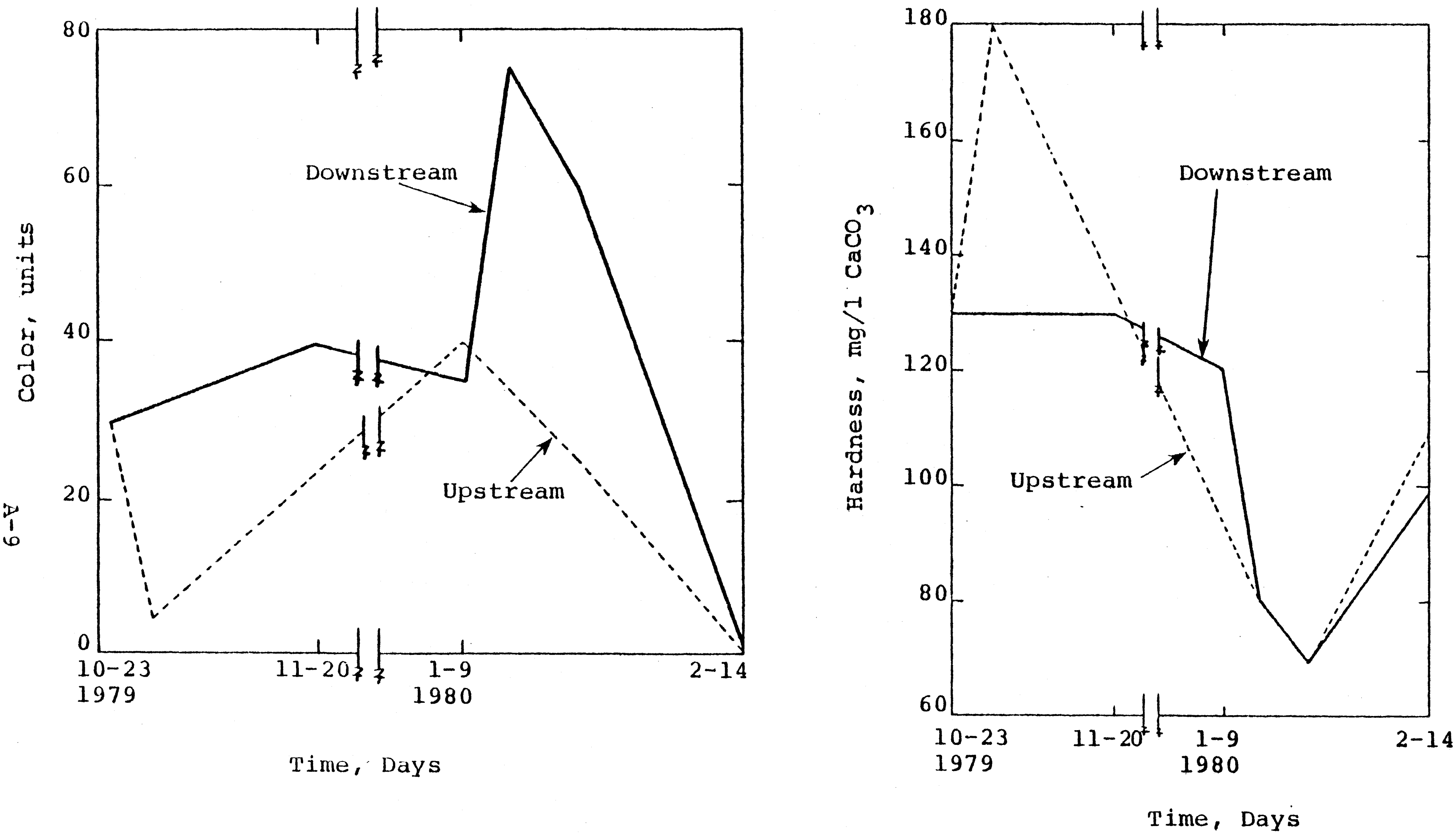


Figure A-9. Color (left) and hardness data (right) for Big Walker Creek.

2346

APPENDIX B

WATER QUALITY, FISH, AND BENTHIC DATA PROVIDED BY ENVIRONMENTAL QUALITY DIVISION

ROUTE 665

WATER QUALITY DATA

Buck Mountain Creek at 665

DATE PARAMETER	6-23-78	10-12-78	3-20-79	6-26-79	10-26-79
D.O	8	11	10	10	9
PH	7.0	7.6	6.8	7.4	7.0
TEMP H_2O (°C)	23	16	11	19	12
Air (°C)	24	27	17	22	20

Piney Creek Near 665

PARAMETER					
D.O	NO	9	10	9	9
PH	SAMPLE	7.0		6.6	6.8
TEMP H_2O (°C)	TAKEN	14	12	19	12
Air (°C)		24	17	22	19

2350

ROUTE: 665
FISH DATA
BUCK MOUNTAIN CREEK
PROJECT: 0665-002-167-501-716

DATE:	8-28-79	
STATION:	Up Stream	Down Stream
CHORDATA		
OSTEICHTHYES		
CYPRINIFORMES		
Catostomidae		
<u>Catostomus commersoni</u> (White Sucker)		10
<u>Hypentelium nigricans</u> (Northern Hogsucker)	3	
<u>Moxostoma rhotnoeca</u> (Torrent Sucker)	3	2
Cyprinidae		
<u>Hybopsis leptocephala</u> (Bluehead Chub)	12	1
<u>Notropis ardens</u> (Rosefin Shiner)	32	1
<u>Notropis cornutus</u> (Common Shiner)		2
<u>Rhinichthys cataractae</u> (Longnose Dace)		1
Ictaluridae		
<u>Ictalurus punctatus</u> (Channel Catfish)		9
<u>Noturus insignis</u> (Margined Madtom)	4	9
PERCIFORMES		
Centrarchidae		
<u>Ambloplites rupestris</u> (Rock Bass)	1	1
<u>Lepomis auritus</u> (Redbreasted Sunfish)		1
<u>Micropterus dolomieui</u> (Smallmouth Bass)	1	
<u>Micropterus salmoides</u> (Largemouth Bass)	1	
Percidae		
<u>Etheostoma flabellare</u> (Fantail Darter)	7	21
TOTAL SPECIES	9	11
TOTAL INDIVIDUALS	64	58

ROUTE: 665
FISH DATA
PINEY CREEK
PROJECT: 0665-002-167-501-716

DATE:	8-25-78
STATION:	Control
CHORDATA	
OSTEICHTHYES	
CYPRINFORMES	
Catostomidae	
Moxostoma rhothoeca (Torrent Sucker)	7
Cyprinidae	
Hybopsis leptocephala (Bluehead Chub)	31
Notropis ardens (Rosefin Shiner)	51
Notropis cornutus (Common Shiner)	32
Rhinichthys atratulus (Blacknose Dace)	6
Semotilus atromaculus (Creek Chub)	7
Ictaluridae	
Noturus insignis (Margined Madtom)	2
PERCIFORMES	
Centrarchidae	
Ambloplites rupestris (Rock Bass)	3
Micropterus dolomieui (Smallmouth Bass)	3
Percidae	
Etheostoma flabellare (Fantail Darter)	5
TOTAL SPECIES	10
TOTAL INDIVIDUALS	147

ROUTE 665

BENTHIC DATA SUMMARY

BUCK MOUNTAIN CREEK (UPSTREAM)

Date:	6-23-78	10-12-78	3-20-79	6-26-79	10-26-79
No. of Organisms	1407	1588	849	986	408
No. of Taxa	30	25	22	16	19
Family Diversity	0.82	0.75	0.83	0.83	0.87
No. of Families With Greatest Abundance	3	2	3	2	4

BUCK MOUNTAIN CREEK (DOWNSTREAM)

No. of Organisms	2617	4799	315	180	100
No. of Taxa	28	27	20	12	15
Family Diversity	0.78	0.74	0.76	0.81	0.84
No. of Families With Greatest Abundance	3	3	4	2	4

PINEY CREEK (CONTROL)

No. of Organisms	290	1669	206	612	395
No. of Taxa	18	25	19	18	24
Family Diversity	0.82	0.70	0.76	0.73	0.85
No. of Families With Greatest Abundance	3	2	2	2	3

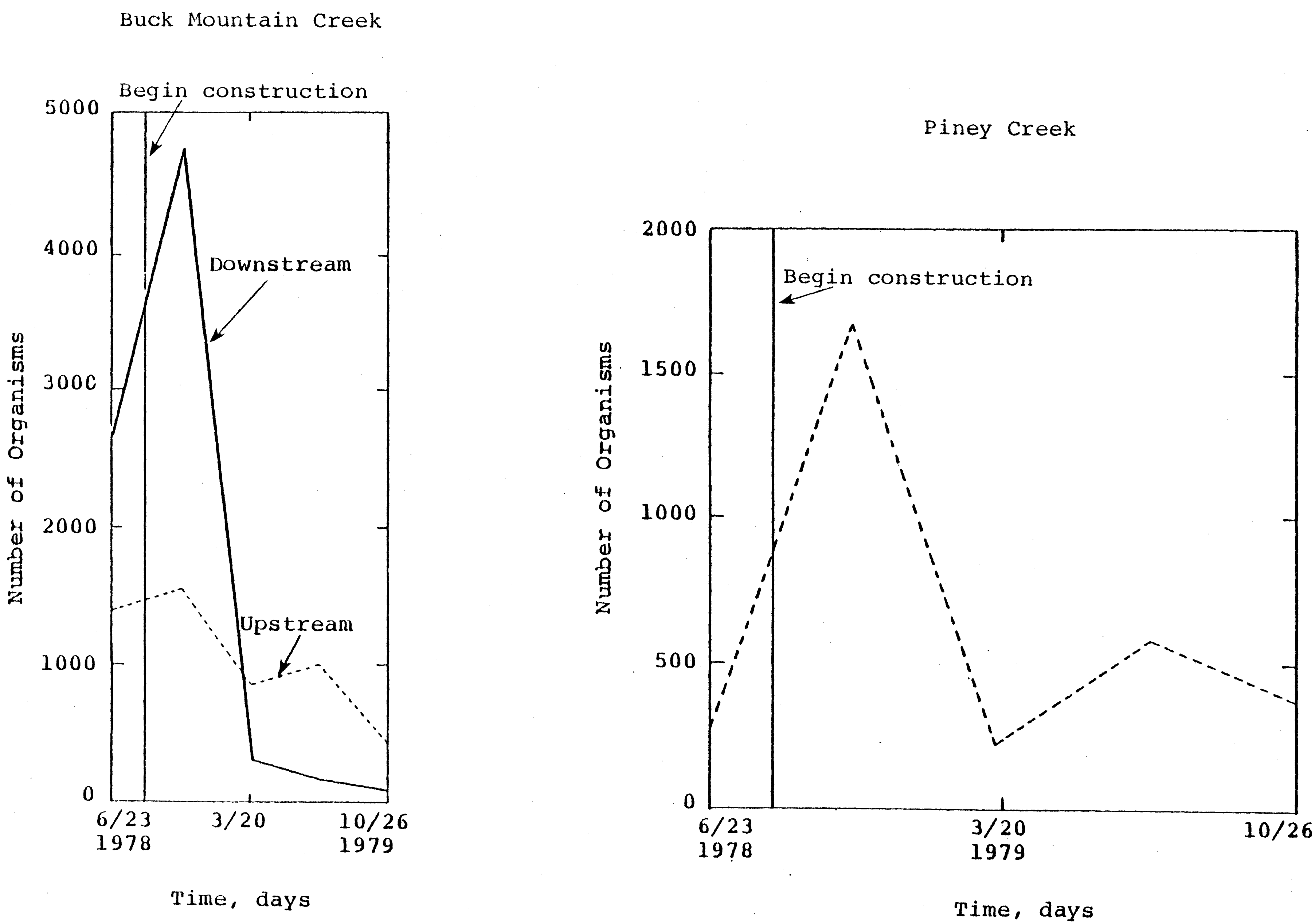
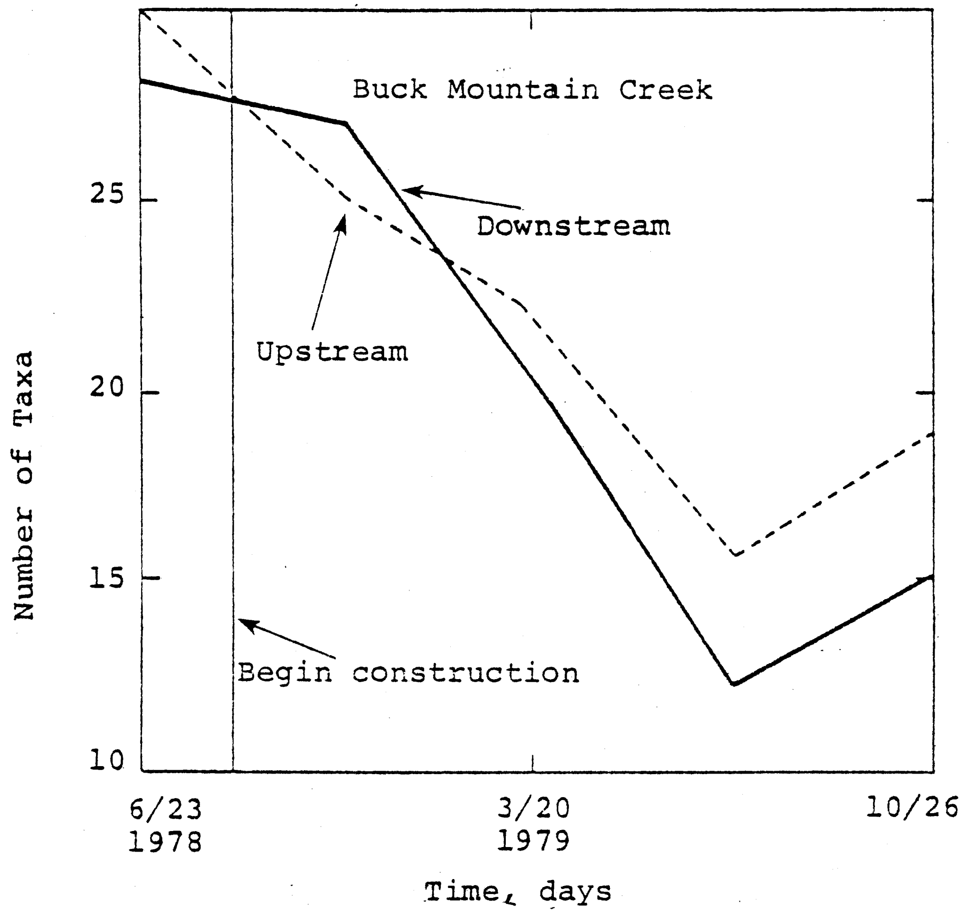


Figure B-5. Number of organisms for Buck Mountain and Piney Creek.

2352



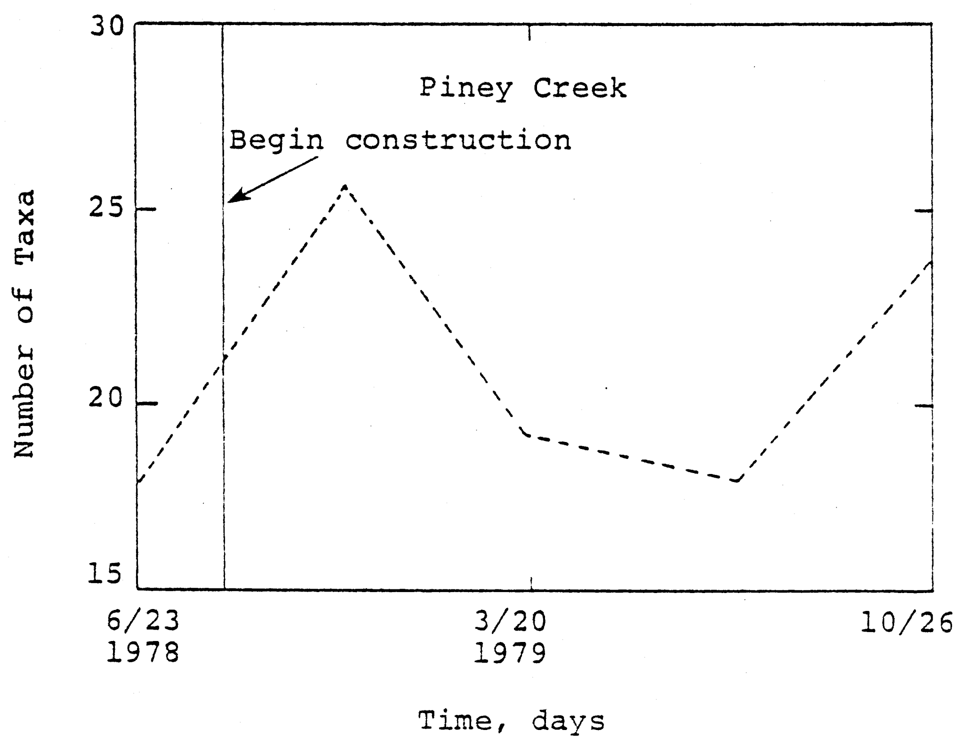
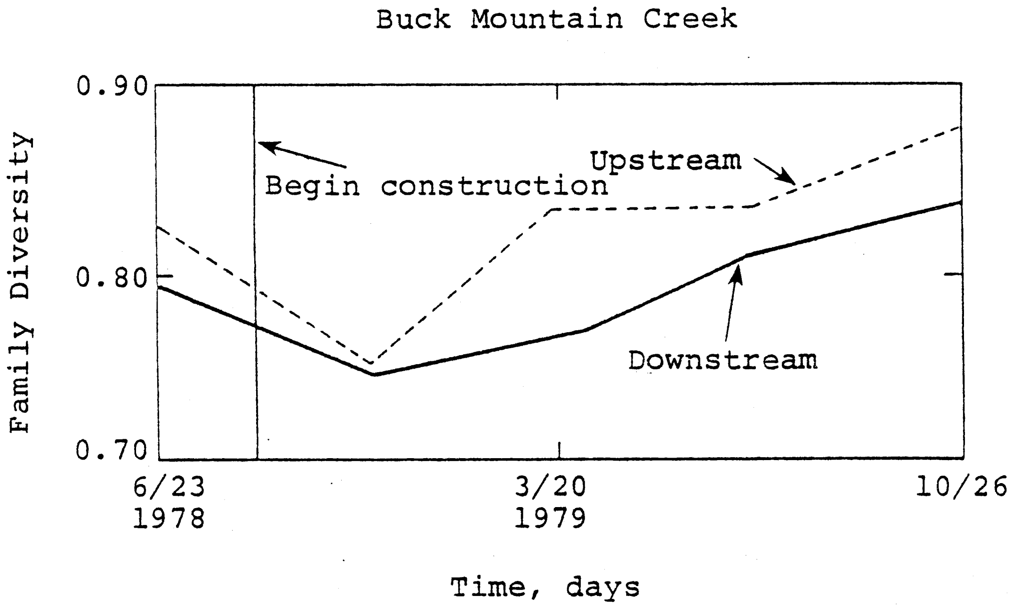


Figure B-6. Number of taxa for Buck Mountain and Piney Creek.



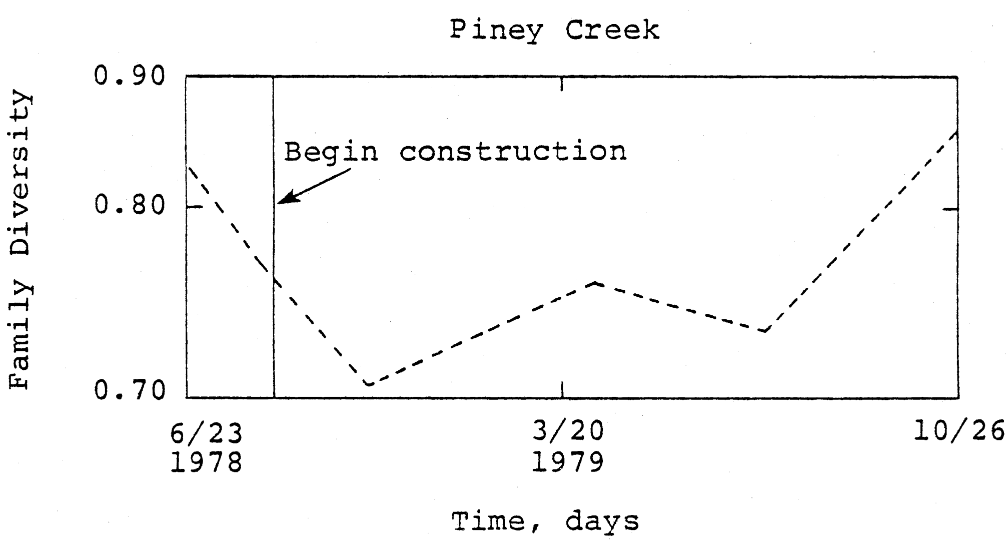


Figure B-7. Family diversity for Buck Mountain and Piney Creek.

