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A COMPREHENSIVE NONPOINT SOURCE FIELD STUDY FOR SEDIMENT, NUTRIENTS, AND PATHOGENS IN THE SOUTH FORK BROAD RIVER WATERSHED IN NORTHEAST GEORGIA

by

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NOTICE

This report was prepared and reviewed by the EPA's National Exposure Research Laboratory's Ecosystems Research Division in Athens, Georgia, and the Region 4's Science and Ecosystem Support Division in Athens, Georgia, and approved for publication.

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FOREWORD

As environmental controls become more costly to implement and the penalties of judgement errors become more severe, environmental quality management requires more efficient management tools based on greater knowledge of the environmental phenomena to be managed. The National Exposure Research Laboratory's Ecosystems Research Division (ERD) in Athens, GA, conducts process, modeling, and field research to assess the exposure risks of humans and ecosystems to chemical and non-chemical stressors. ERD research includes studies of the behavior of contaminants, nutrients, and biota in environmental systems, and the development of mathematical models to assess the response of aquatic systems, watersheds and landscapes to stresses from natural and anthropogenic sources. ERD field and laboratory studies support process research, model development and field testing, and characterize variability and prediction uncertainty.

A cooperative field data collection project was developed in the South Fork Broad River Watershed (SFBR), a 245.18 square mile area with 337.32 stream miles located in the Savannah River Basin, that consists of intensive storm event stream sampling. In 1998, the State of Georgia listed the SFBR watershed as biologically impaired (i.e. 303. (d) list), but the source of contamination was unknown. This project would support: 1) developing sampling protocols to measure the Total Maximum Daily Load (TMDL) of bedload and suspended sediment, nutrients (e.g. indicators total nitrogen, nitrate, ammonia, ortho and total phosphorus), total organic carbon and pathogens (e.g. indicators fecal coliform, E. coli, and enterococci); and 2) developing a comprehensive database to develop, field test and apply mathematical models and protocols for calculating the TMDLs in this watershed and its tributaries in a field setting not available elsewhere in the U.S. Six stream sites were highly instrumented with specialized monitoring equipment (e.g. ISCO water samplers, YSI multi-probes and cableway sampling systems) for collecting data before, during and after storm events.

This project was a great example of joint Federal cooperation where special expertise and technology were being pooled to achieve a common goal. This effort addressed several of the issues identified in the "Twenty Needs Report: How Research Can Improve the TMDL Program", EPA, 2002 and will establish a scientific database for clean sediment and pollutant TMDLs. This project will improve Regional involvement in research planning and enhance ORD's detailed knowledge of the TMDL program. Participants in the study included: The U. S. Environmental Protection Agency, Office of Research and Development, National Exposure Research Laboratory, Ecosystems Research Division, Athens, GA; the EPA Region 4 Science and Ecosystem Support Division, Athens, GA; the EPA Region 4 Water Management Division, Atlanta, GA; and other Federal, State and County Agencies, and landowners.

The report is intended to provide a description of the field project design, quality control, sampling and analysis methodology and standard operating procedures. The database design, architecture, user access, quality control, security and other details will be made available in a separate report.

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ABSTRACT

This technical report provides a description of the field project design, quality control, the sampling protocols and analysis methodology used, and standard operating procedures for the South Fork Broad River Watershed (SFBR) Total Maximum Daily Load (TMDL) project. This watershed is located in the Savannah River Basin and the project constitutes Task 12556, Field Research Program. A TMDL is the sum of the individual pollutant waste load allocation for point sources and load allocation for nonpoint sources and natural background, with a margin of safety (CWA Section 303 (d)(1)(C), EPA 1999).

The field study reported was part of a project designed to develop sampling protocols and predictive models, and to establish a comprehensive database to field test the developed models in a field setting not available elsewhere in the U.S. The protocols and models will then be applied to calculate a series of TMDLs for contaminants of concern (e.g. sediment, nutrients and pathogens). These protocols can be used by the EPA Regions, Office of Water, and States to meet the national requirements for TMDL development and implementation under the Clean Water Act. The field study will establish scientific basis for clean sediment and pollutant TMDLs.

Our selected field site was the SFBR watershed, a 245.18 square mile area located in the Savannah River Basin near Athens, GA. Six sites within the SFBR were highly instrumented with specialized monitoring equipment (e.g. ISCO, YSI multi-probes, cableway sampling system) to collect data before, during and after storm events on stream depth, turbidity, specific conductance, pH, dissolved oxygen (DO), Oxidation Reduction Potential (ORP), and temperature. Rain-event stream sampling was conducted for bedload sediment, total suspended solids (TSS), nutrients (e.g. nitrate, ammonia, total nitrogen, ortho and total phosphorus), total organic carbon and pathogens (e.g. indicators fecal coliform, E. coli, and enterococci). Stream hydrographic data were also collected including stage-discharge relationships, water stage records and velocity profiles. The water stage data was obtained at a continuously recording USGS station (SFBR70) plus several non-recording stations (i.e. SFBR10, 20, 30, 40 and 60). The stage data and the attendant stage-discharge relationships provide the basis for assessing stream discharge. When coupled with analytical measurements, pollutant loadings can then be calculated for the various sampled runoff events.

Two hundred seventy nine stream cross-sectional sites located along stream channels in the SFBR were surveyed and sampling/analysis completed for particle size distribution at 90 of these sites.

Slope-elevation estimates have been developed to generate longitudinal profiles at selected cross-sectional sites along the SFBR and at sites 1500 feet above and below existing bridges, using bridge elevation data as benchmarks obtained from the Georgia Department of Transportation.

A comprehensive relational database system has been designed and populated with data collected from the South Fork Broad River Watershed sampling sites. The database resides in MySQL database server. Field data are recorded in various formats including hand written field and lab sheets, text files, and excel worksheets. A software system has been developed for transferring data from text files and excel worksheets to the relational database. The database created in the SFBR will be unique; there is no other study site with a comparable collection of data in the U.S.

CONTENTS

NOTICE ii
FOREWORD iii
ABSTRACT iv
CONTENTS vi
LIST OF TABLES viii
LIST OF FIGURES ix
ACKNOWLEDGMENTS xi
Chapter 1 1
INTRODUCTION 1
Statement of Problem 1
Background 1
Chapter 2 8
SUMMARY AND CONCLUSIONS 8
Chapter 3 11
DESCRIPTION OF SFBR WATERSHED PROJECT 11
Project Objectives 11
Specific Project Objectives 11
Watershed Characteristics 11
Experimental Design 13
Landowner Approval 13
Field Site Name and Location 18
Stream Monitoring Site Design 22
Installation of Cableway Sampling Systems 23
Site Maintenance 24
Communication at Field Sites 24
Laboratory Modifications 24
Vehicle Requirements 26
Battery Charging 26
Stream Cross Sections 26
Weather Station 28
Storm Event Sampling 28
Pathogen Sampling 30
Monthly Base Flow Sampling 32
Field Sampling procedures 32
Stream Flow 32
Stream Velocity Profiles 33
Laboratory Analysis Procedures 33
Training of Field Sampling and Laboratory Analysis Teams 48
Quality Assurance 48
Database Development 50

Chapter 4 51
Supporting Projects in SFBR 51
Interagency Agreement with the U.S. Geological Survey. 51
Task Order through Region 4 contractor, Integrated Laboratory Systems, Inc. . 51
Interagency Agreements with the U.S. Army Corps of Engineers. 51
Cooperative Agreement with the University of Georgia. 52
In-house research Project by Roger Burke. 52
Chapter 5 55
RESULTS OF STUDY 55
REFERENCES 73
Appendices 75
1. Standard Operating Procedures 75
EAB-001.0 Bridge Sampling Using Bedload and DH-59 Samplers 75
EAB-002.0 Use of Laboratory Balances 77
EAB-003.0 Chemical Analysis of Nutrients Using the AutoAnalyzer 3 79
EAB-004.0.Analysis of Total Suspended Solids (TSS) 83
EAB-005.0 Operation of the Cableway System at SFBR30 87
EAB-006.0 Operation of the Cableway System at SFBR60 92
EAB-007.0 Operation of the Cableway System at SFBR70 97
EAB-008.0 Field Sample Numbering System for Storm Event Sampling 101
EAB-009.0 Stream Cross Section Sample Numbering System 105
EAB-010.0 Particle Size Analysis Using the Coulter LS200 PSA 107
EAB-011.0 Analysis of Total Organic Carbon (TOC) 112
EAB-041.0 Fecal Coliform Membrane (MF) Technique 114
EAB-042.0 Simultaneous Detection of Total Coliform and *Escherichia coli* . 118
EAB-043-0 Detection and Quantification of Enterococci 122
2. Storm Event Sampling Data Analysis 125

LIST OF TABLES

Table: 1. Loadings for SFBR sites for March 12, 2002 Rain Event 9, 67
Table: 2. Stream Site Identification and Drainage Areas 17
Table: 3. Loading rates for SFBR10 Rain Event on March 12, 2002 68
Table: 4. Loading rates for SFBR20 Rain Event on March 12, 2002 69
Table: 5. Loading rates for SFBR30 Rain Event on March 12, 2002 70
Table: 6. Loading rates for SFBR40 Rain Event on March 12, 2002 71
Table: 7. Loading rates for SFBR60 Rain Event on March 12, 2002 72

LIST OF FIGURES

Figure 1. Fecal Coliform Counts in the Savannah River Basin and the South Fork Broad River Watershed 5
Figure 2.Location of South Fork Broad River Watershed in Clarke, Madison and Oglethorpe Counties, GA. 6
Figure 3. South Fork Broad River Watershed Stream Sample Sites, Rain Gage and Weather Station Locations 7
Figure 4: South Fork Broad River Watershed with USGS 12 Digit HUC's 14
Figure 5: Land Cover in the South Fork Broad River Watershed 15
Figure 6: Digitized Soils Map of Oglethorpe County Portion of SFBR 16
Figure 7: SFBR10 19
Figure 8: SFBR20 19
Figure 9: SFBR30 20
Figure 10: SFBR40 20
Figure 11: SFBR60 21
Figure 12: SFBR70 21
Figure 13: ISCO Setup at Each Sampling Site 25
Figure 14: YSI Multi-Probe 25
Figure 15. Stream Cross Sectional Sampling Sites, 305 are Scheduled for Investigation 27
Figure 16: Weather Station 29
Figure 17: Rain Gage 29
Figure 18: 6-inch Helley-Smith Bedload Sampler 31
Figure 19: Depth Integrated Sampler 31
Figure 20a. USGS Precipitation Data at SFBR70 site, 02-13-2003 35
Figure 20b. USGS Gage Height Data at SFBR70 site, 02-13-2003 36
Figure 20c. USGS Discharge Data at SFBR70 Site, 02-13-2003 37
Figure 20d. Stream Velocity Profiles for SFBR10 Site, 02-8 & 12-2002 38
Figure 20e. Stream Velocity Profiles for SFBR20 Site, 02-8-2003 40
Figure 20f. Stream Velocity Profiles for SFBR30 Site, 02-7 & 12-2002 42
Figure 20g. Stream Velocity Profiles for SFBR60 Site, 02-7, 8, & 12-2002 44
Figure 20h. Stream Velocity Profiles for SFBR70 Site, 02-7 & 12-2002 46
Figure 21: South Fork Broad River Laboratory Analysis Flow Chart 49
Figure 22. Location of Seventeen Small Watershed Sampling Sites in SFBR Study Area. . . . 56
Figure 23. Comparison of Monthly Rainfall in SFBR with 20 Year Average 57
Figure 24. SFBR Average vs 2000 and 2001 57
Figure 25. Comparison of TSS vs Stream Level at SFBR 10 Site for Storm Event on March 12, 2002 58
Figure 26. Comparison of Turbidity by YSI vs Stream Level at SFBR 10 Site for Storm Event on March 12, 2002 60
Figure 27. Comparison of TSS vs Turbidity at SFBR 10 Site for Storm Event on March 12, 2002 61

Figure 28. Comparison of Total Suspended Solid Measurements of Depth Integrated and ISCO samplers. 62

Figure 29. Estimated linear relationship between Depth Integrated and ISCO Total Suspended Solid measurements. 62
Figure 30. Comparison of one hour versus two hour ISCO Total Suspended Solid measurements. 64
Figure 31. Linear relationship between one hour and two hour ISCO Total Suspended Solid measurements. 64
Figure 32. Relationship between the standard deviation and the mean of Depth Integrated Total Suspended Solids measurements. 65
Figure 33. Relationship between the coefficient of variability and the mean of Depth Integrated Total Suspended Solids measurements. 65
Figure 34. Relationship between Depth Integrated Total Suspended Solid measurements taken at various locations within a stream cross-section. 66

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3. Mr. Bill Bokey, EPA Region 4 SESD, Chief, Ecological Support Branch, Athens, GA

Chapter 1
INTRODUCTION

Statement of Problem

There is an urgent need for EPA to develop protocols for establishing Total Maximum Daily Load (TMDL) in streams, lakes and estuaries. Prior to the SFBR project, there was limited scientific data available to support TMDL development. The results of the SFBR project will accomplish the following:

- Provide a comprehensive dataset that allows for the development, field testing, and calibration of mathematical models addressing water quality and quantity in a watershed. The dataset created in SFBR will be unique; there is no other study site with a comparable collection of data in the U.S.

- Provide robust data and models that establish a scientific basis for clean sediment and pollutant TMDLs

- Provide a means of testing field and laboratory instrumentation, methodolgy, and development of standard operating procedures for sampling protocols, sample processing and analytical analyses

- Develop procedures for site selection, field instrumentation, maintenance and servicing, frequency of sampling, data requirements, safety and QA

Background

A TMDL is an estimate of the maximum pollutant loading from both point and nonpoint sources that receiving waters can accept without exceeding water quality standards. Point source loadings are essentially continuous in time, while most nonpoint source (NPS) loadings occur intermittently. Under §303(d) of the Clean Water Act, each State must: 1) produce and provide EPA with a list of waters where water quality standards are not being attained, 2) prioritize the development of TMDLs for these water bodies that will result in attainment of standards, and 3) develop and implement the TMDLs. In the event a State fails to develop the list or to develop TMDLs, EPA is obligated to do so. Although the TMDL requirement has been in existence for twenty years, most implementation to date has focused on point source requirements rather than nonpoint loadings. Environmental groups have become impatient with the TMDL process. In the lawsuit, Sierra Club et al. vs. U.S. EPA, Browner, and Hankinson, the court found that EPA's failure to disapprove Georgia's inadequate TMDL submissions was in violation of the Administrative Procedure Act and the Clean Water Act. Sierra Club et al 1996. On September 2, 1996, the district court ordered EPA to ensure that TMDLs were established for all 303(d) listed waters within five years and to ensure that they are implemented through the National Pollutant Discharge Elimination System permitting program of the states. In July, 1997, the parties signed a consent decree that would supersede the court's order of September 2, 1996. The decree sets out a schedule for establishing TMDLs in each of Georgia's watershed basins between 1998 and 2005.

The decree provides that EPA would ensure that the TMDLs are established if Georgia does not. If Georgia fails to propose the TMDLs for the Savannah/Ogeechee Basins by 6/30/04, then EPA shall propose them by 8/30/04 including the Broad River. TMDLs have already been estimated by EPA Region 4 for the South Fork Broad River, and will be reevaluated based on results of this research study.

Protocols are urgently needed by the States and EPA to develop over 10,000 watershed sediment TMDLs that must be established over the next 8 - 15 years to attain the goals of the Clean Water Act and to meet various court ordered deadlines. EPA Region 4 alone has over 1100 sediment-related TMDLs to develop within this time frame. Recent trends in current and evolving environmental regulatory strategies dictate that EPA will have to rely more heavily on predictive modeling technologies in carrying out the increasingly complex array of exposure and risk assessments necessary to develop scientifically defensible TMDL's. There is a pressing need for a comprehensive data set to be developed that will enable such models to be developed and tested with actual field data. The main goal of sediment TMDL analysis is to protect designated or existing uses of natural resource systems in watersheds by:

a. Characterizing properly functioning watershed processes that influence the erosion, transport and storage of sediment;
b. Evaluating the degree to which the current and expected future functioning of these processes is impaired. The impairment usually results from the transport of excessive sediment loads to water bodies (e.g., streams, lakes) within the watershed. The excess sediment loads are usually generated by changes in watershed processes that result from both natural (e.g., wildfires) and anthropogenic (e.g., logging, agriculture) causes; and
c. Identifying land and water management restoration actions that should be implemented to restore the proper functionality of the impacted watershed processes.

An environmental group found the Savannah River Basin to be the seventh most toxic body of water in the nation during a 5-year period (i.e. 1992 through 1996). According to industrial discharge reports to the EPA, 17.4 million pounds of chemicals were discharged into the river during this period (Athens Daily News, September 11, 1998).

From Raschke et al. 1998, twenty streams in twelve, eleven-digit-size watersheds in the Savannah River basin were identified as waters potentially impacted by agricultural nonpoint source pollution. The listing of these waters as potentially impacted by nonpoint source pollution was based on a statewide assessment of watersheds conducted in 1991 by the Soil Conservation Service and Forest Services of the U.S. Department of Agriculture, and the Georgia Soil and Water Conservation Commission. This assessment was based on a number of factors including animal population density, topography, fertilizer and pesticide application rates, and rainfall. To determine the actual condition of the watersheds, the EPA conducted a screening of these same watersheds during 1997. This screening assessed the status of the aquatic biological community, habitat conditions, and included water chemistry measurements.

Based on the results of the EPA assessment, eleven streams in eight of the eleven-digit-sized watersheds in the Savannah River Basin were identified for further study including: 1) South Fork Broad River; 2) South River; 3) North, 4) Middle, and 5) Lower North forks of the Broad River; 6) Broad River; 7) Lake Hartwell tributaries (i.e. Crawford Creek, Little Crawford Creek, Little Shoal Creek, Flat Shoals Creek); and 8) Toccoa Creek.

During 1994 through 1997, EPA Region 4's Science and Ecosystem Support Division conducted a field screening study of wadeable streams in the Savannah River Basin to evaluate ecological conditions as part of the Regional Environmental Monitoring and Assessment Program (REMAP), Raschke et al. 1999. Four ecological response indicators were monitored including: 1) fish community (Index of Biological Integrity-IBI); 2) macro invertebrates (Rapid Bioassessment Protocol-RBP method); 3) habitat (RBP method); and 4) algal growth (Algal Growth Potential Test, AGPT). These indicators represent societal values of biological integrity and trophic condition for small wadeable streams (i.e. 1st to 3rd order) and the tributary embayments of large reservoirs. Sixty stream sites per year were targeted for sampling using the EMAP approach, but only a total of 119 sites were actually sampled due to both property access issues and the fact that some stream sites failed to meet design site criteria. Results of the REMAP study indicated that with respect to habitat, community integrity, and trophic condition, 63% to 95% of the basin's wadeable streams were in fair to poor condition. This meant that about 52% of the stream miles involved in the study were in poor condition based on impacts on the fish community. Two study areas had an unusually high concentration of poor ecological condition, one in Georgia (i.e. SFBR area) and one in South Carolina. The impacted Georgia area had a high population of poultry and cattle production, but the South Carolina impact area had no obvious landscape features to explain the findings. The SFBR watershed, located in Georgia's Madison, Oglethorpe and Clarke Counties, was identified as a sediment impacted stream and found to be in poor ecological condition.

Based on the EPA Region 4 findings and the close proximity of the basin, the Athens ERD selected the Savannah River Basin as it's Near Laboratory Ecological Research Area (NLERA) for field research. Athens ERD conducted a stream water quality study of 40 stream sites in the SRB from June, 1998, to November, 1999, Smith et al. 2002 draft. Results of the Savannah River Basin study indicated that the SFBR watershed had the highest number of fecal coliform counts (i.e. as a pathogen indicator) in the basin, exceeding EPA's recreational water limit of 200 counts per 100 ml, Figure 1.

In 1998, the State of Georgia listed (i. e. the 303 (d) list of the Clean Water Act) the SFBR watershed as being biologically impaired but the source of the contamination was not identified.

Research is now underway in this watershed because it is ideal for simultaneously measuring contaminants and their impacts on ecological health. Athens ERD normally conducts field studies for at least three years so that results account for seasonal variability in weather

patterns and other important factors. Site location (i.e. Madison, Oglethorpe and Clarke counties) characteristics include topography, meteorology, hydrology, point sources of pollution, agricultural production, cropping patterns, agricultural chemical application rates and stream cross-sectional profiles at segmented river reaches, plus other multifaceted data and information in order to relate the causes and effects of the changes in contaminant transport measured.

Data obtained through Athens ERD's field research will be widely used for developing and field-testing models, and providing improved field assessment methodologies and monitoring protocols. Field research will also provide a useful data resource to both the Agency's research and regulatory components, local governmental agencies and the general public for planning and other uses by providing an improved and more realistic understanding of the impacts of contaminants released into the environment.

In response to the Agency's need, researchers at the EPA's National Exposure Research Laboratory operation in Athens, GA, (i.e. the Ecosystems Research Division (ERD)), together with the Region 4 Science and Ecosystem Support and Water Management Divisions have designed and implemented a sampling plan for a comprehensive watershed study in the SFBR watershed within the Savannah River Basin, Figures 2, 3.

This interim report provides a description of the field project sampling and analysis methodology. The database design, architecture, user access, quality control, security and other details will be made available in a separate report.

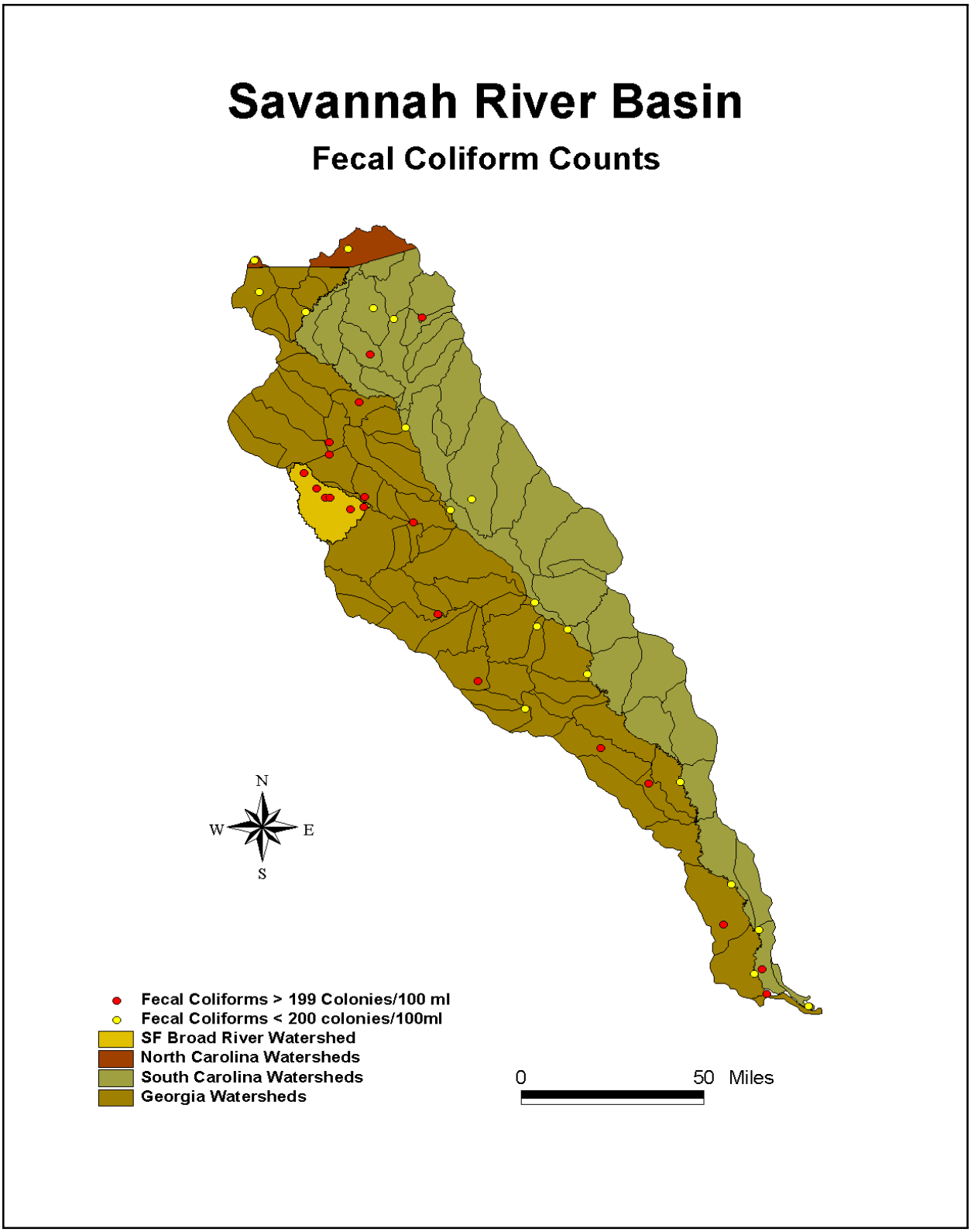


Figure 1. Fecal Coliform Counts in the Savannah River Basin and the South Fork Broad River Watershed

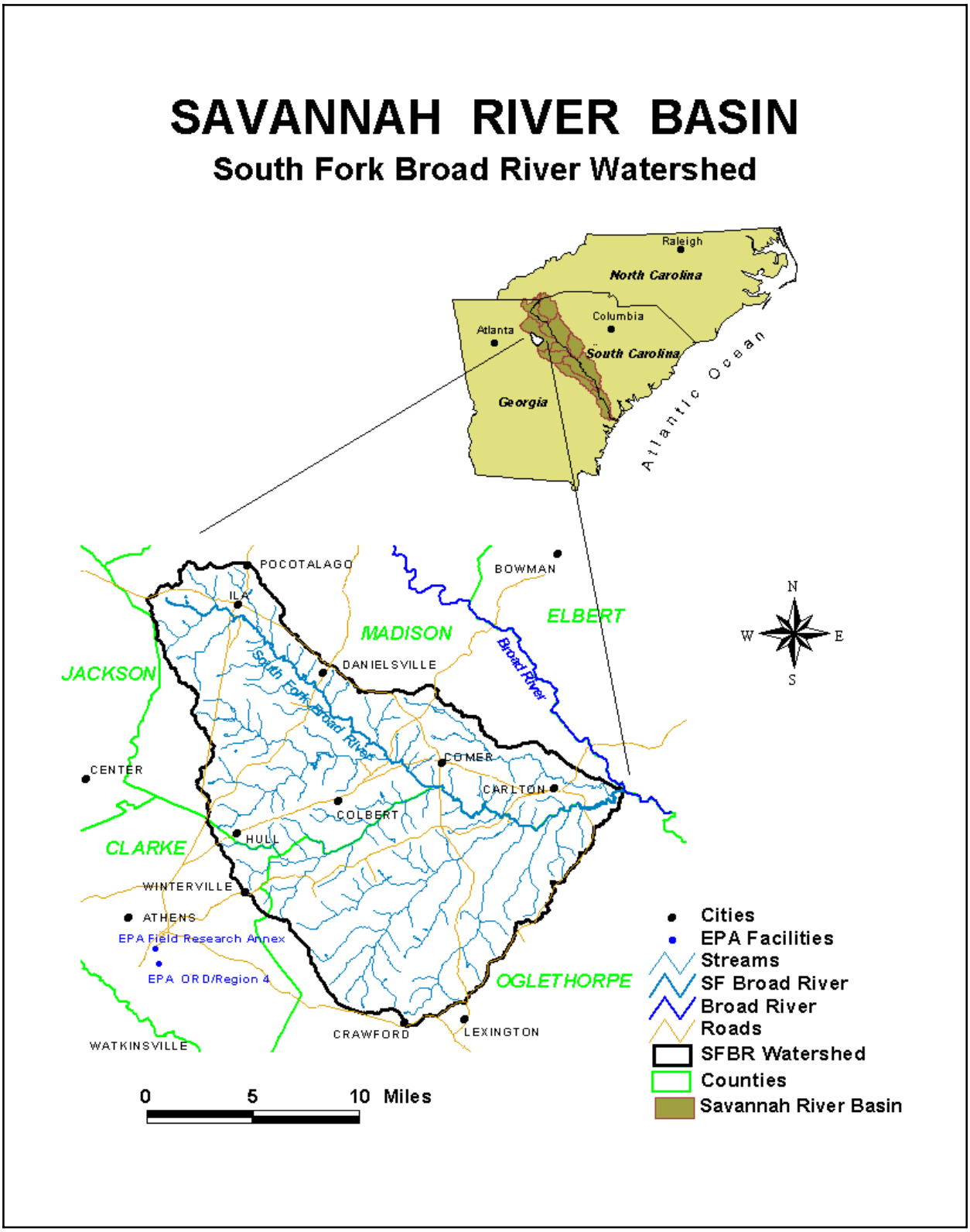


Figure 2. Location of South Fork Broad River Watershed in Clarke, Madison and Oglethorpe Counties, GA.

