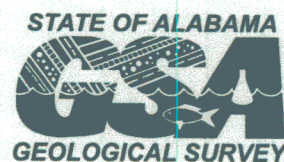
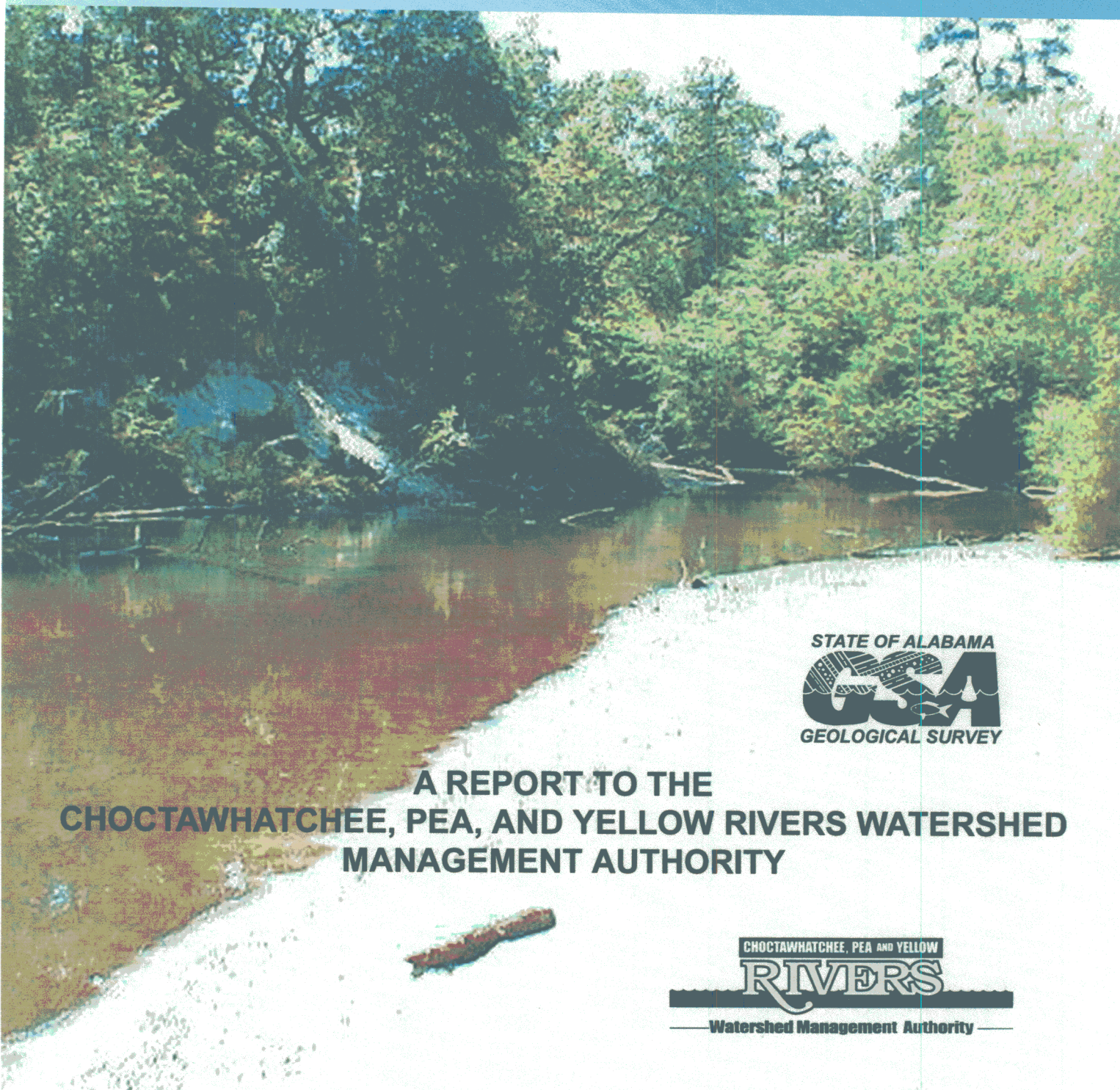


ASSESSMENT OF WATER RESOURCES IN THE YELLOW RIVER WATERSHED IN SOUTH-CENTRAL ALABAMA: SURFACE WATER AND BIOLOGICAL RESOURCES



**A REPORT TO THE
CHOCTAWHATCHEE, PEA, AND YELLOW RIVERS WATERSHED
MANAGEMENT AUTHORITY**



GEOLOGICAL SURVEY OF ALABAMA

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Submitted in partial fulfillment of a contract with the Choctawhatchee, Pea, and Yellow Rivers
Watershed Management Authority

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EXECUTIVE SUMMARY

The Assessment of Water Resource Availability, Protection, and Utilization for the Yellow River Watershed was commissioned by the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority. Work on the project was initiated by the Geological Survey of Alabama on May 1, 2001. The study was funded by the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority (CPYRWMA) and the Geological Survey of Alabama (GSA).

The purpose of the project is to generate data that may be used by the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority, local, state, or federal agencies, or citizens to develop, manage, and protect the water resources of the Yellow River Watershed. The project developed localized hydrogeochemical, biologic, and cultural resource data sets for use in possible development of water supplies from the Yellow River Watershed of south-central Alabama. The streams evaluated during this project are Yellow River in Covington, Crenshaw, and Coffee Counties and Five Runs Creek in central Covington County. This report contains the surface-water, biologic, and cultural resource data.

The data contained in this report are used to determine the hydrogeochemical and biologic character of the selected streams and to determine the viability of selected watersheds for development of surface-water sources. It characterizes cultural resources, threatened and endangered species, sedimentation, and water quality and quantity. Other data required prior to development of a surface-water source such as justification of surface-water need, wetland impacts and mitigation, determination of alternate water sources, and preliminary engineering designs must be considered in future work efforts.

Constituent loading is an important consideration for development of a surface water source. Excessive loading of nutrients or sediment may profoundly affect the quality of water in a stream or impoundment or may substantially reduce effective life of an impoundment or severely diminish the intended uses of the impoundment. Five Runs Creek and Yellow River have very low nutrient loads. All geochemical constituents measured in Five Runs Creek and Yellow River were relatively low when compared to published standards or other streams in the region. Commonly, constituents of concern in streams in South Alabama are nutrients, bacteria, and sediment. However, these constituents were consistently lower than in other streams previously evaluated.

Southeast Alabama is well known for the excessive erosion and sedimentation rates that occur in this area. Five Runs Creek and Yellow River have relatively low sedimentation rates when compared to the nine other streams evaluated in previous Geological Survey of Alabama studies. Although these sedimentation rates are relatively small, steps should be taken to maintain current rates or in the future reduce them. However, the sedimentation rates determined in this assessment do not pose significant impacts on the project life of the potential reservoirs, their effectiveness for supplying water, or the downstream estuaries or the Gulf of Mexico that eventually receive the sediment transported by the evaluated streams.

Dissolved oxygen concentrations were acceptable throughout the monitoring period for both streams.

The portion of the Five Runs Creek Watershed monitored during this project is approximately 70.5 mi² in central Covington County. The normal pool water surface area measured for the potential Five Runs Creek Reservoir is 2.65 mi² or 1,693 acres. The volume of the potential reservoir at normal pool is approximately 16,900 acre-feet. The monitored portion

of the Yellow River Watershed contains approximately 299 mi² in portions of Crenshaw, Coffee, and Covington Counties. According to guidelines established for this series of stream evaluations prepared by the Geological Survey of Alabama in the Choctawhatchee, Pea, and Yellow River Watersheds, no potential reservoir site will be considered for main stems of major rivers in the region. Therefore, no potential reservoir site has been considered for the main stem of Yellow River. However, future water use from the river may be developed by off-stream storage or inter-drainage area transfer.

Sustainable water quantity and required within-year impoundment storage was determined for the Five Runs Creek watersheds. A maximum draft rate of 50 percent was selected in order to ensure that the proposed reservoir would refill each year and to ensure adequate downstream water release. Mean daily annual discharge was evaluated to establish the viability of the potential reservoir to function as an adequate water source. The potential reservoir at Five Runs Creek will be capable of supplying water at a 40 percent draft rate of mean daily discharge (after evaporation loss). The quantity of water supplied at this rate is approximately 30 million gallons per day (mgd). Although no reservoir is proposed for the Yellow River, water may be withdrawn in the future to supply direct in-channel withdrawal or off-stream storage. Yellow River is capable of supplying water at a 50 percent draft rate of mean daily discharge (after evaporation loss). The quantity of water supplied at this rate is approximately 160 mgd. These quantities and draft rates are preliminary estimates. Additional future work elements required for a reservoir permit will verify these findings.

Biological and habitat data collected during this study indicate that sites selected for possible water resource projects vary with respect to biological and habitat conditions. Five Runs Creek is a typical sand-bottomed Coastal Plain stream. Sand-mud shoals with occasional gravel are common at bends, pools are deep with a thin silt or mud layer, and tree-branch snags form glide-run habitats most productive of invertebrates. Habitat scores for Five Runs Creek indicated good conditions compared to fair to excellent conditions at Clear Creek. The benthic macroinvertebrate community composition of streams in the Yellow River watershed is determined by a number of variables including stream size and gradient, land use/land cover, localized disturbance and pollution effects, geologic/geographic template, and microclimates. Benthic macroinvertebrate community composition of Five Runs Creek indicated good stream quality, but biological condition was less than optimal likely due to a combination of nonpoint runoff from agricultural areas and around the city of Andalusia.

A 1996 study by the Geological Survey of Alabama identified 49 fish species in the Alabama portion of the Yellow River watershed. More recent sampling in the Alabama portion of the Yellow River main channel added the gulf sturgeon (*Acipenser oxyrinchus desotoi*). Juvenile individuals 12 inches total length have been found at two locations in the Yellow River: upstream of Covington Co. Hwy. 4 and downstream of Ala. Hwy. 55. These recent sightings of juvenile gulf sturgeon are particularly significant because they indicate the presence of spawning sturgeon in the Yellow River system in Alabama.

INTRODUCTION

The Assessment of Water Resource Availability, Protection, and Utilization for the Yellow River Watershed was commissioned by the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority. Work on the project was initiated by the Geological Survey of Alabama on May 1, 2001. The study was funded by the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority (CPYRWMA) and the Geological Survey of Alabama (GSA).

All public-water supplies in southeast and south-central Alabama are produced from ground-water sources. Widespread, declining water levels in wells, periodic water shortages in major population centers, and concern that ground-water sources may not adequately satisfy future water demand have prompted this assessment. The purpose of the project is to generate data that may be used by the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority, local, state, or federal agencies, or citizens to develop, manage, and protect the surface-water resources of the Yellow River Watershed. The project consists of a comprehensive evaluation of localized hydrogeochemical, biologic, and cultural resource data sets for possible use in development of water supplies from Yellow River and Five Runs Creek Watersheds of south-central Alabama (fig. 1).

The data presented in this report characterize water quality, stream discharge, biological habitat conditions, species of concern, and cultural resources. The water quality and stream discharge data sets are composed of samples collected by the GSA biweekly during portions of the 2001 and 2002 water years. These data may be utilized to determine the quantity and quality of water in the selected streams and to evaluate the effects of land use practices in each assessed watershed so that watershed management practices can be developed to protect and improve water quality and habitat conditions. The archaeological resource and infrastructure data included in this report may be used to evaluate development potential of surface water for future water supplies.

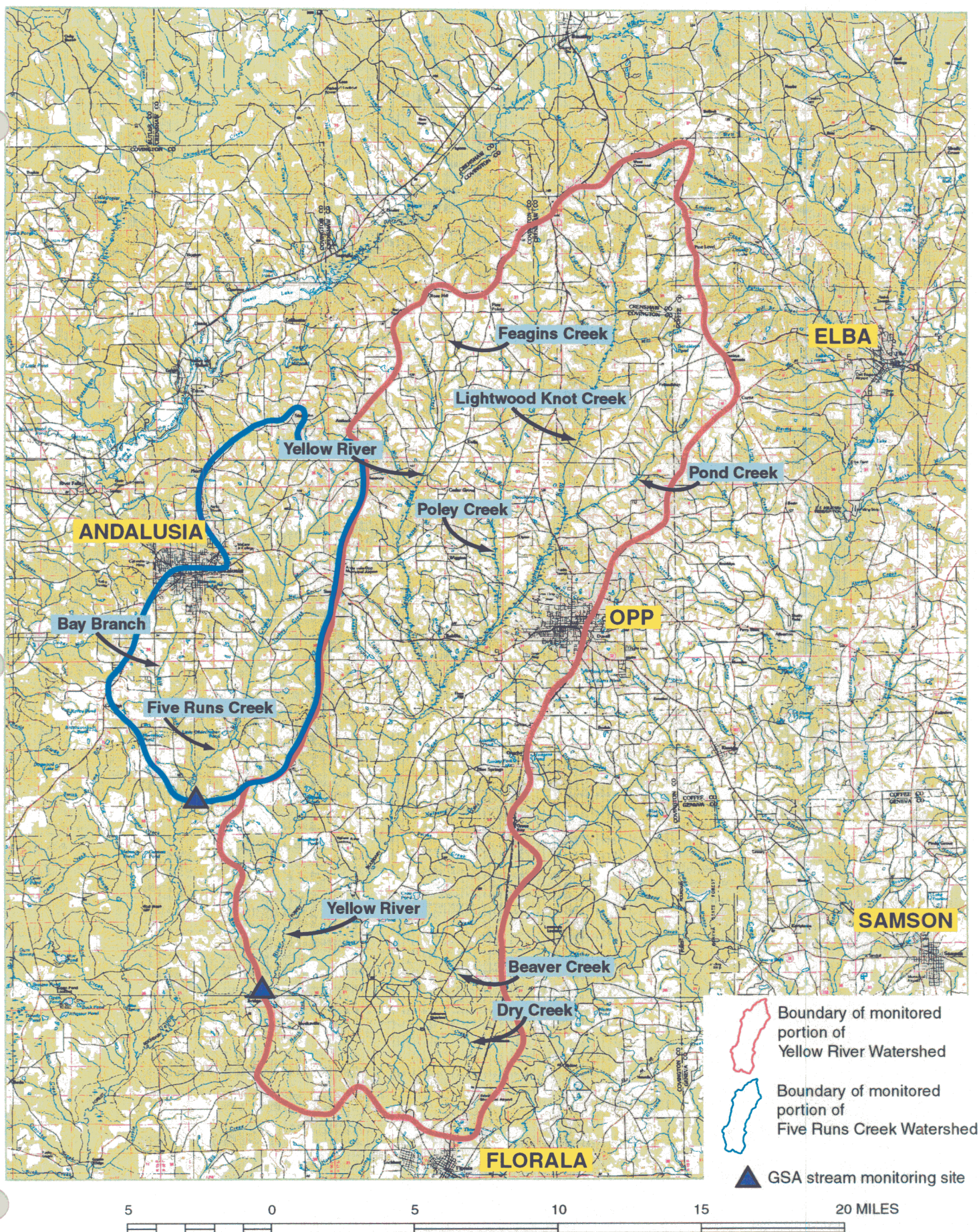


Figure 1.--Monitored portions of the Yellow River and Five Runs Creek Watersheds.

Surface water development can only begin after approval has been obtained from the U.S. Army Corps of Engineers (USACOE), Alabama Department of Environmental Management (ADEM), and the United States Environmental Protection Agency (USEPA). The USACOE 404 permit process requires consideration of eight major issues (Krizman, House-Pearson, and Burke, 1997; and Hosey, 2000):

1. Justification of the need for surface-water development.
2. Survey of cultural resources in the proposed impoundment area.
3. Evaluation of threatened and endangered species.
4. Analyses of alternative water sources.
5. Evaluation of wetlands impacts by a proposed impoundment and mitigation plan.
6. Evaluation of water quality and procurement of the ADEM 401 Water Quality Certification.
7. Completion of an Environmental Impact Statement for the proposed impoundment project.
8. Preparation of a preliminary engineering design for the impoundment.

The ADEM 401 Water Quality Certification requires:

1. Data showing that an impoundment will not degrade water quality.
2. Turbidity data.
3. Dissolved oxygen concentrations.
4. Plan for maintenance of specific downstream discharge.
5. Storm-water permit for construction.
6. Plan for treatment of storm-water runoff.
7. Evidence for use of best management practices (BMPs) in the proposed impoundment watershed for protection and improvement of water quality.
8. Fuel tank spill prevention measures.

The data contained in this report are used to determine the viability of the selected watersheds for development of surface-water sources. The data also characterize cultural resources, threatened and endangered species, sedimentation, and water quality and quantity. Other data required for the USACOE 404 permit such as justification of surface-water need, wetland impacts and mitigation for surface-water development, determination of alternate water sources, and preliminary engineering designs must be considered in future work efforts. Items 5 through 8 for the ADEM 401 Water Quality Certification must also be considered in future work efforts.

ACKNOWLEDGMENTS

The Geological Survey of Alabama would like to acknowledge those individuals and agencies whose participation and cooperation have made this study possible. State Senator Jimmy Holley, Speaker of the Alabama House of Representatives Seth Hammet, CPYRWMA Executive Director Barbara Gibson, Covington County Directors Glen Zorn and Jack Goolsby, and the Board of Directors of the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority were instrumental in initiating this project. The Geological Survey of Alabama would also like to acknowledge the Covington County Commission and Chairman Greg White for their support.

WATER USE

Water use in Alabama is monitored by a cooperative program of the United States Geological Survey (USGS) and the Alabama Department of Economic and Community Affairs (ADECA) Office of Water Resources. At five-year intervals data for water use in the state are compiled and the information is published (Mooty and Richardson, 1995). The data indicate that approximately 39 million gallons of ground water per day are used in the Choctawhatchee, Pea, and Yellow Rivers Watersheds. The quantity of water used in these watersheds does not include portions of the cities of Dothan and Troy that are outside the watershed boundaries. Therefore, this value of water use is probably less than the actual water use for the area. The actual quantity of ground water being used in the project area for 1995 was approximately 60 million gallons per day. Approximately 65 percent of this water was used for public and commercial water supply.

As is the case with most streams in South Alabama, the water in Five Runs Creek and Yellow River flows across Northwest Florida and into the Gulf of Mexico. Future water development may include these surface-water sources. Therefore, cooperation between Alabama and Florida concerning water use and water development issues is essential. The data in this report are essential in determining future water use and development plans in South Alabama and Northwest Florida.

SURFACE-WATER ASSESSMENT

GEOGRAPHIC CHARACTERIZATION OF ASSESSED WATERSHEDS

The Yellow River Watershed contains the Yellow River and three major tributaries; Lightwood Knot Creek, Poley Creek, and Five Runs Creek. The water from these streams flows through Covington County, Alabama, across northwest Florida and enters the Gulf of Mexico through Pensacola Bay.

The Yellow River Watershed is contained in portions of Covington, Crenshaw, and Coffee counties in south Alabama. The watershed area covers approximately 482 square miles (mi²) of the Alabama Coastal Plain. The Five Runs Creek Watershed covers approximately 123 mi². These watersheds lie primarily in the Dougherty Plains physiographic region. The Dougherty Plains region is primarily underlain by limestone residuum that forms broad, flat ridges (Sapp and Emplaincourt, 1975). Streams dissect this area and form relatively narrow floodplains. Elevations in this area are generally less than 350 feet above mean sea level and topographic relief is generally less than 100 feet. The downstream portion of the watershed in Alabama lies in the Southern Pine Hills region. Streams that flow across this area form relatively broad floodplains and a relatively large number of wetland areas. Elevations in this area are generally less than 300 feet above mean sea level and topographic relief is generally less than 100 feet.

HYDROGEOLOGY AND GEOMORPHOLOGY

The Yellow River Watershed is underlain by sediments of Tertiary and Miocene Age that are primarily composed of unconsolidated or poorly consolidated sand and clay, thinly bedded limestone, and residuum. Erosion by water movement has incised stream valleys, exposing the Tallahatta and Lisbon Formations and Residuum derived from solution and collapse of limestones in the Jackson Group and Oligocene Series and slumping of Miocene Series sediments. Near the Florida border the Yellow River flows across sediments of the Miocene Series. Ground water moving through these geologic units issues from seeps and springs in the stream valleys and is the major source of stream discharge during drought conditions. The topographic and geomorphologic characteristics of these streams cause flashy storm runoff. Stream water levels are highly variable, especially during winter and spring. The stream channels are characterized by steep banks and stream beds composed of thick silt and sand with exposures of limestone and residuum.

Five Runs Creek is classified as mature in the downstream reach near the monitoring site. This portion of the stream is characterized by a broad, flat flood plain, and frequent meanders in a narrow meander belt. The gradient for the downstream reach of the stream is 5 feet per mile. The upstream headwaters portion of the stream is characterized by narrow floodplains and v-shaped valleys. The stream gradient for the reach of Five Runs Creek in the headwaters near the town of Andalusia is 8 feet per mile. Yellow River is classified as mature in the downstream reach near the monitoring site at highway 55. This portion of the stream is characterized by a broad, flat flood plain, frequent meanders in a relatively narrow meander belt, and a few cutoffs and oxbow lakes. The gradient for the downstream reach of the stream is 3 feet per mile. The upstream headwaters portion of the river is characterized by narrow floodplains, v-shaped valleys, and narrow meander belts. The stream gradient for the reach of Yellow River in the headwaters in northern Covington County is 15 feet per mile.

The portion of the Five Runs Creek Watershed monitored during this project is approximately 70.5 mi² in central Covington County. The stream flows southward and enters Yellow River approximately 4 miles north of the Florida boundary. The GSA monitoring site was at the county road crossing of Five Runs Creek near the northern boundary of the Conecuh National Forest in section 29, Township 3 North, Range 16 East (fig. 2).

The monitored portion of the Yellow River Watershed contains approximately 299 mi² in southern Crenshaw County, western Coffee County, and central and northern Covington County. The stream flows southward and enters Florida approximately 13 miles west of the town of Florala (fig. 3). The GSA monitoring site for Yellow River was at the State highway 55 crossing approximately 7 miles north of the Florida State boundary.

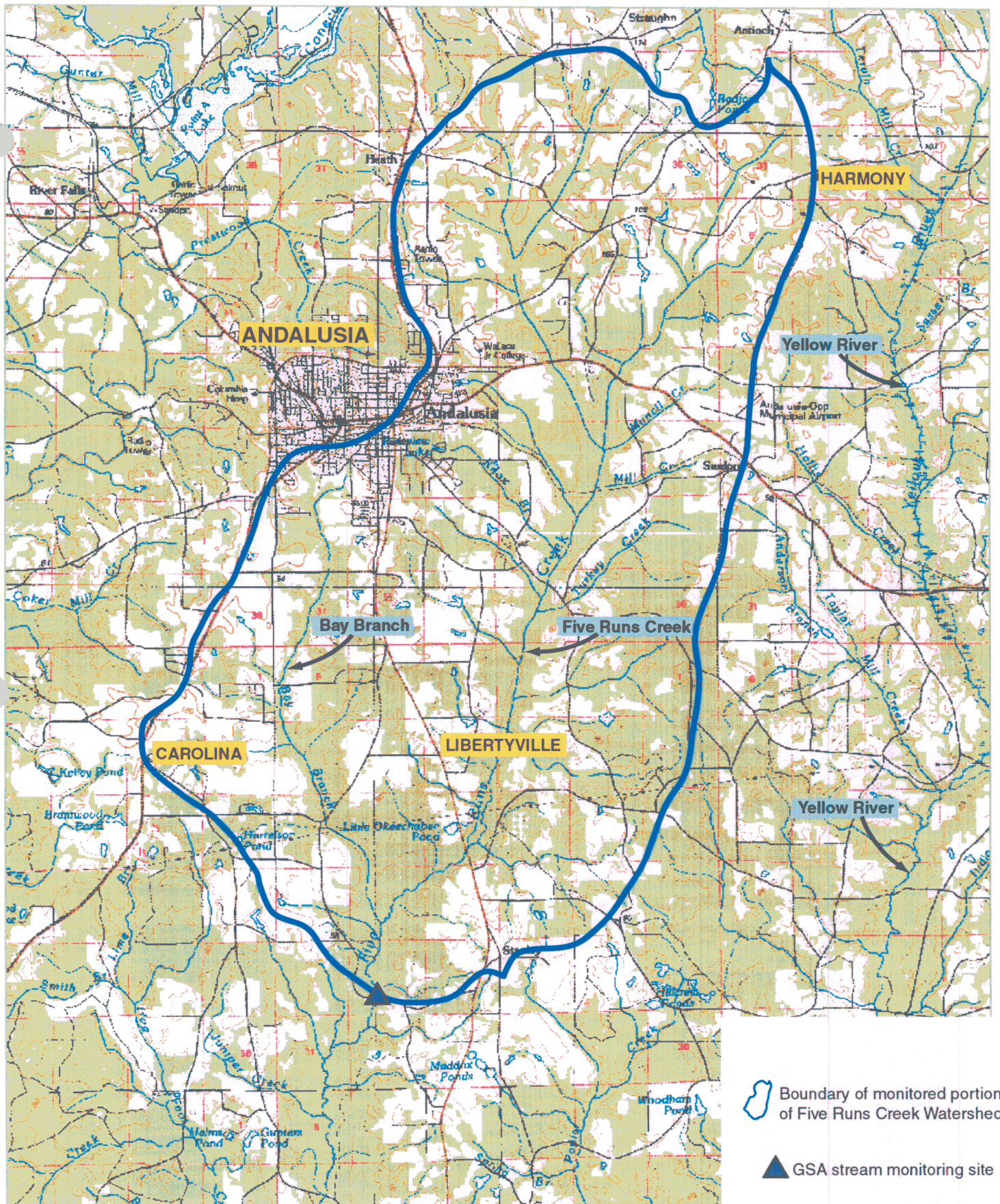


Figure 2.--Monitored portion of the Five Runs Creek Watershed.