ROUTE 29

WATER QUALITY DATA

Buck Creek at Route 29

DATE	6-23-78	10-12-78	3-30-79	6-26-79	10-26-79
PARAMETER					
D.O	9	11	10	10	11
PH	7.4	7.3	7.4	7.4	6.0
TEMP H_2O (°C)	17	10	8	19	12
Air (°C)	24	16	16	22	12

ROUTE 29
FISH DATA
BUCK CREEK
PROJECT 0029-062-104-103-616

DATE:	8-28-78		11-20-79	
STATION:	Up Stream	Down Stream	Up Stream	Down Stream
CHORDATA				
OSTEICHTHYES				
CYPRINFORMES				
Catostomidae				
<u>Catostomus commersoni</u> (White Sucker)	10			
<u>Moxostoma rhothoeca</u> (Torrent Sucker)	142		31	90
Cyprinidae				
<u>Campostoma anomalum</u> (Stoneroller)	51	42	53	82
<u>Chrosomus oreas</u> (Mt. Redbelly Dace)	2	3	33	17
<u>Clinostomus elongata</u> (Redside Dace)	22		2	
<u>Hybopsis leptocephala</u> (Bluehead Chub)	42	30	40	50
<u>Notropis cornutus</u> (Common Shiner)	47	41	35	23
<u>Rhinichthys atratulus</u> (Blacknose Dace)	38	40	37	13
<u>Rhinichthys cataractae</u> (Longnose Dace)	2			
<u>Semotilus atromaculus</u> (Creek Chub)	9			
PERCIFORMES				
Centrarchidae				
<u>Lepomis auritus</u> (Redbreasted Sunfish)	1			
<u>Micropterus dolomieui</u> (Smallmouth Bass)		2		2
Percidae				
<u>Etheostoma flabellare</u> (Fantail Darter)	41	10	27	13
<u>Etheostoma nigrum</u> (Johnny Darter)		1		
<u>Etheostoma olmstedi</u> (tessalated Darter)	1			
TOTAL SPECIES	13	9	8	8
TOTAL INDIVIDUALS	408	211	266	290

ROUTE 29

BENTHIC DATA SUMMARY

BUCK CREEK (DOWNSTREAM)

Date:	6-23-78	10-12-78	3-20-79	6-26-79	10-26-79
No. of Organisms	1772	1082	282	3264	189
No. of Taxa	17	20	17	31	13
Family Diversity	0.72	0.71	0.71	0.81	0.85
No. of Families With Greatest Abundance	2	2	2	3	3

BUCK CREEK (UPSTREAM)

No. of Organisms	1146	1655	346	102	903
No. of Taxa	19	21	17	11	29
Family Diversity	0.87	0.69	0.72	0.79	0.85
No. of Families With Greatest Abundance	3	2	1	3	3

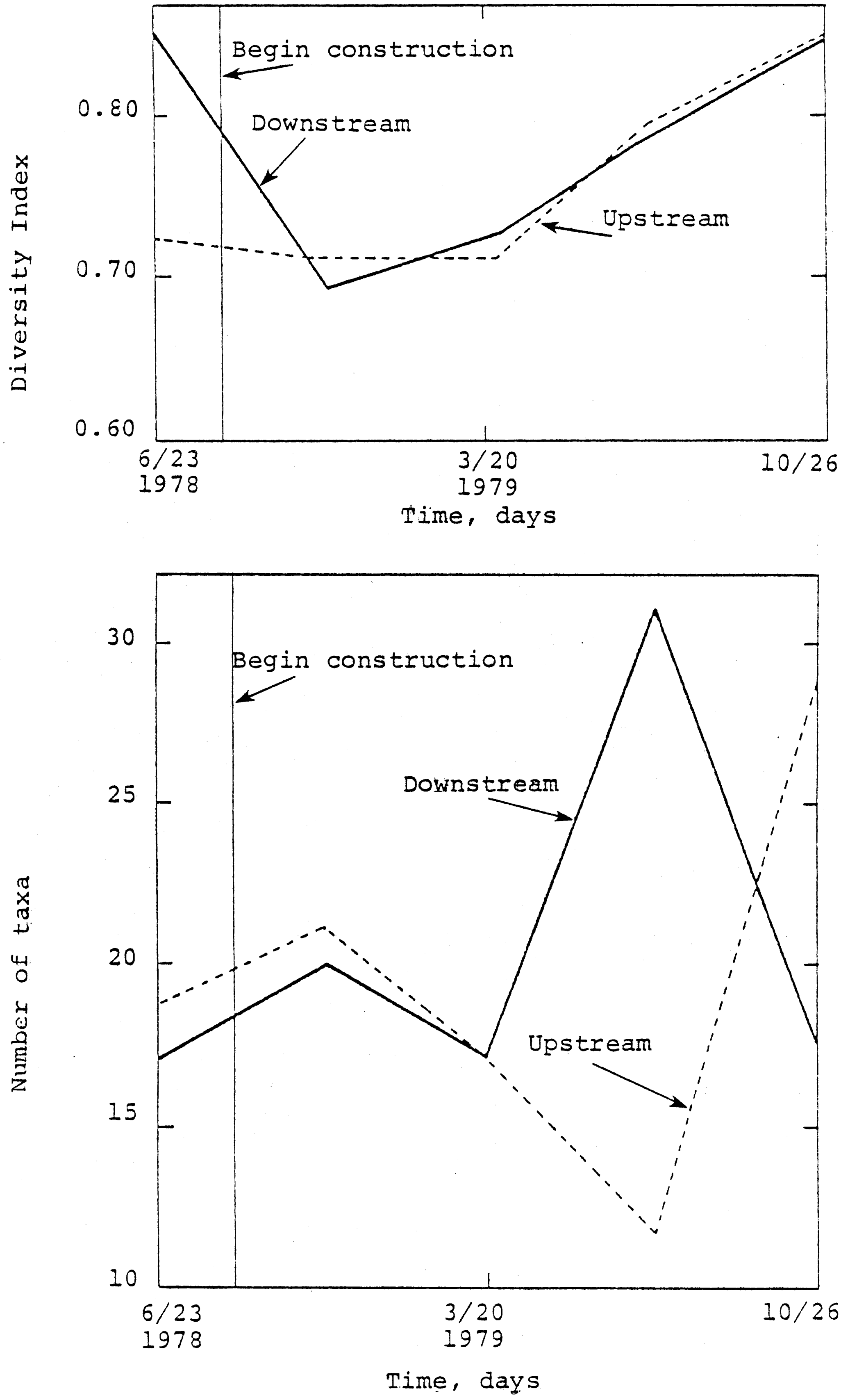


Figure B-11. Diversity index (top) and number of taxa (bottom) for Buck Creek.

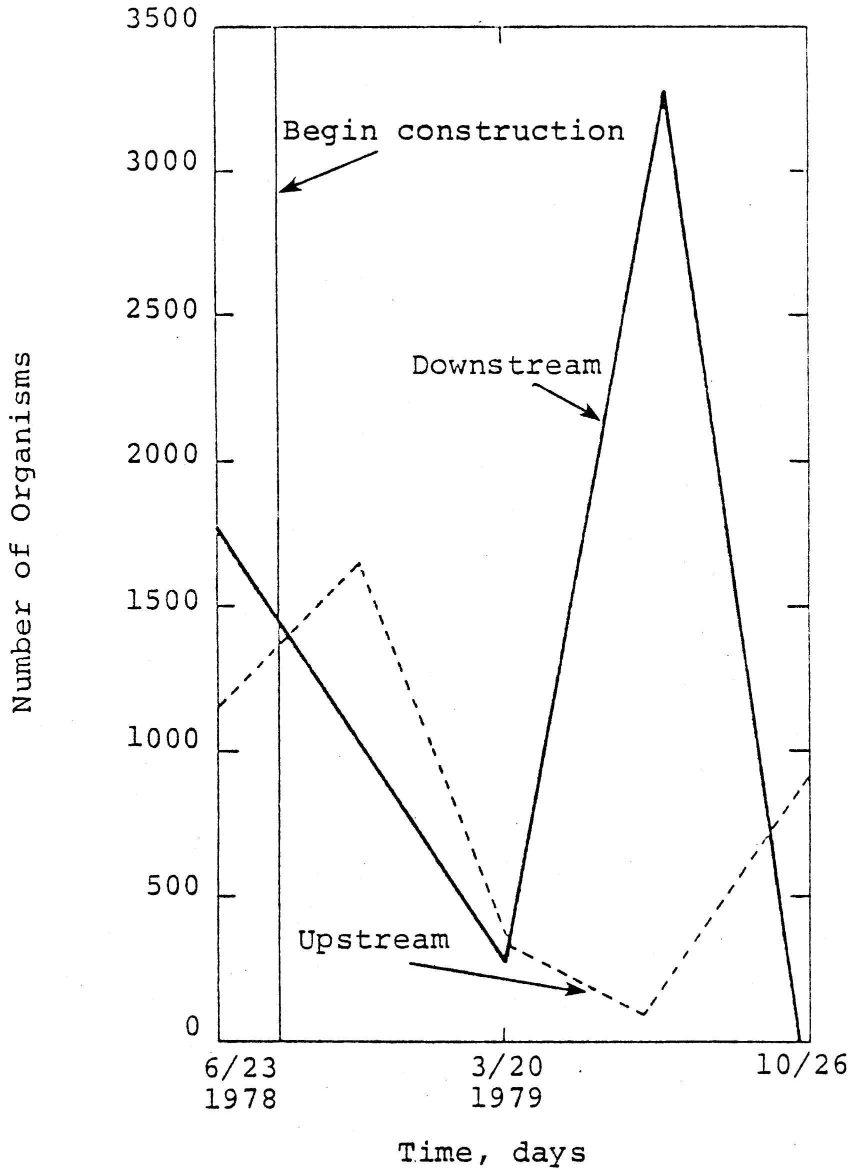


Figure B-12. Number of organisms for Buck Creek.

ROUTE 29

WATER QUALITY DATA

Rockfish River at Route 29

DATE PARAMETER	6-23-78	10-12-78	3-30-79	6-26-79	10-26-79
D.O	8	10	11	9	7
PH	7.1	7.4	7.5	7.2	6.4
TEMP H_2O (°C)	22	15	9	17	16
Air (°C)	30	21	15	21	18

Davis Creek at Route 29

PARAMETER					
D.O	8	9	10	10	11
PH	7.1	7.4	7.4	7.2	7.2
TEMP H_2O (°C)	27	17	12	12	8
Air (°C)	29	25	18	22	10

ROUTE: 29
FISH DATA
ROCKFISH RIVER
PROJECT: 0029-062-104-103-616

DATE:	8-28-78	
STATION:	Up Stream	Down Stream
CHORDATA		
OSTEICHTHYES		
CYPRINFORMES		
Catostomidae		
Hypentelium nigricans (Northern Hogsucker)	2	5
Cyprinidae		
Campostoma anomalum (Stoneroller)	1	
Hybopsis leptocephala (Bluehead Chub)	19	2
Notropis ardens (Rosefin Shiner)		2
Notropis cornutus (Common Shiner)	4	1
Notropis procne (Swallowtail Shiner)	3	
Rhyinichthys cataractae (Longnose Dace)	1	1
Ictaluridae		
Noturus gyrinus (Tadpole Madtom)	6	2
PERCIFORMES		
Centrarchidae		
Lepomis auritus (Redbreasted Sunfish)	2	
Lepomis gibbosus (Pumpkinseed)	1	
Micropterus dolomieui (Smallmouth Bass)	5	7
Percidae		
Etheostoma flabellare (Fantail Darter)	3	
TOTAL SPECIES	11	7
TOTAL INDIVIDUALS	47	20

ROUTE: 29
FISH DATA
DAVIS CREEK
PROJECT: 0029-062-104-103-616

DATE:	8-28-78
STATION:	Control
CHORDATA	
OSTEICHTHYES	
CYPRINFORMES	
Catostomidae	
Moxostoma rhothoeca (Torrent Sucker)	13
Cyprinidae	
Campostoma anomalum (Stoneroller)	63
Hybopsis leptocephala (Bluehead Chub)	7
Notropis cornutus (Common Shiner)	9
Rhinichthys atratulus (Blacknose Dace)	5
Ictaluridae	
Noturus gyrinus (Tadpole Madtom)	2
PERCIFORMES	
Centrarchidae	
Lepomis auritus (Redbreasted Sunfish)	9
Percidae	
Etheostoma olmstedi (Tessalated Darter)	4
TOTAL SPECIES	8
TOTAL INDIVIDUALS	112

2364

ROUTE 29

BENTHIC DATA SUMMARY

ROCKFISH RIVER (DOWNSTREAM)

Date:	6-23-78	10-12-78	3-20-79	6-26-79	10-26-79
No. of Organisms	4119	1184	343	7994	693
No. of Taxa	19	23	14	25	23
Family Diversity	0.87	0.61	0.72	0.70	0.81
No. of Families With Greatest Abundance	3	1	2	2	2

ROCKFISH RIVER (UPSTREAM)

No. of Organisms	3741	967	787	3059	1121
No. of Taxa	28	24	20	25	21
Family Diversity	0.87	0.71	0.67	0.80	0.85
No. of Families With Greatest Abundance	4	2	2	3	2

DAVIS CREEK (CONTROL)

No. of Organisms	1642	1717	899	1026	751
No. of Taxa	14	21	16	18	21
Family Diversity	0.64	0.65	0.16*	0.76	0.71
No. of Families With Greatest Abundance	1	2	1	2	2

*Order Ephemerellidae of the Family Ephemeroptera represents 91% of the sample.

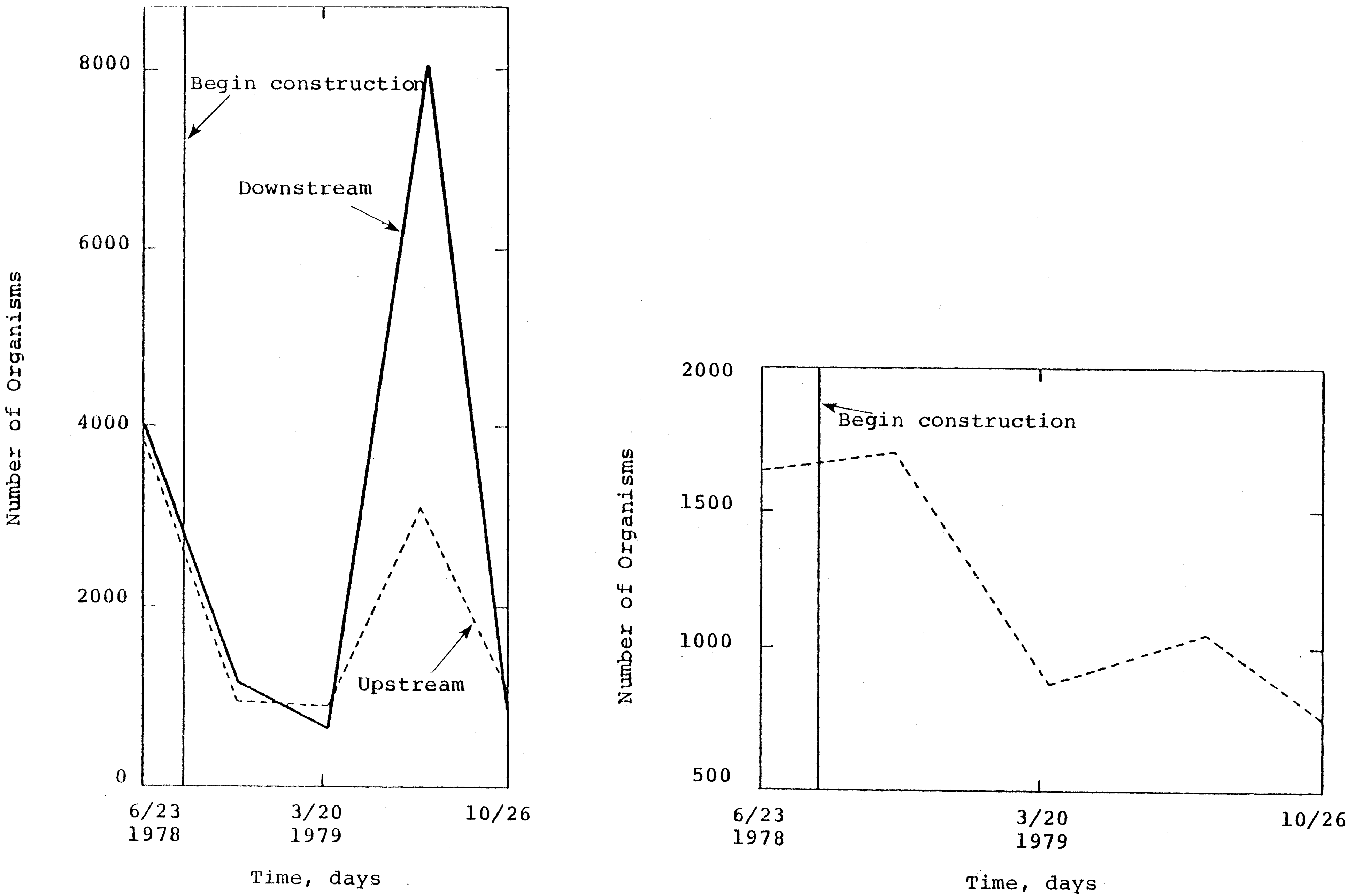


Figure B-17. Number of organisms for Rockfish River (left) and Davis Creek (right).

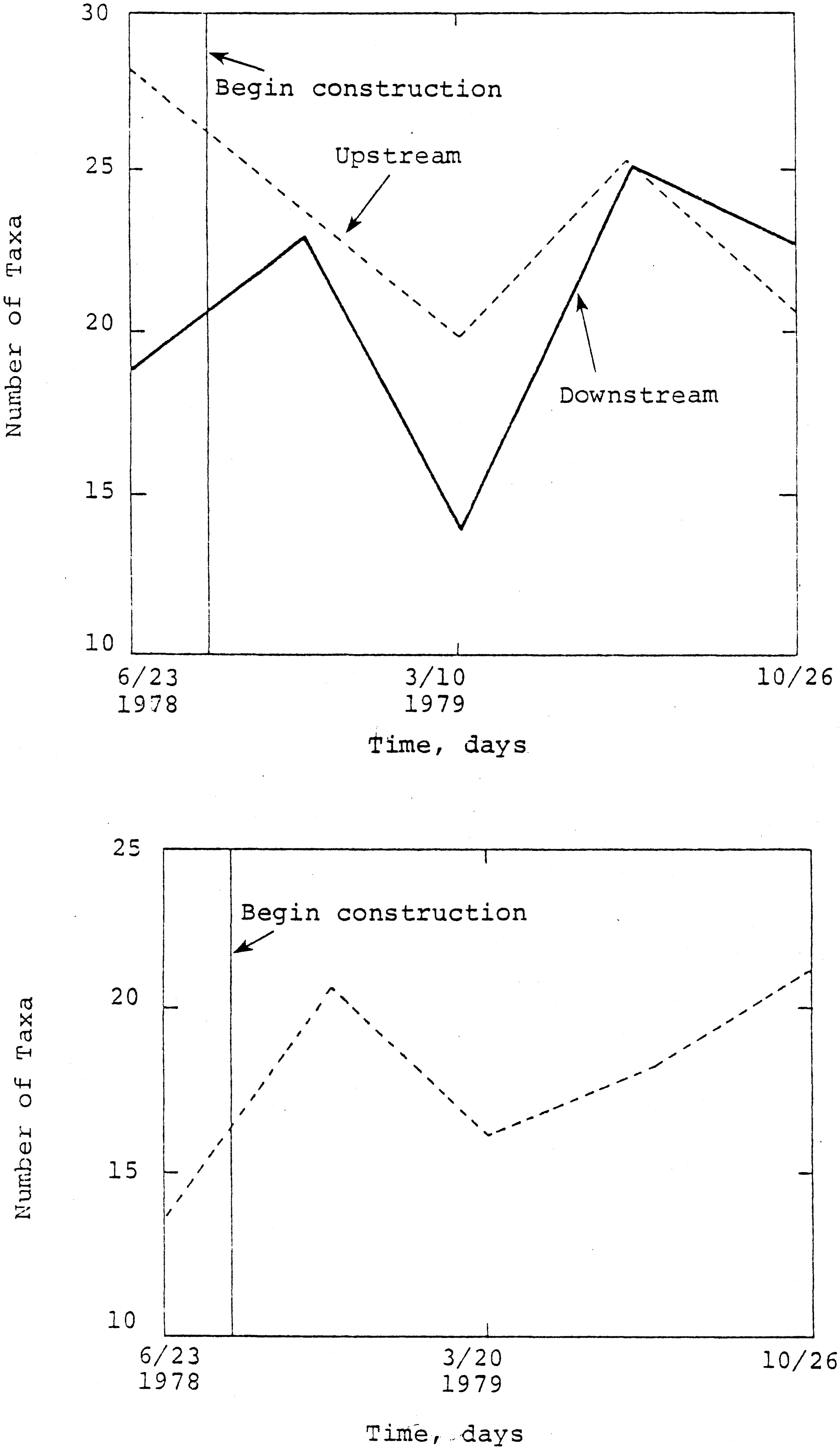


Figure B-18. Number of taxa for Rockfish River (top) and Davis Creek (bottom).