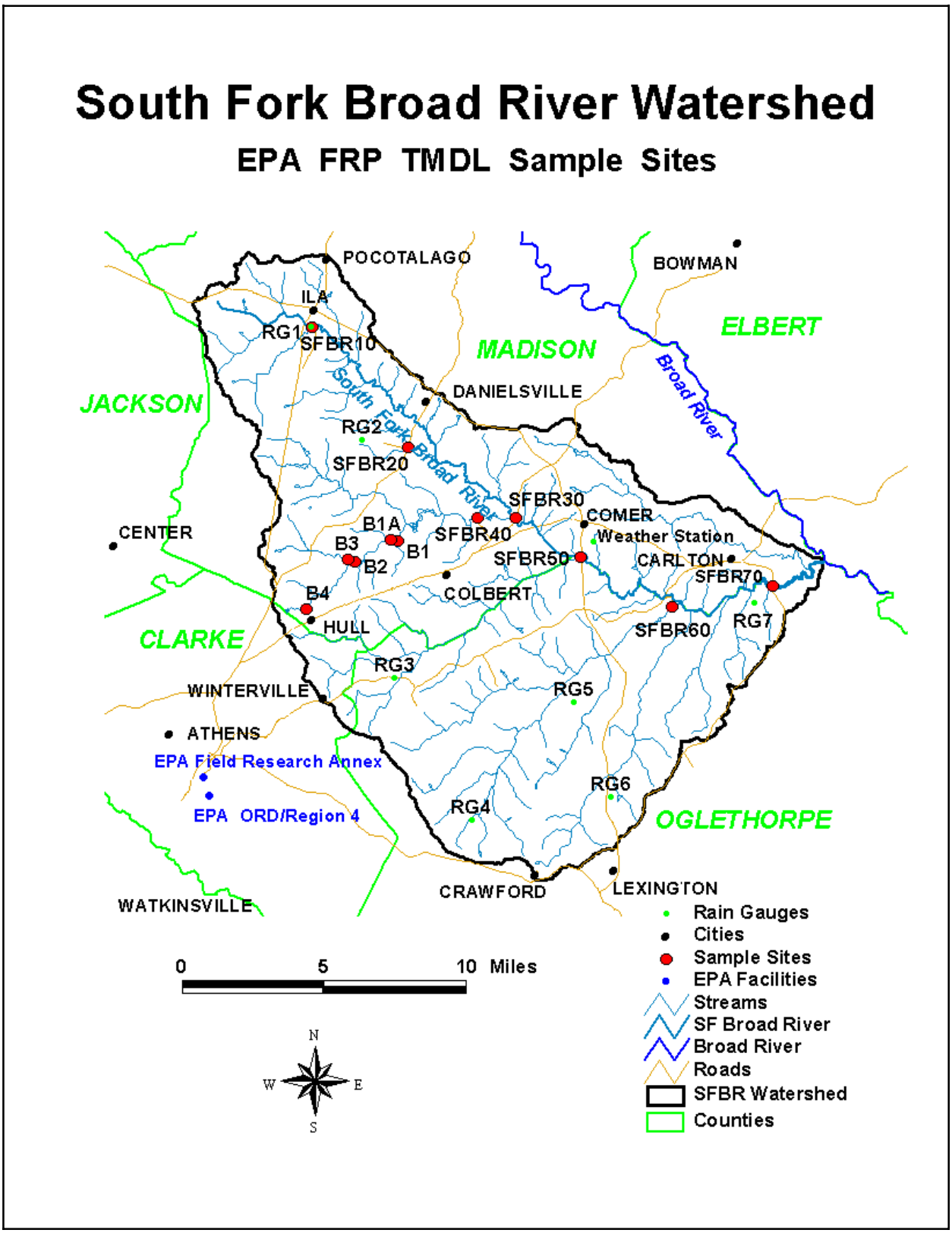


Figure 3. South Fork Broad River Watershed Stream Sample Sites, Rain Gage and Weather Station Locations

Chapter 2
SUMMARY AND CONCLUSIONS

We have successfully designed and are implementing the SFBR watershed study to provide the best available database for developing TMDL sampling protocols, for the field testing of exposure models, and for the development of TMDLs now and in the future. The project had six stream monitoring sites highly instrumented and operational, with extensive background data already collected. In addition, a weather station was installed in the watershed and additional tipping-bucket rain gages located throughout the watershed. Many of the designs used in this study will become part of standard operating procedures (SOP) for data collection in support of TMDL development. Installation of cableway sampling systems was critical to this effort in order to provide a safe environment for sampling teams to collect the required bedload and depth-integrated samples during intensive storm events. To our knowledge, these are the only automated, unmanned stream sampling systems of their size in the United States.

This study has been a most challenging field project to implement due to its complexity and unexpected delays. The effort involved: getting both the field equipment and laboratory operational (e.g. new equipment, lab renovation); getting field staff trained (e.g. sampling and safety); selecting and purchasing the appropriate state-of-the-art equipment for unattended collection of stream samples; the installation of bank-operated cableway systems; obtaining permission from land owners to locate equipment on their property; and obtaining through the General Services Administration (GSA) and purchasing the required vehicles (i.e. 4x4 trucks, crane trucks, 4x4 mules, trailers) for transporting staff and equipment to field sites.

Rain events tracked thus far have not produced significant runoff and sediment loads due to the project area being in its fourth year of a severe drought with stream levels at their lowest in many years. The study area was greater than 30 inches below the 20-year rainfall average of 51.5 inches/year during the period 2000 to 2001. Historically, 100 years ago in March 1902, such great rainfall fell in the project area as reported in a local newspaper (March 14, 2002 issue of The Comer News, Comer, GA 30629), that the Broad River stage rose to levels of 25 to 30 feet above base flow.

Nine (9) storm events have been sampled since January 2001; however, only limited data were collected because of the brevity of the storms. To obtain the needed manpower to manually collect samples during storm events at 2-hour sampling intervals, an additional work request was added to an existing task order through a Region 4 contractor, Integrated Laboratory Systems, Inc. These task orders would provide the staff needed to collect storm event samples for bedload and depth-integrated samples at four high priority sites (i.e. SFBR10, 30, 60 and 70). ISCO sampling was done at 1-hour intervals for all six sites.

More rainfall (i.e. number of events and the amount) occurred during 2003 than any other year since the beginning of the field research project. A large rain event was predicted to occur during early April 2003 that produced a week of field sampling with 4-days of intensive sampling. This rain event was not as intensive as expected for producing heavy runoff but it did

provide a low intensity rain over several days. Unfortunately, during this sampling event, two sites equipped with the Rickly Hydrological Company type cableway systems malfunctioned and became inoperable and unsafe and therefore eliminated further rain event sampling until replacement winches could be installed. After many discussions with the Rickly Company, they finally agreed to replace both winch systems, but not until year 2004. The cableway system problems have caused unexpected delays in obtaining the required data during a period of greater rainfall.

TSS values obtained from an ISCO sampler located at a fixed depth and cross-sectional location in the stream channel were statistically different (i.e. at the 95% confidence level) from depth-integrated samples taken across the stream channel at the same site. However, these values were highly correlated. It is valuable to have a statistical relationship between the automated ISCO sampler produces TSS measures and the more time and labor intensive depth-integrated sampling procedure. However, additional data collection efforts during a variety of different size storm events would be needed to confirm this relationship before a definitive conclusion could be drawn. Data analysis also showed that taking ISCO samples every two hours versus every hour would result in approximately a 26% drop in information content. The methodology behind these conclusions is explained in Chapter 5 and Appendix 2.

An example of stream loading rates for the SFBR based on samples collected from the ISCO samplers were calculated for TSS, nutrients and carbon for each of the 5 sites during a storm event that occurred on March 12, 2002. This storm represents a low-runoff event with rainfall amounts of 0.93 inches. Table 1 provides a summary of the calculated storm event loadings (kg) for each of the five sites for each measured parameter. Estimated TSS loadings at sites SFBR 30 and 60 were the highest at 23,642 and 34,248 kg, respectively. The highest loadings for ammonia, nitrate, phosphorus and total organic carbon were also calculated at these two sites. As expected, lower TSS loadings were observed at site SFBR20 which is a small tributary of the SFBR. One would expect even higher loads to occur during greater rainfall events.

Table: 1. Loadings for SFBR sites for March 12, 2002 Rain Event

Site	TSS	NH_3-N	NO^-_3-N	o-PO_4 as P	Total-P	TOC
	kg	kg	kg	kg	kg	kg
SFBR10	2179.7	2.0	19.6	1.6	2.4	168.0
SFBR20	195.9	0.7	1.9	0.3	0.4	19.8
SFBR30	23641.6	14.0	175.4	8.4	9.1	1592.7
SFBR40	2244.8	5.5	5.5	3.0	4.3	484.2
SFBR60	34248.2	8.0	118.4	6.5	18.1	1121.8

The SFBR watershed is an excellent area to continue watershed research given the diversity of land usage, landowner cooperation, background stream water quality and hydrographic data, and longitudinal stream slope elevations and characterization of about 300 stream cross sections. The SFBR covers an area of 245.18 square miles with 337.32 stream miles. It would take many man-years to establish/characterize a comparable test watershed at another location.

Chapter 3
DESCRIPTION OF SFBR WATERSHED PROJECT

Project Objectives

EPA's Office of Research and Development, National Exposure Research Laboratory, Ecosystems Research Division in Athens, GA (Athens-ERD), together with the Agency's Region 4's Science and Ecosystem Support and Water Management Divisions, have designed and are implementing a sampling plan for a field study in the SFBR watershed to calculate/establish TMDLs. The study involves the collection of storm event samples at six stream sites for the analysis of bedload and suspended sediment, nutrients (i.e. nitrate, ammonia, total nitrogen, ortho and total phosphorus), organic carbon and pathogens (i.e. indicators fecal coliform, E. coli, and enterococci). The objective of the SFBR study is to develop sampling protocols and predictive models, and to establish a comprehensive database to field test the developed models. These protocols and models will then be applied for calculating the TMDLs.

Specific Project Objectives

I. Develop a comprehensive database for SFBR including: 1) instream storm event data for measured bedload and total suspended solids, nutrients, organic carbon, and pathogens; 2) meteorology; 3) stream hydrography (i.e. stage-discharge relationships, water stage records and velocity profiles); 4) stream cross-section characterization; 5) longitudinal stream slope elevations; 6) soil characterization; 7) land cover; and 8) contaminant loading rates.

II. In conjunction with EPA Region 4, develop and implement an intensive rainfall/runoff event driven field sampling program, including development of the sampling protocols and the database needed to calibrate and conduct field performance testing of predictive exposure models.

Watershed Characteristics

The SFBR watershed, a 245.18 square mile area (156,915 acres), (Figure 3), is a tributary of the Broad River Watershed located in the Savannah River Basin. The Savannah River Basin is a 10,577 square mile area located along the border of three states with 5,821 square miles in Georgia, 4,581 square miles in South Carolina and 175 square miles in North Carolina. The Savannah River originates in the mountains of Georgia, South Carolina and North Carolina and flows south-southeasterly about 300 miles to the Atlantic Ocean near the port city of Savannah, GA. Approximately 45 miles of the lower Savannah River are influenced by tidal action. The Broad River Watershed is located in the Piedmont area of North Georgia, is the largest watershed within the Savannah River Basin, and is among the last free-flowing rivers (undammed) in Georgia. It flows from the foothills to the fall line in a southeastly direction from its headwaters in Stephens and Banks Counties through Franklin, Madison and Elbert Counties to its confluence with the Savannah River at the Clark's Hill Reservoir. Poultry, cattle and forestry production, with some row crops, are the major agricultural activities in the watershed. Runoff is the major mode of transport for pollutants entering surface water streams.

Chicken manure is widely used as a fertilizer source on largely sloped pasture land. The Broad River's runoff problems are attributed to effluent from septic systems, landfill leachate, litter, riverbank erosion, destruction of the vegetative buffer, lack of tributary protection and, most importantly, non-point source agricultural runoff. Animals (e.g. cattle, deer) obtaining their drinking water from the river contribute to water pollution, sedimentation, and degradation and destabilization of riverbanks.

The SFBR watershed (Figure 3) is located in the southern Piedmont area near Athens, GA, primarily in Madison and Oglethorpe counties with a small portion in Clarke county. The watershed contains 337.32 stream miles (Figure 4). The watershed had severe erosion problems during the 1900 to 1960's due to the conventional tillage practices (i.e. moldboard plowing) without adequate conservation measures (e.g. terraces, grass waterways). This occured principally in the upland areas of the watershed that were primarily used in the production of cotton (Broad River Soil Conservation District and County Government of Madison County, 1961). In addition, when the use of tractors began in the area (i.e. replacing horses and mules) this added to the erosion problem since farmers would plow the land parallel to slope (personal communication with local farmer). During this time the boll weevil was a serious pest in the production of cotton and several pesticides were used including arsenic, DDT and toxaphene that caused fish kills to occur in nearby streams. Today, most of the land cover in the watershed is in deciduous, evergreen and mixed forests interspersed with pasture, hay and row crops (Figure 5). Many of the agricultural activities today integrate chickens (i.e. broilers, layers), cattle (i.e. beef and dairy), hogs, row crops (i.e. cotton, corn, soybeans, wheat, rye), hay/silage and forest production (i.e. pine and hardwood). Small towns (population numbers obtained from the Georgia County Guide, 2002) located in the watershed include Ila (328), Danielsville (457), Colbert (488), Comer (1052), Hull (160) and Carlton (233). The populations of Madison, Oglethorpe and Clarke Counties are 25,730, 12,635 and 101,489 respectively based on year 2000 census. Madison County has the 5th largest number of poultry houses (616) and the 5th largest number of cow head (15,800) in the State (Georgia County Guide, 2002). Oglethorpe County has 235 poultry houses and 7,500 cow head and Clarke County has 11 poultry houses and 2000 cow head. Runoff delivery of large amounts of sediment, nutrients, pesticides and pathogens are the primary causes of receiving water impairment.

The SFBR watershed consists of well-drained, upland soils with a loamy surface layer and a red clay subsoil (USDA, 1968, 1979, 1991). These soils have a slow to moderate infiltration rate and a good water holding capacity. The soil loss due to erosion during the 1900 to 1960 era was estimated to be 65 percent of the topsoil (Broad River Soil Conservation District and County Government of Madison County, 1961). A digitized soils map for that portion of the watershed in Oglethorpe county is shown in Figure 6. Digitized soils maps for Madison and Clarke counties are not currently available, but are expected to be published within 2 years (personal communication, USDA).

Experimental Design

Statistical design was not used to determine site locations. The following factors were considered in selecting the stream sampling sites:

- site location to measure contaminant loads by runoff at specific upstream and downstream points within the watershed, including the headwaters and confluence or watershed outlet
- stream mixing
- existing USGS stream gaging stations
- vehicle accessibility to site
- availability of an existing highway bridge (in use or abandoned)
- landowner approval

Once a decision was made relative to where to locate a stream monitoring site, contacts were made with the local landowner for approval to allow EPA to install long term monitoring equipment on their property. In some cases, this required going to the Madison County Courthouse to determine the landowner, and then contacting them for approval. In several cases, the landowner lived outside the watershed. Approval for three (i.e. SFBR30, 60, 70) of the more difficult and larger stream sites required approval by the Georgia Department of Transportation (GA-DOT), Georgia Department of Natural Resources and a landowner located in middle Georgia. Each of these sites required the purchase and construction of bank-operated cableway systems requiring additional time and resources.

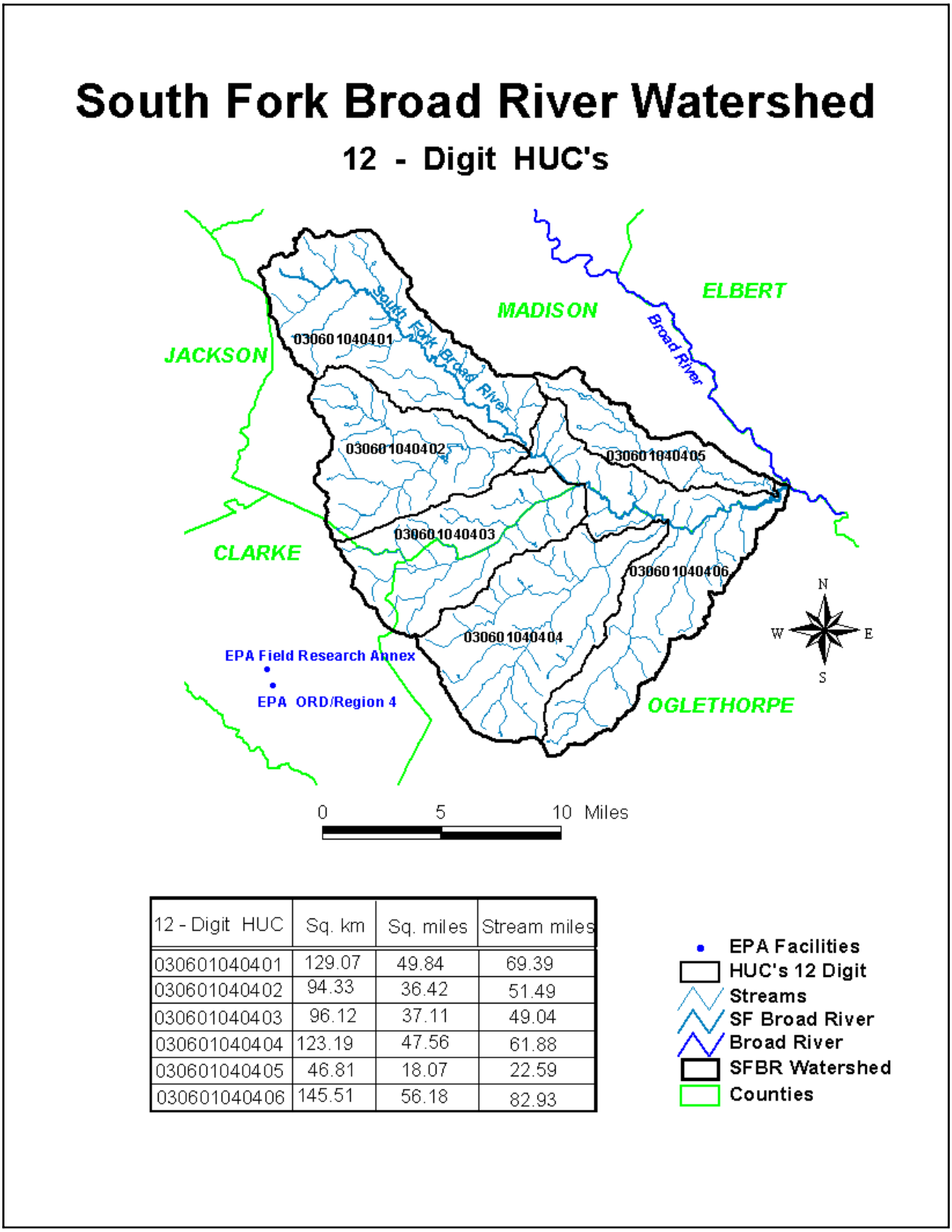
Landowner Approval

A number of unexpected delays and problems were encountered in selecting and establishing the stream monitoring sites, including difficulties in obtaining landowners approval to install equipment on their property.

Site SFBR30 - bridge at highway 172. Permission to sample from existing bridges in the SFBR watershed was denied by the Georgia Department of Transportation because blocking one lane of the bridges and roads during day and night time rain storm sampling for several days would create a safety hazard. Their concern was due to the liability issue in case an accident occurred causing injuries while following GA-DOT road blocking safety protocols. The GA-DOT required protocol is for their staff to get off the road during these critical times. GA-DOT did, however, provide EPA a permit to install the cableway system on their right-of-way.

Site SFBR60 - Clouds Creek in Watson Mill Bridge State Park - we originally evaluated the possibility of restoring the flooring of an old, abandoned steel bridge for use in sampling.

Estimated cost by the Georgia Department of Natural Resources to restore the metal frame, bridge flooring, and guard rails was about $250K. The TMDL project staff reevaluated this site and determined that the bridge would also cause restrictive flow and that it would be better to move upstream and construct a cableway system. To obtain approval at this site for a

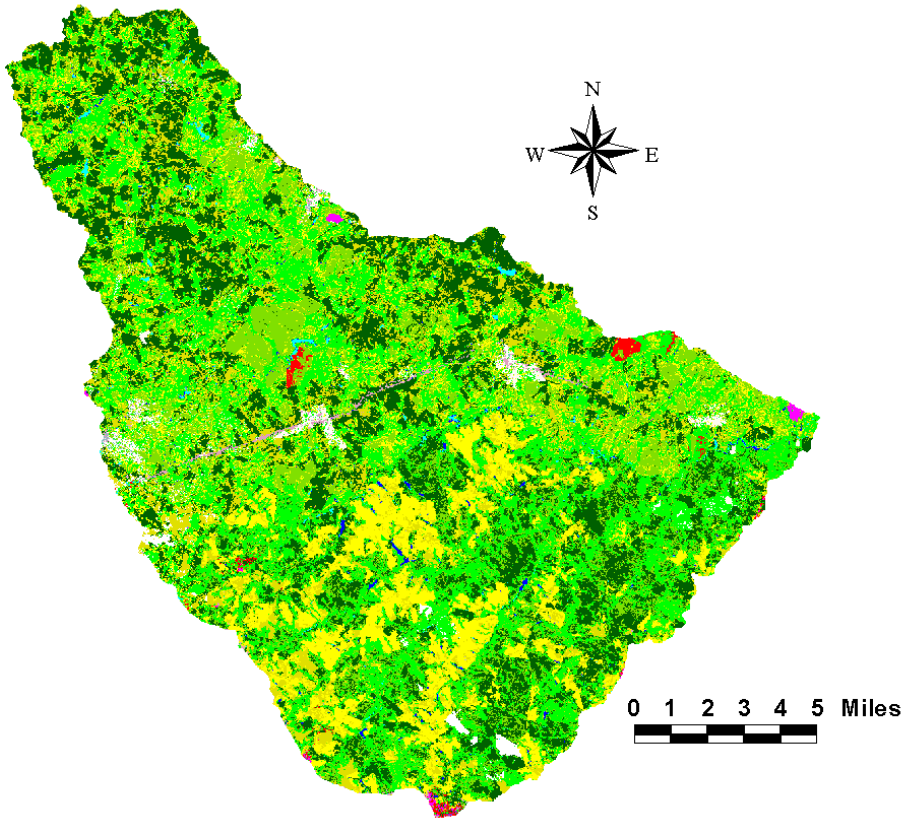


12 - Digit HUC	Sq. km	Sq. miles	Stream miles
030601040401	129.07	49.84	69.39
030601040402	94.33	36.42	51.49
030601040403	96.12	37.11	49.04
030601040404	123.19	47.56	61.88
030601040405	46.81	18.07	22.59
030601040406	145.51	56.18	82.93

Figure 4. South Fork Broad River Watershed with USGS 12 Digit HUC's.

South Fork Broad River Watershed

1996 Landsat TM Land Cover Image



Class	Sq. km	Sq. miles	% Cover
Deciduous Forest	189.10	73.01	29.78
Evergreen Forest	156.32	60.36	24.62
Mixed Forest	103.05	39.79	16.23
Pasture/Hay	101.68	39.26	16.01
Row Crops	61.04	23.57	9.61
Transitional	8.80	3.40	1.39
Woody Wetlands	3.31	1.28	0.52
Open Water	2.51	0.97	0.40
Low Intensity Residential	2.68	1.03	0.42
Quarries/Strip Mines/GravelPits	1.80	0.69	0.28
Commercial/Industrial/Transpor	2.66	1.03	0.42
Urban / Recreational Grasses	0.83	0.32	0.13
Bare Rock / Sand/Clay	0.38	0.15	0.06
Emergent Herbaceous Wetlands	0.27	0.10	0.04
High Intensity Residential	0.15	0.06	0.02
Total	635.03	245.18	100.00

Land Cover SFBR 1996

- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Pasture/Hay
- Row Crops
- Transitional
- Woody Wetlands
- Open Water
- Low Intensity Residential
- Quarries/Strip Mines/Gravel Pits
- Commercial/Industrial/Transportation
- Urban/Recreational Grasses
- Bare Rock/Sand/Clay
- Emergent Herbaceous Wetlands
- High Intensity Residential

Figure 5. Land Cover in the South Fork Broad River Watershed

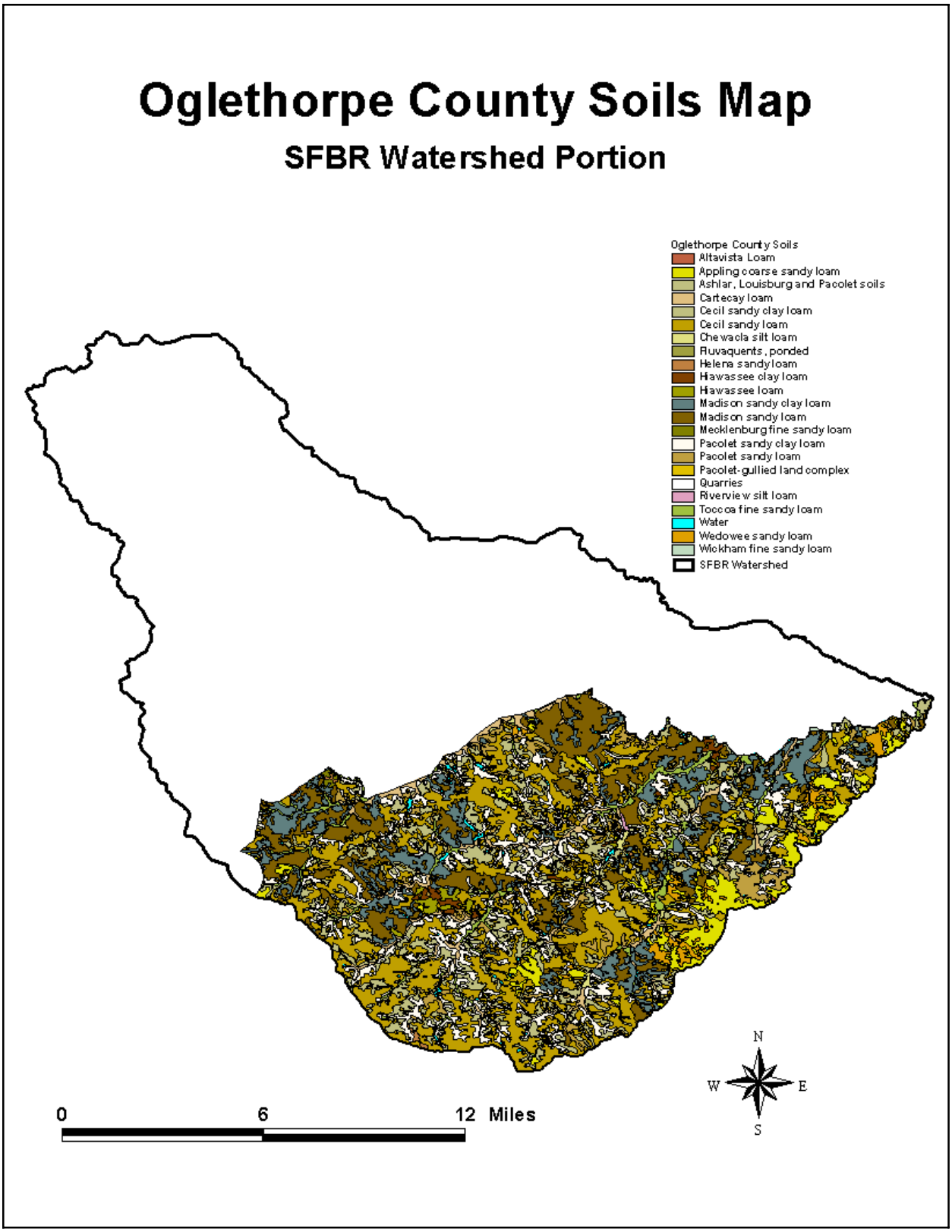


Figure 6. Digitized Soils Map of Oglethorpe County Portion of SFBR

bank-operated cableway system, we had to develop an access agreement that took about 9 months to complete and get approved. Mr. John Cline of EPA- NERL-RTP provided excellent help in obtaining the access agreement by working with EPA's Office of General Council and the Georgia Department of Natural Resources. The agreement, effective February 7, 2000, states that EPA would have access to a 1-acre site for 10 years. Installation of a cableway system at this site also required approval from the private landowner of the opposite bank. This approval necessitated extensive inquires and phone calls to locate the owner.

Site SFBR70 - Carlton site on the Carlton-Lexington road. Initially, a decision was made to try two approaches; 1) find the local landowner as well as 2) contacting the Georgia Department of Transportation for a permit to install a cableway on their right-of-way as was previously done at the SFBR30 site. The Georgia Department of Transportation notified us that this was a county road, not state-owned. Upon identification of the landowner, he was contacted by phone to discuss the possibility of locating our cableway system on his property. He informed us that he owned the land on both sides of the river, that he would be willing to cooperate with EPA, and that there was already an agreement (dated February 10, 1998) with EPA Region 4 that could be revised and used. With the help of Walter Stutts, NERL-Cincinnati, a 10-year access agreement effective October 10, 2001 was obtained.

Six stream sites were ultimately selected in the SFBR watershed for collecting data before, during and after storm events. Originally four sampling sites were selected along the main stem SFBR (SFBR10, 30, 50, and 70) and three more along the major tributaries of the SFBR (SFBR20, 40 and 60, see Table 2). Site SFBR50 was finally canceled due to resource limitations in that this site required the installation of another cableway sampling system. Along the main stem of the SFBR, there are three existing dams constructed many years ago: 1) Rogers Mill dam below the SFBR10 site; 2) Bullock Mill; and 3) Watson Mill. Numerous farm ponds are located in the watershed, and several beaver dams have been located in the streams.

Table 2. Stream Site Identification and Drainage Areas

Site Number	Site Name	Drainage area (mi^2)
1	SFBR10 (Ila)	16.9
2	SFBR20 (Double Branch)	4.8
3	SFBR30 (Highway 172)	85.9
4	SFBR40 (Brush Creek)	34.1
5	SFBR50 (Beaverdam Creek)	site canceled
6	SFBR60 (Clouds Creek)	47.5
7	SFBR70 (Carlton)	224.0

Five additional sampling sites were selected by Region 4's Science and Ecosystems Support Division (SESD); stations B1, B1A, B2, B3 and B4 (Figure 3.) located on Biger Creek, a tributary of Brush Creek in the SFBR watershed. A reference watershed site was located in Hart County, GA, at Lightwood Log Creek. This site had already been sampled by Region 4's SESD. Field site information and stream sampling regarding these latter six sites are not provided in this report.