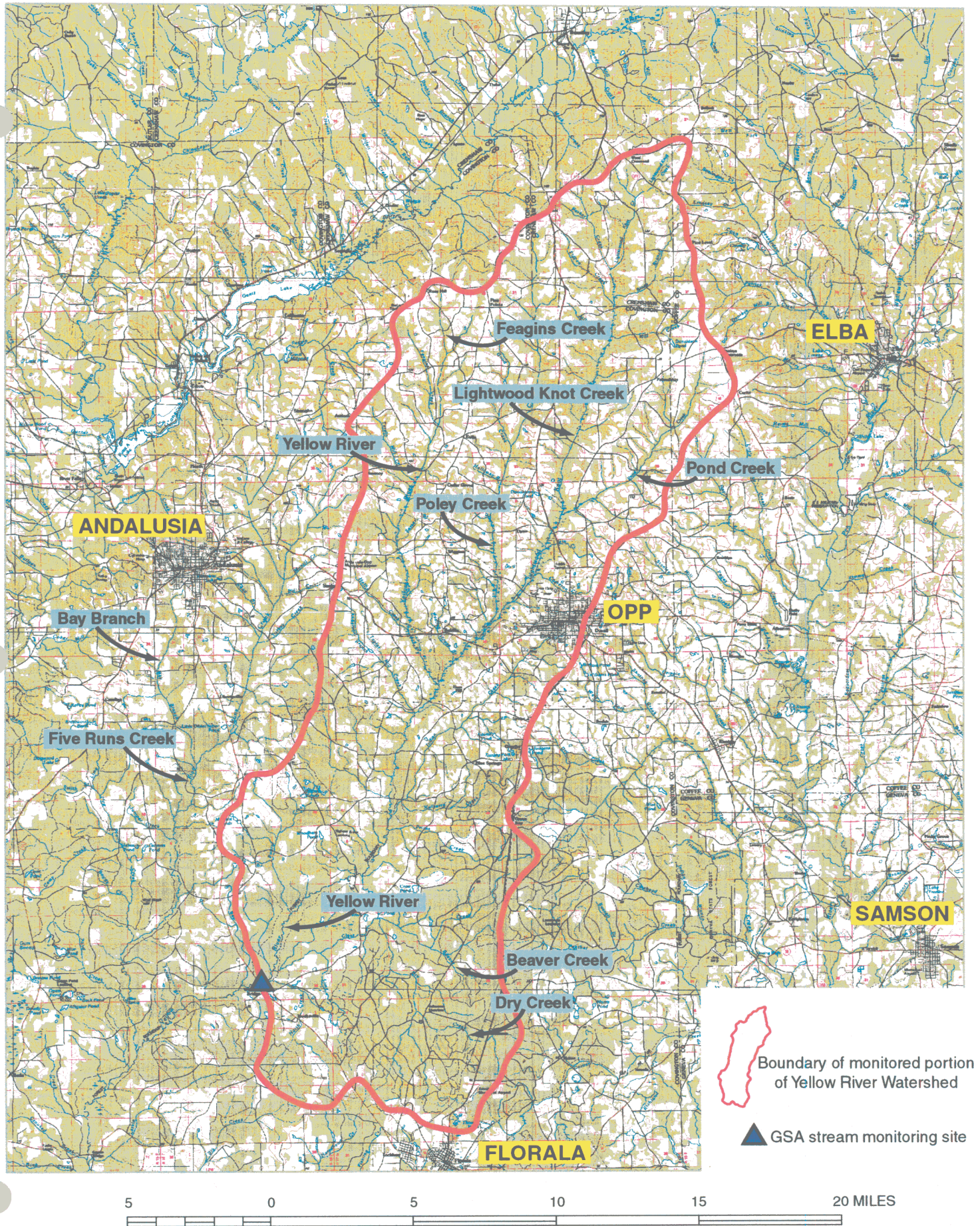


Figure 3.--Monitored portion of Yellow River Watershed.

INFRASTRUCTURE

Development of surface-water resources by impoundment of streams requires inundation of a portion of the watershed. Structures affected by impoundments will require relocation from the impounded area. Five types of structures are present in the possible future impounded areas (table 1). One major electrical transmission line traverses the proposed impoundment area. Roadways, bridges, and buildings are also present in the area. Three small impoundments will also be affected.

Table 1—Infrastructure in or near potential impounded areas of project watersheds.

Proposed Reservoir Watershed	Roadway Crossing	Residential Structures	Commercial Structures	Electrical Transmission Lines	Impoundments
Five Runs Creek	9	9	3	1	3

ARCHAEOLOGICAL ARTIFACTS

Archaeological artifacts, both historic and pre-historic, are important indicators of peoples and cultures that inhabited the land in the past. Archaeological sites are primarily characterized by Aboriginal artifacts that include lithic and ceramic material. Lithic material is composed of thermally altered chert flakes, chert tools, blades and axes, and chert and quartzite projectiles. Ceramic material consists of numerous types of pottery and ornaments. Artifacts in possible areas of construction or water impoundment must be investigated prior to initiation of land development activities. Although no archaeological artifacts have been documented by the Alabama Museum of Natural History in the possible future impounded area of Five Runs Creek, several sites have been documented in the general area of both Five Runs Creek and Yellow River in Covington County. These sites are characterized and listed in appendix A.

CHEMICAL AND PHYSICAL PARAMETERS

STREAM DISCHARGE

Discharge is a primary physical parameter that influences or affects surface-water quality. Ionic concentrations, conductance, dissolved oxygen (DO), biochemical oxygen demand (BOD), total suspended solids (TSS), bedload sediment, and bacterial concentrations are all influenced by the volume of stream discharge. Discharge is an essential component of constituent loading calculations and interwatershed comparisons of ionic concentrations and normalization of data. Characterization of discharge is also a primary consideration in the development of a stream as a water supply source.

The evaluated streams generally attain low flow conditions during July or August. Except for occasional runoff from isolated cyclonic storms, most of the discharge from the watersheds during August, September, and October of each year can be attributed to ground-water seepage. Field observations indicate that storm-water runoff is flashy and is characterized by rapid rise and fall of stream water levels. Although no flooding occurred during the monitoring period, flooding occurs periodically and is caused by cyclonic storms associated with spring weather fronts or by summer and fall tropical storms or hurricanes that move through south Alabama.

The GSA data set is composed of biweekly discharge measurements collected during the 2001 and 2002 water years. The data were collected using a Price AA flow meter attached to a top set wading rod or a bridgeboard. The data were collected according to United States Geological Survey (USGS) flow measurement guidelines. Continuously collected water level data were available for Yellow River from a flood monitoring station installed by the CPYRWMA in May 2001 at the state highway 55 crossing. These data were utilized in combination with GSA bi-weekly discharge measurements to calculate average daily discharge values for Yellow River and Five Runs Creek during the monitoring period. Average daily discharge values are shown in table 2 and were used in some of the statistical analyses requiring long-term and daily discharge data, included later in this report. A discharge rating table for the Yellow River is shown in table 3.

Low flow discharge is important in determining the contribution of ground water to surface-water discharge during periods of drought. Low flow is also important in determining the volume of minimum flow that can be expected during specific intervals of time. Two classifications of low flow, 7-day Q_2 and 7-day Q_{10} , are generally accepted for characterizing minimal stream flow conditions. Seven day Q_2 is defined as the lowest discharge in a stream that occurs over 7 days during a 2-year period. Seven day Q_{10} discharge generally occurs during extreme drought conditions and is defined as the lowest discharge in a stream that occurs over 7 days during a 10-year period. Seven day Q_2 and 7-day Q_{10} discharge values were calculated for each of the five project streams (table 2). The low flow discharges were determined using calculated values from measured discharge (Peirce, 1967) and estimated low flows using a technique developed by Bingham (1979).

Five Runs Creek

During the study period, maximum discharge of 521 cubic feet per second (cfs) was measured at Five Runs Creek on February 8, 2002 (fig. 4). Minimum discharge during the monitoring period was 2.2 cfs and was measured on May 27, 2002 (fig. 4). The 7-day Q_2

discharge for Five Runs Creek is 3.6 cfs (0.05 cfs per square mile of drainage area (cfsm)) (fig. 4). The 7-day Q_{10} discharge is 2.0 cfs (0.03 cfsm) (fig. 4).

Yellow River

During the study period, maximum discharge of 1,280 cfs was measured at Yellow River on August 7, 2001 (fig. 5). Minimum discharge during the monitoring period was 10 cfs and was measured on May 27, 2002 (fig. 5). The 7-day Q_2 discharge for Yellow River is 120.6 cfs (0.40 cfsm) (fig. 5). The 7-day Q_{10} discharge is 67.0 cfs (0.22 cfsm) (fig. 5).

A flood warning station for Yellow River is located at the Highway 55 crossing. The station is operated by the CPYRWMA and collects water level and precipitation data. The GSA discharge data collected during the project were used to prepare a rating table that may be used to convert water level data collected at the flood warning station to discharge. Due to drought conditions that persisted throughout the Yellow River project, high water levels and their corresponding discharges were not measured. Therefore, the rating table only contains data for water levels and discharge less than bank-full. Figure 6 depicts the Yellow River stream channel and floodplain profile. The rating table is contained in table 3.

Table 2—Discharge measured in project streams.

Watershed	Average Mean Daily Discharge (May 2001-July 2002)		Adjusted Mean Daily Discharge (1967-2002)		Base Flow Discharge Millions gallons per day (Mgd)	
	cfs	Mgd	cfs	Mgd	7-day Q_2	7-day Q_{10}
Five Runs Creek	63	41	118	76	2.3	1.3
Yellow River	268	173	502	325	78.0	43.3

Table 3—Discharge rating table for Yellow River.

Water Level (CPYRWMA Station)	Water Level Elevation	Discharge
feet	(Ft. AMSL)	cfs
.5	104.83	38
1	105.33	98
1.5	105.83	153
2	106.33	208
2.5	106.83	258
3	107.33	310
3.5	107.83	365
4	108.33	415
4.5	108.83	465
5	109.33	513
5.5	109.83	560
6	110.33	610
6.5	110.83	650
7	111.33	695
7.5	111.83	735
8	112.33	780
8.5	112.83	820
9	113.33	865
9.5	113.83	900
10	114.33	935
10.5	114.83	975
11	115.33	1,010

Figure 4.--Five Runs Creek Discharge Rating Graph

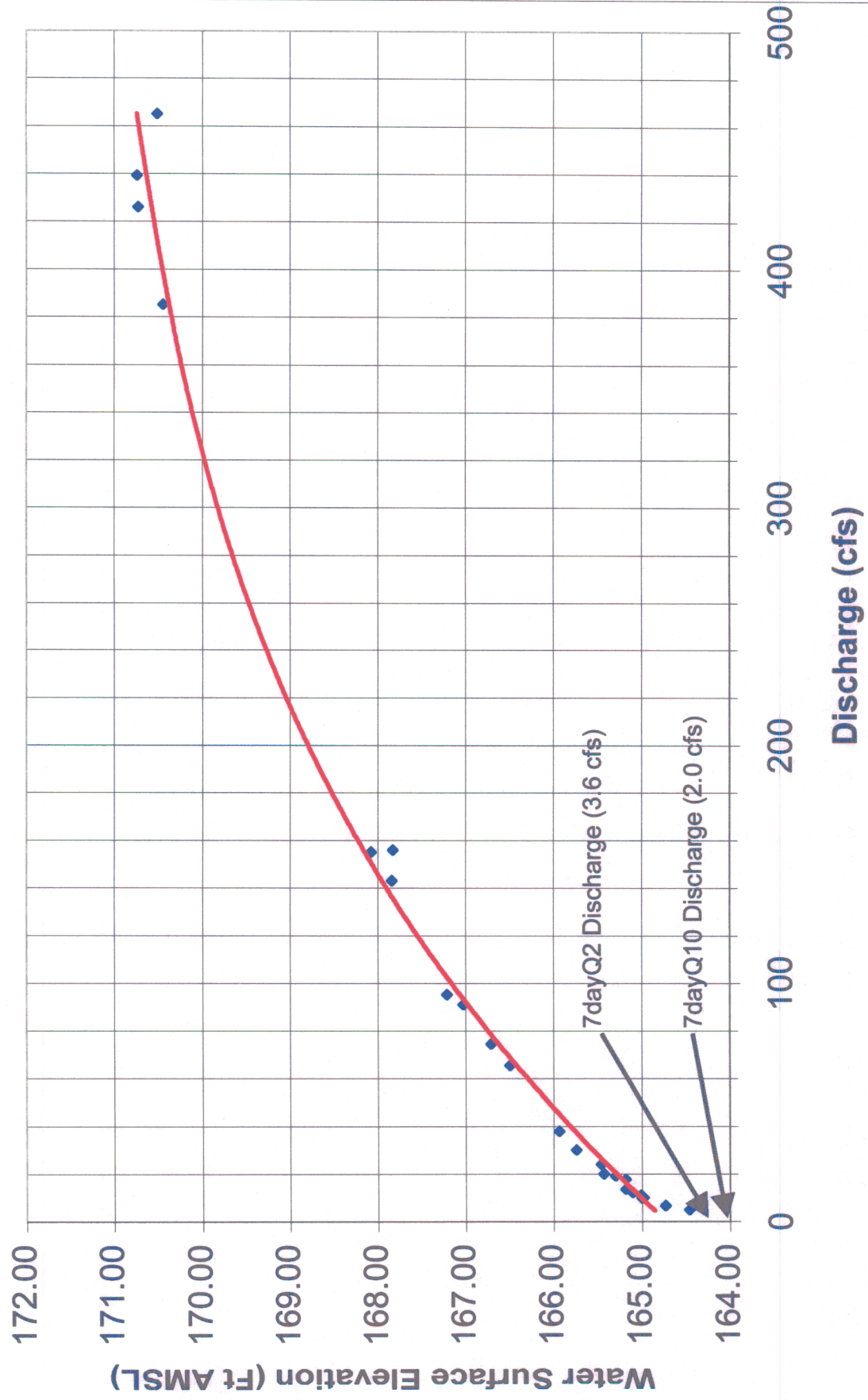
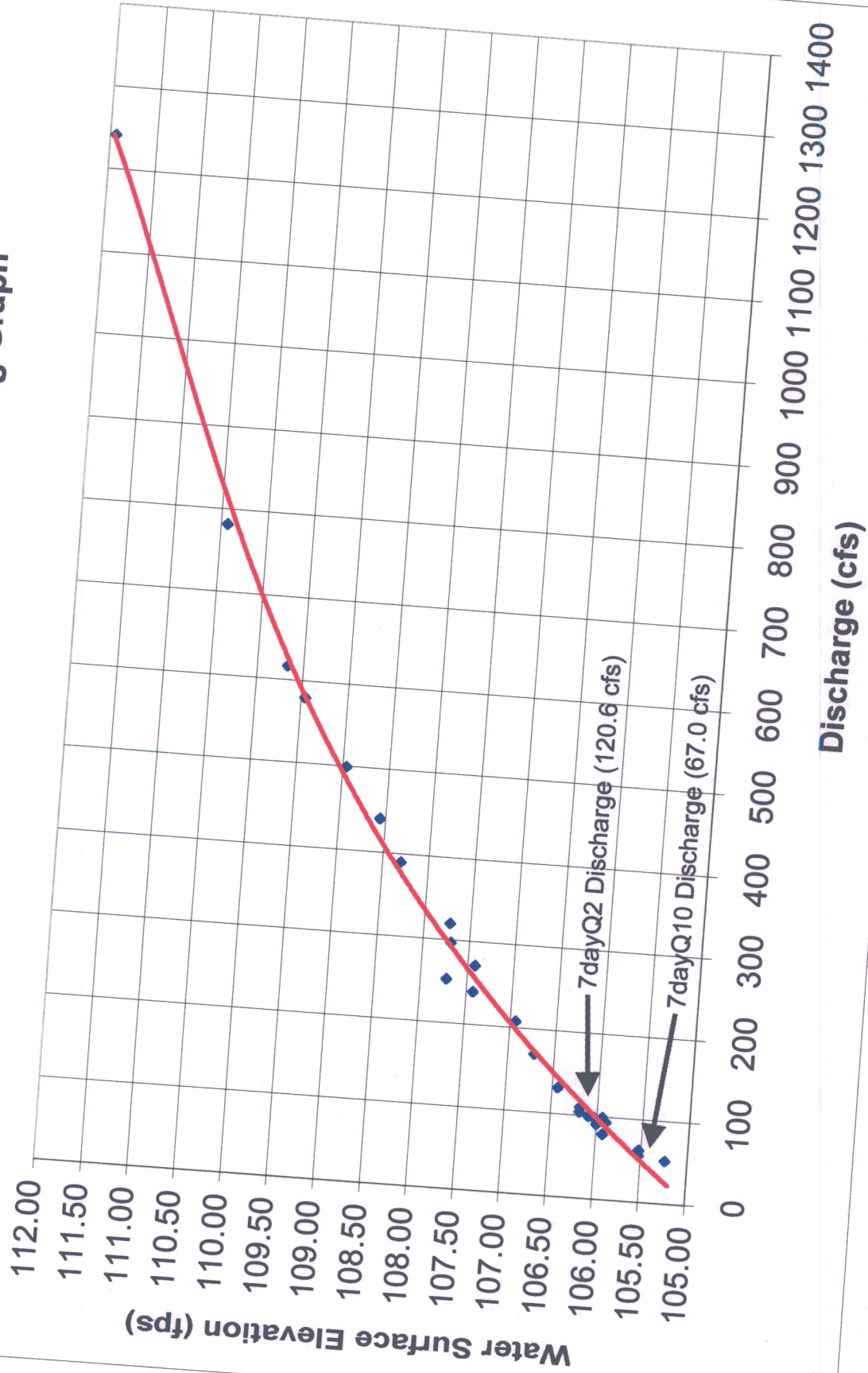
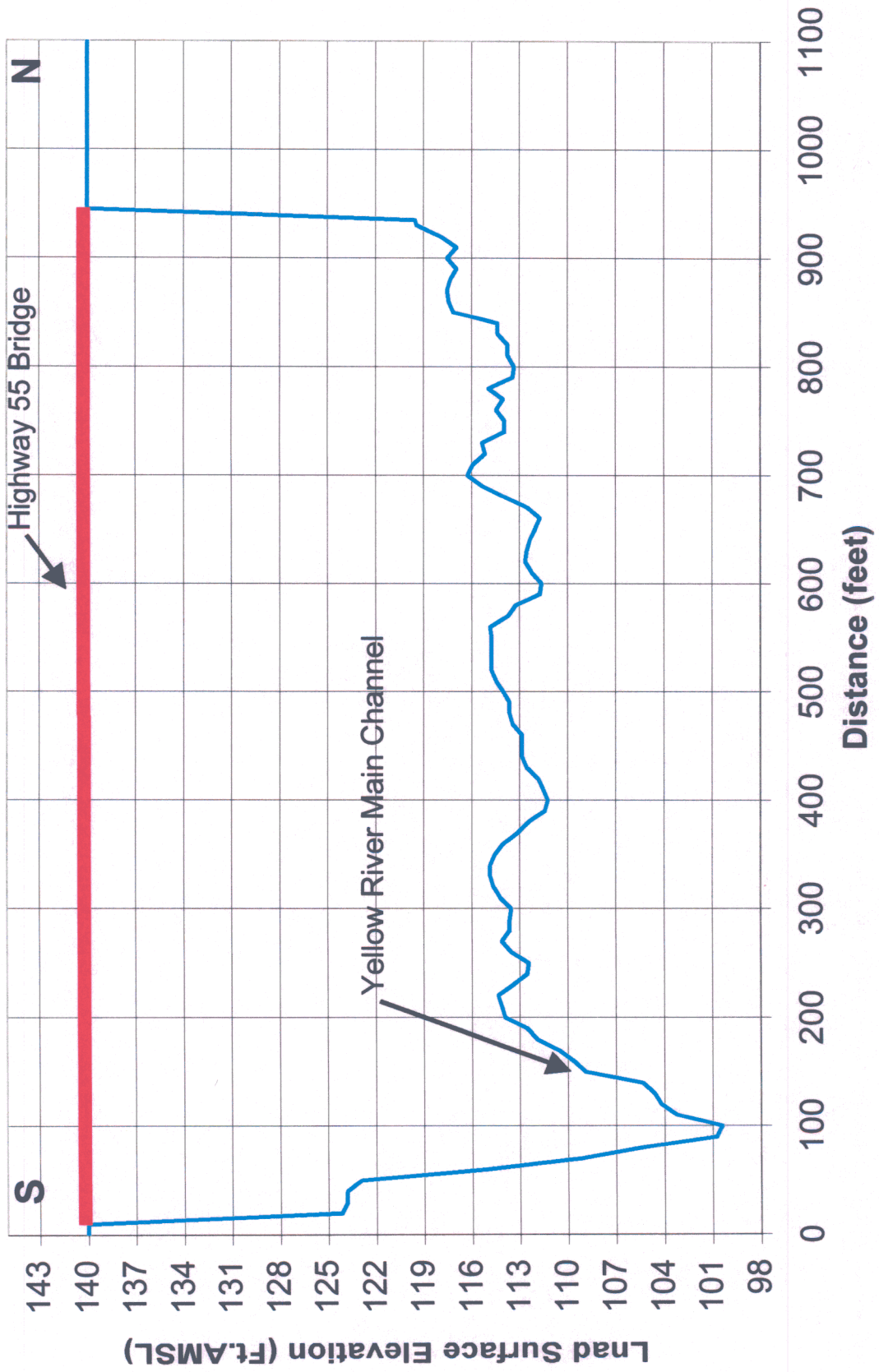


Figure 5.-- Yellow River Discharge Rating Graph



**Figure 6.--Yellow River at Highway 55 Crossing
River Channel and Flood Plain Profile**



STREAM TEMPERATURE

Water temperature is an important catalyst that affects the physical and geochemical characteristics of a stream. Dissolved oxygen, biological activity and equilibrium reactions are significantly influenced by water temperature. The standard for maximum temperature established by the Alabama Department of Environmental Management (ADEM, 1992) for surface water classified as Fish and Wildlife is 32.2°C. The maximum temperature standard was not exceeded in any monitored stream during the project period (table 4).

Table 4—Temperature values measured in project streams.

Watershed	Maximum Temperature (Degrees C)	Minimum Temperature (Degrees C)	Average Temperature (Degrees C)
Five Runs Creek	26	4	19
Yellow River	27	7	20

SPECIFIC CONDUCTANCE

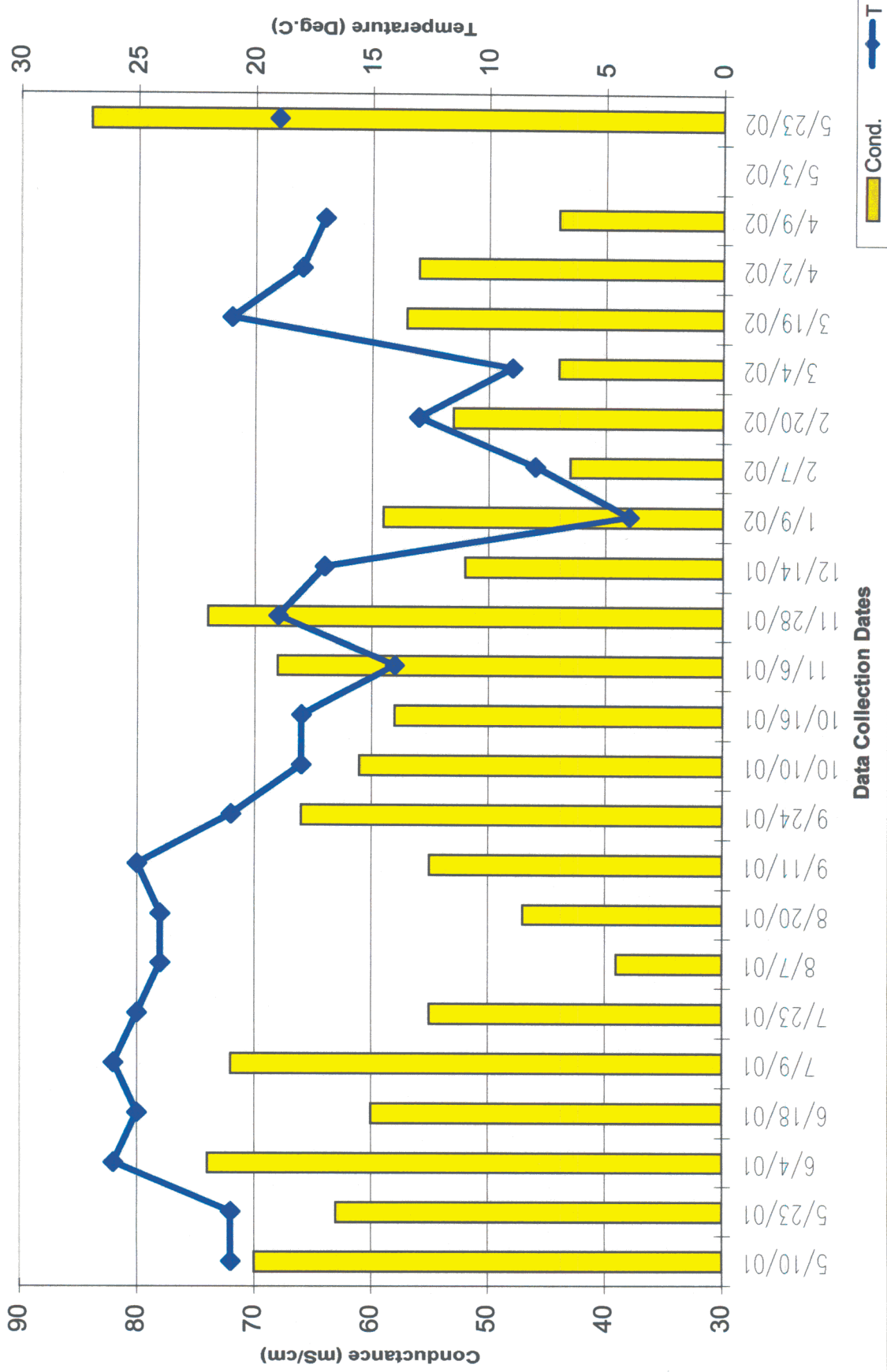
Surface water in each project watershed is characterized by a unique specific conductance (microseimens/centimeter ($\mu\text{S}/\text{cm}$)) profile based on physical and chemical properties. The variability of conductivity is influenced by differences in stream temperature, discharge, total dissolved solids, local geology and soil conditions, and possible ionic influxes from nonpoint sources of pollution. The effects of temperature on fluctuations of conductivity have been well documented (Hem, 1985). Long-term trends of temperature and conductivity values correlate well for the streams throughout the monitoring period (figs. 7, 8). However, the effect of discharge was also observed, as shown in figures 9, 10. The long-term trend of discharge and conductivity is an inverse relationship. As discharge increases, conductivity decreases and as discharge decreases, conductivity increases. The relationship of discharge and conductivity may also be dependent on the type of surface- and ground-water flow systems and the amount and nature of nonpoint source pollutants that enter the stream.