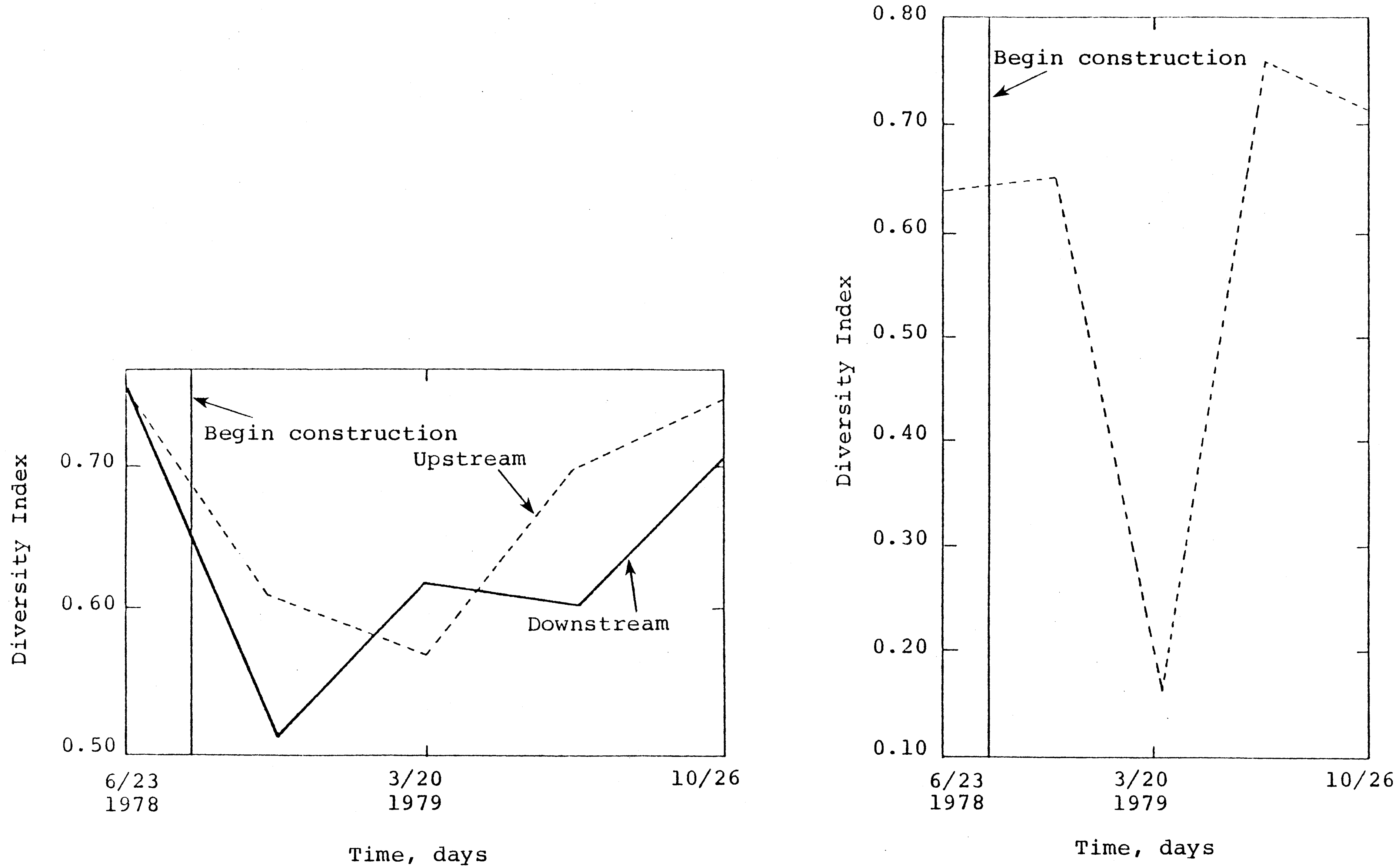


Figure B-19. Diversity index for Rockfish River (left) and Davis Creek (right).

ROUTE 667

BENTHIC DATA

BIG WALKER CREEK

Project 0667-035-135, C501, 716

DATE: November 19, 1979

STATION:	Upstream	Downstream
ARTHROPODA		
INSECTA		
Coleoptera		
Elmidae	458	1671
Psephenidae	75	129
Dryopidae	6	23
Hydrophilidae		2
Diptera		
Simuliidae	53	18
Tipulidae	12	31
Chironomidae	116	74
Stratiomyidae	1	1
Rhagionidae	59	87
Tabanidae	2	4
Anthomyiidae	1	
Ephemeroptera		
Heptageniidae	651	1776
Leptophlebiidae	40	130
Siphlonuridae	176	335
Ephemeridae	2	31
Caenidae		11
Baetidae	18	21
Ephemerellidae*	828	942
Lepidoptera		
Pyralidae		2
Megaloptera		
Corydalidae	9	72
Sialidae	1	9

STATION:	Upstream	Downstream
Odonata		
Gomphidae	1	15
Aeshnidae	7	5
Cordulegastridae		2
Coenagrionidae*		21
Plecoptera		
Perlidae	94	74
Capniidae	222	301
Taeniopterygidae	387	238
Trichoptera		
Glossosomatidae		4
Philopotamidae	11	8
Polycentropodidae	8	16
Limnephilidae	9	127
Lepidostomatidae	16	27
Hydroptilidae	1	1
Helicopsychidae		27
Molannidae	73	75
Phryganeidae		1
Brachycentridae	9	
Hydropsychidae	206	302
CRUSTACEA		
Decapoda		
Astacidae	1	2
Amphipoda		
Gammaridae		30
ARACHNOIDEA		
HYDRACARINA		
Hydrachnellae	1	14
MOLLUSCA		
GASTROPODA		
Mesogastropoda		
Viviparidae	138	247
Planorbidae		1
Physidae	2	17
PELECYPODA		
Heterodonta		
Spaeridae	32	218
ANNELIDAE		
OLIGOCHAETA	4	93
HIRUDINEA	1	2
TOTAL FAMILIES:	38	46
TOTAL INDIVIDUALS:	3731	7237
DIVERSITY INDEX:	0.86	0.85

*(Merrit & Cummings)

APPENDIX C

STAGE-DISCHARGE CURVE AND SUSPENDED SOLIDS, FLOW, AND RAINFALL DATA

2372

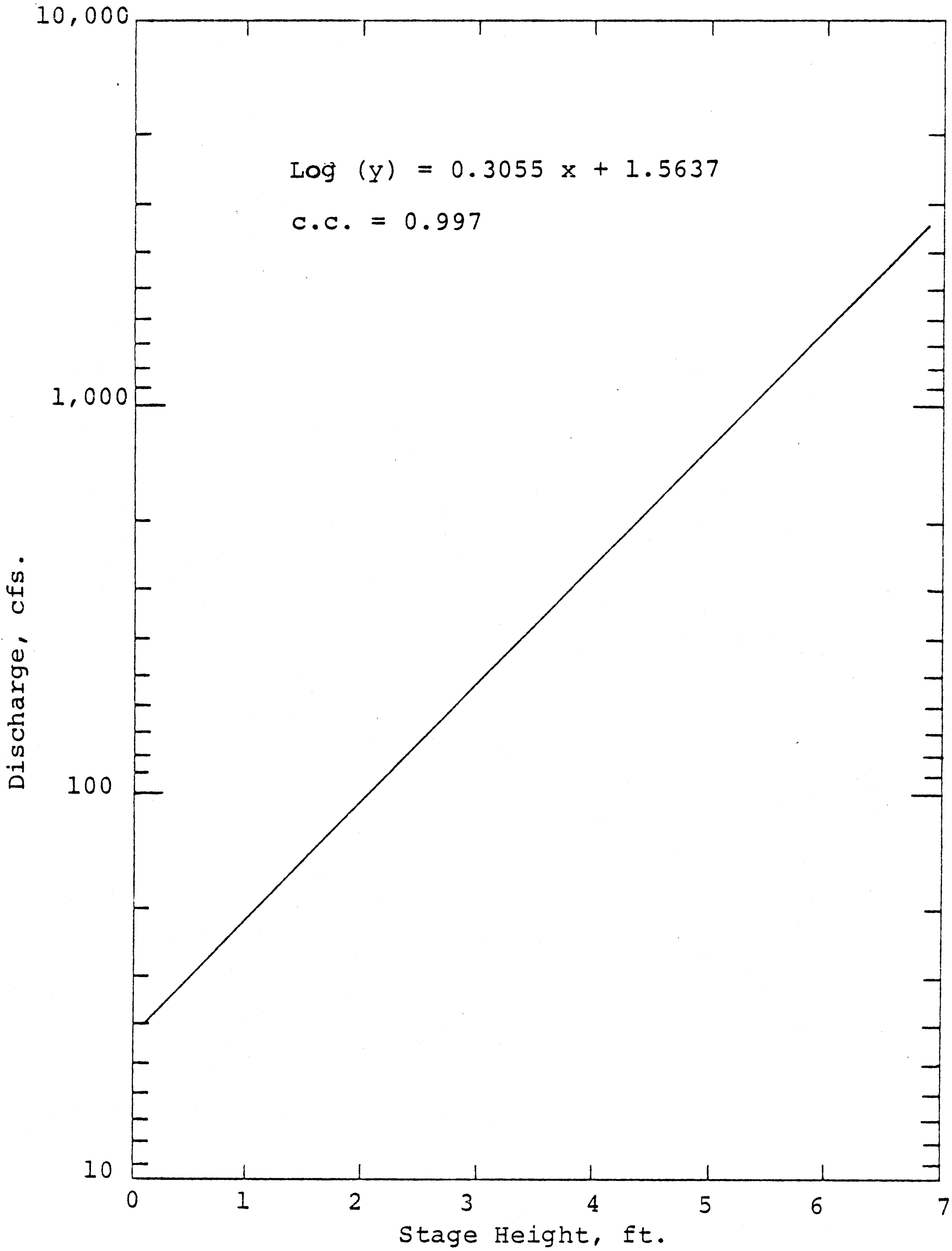


Figure C-1. Stage discharge curve for Buck Mountain Creek.

2374

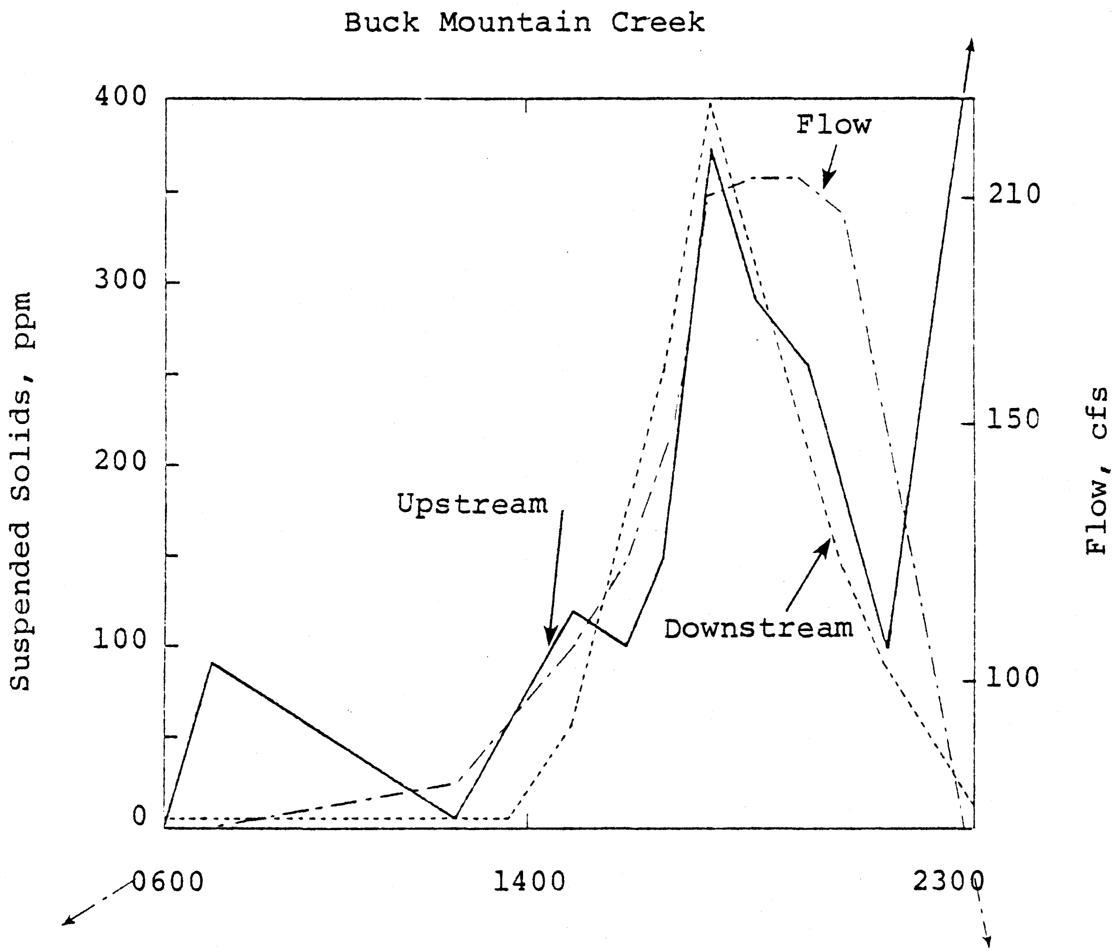
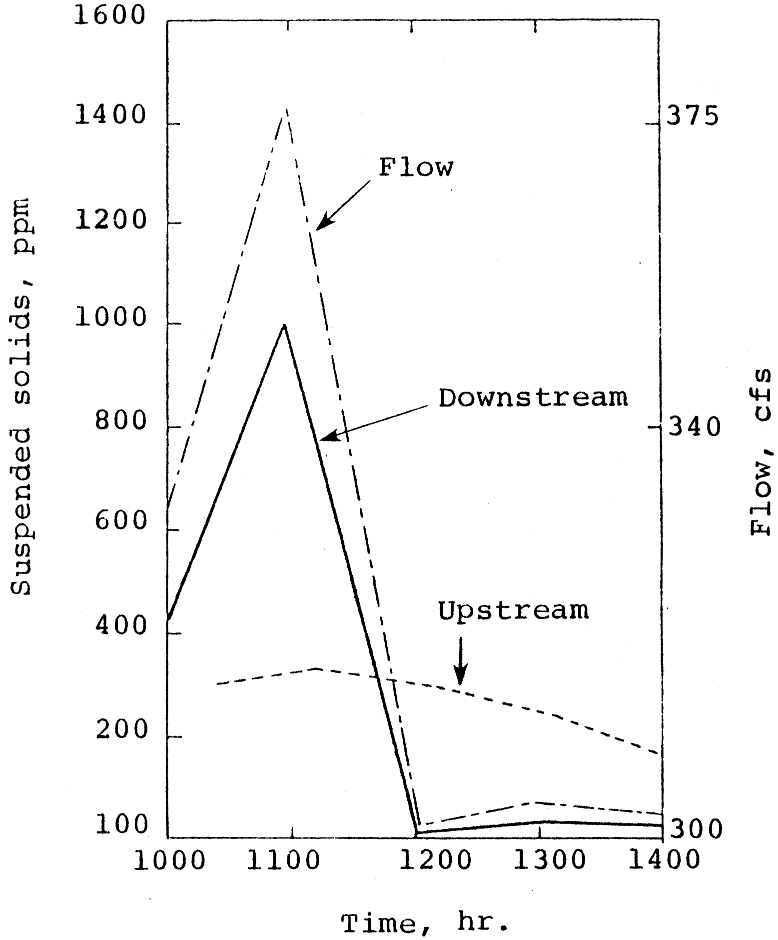


Figure C-2. Suspended solids and flow curves for December 9, 1978 storm event (total rainfall = 1.12 in.).

Buck Mountain Creek



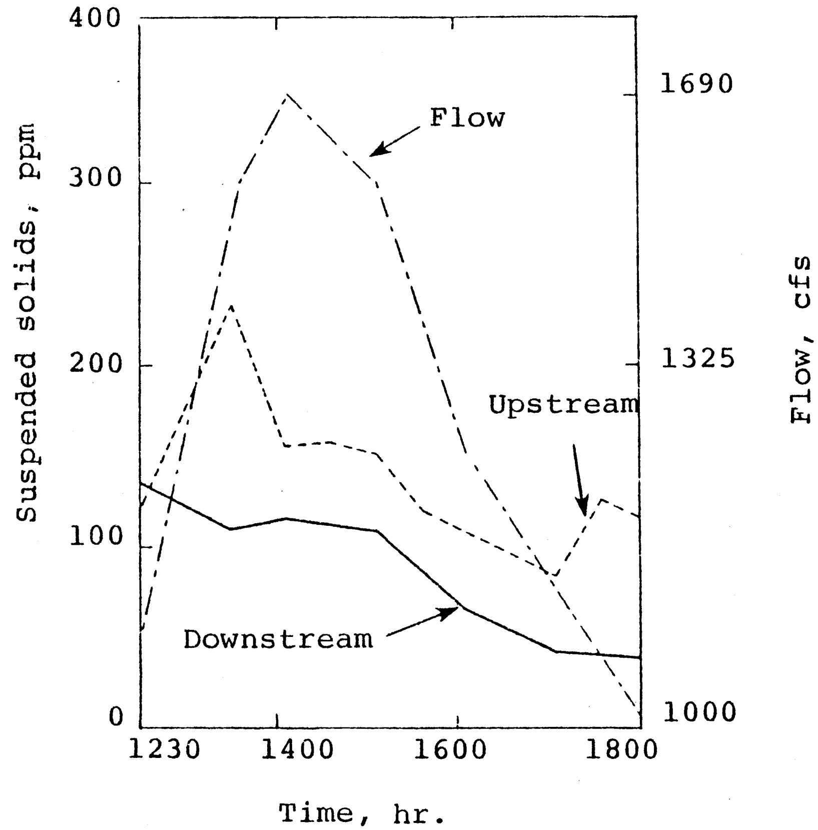
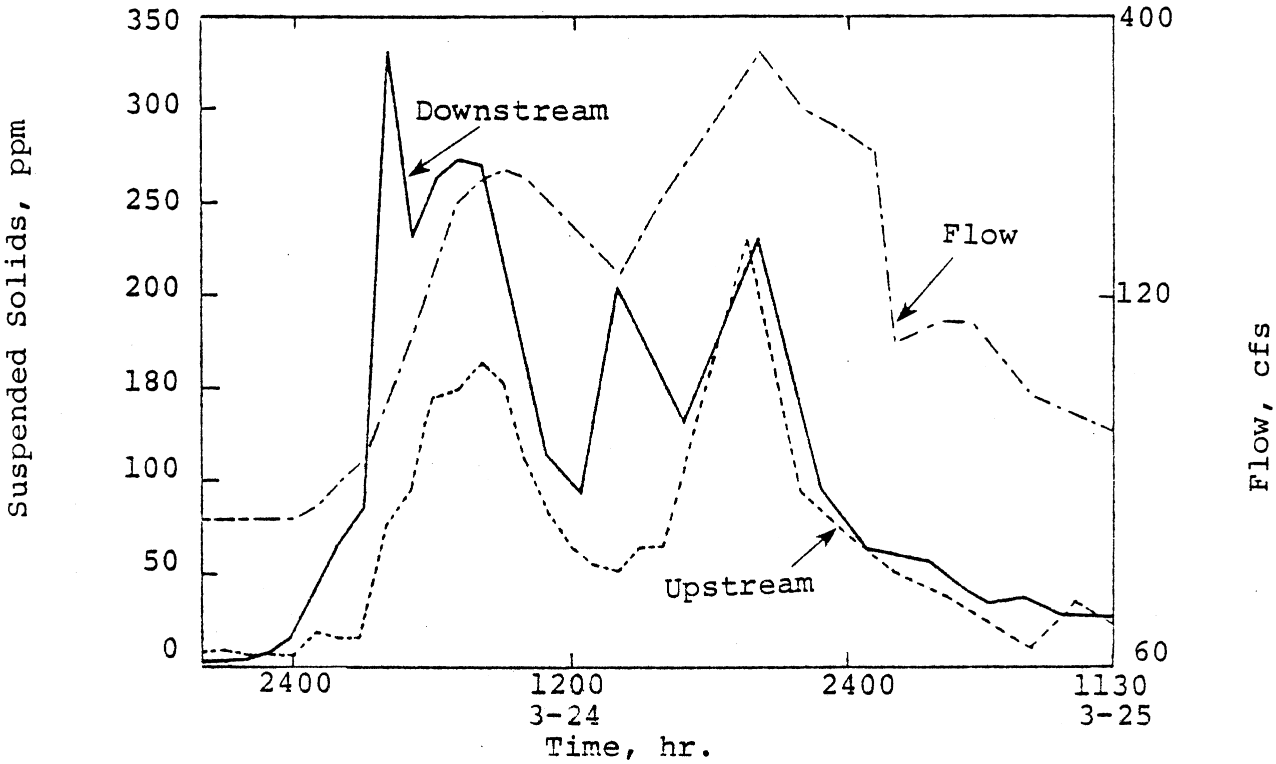


Figure C-3. Suspended solids and flow curves for January 2, 1979 storm event (total rainfall = 1.70 in.)(left) and January 24, 1979 (total rainfall = 1.64 in.)(right).