Field Site Name and Location

The following is a brief description of the stream sampling site names and their locations in the SFBR watershed.

SFBR10 - This is an upstream headwater site located south of Ila, GA, off highway 106 on Old Ila Road. There is an old steel bridge at this site, located just downstream of the currently used concrete bridge, from which sampling is conducted using a truck outfitted with a crane system (Figure 7).

SFBR20 - located south of Danielsville, GA, along highway 29 about 150 feet downstream of the highway culvert. Two branches merge upstream and above highway 29 and form Double Branch Creek. This is a wadeable stream site for sampling (Figure 8).

SFBR30 - located north of Colbert, GA, near a bridge on Highway 172 immediately downstream from the confluence of Brush Creek with the SFBR. Sampling is conducted with a cableway system (Figure 9).

SFBR40 - Brush Creek sampling site is located at a wooden bridge on the McCarty-Dodd Road between highway 172 and Bullock Mill road. The Georgia Department of Transportation plans to replace the wood bridge with a concrete structure in the near future. The Brush Creek site is unique in that runoff from an unpaved road conveys a large amount of sediment into the stream during rain events (Figure 10).

SFBR50 - located south of Comer, GA, near a bridge on Highway 22 immediately downstream from the confluence of Beaverdam Creek and the SFBR. This site was canceled due to resource limitations because it required the installation of another cableway sampling system.

SFBR60 - this site is located on Big Clouds Creek approximately 800 feet upstream from its confluence with the SFBR in the Watson Mill Bridge State Park primitive camping area. Sampling is conducted with a cableway system (Figure 11).

SFBR70 - located next to the Carlton-Lexington road bridge (near Sandy Cross) over the SFBR near Carlton, GA. This site is near the outlet of the SFBR into the Broad River, which is located about 2 miles downstream. This site is the nearest access point to the Broad River for establishing a monitoring site. Sampling is conducted by cableway system (Figure 12).

Figure 7: SFBR10

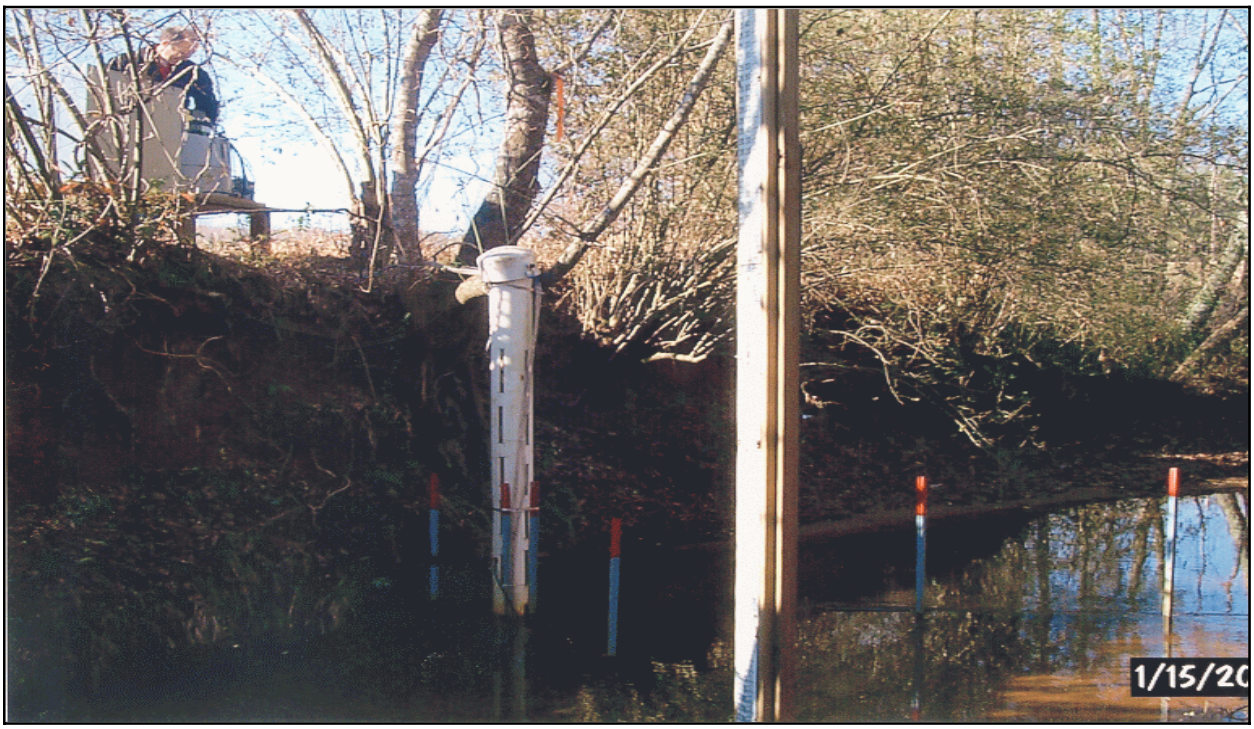


Figure 8: SFBR20

Figure 9: SFBR30

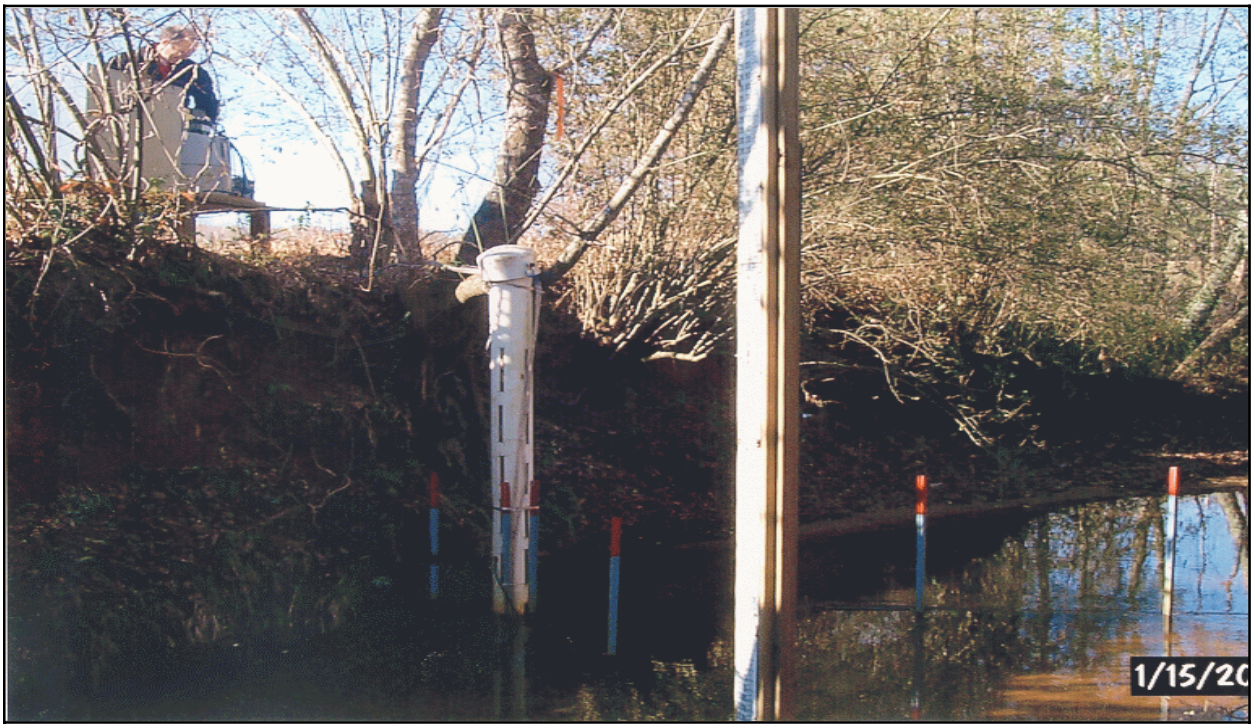


Figure 10 SFBR40

Figure 11: SFBR60

Figure 12: SFBR70

Stream Monitoring Site Design

Each of the six stream sites was instrumented with two automatic ISCO samplers (Figure 13) and a YSI multi-probe (Figure 14) located at a fixed point (i.e. position and depth) in the stream. The two ISCO samplers are used to: 1) provide a duplicate set of samples for analysis in the laboratory for sediment and one set of samples for nutrient analysis; and 2) to provide backup samples in case one of the ISCO samplers fails to collect or overfills. A software interface problem surfaced when the ISCO sampler was coupled to the YSI probe. This required lengthy manufacturer efforts to resolve. A wooden support platform was constructed for the two ISCO's using treated 2-inch x 4-inch wood frame with plywood deck (1 foot high by 2-feet wide by 6 feet long) secured to ground by concrete. For security purposes, galvanized metal boxes were designed and constructed with treated plywood bottoms to house each ISCO and a 12-v battery power source.

A 6-inch diameter PVC stilling well, [with 1-inch x 6-inch slots cut at several locations along the side wall to a height of estimated stream rise (i.e. 5 feet) to allow water in/out] is used to surround and fix the position of the YSI probe to protect it from debris, and to support the two ISCO strainers positioned (one on each side) on the outside of the stilling well, about 2 inches from the stream bottom. A support stand for the YSI probes was designed and constructed to secure and position the YSI probe in the stilling well at 2 inches from the stream bottom. The bottom of the stilling well is secured by large clamps to metal fence posts driven into the stream bed. The top of the stilling well is secured to a bridge rail at SFBR10, the bridge pillow at SFBR30, and trees at SFBR20, SFBR40, and SFBR60. A 4-inch PVC pipe was run from the stilling well to the ISCO sampler to house and provide access to the ISCO tubing and YSI cable, as needed. The PVC pipe was installed with a gradual slope to prevent potential water ponding in the ISCO tubing that could cause contamination and purging problems. The ISCO tubing is at the maximum length of 99 feet (as provided by the manufacturer) at SFBR30 and 85 feet at SFBR60.

Due to drought conditions causing low stream water levels, the YSI probe was removed from the stilling wells at sites SFBR20 and 60 and secured in a horizontal position using a 3-inch PVC pressure coupling. For the location of the pressure transducer on the YSI to measure stream level, water levels must be at least 8 inches deep located in a vertical position or at least 4 inches deep in a horizontal position.

At the watershed outlet site SFBR70, installation of the support structure to secure the two ISCO strainers and YSI multi-probe near the center of the 180-foot wide river at this point was very difficult because the river bed consisted of loose sand (2 feet deep) overlying bedrock. This installation required a contractor to bore into the river bed rock with an air drill and install ten, 8 feet long drill bits located at 10-foot intervals. At each drill bit, a 2-inch wide unistrut was placed over the drill bits and driven into the stream bottom as deeply as possible. A 4-inch PVC pipe was then placed over each drill bit/unistrut and driven into the stream bottom; the unistrut extended above the PVC pipe approximately 6 inches. The PVC pipe was then filled with

concrete for extra strength. A 4-inch PVC pipe, containing ISCO tubing and YSI vented connecting cable, was installed from the cableway platform along the top of the unistrut posts to the support frame for the YSI probe that was located 70 feet into the river from the bank. The support frame was designed to allow easy access to the YSI probe for servicing. The support frame consists of a 2-inch wide metal unistrut frame connected to 6-inch PVC couplings that slide over 4-inch PVC support posts located 4-feet apart.

During rain events, the support structure as described above at SFBR70 site, trapped floating trees and debris. This caused a log jam that partially destroyed the supporting structure at this site including drill bits and breaking the pvc pipe. The damage by the trees required moving the YSI and ISCO sampling equipment within 30 feet from the river bank. Later, another large tree lodged on top of the sampling equipment and deposited a large area of sand. However, the sampling equipment was not damaged. One idea was to solve this problem by installing a large pipe along the bottom of the river from the cableway platform and the sampling equipment positioned at the end of the pipe. This idea was eliminated when large deposits of sand was observed at SFBR70 that would have caused the sampling equipment to be buried underneath. All supporting equipment that was originally installed was later removed from the river and new supporting equipment was relocated near the stream bank to eliminate potential problems with log jams and damage to sampling equipment. It is very difficult to keep monitoring equipment in the river to collect representative stream data without causing serious trapping problems.

Installation of Cableway Sampling Systems

Three cableway systems were installed under an Interagency Agreement with the U.S Army Corps of Engineers, Vicksburg, MS, working in concert with staff from Athens ERD's Field Research Annex. Sites SFBR30 and 60 were the first cableways installed using the model DDT 900 system from Rickly Hydrological Company, 1700 Joyce Avenue, Columbus, Ohio 43219. The original design of the equipment when the order was placed with Rickly was to be powered by 12-v power. The purchase order was changed later to be powered by 110-v electrical system. After installation, many mechanical problems became apparent using the first two cableways, specifically the systems were found not to be capable of lifting the 170-pound bedload sampler. This required disassembling the system for repair and modification by the manufacturer, including installation of a more powerful AC motor and gear drive mechanism. Extensive time and effort was then required to calibrate the cableways for collecting stream samples at designated locations across the stream channel, and to develop SOP's for sample collection using the bedload and depth-integrated samplers.

The last site, SFBR70, became operational May 16, 2002. An OTT (OTT Hydrometry, Ludwigstr 16, PO Box 2140, Kempton, HI D-87411) model SK-V-G/W cableway system was installed at this site.

At field sites SFBR30 and 70, direct AC electrical power is used to power the cableways.

At the SFBR70 site, an 11kw generator, operating on propane fuel, has been installed for backup power with an automatic start-up and transfer switch to provide continuous power in the event of electrical power loss during sampling events. The SFBR60 site has a similar 11kw propane-fueled generator setup to provide all the electrical power for equipment and lights. There is no backup generator power at the SFBR30 site since the overhead electrical lines are the major power source for that area and the chances of extended power outage are minimal. Each of the three cableway sites is designed with proper lighting at the cableway platform and across the river for night time sampling and worker safety.

Site Maintenance

Maintenance of the 6 sites required frequent visits to remove and exchange the YSI probe for cleaning, calibration and individual probe replacement. Data was being collected continuously from each site; however, drought conditions resulted in low water levels that caused severe damage to the YSI probes. In addition, the stream bed sediment constantly shifts causing "silting-in" of the monitoring equipment. The state-of-the-art field equipment being used does not appear to be sufficiently rugged for continuous instream monitoring. After each storm event sampling, debris has to be removed from the site, and in some cases logs have to be cut with a chain saw for removal.

Communication at Field Sites

Several methods were used to communicate between field and laboratory staff and for emergency use. These methods included cell phones walkie-talkies, pagers and a base station located at the FRA. Four field sites, SFBR10, 30, 60, 70, and the weather station had telephones (i.e. voice and modem); however, the weather station had only a modem line. Newer model ISCO samplers have been installed with modems and remote access control via phone line connection between the four high priority stream sites (i.e. SFBR10, 30, 60, 70) in the watershed and the FRA. This saved the FRA staff valuable time since the samplers could be accessed remotely instead of requiring personnel to go to the field to activate the instruments before each rain event. It also ensured that the beginning of each rain event would be sampled since no time would be lost in driving to the different sampling sites while the event was progressing. This allowed more control during the most critical time of the rain event by reducing response time for sampling start-up. It also allowed remote monitoring of the sampling operation and minimized the number of samples lost because of equipment malfunction.

Laboratory Modifications

In order to conduct the large number of required analyses for this project, extensive modifications were required at the FRA laboratory. Installation of individual laboratory cooling and vacuum systems was required to handle the heat load of the many ovens and muffle furnaces needed to conduct TSS analyses.

Figure 13: ISCO Setup at Each Sampling Site

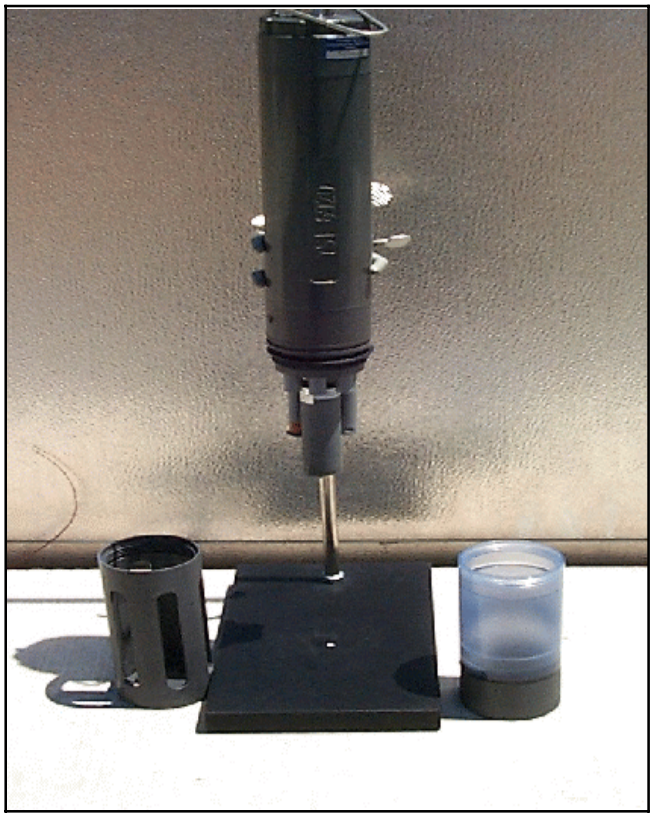


Figure 14: YSI Multi-Probe

To properly store the large number of analytical samples required the design, purchase and installation of a walk-in freezer and cooler.

Storage of all sampling equipment and personnel protective safety equipment for sampling team members required installation and modification of two storage buildings (12 feet X 50 feet).

Vehicle Requirements

A fleet of 4-wheel drive vehicles, some with specialized equipment such as cranes mounted on flat bed trucks for sampling from bridge structures, were required to collect storm event samples at the 6 sites. Some sites required the use of a Kawasaki Mule (4x4) to transport equipment for routine maintenance and access during storm event sampling. A boat was required to service the stream monitoring equipment at the SFBR70 site.

Battery Charging

A large quantity of 12-v battery power sources were required to operate equipment at remote field sites. A battery-charging facility was constructed at the FRA to support this need in a safe environment for our staff.

Stream Cross Sections

In addition to the six stream monitoring sites, 279 stream cross sectional sampling sites were selected, surveyed and samples collected from 90 sites of these sites for characterization (Figure 15). Engineering surveys were conducted using a TOPCON total station laser surveying instrument. Locational data was obtained using a Global Positioning System (GPS). Stream elevations are being determined between sites. In addition, sediment core samples are being collected at 6-inch depth increments for characterization of particle size and organic carbon content by Loss on Ignition (LOI). Core samples were collected at each cross section at five locations across the stream channel; at the center of right bank, the thalweg, equal distant between thalweg and right bank sample, at the center of the left bank and equal distant between the left bank sample and the thalweg. Digital pictures were taken at each location documenting the sampling site; field notes were recorded in field log books. Laboratory analyses of the core samples include particle size characterization for < 2-mm size using a LS 200 Beckman Coulter Particle Size Analyzer, with the results shown as a histogram and volume % for selected particle diameters (um) (0.375, 2, 4, 16, 31, 63, 125, 250, 500, 1000, 2000). Particle sizes > 2 mm (2-4, 4-8, >8) are shown as fractions collected manually using wet sieving techniques, with the results reported in dry weight and after LOI. LOI and dry weight are also reported for the total sediment fraction < 2 mm.

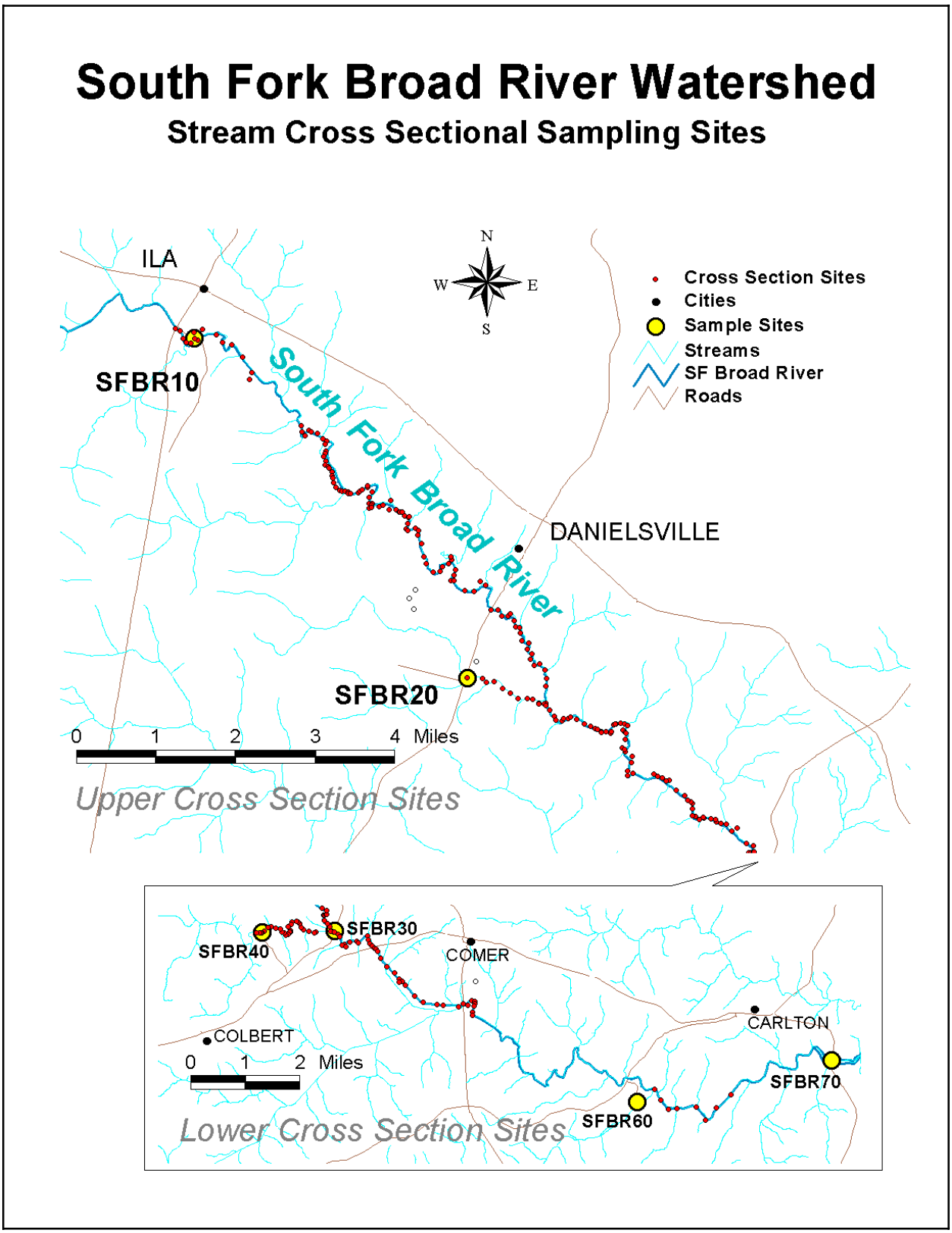


Figure 15. Stream Cross Sectional Sampling Sites, 305 are Scheduled for Investigation

Weather Station

A Class A weather station (Figure 16) was located near the town of Comer, GA, to measure meteorological parameters at hourly intervals that include; precipitation rate, solar radiation, relative humidity, temperature, wind speed/direction, barometric pressure, and evaporation rate. The town of Comer provided the EPA with access to their property for the installation of this weather station. A fence was constructed around the site for security. The nearest existing weather station with long term records is located in Athens, GA, near the airport, and is not in the watershed.

In addition to the weather station, seven tipping-bucket rain gages (RG1 through RG7) were installed at other locations throughout the watershed to provide basin-wide spatial coverage of rainfall quantities (Figure 17). Approval was obtained from the various land owners for the installation of this equipment on their property.

The project area had four years of a severe drought condition beginning June, 1998, (i.e. 15 inches below the normal 51.5 inches/year rainfall for this area) as recorded by Mark Jenkins, a cooperative observer of Madison County for the National Weather Service.

Storm Event Sampling

The sampling scheme consists of two automatic ISCO water samplers at each of six stream sites; one collects samples for sediment and the other for nutrient/organic carbon analyses at 1-hour sampling intervals. For the initial sampling of storm events during 2001 at sites

Figure 16: Weather Station

Figure 17: Rain Gage

SFBR10 and 20, the sampling frequency for the ISCO, was 30 minutes. A YSI multi-probe at each of the same six sites collected continuous instream data on depth (stage), turbidity, specific conductance, temperature, dissolved oxygen, pH, and oxidation-reduction potential at 15-minute intervals. A 6-inch Helley-Smith bedload sampler (Figure 18) and a DH- 59 depth-integrated sampler (Figure 19) were used to collect samples at several points across the stream channel for sediment analysis at the four previously listed priority sites at 2-hour intervals. A grab sample was also collected for pathogen analysis at 2-hour intervals at mid-stream and mid-depth at the four priority sites.

The number of expected rain events (2 inches or greater) to sample during the year is difficult and uncertain to determine based on predictions by the weather service. Based on analysis of historical rainfall data, the number of events producing at least 2 inches for Athens, GA, ranges from 3 to 15 with a mean of 12.

For each storm event tracked for potential sampling, Athens-ERD staff decided when to make the call to initiate and stop sampling. An EPA contractor provides the staff required to man the four priority stream monitoring sites in the SFBR. A minimum time notice of 24 hours was provided to the contractor by Athens-ERD to alert, assemble and organize the sampling teams for each of the sites. After the alert notice, EPA made the call to the contractor regarding when to actually mobilize the teams for sampling. After the call for mobilization, the contractor was expected to be at the four high priority stream monitoring sites within 2 hours.

The contractor collected the bedload and DH-59 depth-integrated sediment samples at 2-hour intervals at several established calibration points (5 to 10) across the stream channel. The DH-59 samples are instantaneously collected samples whereas the bedload samples are composites from across the stream channel over each 2-hour sampling interval. The DH-59 samples will be used to assess cross-sectional variability in fluvial sediment. The contractor also collected the grab samples for pathogens at 2-hour intervals at mid-stream and mid-depth. Sampling continued round-the-clock at each site during both the rising and falling stages of the runoff hydrograph until the stage falls one half the stage rise and/or turbidity level is 100 NTU or less. At the beginning of each 12-hour shift, the contractor records the staff gage reading for quality control and to establish a relationship between staff gage readings and the YSI level readings in order to calculate contaminant loadings.

Pathogen Sampling

Sampling plans were developed to collect bacteriological samples for pathogens analysis (i.e. as represented by the indicators fecal coliform, E. coli, and enterococci) during rain events over several days at SFBR10, 30, 60 and 70 sites beginning in December 2002. Samples were collected for bacteriological analysis from each site such that the maximum 6-hour holding times for the analyses are not exceeded. The DH-59 sampler was modified with a customized removable bottle holder for the 250-mL sterilized sample bottle in order to collect uncontaminated bacteriological stream samples. An EPA field mobile laboratory was set up

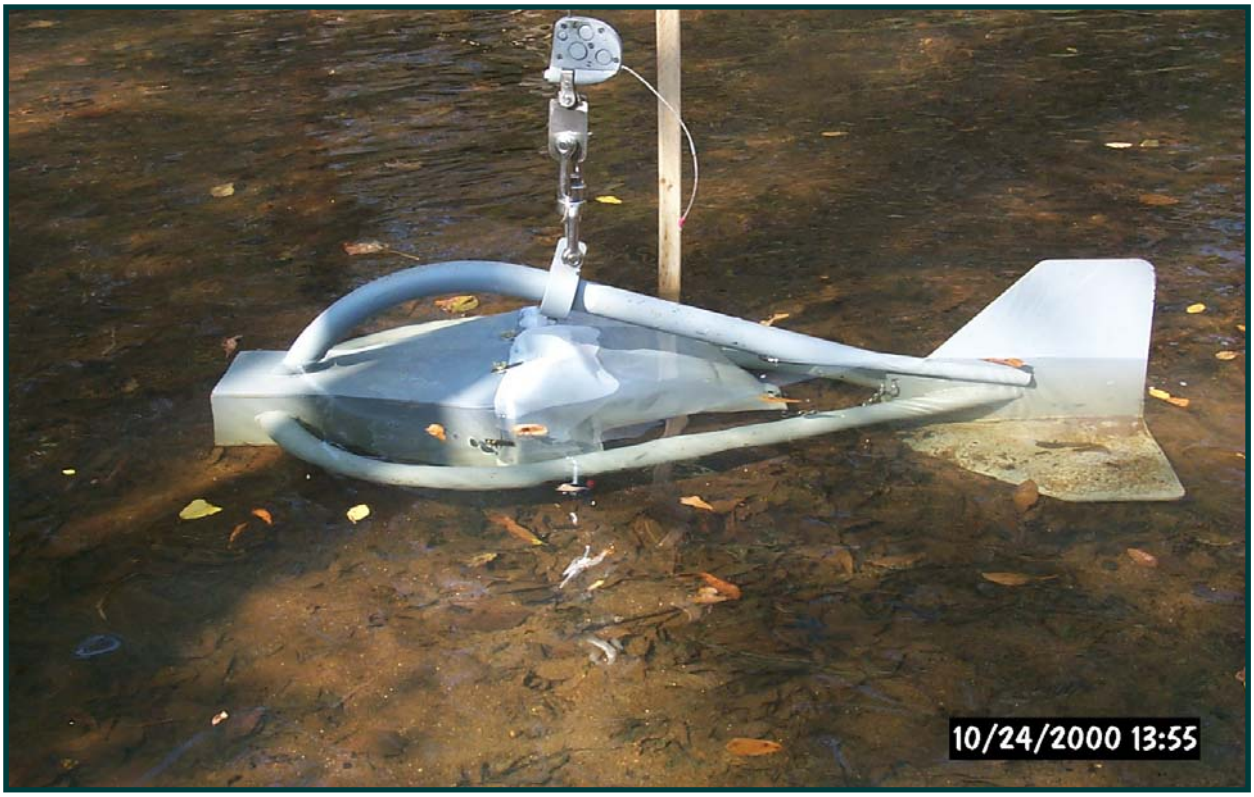


Figure 18: 6-inch Helley-Smith Bedload Sampler

Figure 19: Depth Integrated Sampler

in Comer, GA, to conduct these analyses. The analyst set-up samples for incubation immediately upon receipt. Analysis was conducted according to Region 4 SOP's and the manufacturer protocols. All samples collected are prepared and processed according to specified Quality Assurance/Quality Control (QA/QC) procedures.