Low conductivity values were measured during the largest discharge events measured during the project period and are indicative of rainfall that made up the majority of stream discharge during these measurement periods (table 5). Low conductivity may also indicate that the concentration of nonpoint source pollutants commonly flushed into streams during high discharge events was negligible. The highest conductivity values were measured during periods of minimal discharge (table 5).

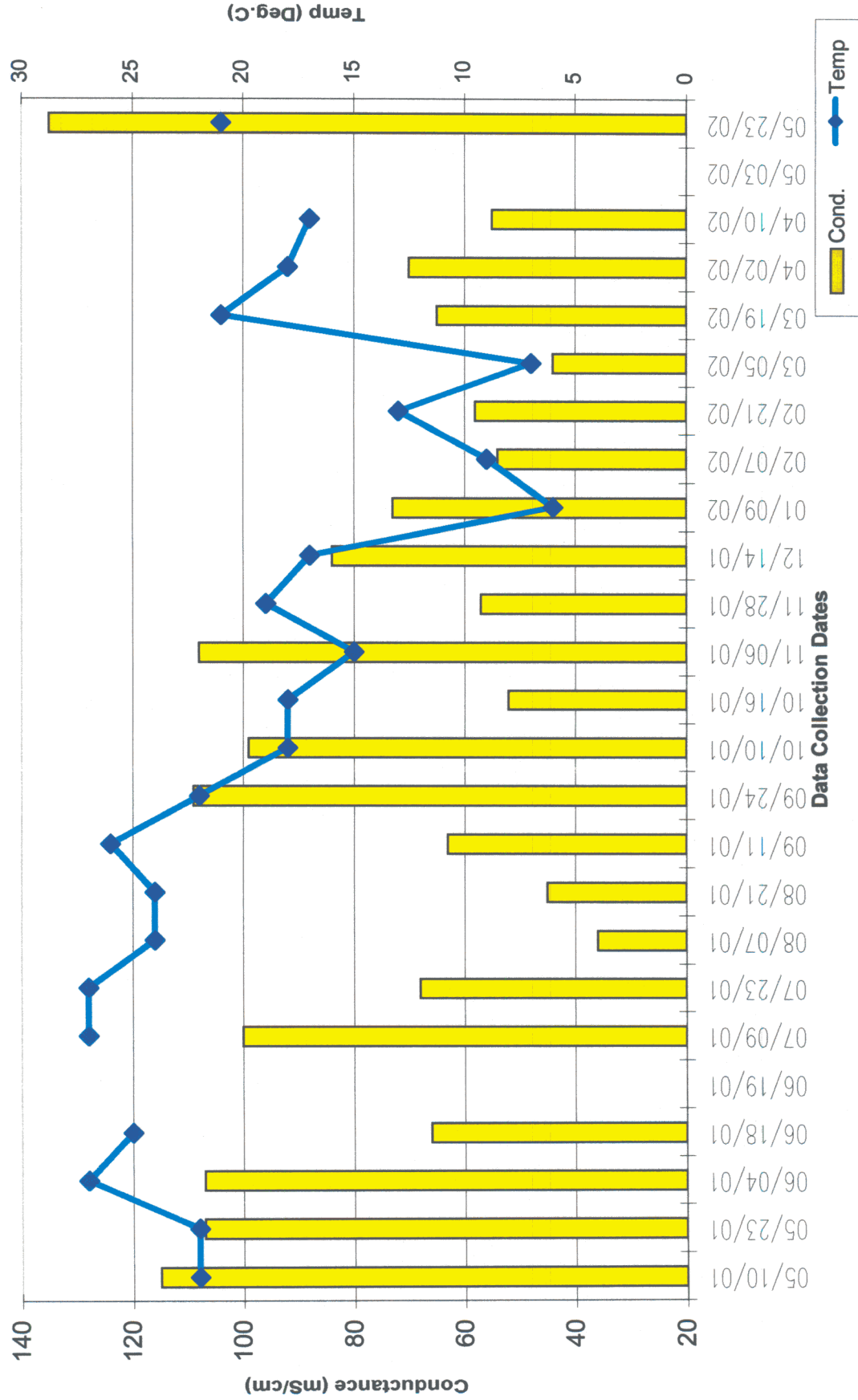
Table 5—Conductivity values measured in project streams.

Watershed	Maximum Conductivity ($\mu\text{S}/\text{cm}$)	Minimum Conductivity ($\mu\text{S}/\text{cm}$)	Average Conductivity ($\mu\text{S}/\text{cm}$)
Five Runs Creek	84	39	60
Yellow River	152	36	86

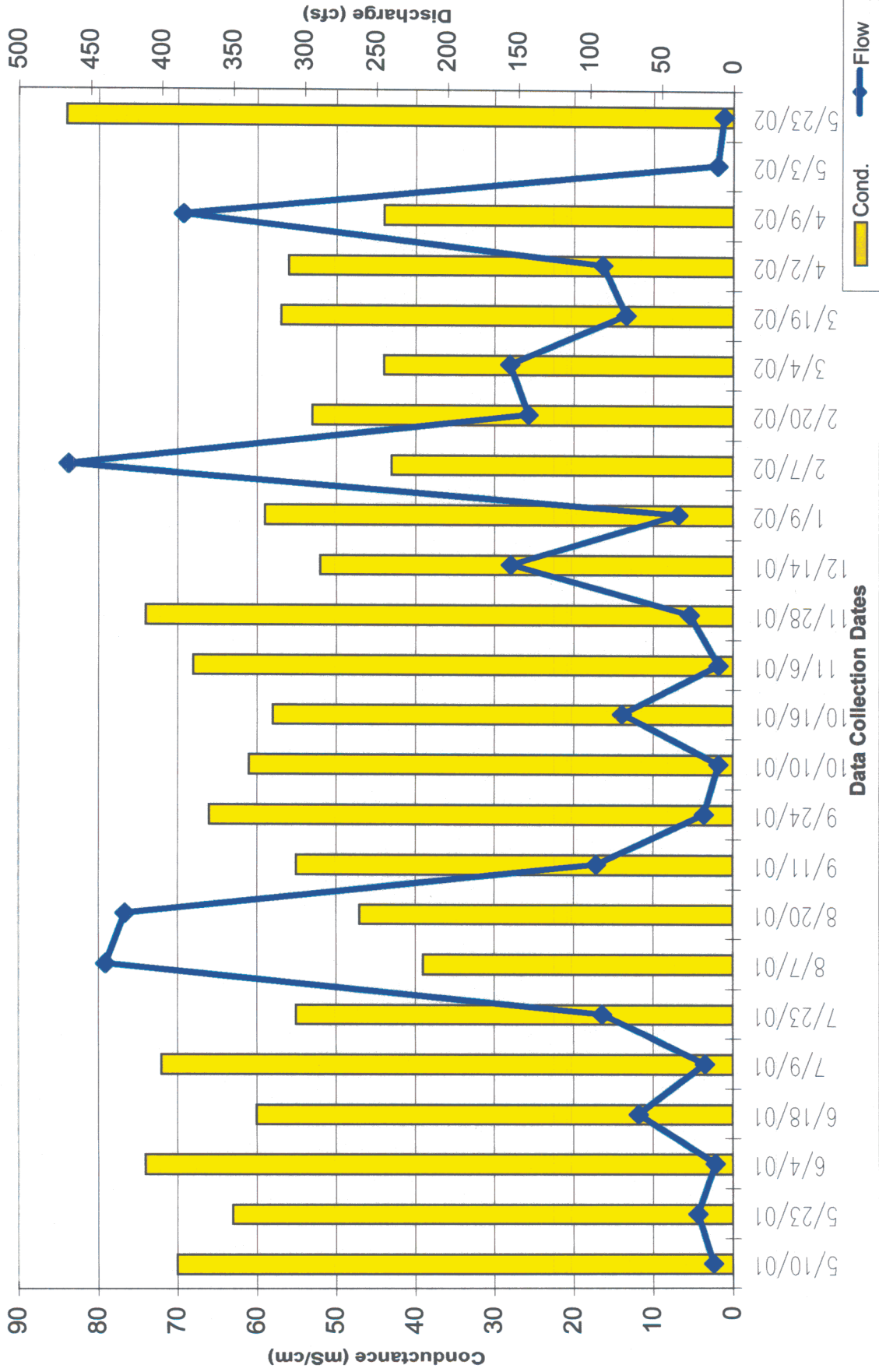
**Figure 7.--Five Runs Creek
Specific Conductance and Stream Temperature**



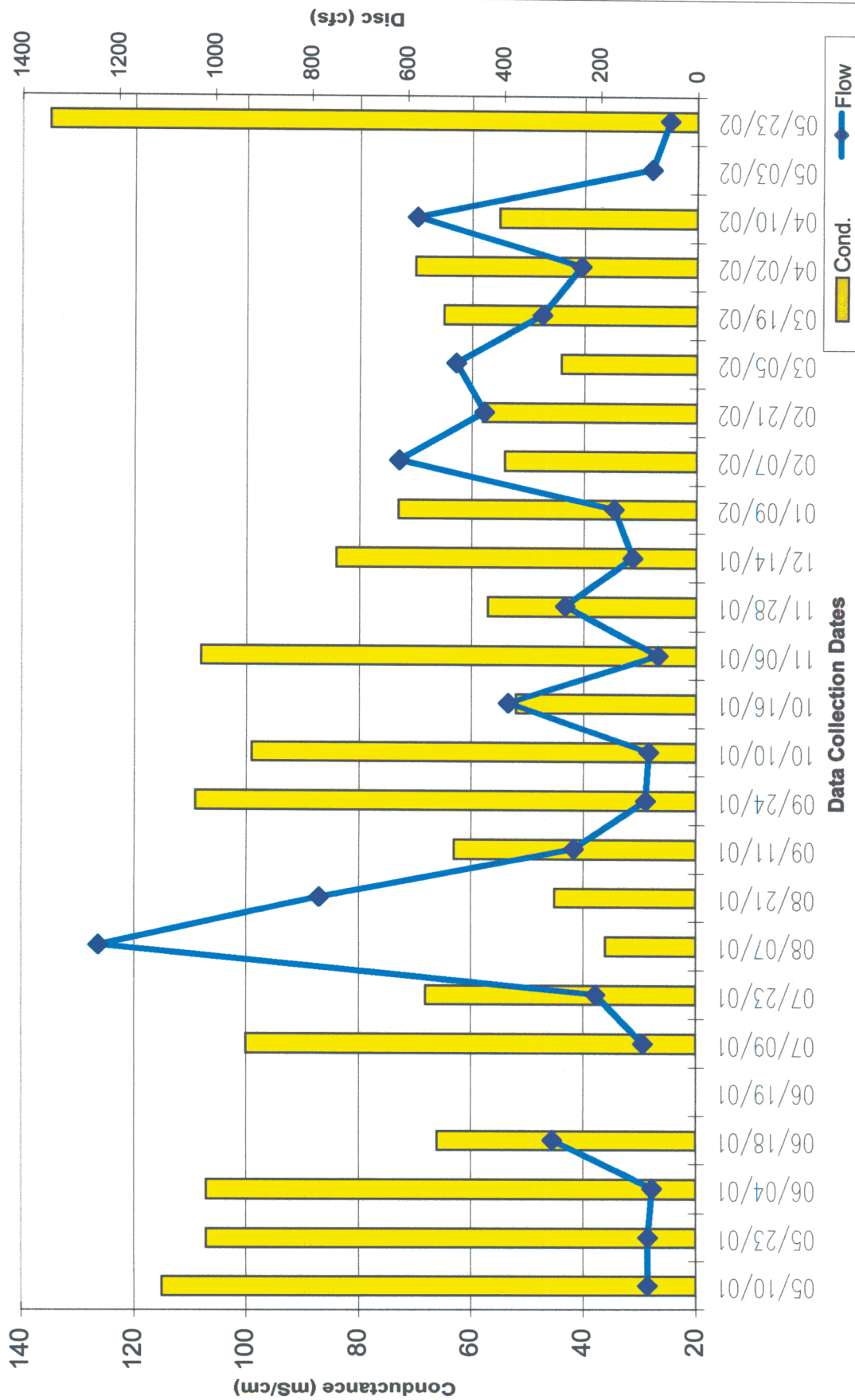
**Figure 8.--Yellow River
Specific Conductance and Stream Temperature**



**Figure 9.--Five Runs Creek
Specific Conductance and Stream Discharge**



**Figure 10.--Yellow River
Specific Conductance and Stream Discharge**



PH

The concentration of hydrogen ions (H^+) is a critical water quality parameter in natural and treated waters. Concentrations of hydrogen ions control speciation of other constituents, influence dissolution and precipitation of chemical elements, and determine whether the water will support aquatic life. Aquatic organisms are sensitive to pH changes and require a pH of 6 to 9. Water treatment with specific types of chemicals, including disinfection, requires stringent pH control.

Hydrogen ion activity, or pH, is controlled by interrelated chemical reactions that produce or consume hydrogen ions (Hem, 1985). Therefore, pH is an important indicator of the status of equilibrium reactions that determine the ionic composition of water that flows through the project watersheds. Maximum values of pH of waters collected from streams in their respective subwatersheds are similar (figs. 11, 12; table 6). However, minimum and average values of pH measured for each stream vary significantly (table 6). A long-term trend of pH fluctuation is also evident for each site. These fluctuations may be caused by changes in water temperature (increased temperature causes decreased values of pH), precipitation (acid rain), oxidation of inorganic metallic and nonmetallic constituents such as ferrous iron and sulfur species (causes reduction in pH), and introduction into the water system of ions associated with pollutants.

Table 6—pH measured in project streams.

Watershed	Maximum pH	Minimum pH	Average pH
Five Runs Creek	7.3	5.8	6.4
Yellow River	7.7	6.2	6.8

The lowest pH values measured during the project period were measured during large discharge events. Low pH may indicate the acidity of rainfall that made up the majority of water in the streams during periods of high discharge.

Figure 11.--Five Runs Creek
pH

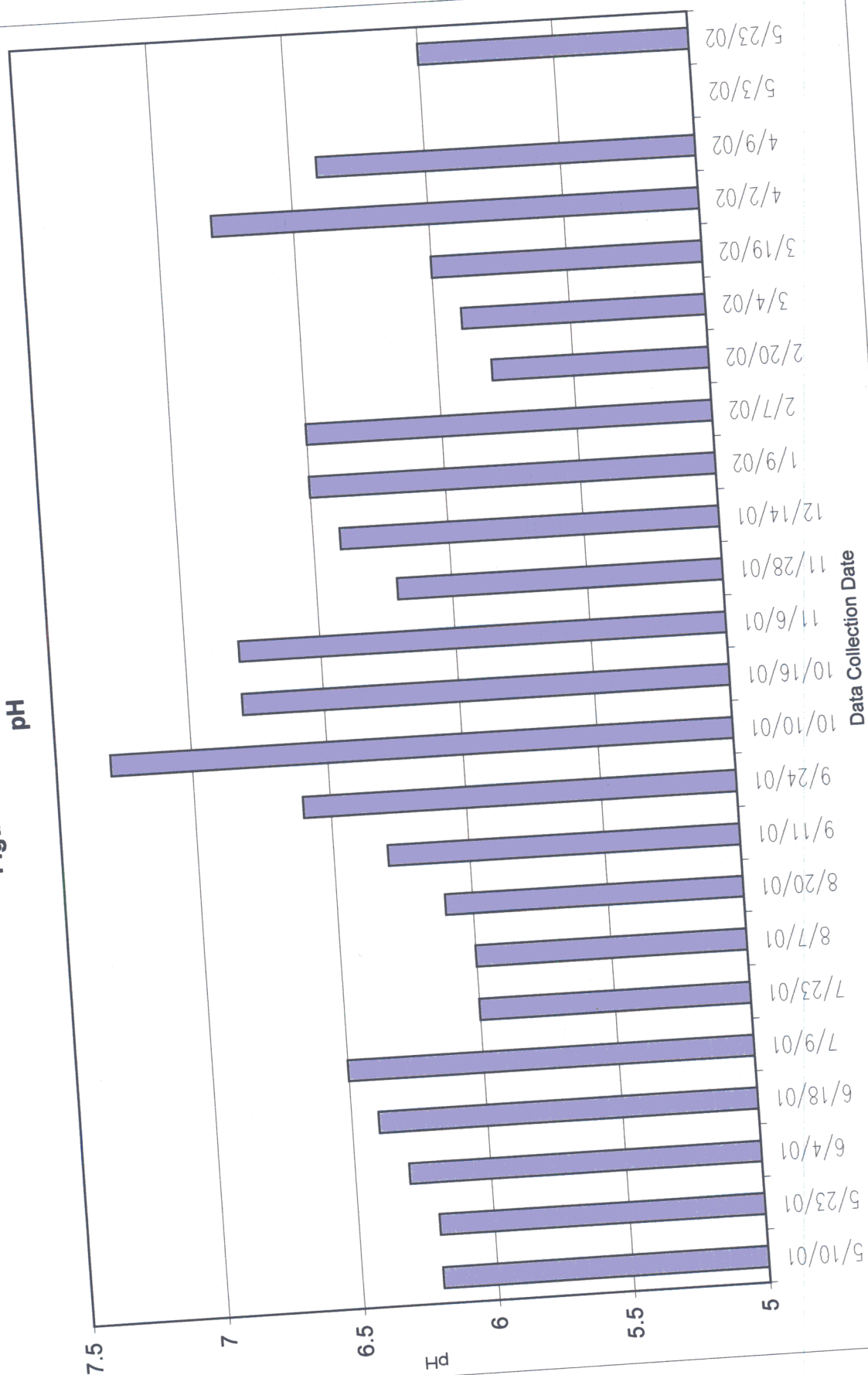
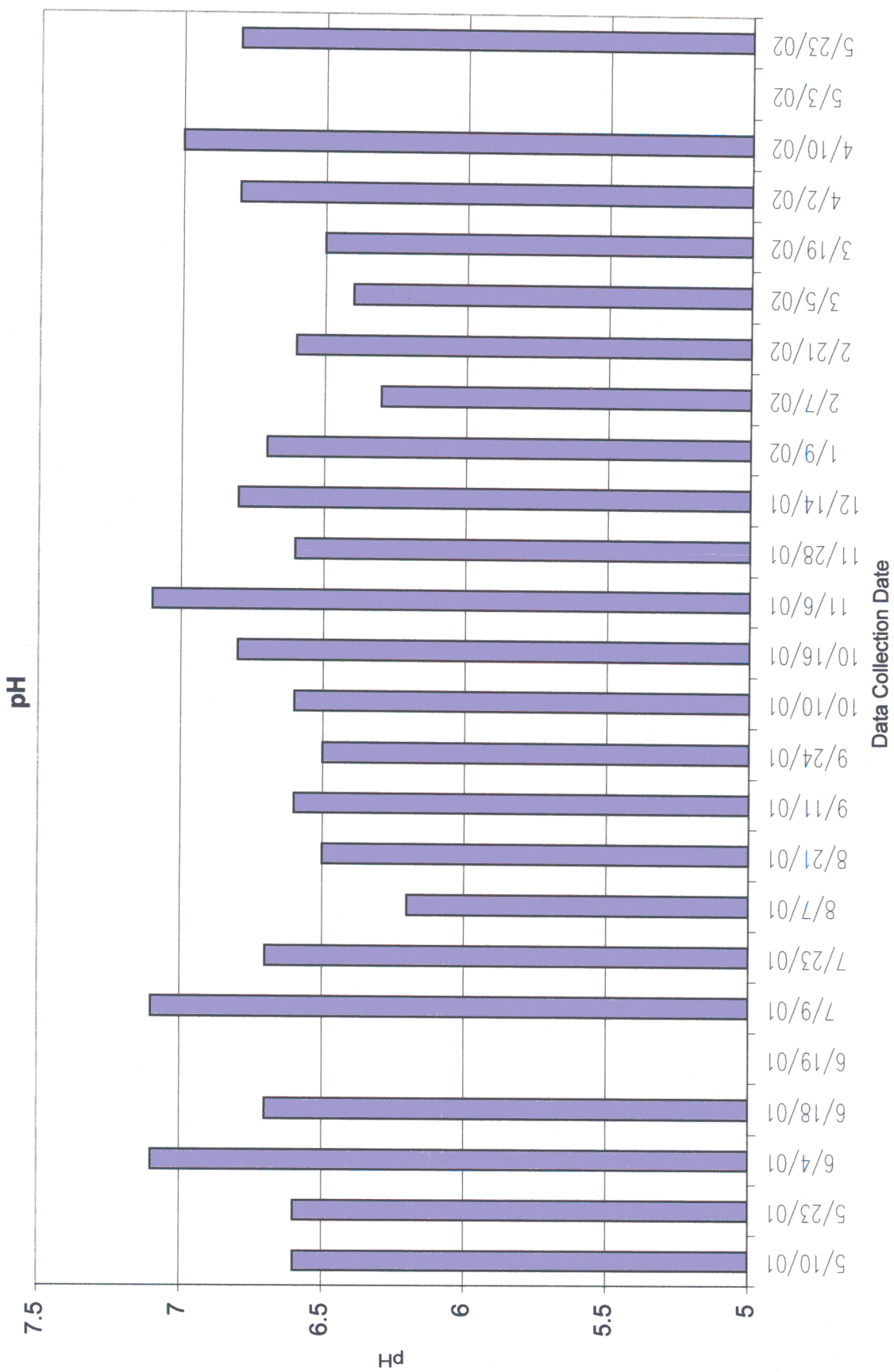


Figure 12.--Yellow River



DISSOLVED OXYGEN

Dissolved oxygen (DO) concentration affects the biological health and the hydrochemical composition of surface waters. Biological processes, oxidation, and sediment loads all contribute to depletion of DO in surface water. The ADEM standard for DO in surface water classified as Fish and Wildlife is 5.0 mg/L except under extreme conditions where it may be as low as 4.0 mg/L. The effects of an impoundment on DO in the impounded waters and in the downstream release from the impoundment must be carefully considered in the planning and design stage of a reservoir project.