2375

Buck Mountain Creek



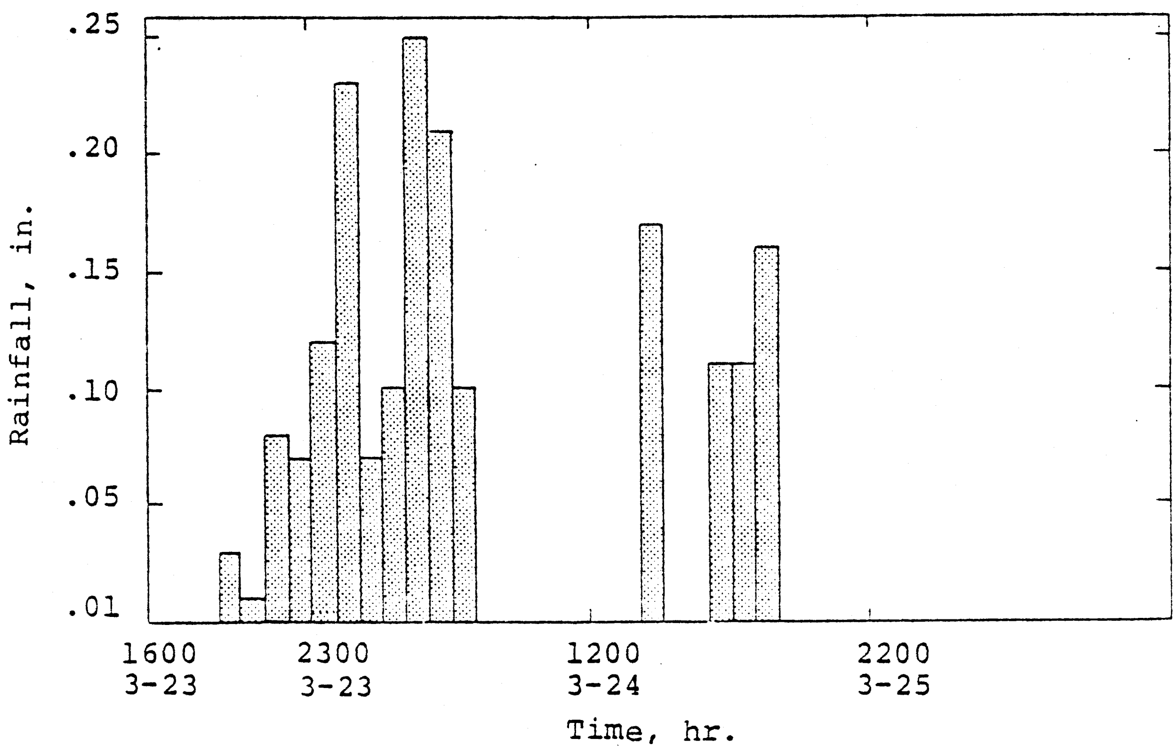
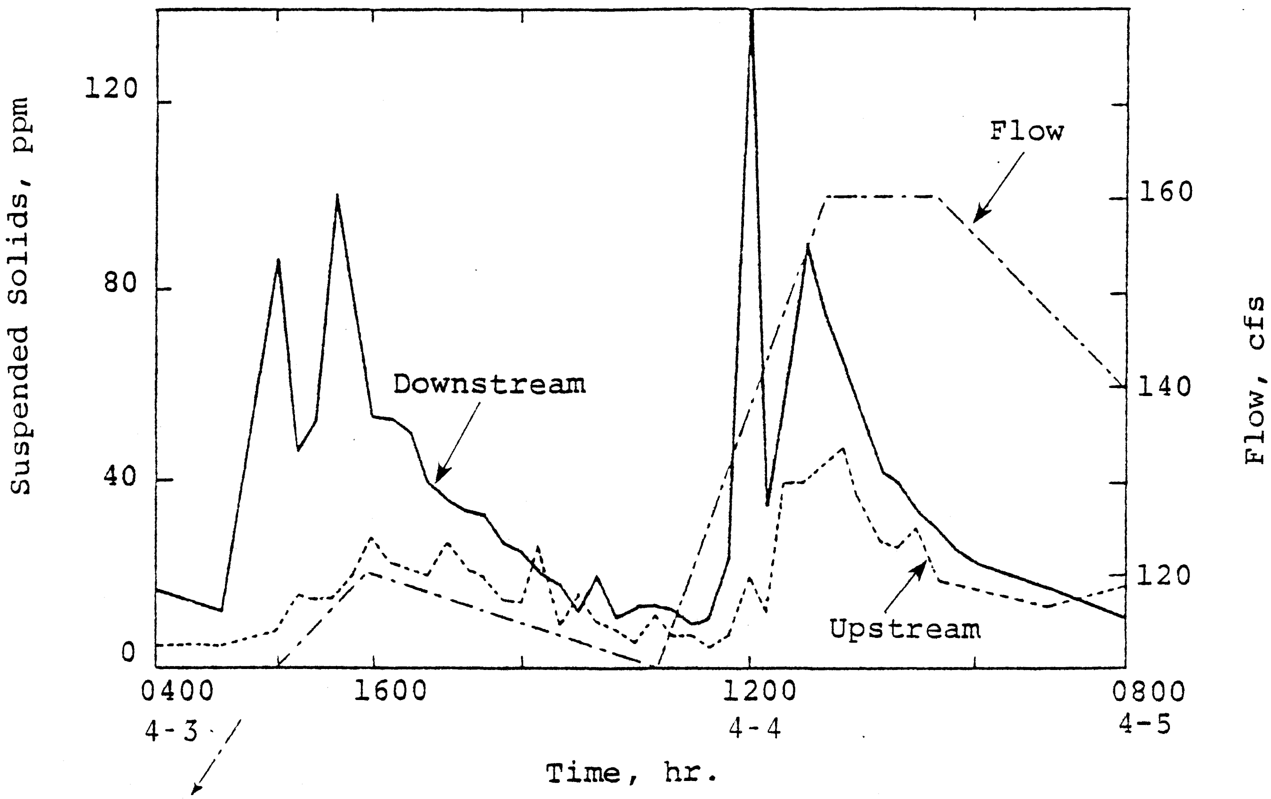


Figure C-4. Suspended solids and flow curves (top) and rainfall data (bottom) for March 23-25, 1979 storm event (total rainfall = 1.82 in.).

Buck Mountain Creek



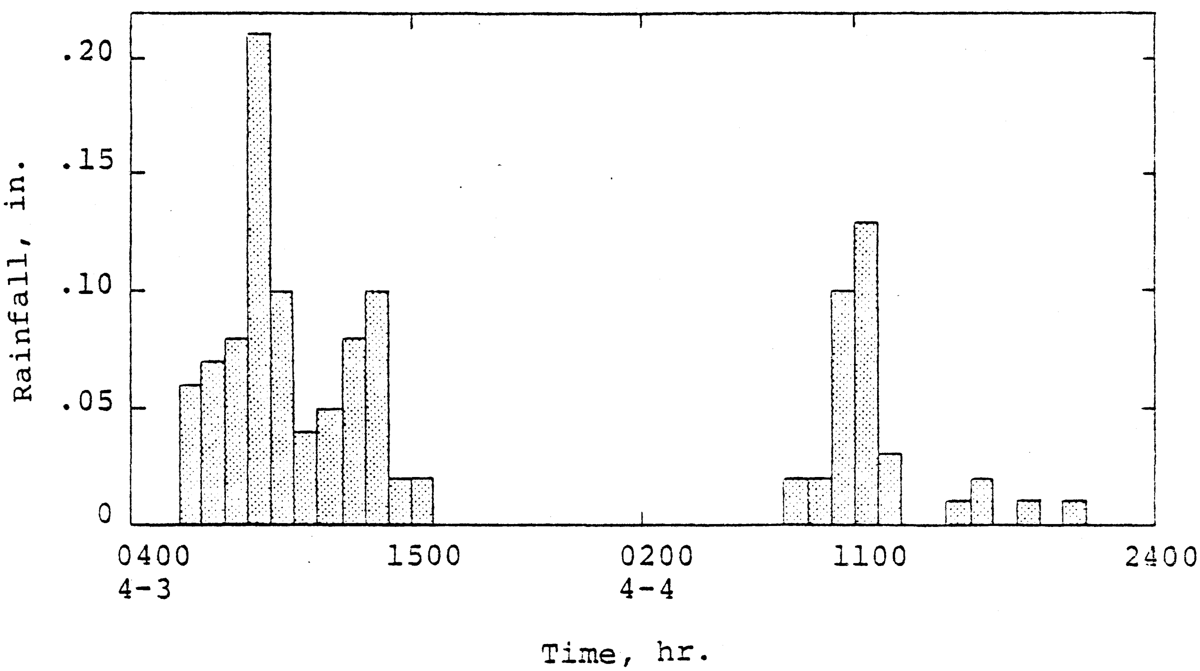


Figure C-5. Suspended solids and flow curves (top) and rainfall data (bottom) for April 3-5, 1979 storm event (total rainfall = 1.18 in.).

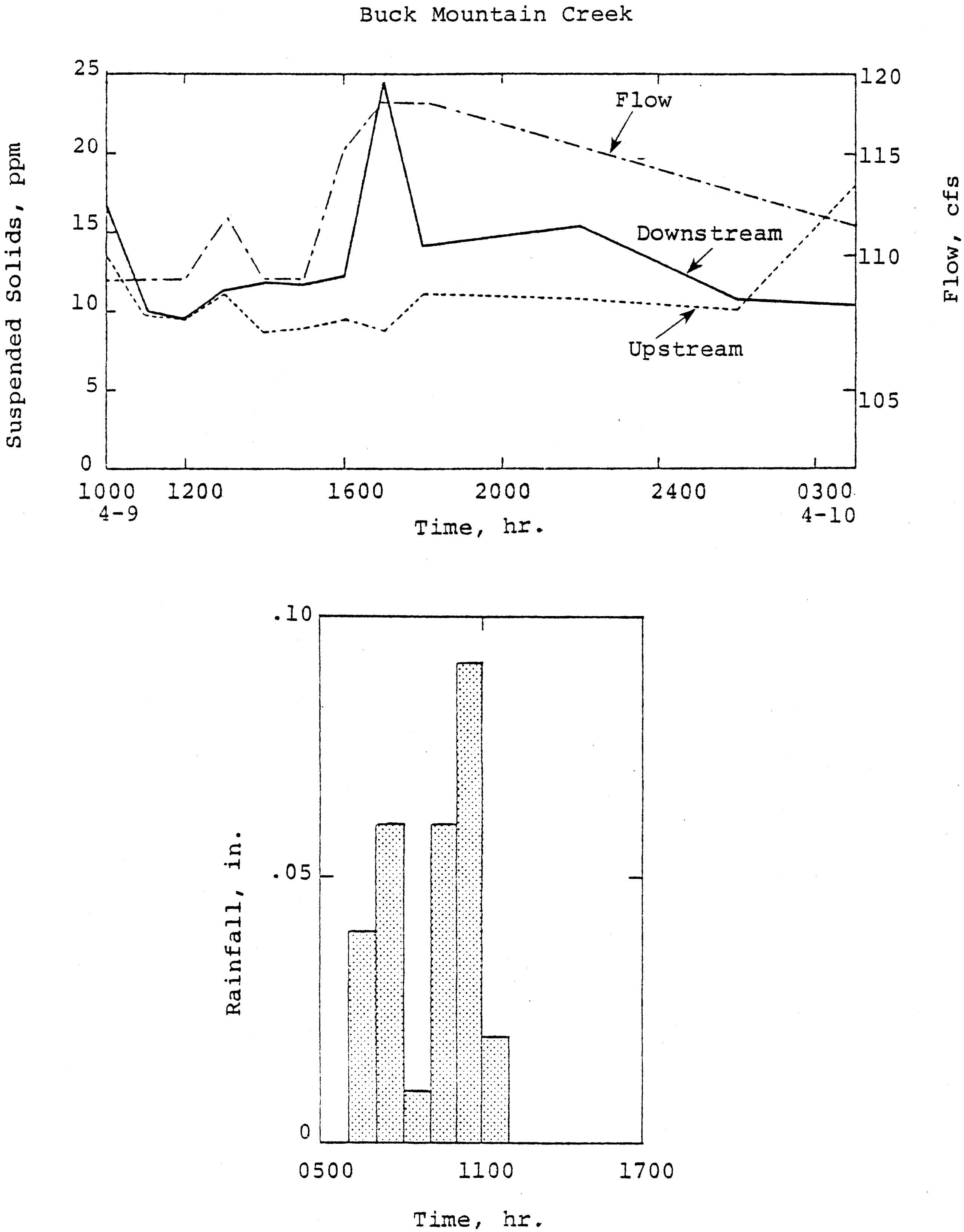
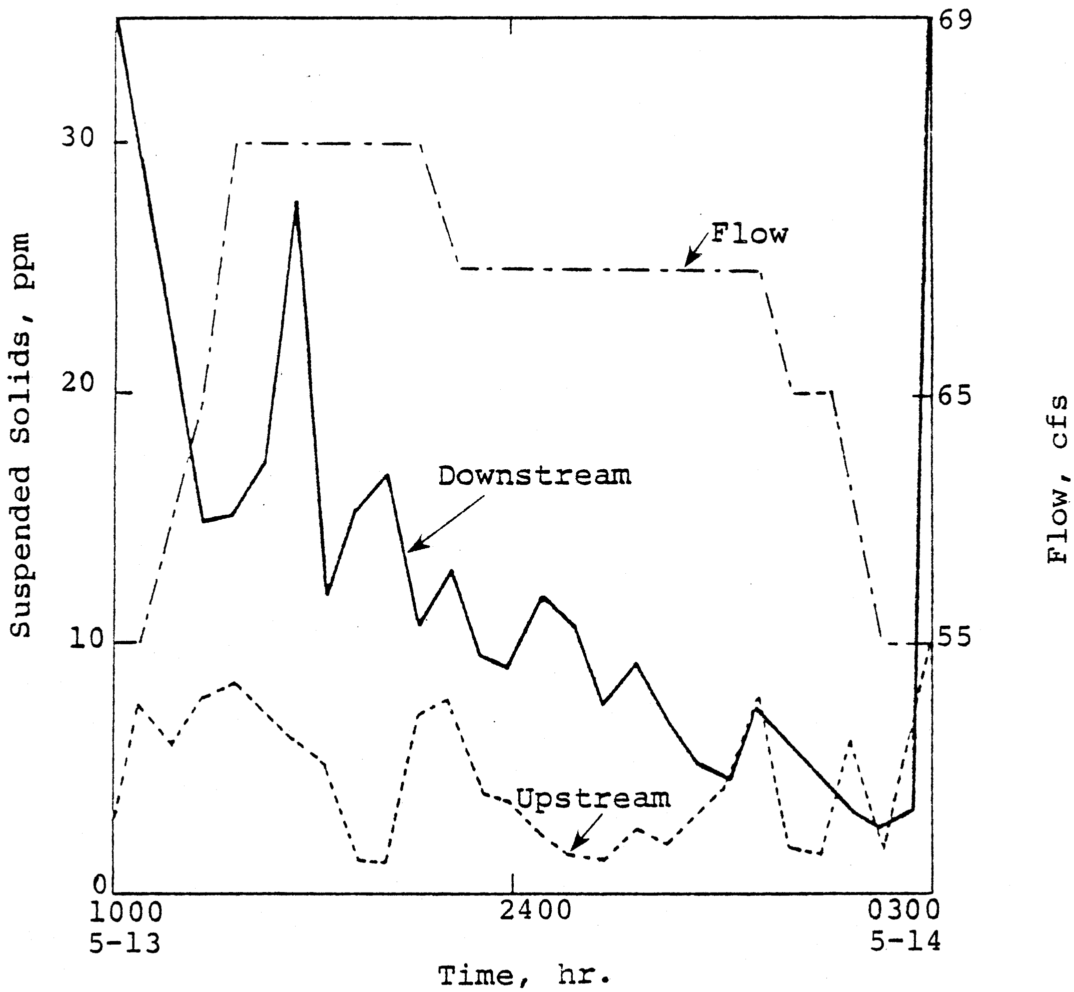


Figure C-6. Suspended solids and flow curves (top) and rainfall data (bottom) for April 9, 1979 storm event (total rainfall = 0.28 in.).

Buck Mountain Creek



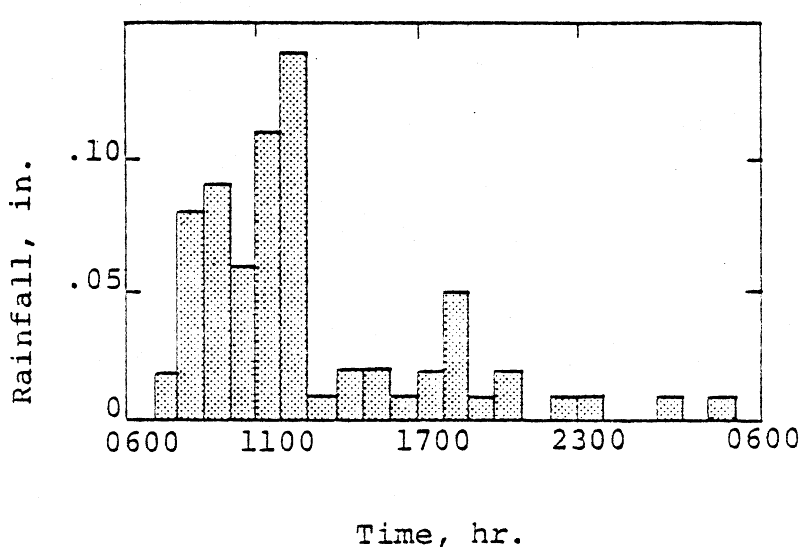


Figure C-7. Suspended solids and flow curves (top) and rainfall data (bottom) for April 13, 1979 storm event (total rainfall = 0.7 in.).