Monthly Base Flow Sampling

Each month, base flow stream samples were collected for background analysis of total suspended solids, nutrients and organic carbon from each of the six stream monitoring sites. Pathogen samples were also collected for analysis as part of the base flow sampling, starting in December, 2002. Staff gage readings were recorded at time of sample collection.

Field Sampling procedures

Field and laboratory SOPs (see appendix 1) were developed by EPA Athens-ERD and are being followed, that incorporate those of the Analytical Support Branch, Ecological Assessment Branch and Enforcement and Investigation Branch of EPA Region 4 (2002).

Stream Flow

EPA had two Interagency Agreements with the USGS to collect stream flow data: 1) a real-time station was established at the SFBR70 site to collect long-term continuous river stage (i.e. level), stream flow (i.e. discharge), and precipitation data at the USGS station 02191743 at Carlton GA; and 2) long-term, non-continuous river stage (level), and stream flow (discharge) data were collected for the remaining five stream sites (SFBR10, 20, 30, 40, and 60).

At the real-time station, data was collected at 15-minute intervals and transmitted via satellite every four hours to the USGS office in Atlanta, GA. The web site can be accessed for real-time data at: http://water.usgs.gov/ga/nwis/uv?02191743. The data was usually checked on a daily basis to ensure that the station was working properly. A USGS field person visits the gage frequently to ensure that the sensors are properly cleaned and calibrated, and usually performs a stream flow measurement to relate stream flow to river stage. Additional data for the state collected during 1999, 2000 and 2001 are published in the Georgia District Annual Data CD-Report.

For the collection of non-continuous stage data at the other five sites by the USGS, a staff person visited each site to perform stream flow measurements at frequent intervals to develop and maintain site-specific rating curves to relate stream flow to river stage. After a series of measurements were made that covers a full range of river stages, a rating curve was created to relate river stage to stream flow. Once this rating curve has been verified and entered into the database, it can be used to calculate stream flow values associated with the staff gage readings or the level data obtained by the YSI multi-probe. Continued stream flow measurements are required after the determination of the initial rating curve to ensure that it is still valid. This relationship can change due to changes in the channel, vegetation growth, and other factors. If a series of measurements are found to deviate from the rating curve by more than five percent, a new rating curve is usually called for. Stream stage-flow rating data for the five stations are

presented in Appendix 10.

Once every three years, USGS staff from outside the Georgia District perform an external review to ensure that the practices used are nationally accepted procedures.

Stream Velocity Profiles

Vertical stream velocity profiles were conducted at sites SFBR 10, 20, 30 and 70 during February 7, 8 and 12, 2002 at varying stream stages for use in the calibration/verification of mathematical modeling of stream bed scour and sediment transport. Precipitation of 2.2 inches (Figure 20A) was recorded at the USGS real-time station at the SFBR70 site during the period of 0600 on 2/6 to 1200 on 02/07/2002. Stage and discharge data also collected at SFBR70 site is shown in Figures 20B and 20C. This rain event provided an opportunity to measure stream velocities at a relatively high stage and the following stream recession at lower stages. Accordingly, velocity measurements were made on Feb. 7 and 8, and then after the stream stage receded on Feb. 12, 2002.

Measurements were made by a combination of acoustical doppler velocimeters and bridge suspension apparatus coupled with Price AA current meters. Velocity profiles were measured at stream quarter points at selected representative stream sections. All profiles proceeded from near the stream bed to near the stream surface. Typically, the range of observation points was from 0.2 feet above the stream substrate to 0.2 feet below the stream surface. All measurements were accompanied by a determination of stream stage by either "tape down" from an established reference point (RP) or by existing staff gage.

The velocity profiles and their attendant data tables are shown in Figures 20D, 20E, 20F, 20G and 20H. In most cases, as presented, the profile data supported a regression fit of the velocity versus depth data.

Laboratory Analysis Procedures

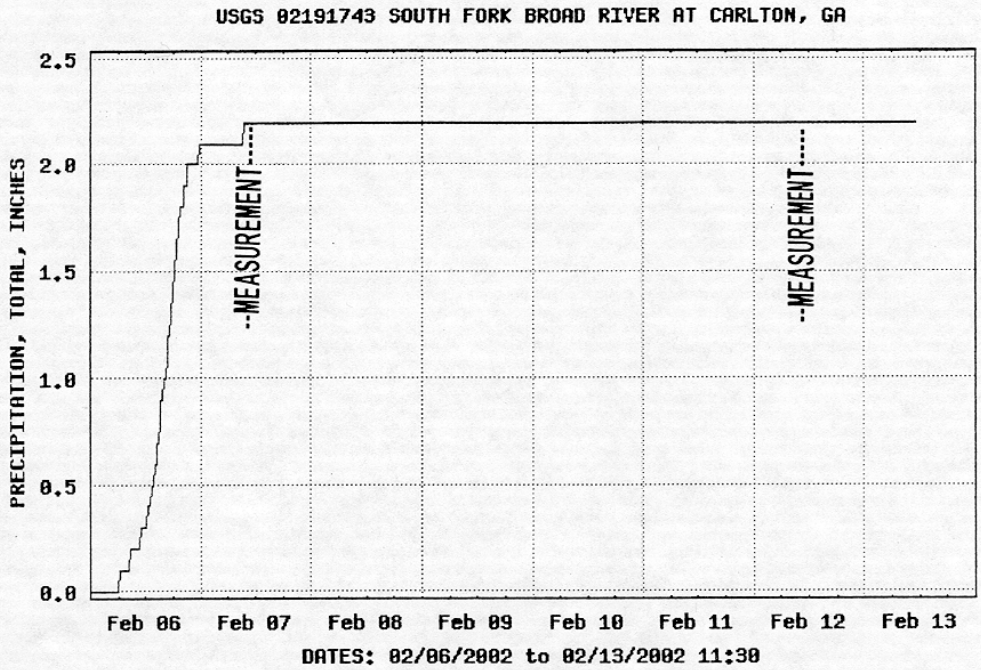
Specific analysis methods for sediment and nutrients in the low milligrams per liter range, and for pathogens in counts per milliliter, are required for TMDL development and model testing. All standard operating procedures (SOP's) are in Appendix 1. Analysis of TSS was conducted using a modified method in Standard Methods, 1998, SOP EAB-004.0 . The analysis of nutrients was performed using a Bran+Luebbe AutoAnalyzer 3, SOP EAB-003.0 whereas the analysis of organic carbon utilized Shimadzu's TOC 5050A instrument with an ASI 5000A autosampler attached, SOP EAB-011.0. Particle size analysis for particles less than 2 mm was conducted with a Beckman Coulter LS 200 instrument, SOP EAB-010.0. The analysis of particles greater than 2 mm was conducted manually by wet-sieving.

All laboratory analyses for sediment, nutrients, and organic carbon were conducted at EPA's Ecosystems Research Division Field Research Annex by a team having extensive laboratory experience. See Figure 21 for the Laboratory Analysis Flow Chart. Pathogen analyses were conducted in a mobile laboratory on site and at EPA's Region 4 laboratories.

Holding times before analysis for the different species are 6 hours maximum for pathogens; 24 hours preferably, but not longer than 7 days, for TSS; 48 hours for nutrients; and indefinite for bedload samples after freezing.

PRECIPITATION, TOTAL, INCHES

Most recent value: .00 02-13-2002 11:30



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Real-time Data for Georgia
http://water.usgs.gov/ga/nwis/uv?

Retrieved on 2002-02-13 14:36:53 EST
Department of the Interior, U.S. Geological Survey
USGS Water Resources of Georgia
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1.78 1.34

Figure 20a. USGS Precipitation Data at SFBR70 site, 02-13-2003

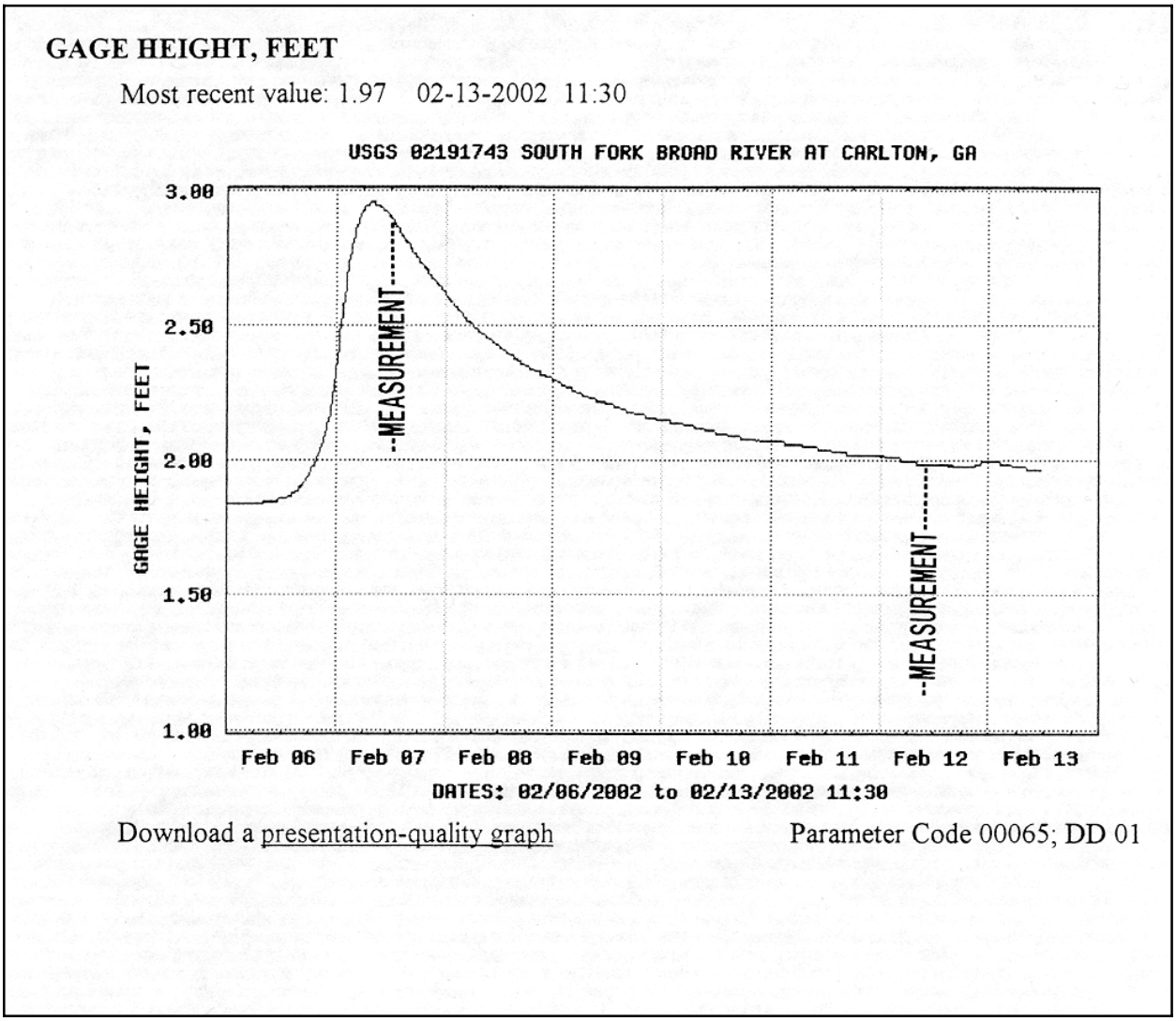
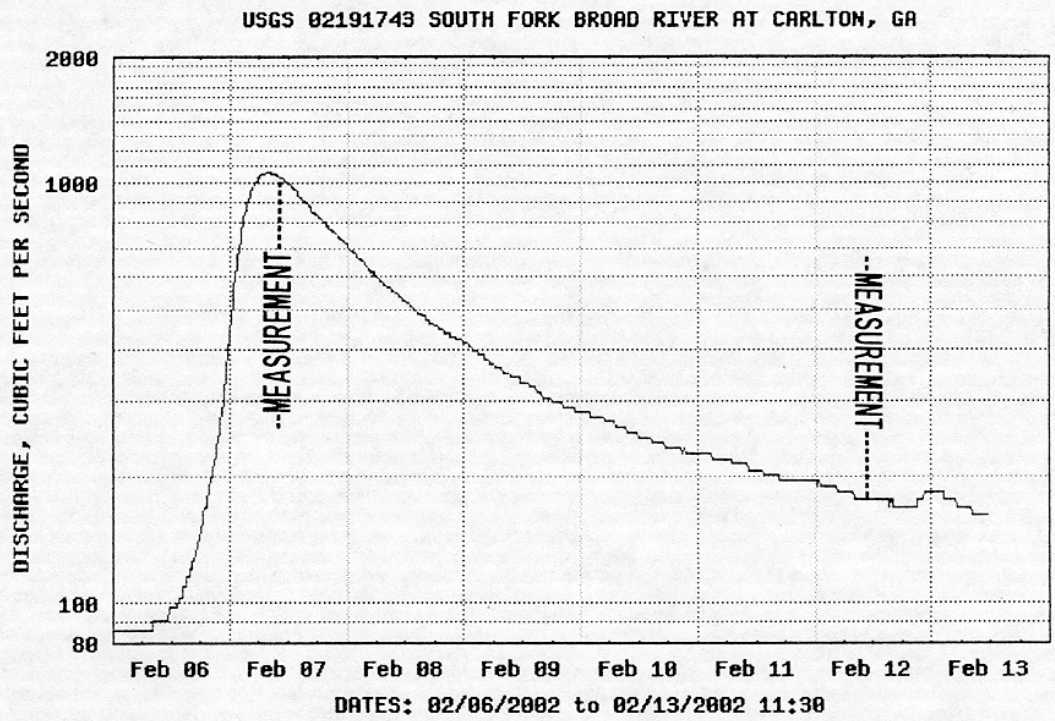


Figure 20b. USGS Gage Height Data at SFBR70 site, 02-13-2003

DISCHARGE, CUBIC FEET PER SECOND

Most recent value: 162 02-13-2002 11:30



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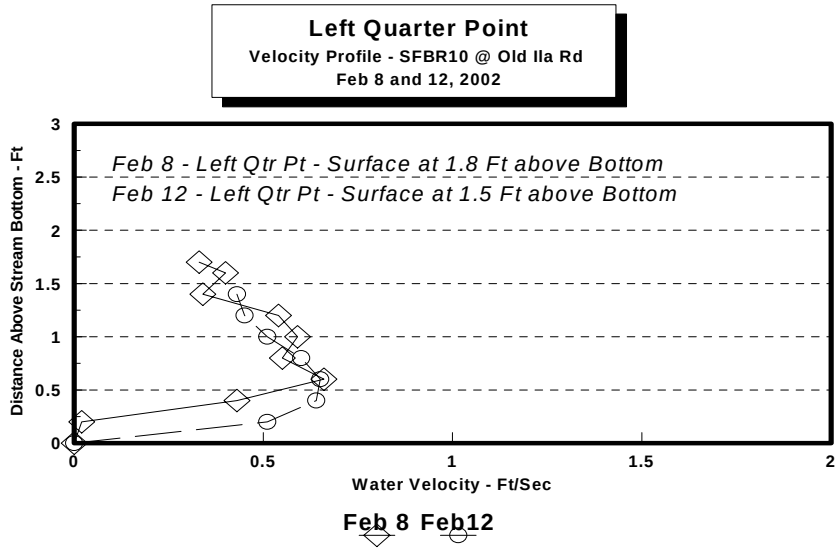
Daily mean flow statistics for 2/13 based on 0 year of record in ft^3/sec

Current Flow	Minimum	Mean	Maximum	80 percent exceedence	50 percent exceedence	20 percent exceedence
162	--	--	--	--	--	--

Percent exceedance means that 80, 50, or 20 percent of all daily mean flows for 2/13 have been greater than the value shown.

Figure 20c. USGS Discharge Data at SFBR70 Site, 02-13-2003



SFBR10

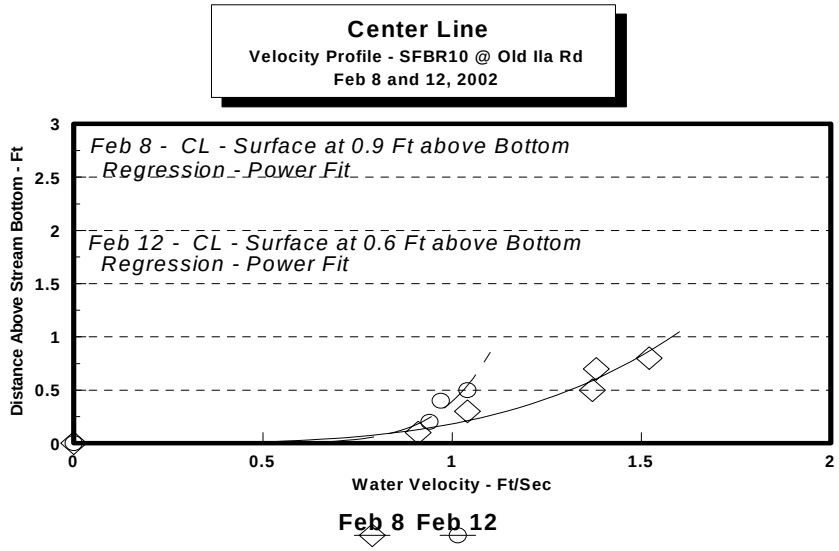
Feb 8 and 12, 2002

Feb 8

Total Width at Section = 32 Ft
Staff Gage = 21.38 Ft

Feb 12

Total Width at Section = 29 Ft
Staff Gage = 20.96 Ft



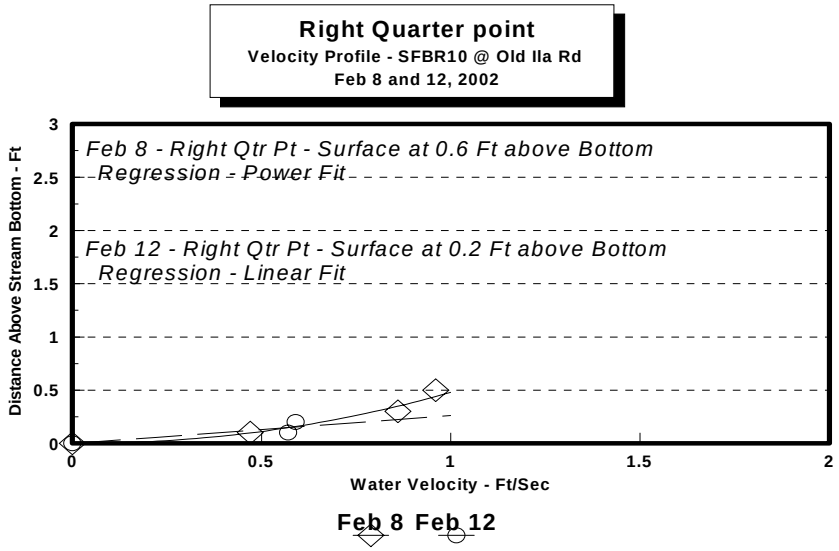


Figure 20d. Stream Velocity Profiles for SFBR10 Site, 02-8 & 12-2002

Quarter Point Velocity Profiles

Station: SFBR10 | Date: 02/08/2002 | Time: 0930-1030

Staff Gage: 21.38 Ft | Tape Down: 19.47 Ft | Stream Width: 32.0 Ft

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth*	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
0	0	0	0	0	0
0.2	0.02	0.1	0.91	0.1	0.47
0.4	0.43	0.3	1.04	0.3	0.86
0.6	0.66	0.5	1.37	0.5	0.96
0.8	0.55	0.7	1.38		
1	0.59	0.8	1.52		
1.2	0.54				
1.4	0.34				
1.6	0.4				
1.7	0.33				

Station: SFBR10 | Date: 02/12/2002 | Time: 1400-1500

Staff Gage: 20.96 Ft | Tape Down: | Stream Width: 29.0 Ft

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
0	0	0	0	0	0
0.2	0.51	0.2	0.94	0.1	0.57
0.4	0.64	0.4	0.97	0.2	0.57
0.6	0.65	0.5	1.04		
0.8	0.6				
1	0.51				
1.2	0.45				
1.4	0.43				

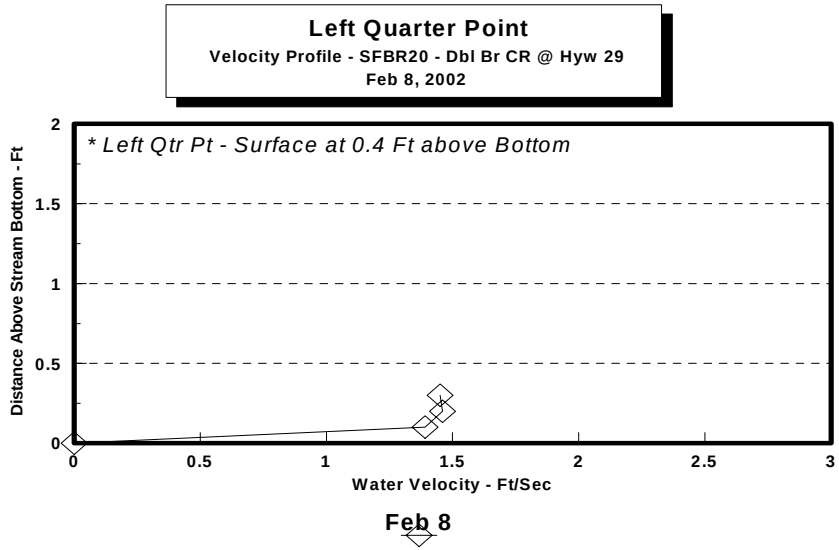
Station: | Date: | Time:

Staff Gage: | Tape Down: | Stream Width:

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS

Lft Qtr Pt* = As looking up stream.
Depth* = Distance above stream bed.

Figure 20d. Continued

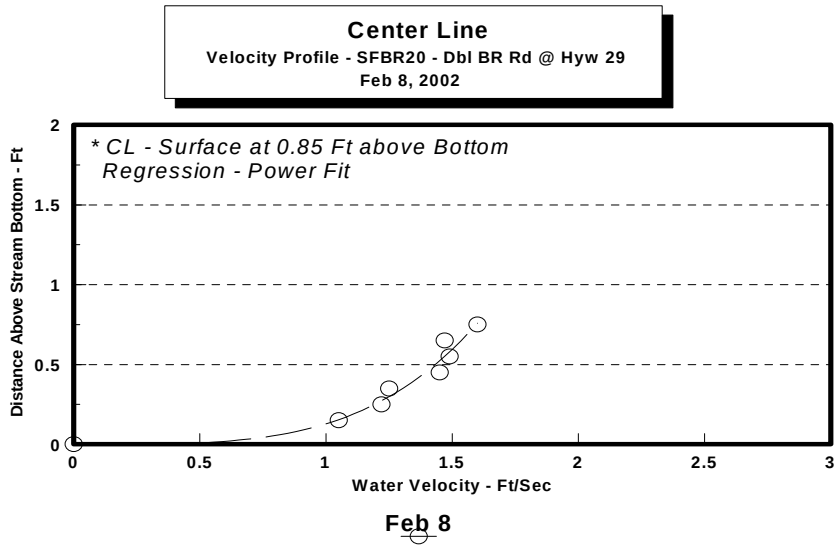


SFBR20

Feb 8, 2002

Total Width at Section = 12 Ft

Staff Gauge = 21.36 Ft



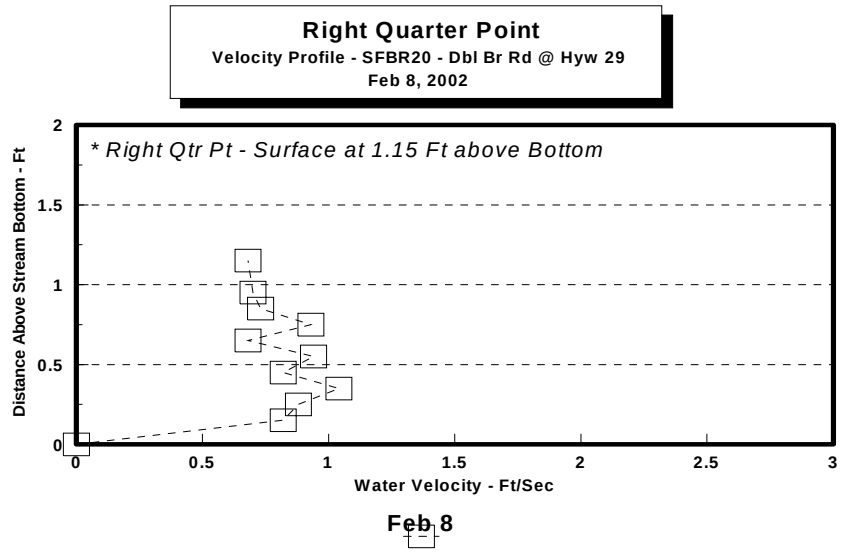


Figure 20e. Stream Velocity Profiles for SFBR20 Site, 02-8-2003

Quarter Point Velocity Profiles

Station: SFBR20 | Date: 02/08/2002 | Time: 1100-1200

Staff Gage: 21.36 Ft | Tape Down: | Stream Width: 12.0 Ft

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth*	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
0	0	0	0	0	0
0.1	1.39	0.15	1.05	0.15	0.82
0.2	1.46	0.25	1.22	0.25	0.88
0.3	1.45	0.35	1.25	0.35	1.04
		0.45	1.45	0.45	0.82
		0.55	1.49	0.55	0.94
		0.65	1.47	0.65	0.68
		0.75	1.6	0.75	0.93
				0.85	0.73
				0.95	0.7
				1.05	0.68

Station: | Date: | Time:

Staff Gage: | Tape Down: | Stream Width:

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS

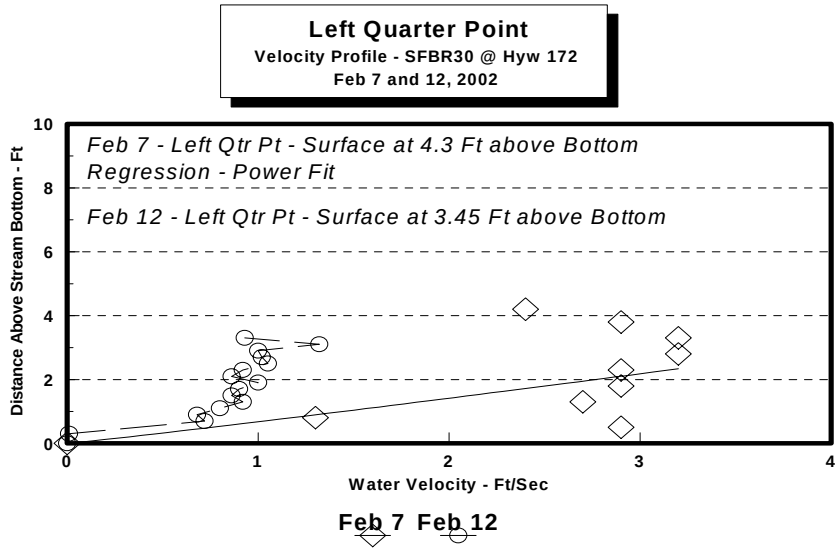
Station: | Date: | Time:

Staff Gage: | Tape Down: | Stream Width:

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS

Lft Qtr Pt* = As looking up stream.
Depth* = Distance above stream bed.