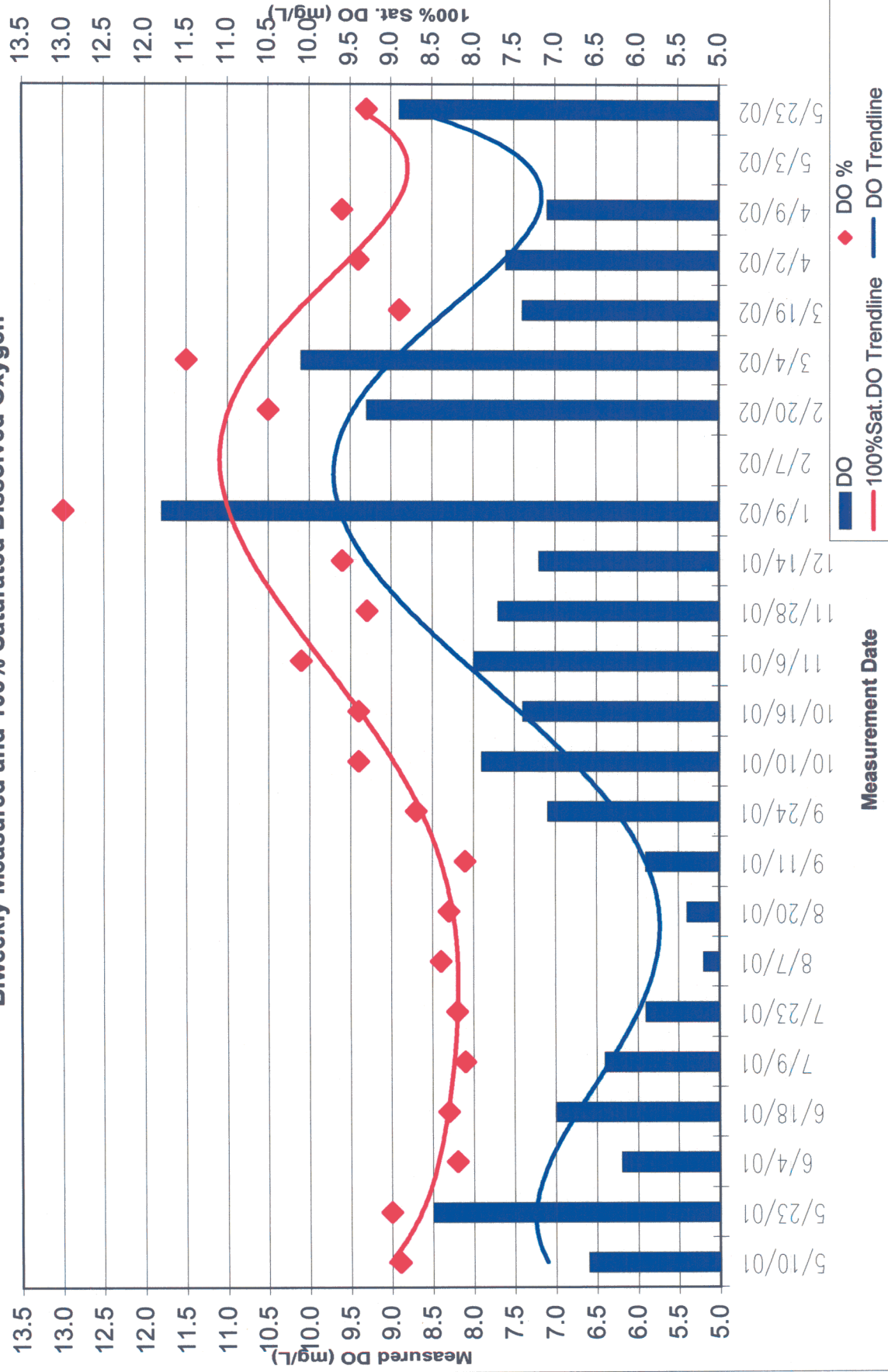
The equilibrium concentration of DO in water that is in contact with air is primarily related to water temperature and barometric pressure and secondarily related to concentrations of other solutes (Hem, 1985). Equilibrium DO in water at 10°C and 25°C is 11.27 mg/L and 8.24 mg/L, respectively. DO concentrations in the project watersheds are significantly affected by water temperature, stream discharge and concentrations of organic material in the water. These factors are represented in figures 13 and 14 where observed DO is compared to the 100 percent dissolved oxygen saturation for the observed stream temperature for each of the monitoring periods. Average observed DO as a percentage of atmospheric saturation for the monitoring period is 80 percent for Five Runs Creek and 87 percent for Yellow River.

The minimum standard for dissolved oxygen concentrations established by ADEM (5 mg/L) was not violated in Five Runs Creek or Yellow River during the monitoring period. Annual trends of dissolved oxygen concentrations indicate that the highest DO occurs during November through April when water temperatures are cooler and discharge is higher than during the rest of the year.

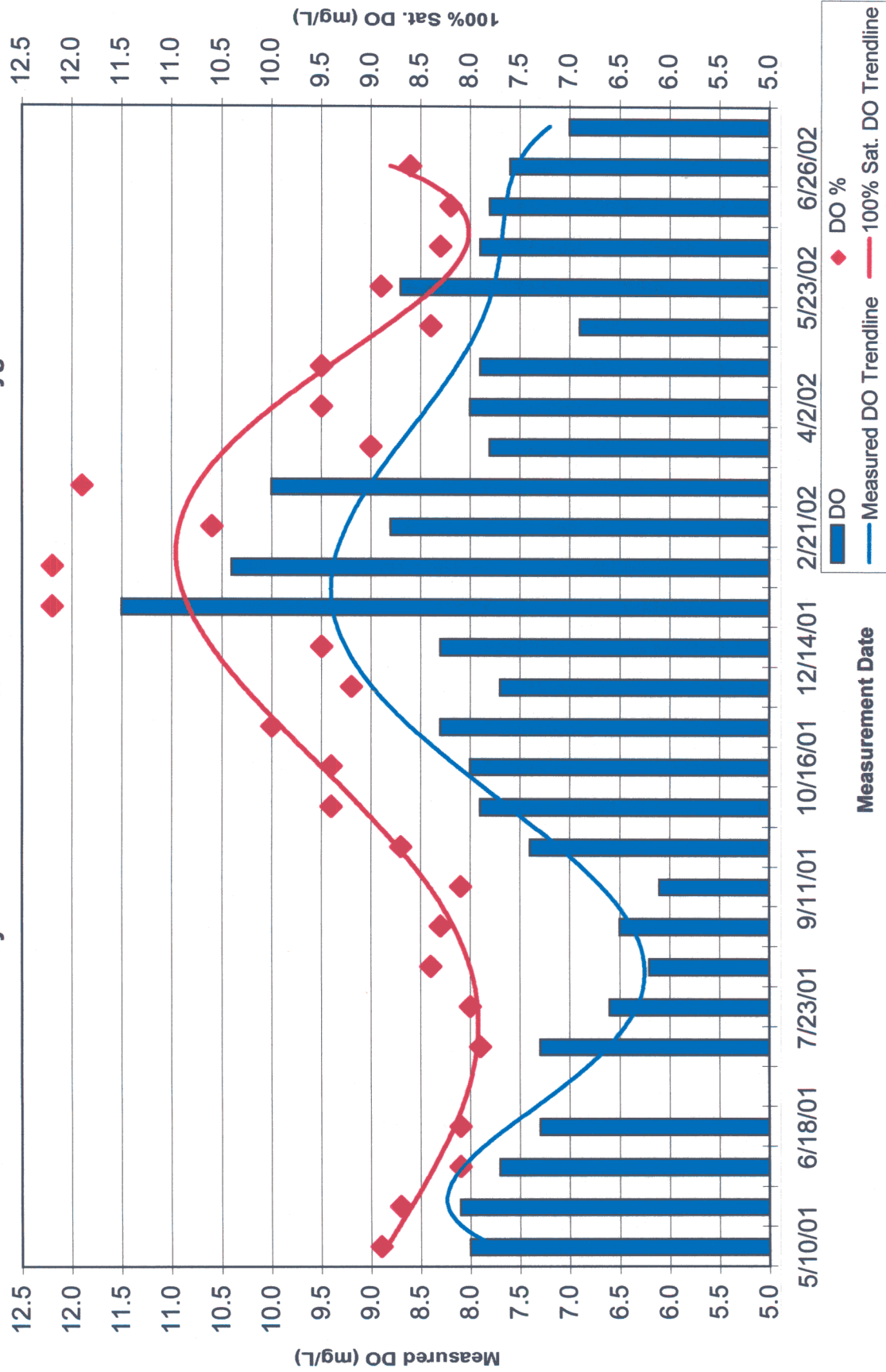
Table 7—Dissolved oxygen measured in project streams.

Watershed	Maximum DO (mg/L)	Minimum DO (mg/L)	Average DO (mg/L)
Five Runs Creek	11.8	5.2	7.4
Yellow River	11.5	6.1	8.0

**Figure 13.--Five Runs Creek
Biweekly Measured and 100% Saturated Dissolved Oxygen**



**Figure 14.--Yellow River
Biweekly Measured and 100% Saturated Dissolved Oxygen**



BIOCHEMICAL OXYGEN DEMAND

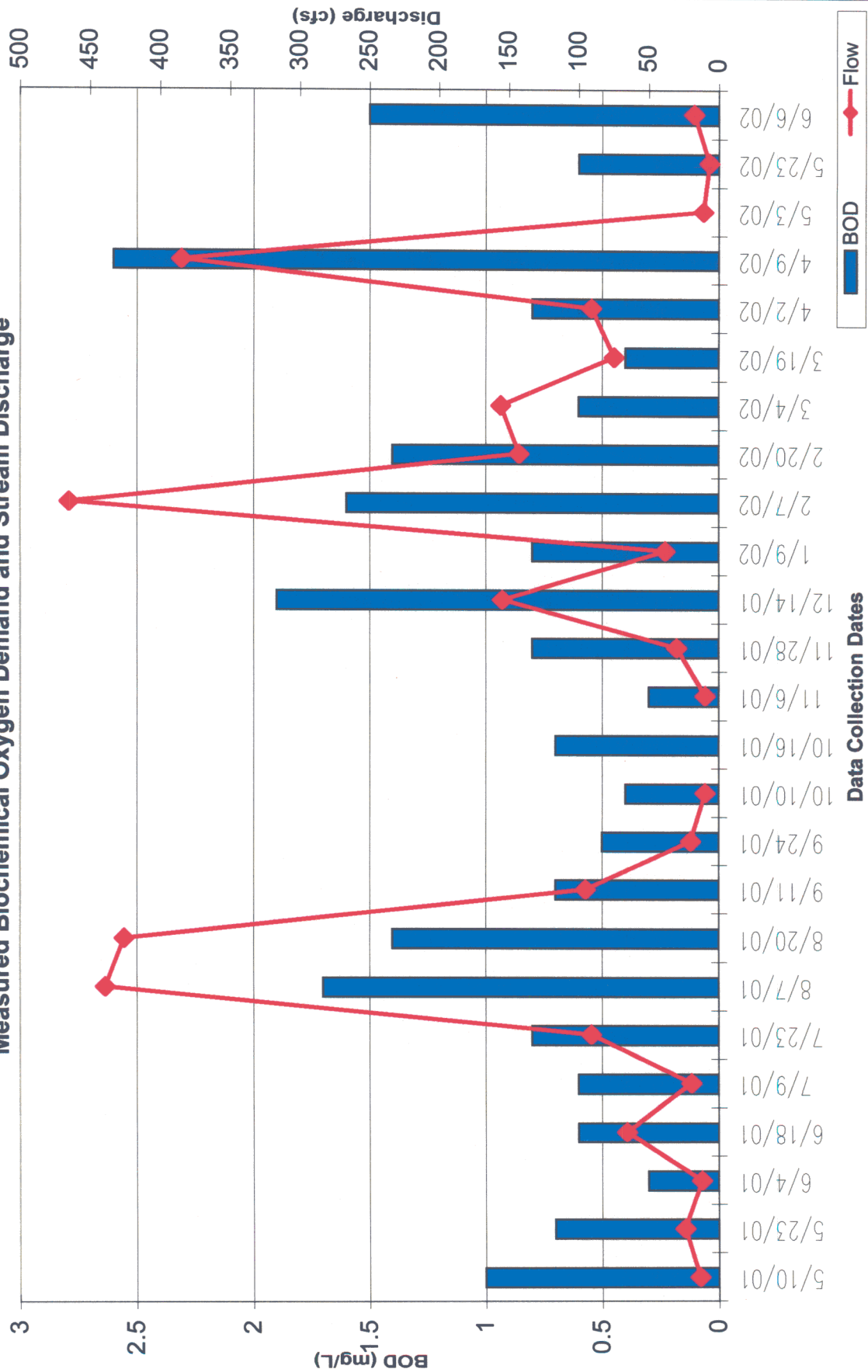
The biochemical oxygen demand (BOD) is an empirical measure of the amount of oxygen used for the biochemical oxidation of organic matter by the microbial population of a water body. This parameter may be used to indicate the presence and magnitude of organic pollutants. It is often used to determine the effect of waste discharges on the oxygen resources of receiving waters. BOD limitations for effluent established by the USEPA for biologically treated municipal wastewater is 30 mg/L. Standards established by some states for water-quality sensitive surface-water bodies may be as low as 5 mg/L (Mays, 1996).

Average BOD for both monitored streams was relatively low (table 8). Water samples collected from Five Runs Creek had the highest average BOD levels measured during the monitoring period (1.0 mg/L) (figs. 15, 16). BOD values in the monitored streams increased dramatically during periods of high discharge and high turbidity when large amounts of organic material were flushed into the stream by flashy runoff.

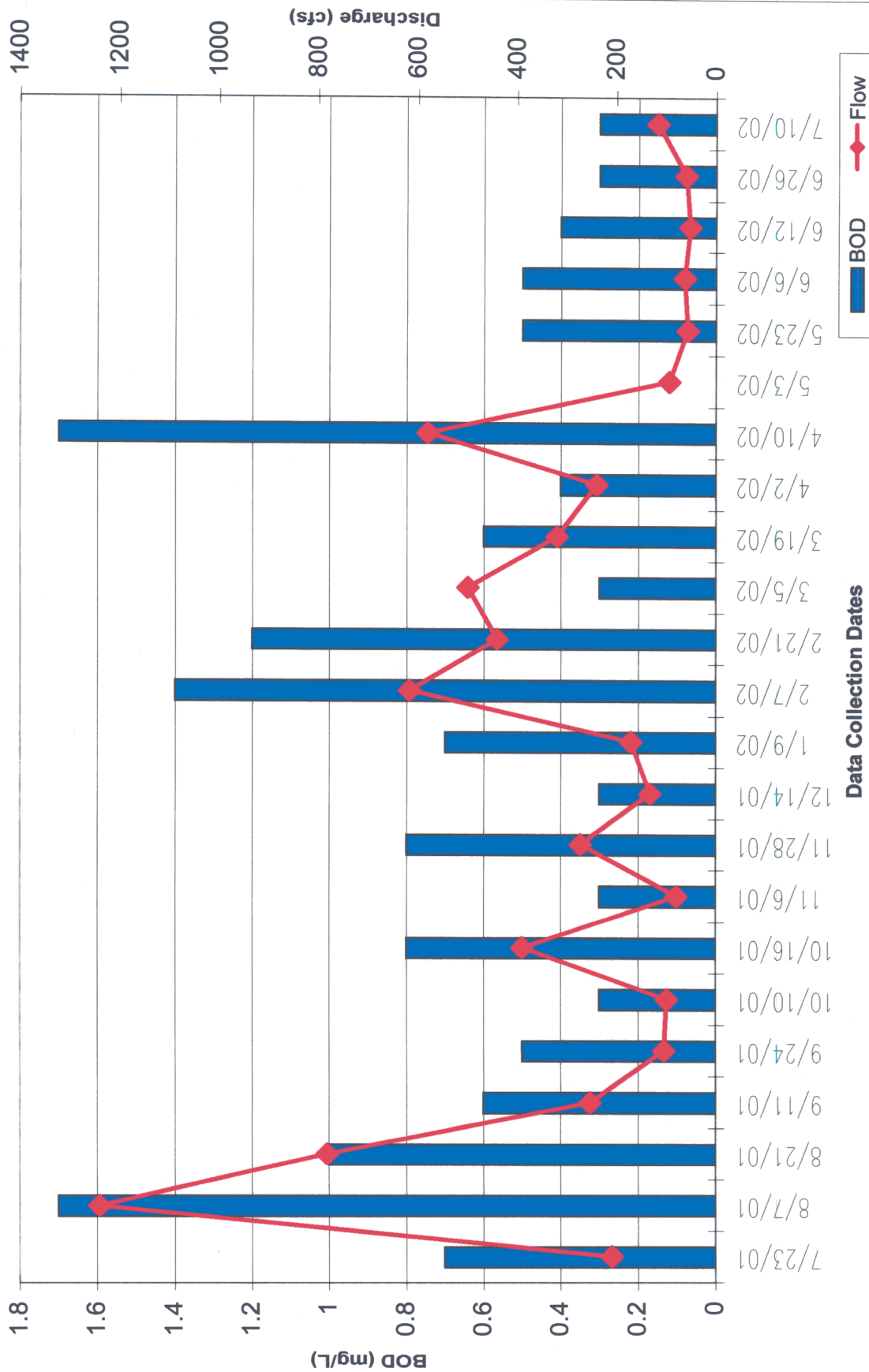
Table 8—Biochemical oxygen demand measured in project streams.

Watershed	Maximum BOD	Minimum BOD	Average BOD
Five Runs Creek	2.6	0.3	1.0
Yellow River	1.7	0.3	0.7

**Figure 15.--Five Runs Creek
Measured Biochemical Oxygen Demand and Stream Discharge**



**Figure 16.--Yellow River
Measured Biochemical Oxygen Demand and Stream Discharge**



TOTAL DISSOLVED SOLIDS

Natural water has suspended particles with a wide range of sizes that may, under favorable conditions, remain in suspension indefinitely. The smaller colloidal particles are considered to be in the dissolved state. Total dissolved solids (TDS) is a measure of these dissolved particles that remain in the water after larger suspended solids have been removed by filtering. TDS may be an indicator of water quality, especially in areas with land use practices such as agriculture. Average concentrations of TDS during the sampling period were similar for Five Runs Creek and Yellow River (table 9). These concentrations are typical for most rivers and streams (Maidment, 1993).

Table 9—Total dissolved solids measured in project streams.

Watershed	Maximum TDS (mg/L)	Minimum TDS (mg/L)	Average TDS (mg/L)
Five Runs Creek	49	22	34
Yellow River	83	27	44

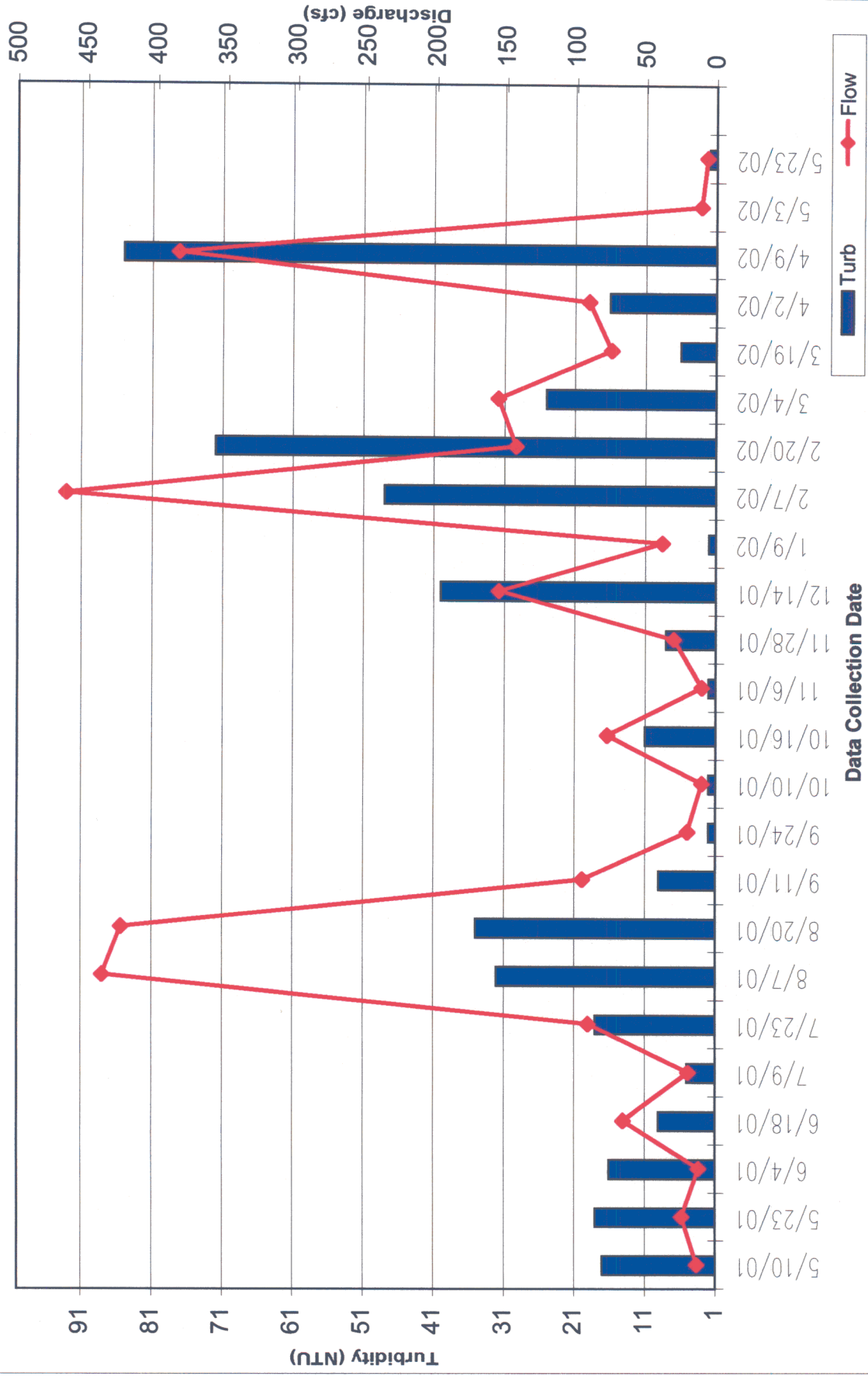
TURBIDITY

Turbidity values measured from water samples may be utilized to formulate a rough estimate of long-term trends of total suspended solids (TSS). Turbidity data may also be used to evaluate the type of treatment necessary to remove sediment from water utilized for public water supply. Turbidity values measured for the project streams are portrayed in table 10 and figures 17 and 18.

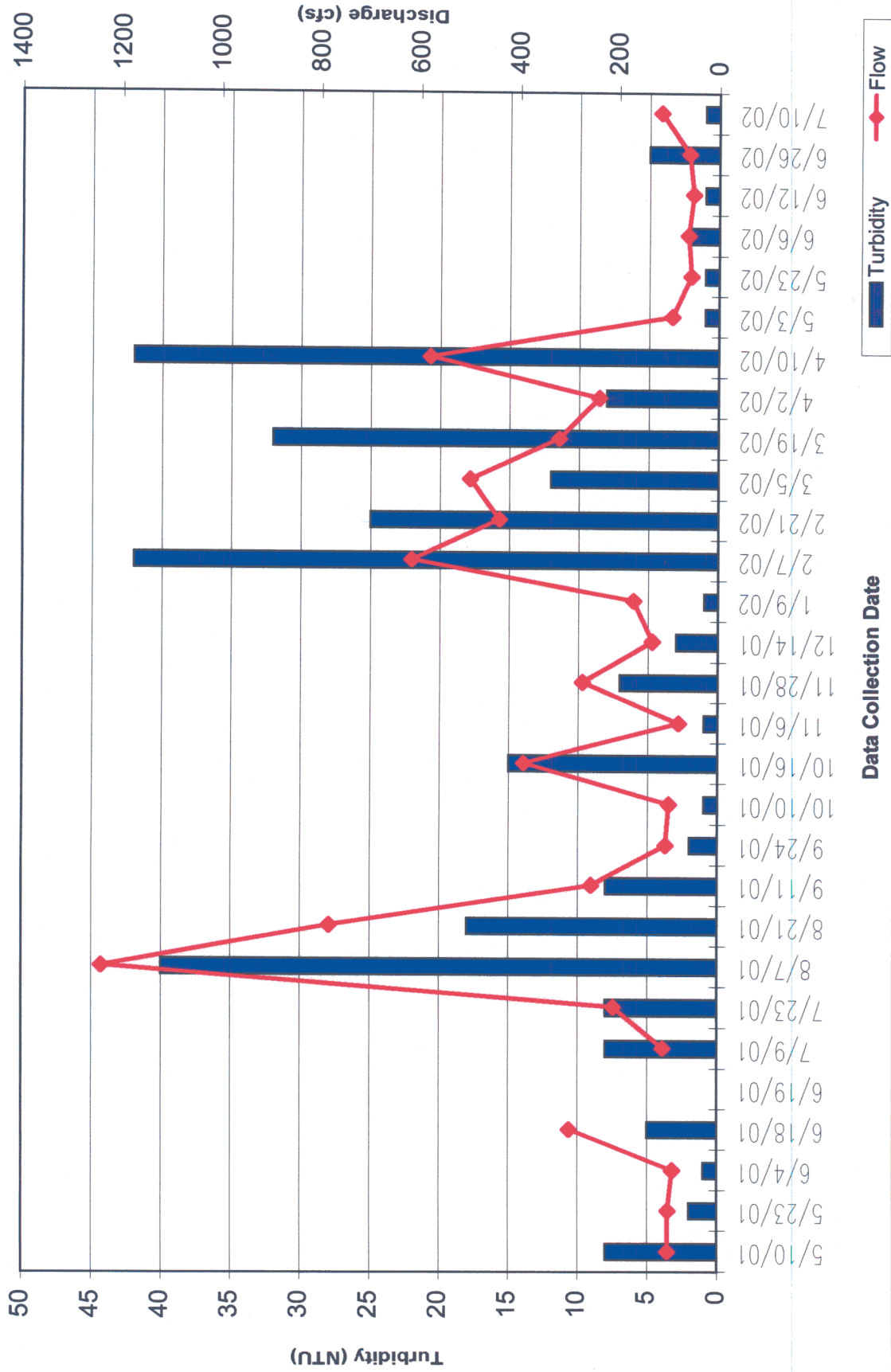
Table 10—Turbidity measured in project streams.

Watershed	Maximum Turbidity (nephelometric turbidity units NTU)	Minimum Turbidity (NTU)	Average Turbidity (NTU)
Five Runs Creek	85	2	21
Yellow River	42	1	11

**Figure 17.--Five Runs Creek
Biweekly Turbidity and Stream Discharge**



**Figure 18.--Yellow River
Biweekly Turbidity and Stream Discharge**



CONSTITUENT LOADING IN PROJECT STREAMS

The basic concept of constituent loads in a river or stream is simple. However, the mathematics of determining a constituent load may be quite complex. The constituent load is the mass or weight of a constituent that passes a cross-section of a stream in a specific amount of time. Loads are expressed in mass units (e.g., tons, kilograms) and are considered for time intervals that are relative to the type of pollutant and the watershed area for which the loads are calculated. Loads are calculated from concentrations of constituents obtained from analytical analyses of water samples and stream discharge, which is the volume of water that passes a cross-section of the river in a specific amount of time.

The computer model *Regr_Cntr.xls* (*Regression with Centering*) was selected to calculate constituent loads for this project. The program is an Excel implementation of the USGS seven-parameter regression model for load estimation (Cohn and others., 1992). It estimates loads in a manner very similar to that used most often by the *Estimatr.exe* (*USGS Estimator*) program. The *Regr_Cntr.xls* program was adapted by R. Peter Richards at the Water Quality Laboratory at Heidelberg College (Richards, 1999).