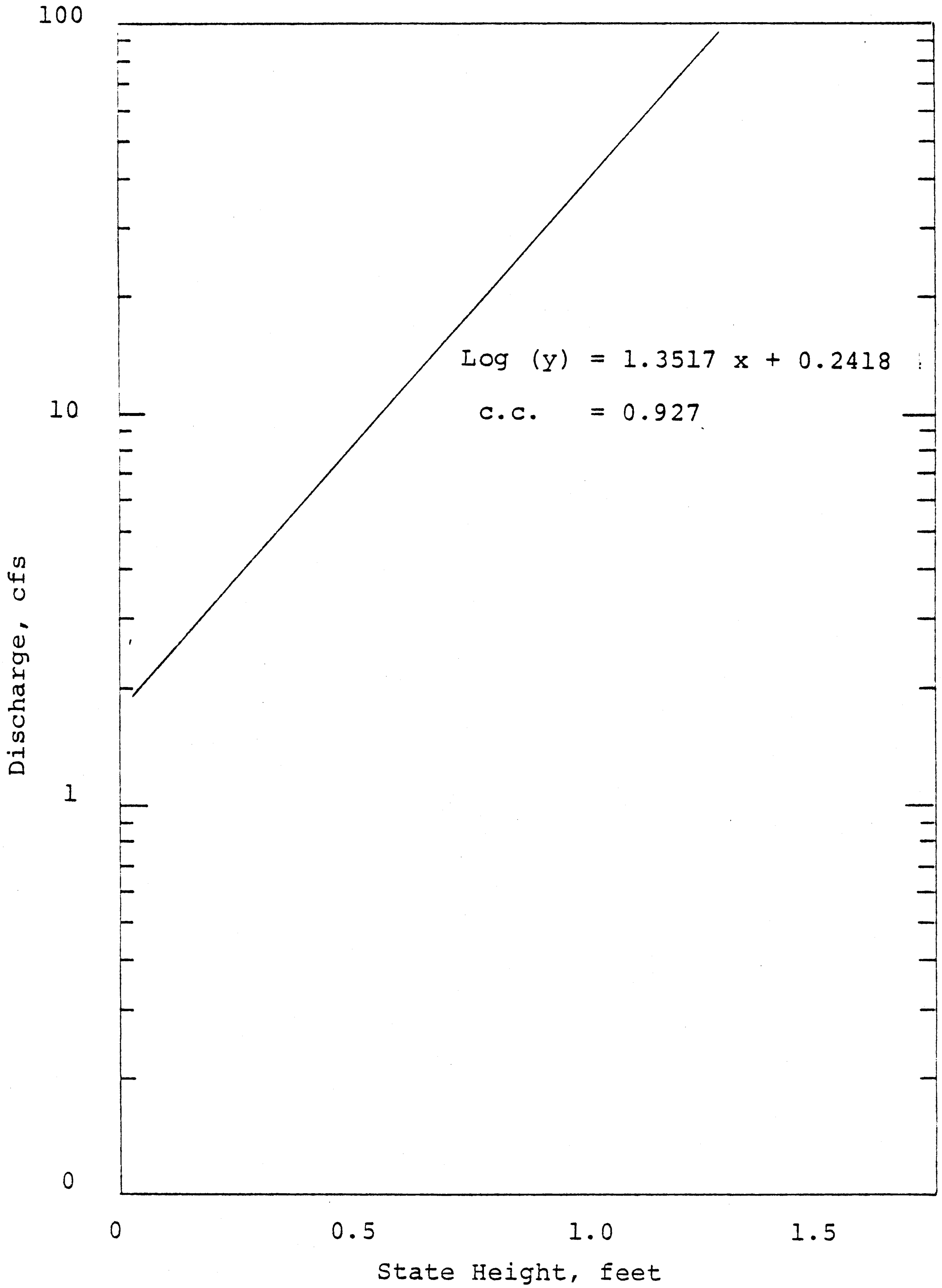


Figure C-8. Stage-discharge curve for Buck Creek.

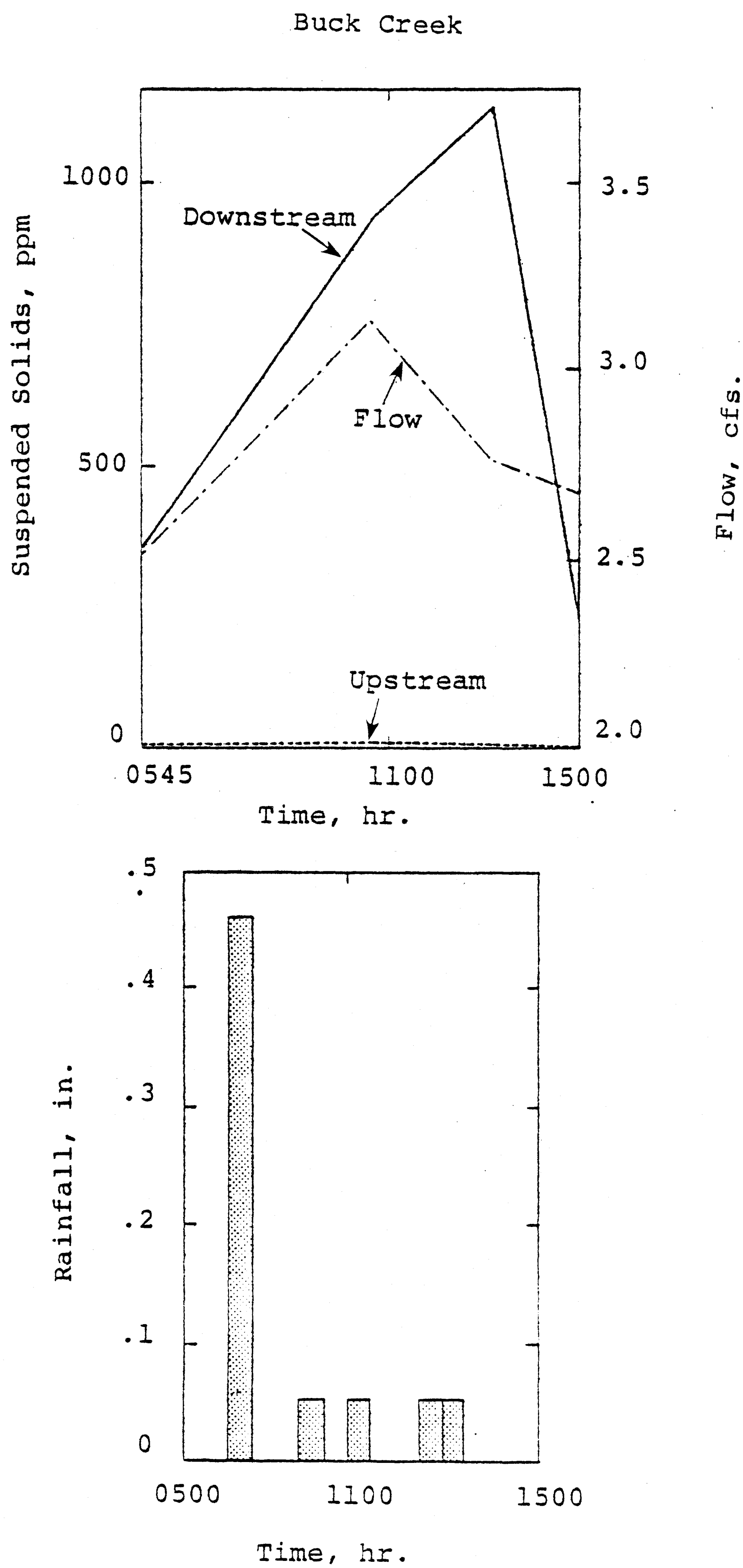


Figure C-9. Suspended solids, flow, (top) and rainfall data (bottom) for November 17, 1978 storm event (total rainfall = 0.66 in.).

Buck Creek

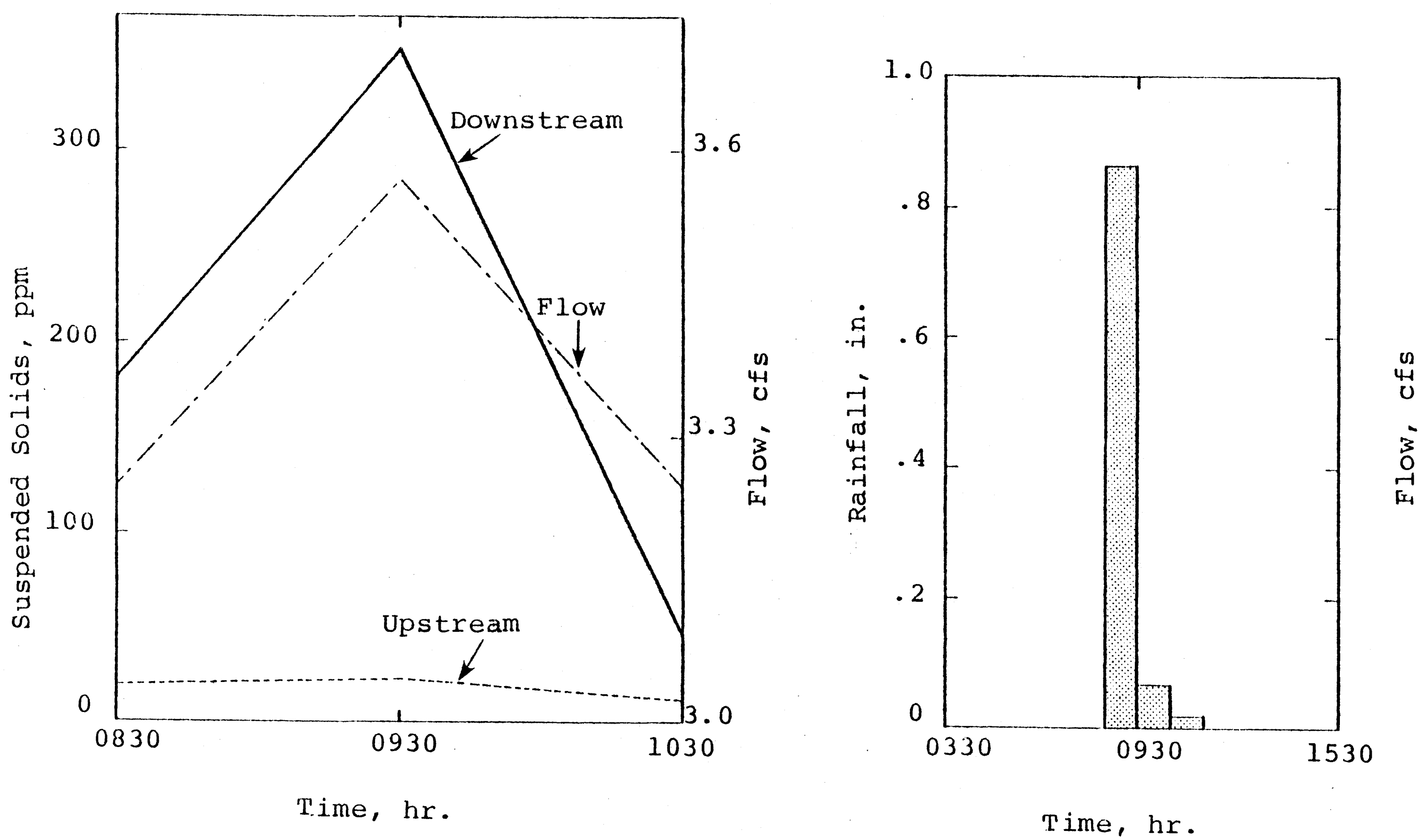
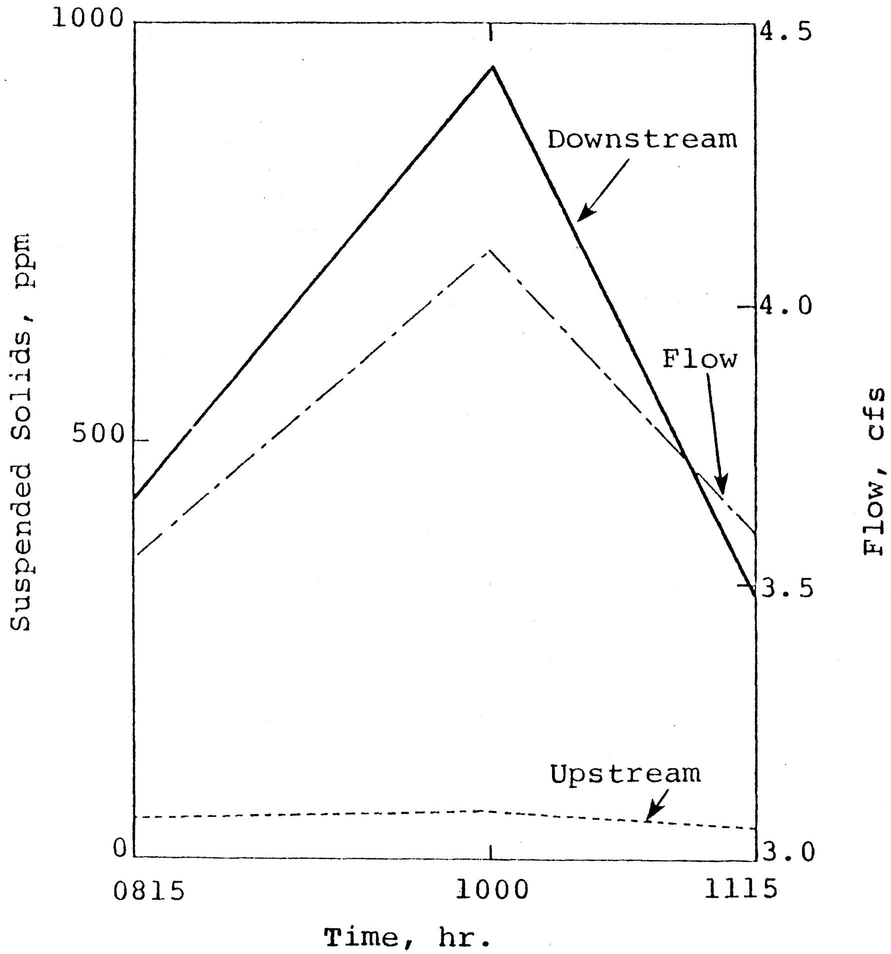


Figure C-10. Suspended solids, flow, and rainfall data for December 4, 1978 storm event (total rainfall = 0.91 in.).

Buck Creek



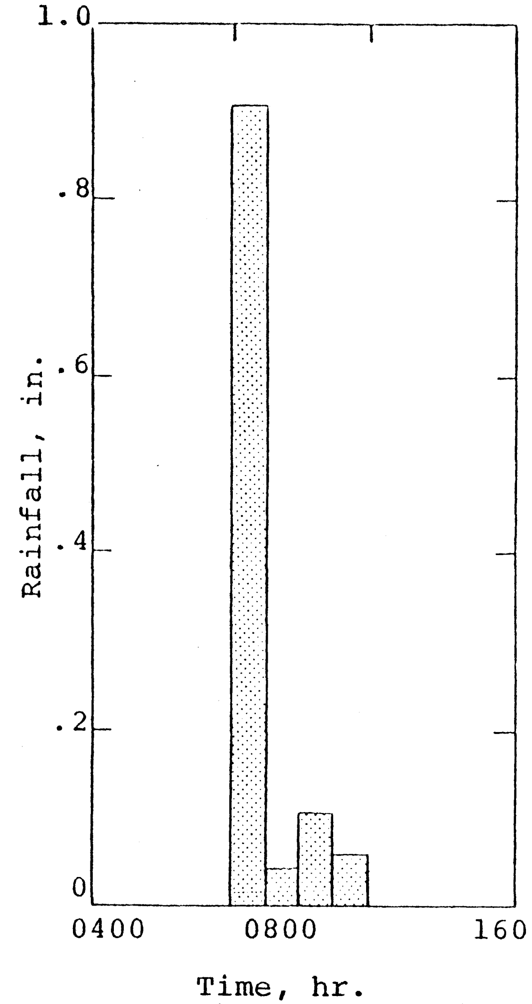


Figure C-11. Suspended solids, flow, and rainfall data for November 27, 1978 storm event (total rainfall = 1.09 in.).

Buck Creek

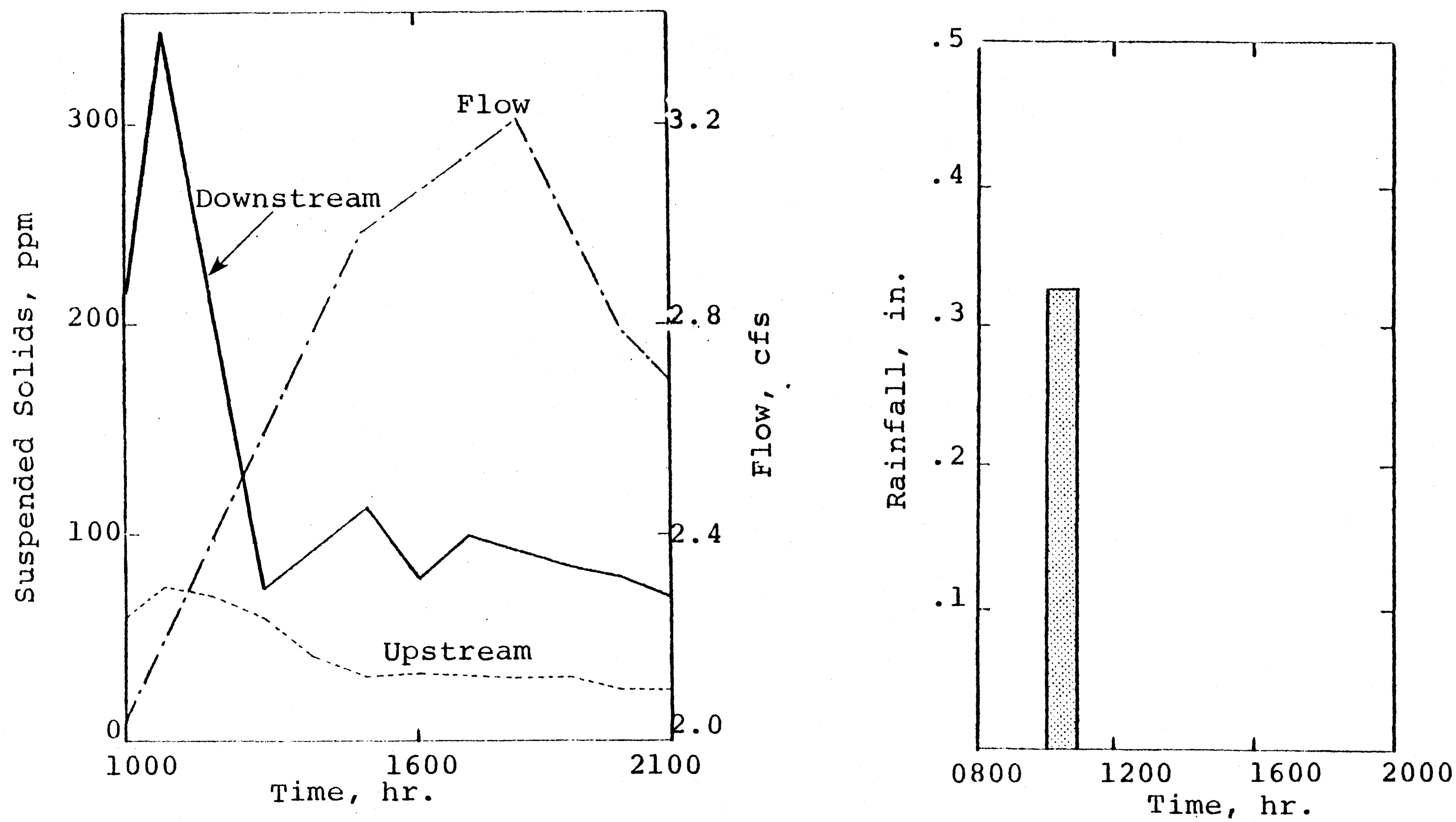
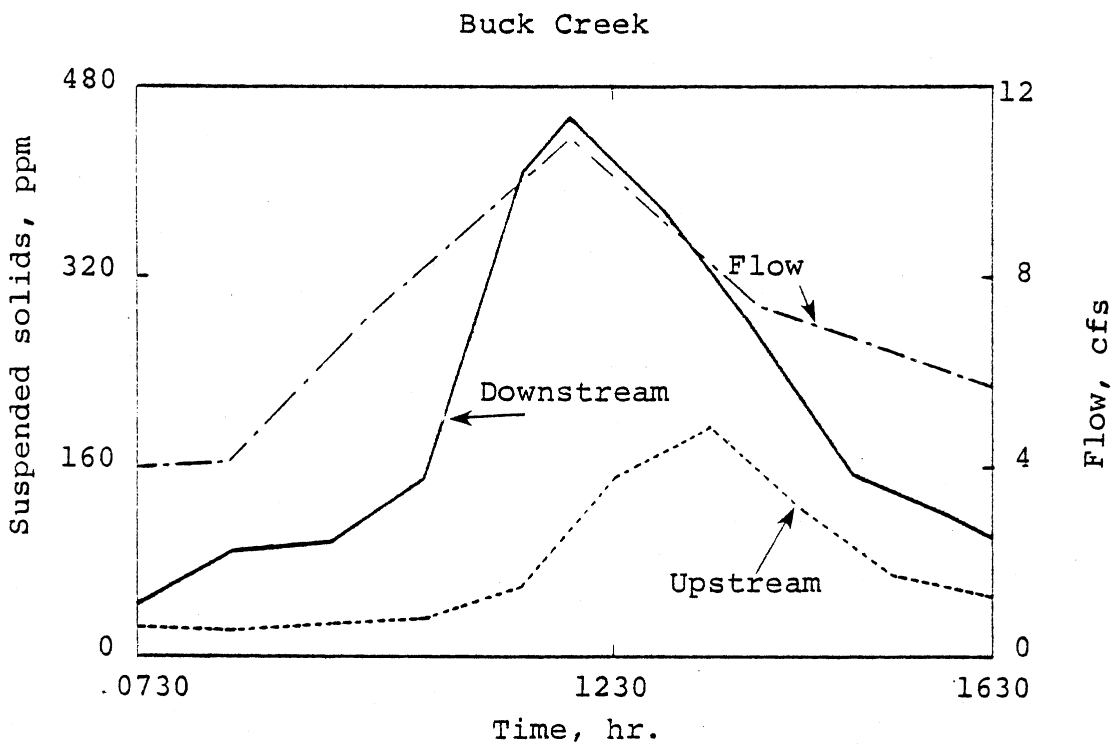


Figure C-12. Suspended solids, flow, and rainfall data for April 3, 1979 storm event (total rainfall = 0.31 in.).