Figure 20e. Continued



SFBR30

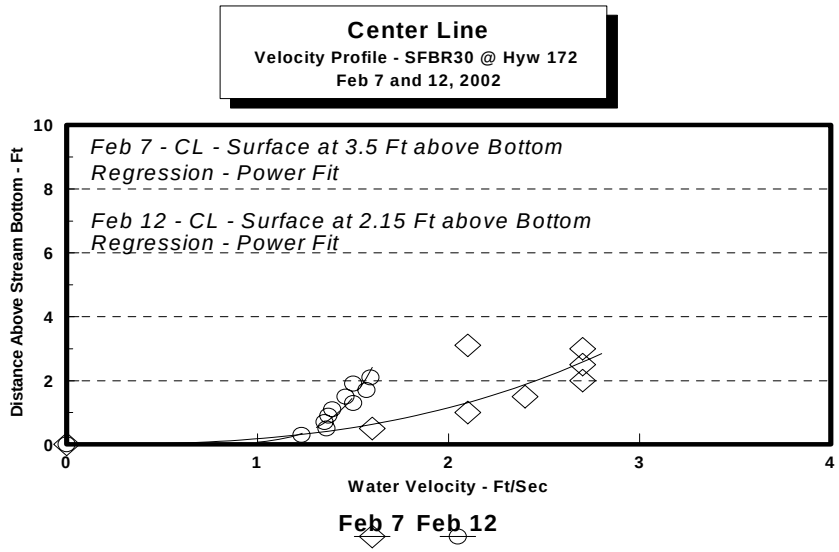
Feb 7 and 12, 2002

Feb 7

Total Width at Section = 54 Ft
Tape Down from RP = 28.09 Ft

Feb 12

Total Width at Section = 41 Ft
Staff Gage = 39.94 Ft



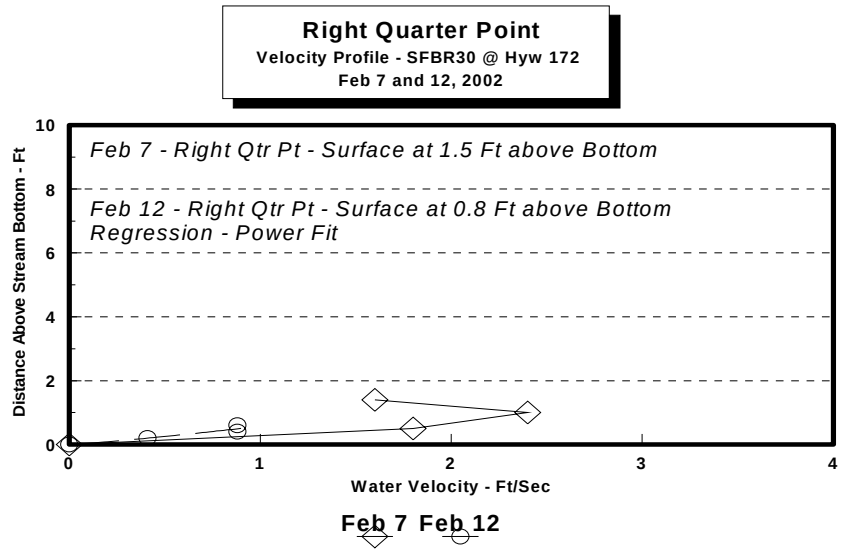


Figure 20f. Stream Velocity Profiles for SFBR30 Site, 02-7 & 12-2002

Quarter Point Velocity Profiles

Station: SFBR30 | Date: 02/07/2002 | Time: 1320-1420

Staff Gage: | Tape Down: 28.09 FT | Stream Width: 54.0 Ft

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth*	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
0	0	0	0	0	0
0.5	2.9	0.5	1.6	0.5	1.8
0.8	1.3	1	2.1	1	2.4
1.3	2.7	1.5	2.4	1.4	1.6
1.8	2.9	2	2.7		
2.3	2.9	2.5	2.7		
2.8	3.2	3	2.7		
3.3	3.2	3.4	2.1		
3.8	2.9				
4.2	2.4				

Station: SFBR30 | Date: 02/12/2002 | Time: 1200-1300

Staff Gage: 34.94 Ft | Tape Down: | Stream Width: 41.0 Ft

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
0	0	0	0	0	0
0.3	0.01	0.3	1.23	0.2	0.41
0.5	0.8	0.5	1.36	0.4	0.88
0.7	0.72	0.7	1.35	0.6	0.88
0.9	0.68	0.9	1.37		
1.1	0.68	1.1	1.39		
1.3	0.92	1.3	1.5		
1.5	0.86	1.5	1.46		
1.7	0.9	1.7	1.57		
1.9	1	1.9	1.5		
2.1	0.86	2.1	1.59		
2.3	0.92				
2.5	1.05				
2.7	1.02				
2.9	1				
3.1	1.32				
3.3	0.93				

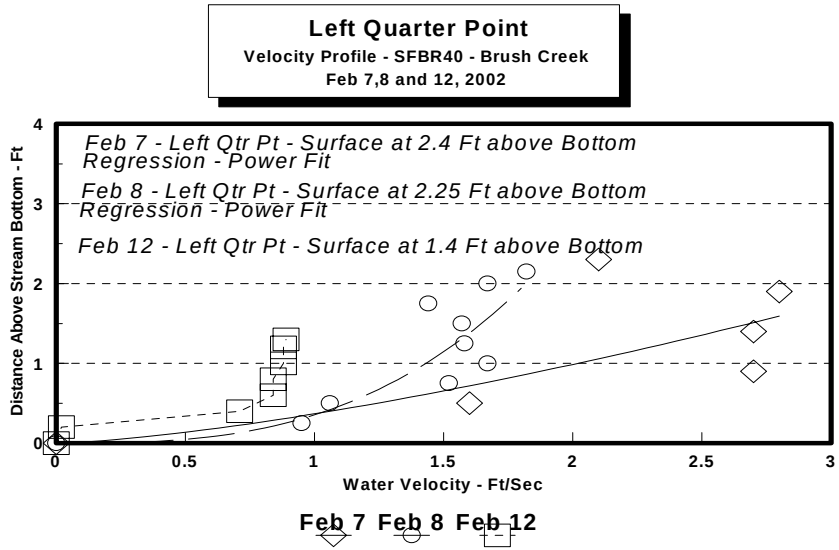
Station: | Date: | Time:

Staff Gage: | Tape Down: | Stream Width:

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS

Lft Qtr Pt* = As looking up stream.
Depth* = Distance above stream bed.

Figure 20f. Continued



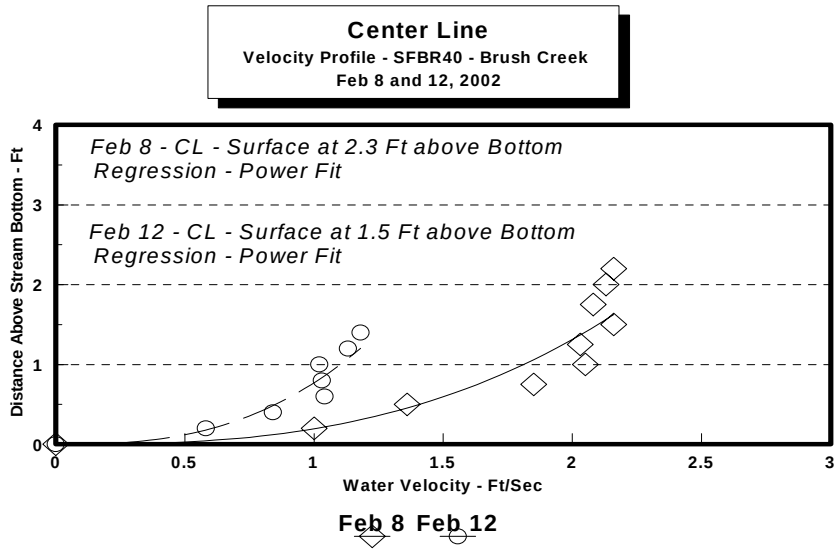
SFBR40

Feb 7,8 and 12, 2002

Feb 7
Total Width at Section = 31.5 Ft
Tape Down from RP = 9.83 Ft
Staff Gauge = 12.70 Ft

Feb 8
Total Width at Section = 26 Ft
Tape Down from RP = 10.51 Ft
Staff Gauge = 12.03 Ft

Feb 12
Total Width at Section = 27 Ft
Staff Gauge = 11.44 Ft



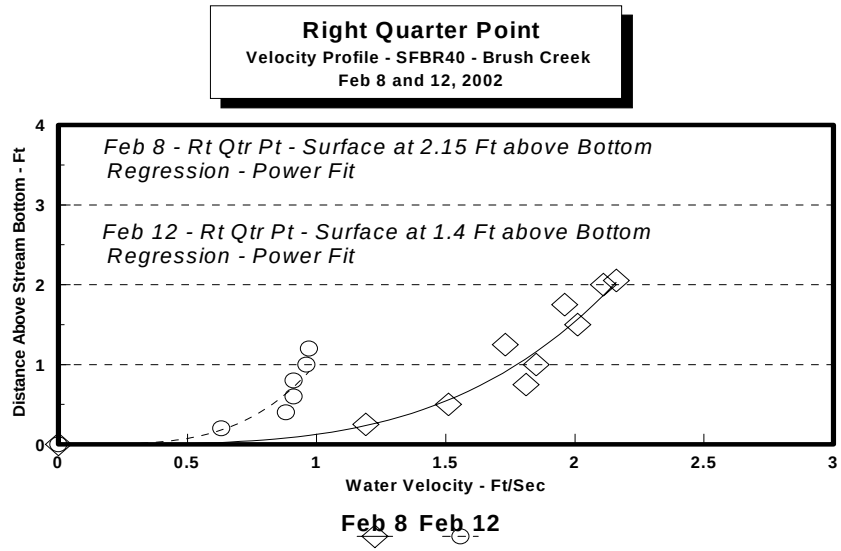


Figure 20g. Stream Velocity Profiles for SFBR60 Site, 02-7, 8, & 12-2002

Quarter Point Velocity Profiles

Station: SFBR40 | Date: 02/07/2002 | Time: 1430-1500

Staff Gage: 12.70 Ft | Tape Down: 9.83 Ft | Stream Width: 31.5 Ft

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth*	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
0	0				
0.5	1.6				
0.9	2.7				
1.4	2.7				
1.9	2.8				
2.3	2.1				

Station: SFBR40 | Date: 02/08/2002 | Time: 1230-1330

Staff Gage: 12.03 Ft | Tape Down: 10.51 Ft | Stream Width: 26.0 Ft

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
0	0	0	0	0	0
0.25	0.95	0.2	1	0.25	1.19
0.5	1.06	0.5	1.36	0.5	1.51
0.75	1.52	0.75	1.85	0.75	1.81
1	1.67	1	2.05	1	1.85
1.25	1.58	1.25	2.03	1.25	1.73
1.5	1.57	1.5	2.16	1.5	2.01
1.75	1.44	1.75	2.08	1.75	1.96
2	1.67	2	2.13	2	2.11
2.15	1.82	2.2	2.16	2.05	2.16

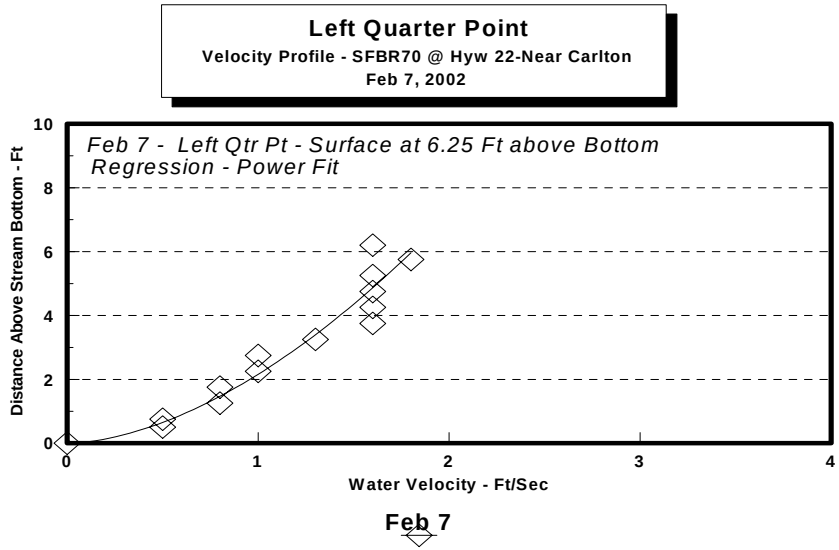
Station: SFBR40 | Date: 02/12/2002 | Time: 1245-1345

Staff Gage: 11.44 Ft | Tape Down: | Stream Width: 27.0 Ft

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
0	0	0	0	0	0
0.2	0.02	0.2	0.58	0.2	0.63
0.4	0.71	0.4	0.84	0.4	0.88
0.6	0.84	0.6	1.04	0.6	0.91
0.8	0.84	0.8	1.03	0.8	0.91
1	0.88	1	1.02	1	0.96
1.2	0.88	1.2	1.13	1.2	0.97
1.3	0.89	1.4	1.18		

Lft Qtr Pt* = As looking up stream.
Depth* = Distance above stream bed.

Figure 20g. Continued



SFBR70

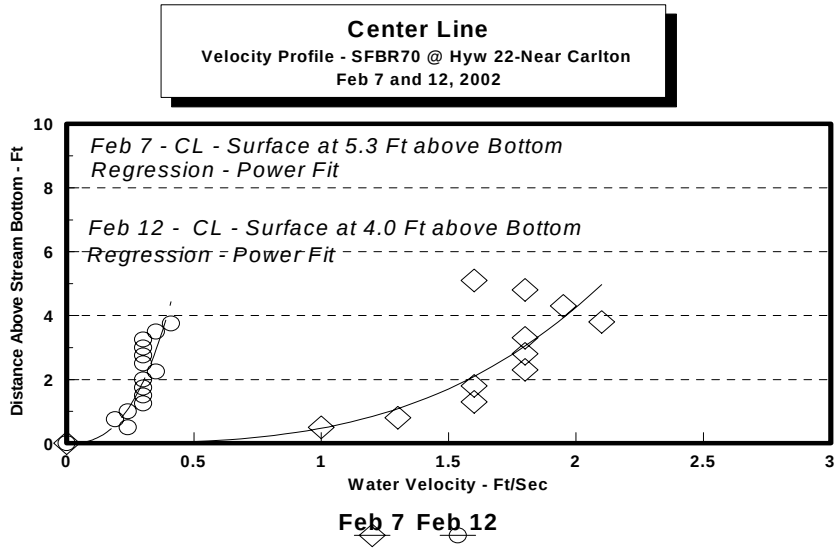
Feb 7 and 12, 2002

Feb 7, 2002

Total Width at Section = 183 Ft
Tape Down from RP = 31.14 Ft

Feb 12, 2002

Total Width at Section = 183 Ft
Tape Down from RP = 32.07 Ft



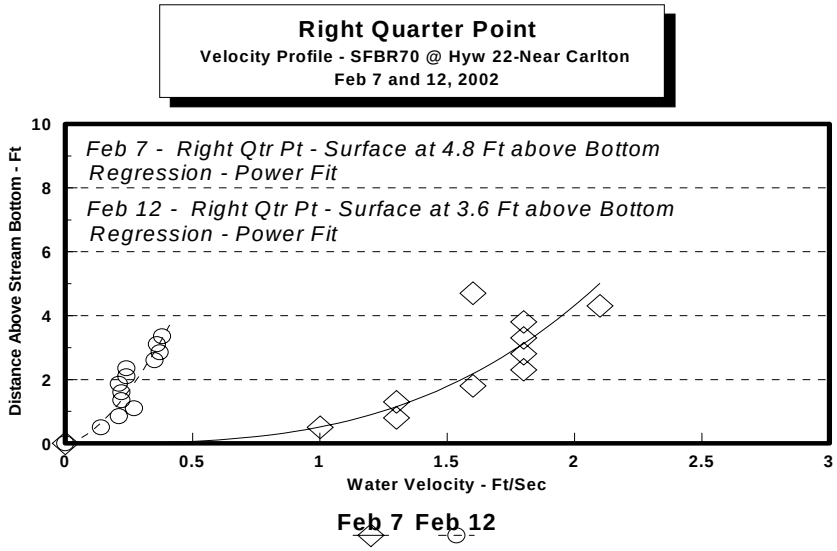


Figure 20h. Stream Velocity Profiles for SFBR70 Site, 02-7 & 12-2002

Quarter Point Velocity Profiles

Station: SFBR70 | Date: 02/07/2002 | Time: 1100-1200

Staff Gage: | Tape Down: 31.14 Ft | Stream Width: 183 Ft

Left Qtr Pt*		Center Line		Rt Qtr Pt	
Depth*	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
0	0	0	0	0	0
0.5	0.5	0.5	1	0.5	1
0.75	0.5	0.8	1.3	0.8	1.3
1.25	0.8	1.3	1.6	1.3	1.3
1.75	0.8	1.8	1.6	1.8	1.6
2.25	1	2.3	1.8	2.3	1.8
2.75	1	2.8	1.8	2.8	1.8
3.25	1.3	3.3	1.8	3.3	1.8
3.75	1.6	3.8	2.1	3.8	1.8
4.25	1.6	4.3	1.95	4.3	2.1
4.75	1.6	4.8	1.8	4.7	1.6
5.25	1.6	5.2	1.6		
5.75	1.8				
6.15	1.6				

Station: SFBR70 | Date: 02/12/2002 | Time: 1030-1130

Staff Gage: | Tape Down: 32.07 Ft | Stream Width: 183 Ft

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS
		0	0	0	0
		0.5	0.24	0.5	0.14
		0.75	0.19	0.85	0.21
		1	0.24	1.1	0.27
		1.25	0.3	1.35	0.22
		1.5	0.3	1.6	0.22
		1.75	0.3	1.85	0.21
		2	0.3	2.1	0.24
		2.25	0.35	2.35	0.24
		2.5	0.3	2.6	0.35
		2.75	0.3	2.85	0.37
		3	0.3	3.1	0.36
		3.25	0.3	3.35	0.38
		3.5	0.35		
		3.75	0.41		

Station: | Date: | Time:

Staff Gage: | Tape Down: | Stream Width:

Left Qtr Pt		Center Line		Rt Qtr Pt	
Depth	Velocity	Depth	Velocity	Depth	Velocity
Ft	FPS	Ft	FPS	Ft	FPS

Lft Qtr Pt *= As looking up stream.
Depth* = Distance above stream bed.

Figure 20h. Continued

Training of Field Sampling and Laboratory Analysis Teams

Approximately 25 EPA volunteer field team members from Athens ERD were trained for both day and night time sampling. In addition to the field team, a laboratory analysis and logging team was organized possessing extensive laboratory experience in conducting these analyses and in the logging of samples into the laboratory.

During October 2002, an EPA contractor was funded under an existing task order to collect storm event bedload and depth-integrated sediment samples from four high priority sites as discussed previously. The contract field staff were trained for sampling by EPA staff using the EPA developed procedures and protocols.

Quality Assurance

Development of QA/QC procedures began in the project's planning stage and will continue through sample collection, analyses, reporting and in the database development. The primary objective of the project was to collect a representative set of high quality data for the SFBR watershed TMDL study. One duplicate field sample was collected for pathogen analysis during each 12-hour shift. One duplicate sample for sediment analysis was assigned by laboratory staff from the ISCO samples approximately every 10th sample. Standards are run in the laboratory before and after analyses and during selected (every 10th sample) analyses. Standard curves are run before analysis. There was no TSS standard; however, balances were checked frequently. Field duplicate samples of the sediment core samples were collected at every 10th stream cross sectional sampling site and noted with a "Q" at the end of the sample ID. Field notes were kept in log books.

All field samples were kept on ice during sampling and transport to the FRA for analysis. At the end of a 12-hour sampling shift, all samples were returned to the FRA, removed from the ice chests and placed in cold storage. The DH-59 samples were placed in the walk-in-cooler, grouped by site and accompanied with the following information: date and time of arrival; site where samples were collected; number of DH-59 and bedload samples; and the names of the sample collectors. The bedload samples were placed in the walk-in freezer, grouped by site, and accompanied with the same documentation as with the DH-59 samples. All sample information is recorded in a record book located in a secure box at the rear door of the FRA. ISCO samples were also placed in the walk-in-cooler by FRA personnel, grouped by site, and labeled with the date and time at which the last sample was collected.

All samples collected in the field for pathogen analysis were held on ice at <10˚C. These samples are picked-up frequently and analyzed as soon as possible to ensure that the maximum allowable holding time of 6 hours is not exceeded.

Field records were kept in log books for each of the four high priority stream monitoring sites to include: site shift leader; date and time of hourly stream stage data for depth; and turbidity from the LCD of the ISCO sampler on site. In addition, any problems noted during sampling was required to be recorded. All log books remained on site except at SFBR10 which remained in the crane truck.

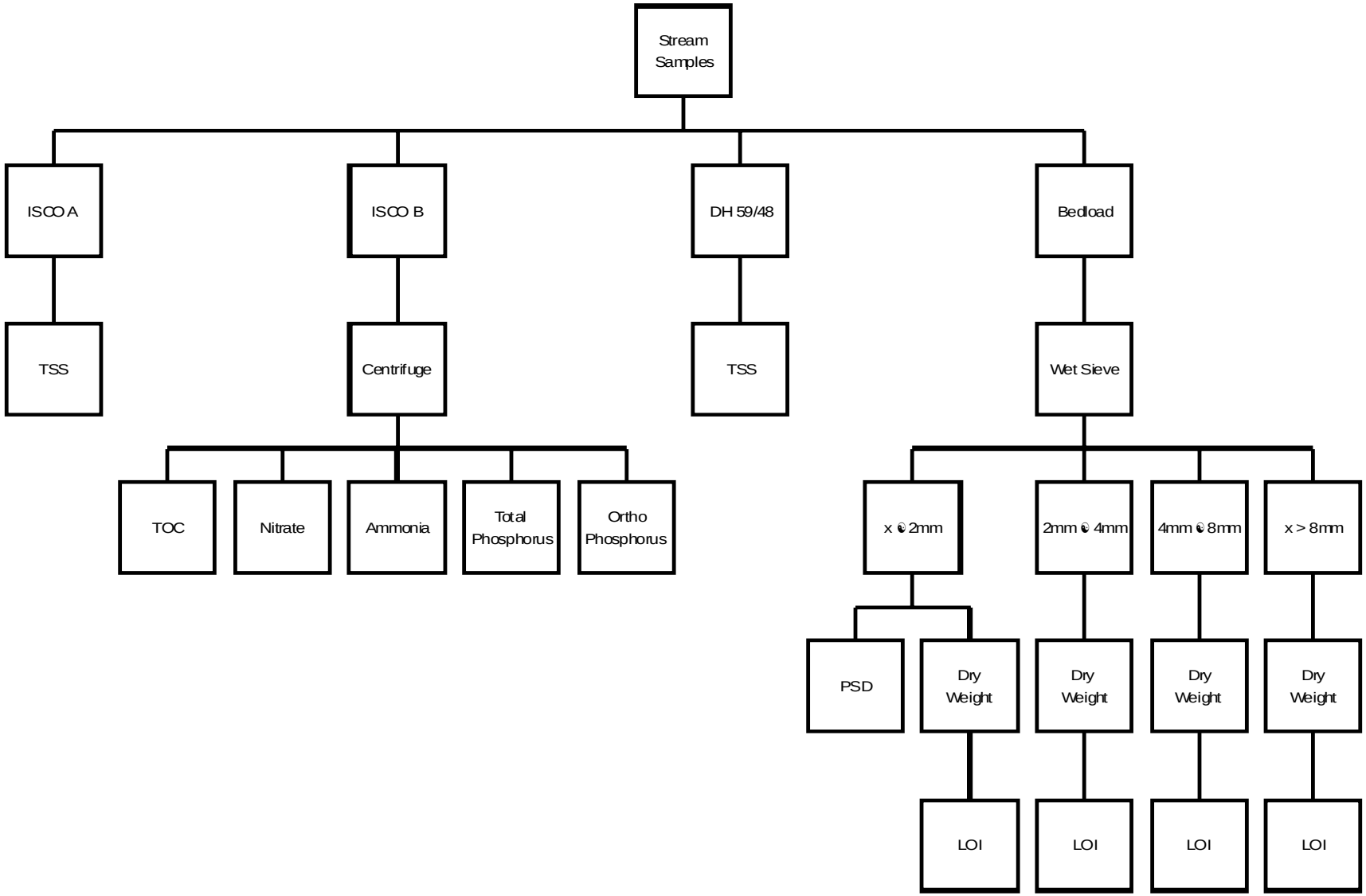


Figure 21: South Fork Broad River Laboratory Analysis Flow Chart

Database Development

A comprehensive relational database system has been designed and populated with data collected from the South Fork Broad River Watershed sampling sites. The database resides in MySQL database server. Field data are recorded in various formats including hand written field and lab sheets, text files, and excel worksheets. A software system has been developed for transferring data from text files and excel worksheets to the relational database. The database design, architecture, user access, quality control, security, and other details will be made available in a separate report.

Chapter 4
Supporting Projects in SFBR

The following were projects that supported the South Fork Broad River Watershed Research Project.

1. Interagency Agreement with the U.S. Geological Survey.

a. Through an IAG with the USGS, a real-time gaging station was installed near Carlton, GA at the watershed outlet (SFBR70) to provide real-time stage-discharge and rainfall data. The station web site can be accessed at: http://water.usgs.gov/ga/nwis/uv?02191743.

b. Through another IAG with the USGS, stage-discharge rating curves are being developed by installing staff gages at the six stream monitoring sites and then measuring the discharges corresponding to at least ten different stages during rain events. Data collected under the original IAG consisted of low flow stream rating curves. A new IAG is in effect that includes a range of low and high stream flow conditions to provide critical data for estimating contaminant loading rates.

2. Task Order through Region 4 contractor, Integrated Laboratory Systems, Inc.

This task order was funded to conduct sediment investigation in the SFBR watershed as part of the development of a sediment TMDL protocol. The task order includes: conducting stream cross-sectional surveys for about 300 sites; developing elevations of the stream cross sections relative to bridge benchmarks; and collecting storm event samples for bedload and depth-integrated samplers at four high priority sites (SFBR10, 30, 60, and 70).

3. Interagency Agreements with the U.S. Army Corps of Engineers.

a. Through an IAG with the U.S. Army Corps of Engineers, three cableway stream sampling systems were successfully designed and constructed. The installation of the cableway sampling systems was critical to our field research project in order to provide a safe environment for sampling teams to collect the required bedload and depth-integrated samples during intensive storm events. To our knowledge, these are the only automated, unmanned stream sampling systems of their size in the United States.

b. Through another IAG with the U.S. Army Corps of Engineers, a computerized data repository is being developed that can incorporate information from different sources and hardware platforms, that will provide data exploration capabilities, and that make the data accessible to users via the Internet. The repository will accommodate geospatial data, tabular data, and electronic documents. Organizational goals and needs, including watershed level extrapolation and modeling, multi-model integration, regional scale analyses, and interagency collaboration and coordination are being considered in this development.

4. Cooperative Agreement with the University of Georgia.

A Cooperative Agreement was developed with the University of Georgia to measure sediment at selected sites in the SFBR watershed using a pressure transducer and to compare these data with actual stream sediment data collected during storm events. Results of this research effort thus far indicate that development and use of pressure transducers are in a research mode and not ready at this time to produce reliable and defensible data in the field during storm events for our TMDL project.

5. In-house research Project by Roger Burke.

The research project described below is currently ongoing in the SFBR and will provide additional data.

Nutrient and Trace Gas Concentrations in Headwater Streams of the South Fork Broad River Watershed

Introduction

According to the U.S. Census Bureau (http://quickfacts.census.gov/qfd/), population increases in Madison and Oglethorpe counties, which contain most of the SFBR watershed, between 1990 and 2000 were 22% and 29%, respectively. By comparison, between 1990 and 2000 population increases in the state of Georgia and in the U.S. were 26% and 13%, respectively. Population is expected to increase in the Savannah River basin in the future at a similar rate. The additional growth is expected to place increased stresses on streams, notably flashier hydrographs, due to increases in water use and levels of impervious surfaces in developed watersheds, and reduced water quality due to greater contamination of streams by sediments, nutrients, organic material, agricultural chemicals and other toxics [Mulholland and Lenat, 1992; Georgia Dept. of Environmental Protection, 2001]. We have chosen to work on headwater streams for several reasons. Largely because of their shallow depths and high surface-to-volume ratios, headwater streams are highly efficient at retaining nutrients and organic matter (Peterson et al., 2001). First- and second-order streams are a critical part of the overall river network, comprising an estimated 95% of the total stream channels and 73% of the total stream channel length in the US (Meyer and Wallace, 2001). Because of their importance in the river network and high rate of biogeochemical cycling, headwater streams provide valuable ecosystem services by reducing transport of various pollutants to downstream ecosystems such as rivers and lakes (Meyer and Wallace, 2001). Headwater streams also provide refuge for species from downstream ecosystems and are an important food source for some birds (Meyer and Wallace, 2001). Headwater streams are inadequately protected, and because of their small size, their ecosystem function is easily impaired by human disturbance of their catchment, riparian zone, and channel (Meyer and Wallace, 2001). For these reasons, headwater streams probably deserve more intensive study and greater protection.

Goals

The overall goals of this research are to: (1) relate watershed land use to concentrations of trace gases, nutrients, oxygen, chl a (planned), dissolved organic carbon and nitrogen, alkalinity, and conductivity and temperature in first order streams of the Georgia Piedmont; (2) elucidate the instream and watershed processes responsible for the concentration and distribution

of these parameters; and (3) evaluate the utility of trace gas concentrations as indicators of stream ecosystem function. Land use changes induced by the growing human population will continue to have marked influences on important watershed processes such as C and N cycling, trace gas emission, and hydrology that are expected to directly impact stream ecosystem function because of altered water flows and decreased water quality.

Approach and Results to Date

Seventeen headwater watersheds within the SFBR watershed, ranging from 0.5 to 3.4 km2 were selected (Figure 22). Percentages of forested land, agricultural and pasture land, residential areas, wetlands and open water surfaces within the watershed were calculated from the National Land Cover Data (NLCD) database. Water samples have been collected monthly from November 2001 to the present at the outlet of each watershed.

Nitrogen Concentrations

Linear models relating land uses to the nitrogen concentrations in the streams were developed by step-wise regression. Preliminary analysis of the data indicates that the percentage of forested land in a watershed is a good indicator of nitrogen concentration in streams, especially for total nitrogen (TN) and dissolved inorganic nitrogen (DIN). Similar relationships between land-cover and stream N content have been observed at much larger scales by others [e.g., Omernik, 1977; Jones et al., 2001]. Up to 70% of the TN in streams draining residential areas was DIN. In contrast, streams in forested watersheds had relatively less nitrogen (45%) in inorganic form and about twice as much nitrogen (45%) in organic form compared to streams that drain residential areas. Streams in agricultural and pasture land-dominated watersheds had about twice as much nitrogen (15%) in particulate form as those from either forested or residential watersheds. The amount (%) of forested land within the watershed was the best predictor to the concentrations of the different forms of nitrogen in the streams.