The program establishes a regression model using a calibration set of data composed of concentrations of the constituent of interest and discharge values measured at the time of water sampling. Constituent loads can be estimated for any year for which mean daily discharge data are provided.

SEDIMENTATION

Sedimentation is a process by which eroded particles of rock are primarily transported by moving water from areas of relatively high elevation to areas of relatively low elevation where the particles are deposited. Upland sediment transport is primarily accomplished by overland flow and rill and gully development. Lowland or floodplain transport occurs in varying order streams where upland sediment joins sediment eroded from floodplains, stream banks and streambeds. Erosion rates are accelerated by human activity related to agriculture, construction, timber harvesting, unimproved roadways or any activity where soils or geologic units are exposed or disturbed. Sedimentation is detrimental to water quality, destroys biologic habitat, reduces storage volume of water impoundments, impedes the usability of aquatic recreational areas, and causes damage to structures.

Sediment loads in streams are primarily composed of relatively small particles suspended in the water column (suspended solids) and larger particles that move on or periodically near the streambed.

TOTAL SUSPENDED SOLIDS

Suspended solids are defined as that portion of a water sample that is separated from the water by filtering. This solid material may be composed of organic and inorganic material that includes algae, industrial and municipal wastes, urban and agricultural runoff, and eroded material from geologic formations. These materials are transported by overland flow related to storm-water runoff to stream channels. Suspended sediment is quantified by the formula:

$$Q_s = Q_w C_s k,$$

where

Q_s is the sediment discharge, in tons per day (tons/day)

Q_w is the water discharge, in cubic feet per second (cfs)

C_s is the concentration of suspended sediment, in milligrams per liter (mg/L)

and

k is a coefficient based on the unit of measurement of water discharge and assumes a specific weight of 2.65 for sediment (Porterfield, 1972).

The concentrations of total suspended solids (TSS) in mg/L were determined by laboratory analysis of biweekly water grab samples. These results were used to calculate the mass of TSS in tons/day, for specific individual samples, by applying the Porterfield formula to the laboratory analytical results. Water samples were collected during several storm events during the sampling period. Comparisons of results of analysis of storm samples and samples collected during normal flow indicate that TSS concentrations from storm samples varied from two times to more than seven times that of normal flow samples at Five Runs Creek. TSS concentrations from storm samples collected from Yellow River varied from three times to more than 20 times that of normal flow samples. TSS values increased periodically in all the streams during the sampling period in response to increased stream discharge, increased influx of organic material and iron bacterial activity. TSS loads for each stream during the monitoring period were determined using measured TSS concentrations and estimated mean daily discharge values and the regression with centering model, discussed previously in this report. TSS concentrations and

calculated TSS loads for each monitored stream are shown in table 11. TSS concentrations measured in monitored streams are portrayed in figures 19 and 20.

Table 11—Total suspended solids and TSS loads measured in project streams.

Watershed	Maximum TSS (mg/L)	Minimum TSS (mg/L)	Average TSS (mg/L)	TSS Load ¹ (Tons/year)	Tons/year (tons/square mile/year)
Five Runs Creek	46	BDL ³	15	3,060	12.4 (1.7)
Yellow River	157	BDL	19	10,520	5,543 (19)

¹ Porterfield Method using average TSS value.

² Regression with centering method.

³ BDL=below detection limit 4 mg/L.

**Figure 19.--Five Runs Creek
Biweekly Total Suspended Solids and Mean Streamflow Velocity**

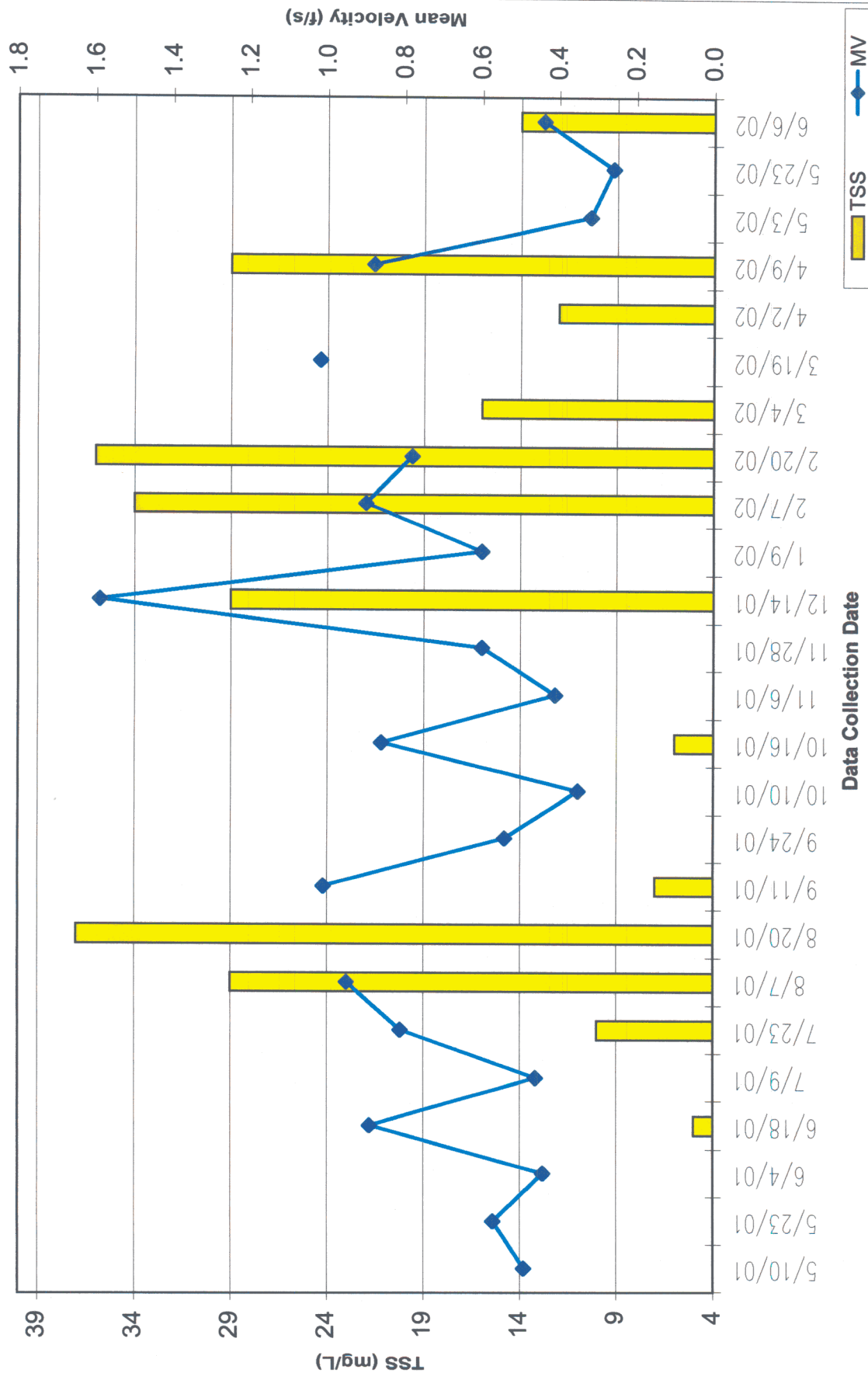
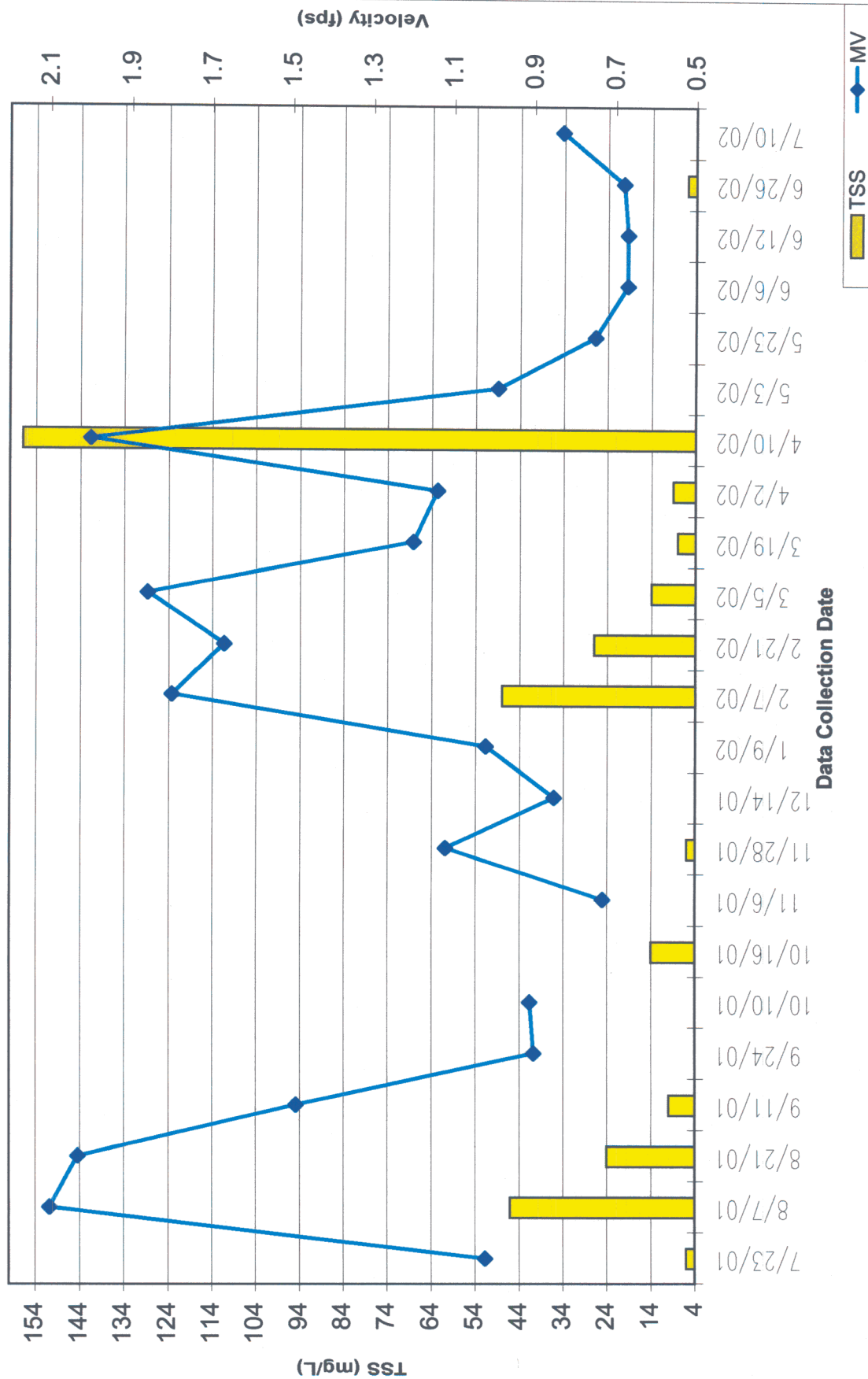


Figure 20.--Yellow River
Biweekly Total Suspended Solids and Mean Streamflow Velocity



Stream Bedload Sediment

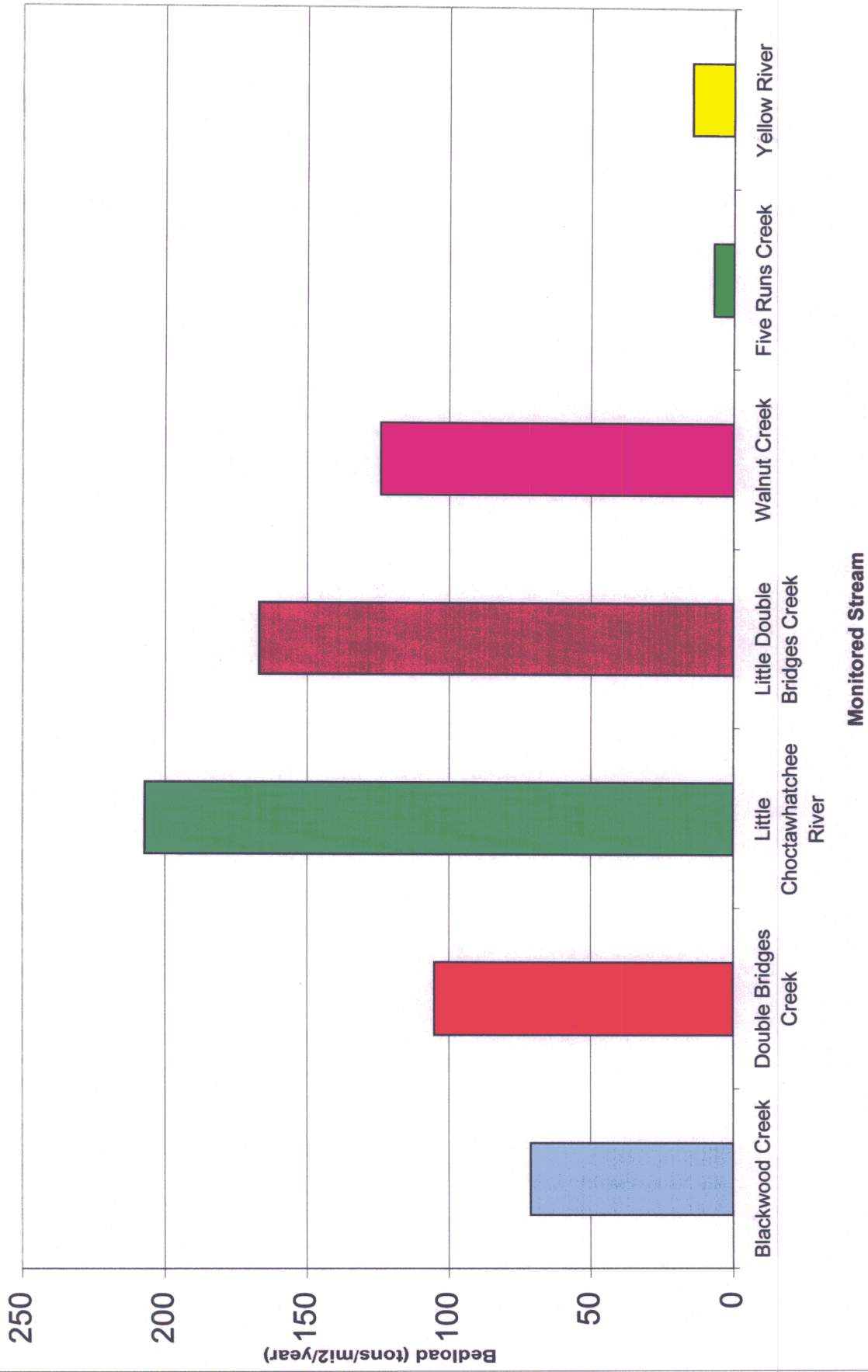
Bedload sediment is composed of particles that are too large or too dense to be carried in suspension by streamflow. These particles roll, tumble, or are periodically suspended as they move downstream. Traditionally, bedload sediment has been hard to quantify due to the difficulty in accurately measuring or estimating volumes of sediment being transported along the streambed. This is particularly true with streams that flow at high velocity or in streams with excessive sediment loads.

The Geological Survey of Alabama has developed a portable bedload sedimentation rate monitoring device that was designed to accurately measure bedload sediment in shallow, sand bed streams. Bedload was measured periodically during the project period to obtain a well-distributed data set with respect to stream discharge and velocity. These data were used to create a regression model. The bedload regression was applied to mean daily discharge for monitoring period for each stream. Values of mean daily bedload volume and mass were calculated from these data. Annual bedload for Five Runs Creek, Yellow River and the other previously evaluated streams in the Choctawhatchee, Pea, and Yellow Rivers Watersheds is portrayed in figure 21. Table 12 includes bedload sediment data for Five Runs Creek and Yellow River.

Table 12—Bedload sediment measured in project streams.

Watershed		Bedload Sediment (Tons/year)	Bedload Sediment (Tons/square mile/year)	Bedload Sediment (Cubic- feet/year)	Bedload Sediment (Acre- feet/year)
Five Runs Creek		50	7	794	0.02
Yellow River		4,589	15	82,000	1.9

Figure 21.--Annual Bedload for Monitored Streams



NUTRIENTS IN PROJECT STREAMS

A typical aquatic ecosystem includes plants and animals that are composed of carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur. These carbonaceous, nitrogenous, phosphorous, and sulfurous substances undergo decomposition upon death of plants and animals and serve as nutrients for development of new organisms. However, excessive nutrient enrichment is a major cause of water-quality impairment. Excessive concentrations of nutrients, primarily nitrogen and phosphorus, in the aquatic environment may lead to increased biological activity, decreased dissolved oxygen concentrations, and decreased numbers of species (Mays, 1996). This process is called eutrophication.

Nutrient impaired waters are characterized by numerous problems related to growth of algae, other aquatic vegetation, and associated bacterial strains. Blooms of algae and associated bacteria can cause taste and odor problems in drinking water. Toxins also can be produced during blooms of particular algal species. Nutrient impaired water can dramatically increase treatment costs required for drinking water.

AMMONIA

Concentrations of ammonia (NH_3 as N) in uncontaminated streams may be as low as 0.01 mg/L. Concentrations of ammonia in contaminated streams and in streams downstream from wastewater discharges are generally from 0.5 to 3.0 mg/L.

Concentrations higher than 0.5 mg/L may cause significant ammonia toxicity to fish and other organisms (Maidment, 1993). The toxicity limit (0.5 mg/L) was not exceeded in either stream monitored during the project period. Measured ammonia concentrations and ammonia loads are shown in table 13.

Table 13—Ammonia measured in project streams.

Watershed	Maximum Ammonia (NH_3 as N) (mg/L)	Minimum Ammonia (NH_3 as N) (mg/L)	Average Ammonia (NH_3 as N) (mg/L)	Ammonia Load Tons/year (pounds/square mile/year)
Five Runs Creek	0.091	BDL ¹	0.020	1.9 (54)
Yellow River	0.080	BDL	0.017	5.0 (33)

¹ BDL=Below detection limit.

NITRATE

The U.S. EPA Maximum Contaminant Level (MCL) for nitrate in drinking water is 10 mg/L. Typical nitrate (NO_3 as N) concentrations in streams vary from 0.5 to 3.0 mg/L. Concentrations of nitrate in streams without significant nonpoint sources of pollution vary from 0.1 to 0.5 mg/L. Streams fed by shallow ground water draining agricultural areas may approach 10 mg/L (Maidment, 1993). Nitrate concentrations in streams without significant nonpoint sources of pollution generally do not exceed 0.5 mg/L (Maidment, 1993). This standard was not exceeded at Five Runs Creek or Yellow River (figs. 22, 23).

Total nitrate loads were determined by application of the regression with centering computer program to nitrate concentrations and mean daily discharge obtained for each monitored stream during the monitoring period. The maximum annual nitrate load limit was calculated by application of the regression with centering computer program to the single sample nitrate limit (0.5 mg/L NO₃ as N) and mean daily discharge obtained for each monitored stream during the monitoring period (table 14). A comparison of nitrate loads for 7 streams in South Alabama evaluated by the Geological Survey of Alabama is depicted on figure 24.

Table 14—Nitrate measured in project streams.

Watershed	Maximum Nitrate (NO ₃ as N) (mg/L)	Minimum Nitrate (NO ₃ as N) (mg/L)	Average Nitrate (NO ₃ as N) (mg/L)	Nitrate Load Tons/year (tons/ square mile/year)	Nitrate Limit Tons/year (tons/ square mile/year)
Five Runs Creek	0.215	0.021	0.118	8.8 (.13)	45 (.64)
Yellow River	0.148	0.027	0.092	31 (0.10)	159 (.53)

**Figure 22.--Five Runs Creek
Measured Nitrate (NO₃-N) and Stream Discharge**



**Figure 23.--Yellow River
Measured Nitrate (NO₃-N) and Stream Discharge**

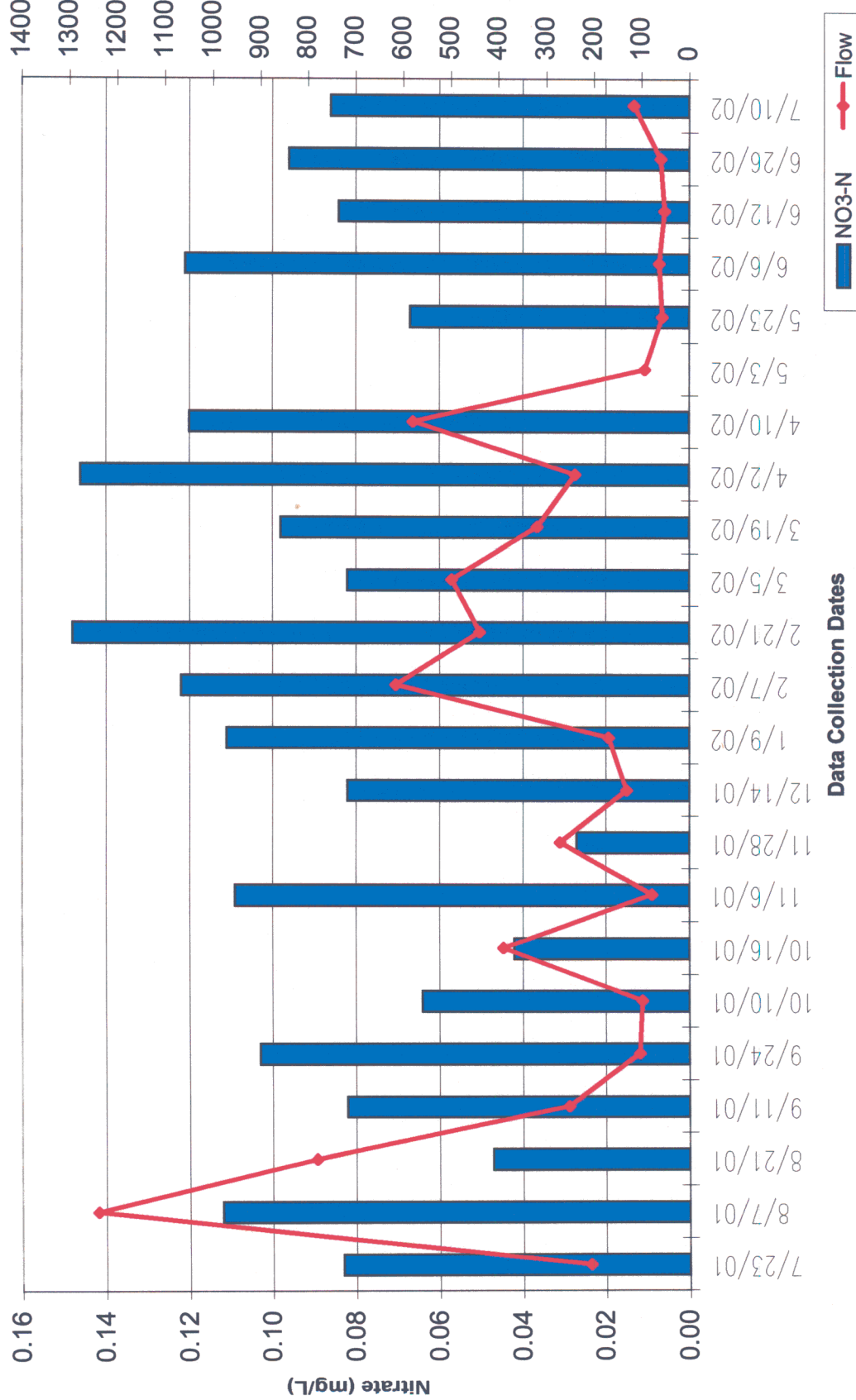
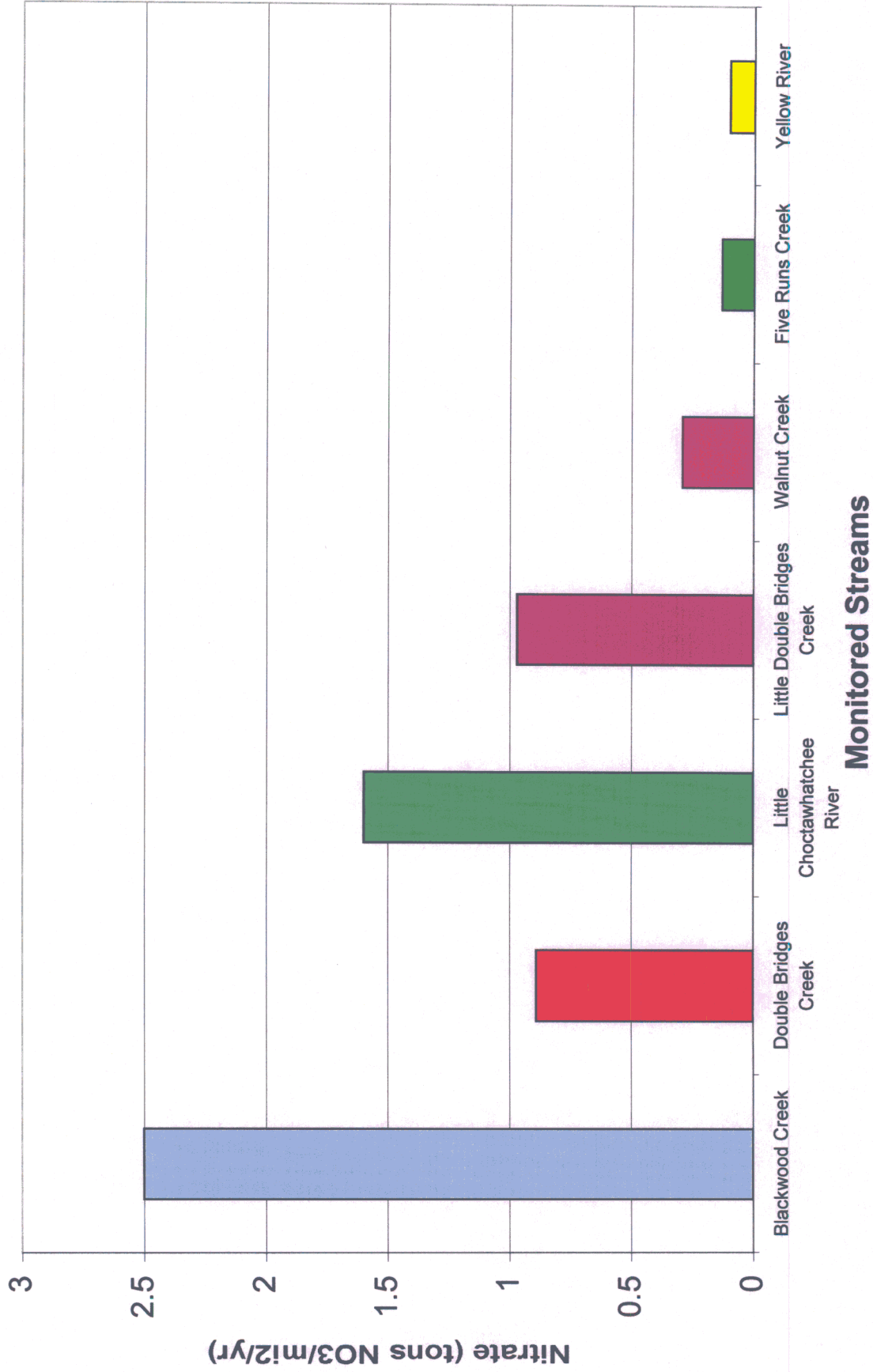