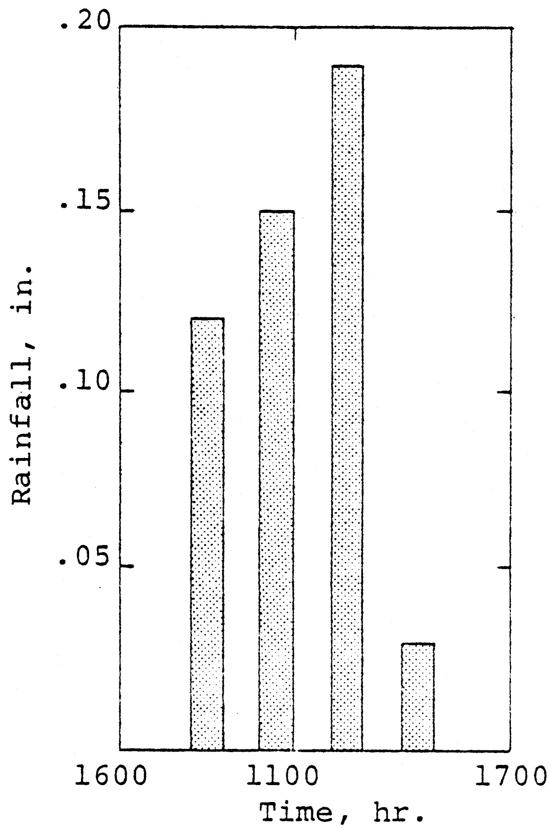
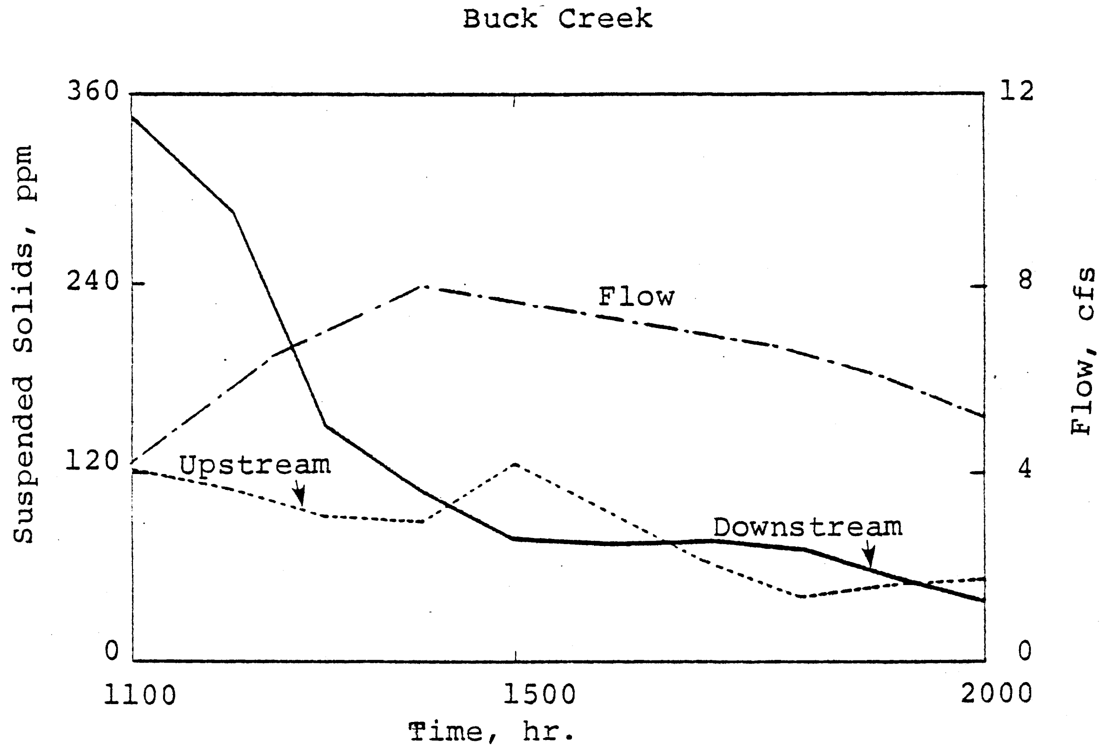


Figure C-13. Suspended solids, flow, and rainfall data for April 4, 1979 storm event (total rainfall = 0.49 in.).



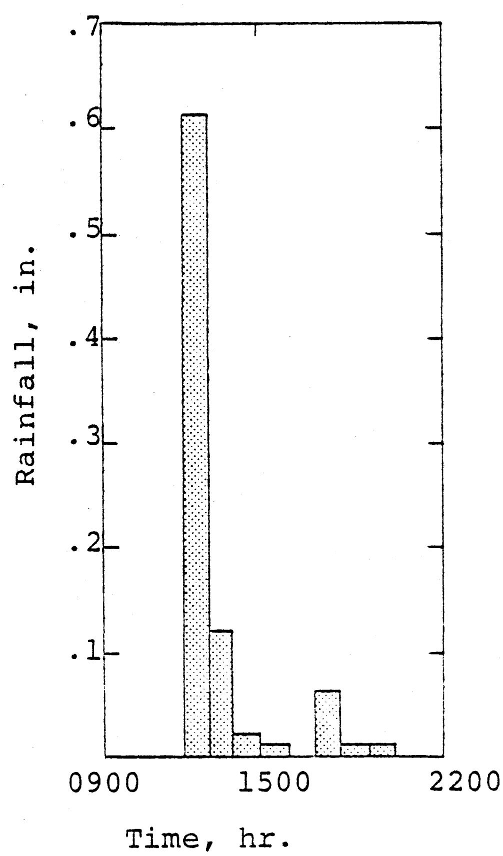


Figure C-14. Suspended solids, flow, and rainfall data for April 13, 1979 storm event (total rainfall = 0.84 in.).

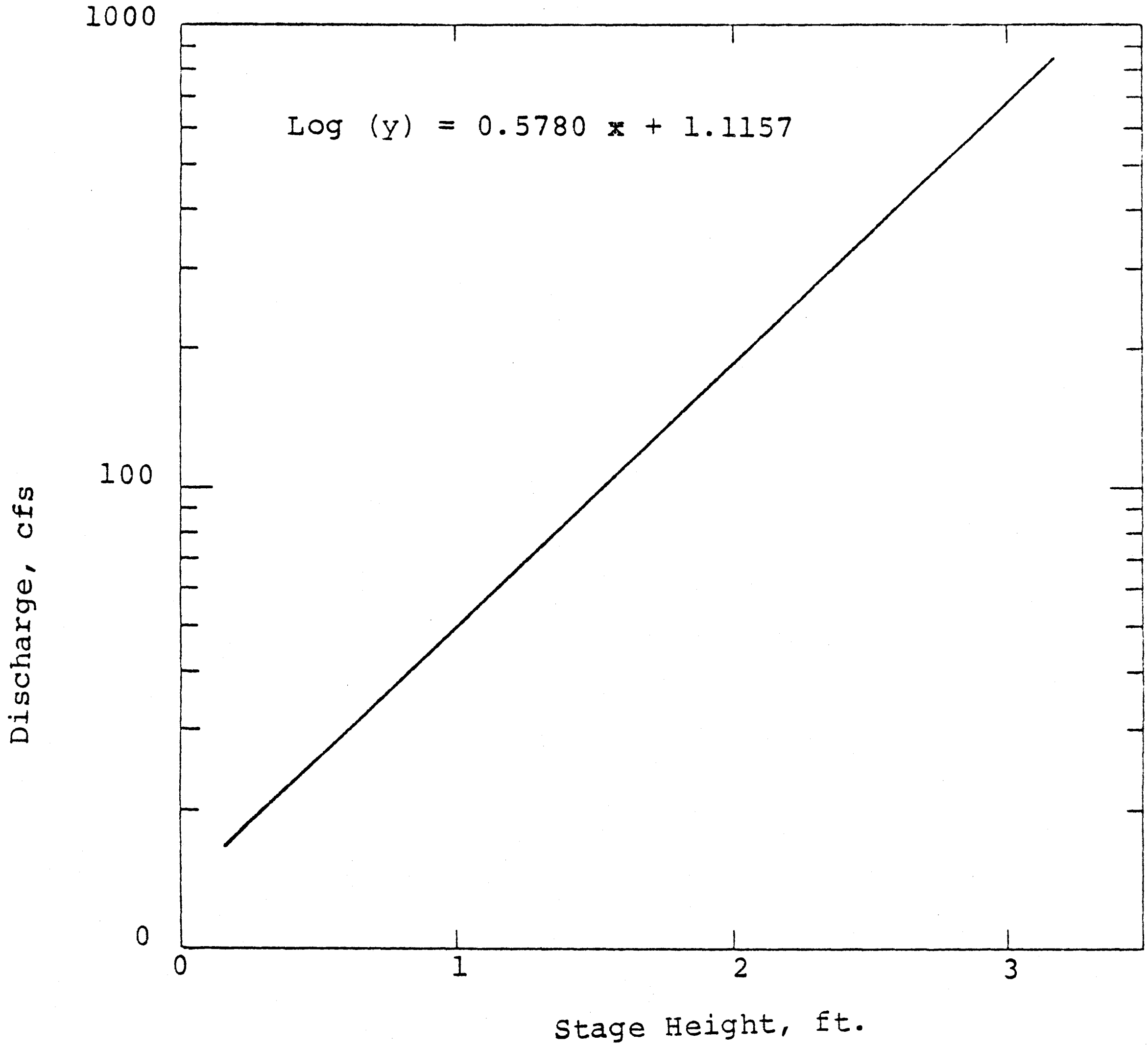


Figure C-15. State-discharge curve for Rockfish River.

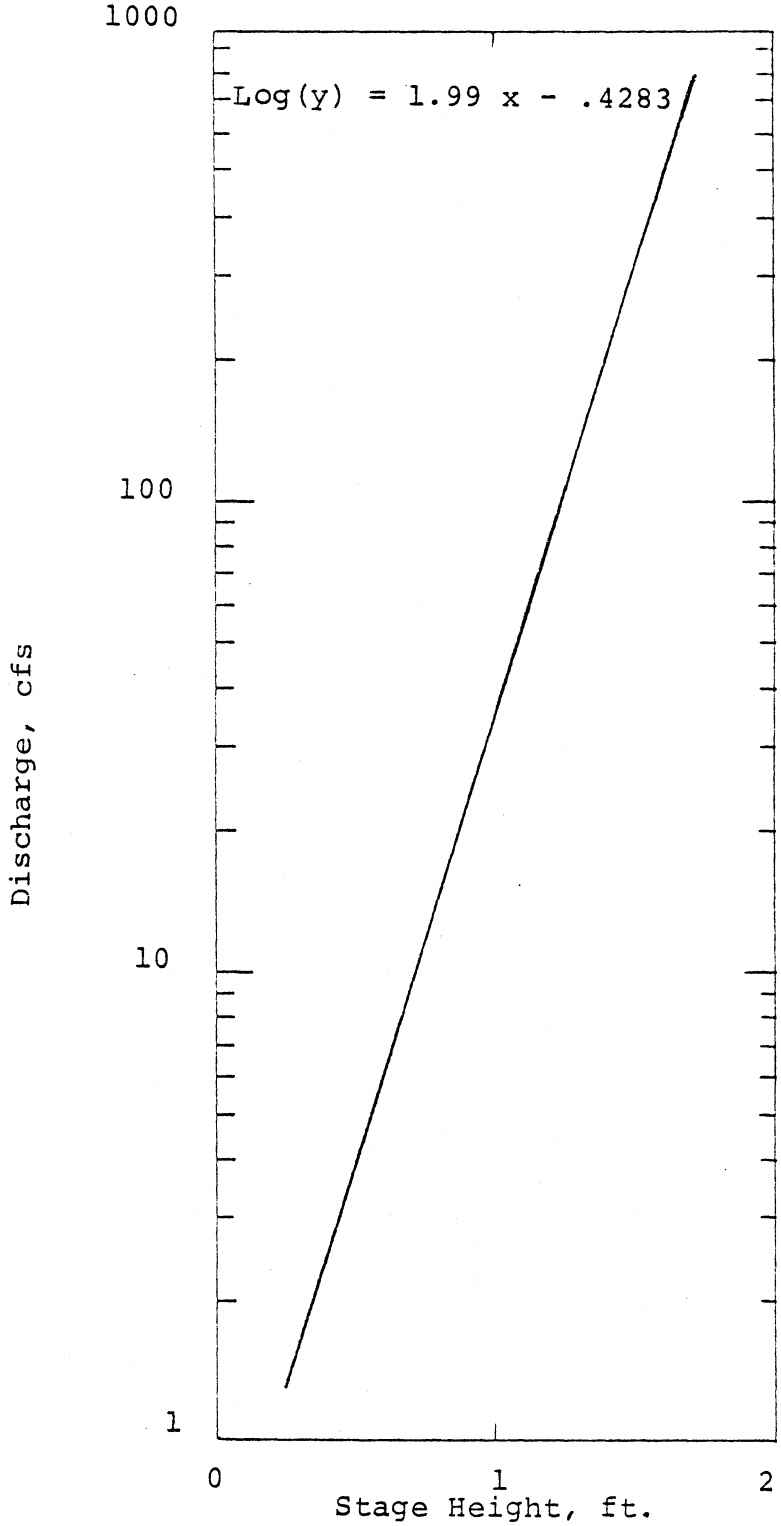


Figure C-16. Stage-discharge curve for Davis Creek.

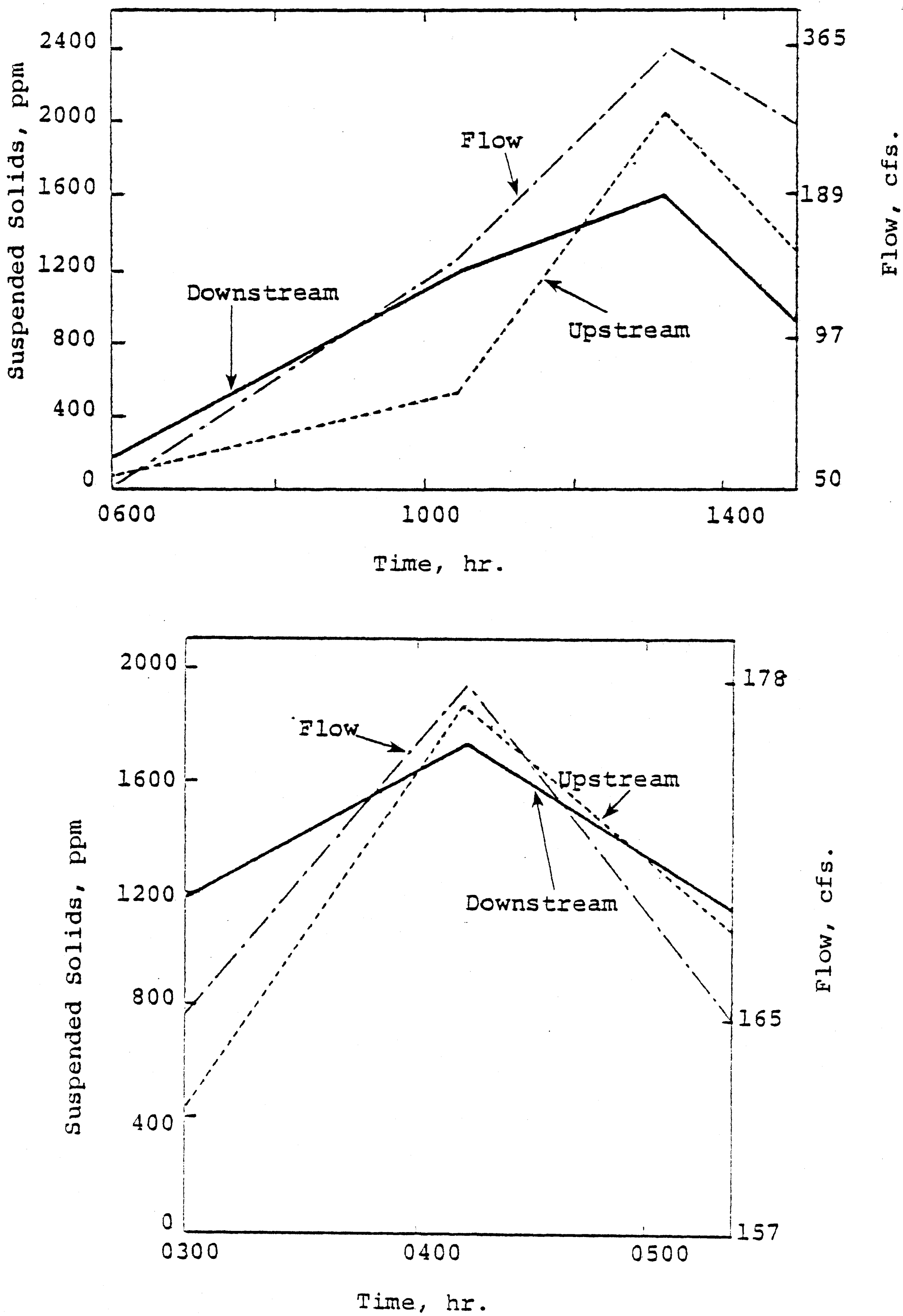
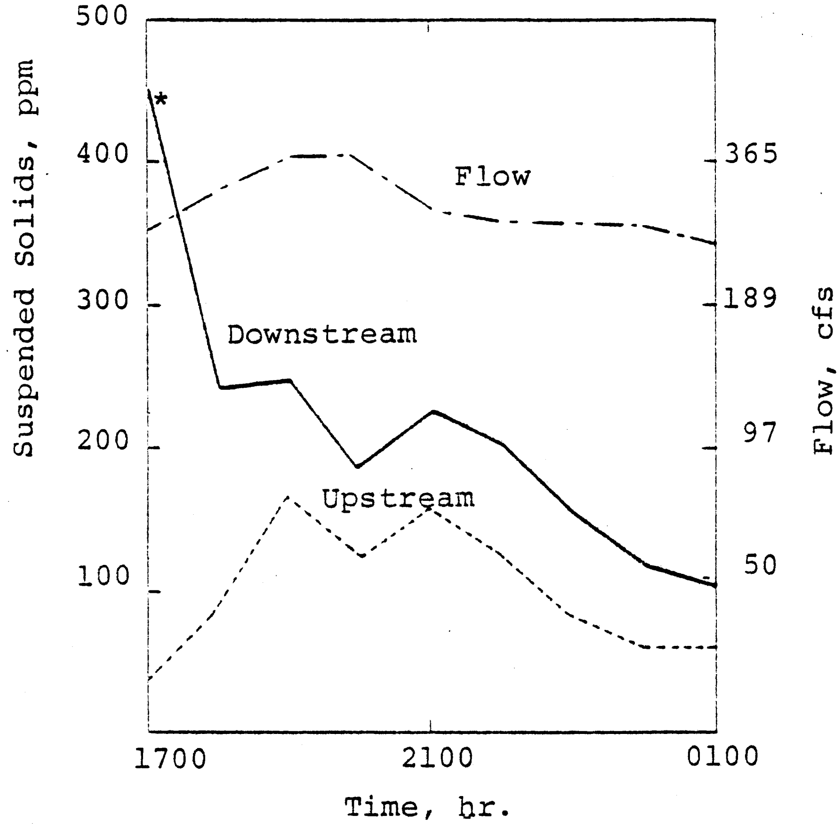


Figure C-17. Suspended solids and flow data for November 17, 1978 storm event (total rainfall = 0.66 in.) (top) and December 9, 1978 storm event (total rainfall = 0.99 in.) (bottom). Rockfish River and Davis Creek.