Trace Gas Concentrations

Nitrous oxide concentrations varied widely from 10 nM (atmospheric equilibrium concentration) to nearly 80 nM among the streams. Overall, the streams draining watersheds dominated by developed land use had the highest dissolved nitrous oxide concentrations, although the difference is statistically significant only for comparisons between the forest and mixed land use watersheds. Also, the streams draining watersheds dominated by pasture had significantly greater nitrous oxide concentrations overall than streams draining forested watersheds. These results suggest that small streams could be a significant source of nitrous oxide to the atmosphere in some watersheds. Carbon dioxide concentrations in the streams range from about 30 to 900 mM (about 3 to 75 supersaturated with respect to the atmosphere). Similarly to that for nitrous oxide, the streams draining residential areas had the highest overall carbon dioxide concentrations, although the only statistically significant comparison was between them and streams draining forested areas. Methane concentrations ranged from about 0.06 to 40 mM (about 30 to 20,000 supersaturated with respect to the atmosphere). Overall, streams draining watersheds dominated by pastures had significantly higher methane concentrations than streams draining any other land use type. Similar to the case for nitrous oxide and carbon dioxide, the streams from forested watersheds had the lowest methane concentrations.

Summary of Nutrient and Trace Gas Concentration Project

The observations discussed here support the contention that land uses within the watershed have a significant impact on nitrogen concentrations and forms and trace gas concentrations in headwater stream waters. Also, use of data derived from the NLCD database to assess the impact of land uses on nitrogen and trace gas concentrations in streams at a local scale is a promising approach. The data collected in this project, including a more detailed analysis, will be reported at a later date in separate publications and a report.

Chapter 5
RESULTS OF STUDY

Data from the weather station have been collected hourly since January 1, 2000 to the present. Twenty (20) year monthly rainfall averages for the Danielsville, Georgia, area of the watershed were provided by Mark A. Jenkins, a National Weather Service Cooperative Observer. Comparison of these monthly averages with years 2000, 2001 and 2002 through July is presented in Figure 22. These later year total monthly rainfall amounts are corresponding less than the 20-year monthly averages except in September 2000 and March and July 2001. Figure 24 shows that the total rainfall for 2000 and 2001 was each about 15 inches less than the 20-year annual average. The reduction in total rainfall was over 40 inches from January 2000 to August 2002.

More rainfall (number of events and the amount) occurred during 2003 than any other year since the beginning of the field research project. A large rain event was predicted to occur during early April 2003 that produced a week of field sampling with 4-days of intensive sampling. This rain event was not as intensive as expected for producing heavy runoff but it did provide a low intensity rain over several days. Unfortunately, during this sampling event, two sites equipped with Rickly Hydrological Company type cableway systems malfunctioned and became inoperable and unsafe and therefore eliminated further rain event sampling until replacement winches could be installed. After many discussions with the Rickly Company, they finally agreed to replace both winch systems, but not until next year, 2004. The cableway system problems has caused unexpected delays in obtaining the required data during a period of greater rainfall.

The YSI multi-probe instream data [depth or level, turbidity, specific conductance, pH, DO, ORP, and temperature] was collected continuously at 15-minute intervals at each of the six sites. We have attempted to collect continuous instream data; however, this was very difficult to accomplish due to probe malfunctioning (mainly due to extremely low water flow condition), or the probes being silted-in by sand during a storm event. Judgement calls were made to determine when to omit erroneous data.

Baseflow (or background) sampling and analysis for TSS, NH3-N, NO-3-N, o-PO4 as P, Total-P and TOC contents were conducted monthly to provide background data between rain events for the six sites. Also, prior to an event, background samples were collected for analysis.

Rain event samples were collected by the ISCO samplers (i.e fixed location and depth in stream cross-section) and analyzed for TSS, NH3-N, NO-3-N, Total-N, o-PO4 as P, Total-P and TOC. In addition, rain event samples were collected at three to five locations across the stream cross-section by the bedload and depth-integrated samplers. The depth-integrated samples were analyzed for TSS and the bedload samples were analyzed for particle size distribution and loss on ignition.

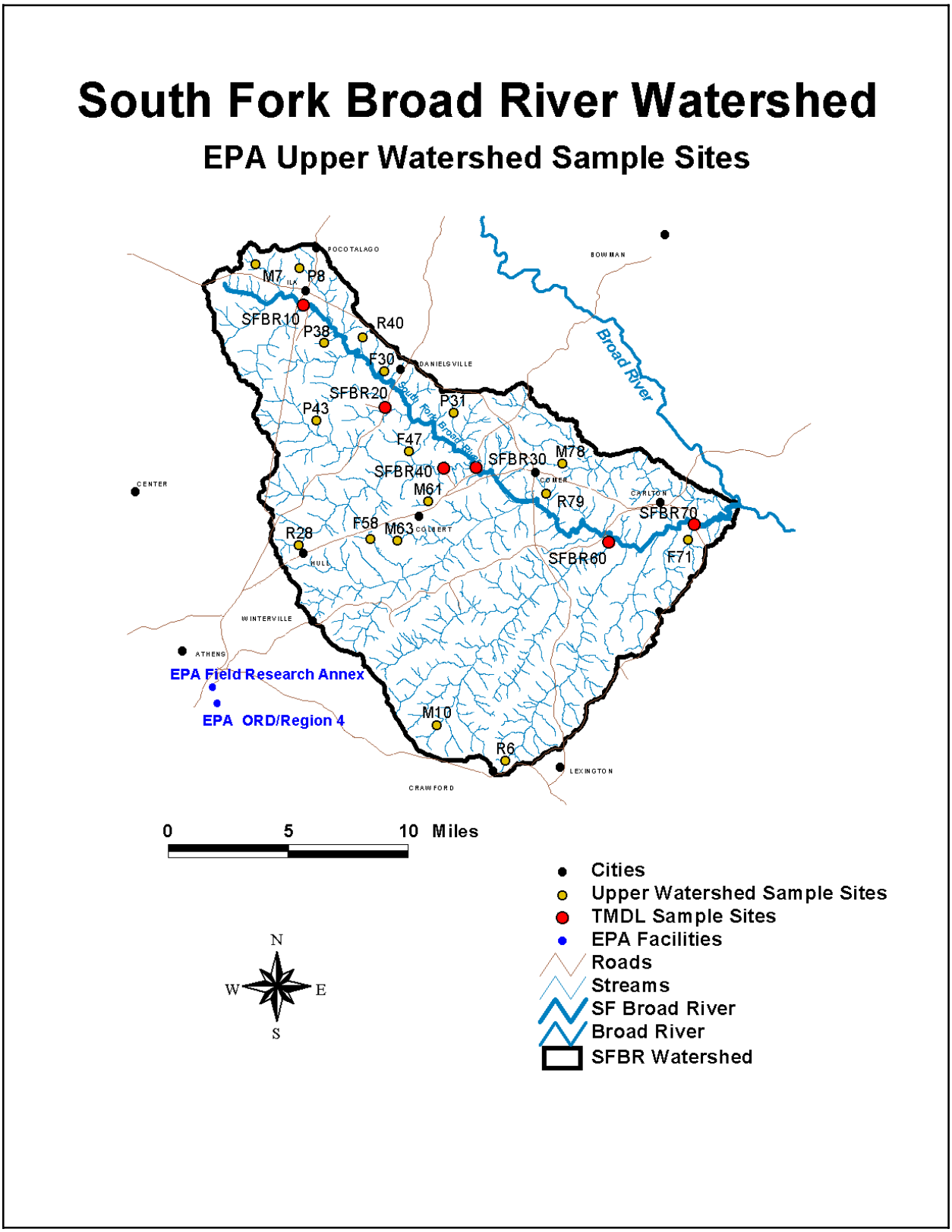


Figure 22. Location of Seventeen Small Watershed Sampling Sites in SFBR Study Area.

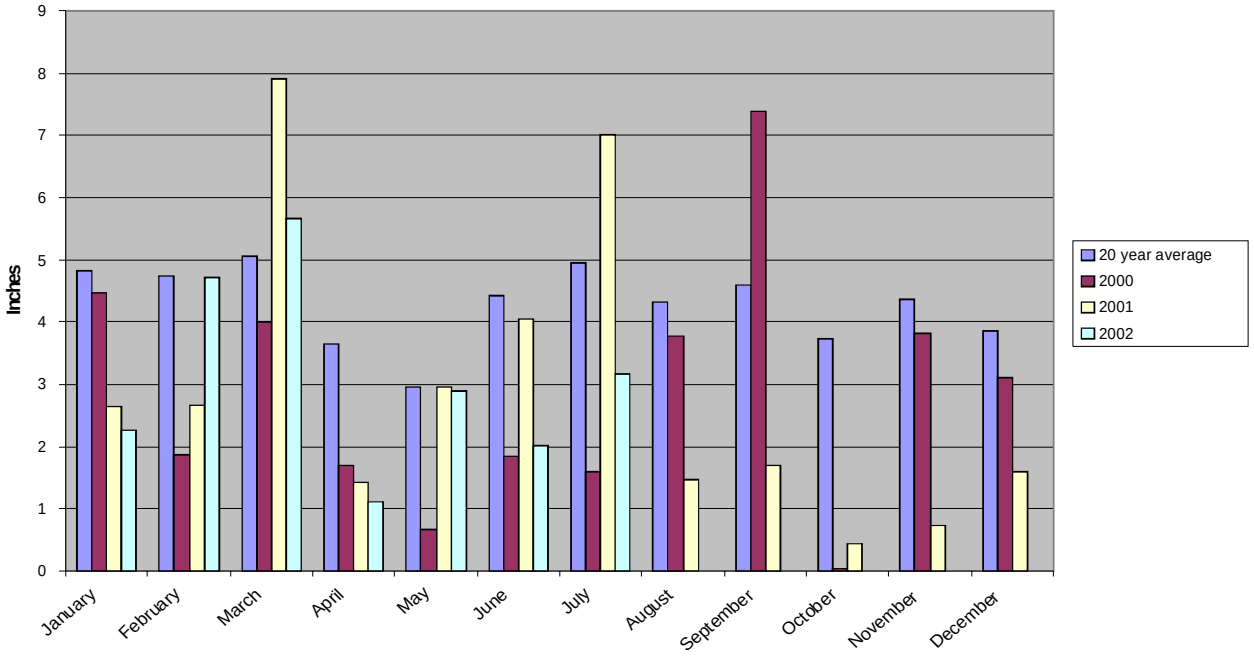


Figure 23. Comparison of Monthly Rainfall in SFBR with 20 Year Average

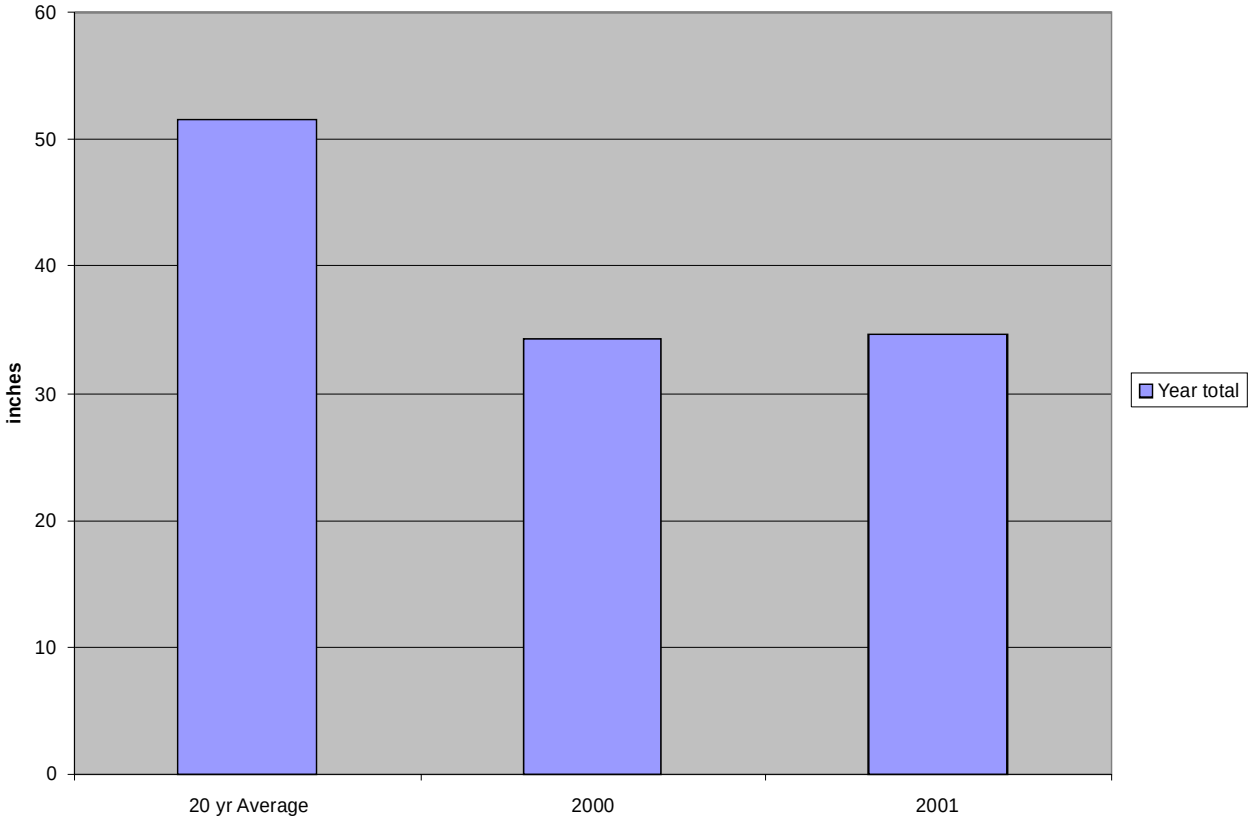
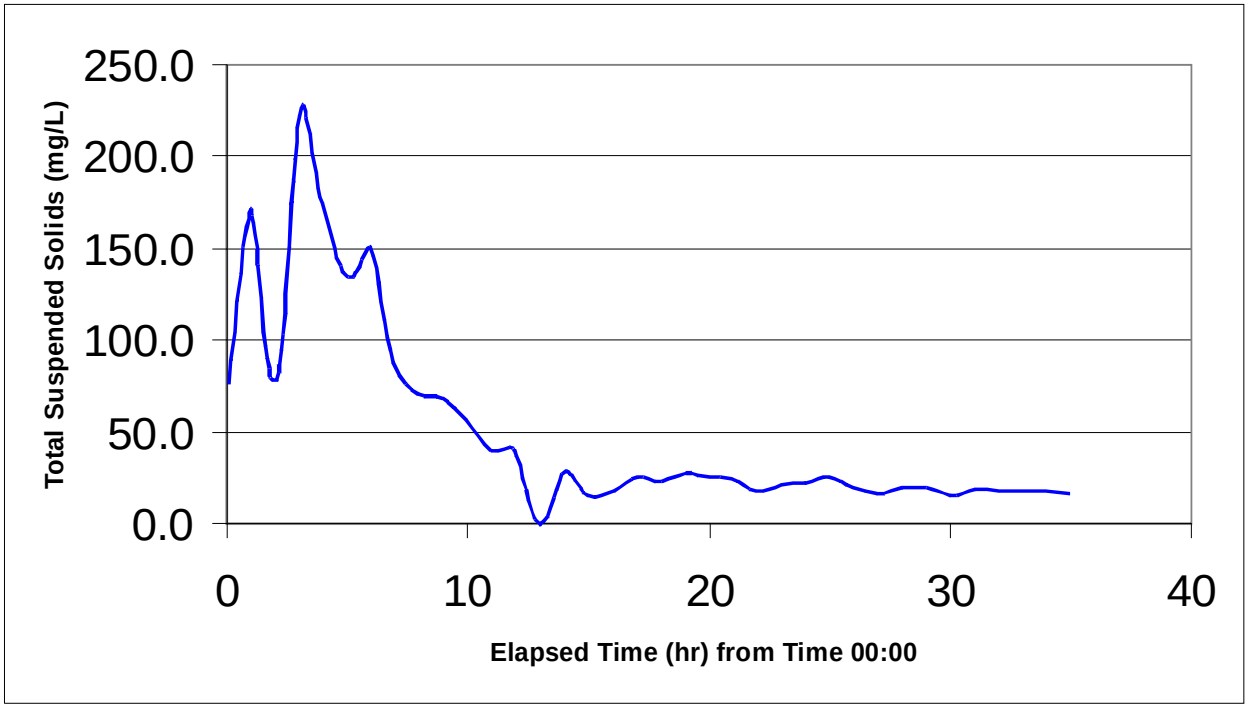


Figure 24. SFBR Average vs 2000 and 2001



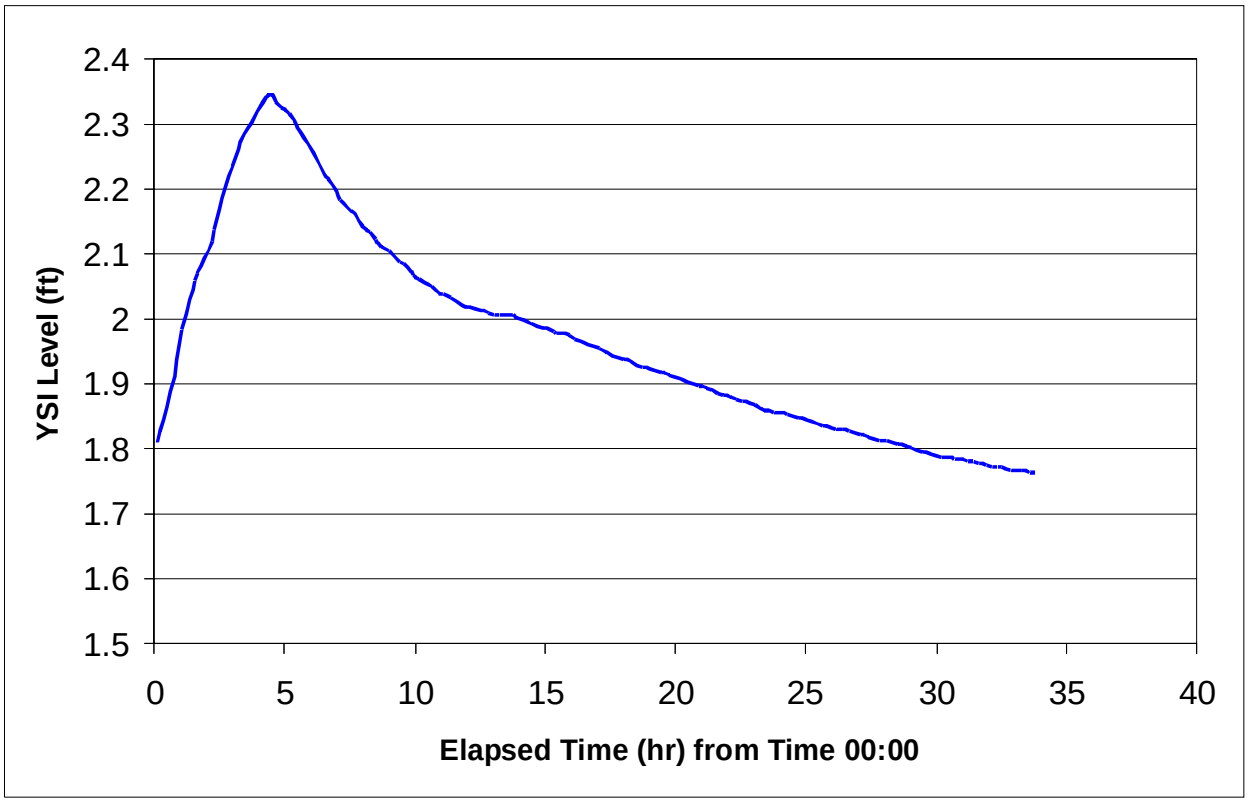


Figure 25. Comparison of TSS vs Stream Level at SFBR 10 Site for Storm Event on March 12, 2002

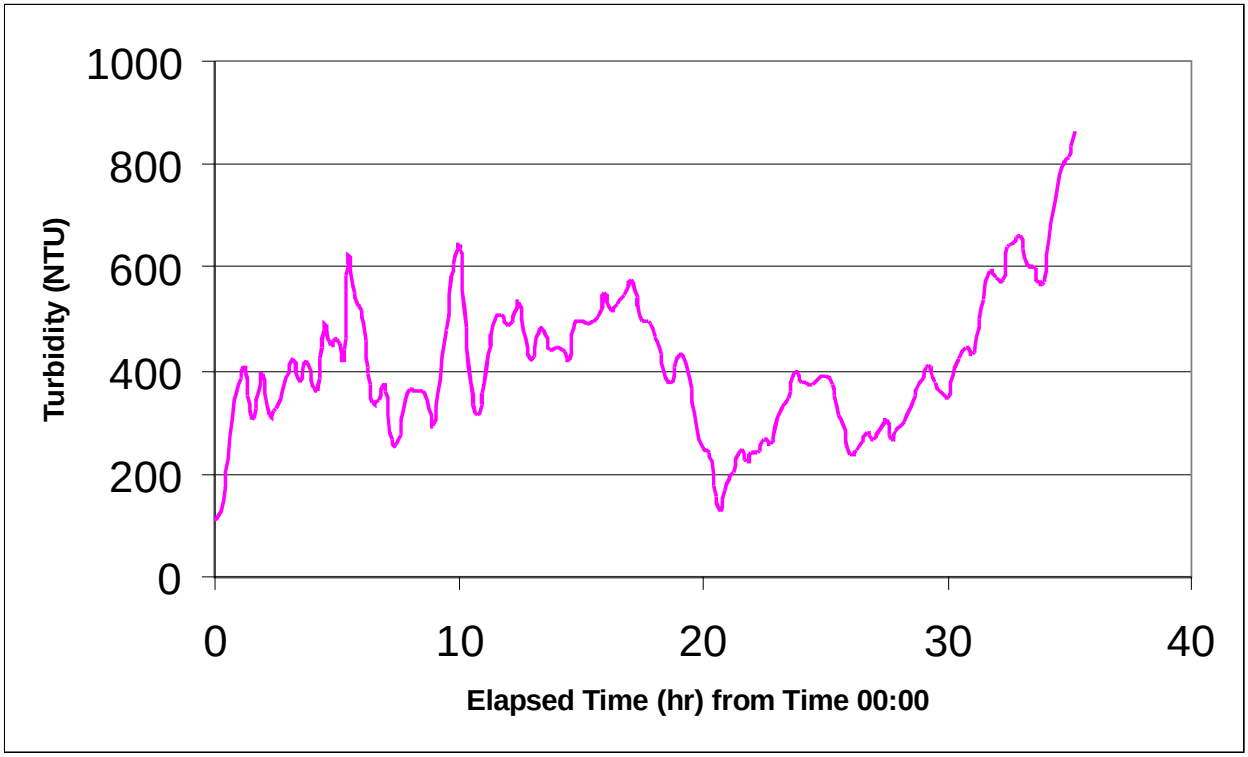
The comparison of TSS values from samples collected during the March 12, 2002 rain event by the ISCO samplers versus stream level (stage) measured by the YSI (25) indicate that the highest concentrations of TSS match the observed stream peak flow levels. The comparison of measured turbidity versus stream level (stage) rise by the YSI multi-probes does not appear to be as well defined as the TSS comparison (Figure 26). Figure 27 shows the comparison of measured TSS versus turbidity.

The data obtained from the ISCO samplers located at a fixed depth and cross-sectional location representing a single-point measurement in the stream channel compare favorably with the average data from the depth-integrated samplers taken at several locations across the stream channel at the same site. Figure 28 shows a comparison of TSS values using these two measurement methods for a single storm event. Figure 29 shows a scatter plot of each DI TSS value versus the corresponding ISCO value. Because DI samples were not taken at exactly the same time as the ISCO samples, linear interpolation between temporally adjacent ISCO samples was used to estimate an ISCO TSS value that matched the time of a DI TSS value. These data represent six rain-sampling events, and 75 total points.

The regression coefficient (R^2) is highly significant ($F_{(1,23)} = 883$, $p<0.0001$). Since the intercept is greater than zero and the slope greater than one, there is an indication of bias between the two values, namely that ISCO measures tended to be higher than DI values. But in analysis of data from a later storm event, this bias was reversed (Appendix 2). Note the large circular outlier at an ISCO TSS value of about 100. This could have been due to malfunction of the ISCO sampling gear. Due to its location, this outlier actually depresses the estimate of the slope somewhat. With this point removed, the slope estimate increases to 1.111 from 1.098. Additional data derived from various size storm events are needed to confirm these results before any reliable conclusions can be drawn.

Our results indicated that the information loss when automated ISCO samples are taken every two hours, instead of every hour, is measureable, not severe. Figure 30 presents a typical storm-event pollutograph, with the two-hour time series simply equivalent to the one-hour time series, with every other value removed.

Figure 31 depicts a scatter plot that matches every other actual TSS value from the one-hour time series to an interpolated value based on the two hour interval ISCO time series. For example, if a one-hour ISCO time series had TSS values for hours 3, 4, and 5, the corresponding two-hour time series would only have TSS values for hours 3 and 5. In Figure 30, the actual TSS value of the one-hour series at hour 4 would be compared to a TSS value derived from linear interpolation of the hour 3 and hour 5 values. This interpolated value is the mean of the hour 3 and hour 5 values. A total of 145 data points from eight storm events were included in the analysis.



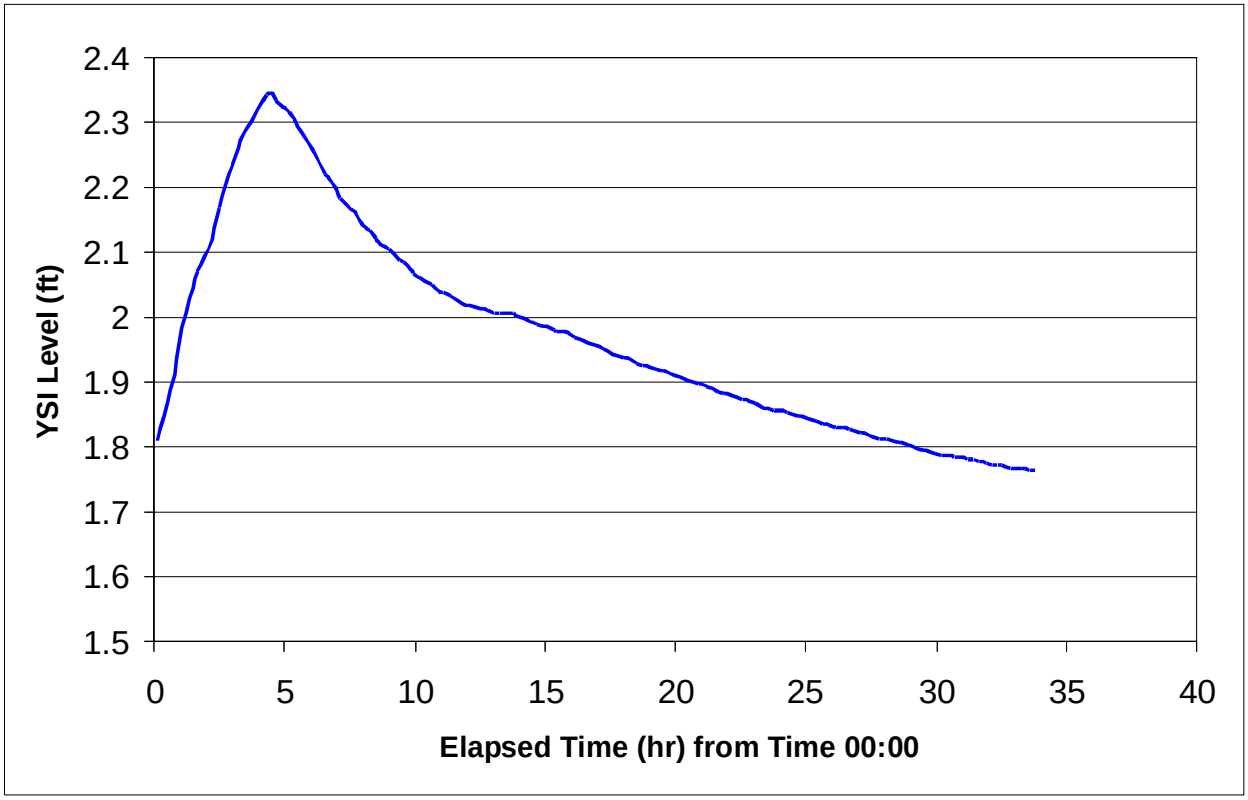
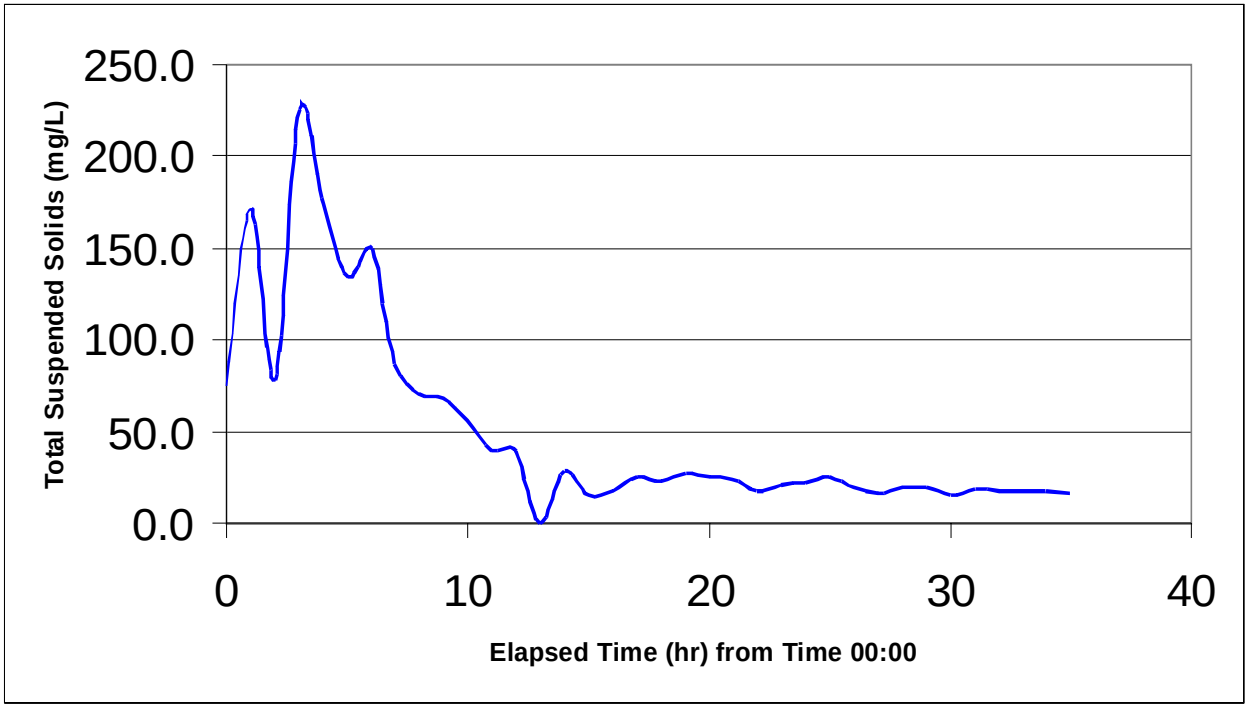