Figure 24.--Total Annual Nitrate Loads



PHOSPHORUS

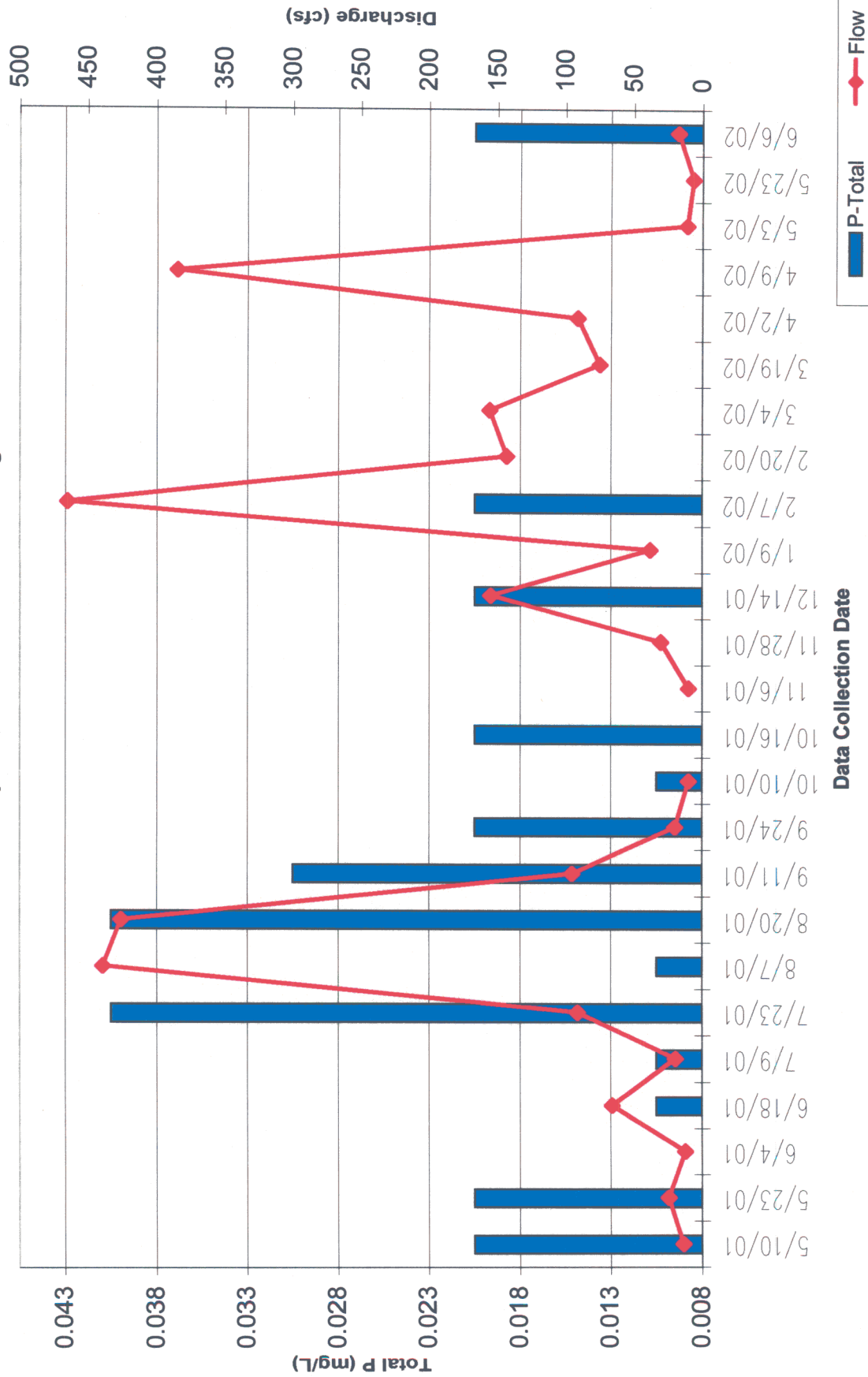
The origin of phosphorus in streams is the mineralization of phosphates from the soil and rocks, or drainage containing fertilizer or other industrial products. The principal components of the phosphorus cycle involve organic phosphorus and inorganic phosphorus, in the form of orthophosphate (PO_4) (Maidment, 1993). Orthophosphate is soluble and considered to be the only biologically available form of phosphorus. The natural background concentration of total dissolved phosphorus is approximately 0.025 mg/L. Phosphorus concentrations as low as 0.01 to 0.005 mg/L may cause excessive algae growth, but the critical level of phosphorus necessary for excessive algae is around 0.05 mg/L. Although no official water quality criterion has been established in the United States for phosphorus, to prevent the development of biological nuisances, total phosphorus should not exceed 0.05 mg/L in any stream or 0.025 mg/L within a lake or reservoir (Maidment, 1993). In many streams phosphorus is the primary nutrient that influences excessive biological activity. These streams are termed "phosphorus limited." The phosphorus standard (0.05 mg/L-total P) was not exceeded in either of the monitored streams (figs. 25, 26). Phosphorus concentrations not depicted on figures 25 and 26 were below detection limit (0.01 mg/L). Total phosphorus loads were determined by application of the regression with centering computer program to phosphorus concentrations and mean daily discharge obtained for each monitored stream during the monitoring period (table 15). A comparison of total phosphorus loads for seven streams in South Alabama evaluated by the Geological Survey of Alabama is depicted on figure 27.

Table 15—Phosphorus measured in project streams.

Watershed	Maximum Phosphorus (Total P) (mg/L)	Minimum Phosphorus (Total P) (mg/L)	Average Phosphorus (Total P) (mg/L)	Phosphorus Load Tons/year (tons/ square mile/year)	Phosphorus Limit Tons/year (tons/ square mile/year)
Five Runs Creek	0.040	BDL ¹	0.014	1.1 (0.02)	4.5 (0.06)
Yellow River	0.030	BDL	0.014	5.6 (0.02)	14.5 (0.05)

¹ BDL=Below detection limit.

Figure 25.--Five Runs Creek
Total Phosphorus and Stream Discharge



**Figure 26.--Yellow River
Total Phosphorus and Stream Discharge**

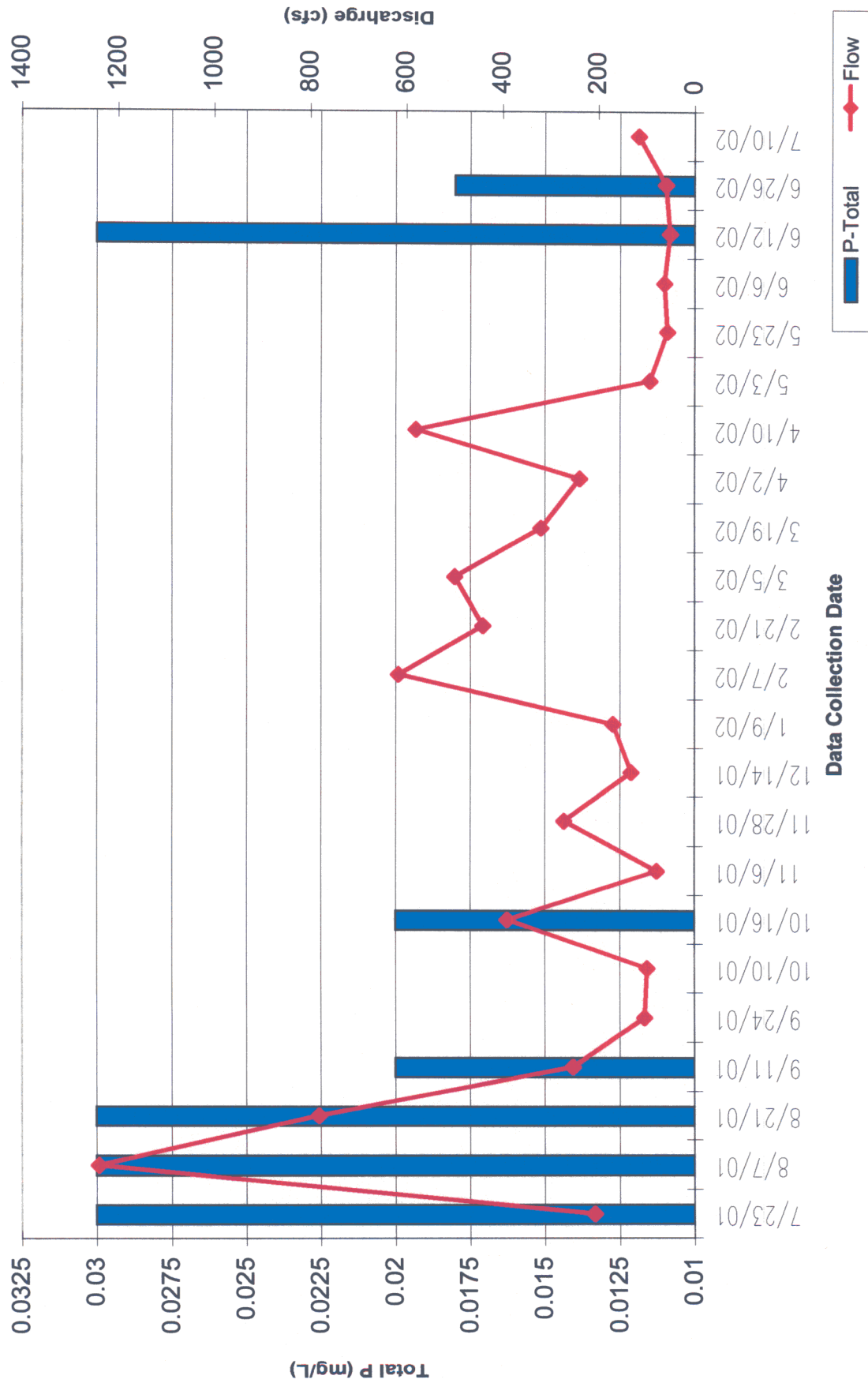
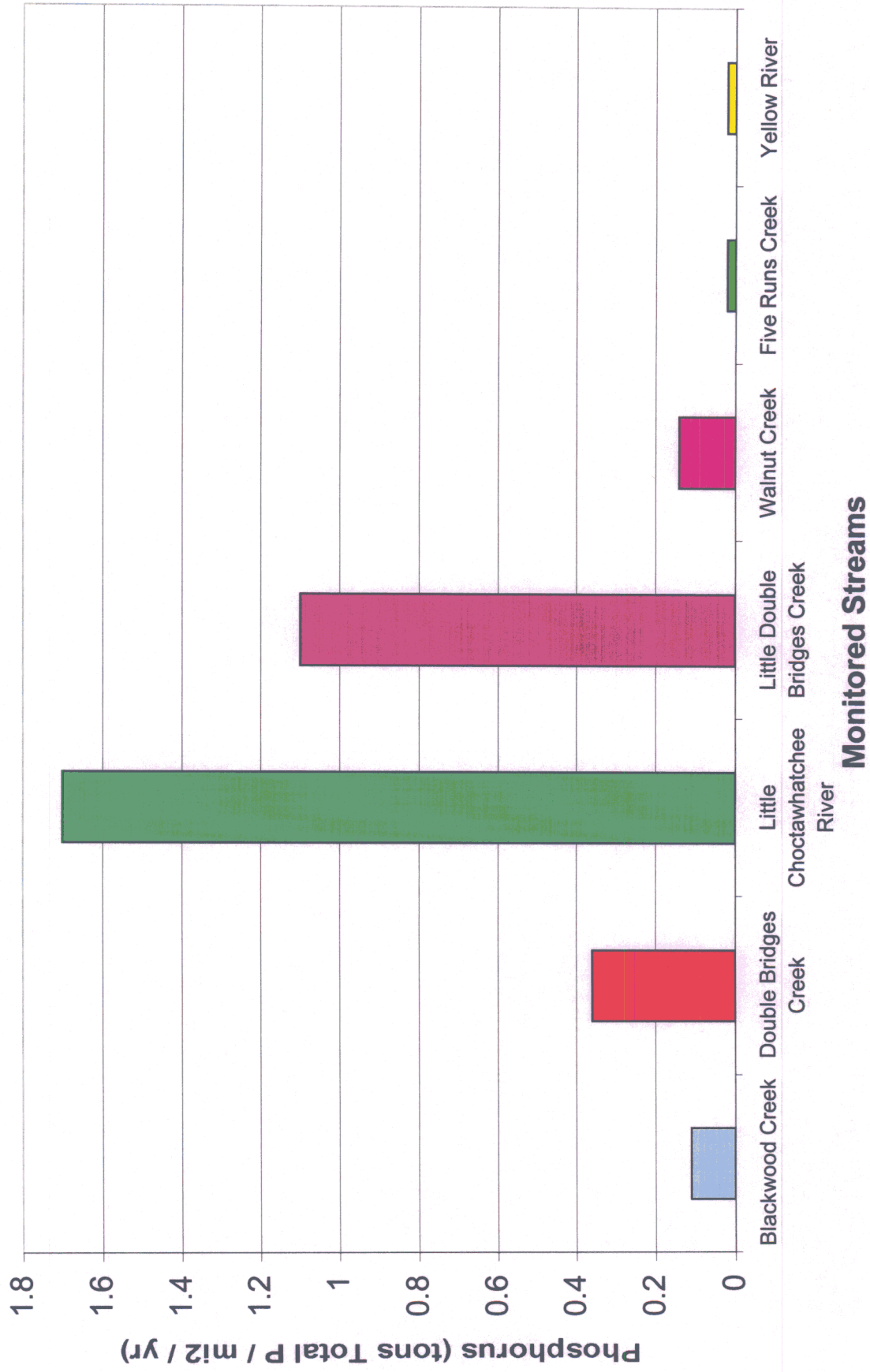


Figure 27.--Total Annual Phosphorus Loads



BACTERIA

Microorganisms are present in all surface waters and include viruses, bacteria, fungi, algae, and protozoa. Analyses of bacteria levels may be used to assess the quality of water and to indicate the presence of human and animal waste in surface and ground water. Fecal coliform and fecal streptococcus groups of bacteria are used as the primary indicator organisms of this type of water pollution. The membrane filter procedure as described in the 19th Edition of Standard Methods (Eaton and others, 1995) is used for determining fecal coliform and fecal streptococcus bacteria counts for water samples collected from streams at project sampling sites.

For many years the ratio of fecal coliform to fecal streptococcus colonies has been used to differentiate human fecal contamination from that of other warm-blooded animals (table 16). A ratio of 4 was considered indicative of human fecal contamination, whereas a ratio of less than 0.7 was considered to be contamination by nonhuman sources.

The 19th Edition of Standard Methods (Eaton and others, 1995) reports that the value of this ratio has been questioned because of variable survival rates of fecal streptococcus group species in water and the methods for enumerating fecal streptococci. However, a large body of literature is available that documents the differences in bacteria concentrations between humans and animals and the utility of the ratio method as a means to differentiate human and animal contamination of water.

Fecal streptococci bacteria were more prevalent than fecal coliform bacteria during the sampling period, as expected, due to the land-use characteristics of the project watersheds (table 17). Average ratios of fecal coliform to fecal streptococci bacteria for the sampling period were 0.65 at Five Runs Creek and 0.75 at Yellow River (table 17). These ratios suggest that bacterial contamination in streams in the project watersheds originates from animals.

The limit for fecal coliform bacteria, established for surface waters classified as Fish and Wildlife, is 2,000 colonies per 100 milliliter sample for single samples (ADEM, 1992). Sampling results indicate that the single sample limit was exceeded in 17 percent of samples collected at Five Runs Creek and 9 percent of samples collected at Yellow River (figs. 28, 29).

Table 16.--Estimated per capita contribution of indicator microorganisms from humans and selected animals.

Source: From Tchobanoglous and Schroeder (1985)

Animal	Average Indicator Organisms (number/grams feces)		Ratio FC/FS
	Fecal Coliform (FC) 10 ⁶	Fecal Streptococci (FS) 10 ⁶	
Human	13.0	3.0	4.4
Chicken	1.3	3.4	0.4
Cow	0.23	1.3	0.2
Duck	33.0	54.0	0.6
Pig	3.3	84.0	0.04
Sheep	16.0	38.0	0.4
Turkey	0.29	2.8	0.1

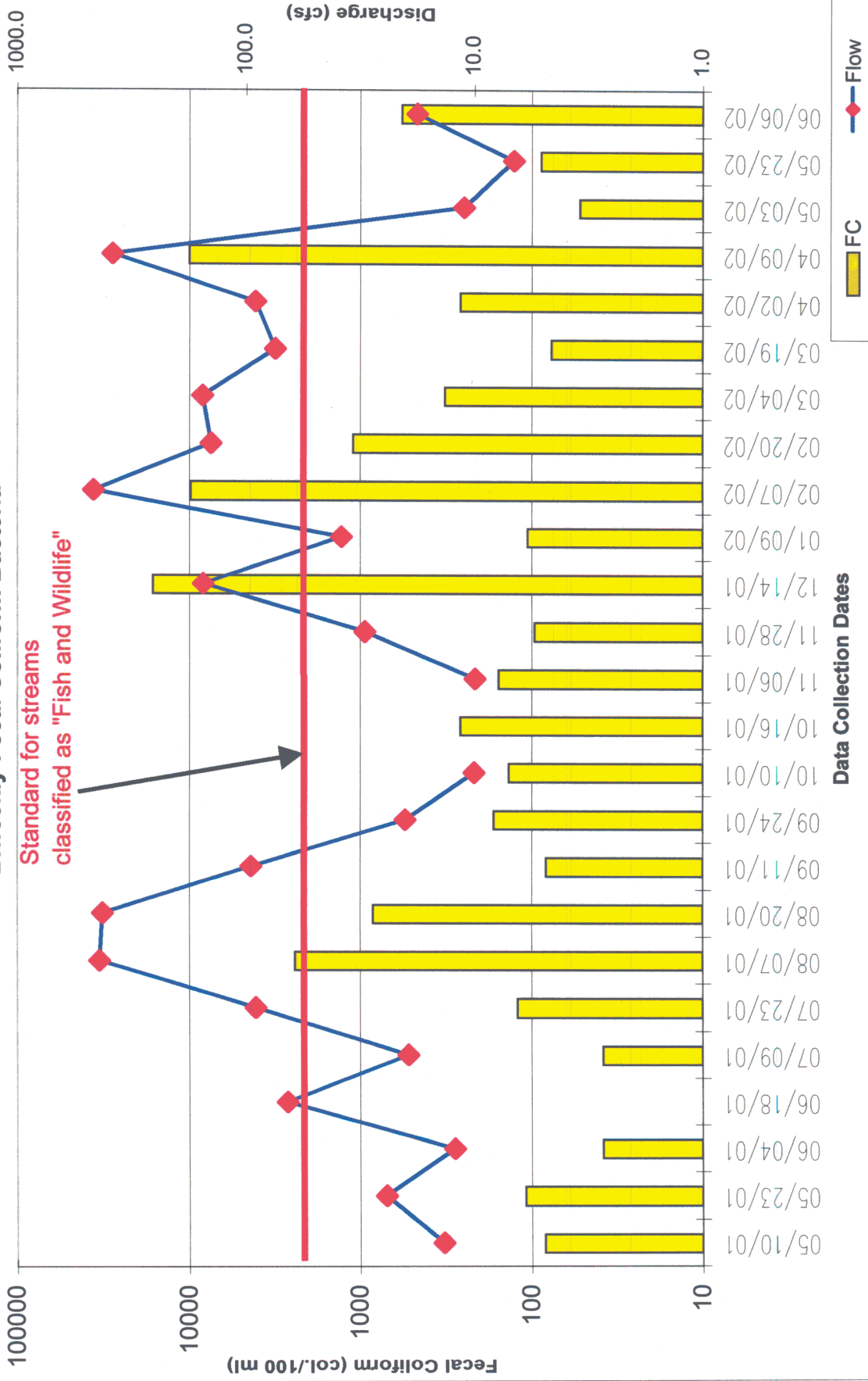
Table 17.--Summary data for fecal coliform and fecal streptococci bacteria measured in water collected from streams in the project subwatersheds

Monitored Watershed	Max FC ¹ (col/100ml)	Max FS ² (col/100ml)	Average FC (col/100ml)	Average FS (col/100ml)	Average Ratio FC/FS
Five Runs Creek	16,300	11,600	1,800	2,107	0.65
Yellow River	3,300	5,600	575	900	0.75

¹Max FC (col/100 ml) = Maximum Fecal Coliform (colonies per 100 milliliters of sample)

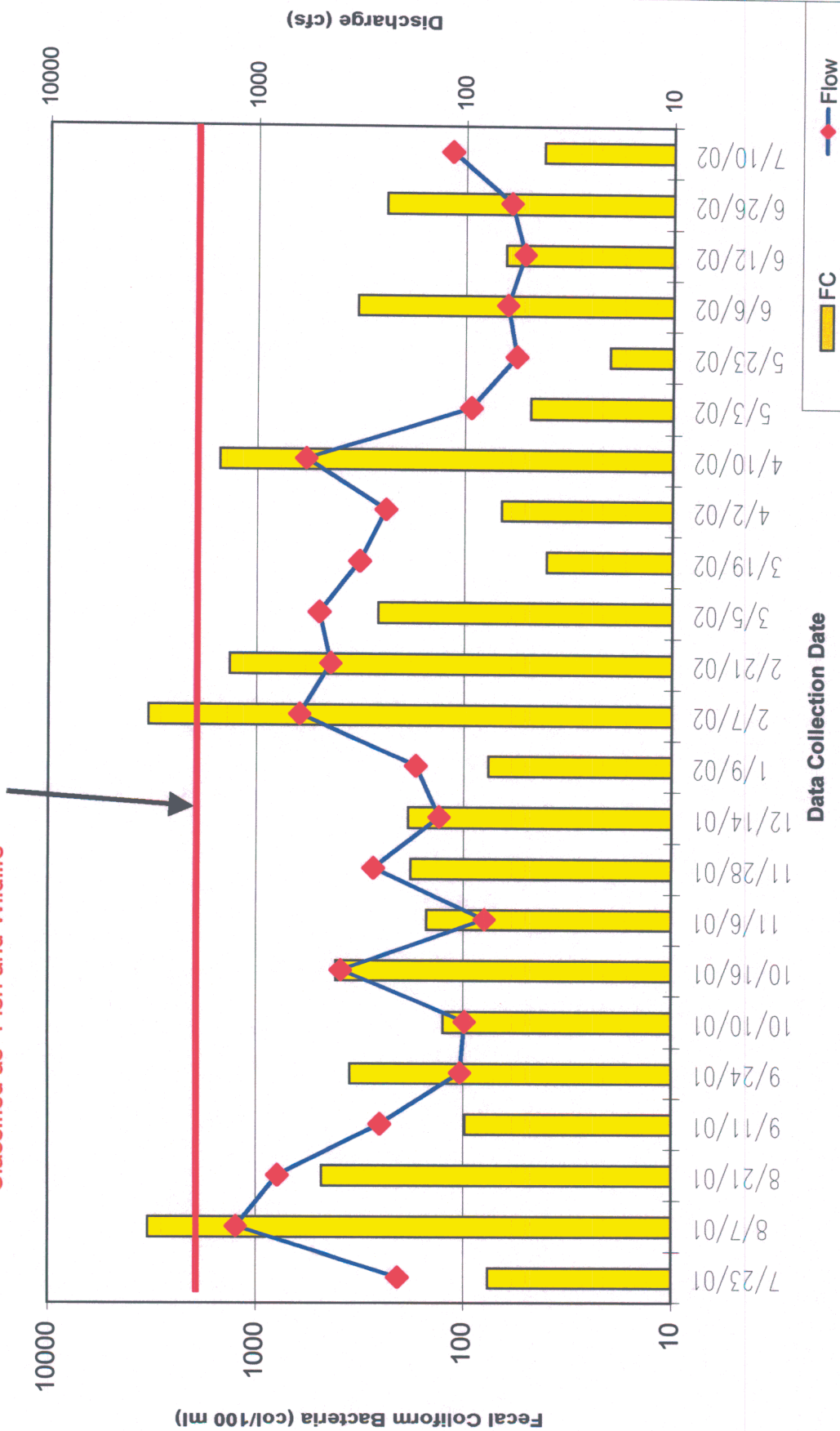
²Max FS (col/100 ml) = Maximum Fecal Streptococci (colonies per 100 milliliters of sample)

**Figure 28.--Five Runs Creek
Biweekly Fecal Coliform Bacteria**



**Figure 29.--Yellow River
Biweekly Fecal Coliform Bacteria**

Standard for streams
Classified as "Fish and Wildlife"



METALLIC CONSTITUENTS

Water samples collected from the project streams were analyzed for selected metallic constituents. Table 18 contains average concentrations for detected metallic constituents and the percentage of samples that exceeded US Environmental Protection Agency drinking water standards.