Rockfish River and Davis Creek



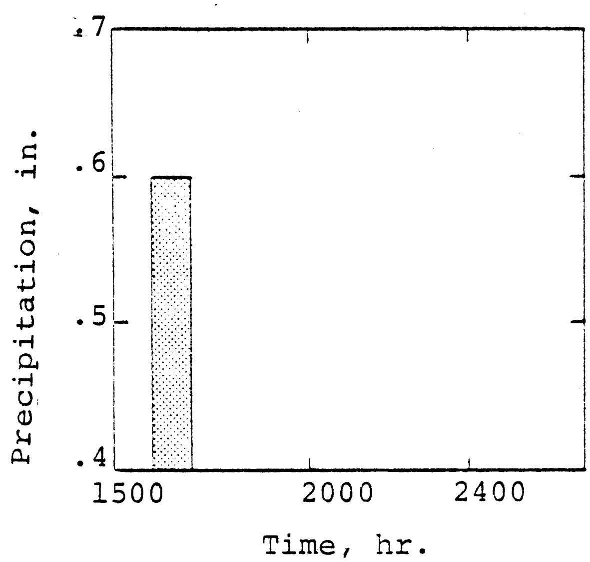
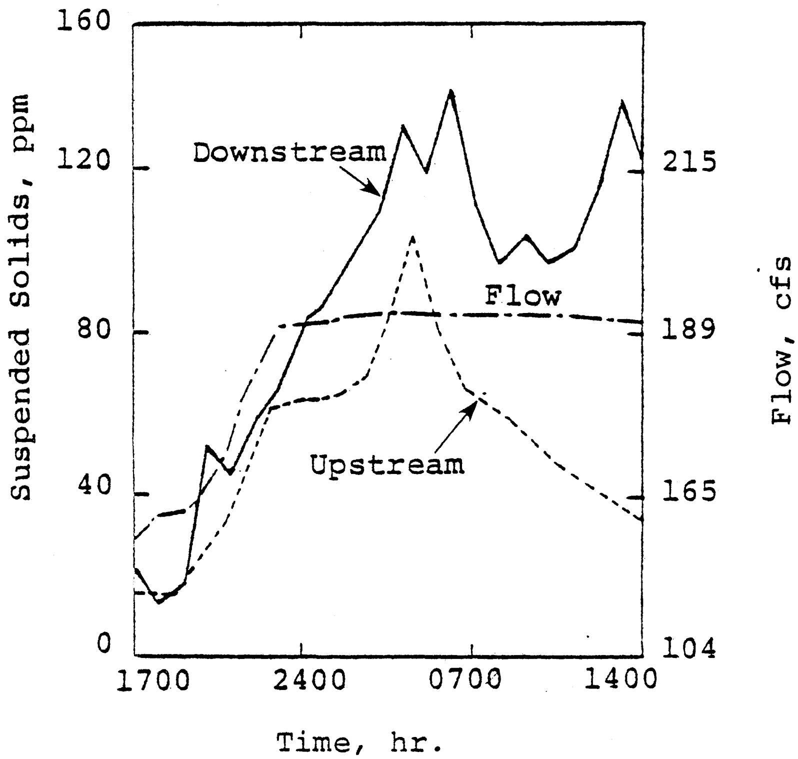


Figure C-18. Suspended solids, flow, and rainfall data for August 30-31, 1979 storm event (total rainfall = 0.72 in.). *High suspended solids caused by localized storm event on Davis Creek watershed.



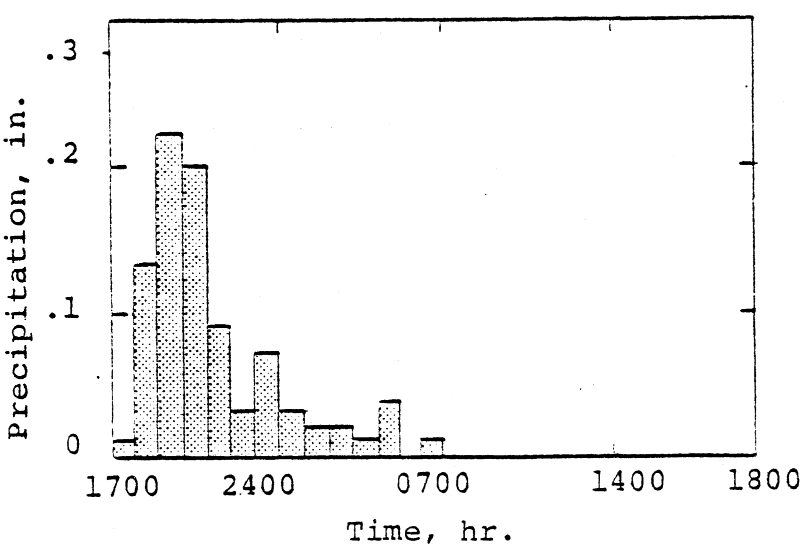


Figure C-19. Suspended solids, flow, and rainfall data for September 13-14, 1979 storm event (total rainfall = 0.88 in.). Rockfish River and Davis Creek.

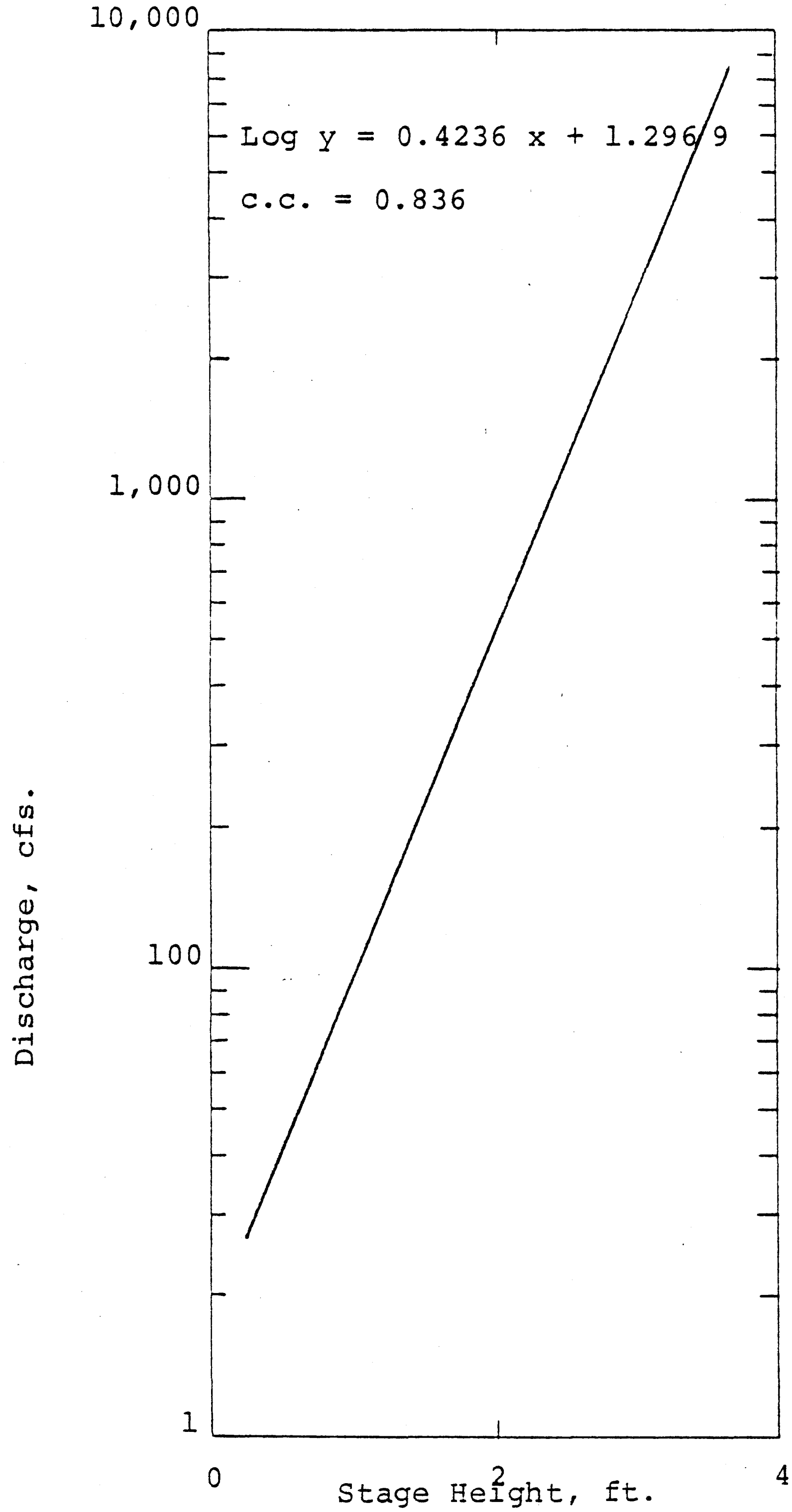


Figure C-20. Stage-discharge curve for Big Walker Creek.

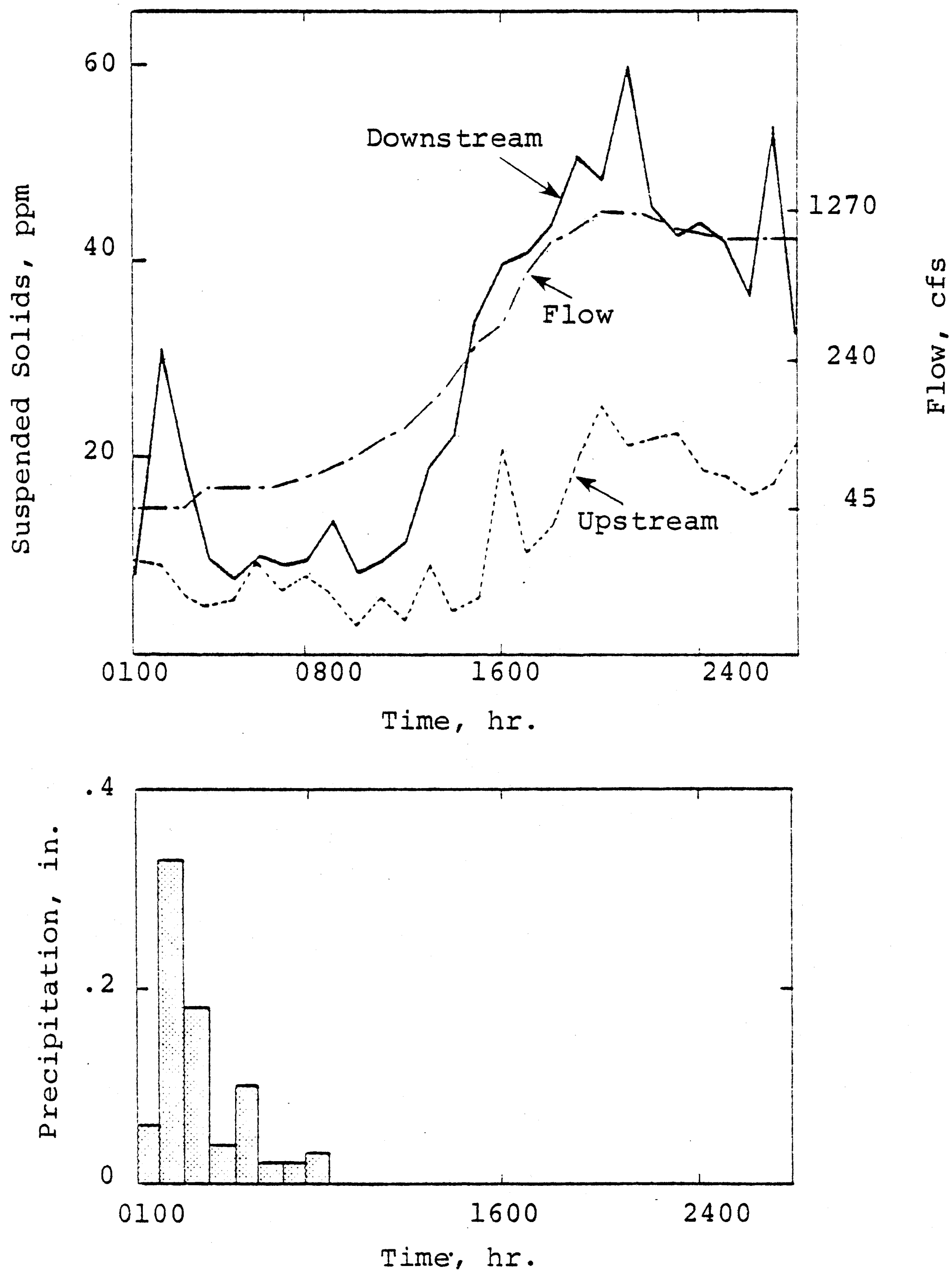


Figure C-21. Suspended solids, flow, and rainfall data for November 9-10, 1979 storm event (total precipitation = 0.78 in.).

2394

Big Walker Creek

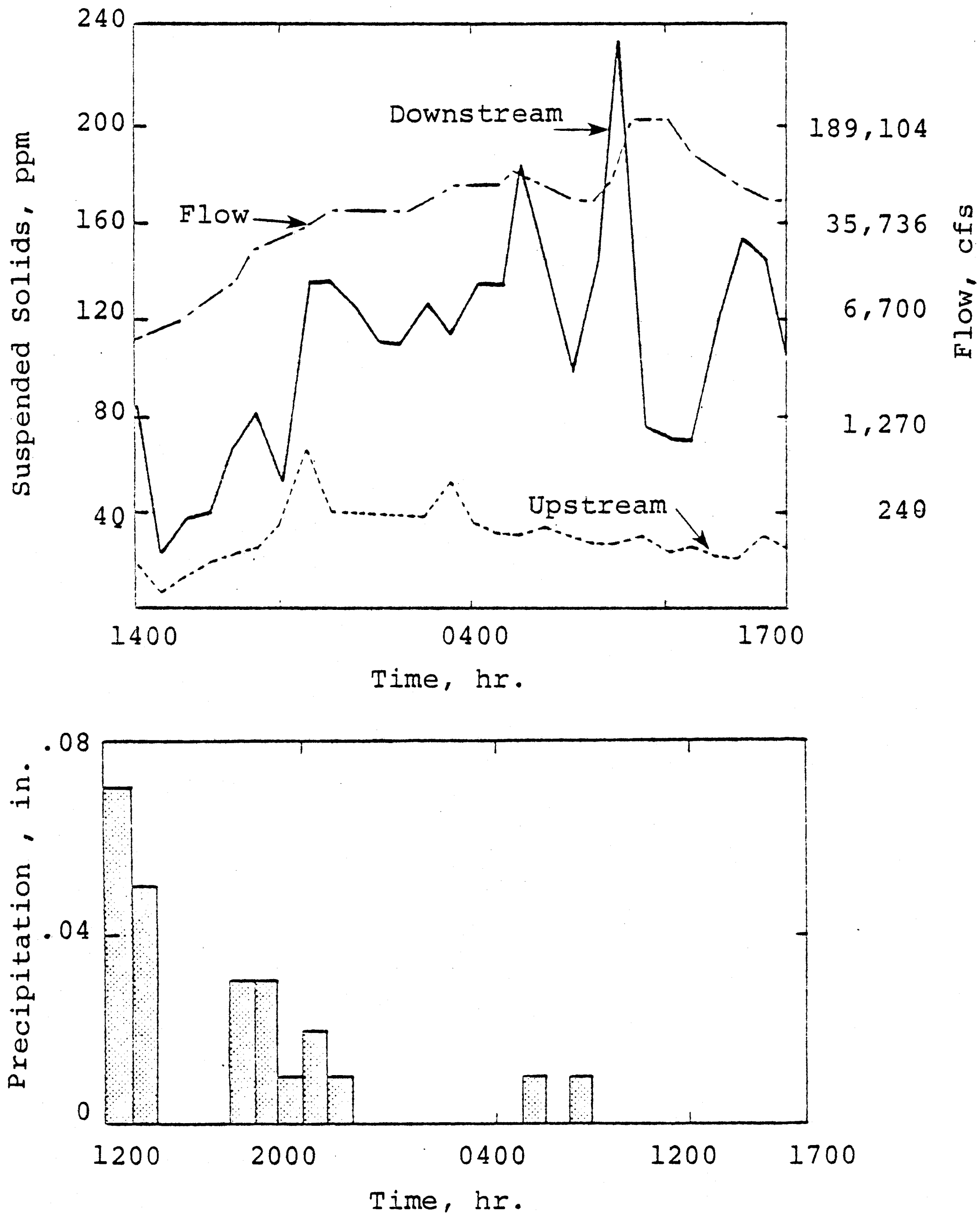
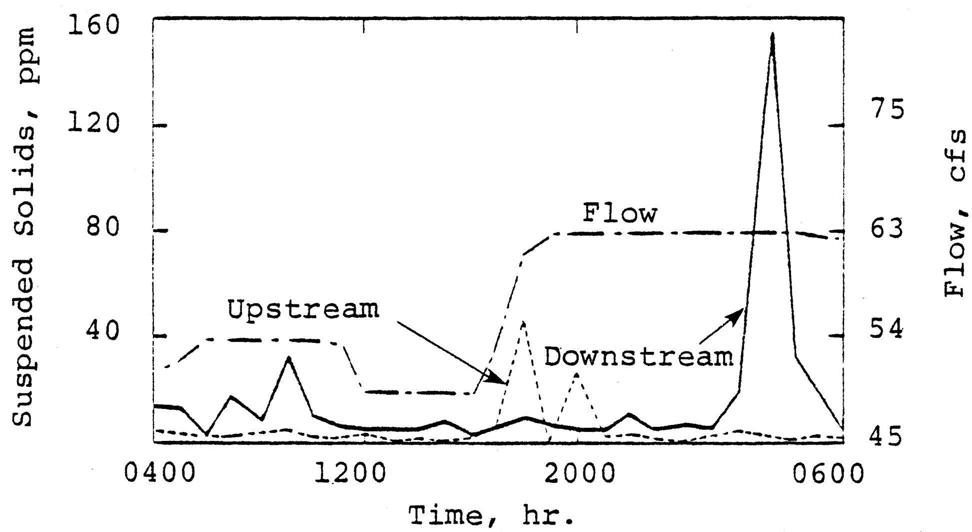


Figure C-22. Suspended solids, flow, and rainfall data for November 10-11, 1979 storm events (total rainfall = 0.24 in.).