Figure 26. Comparison of Turbidity by YSI vs Stream Level at SFBR 10 Site for Storm Event on March 12, 2002



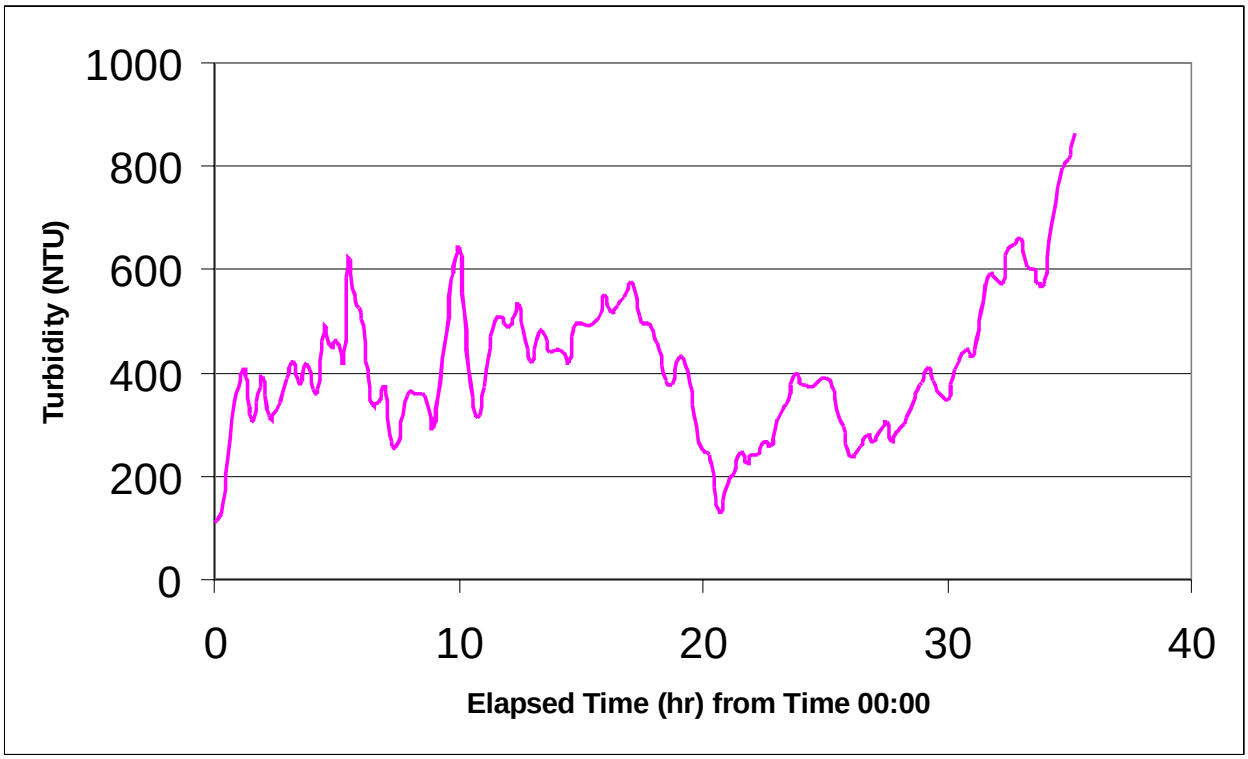


Figure 27. Comparison of TSS vs Turbidity at SFBR 10 Site for Storm Event on March 12, 2002

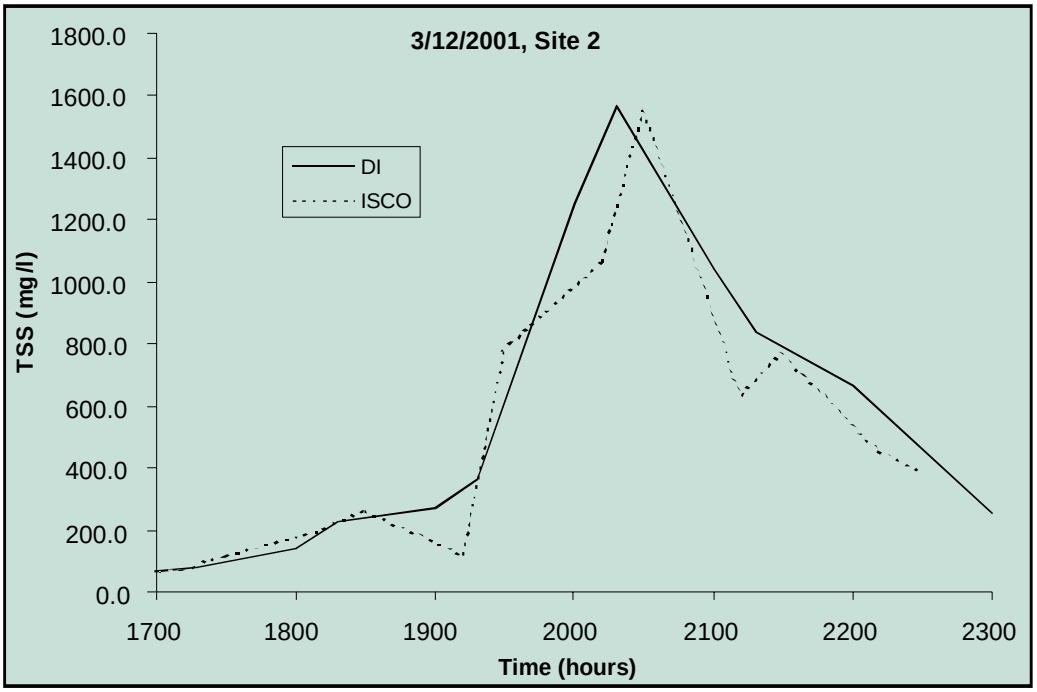


Figure 28. Comparison of Total Suspended Solid Measurements of Depth Integrated and ISCO samplers.

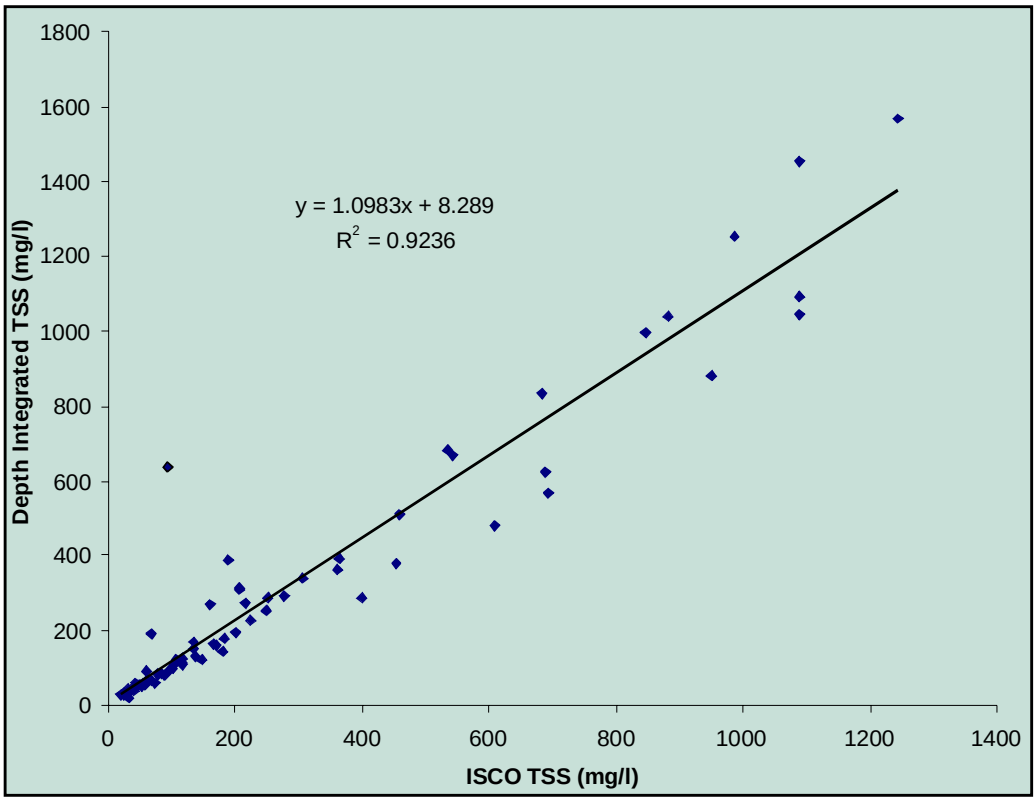


Figure 29. Estimated linear relationship between Depth Integrated and ISCO Total Suspended Solid measurements.

The R2 value of 0.94 from the Figure 31 comparison plot indicates that only about 6% of the total deviation was left unexplained by the regression relationship (which was highly significant ($F(1,143)=2154$, $p<0.0001$)). This is one way to measure the cost incurred by moving to a two-hour interval sampling regime. The 95% confidence interval on the slope (0.847,0.922) does not contain 1.0, however. This means that even though very little unexplained variation remained, the TSS values estimated by interpolation (y-values) tended to be lower than the TSS values actually measured (x-values). We do not have an explanation for this phenomenon at the moment, and more data need to be collected to investigate this relationship.

As stated previously, when sampling for TSS using the DI methodology, TSS was measured at three to five locations across the stream, and then a mean was computed. We were interested in quantifying the cross-sectional variability of these multiple TSS measures and determining any patterns existing in the variability. Figure 32 shows that the higher the mean TSS, the more variability in the TSS measures. This is a typical occurrence and presents no cause for alarm. Standardized variability, however, as measured by the coefficient of variation (the standard deviation divided by the mean) showed no relationship to the mean TSS, Figure 33.

Finally, TSS values taken in midstream were not statistically different than TSS values taken along the edges of the stream (Student's t test, $p > 0.05$). When 3 sites at a cross section were sampled, site 2 (i.e. midstream) was compared to the mean of sites 1 and 3 (i.e. edge). When 4 sites were sampled, the mean of sites 2 and 3 (i.e. midstream) was compared to the mean of sites 1 and 4 (i.e. edge). When 5 sites were sampled, the mean of sites 2, 3, and 4 (i.e. midstream) was compared to the mean of sites 1 and 5 (i.e. edge). A scatter plot showing the midstream versus edge TSS measures is shown in Figure 34.

Bedload sampling represents the composite of three to five samples taken at the stream cross section with time. Analyses include dry weight of sample, particle size distribution and LOI for each size fraction. These samples consisted of a large quantity of leaves and woody debris that were washed to remove the sediment. The debris was removed and not included in the sample analysis. These data indicate that the sediment being transported during storm events in the SFBR was primarily less than 2 mm.

About 90 of the 279 stream cross-sectional sites have been completed. Sediment core samples were collected at 6-inch depth increments and analyzed including dry weight of sample, particle size distribution and LOI for each size fraction. GPS locational data for the sampled stream cross sections are available in the database.

Slope elevation estimates are being developed for longitudinal profiles at the sampled cross-sectional sites along SFBR and at 1500 feet above and below existing bridges using bridge elevation data from the Georgia Department of Transportation as benchmarks. This field survey work is not complete. The stream slope appears to be less than one percent based on an estimate between stream channel bottom thalweg points.

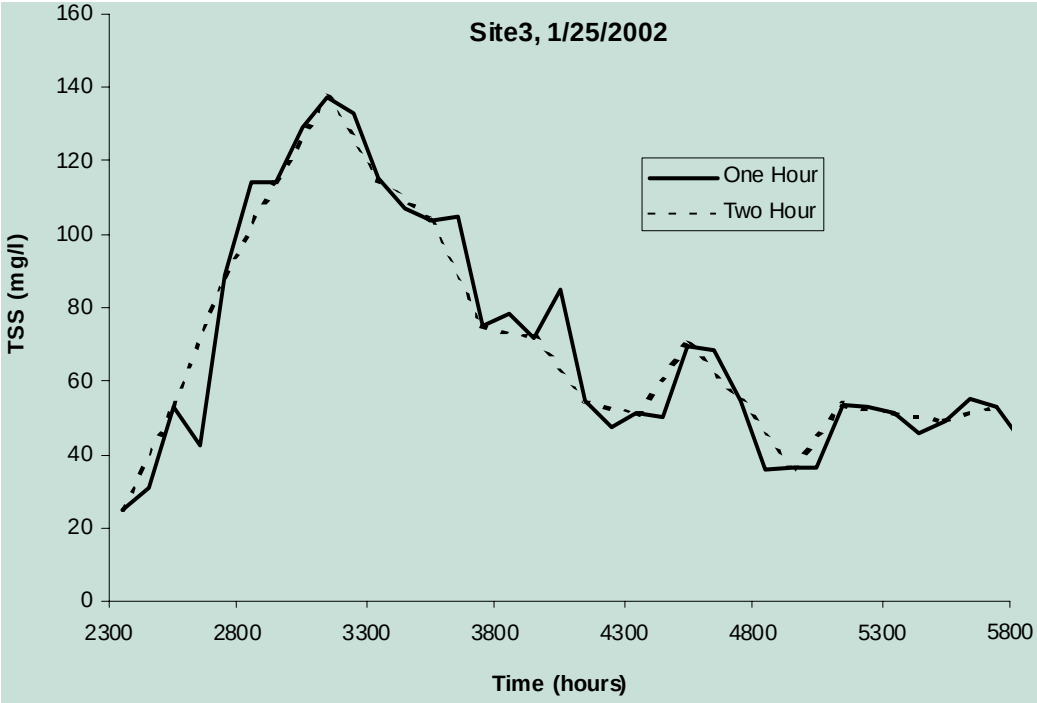


Figure 30. Comparison of one hour versus two hour ISCO Total Suspended Solid measurements.

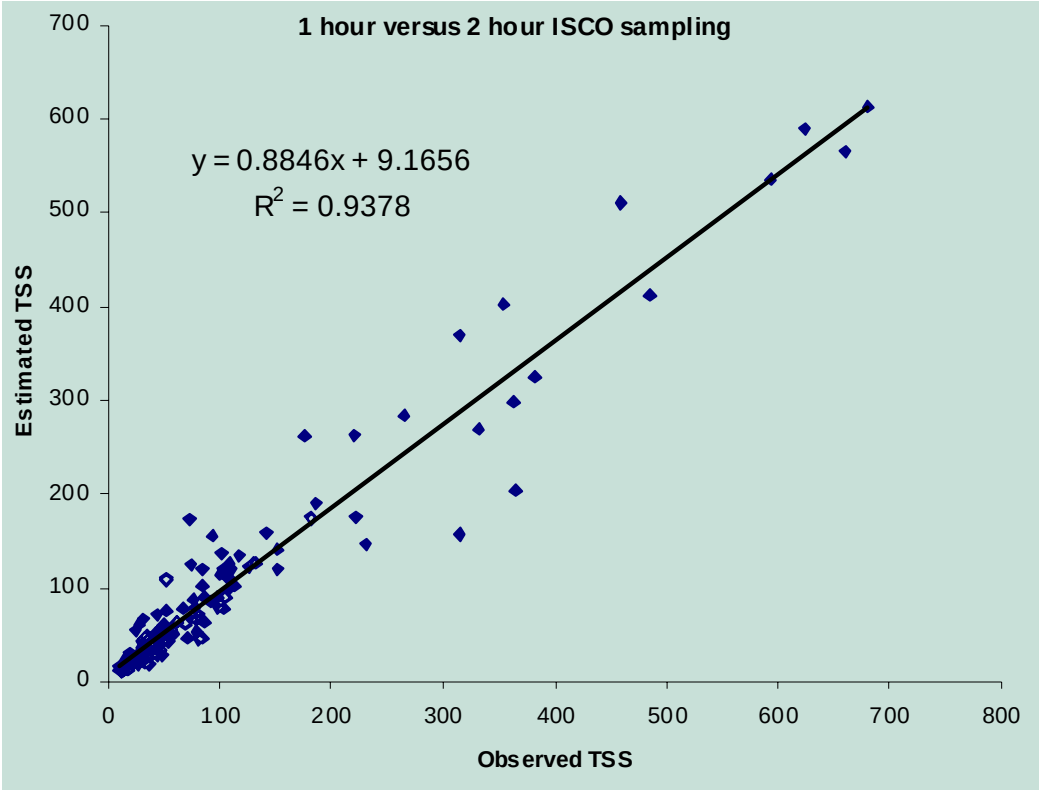


Figure 31. Linear relationship between one hour and two hour ISCO Total Suspended Solid measurements.

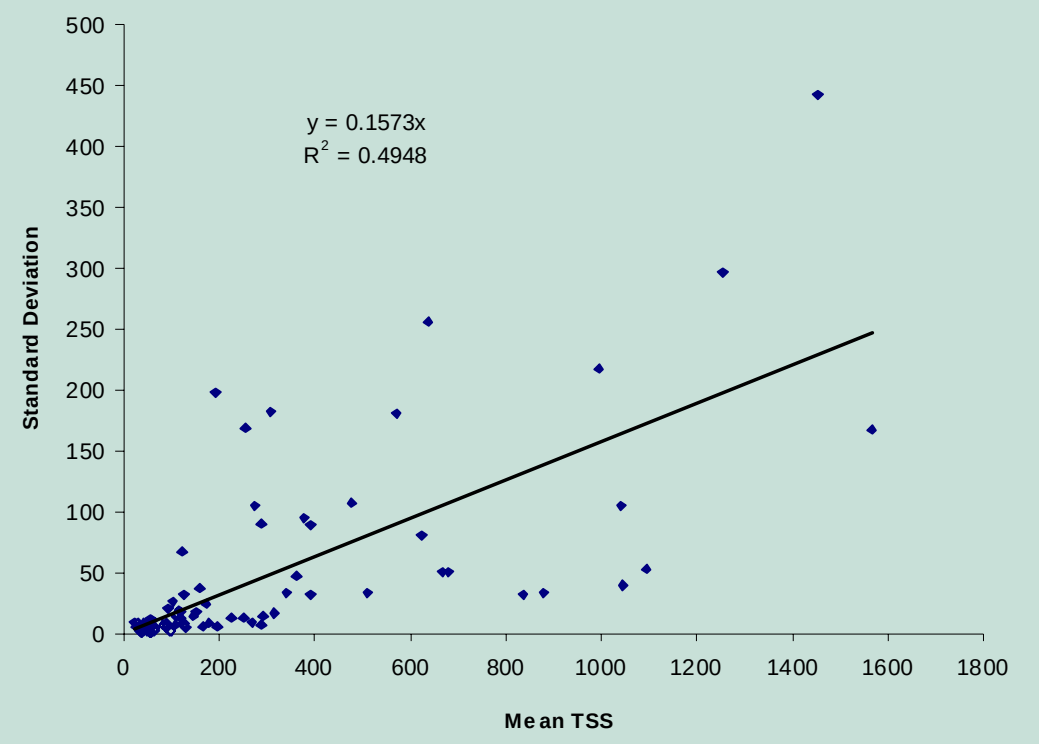


Figure 32. Relationship between the standard deviation and the mean of Depth Integrated Total Suspended Solids measurements.

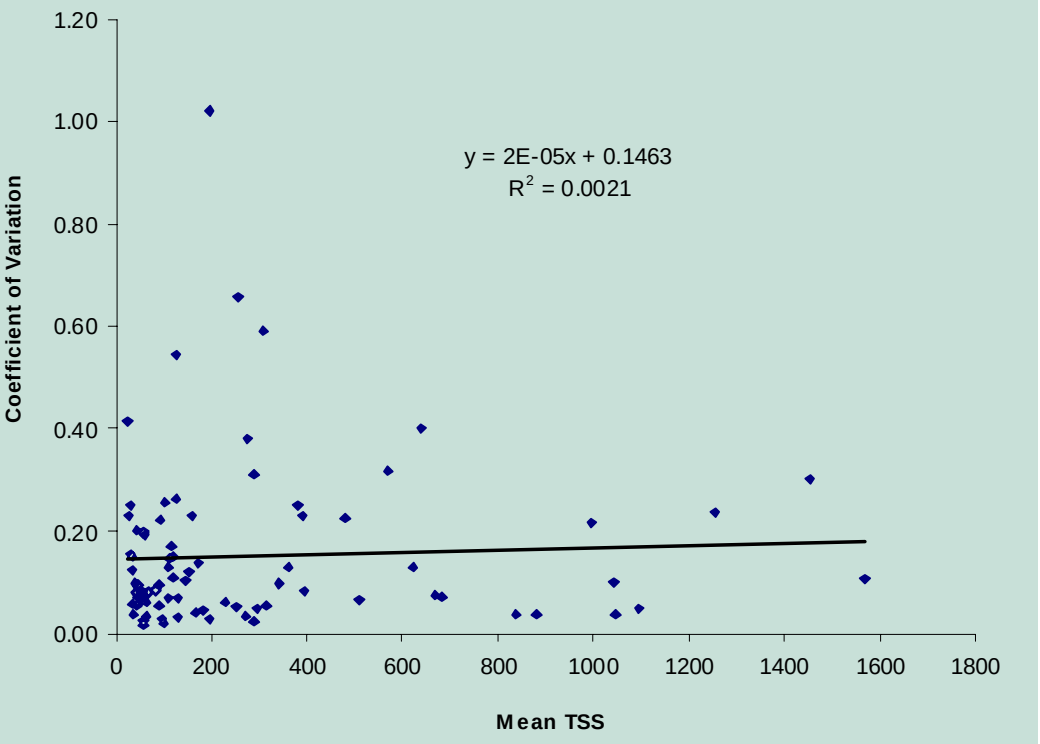


Figure 33. Relationship between the coefficient of variability and the mean of Depth Integrated Total Suspended Solids measurements.

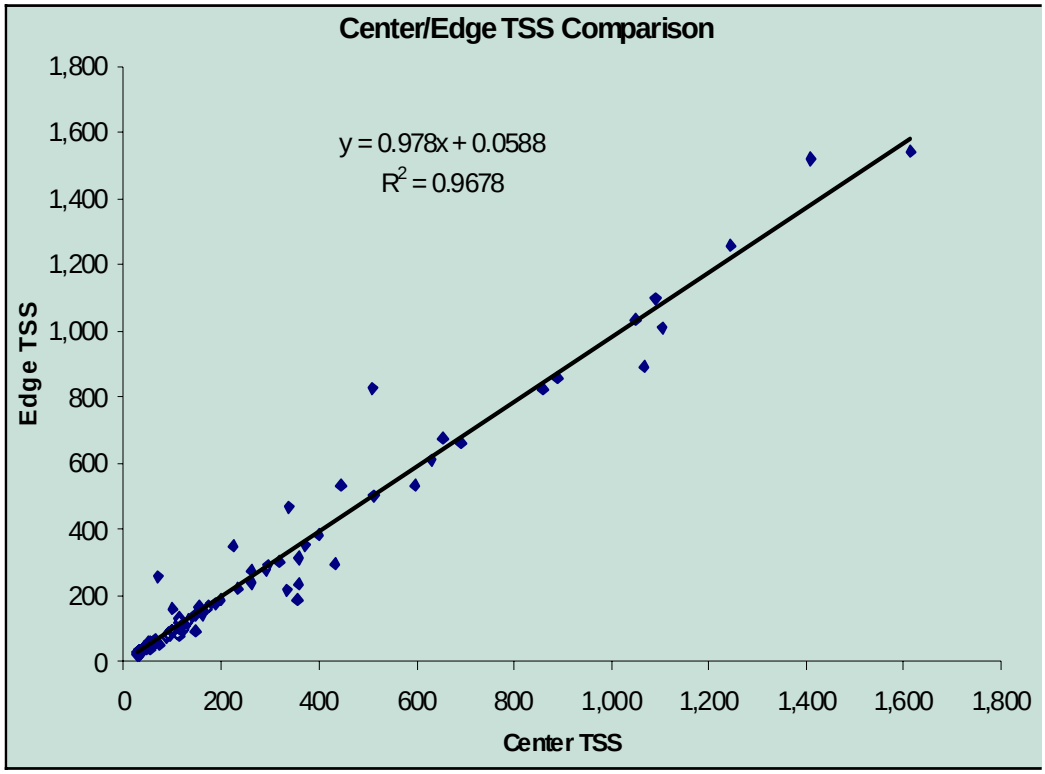


Figure 34. Relationship between Depth Integrated Total Suspended Solid measurements taken at various locations within a stream cross-section.

In support of the South Fork Broad River Watershed Project, EPA Region 4 staff conducted measurements of water current velocities at selected locations in the watershed. The purpose of these measurements was to provide an assessment of the stream velocities at varying stream stages for use in the calibration/verification of mathematical modeling of stream bed scour and sediment transport. Vertical velocity profiles were measured at designated stream sites (i.e. SFBR 10, 20, 30, 40, and 70) on February 7, 8 and 12, 2002. Rainfall of 2.2 inches was recorded at SFBR 70 site during the period of 0600 on 02/02/2002 to 1200 on 02/07/2002. This rainfall event provided an opportunity to collect stream velocities at a relatively high stage and then following stream recession, at a lower stage. Accordingly, velocity measurements were made on Feb. 7 and 8 and then after the streams receded on Feb. 12, 2002. Measurements were made by a combination of acoustical doppler velocimeters and bridge suspension apparatus coupled with Price AA current meters. Velocity profiles were made at stream quarter points along representative stream sections. All profiles proceeded from near the stream bed to near the stream surface. Typically the range of observation points was from 0.2 feet above the stream substrate to 0.2 feet below the stream surface. All measurements were accompanied by a determination of stream stage by either "tape down" from an established reference point "RP" or by existing staff gage. The attached graphs and their attendant data tables shown in Figures 20A through 20H present the results of the measurements for stream sites SFBR10, 20, 30, 40 and 70. In most cases, as presented, the profile data supported a regression fit of the velocity versus depth data.

Hydrographic data, including stage-discharge relationships, water stage records and velocity profiles, are available for each site. The water stage data includes both continuously recording USGS station (SFBR70) input as well as that from non-recording stations (SFBR10, 20, 30, 40 and 60). These data and the attendant stage-discharge relationships provide the basis for assessing stream discharge. When coupled with pollutant analytical results, pollutant loadings can then be calculated for the various sampled runoff events.

Stream contaminant loading rates were determined by matching the date/time when samples were collected by the ISCO sampler (30-minute or 1-hour increment) with the YSI multi-probe level readings at 15-minute intervals adjusted to the staff gage readings provided by the USGS. Then the contaminant loading rates were estimated by multiplying the flow in cubic feet per second (CFS), obtained from the rating curve for a particular stream site times the measured contaminant concentrations (mg/L) to obtain the loading rate in kg/hour as follows:

(ft^3/sec) (mg/L) $(28.32L/ft^3)$ (3600 sec/hr) (gm/1000mg) (kg/1000 gm) or

(ft^3/sec) (mg/L) 0.102 = kg/hr

Example contaminant loading rates, based on samples collected from ISCO samplers were calculated for TSS, nutrients and carbon for each of the 5 instream sites during a storm event that occurred on March 12, 2002, (see Tables 1, 3, 4, 5, 6, and 7). This event represents a low -runoff-yielding event due to a rainfall amount of 0.93 inches. Because of the lack of a stage-discharge rating curve for higher stages (due to the drought), contaminant loadings could not be estimated for these type events.

Table 1 provides a summary of the calculated total event loadings (kg) for each of the five sites and for each measured contaminant for the March 12, 2002 storm sampling event. Estimated TSS loadings were highest at sites SFBR 30 and 60 at 23,642 and 34,248 kg, respectively. In addition, highest loadings were calculated for ammonia, nitrate, phosphorus and total organic carbon at these two sites. As expected, lower TSS loadings were estimated at site SFBR20, which is a small tributary to the SFBR. One would expect even higher loads to occur during higher rainfall events of 2 inches or more.