Table 18.--Average concentrations of metallic constituents and percentage of samples that exceed drinking water standards in water samples collected in project streams.

Metallic Constituent (mg/L)	Five Runs Creek (mg/L)	Percentage of samples exceeding drinking water standards	Yellow River (mg/L)	Percentage of samples exceeding drinking water standards
Aluminum	.132	63	.079	47
Barium	.029	0	.024	0
Calcium	6.0	N/A	11.9	N/A
Fluoride	.03	0		0
Iron	.997	100	.602	78
Lead	BDL ¹	0	BDL ¹	0
Magnesium	1.47	N/A	2.00	N/A
Manganese	.089	29	.045	39
Zinc	.011	0	.010	0

BDL¹ (Below Detectable Limit)

ORGANIC CONSTITUENTS

Organic compounds are commonly used in our society today. Frequently, these compounds appear in streams and ground-water aquifers. Many of these compounds have been found to be harmful to human health and the health of the aquatic environment.

Five classes of these compounds were analyzed in samples collected in Five Runs Creek and Yellow River. Water samples were collected during base flow and during an elevated discharge period. The water samples were analyzed for 68 volatile organic hydrocarbon compounds. All compounds were below detectable limits and are assumed not to be present in the evaluated streams. Water samples were also analyzed for 61 base-neutral/acid extractable compounds. All these compounds were below detectable limits and are assumed not to be present in the evaluated streams. Water samples were analyzed for 20 compounds found in pesticides. All the evaluated compounds were below detectable limits and are assumed not to be present in the evaluated streams. Water samples were analyzed for 10 compounds found in herbicides. All compounds were below detectable limits and are assumed not to be present in the evaluated streams. Water samples were analyzed for seven polychlorinated biphenyls. These were all below detectable limits and are assumed not to be present in the evaluated streams.

WATERSHED AND POTENTIAL IMPOUNDMENT PHYSICAL CHARACTERISTICS

WATERSHED AREA AND LAND USE

METHOD USED FOR LAND USE DETERMINATION

Land use was determined by using a combination of data available on topographic maps and data collected by driving each road in the watershed. During the on-site survey, approximate areas covered by each land-use type were outlined on the 7.5-minute (1:24,000) topographic map of the area. The Danleys Crossroads, Dozier, Gantt, River Falls, Andalusia, Opp West, Opp East, Onycha, Libertyville, Carolina, Watkins Bridge, and Florala 7.5-minute topographic maps were used to cover the two watersheds. The small part of the Yellow River Watershed north of the area covered by these maps (north of 30.5 degrees latitude or about 2 miles north of the town of Dozier) was not included in the land-use classification. The land-use categories used were forest, fallow, row crop, pasture, hay, open water, and urban. The number of poultry houses and number and type of other livestock were also noted. Following the survey, the area in acres covered by each category was determined from these topographic maps. Additional information available on the maps, such as ponds, features not visible from the roads, and the total area covered by forest (unless otherwise noted in the survey) was used to complement the survey information. An attempt was made to assign all the area to one or more of the above categories. Areas of clear-cut timber as well as sand pits and quarries were assigned to the fallow category. Most orchards (principally pecans) were included with row crops. Areas that appeared as unforested on the topographic maps, but were otherwise unassigned to a category, were counted as pasture.

FIVE RUNS CREEK WATERSHED

The monitored part of the Five Runs Creek Watershed contains 70.5 square miles (45,100 acres). Most of the land in the watershed is covered by forest or pasture. Approximately 59 percent of the watershed is covered by mature, mixed pine and hardwood timber (29,021 acres). Approximately 2,082 acres (about 4 percent) of the land in the watershed is used to grow a variety of crops including peanuts, cotton, corn, wheat, pecans, and vegetables. Approximately 657 acres (about 1 percent) of the watershed is composed of urban or paved area in and near the city of Andalusia and the towns of Libertyville and Carolina. Approximately 9,043 acres (18 percent) of the watershed is used as pasture for cattle or other livestock including horses and ponies. During the survey, 420 head of livestock were counted as well as additional animals which were observed but not counted. This does not account for animals not visible. In addition, 511 acres (about 1 percent) are currently being used for hay production. Thirty poultry houses were noted during the survey or determined from the topographic maps. Poultry houses which appear on the topographic maps, but were determined by the survey to be no longer in use, were not included in this total. Land counted as fallow included 7,981 acres or 16 percent. Open water (ponds and lakes) cover 474 acres.

YELLOW RIVER WATERSHED

The monitored part of the Yellow River Watershed includes Yellow River above Watkins Bridge, Lightwood Knot Creek, and Poley Creek. This watershed area contains 299 square miles (191,000 acres). The land use survey included all but the northernmost tip of the watershed (see above). Most of the land in the watershed is covered by forest or is used for row crop agriculture. Approximately 72 percent of the watershed is covered by mature, mixed pine and hardwood timber (115,778 acres). Approximately 7,684 acres (5 percent) of the land in the watershed is used to grow a variety of crops including peanuts, cotton, corn, wheat, pecans, and vegetables. Approximately 1,498 acres (about 1 percent) of the watershed is composed of urban or paved area in and near the cities of Andalusia, Opp, and Florala. Approximately 25,717 acres (16 percent) of the watershed is used as pasture for cattle or other livestock including horses and ponies. During the survey, 1,884 head of livestock were counted as well as additional animals which were observed but not counted. This does not account for animals not visible. In addition, 2,945 acres (about 2 percent) are currently being used for hay production. One hundred thirty-nine poultry houses were noted during the survey or determined from the topographic maps. Poultry houses which appear on the topographic maps, but were determined by the survey to be no longer in use, were not included in this total. Land counted as fallow included 5,621 acres or about 3 percent. Open water (ponds and lakes) cover 1,740 acres or 1 percent of the watershed. This includes Frank Jackson Lake.

POTENTIAL IMPOUNDMENT AREA AND VOLUME

The normal pool water surface area and volume for the potential reservoir were selected by the Geological Survey of Alabama according to specifications previously provided by the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority. The area was planimeted on USGS 7.5 minute topographic maps (fig. 30, table 19). The volume was calculated from the area determined for each 10-foot contour interval from the streambed elevation to the normal pool elevation (table 19). These data were utilized for preliminary analysis. Future design and engineering evaluations will determine the final reservoir characteristics.

Table 19.--Potential impoundment physical characteristics.

Watershed	Normal Pool Elevation (Feet above mean sea level)	Normal Pool Surface Area (Square Miles (Acres))	Normal Pool Storage Capacity (Acre feet)
Five Runs Creek	200	2.65 (1,693)	16,900

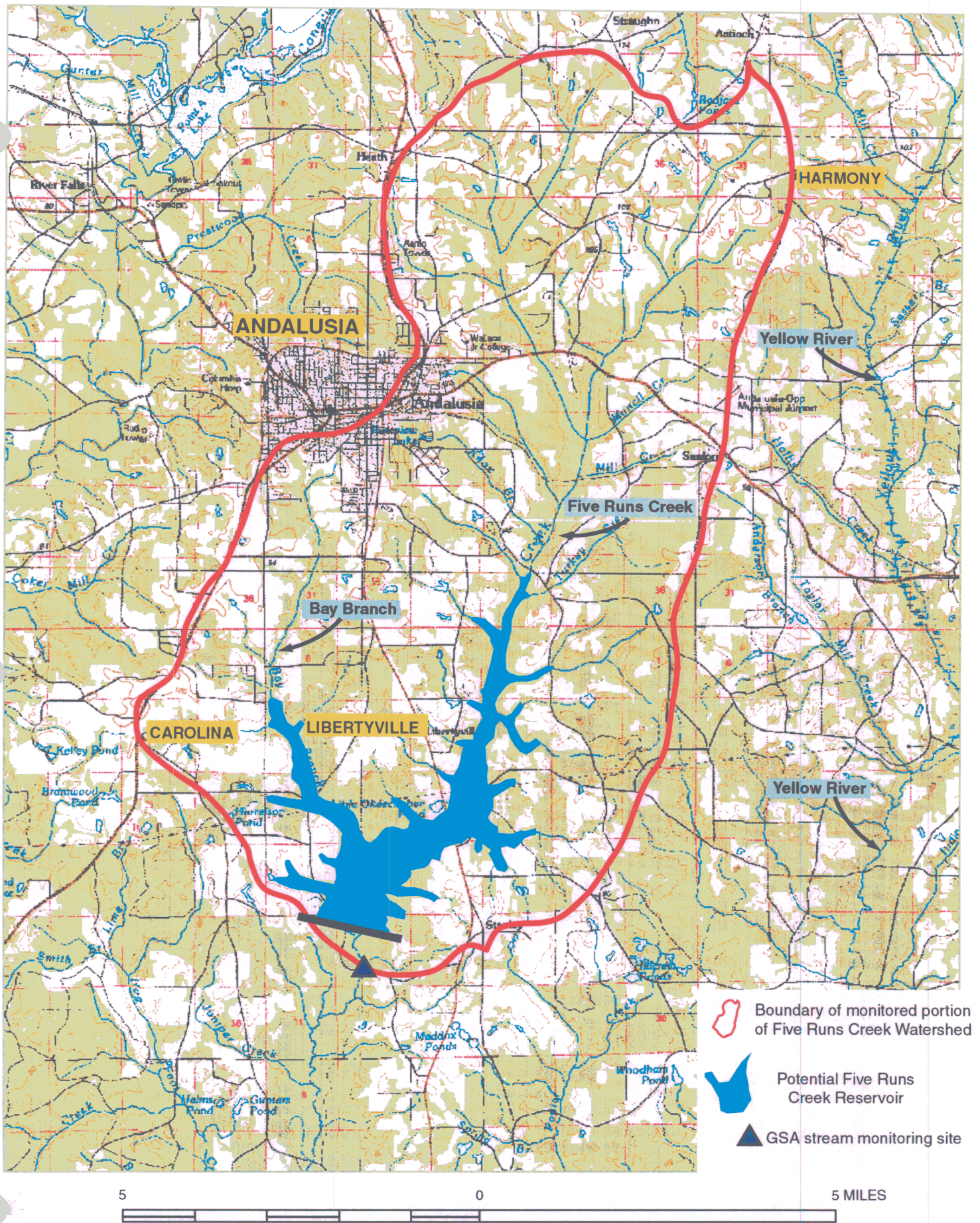


Figure 30.--Potential Impoundment of Five Runs Creek.

PREDICTED SEDIMENTATION RATE FOR THE POTENTIAL IMPOUNDMENT

Sediment load transport is an important consideration for the viability of a reservoir to supply water demands over the project life of the impoundment. Proposed reservoirs with excessive projected sedimentation fill rates may require implementation of a watershed erosion and sedimentation reduction plan prior to reservoir construction.

Sediment loads transported by streams consist of suspended load and bedload (table 20). The suspended loads for this evaluation were calculated using TSS concentrations and mean daily discharge entered into the regression with centering load modeling computer program. Bedload was calculated using measured bedload data and mean daily discharge. Annual sediment load mass for each evaluated stream was converted to volume and applied to the potential reservoir volume to obtain estimated fill rates (table 20).

Table 20.--Sedimentation rates and potential impoundment fill rates.

Watershed	Suspended Sediment (Tons/year)	Bedload Sediment (Tons/year)	Impoundment Fill Rate (Acre-feet/year)
Five Runs Creek	12.4	50	.02

VIABILITY OF POTENTIAL IMPOUNDMENT FOR PUBLIC WATER SUPPLY SOURCE

In order for the construction of a reservoir to be a worthwhile venture it must serve the purpose for which it was constructed. The reservoir site considered in this evaluation has a primary purpose of public water supply. It may be classified as multipurpose reservoir by supplying some recreational benefit. However, the benefit of the reservoir must justify the capital expenditure required for the project. The viability of the evaluated reservoir site was determined by the ability of the host watershed to satisfy criteria addressed in this report. These criteria are:

1. Sustainable water quantity capable of supplying future water demand.
2. Adequate water quality for all proposed water uses.
3. Acceptable reservoir life based on current or attainable future sedimentation rates.

Sustainable water quantity and required within-year impoundment storage for the evaluated watershed were determined using a coaxial diagram established for west-central Alabama streams and adapted for use with streams in the Choctawhatchee, Pea, and Yellow Rivers Watersheds. The diagram was established from multiple regressions of a range of draft rates from 25 to 50 percent of average daily discharge (Jefferson, 1968). This method determines required within-year storage by evaluating average mean annual daily discharge based on a period of record of at least 10 years. Discharge is equated with mean annual low flow (7-day Q_2) and proposed draft rate (from 25 percent to 50 percent of discharge) to determine required storage (fig. 31). A maximum draft rate of 50 percent was selected in order to ensure that the proposed reservoir would refill each year and to ensure adequate downstream water release.

Values of average daily discharge estimated for the period 1967-2001 and mean annual low flow for each of the project streams were input into the coaxial diagram. The resulting range of required storage values were compared to the normal pool volume determined for the proposed reservoir. If the proposed reservoir volume satisfied the required within-year storage then the potential reservoir was considered viable (table 21). The modeled draft rate must be compared to current and projected future water production demands for the potential reservoir supply area. This comparison will determine the viability of the proposed reservoir as a sustainable future water source.

Results of evaluation of draft sustainability by use of the Jefferson coaxial diagram indicate that the potential reservoir in the Five Runs Creek Watershed could not support a draft rate of 50 percent of average daily stream discharge (fig. 31).

The Jefferson coaxial model does not take into account impoundment storage losses due to evaporation. Regional lake evaporation data may supply approximate values of evaporation and may be useful in water resource planning or in the early stages of reservoir design (Dunne and Leopold, 1978). Mean annual lake evaporation for southeast Alabama is approximately 44 inches (Kohler and others, 1959). The resulting annual loss of water is approximately 5,900 acre-feet per year or about 18 percent of the proposed storage in the potential impoundment of Five Runs Creek.

Loss of water storage due to evaporation does not negate the viability of the potential impoundments to supply quantities of water presented previously in this report. However, after consideration of evaporation, the proposed reservoir for Five Runs Creek could support a draft rate of 40 percent or approximately 30 million gallons per day (mgd).

The probability of constructing an impoundment on Yellow River is relatively low. Therefore, no potential impoundment was considered during this evaluation. However, Yellow River could potentially supply a large quantity of excellent quality water for future needs. This water may be utilized via offstream storage or other viable water storage options that would not disrupt the free-flowing character of this important natural resource. Table 21 illustrates the water production potential of Yellow River.

Table 21.--Required storage for potential impoundment with selected draft rate and long-term average daily discharge.

Watershed	Average Daily Stream Discharge (mgd)	Proposed Impoundment Storage (Acre-feet)	Draft Rate (Percent of average discharge)	Potential Water Production (mgd) **	Required Impoundment Storage (Acre-feet)
Five Runs Creek	76	16,900	50	38	21,000
			25	19	8,000
Yellow River	325	*	50	163	85,000
			25	81	31,000

*No impoundment is proposed for Yellow River. Potential storage of water from Yellow River would be for off-stream storage only.

**Discharge values do not account for evaporation losses.

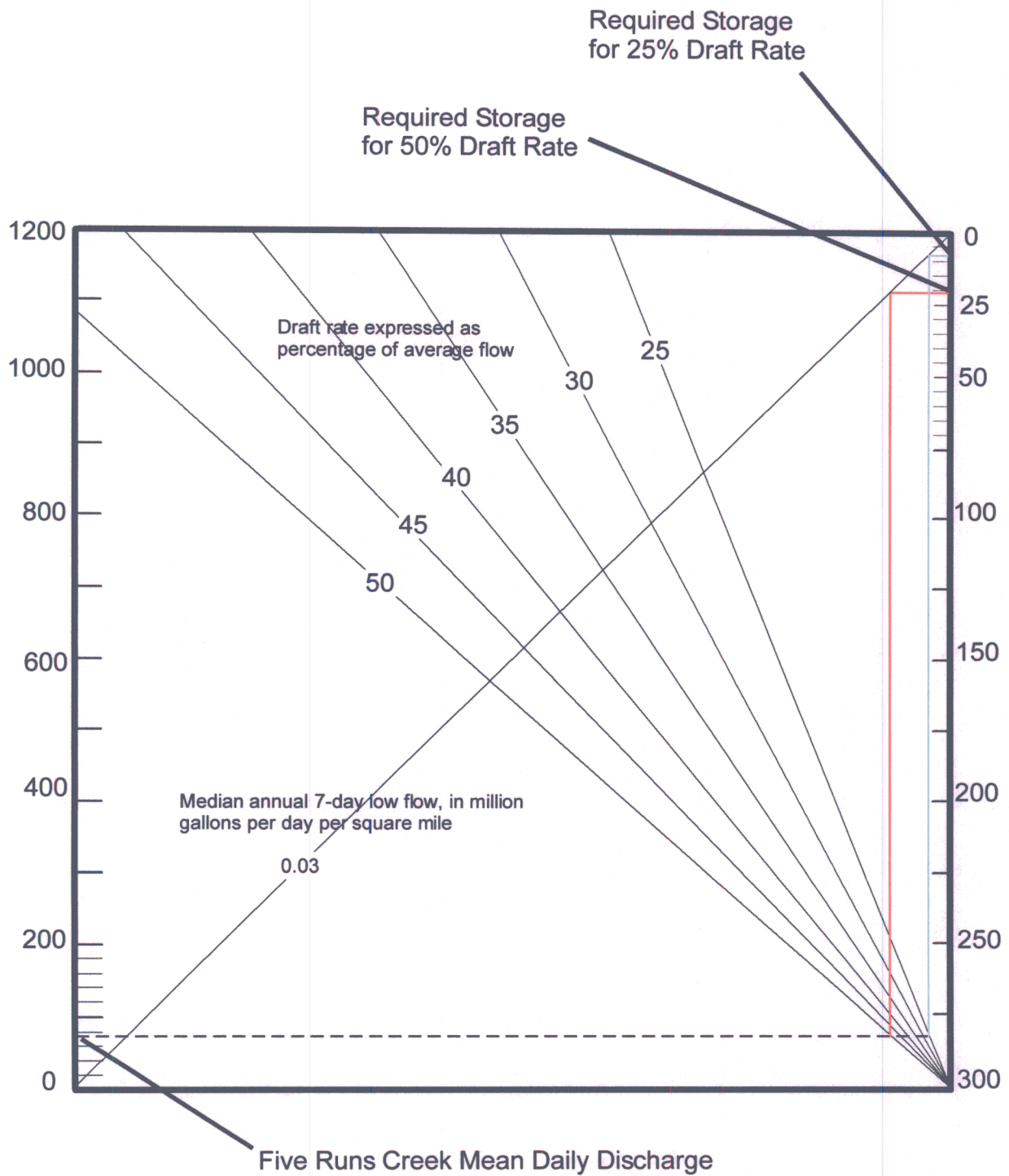


Figure 31.--Required impoundment storage for specified draft rate at potential Five Runs Creek Reservoir (modified from Jefferson, 1968).

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BIOMONITORING

INTRODUCTION

Biological and habitat studies of Five Runs Creek were undertaken in support of a project to evaluate the feasibility of surface water supply development. The goals of this effort were to (1) develop a biological and habitat profile of Five Runs Creek, based on a limited period of sampling; and (2) conduct literature and field studies for threatened and endangered aquatic species likely affected by water development projects. Based on the types and quantities of organisms collected, along with an accompanying habitat assessment, a determination of biological stream condition for the Five Runs Creek site was made.

The systematic assessment of water quality is a fundamental step for developing watershed management programs because it provides a sound technical basis from which to measure the effectiveness of conservation and pollution reduction efforts. Protection of stream water quality in Alabama is based on the water-use classification system where stream and river segments are classified according to one of seven water-use types. Water-quality criteria consisting of physical and chemical parameters, toxic substances, taste and odor, bacteria, radioactivity, and in some cases whole-effluent toxicity parameters are established for each water use classification. These criteria are applied to samples taken from permitted effluents, mixing zones immediately downstream of a discharge point, or ambient stream samples from a watershed. Over the last 25 years considerable effort has been expended to control point source pollution with less emphasis placed on managing water quality in entire watersheds and the water-quality implications of nonpoint source pollution.

Point source pollution is relatively easy to define in space and time and allows some degree of mathematical modeling to assist in managing water quality. In contrast, assessment of streams with polluted runoff from nonpoint sources is much more difficult to conduct because many contributing sources occur over wide geographic areas, discharge and release of polluted runoff occurs generally during storm events which are unpredictable in occurrence and intensity, and water-quality effects of polluted runoff are seen during both high and low stream flows. For example, sediment and bacterial pollution is highest during flood events while the effects of over nutrification are most severe during average to low stream flows in summer during the growing

season. As such, the accurate assessment and analysis of polluted runoff from nonpoint sources in watersheds requires additional tools that integrate the effects of climate, space, and time.

The methods of aquatic biomonitoring are well suited for assessing water-quality conditions and water-use attainment in streams and watersheds affected by polluted runoff. One intent of the Clean Water Act is to preserve and maintain “biological integrity” of the nation’s waters and biomonitoring directly measures biological integrity with no need to infer water-quality status from physical and chemical measurements. The total effect of all polluted runoff sources is measured through the integrating nature of species and populations. Because most aquatic organisms live in water their entire life cycle they cannot escape polluted runoff and must deal with environmental stress through physiological adaptation, population adjustment, or through altered population and community interactions such as competition, predation, disease, and parasitism. Therefore, organisms are forced to integrate all past and present water-quality stress into their population and community organization through loss of species, explosive growth or decline of some species, or alteration in productivity. On the other hand, biomonitoring data may be insufficient to detect stream impairment without appropriate reference conditions, and biosurveys generally cannot isolate the causative factors leading to stream impairment unlike chemical, physical, and toxicological methods. Biomonitoring studies also cannot predict future water-quality problems and generally do not directly assess human health risk.

Water-quality impacts associated with polluted runoff from crop and animal production, silviculture, and rural areas are relatively well known, consisting of elevated concentrations of sediments, nutrients, pesticides, and bacteria. The degree of impact to water-use attainment in rural watersheds is, however, often difficult to assess using conventional water analysis techniques because of differences in climate, local geography, and time. Therefore, assessment of nonpoint source pollution in these situations requires an integrated approach of physical and chemical characteristics, biological condition, and habitat quality. This triad assessment framework provides an array of tools for assessing stream water quality.

The selection of water quality assessment techniques should be dictated by the goals of water quality management such as permitting, water-use attainment studies, watershed assessments, and(or) long-term water-quality monitoring. The use of biomonitoring in

watershed assessments and water-use attainment studies can significantly enhance the scientific basis of all water-quality management decisions.

METHODS

BIOLOGICAL SAMPLING AND ANALYSIS

Incorporation of biological sampling into watershed assessment studies provides a significant additional tool for analyzing and describing sources of water-quality impairment in watersheds. Recent advances in the development of rapid bioassessment techniques for benthic macroinvertebrates and development of the index of biotic integrity for fishes has allowed biological data to become an equal partner to chemical and physical water-quality data for assessing watershed condition. Measures of biological condition seem particularly well suited for assessing nonpoint source pollution because substrate and habitat effects associated with polluted runoff generally correlate with declining biological condition. Biomonitoring samples were collected three times in Five Runs Creek: July 2001, October 2001, and January 2002.

BENTHIC MACROINVERTEBRATES

A modified version of the rapid bioassessment technique outlined in USEPA (1989) and ADEM (1996) was used to collect aquatic macroinvertebrates (table 1). A field team consisting of two or three persons sampled each site. Two persons used aquatic kick nets independently to sample as many different microhabitats as possible in 30 minutes, field sorting and preserving the specimens on site. Microhabitats included riffles (if present), leaf packs (or CPOM-coarse particulate organic matter), rock or log snags, root banks, macrophytes, and sand patches. Additionally, one small-mesh seine sample was made in the most optimum habitat at the site and picked for 60 minutes yielding a total sample time of two hours per site.

The biomonitoring goal of this project was to establish ambient biological conditions of Five Runs Creek. In the laboratory the majority of macroinvertebrate samples were identified to genus, with the exception of Cambaridae (crayfishes) which were identified to family, and this information was entered into a database for management and analysis. Guides used for specimen identification included Brigham and others (1982), Edmunds and others (1976), Epler (1996), Harris (1987), Merritt and Cummins (1984, 1996), Parrish (1975), Stewart and Stark (1988), Wiederholm (1983), and Wiggins (1977). Steve Harris of Clarion University, Pennsylvania

identified all Diptera in the families Chironomidae, Ceratopogonidae, and all aquatic worms in the order Oligochaeta.