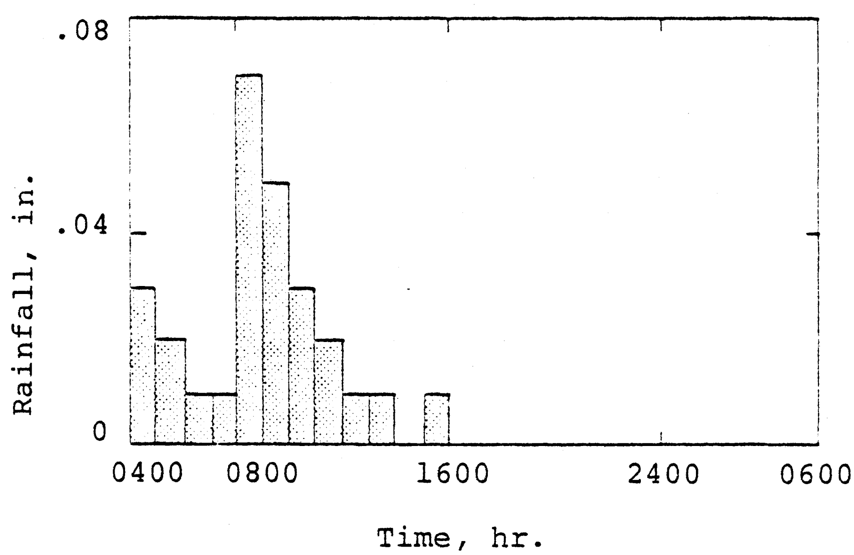


Figure C-23. Suspended solids, flow, and rainfall data for December 13-14, 1979 storm event (total rainfall = 0.27 in.).

2396

Big Walker Creek

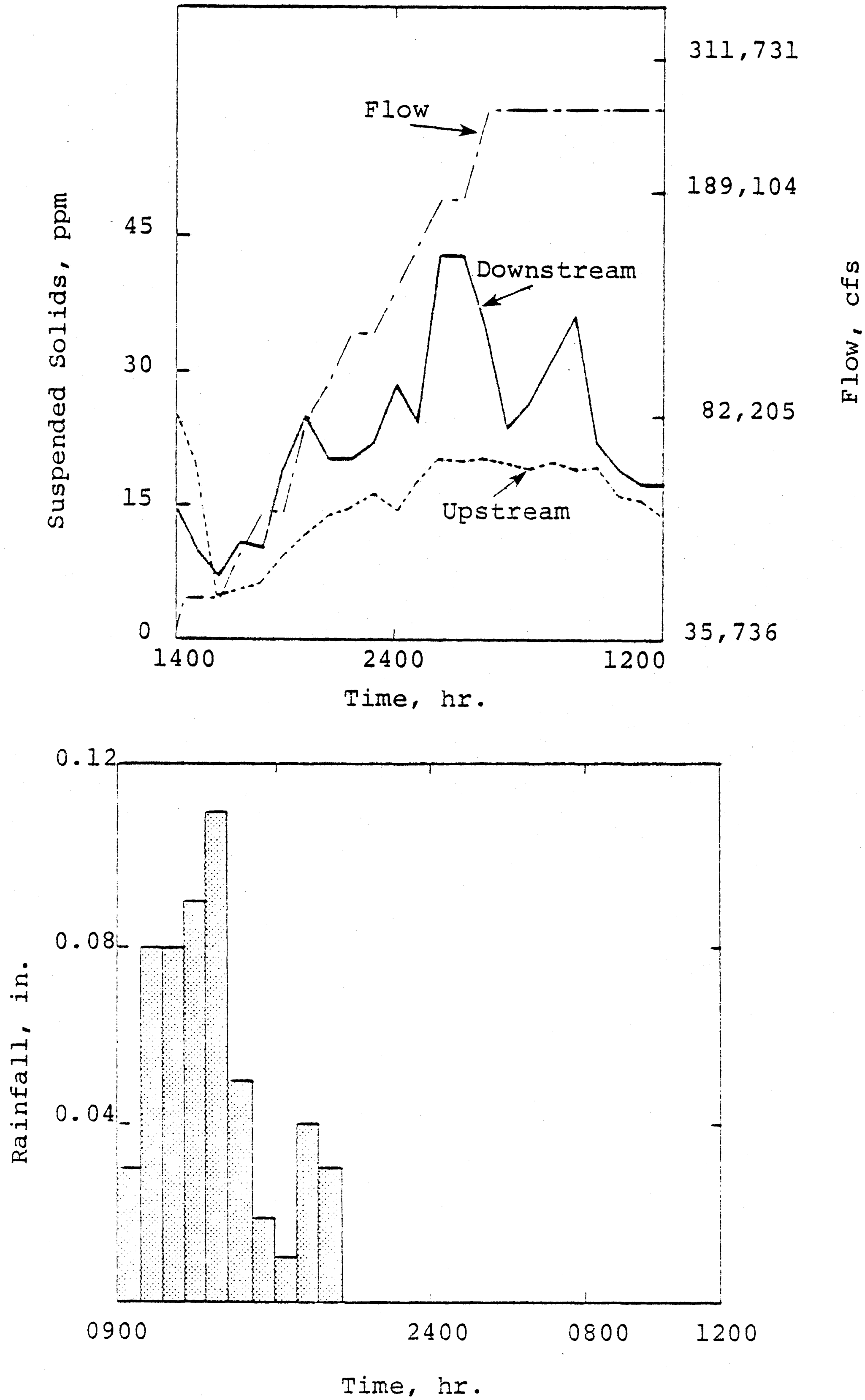


Figure C-24. Suspended solids, flow, and rainfall data for January 19-20, 1980 storm event (total rainfall = 0.54 in.).

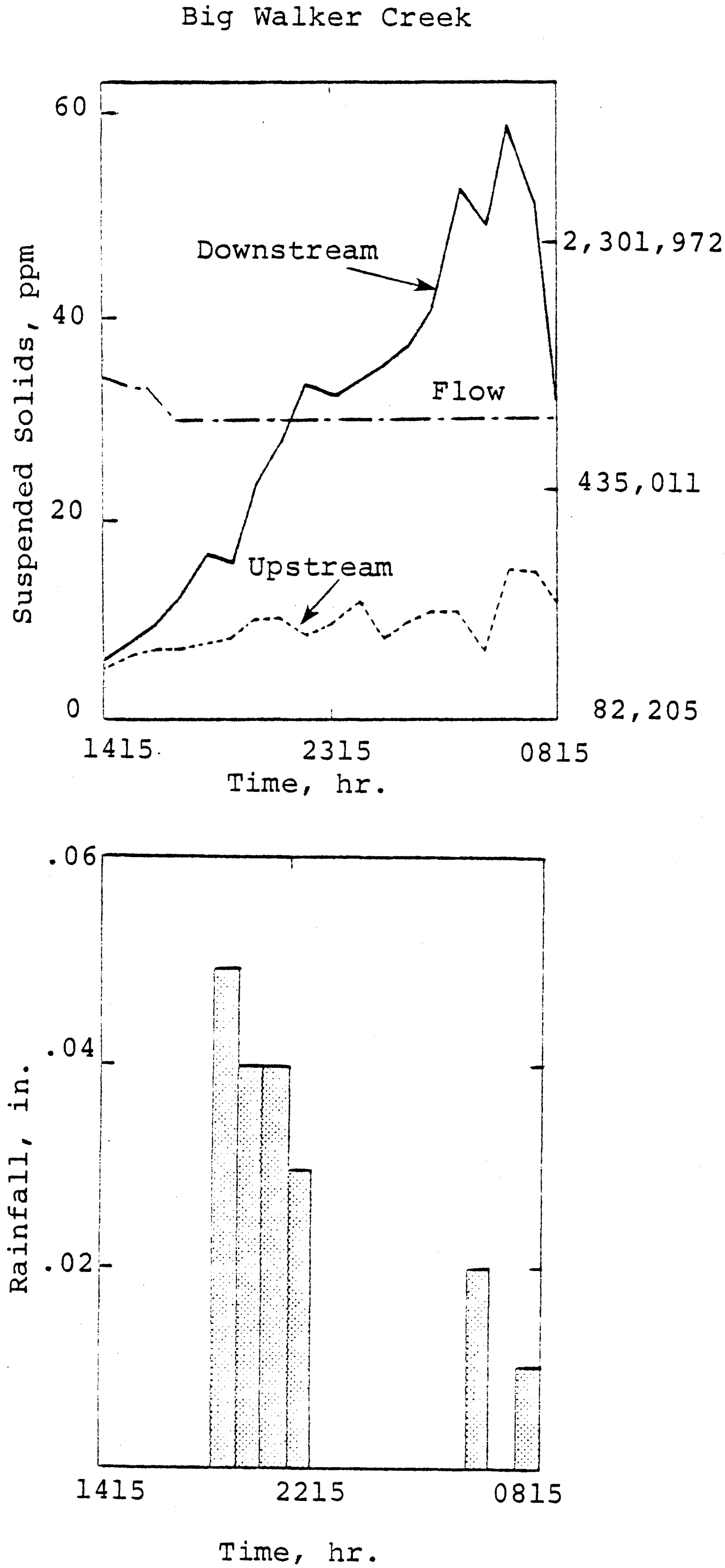


Figure C-25. Suspended solids, flow, and rainfall data for March 8, 1980 storm event (total rainfall = 0.21 in.).

APPENDIX D

DIAGRAMS OF BUCK MOUNTAIN CREEK, BUCK CREEK, ROCKFISH RIVER, AND BIG WALKER CREEK

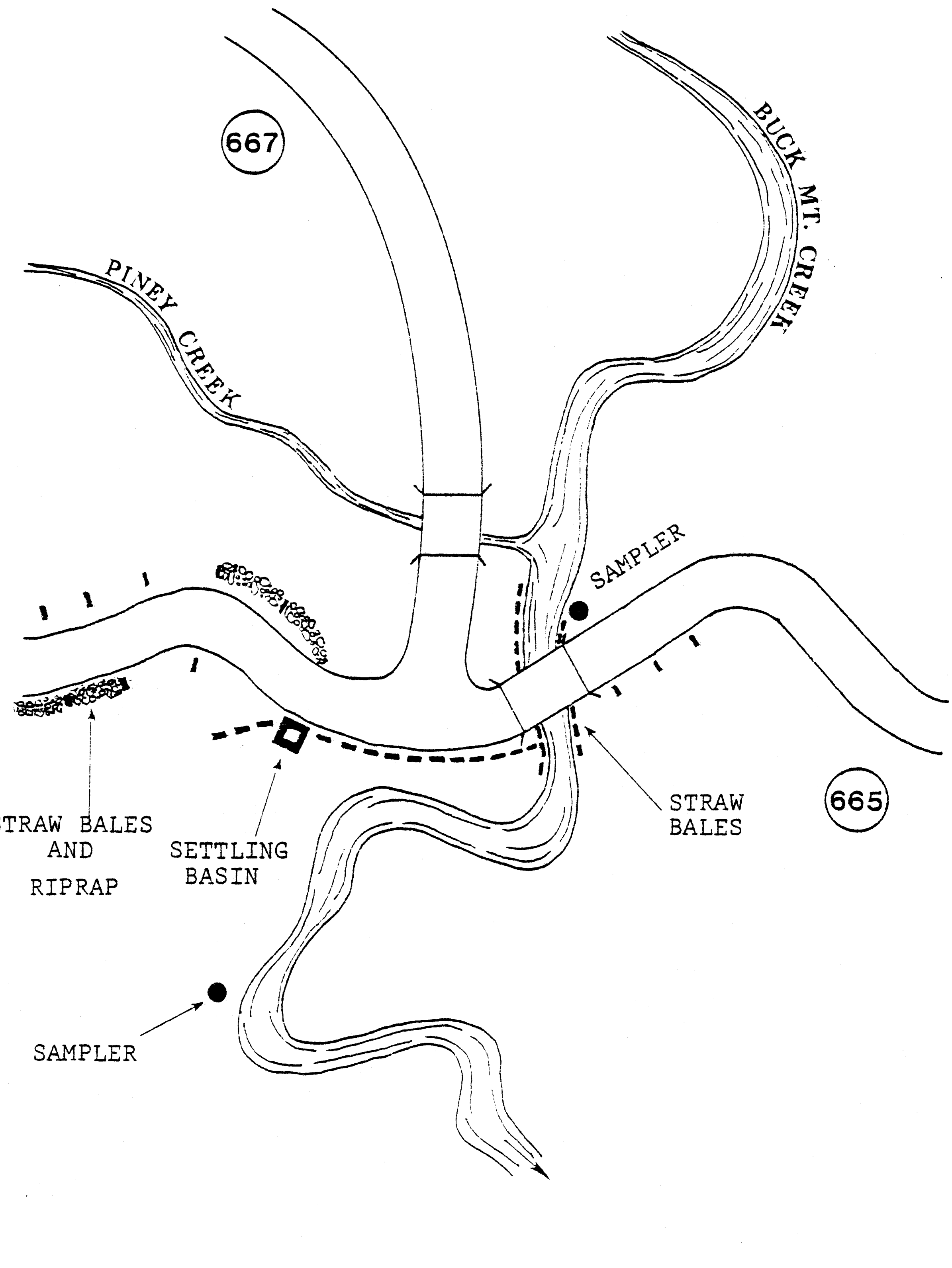


Figure D-1. Plan view of Buck Mt. Creek erosion controls and sampler locations.

2402

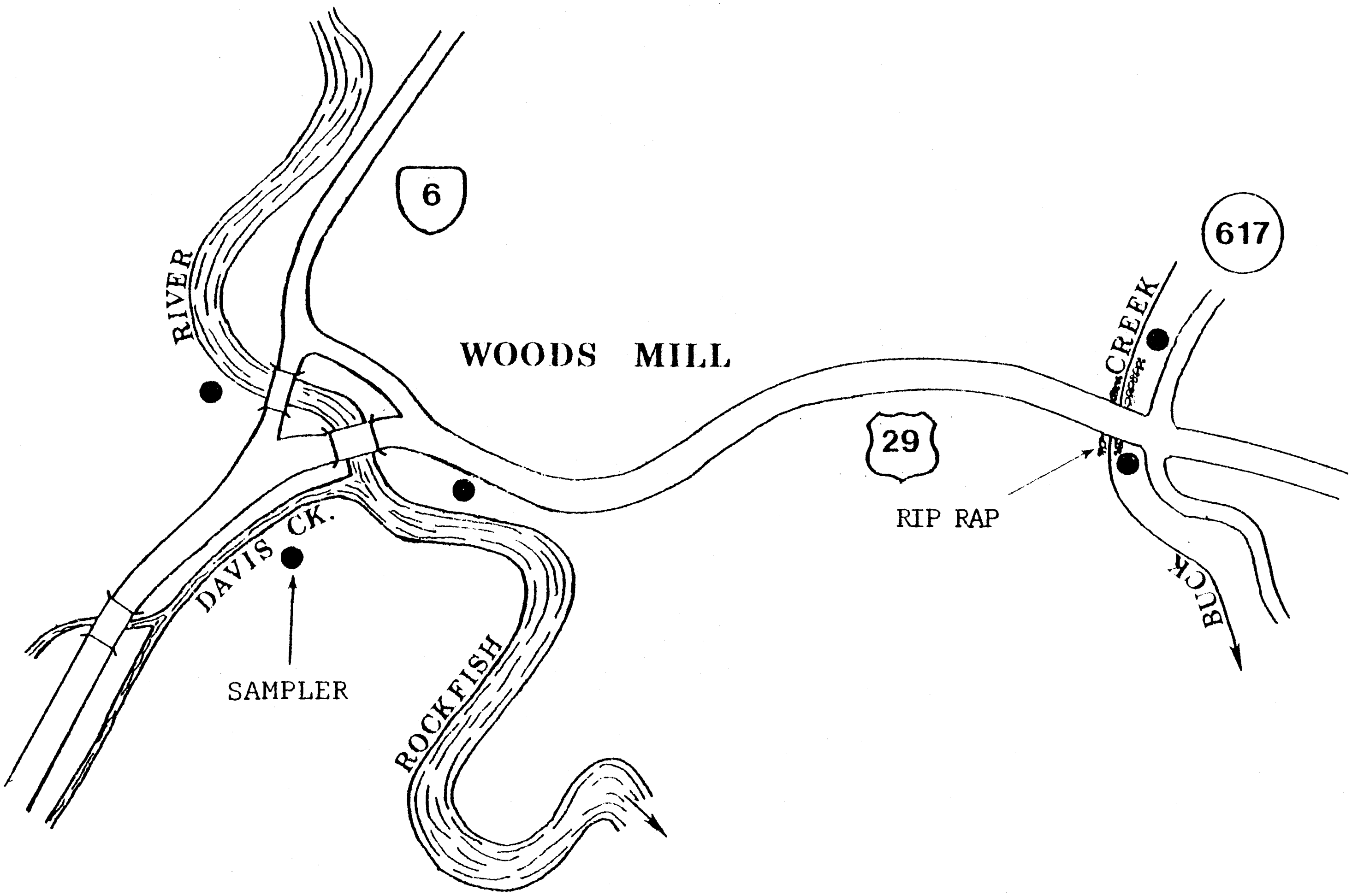


Figure D-2. Plan view of Rockfish River sampler locations. No erosion controls.
Plan view of Buck Creek sampler locations and erosion controls.

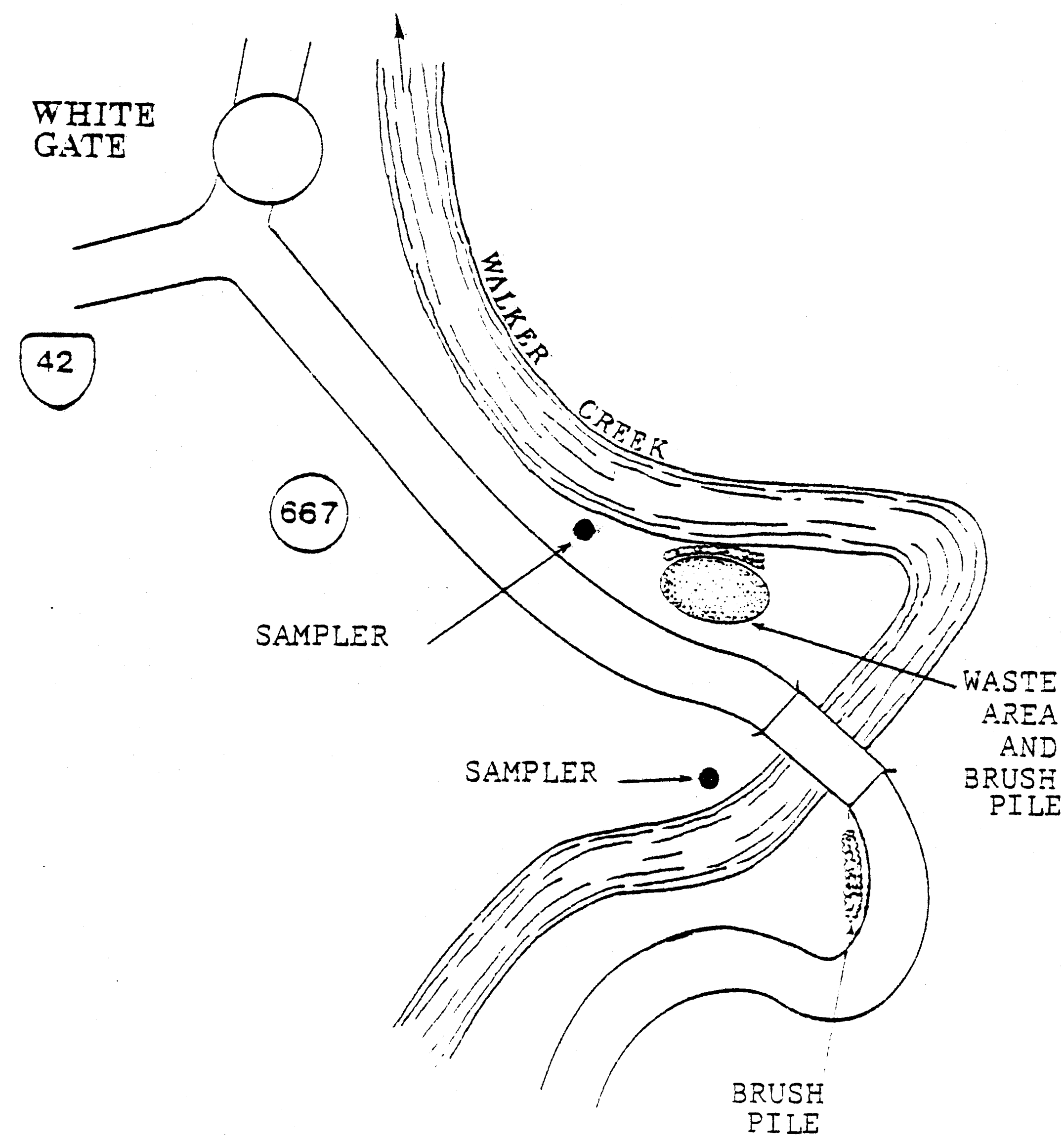


Figure D-3. Plan view of Big Walker Creek erosion controls and sampler locations.

2404