Various analysis measures (metrics) were used to describe the biological condition of Five Runs Creek using the macroinvertebrate data (table 2). These measures were grouped into those that measure structural, balance, or functional components of the benthic macroinvertebrate community. Structural measures included total taxa, total families, total individuals collected per sampling unit (catch), and the EPT index. Total taxa is the number of distinct macroinvertebrate taxa, in this case genera, collected at a site. Likewise, total families is the number of macroinvertebrate families collected at a site. In general, streams that have good biological condition have more macroinvertebrate taxa and families than streams in poor biological condition. Total catch is the number of specimens collected in each sample based on our standardized sampling protocol (table 2). Those samples with a high catch typically indicate excessive productivity stimulated by some source of enrichment. The EPT index is the number of genera in the insect orders Ephemeroptera, Plecoptera, and Trichoptera. These insect orders are generally less tolerant of environmental change whether related to pollution or habitat degradation. The Hilsenhoff Biotic Index (HBI) is another measure of community structure that relates the abundance of a taxon to that taxon's pollution tolerance (Hilsenhoff, 1987) and was used to determine biological condition at Five Runs Creek. To calculate the HBI the number of individuals in each taxon was multiplied by a tolerance value, then these quantities were summed for the sample and divided by the total number of individuals in the sample. Tolerance values for each taxon range from 0 to 10, with 10 being very tolerant and 0 being very intolerant of pollution. Tolerance values were taken from ADEM (1996). The ADEM values were derived from the work of Lenat (1993), Hilsenhoff (1987), and Bode (1988). Criteria for determining biological condition using the HBI are shown in table 2.

Although the biological classification system developed by Hilsenhoff for ranking the biological condition of flowing streams was based on organic pollution tolerance, we have applied the measure as a general index of community health that incorporates not only organic enrichment but also the effects of nonpoint source pollution including habitat degradation, toxicity from pesticides and other chemicals, and sedimentation. The utility of applying the Hilsenhoff indices to Coastal Plain stream habitats will have to be carefully evaluated in the future because these streams are very different relative to habitat structure compared to those

streams for which the index was developed. Once a sufficient data base has been acquired, the biotic index criteria should be reinterpreted to be more sensitive to biological conditions and variation in Coastal Plain streams.

Measures of community balance attempt to quantify the evenness of the community where evenness is defined as the distribution of abundance among species. Communities out of balance have a disproportionate number of individuals in just a few taxa while communities in balance have a more equitable distribution of individuals among the taxa. A simple measure of community balance is the percent contribution by the dominant taxon. The proportion of midges (family Chironomidae) is another metric for assessing community balance. If an unusually large percentage of the most abundant taxon of midges is found, then the community is often out of balance due to pollution or habitat stress.

HABITAT ANALYSIS

Habitat evaluations are an important part of any effort to describe biological conditions because good biological condition is quite often predicated on the presence of stable and diverse habitat. The procedure used to quantify habitat conditions was reported in USEPA (1989). Three characteristics of habitat contribute to the maintenance and persistence of aquatic biological communities: the availability and quality of substrate and instream cover; morphology of the instream channel; and structure of the bank and riparian vegetation zone (USEPA, 1989). In the habitat evaluation procedure substrate parameters are weighted more heavily (0-20) than either channel parameters (0-15) or bank parameters (0-10) reflecting the relative importance of the habitat components to biological condition. The maximum habitat score is 155; however, habitat quality is sometimes taken as a percentage of the "best available habitat" or reference within a watershed. This reference value is considered the highest attainable value given the natural setting of the watershed and is assigned 100 percent. For this study, raw habitat scores were compared and ranked Good-Fair-Poor relative to habitat conditions at a site.

RESULTS

BIOLOGICAL CONDITION

A total of 556 individuals from three benthic macroinvertebrate samples was collected in three samples taken in Five Runs Creek from July 2001 to January 2002. Total individuals collected per sample ranged from 129 to 216. These individuals were found in 69 taxa representing annelid worms, mollusks, crustaceans, mites, and aquatic insects (table 3). Total taxa ranged from 32 in January to 44 in October. Total EPT taxa was 20 and ranged from 9 to 13 for the individual collections.

The most commonly encountered insect group was the true flies (Diptera) which comprised 33.4 percent of all invertebrates collected (table 3) and ranged from 20 percent in July to 57 percent in January. The second most common insect group was the mayflies (Ephemeroptera) which comprised 23.6 percent of all specimens collected and ranged from 10.8 percent in July to 33.8 percent in October (table 3). The third most common group were the dragonflies and damselflies (Odonata) which accounted for approximately 9.9 percent of all specimens collected and ranged from 3.3 percent in January to 15.7 percent in October (table 3).

The Hilsenhoff biotic index ranged from 5.68 (good) to 6.03 (good-fair) at Five Runs Creek (table 4). The Alabama Department of Environmental Management has a stream reference site in Clear Creek, just to the southeast of Five Runs Creek. ADEM has sampled Clear Creek four times and their results are also present in table 4 for comparison. Taxa diversity was lower and the biotic indexes were higher at Five Runs Creek indicating somewhat impaired biological conditions compared with good to excellent biological conditions at Clear Creek.

Five Runs Creek is a typical sand-bottomed Coastal Plain stream. Sand-mud shoals with occasional gravel are common at bends; pools are deep with a thin silt or mud layer; and tree-branch snags form glide-run habitats most productive of invertebrates. Habitat scores for Five Runs Creek indicated good conditions compared to fair to excellent conditions at Clear Creek.

The benthic macroinvertebrate community composition of streams in the Yellow River watershed is determined by a number of variables including stream size and gradient, land use/land cover, localized disturbance and pollution effects, geologic/geographic template, and microclimates. Benthic macroinvertebrate community composition of Five Runs Creek indicated

good stream quality, but biological condition was less than optimal likely due to a combination of nonpoint runoff from agricultural areas and around the city of Andalusia.

FISHES AND MUSSELS OF THE YELLOW RIVER WATERSHED

Mettee and others (1996) reported 49 fish species in the Alabama portion of the Yellow River watershed (table 5). More recent sampling in the Alabama portion of the Yellow River main channel added the gulf sturgeon (*Acipenser oxyrinchus desotoi*). Juvenile individuals 12 inches total length have been found at two locations in the Yellow River: upstream of Covington Co. Hwy. 4 (O'Neil and others, 2000) and downstream of Ala. Hwy. 55 (Ken Weathers, Wildlife and Freshwater Fisheries Division of the Alabama Department of Conservation and Natural Resources, personal communication). These recent sightings of juvenile gulf sturgeon are particularly significant because they indicate the presence of spawning sturgeon in the Yellow River system in Alabama.

Gulf sturgeon migrate upstream in the spring and are known to spawn as far as Newton in the Choctawhatchee River and the Elba dam in the Pea River. Fox and others (2000) provided evidence that the upper reaches of both the Choctawhatchee and Pea Rivers are important for successful reproduction of the species in these rivers. Sturgeon apparently require a hard substrate for spawning and actively avoid areas of loose sand and sediment. Hard limestone shoals of the Jackson and Claiborne Groups occur throughout the Choctawhatchee system in Alabama and provide critical spawning habitat for sturgeon. Similar limestone formations are known to outcrop in the Yellow River. This coupled with the fact that sturgeon are not known to spawn in the unconsolidated sandy substrates in Florida, highlight the fact that the Yellow, Pea, and Choctawhatchee Rivers main channels in Alabama are critical reproductive habitat for this species.

Fourteen species of freshwater mussels are known from the Yellow River system (table 5) (James D. Williams, U.S. Geological Survey, Florida Caribbean Science Center, personal communication). The Alabama moccasinshell (*Medionidus acutissimus*) was listed as endangered in 1993 and is known from the Yellow River system. Species diversity in this system is low, but future sampling may yield additional species and populations.

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Table 1. Benthic macroinvertebrate multi-habitat bioassessment procedures used by the Geological Survey of Alabama.

Habitat Selection	Two sample types are collected. One small-mesh seine sample is taken from a good riffle habitat or the most optimum available habitat . Kick net samples are taken from root banks, leaf packs, riffles, pools of sand/mud, aquatic macrophyte beds, all habitat types are sampled.
Sample Gear	Seine (4'x4'; 1/16" mesh) D-frame kick net Preservation-95% ethanol diluted to around 80%, samples picked on site and preserved in wide mouth plastic Nalgene bottles.
Sampling Method	<u>Seine</u> - sample is field picked for a total time of 1-hour or until no organisms can be found. <u>Kick Net</u> - two field personnel collect kick samples for a total of 30 minutes. During this time each person samples at a minimum the following habitats: Rootbanks - 2 samples Log/rock snags - 1 sample Pools (sand/mud) - 1 sample Leaf paks - 2 samples Macrophytes (if present) - 1 sample
Subsampling and Enumeration	Samples picked and preserved in the field. All organisms identified. No subsampling.
Taxonomic Level	<u>Family</u> : Annelida, some decapoda, some Mollusca, some Diptera <u>Genus</u> : All others
QA Procedures	<u>Field</u> : All personnel undergo yearly assessment of sampling techniques, refine sampling as needed. <u>Identifications</u> : Reidentify no more than 10% of samples in house. <u>Verification</u> : Random whole samples, and selected taxa sent to outside experts for verification.
Habitat Assessment	USEPA Physical Habitat Assessment Protocol (USEPA, 1989)
Metrics	Taxa richness, total individuals/time, EPT, Chironomidae richness, Biotic Index (Based on North Carolina tolerance values as modified), % Dominant Family, trophic composition
Comments	Our procedure can be described as "go for the bugs". Although we in general systematically sample representative habitat types at each site, the timed basis is our approach for confining our sampling efforts within a quantifiable limit.

Table 2. Benthic macroinvertebrate and habitat metrics.

Metric	Interpretation
Number of macroinvertebrate genera or families (taxa richness)	Declines with degrading water quality and (or) habitat degradation. Headwater streams are naturally unproductive and enrichment may yield an increase in family diversity.
Catch per sample	Increases with enrichment, becomes variable with habitat changes, decreases in highly stressed environments.
EPT index	Declines with degrading water-quality and (or) habitat degradation. May increase in headwater streams with enrichment.
Percent dominant taxon	Increases in a stressed environment. The most dominant taxon in least impaired streams should generally comprise <30 percent of the total abundance.
Biotic index (family or genus level)	Increases in a stressed environment

Biotic Index criteria			Biological Condition
Hilsenhoff (1988) family index	Modified family index criteria	Lenat (1993) criteria for Coastal Plain	
< 3.75	< 3.75	<5.24	Excellent
3.76 - 4.25	--	--	Very Good
4.26 - 5.00	3.76 - 5.00	5.25-5.96	Good
--	--	5.96-6.67	Good-Fair
5.01 - 5.75	5.01 - 6.00	6.68-7.70	Fair
5.76 - 6.50	--	--	Fairly Poor
6.51 - 7.25	6.01 - 7.25	>7.71	Poor
> 7.25	> 7.25	--	Very Poor

Table 3. Macroinvertebrate taxa collected from Five Runs Creek, 2001-02.

Macroinvertebrate taxa			Number collected				Percent composition
			July 01	Oct 01	Jan 02	Total	
Annelida	Hirudinea	Branchiobdellidae		2		2	2.52
	Oligochaeta	Lumbriculidae	2	4	6	12	
Acarina	Arrenuridae	<i>Arrenurus</i>		2		2	4.32
	Lebertiidae	<i>Lebertia</i>	18	2		20	
	Limnesiidae	<i>Limnesia</i>		1		1	
	Sperconidae	<i>Spercon</i>	1			1	
Crustacea	Asellidae	<i>Asellus</i>	2	1		3	8.27
	Cambaridae		12	17	5	34	
	Palaemonidae	<i>Palaemonetes</i>		1		1	
	Talitridae	<i>Hyaella</i>	8			8	
Coleoptera	Dytiscidae	<i>Hydroporus</i>		9	6	15	5.94
		<i>Ancyronyx</i>		7		7	
		<i>Dubiraphia</i>		1		1	
		<i>Macronychus</i>	1	1	1	3	
	Elmidae	<i>Stenelmis</i>		3	1	4	
	Gyrinidae	<i>Dineutus</i>	2		1	3	
		<i>Mallochohelea</i>		2	2	4	
		nr. <i>Bezzia</i>		1		1	
Diptera	Ceratopogonidae	<i>Probezzia</i>		3		3	33.45
		<i>Ablabesmyia</i>	3	4	3	10	
		<i>Cladotanytarsus</i>	1			1	
		<i>Cricotopus</i>	2			2	
		<i>Cryptochironomus</i>	3		1	4	
		<i>Paramerina</i>	1			1	
		<i>Polypedilum</i>	2	5	3	10	
		<i>Stenochironomus</i>		1		1	
		<i>Tanytarsus</i>	6	20	4	30	
		<i>Thienemanniella</i>	1			1	
		<i>Thienemannimyia</i> gr.	1			1	
	Chironomidae	<i>Tribelos</i>	4	1	107	112	
	Simuliidae	<i>Simulium</i>			1	1	
		<i>Dicranota</i>	1			1	
	Tipulidae	<i>Hexatoma</i>	1	2		3	
Ephemeroptera		<i>Acerpenna</i>		3	1	4	23.56
		<i>Baetis</i>	5	10	9	24	
		<i>Barbetis</i>			1	1	
	Baetidae	<i>Centroptilum</i>		1		1	
	Caenidae	<i>Caenis</i>	1	5		6	
	Ephemerellidae	<i>Eurylophella</i>			2	2	
	Ephemeridae	<i>Hexagenia</i>	1	6		7	

Macroinvertebrate taxa			Number collected				Percent composition
			July 01	Oct 01	Jan 02	Total	
		<i>Stenacron</i>			4	4	
	Heptageniidae	<i>Stenonema</i>	7	48	25	80	
	Leptophlebiidae	<i>Paraleptophlebia</i>			2	2	
Hemiptera		<i>Limnopus</i>		1		1	
	Gerridae	<i>Trepobates</i>	1			1	
	Nepidae	<i>Ranatra</i>		2		2	
		<i>Microvelia</i>	1		1	2	
	Veliidae	<i>Rhagovelia</i>	1			1	1.26
Megaloptera	Sialidae	<i>Sialis</i>	5	2		7	1.26
Odonota	Aeshnidae	<i>Boyeria</i>	5	2		7	
	Calopterygidae	<i>Calopteryx</i>	3	1	1	5	
	Coenagrionidae	<i>Argia</i>	3	24	2	29	
	Corduliidae	<i>Macromia</i>	2	3		5	
		<i>Gomphus</i>		2	1	3	
		<i>Hagenius</i>			3	3	
	Gomphidae	<i>Progomphus</i>	1	1		2	
	Libellulidae	<i>Pachydiplax</i>		1		1	9.89
Plecoptera		<i>Acroneuria</i>		1		1	
		<i>Neoperla</i>		2		2	
	Perlidae	<i>Perlesta</i>			5	5	
	Perlodidae	<i>Diploperla</i>			1	1	1.62
Trichoptera	Hydropsychidae	<i>Cheumatopsyche</i>	2	1	6	9	
	Leptoceridae	<i>Nectopsyche</i>	2			2	
	Limnephilidae	<i>Pycnopsyche</i>			2	2	
	Philopotamidae	<i>Chimarra</i>	1	1	1	3	
		<i>Phylocentropus</i>	1			1	
	Polycentropodidae	<i>Polycentropus</i>	1		2	3	3.6
Mollusca	Corbiculidae	<i>Corbicula</i>	12	7	1	20	
	Pleuroceridae	<i>Elimia</i>	2	2		4	4.32
Total Individuals			129	216	211	556	
Total taxa			40	44	32	69	
Total families			28	31	24	42	
Total EPT taxa			9	10	13	20	

Table 4. Habitat and biological characteristics at Five Runs Creek, 2001-02.

Habitat characteristics		Sampling date		
		17 July 2001	26 Oct 2001	31 Jan 2002
Temperature (°C)		24.2	14.7	17.0
Dissolved oxygen (mg/L)		--	8.4	7.8
Percent saturation		--	85	82
pH		--	5.9	6.5
Specific conductance (µS/cm)		82	74	66
Substrate composition (percent coverage)	Sand	75	65	60
	Silt	10	15	15
	Detritus/snags	15	20	25
Habitat evaluation	Substrate	30	33	31
	Channel	26	24	28
	Bank	20	23	20
	Total score ¹	76	80	79
	Rank	good	good	good
Biological characteristics				
Total individuals		129	216	211
Total taxa		40	44	32
EPT taxa		9	10	13
Hilsenhoff index		6.03	5.88	5.68
Biological condition		good-fair	good	good
ADEM Biological Reference site Clear Creek-Covington County 33 mi ² drainage area		Jun 1993	May 1995	Dec 1996
Total taxa		46	50	64
EPT taxa		16	18	24
Biological condition		excellent	good	good
Habitat index		good	fair	excellent

¹ - habitat score criteria: 0-35 poor; 36-70 fair; 71-105 good; >105 excellent.

Table 5. Fish and mussel species reported from the Yellow River system in Alabama.

ACIPENSERIDAE- STURGEONS

Acipenser oxyrinchus desotoi- gulf sturgeon

CYPRINIDAE- CARPS AND MINNOWS

Cyprinella venusta- blacktail shiner

Ericymba buccata- silverjaw minnow

Hybopsis sp.cf *winchelli* - undescribed chub

Lythrurus atrapiculus- blacktip shiner

Macrhybopsis sp.cf *aestivalis*- undescribed chub

Notemigonus crysoleucas- golden shiner

Notropis chalybaeus- ironcolor shiner

N. harperi- redeye chub

N. longirostris- longnose shiner

N. texanus- weed shiner

Pteronotropis hypselopterus- sailfin shiner

P. signipinnis- flagfin shiner

P. welaka- bluenose shiner

Semotilus thoreauianus- Dixie chub

CATOSTOMIDAE- SUCKERS

Erimyzon sucetta- lake chubsucker

E. tenuis- sharpfin chubsucker

Minytrema melanops- spotted sucker

Moxostoma poecilurum- blacktail redhorse

ICTALURIDAE- BULLHEAD CATFISHES

Ameiurus natalis- yellow bullhead

A. nebulosus- brown bullhead

Noturus funebris- black madtom

N. gyrinus- tadpole madtom

N. leptacanthus- speckled madtom

ESOCIDAE-PIKES

Esox americanus- redbfin pickerel

E. niger- chain pickerel

APREDODERIDAE- PIRATE PERCH

Aphredoderus sayanus- pirate perch

FUNDULIDAE- TOPMINNOWS

Fundulus escambiae- russetfin topminnow

F. olivaceus- blackspotted topminnow

POECILIIDAE

Gambusia holbrooki- eastern mosquitofish

ELASSOMATIDAE- PYGMY SUNFISHES

Elassoma zonatum- banded pygmy sunfish

CENTRARCHIDAE- SUNFISHES

Ambloplites ariommus- shadow bass

Centrarchus macropterus- flier

Lepomis gulosus- warmouth

L. macrochirus- bluegill

L. marginatus- dollar sunfish

L. megalotis- longear sunfish

L. microlophus- redbear sunfish

L. miniatus- redspotted sunfish

Micropterus punctulatus- spotted bass

M. salmoides- largemouth bass

Pomoxis annularis- white crappie

P. nigromaculatus- black crappie

PERCIDAE- PERCHES

Ammocrypta bifascia- Florida sand darter

Etheostoma colorosum- coastal darter

E. davisoni- Choctawhatchee darter

E. edwini- brown darter

E. parvipinne- goldstripe darter

E. swaini- gulf darter

Percina nigrofasciata- blackbanded darter

UNIONIDAE-FRESHWATER MUSSELS¹

Elliptio crassidens- elephantear

E. icterina- variable spike

Fusconaia succissa- purple pigtoe

Lampsilis australis- southern sandshell

L. straminea claibornensis- southern fatmucket

Medionidus acutissimus- Alabama moccasinshell

Pleurobema strodeanum- fuzzy pigtoe

Ptychobranhus jonesi- southern kidneyshell

Toxolasma parvus - lilliput

Uniomerus tetralasmus- pondhorn

Utterbackia imbecillis- paper pondshell

Villosa choctawensis- Choctaw bean

V. lienosa- little spectaclecase

V. vibex- southern rainbow

1- Personal communication, James D. Williams, U.S. Geological Survey, Florida Caribbean Science Center, Gainesville, Florida.

Appendix A

Archaeological Artifacts in Evaluated Watershed Areas

Watershed	Site No.	Site Location	National Historic Register Eligibility	Site Characterization
Five Runs Creek	CV 90	Wing Quad Sec 1 T1N R15E	No	None noted
	CV 137	Wing Quad Sec 35 T2N R15E	No	None noted
	CV 138	Wing Quad Sec 35 T2N R15E	No	Artifact scatter
	CV 139	Wing Quad Sec 2 T1N R15E	No	Features
	CV 140	Wing Quad Sec 2 T1N R15E	No	Features
	CV 151	Wing Quad Sec 35 T2N R15E	No	None noted
	CV 186	Wing Quad Sec 24 T2N R15E	No	Artifact scatter
	CV 187	Wing Quad Sec 24 T2N R15E	No	Artifact scatter
	CV 188	Wing Quad Sec 25 T2N R15E	Yes	Artifact scatter
Yellow River	CV 189	Watkins Bridge Quad S35 T1N, R16E	No	Artifact scatter
	CV 214	Libertyville Quad S22 T2N R16E	No	Artifact scatter
	CV 215	Libertyville Quad S22 T2N R16E	No	Artifact scatter and standing historic structure

Appendix B

Primary and Secondary Drinking Water Standards July 2002 (US EPA, 2002)



National Primary Drinking Water Standards

Contaminant	MCLG ¹ (mg/L) ²	MCL or TT ¹ (mg/L) ²	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water
MICROORGANISMS				
<i>Cryptosporidium</i>	zero	TT ³	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and fecal animal waste
<i>Giardia lamblia</i>	zero	TT ³	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste
Heterotrophic plate count (HPC)	n/a	TT ³	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment
<i>Legionella</i>	zero	TT ³	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems
Total Coliforms (including fecal coliform and <i>E. coli</i>)	zero	5.0% ⁴	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present ⁵	Coliforms are naturally present in the environment; as well as feces; fecal coliforms and <i>E. coli</i> only come from human and animal fecal waste.
Turbidity	n/a	TT ³	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff
Viruses (enteric)	zero	TT ³	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste
DISINFECTION BYPRODUCTS				
Bromate	zero	0.010	Increased risk of cancer	Byproduct of drinking water disinfection
Chlorite	0.8	1.0	Anemia; infants & young children: nervous system effects	Byproduct of drinking water disinfection
Haloacetic acids (HAA5)	n/a ⁶	0.060	Increased risk of cancer	Byproduct of drinking water disinfection
Total Trihalomethanes (TTHMs)	none ⁷ n/a ⁶	0.10 0.080	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection
DISINFECTANTS	MRDL ¹ (mg/L) ²	MRDL ¹ (mg/L) ²		

Contaminant	MCLG ¹ (mg/L) ²	MCL or TT ¹ (mg/L) ²	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water
Oxamyl (Vydate)	0.2	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes
Polychlorinated biphenyls (PCBs)	zero	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals
Pentachlorophenol	zero	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood preserving factories
Picloram	0.5	0.5	Liver problems	Herbicide runoff
Simazine	0.004	0.004	Problems with blood	Herbicide runoff
Styrene	0.1	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills
Tetrachloroethylene	zero	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners
Toluene	1	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories
Toxaphene	zero	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle
2,4,5-TP (Silvex)	0.05	0.05	Liver problems	Residue of banned herbicide
1,2,4-Trichlorobenzene	0.07	0.07	Changes in adrenal glands	Discharge from textile finishing factories
1,1,1-Trichloroethane	0.20	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories
1,1,2-Trichloroethane	0.003	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories
Trichloroethylene	zero	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories
Vinyl chloride	zero	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories
Xylenes (total)	10	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories
RADIONUCLIDES				
Alpha particles	none ⁷	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation
Beta particles and photon emitters	none ⁷	4 millirems per year (mrem/yr)	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation
Radium 226 and Radium 228 (combined)	none ⁷	5 pCi/L	Increased risk of cancer	Erosion of natural deposits

Contaminant	MCLG ¹ (mg/L) ²	MCL or TT ¹ (mg/L) ²	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water
Uranium	zero	30 ug/L as of 12/08/03	Increased risk of cancer, kidney toxicity	Erosion of natural deposits

NOTES

1 - Definitions

Maximum Contaminant Level Goal (MCLG) - The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

Maximum Residual Disinfectant Level Goal (MRDLG) - The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

Maximum Residual Disinfectant Level (MRDL) - The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

Treatment Technique (TT) - A required process intended to reduce the level of a contaminant in drinking water.

2 - Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 - EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

Cryptosporidium (as of 1/1/02 for systems serving >10,000 and 1/14/05 for systems serving <10,000) 99% removal.

Giardia lamblia: 99.9% removal/inactivation

Viruses: 99.99% removal/inactivation

Legionella: No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, *Legionella* will also be controlled.

Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month.

HPC: No more than 500 bacterial colonies per milliliter

Long Term 1 Enhanced Surface Water Treatment (Effective Date: January 14, 2005); Surface water systems or (GWUDI) systems serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).

Filter Backwash Recycling; The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

4 - No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli* if two consecutive TC-positive samples, and one is also positive for *E. coli* fecal coliforms, system has an acute MCL violation.

5 - Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.

6 - Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:

- Haloacetic acids: dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- Trihalomethanes: bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

7 - MCLGs were not established before the 1986 Amendments to the Safe Drinking Water Act. The standard for this contaminant was set prior to 1986. Therefore, there is no MCLG for this contaminant.

8 - Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

9 - Each water system must certify, in writing, to the state that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05% dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent).

Office of Water (4606)

EPA 816-F-02-013

www.epa.gov/safewater

July 2002

For More Information:
Call the Safe Drinking Water Hotline, 1-800-426-4791

Appendix B (continued)

Secondary Drinking Water Standards

Contaminant	Level
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 color units
Copper	1.0 mg/L
Corrosivity	Non-corrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5 – 8.5
Silver	0.1 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L