Table: 1. Loadings for SFBR sites for March 12, 2002 Rain Event

Site	TSS	NH_3-N	NO^-_3-N	o-PO_4 as P	Total-P	TOC
	kg	kg	kg	kg	kg	kg
SFBR10	2179.7	2.0	19.6	1.6	2.4	168.0
SFBR20	195.9	0.7	1.9	0.3	0.4	19.8
SFBR30	23641.6	14.0	175.4	8.4	9.1	1592.7
SFBR40	2244.8	5.5	5.5	3.0	4.3	484.2
SFBR60	34248.2	8.0	118.4	6.5	18.1	1121.8

Table 3. Loading Rates for SFBR10 Rain Event on March 12, 2002

YSI Data				ISCO Data from SFBR10											
Date/Time	Level	Stage	Flow	Sample#	Sample ID	Date	Time		TSS	TSS	NH_3-N	NH_3-N	NO^-_3-N	NO^-_3-N	o-PO_4 as P
	(ft)	(ft)	(cfs)				(24hr)		mg/l	kg/hr	mg/l	kg/hr	mg/l	kg/hr	mg/l
3/12/2002 21:30	1.784	20.924	9.02	1	1IsA0312022136	3/12/2002	2136		74.8	68.8	0.09	0.08	0.54	0.50	0.06
3/12/2002 22:30	1.968	21.108	10.70	2	1IsA0312022236	3/12/2002	2236		172.2	187.9	0.12	0.13	0.49	0.53	0.08
3/12/2002 23:30	2.095	21.235	11.80	3	1IsA0312022336	3/12/2002	2336		78.2	94.1	0.13	0.16	0.47	0.57	0.10
3/13/2002 0:30	2.231	21.371	13.11	4	1IsA0313020036	3/13/2002	0036		226.2	302.5	0.12	0.16	0.49	0.66	0.09
3/13/2002 1:30	2.317	21.457	13.87	5	1IsA0313020136	3/13/2002	0136		174.4	246.7	0.12	0.17	0.51	0.72	0.10
3/13/2002 2:30	2.324	21.464	13.94	6	1IsA0313020236	3/13/2002	0236		134.2	190.8	0.11	0.16	0.57	0.81	0.07
3/13/2002 3:30	2.268	21.408	13.38	7	1IsA0313020336	3/13/2002	0336		149.8	204.4	0.11	0.15	0.57	0.78	0.07
3/13/2002 4:30	2.199	21.339	12.78	8	1IsA0313020436	3/13/2002	0436		87.4	113.9	0.10	0.13	0.57	0.74	0.06
3/13/2002 5:30	2.147	21.287	12.26	9	1IsA0313020536	3/13/2002	0536		70.8	88.5	0.10	0.13	0.58	0.73	0.05
3/13/2002 6:30	2.099	21.239	11.88	10	1IsA0313020636	3/13/2002	0636		68.4	82.9	0.10	0.12	0.60	0.73	0.05
3/13/2002 7:30	2.066	21.206	11.55	11	1IsA0313020736	3/13/2002	0736		56.4	66.4	0.09	0.11	0.57	0.67	0.05
3/13/2002 8:30	2.036	21.176	11.25	12	1IsA0313020836	3/13/2002	0836		39.6	45.4	0.08	0.09	0.56	0.64	0.04
3/13/2002 9:30	2.013	21.153	11.03	13	1IsA0313020936	3/13/2002	0936		39.2	44.1	0.08	0.09	0.54	0.61	0.05
3/13/2002 10:30	1.996	21.136	10.85	14	1IsA0313021036	3/13/2002	1036		0.0	0.0	0.03	0.03	0.53	0.59	0.03
3/13/2002 11:30	1.990	21.130	10.80	15	1IsA0313021136	3/13/2002	1136		28.6	31.5	0.02	0.02	0.53	0.58	0.03
3/13/2002 12:30	1.976	21.116	10.75	16	1IsA0313021236	3/13/2002	1236		15.6	17.1	0.01	0.01	0.52	0.57	0.03
3/13/2002 13:30	1.961	21.101	10.61	17	1IsA0313021336	3/13/2002	1336		17.2	18.6	0.01	0.01	0.52	0.56	0.02
3/13/2002 14:30	1.947	21.087	10.46	18	1IsA0313021436	3/13/2002	1436		25.2	26.9	0.01	0.01	0.50	0.53	0.03
3/13/2002 15:30	1.929	21.069	10.28	19	1IsA0313021536	3/13/2002	1536		22.6	23.7	0.00	0.00	0.50	0.52	0.02
3/13/2002 16:30	1.915	21.055	10.15	20	1IsA0313021636	3/13/2002	1636		27.0	28.0	0.00	0.00	0.49	0.51	0.03
3/13/2002 17:30	1.900	21.040	10.00	21	1IsA0313021736	3/13/2002	1736		25.6	26.1	0.00	0.00	0.49	0.50	0.02
3/13/2002 18:30	1.887	21.027	9.92	22	1IsA0313021836	3/13/2002	1836		23.8	24.1	0.00	0.00	0.48	0.49	0.02
3/13/2002 19:30	1.872	21.012	9.79	23	1IsA0313021936	3/13/2002	1936		17.4	17.4	0.00	0.00	0.47	0.47	0.02
3/13/2002 20:30	1.858	20.998	9.67	24	1IsA0313022036	3/13/2002	2036		21.0	20.7	0.01	0.01	0.47	0.46	0.02
3/13/2002 21:30	1.844	20.984	9.54	25	1IsA0313022136	3/13/2002	2136		21.6	21.0	0.01	0.01	0.47	0.46	0.02
3/13/2002 22:30	1.833	20.973	9.45	26	1IsA0313022236	3/13/2002	2236		25.6	24.7	0.01	0.01	0.47	0.45	0.02
3/13/2002 23:30	1.822	20.962	9.36	27	1IsA0313022336	3/13/2002	2336		20.0	19.1	0.02	0.02	0.47	0.45	0.02
3/14/2002 0:30	1.808	20.948	9.24	28	1IsA0314020036	3/14/2002	0036		16.2	15.3	0.01	0.01	0.46	0.43	0.02
3/14/2002 1:30	1.801	20.941	9.18	29	1IsA0314020136	3/14/2002	0136		19.4	18.2	0.01	0.01	0.46	0.43	0.02
3/14/2002 2:30	1.789	20.929	9.07	30	1IsA0314020236	3/14/2002	0236		19.6	18.1	0.02	0.02	0.46	0.43	0.02
3/14/2002 3:30	1.779	20.919	8.99	31	1IsA0314020336	3/14/2002	0336		15.6	14.3	0.01	0.01	0.46	0.42	0.02
3/14/2002 4:30	1.767	20.907	8.88	32	1IsA0314020436	3/14/2002	0436		18.2	16.5	0.02	0.02	0.46	0.42	0.02
3/14/2002 5:30	1.758	20.898	8.81	33	1IsA0314020536	3/14/2002	0536		17.4	15.6	0.01	0.01	0.46	0.41	0.02
3/14/2002 6:30	1.750	20.890	8.74	34	1IsA0314020636	3/14/2002	0636		17.2	15.3	0.03	0.03	0.47	0.42	0.02
3/14/2002 7:30	1.742	20.882	8.67	35	1IsA0314020736	3/14/2002	0736		18.0	15.9	0.03	0.03	0.47	0.42	0.02
3/14/2002 8:30	1.736	20.876	8.62	36	1IsA0314020836	3/14/2002	0836		17.0	14.9	0.03	0.03	0.47	0.41	0.02

Table 4. Loading Rates for SFBR20 Rain Event on March 12, 2002

YSI Data				ISCO Data from SFBR20											
Date/Time	Level	Stage	Flow	Sample#	Sample ID	Date	Time		TSS	TSS	NH_3-N	NH_3-N	NO^-_3-N	NO^-_3-N	o-PO_4 as P
	(ft)	(ft)	(cfs)				(24hr)		mg/l	kg/hr	mg/l	kg/hr	mg/l	kg/hr	mg/l
3/12/2002 22:00	0.98	21.004	0.85	1	2IsB0312022157	3/12/2002	2157		53.0	4.6	0.08	0.01	0.32	0.03	0.03
3/12/2002 23:00	1.114	21.138	2.49	2	2IsB0312022257	3/12/2002	2257		90.0	22.9	0.09	0.02	0.33	0.08	0.03
3/13/2002	1.231	21.255	4.59	3	2IsB0312022357	3/12/2002	2357		75.4	35.3	0.09	0.04	0.32	0.15	0.03
3/13/2002 1:00	1.301	21.325	5.88	4	2IsB0313020057	3/13/2002	0057		69.0	41.4	0.08	0.05	0.30	0.18	0.02
3/13/2002 2:00	1.344	21.368	7.08	5	2IsB0313020157	3/13/2002	0157		59.0	42.6	0.08	0.06	0.33	0.24	0.03
3/13/2002 3:00	1.266	21.290	5.21	6	2IsB0313020257	3/13/2002	0257		66.2	35.2	0.15	0.08	0.40	0.21	0.06
3/13/2002 4:00	1.186	21.210	3.63	7	2IsB0313020357	3/13/2002	0357		no data	no data	0.26	0.10	0.56	0.21	0.01
3/13/2002 5:00	1.161	21.185	3.12	8	2IsB0313020457	3/13/2002	0457		no data	no data	0.34	0.11	0.69	0.22	0.19
3/13/2002 6:00	1.115	21.139	2.49	9	2IsB0313020557	3/13/2002	0557		no data	no data	0.34	0.09	0.71	0.18	0.18
3/13/2002 7:00	1.067	21.091	1.80	10	2IsB0313020657	3/13/2002	0657		no data	no data	0.30	0.06	0.65	0.12	0.15
3/13/2002 8:00	1.03	21.054	1.34	11	2IsB0313020757	3/13/2002	0757		37.8	5.2	0.25	0.03	0.61	0.08	0.11
3/13/2002 9:00	1.001	21.025	1.03	12	2IsB0313020857	3/13/2002	0857		30.6	3.2	0.21	0.02	0.58	0.06	0.11
3/13/2002 10:00	0.98	21.004	0.85	13	2IsB0313020957	3/13/2002	0957		25.2	2.2	0.19	0.02	0.56	0.05	0.08
3/13/2002 11:00	0.96	20.984	0.57	14	2IsB0313021057	3/13/2002	1057		24.8	1.4	0.16	0.01	0.55	0.03	0.06
3/13/2002 12:00	0.942	20.966	0.46	15	2IsB0313021157	3/13/2002	1157		13.0	0.6	0.05	0.00	0.57	0.03	0.04
3/13/2002 13:00	0.929	20.953	0.29	16	2IsB0313021257	3/13/2002	1257		10.2	0.3	0.04	0.00	0.59	0.02	0.04
3/13/2002 14:00	0.915	20.939	0.22	17	2IsB0313021357	3/13/2002	1357		15.2	0.3	0.03	0.00	0.58	0.01	0.04
3/13/2002 15:00	0.904	20.928	0.17	18	2IsB0313021457	3/13/2002	1457		15.8	0.3	0.02	0.00	0.59	0.01	0.04
3/13/2002 16:00	0.894	20.918	0.12	19	2IsB0313021557	3/13/2002	1557		9.4	0.1	0.02	0.00	0.59	0.01	0.03
3/13/2002 17:00	0.883	20.907	0.09	20	2IsB0313021657	3/13/2002	1657		10.0	0.1	0.00	0.00	0.61	0.01	0.03
3/13/2002 18:00	0.873	20.897	0.06	21	2IsB0313021757	3/13/2002	1757		11.0	0.1	0.01	0.00	0.61	0.00	0.03
3/13/2002 19:00	0.865	20.889	0.04	22	2IsB0313021857	3/13/2002	1857		11.8	0.1	0.01	0.00	0.59	0.00	0.03
3/13/2002 20:00	0.857	20.881	0.03	23	2IsB0313021957	3/13/2002	1957		15.2	0.0	0.00	0.00	0.60	0.00	0.03
3/13/2002 21:00	0.85	20.874	0.02	24	2IsB0313022057	3/13/2002	2057		1.6	0.0	0.01	0.00	0.60	0.00	0.03
3/13/2002 22:00	0.844	20.868	0.02	25	2IsB0313022157	3/13/2002	2157		11.0	0.0	0.02	0.00	0.59	0.00	0.03
3/13/2002 23:00	0.838	20.862	0.01	26	2IsB0313022257	3/13/2002	2257		9.2	0.0	0.02	0.00	0.59	0.00	0.03
3/14/2002	0.831	20.855	0.01	27	2IsB0313022357	3/13/2002	2357		9.2	0.0	0.02	0.00	0.57	0.00	0.03
3/14/2002 1:00	0.827	20.851		28	2IsB0314020057	3/14/2002	0057		10.4		0.02		0.58		0.03
3/14/2002 2:00	0.822	20.846		29	2IsB0314020157	3/14/2002	0157		10.8		0.04		0.57		0.04
3/14/2002 3:00	0.818	20.842		30	2IsB0314020257	3/14/2002	0257		6.0		0.03		0.56		0.03
3/14/2002 4:00	0.821	20.845		31	2IsB0314020357	3/14/2002	0357		8.4		0.04		0.55		0.03
3/14/2002 5:00	0.817	20.841		32	2IsB0314020457	3/14/2002	0457		9.2		0.05		0.55		0.03
3/14/2002 6:00	0.808	20.832		33	2IsB0314020557	3/14/2002	0557		9.2		0.03		0.54		0.03
3/14/2002 7:00	0.808	20.832		34	2IsB0314020657	3/14/2002	0657		7.8		0.04		0.54		0.03
3/14/2002 8:00	0.803	20.827		35	2IsB0314020757	3/14/2002	0757		9.2		0.03		0.54		0.03
3/14/2002 9:00	0.797	20.821		36	2IsB0314020857	3/14/2002	0857		6.4		0.03		0.53		0.03
3/14/2002 10:00	0.792	20.816		37	2IsB0314020957	3/14/2002	0957		6.8		0.02		0.53		0.03

Table 5. Loading Rates for SFBR30 Rain Event on March 12, 2002

YSI Data				ISCO Data from											
Date/Time	Level	Stage	Flow	Sample#	Sample ID	Date	Time		TSS	TSS	NH_3-N	NH_3-N	NO^-_3-N	NO^-_3-N	o-PO_4 as P
	(ft)	(ft)	(cfs)				(24hr)		mg/l	kg/hr	mg/l	kg/hr	mg/l	kg/hr	mg/l
3/12/2002 21:15	2.878	34.814	53.9	1	3IsA0312022122	3/12/2002	2122		16.0	88.0	0.04	0.2	0.35	1.9	0.02
3/12/2002 22:15	3.001	34.937	64.0	2	3IsA0312022222	3/12/2002	2222		37.8	246.8	0.04	0.3	0.42	2.7	0.02
3/12/2002 23:15	3.117	35.053	73.8	3	3IsA0312022322	3/12/2002	2322		58.0	436.6	0.05	0.4	0.35	2.6	0.02
3/13/2002 0:15	3.326	35.262	95.6	4	3IsA0313020022	3/13/2002	022		78.4	764.5	0.05	0.5	0.33	3.2	no data
3/13/2002 1:15	3.477	35.413	112.9	5	3IsA0313020122	3/13/2002	0122		72.6	836.0	0.04	0.5	0.36	4.1	0.02
3/13/2002 2:15	3.693	35.629	141.0	6	3IsA0313020222	3/13/2002	0222		84.8	1219.6	0.05	0.7	0.37	5.3	0.03
3/13/2002 3:15	3.76	35.696	150.6	7	3IsA0313020322	3/13/2002	0322		131.6	2021.5	0.06	0.9	0.37	5.7	0.03
3/13/2002 4:15	3.811	35.747	157.7	8	3IsA0313020422	3/13/2002	0422		151.2	2432.1	0.06	1.0	0.34	5.5	0.03
3/13/2002 5:15	3.841	35.777	162.0	9	3IsA0313020522	3/13/2002	0522		108.6	1794.5	0.06	1.0	0.37	6.1	0.03
3/13/2002 6:15	3.826	35.762	159.1	10	3IsA0313020622	3/13/2002	0622		76.2	1236.6	0.05	0.8	0.37	6.0	0.02
3/13/2002 7:15	3.786	35.722	153.5	11	3IsA0313020722	3/13/2002	0722		65.8	1030.2	0.06	0.9	0.35	5.5	0.02
3/13/2002 8:15	3.748	35.684	147.9	12	3IsA0313020822	3/13/2002	0822		60.2	908.2	0.05	0.8	0.33	5.0	0.03
3/13/2002 9:15	3.726	35.662	145.1	13	3IsA0313020922	3/13/2002	0922		58.8	870.3	0.05	0.7	0.33	4.9	0.02
3/13/2002 10:15	3.715	35.651	143.8	14	3IsA0313021022	3/13/2002	1022		51.4	753.9	0.15	2.2	0.35	5.1	0.02
3/13/2002 11:15	3.704	35.640	142.4	15	3IsA0313021122	3/13/2002	1122		47.8	694.3	0.06	0.9	0.35	5.1	0.02
3/13/2002 12:15	3.689	35.625	139.7	16	3IsA0313021222	3/13/2002	1222		80.8	1151.4	0.06	0.9	0.37	5.3	0.02
3/13/2002 13:15	3.679	35.615	139.7	17	3IsA0313021322	3/13/2002	1322		41.0	584.2	0.00	0.0	0.38	5.4	0.02
3/13/2002 14:15	3.667	35.603	137.0	18	3IsA0313021422	3/13/2002	1422		42.2	589.7	0.00	0.0	0.38	5.3	0.02
3/13/2002 15:15	3.649	35.585	147.9	19	3IsA0313021522	3/13/2002	1522		27.4	413.4	0.00	0.0	0.38	5.7	0.02
3/13/2002 16:15	3.626	35.562	131.7	20	3IsA0313021622	3/13/2002	1622		36.0	483.6	0.00	0.0	0.38	5.1	0.02
3/13/2002 17:15	3.605	35.541	129.2	21	3IsA0313021722	3/13/2002	1722		34.2	450.7	0.01	0.1	0.39	5.1	0.02
3/13/2002 18:15	3.585	35.521	126.6	22	3IsA0313021822	3/13/2002	1822		34.2	441.6	0.00	0.0	0.39	5.0	0.02
3/13/2002 19:15	3.56	35.496	124.0	23	3IsA0313021922	3/13/2002	1922		30.8	389.6	0.01	0.1	0.39	4.9	0.02
3/13/2002 20:15	3.541	35.477	121.5	24	3IsA0313022022	3/13/2002	2022		29.8	369.3	0.01	0.1	0.39	4.8	0.01
3/13/2002 21:15	3.522	35.458	119.0	25	3IsA0313022122	3/13/2002	2122		30.6	371.4	0.00	0.0	0.38	4.6	0.01
3/13/2002 22:15	3.501	35.437	116.6	26	3IsA0313022222	3/13/2002	2222		26.8	318.7	0.00	0.0	0.38	4.5	0.01
3/13/2002 23:15	3.48	35.416	114.1	27	3IsA0313022322	3/13/2002	2322		25.4	295.6	0.00	0.0	0.38	4.4	0.01
3/14/2002 0:15	3.46	35.396	111.7	28	3IsA0314020022	3/14/2002	0022		22.0	250.7	0.01	0.1	0.38	4.3	0.01
3/14/2002 1:15	3.44	35.376	109.3	29	3IsA0314020122	3/14/2002	0122		23.6	263.1	0.00	0.0	0.37	4.1	0.01
3/14/2002 2:15	3.422	35.358	107.0	30	3IsA0314020222	3/14/2002	0222		13.6	148.4	0.01	0.1	0.38	4.1	0.01
3/14/2002 3:15	3.405	35.341	104.7	31	3IsA0314020322	3/14/2002	0322		22.4	239.2	0.01	0.1	0.37	4.0	0.01
3/14/2002 4:15	3.389	35.325	103.5	32	3IsA0314020422	3/14/2002	0422		20.8	219.6	0.01	0.1	0.38	4.0	0.01
3/14/2002 5:15	3.374	35.310	101.2	33	3IsA0314020522	3/14/2002	0522		20.6	212.6	0.02	0.2	0.38	3.9	0.01
3/14/2002 6:15	3.355	35.291	98.9	34	3IsA0314020622	3/14/2002	0622		26.6	268.3	0.01	0.1	0.37	3.7	0.01
3/14/2002 7:15	3.342	35.278	97.8	35	3IsA0314020722	3/14/2002	0722		15.6	155.6	0.01	0.1	0.37	3.7	0.01
3/14/2002 8:15	3.325	35.261	95.6	36	3IsA0314020822	3/14/2002	0822		19.6	191.1	0.01	0.1	0.38	3.7	0.01
3/14/2002 9:15	3.31	35.246	94.5	37	3IsA0314020922	3/14/2002	0922		18.1	174.8	0.01	0.1	0.37	3.6	0.01
3/14/2002 10:15	3.295	35.231	92.3	38	3IsA0314021022	3/14/2002	1022		18.4	173.2	0.00	0.0	0.38	3.6	0.01
3/14/2002 11:15	3.284	35.220	91.2	39	3IsA0314021122	3/14/2002	1122		16.4	152.6	0.00	0.0	0.37	3.4	0.01

Table 6. Loading Rates for SFBR40 Rain Event on March 12, 2002

YSI Data				ISCO Data from											
Date/Time	Level	Stage	Flow	Sample#	Sample ID	Date	Time		TSS	TSS	NH_3-N	NH_3-N	NO^-_3-N	NO^-_3-N	o-PO_4 as P
	(ft)	(ft)	(cfs)				(24hr)		mg/l	kg/hr	mg/l	kg/hr	mg/l	kg/hr	mg/l
3/12/2002 21:30	2.029	11.455	29.6	1	4IsA0312022132	3/12/2002	2132		693.0	2092.3	0.05	0.2	0.05	0.2	0.04
3/12/2002 22:30	2.211	11.637	41.1	2	4IsA0312022232	3/12/2002	2232		154.8	649.0	0.04	0.2	0.04	0.2	0.02
3/12/2002 23:30	2.394	11.820	54.4	3	4IsA0312022332	3/12/2002	2332		135.6	752.4	0.04	0.2	0.04	0.2	0.02
3/13/2002 0:30	2.377	11.803	52.9	4	4IsA0313020033	3/13/2002	0033		153.2	826.6	0.05	0.3	0.05	0.3	0.03
3/13/2002 1:30	2.431	11.857	57.7	5	4IsA0313020133	3/13/2002	0133		330.8	1946.9	0.05	0.3	0.05	0.3	0.04
3/13/2002 2:30	2.435	11.861	57.7	6	4IsA0313020233	3/13/2002	0233		129.4	761.6	0.05	0.3	0.05	0.3	0.03
3/13/2002 3:30	2.448	11.874	58.5	7	4IsA0313020333	3/13/2002	0333		68.8	410.5	0.04	0.2	0.04	0.2	0.02
3/13/2002 4:30	2.426	11.852	56.9	8	4IsA0313020433	3/13/2002	0433		52.8	306.4	0.05	0.3	0.05	0.3	0.02
3/13/2002 5:30	2.416	11.842	56.1	9	4IsA0313020533	3/13/2002	0533		43.4	248.3	0.04	0.2	0.04	0.2	0.02
3/13/2002 6:30	2.424	11.850	56.9	10	4IsA0313020633	3/13/2002	0633		41.2	239.1	0.04	0.2	0.04	0.2	0.02
3/13/2002 7:30	2.435	11.861	57.7	11	4IsA0313020733	3/13/2002	0733		36.8	216.6	0.04	0.2	0.04	0.2	0.02
3/13/2002 8:30	2.448	11.874	58.5	12	4IsA0313020833	3/13/2002	0833		36.6	218.4	0.04	0.2	0.04	0.2	0.02
3/13/2002 9:30	2.46	11.886	60.2	13	4IsA0313020933	3/13/2002	0933		32.0	196.5	0.04	0.2	0.04	0.2	0.01
3/13/2002 10:30	2.469	11.895	61.0	14	4IsA0313021033	3/13/2002	1033		31.2	194.1	0.03	0.2	0.03	0.2	0.01
3/13/2002 11:30	2.475	11.901	61.0	15	4IsA0313021133	3/13/2002	1133		17.2	107.0	0.02	0.1	0.02	0.1	0.01
3/13/2002 12:30	2.475	11.901	61.0	16	4IsA0313021233	3/13/2002	1233		22.2	138.1	0.01	0.1	0.01	0.1	no data
3/13/2002 13:30	2.47	11.896	61.0	17	4IsA0313021333	3/13/2002	1333		13.8	85.9	0.02	0.1	0.02	0.1	0.01
3/13/2002 14:30	2.462	11.888	60.2	18	4IsA0313021433	3/13/2002	1433		10.0	61.4	0.01	0.1	0.01	0.1	0.01
3/13/2002 15:30	2.454	11.880	59.3	19	4IsA0313021533	3/13/2002	1533		18.6	112.5	0.02	0.1	0.02	0.1	0.01
3/13/2002 16:30	2.443	11.869	58.5	20	4IsA0313021633	3/13/2002	1633		18.6	111.0	0.01	0.1	0.01	0.1	0.01
3/13/2002 17:30	2.431	11.857	57.7	21	4IsA0313021733	3/13/2002	1733		8.2	48.3	0.01	0.1	0.01	0.1	0.01
3/13/2002 18:30	2.418	11.844	56.1	22	4IsA0313021833	3/13/2002	1833		14.2	81.3	0.01	0.1	0.01	0.1	0.01
3/13/2002 19:30	2.405	11.831	55.2	23	4IsA0313021933	3/13/2002	1933		15.6	87.8	0.02	0.1	0.02	0.1	0.01
3/13/2002 20:30	2.39	11.816	54.4	24	4IsA0313022033	3/13/2002	2033		7.0	38.8	0.01	0.1	0.01	0.1	0.01
3/13/2002 21:30	2.376	11.802	52.9	25	4IsA0313022133	3/13/2002	2133		11.6	62.6	0.00	0.0	0.00	0.0	0.01
3/13/2002 22:30	2.364	11.790	52.1	26	4IsA0313022233	3/13/2002	2233		13.8	73.3	0.02	0.1	0.02	0.1	0.01
3/13/2002 23:30	2.347	11.773	50.5	27	4IsA0313022333	3/13/2002	2333		14.6	75.2	0.02	0.1	0.02	0.1	0.01
3/14/2002 0:30	2.335	11.761	49.8	28	4IsA0314020033	3/14/2002	0033		14.4	73.1	0.02	0.1	0.02	0.1	0.01
3/14/2002 1:30	2.322	11.748	49.0	29	4IsA0314020133	3/14/2002	0133		14.2	71.0	0.03	0.1	0.03	0.1	0.01
3/14/2002 2:30	2.31	11.736	48.3	30	4IsA0314020233	3/14/2002	0233		12.0	59.1	0.03	0.1	0.03	0.1	0.01
3/14/2002 3:30	2.298	11.724	46.8	31	4IsA0314020333	3/14/2002	0333		9.8	46.8	no data	no data	no data	no data	0.01
3/14/2002 4:30	2.285	11.711	46.0	32	4IsA0314020433	3/14/2002	0433		14.6	68.5	0.02	0.1	0.02	0.1	0.01
3/14/2002 5:30	2.272	11.698	45.3	33	4IsA0314020533	3/14/2002	0533		9.4	43.4	0.00	0.0	0.00	0.0	0.02
3/14/2002 6:30	2.259	11.685	43.9	34	4IsA0314020633	3/14/2002	0633		13.6	60.9	0.02	0.1	0.02	0.1	0.01
3/14/2002 7:30	2.248	11.674	43.2	35	4IsA0314020733	3/14/2002	0733		8.8	38.8	0.03	0.1	0.03	0.1	0.01
3/14/2002 8:30	2.237	11.663	42.5	36	4IsA0314020833	3/14/2002	0833		9.6	41.6	0.03	0.1	0.03	0.1	0.01
3/14/2002 9:30	2.227	11.653	41.8	37	4IsA0314020933	3/14/2002	0933		5.8	24.7	0.03	0.1	0.03	0.1	0.01
3/14/2002 10:30	2.215	11.641	41.1	38	4IsA0314021033	3/14/2002	1033		7.6	31.9	0.03	0.1	0.03	0.1	0.01

Table 7. Loading Rates for SFBR60 Rain Event on March 12, 2002

YSI Data				ISCO Data from											
Date/Time	Level	Stage	Flow	Sample#	Sample ID	Date	Time		TSS	TSS	NH_3-N	NH_3-N	NO^-_3-N	NO^-_3-N	o-PO_4 as P
	(ft)	(ft)	(cfs)				(24hr)		mg/l	kg/hr	mg/l	kg/hr	mg/l	kg/hr	mg/l
3/12/2002 22:15	2.502	33.620	35.3	1	6IsA0312022220	3/12/2002	2220		34.8	125.3	0.03	0.1	0.34	1.2	0.01
3/12/2002 23:15	2.518	33.636	36.0	2	6IsA0312022320	3/12/2002	2320		31.0	113.8	0.03	0.1	0.38	1.4	0.01
3/13/2002 0:15	2.542	33.660	36.7	3	6IsA0313020020	3/13/2002	0020		32.6	122.0	0.03	0.1	0.33	1.2	0.04
3/13/2002 1:15	2.598	33.716	38.9	4	6IsA0313020120	3/13/2002	0120		43.6	173.0	0.04	0.2	0.35	1.4	0.05
3/13/2002 2:15	2.73	33.848	48.2	5	6IsA0313020220	3/13/2002	0220		80.0	393.3	0.03	0.1	0.36	1.8	0.02
3/13/2002 3:15	3.073	34.191	58.8	6	6IsA0313020320	3/13/2002	0320		176.0	1055.6	0.03	0.2	0.32	1.9	0.01
3/13/2002 4:15	3.447	34.565	76.9	7	6IsA0313020420	3/13/2002	0420		318.4	2497.5	0.04	0.3	0.37	2.9	0.02
3/13/2002 5:15	3.666	34.784	88.6	8	6IsA0313020520	3/13/2002	0520		484.6	4379.4	0.07	0.6	0.44	4.0	0.03
3/13/2002 6:15	3.775	34.893	94.7	9	6IsA0313020620	3/13/2002	0620		401.0	3873.4	0.06	0.6	0.45	4.3	0.03
3/13/2002 7:15	3.814	34.932	97.0	10	6IsA0313020720	3/13/2002	0720		247.2	2445.8	0.07	0.7	0.47	4.7	0.03
3/13/2002 8:15	3.817	34.935	97.5	11	6IsA0313020820	3/13/2002	0820		265.8	2643.4	0.08	0.8	0.49	4.9	0.04
3/13/2002 9:15	3.788	34.906	95.8	12	6IsA0313020920	3/13/2002	0920		154.6	1510.7	0.09	0.9	0.52	5.1	0.04
3/13/2002 10:15	3.742	34.860	93.0	13	6IsA0313021020	3/13/2002	1020		225.8	2141.9	0.08	0.8	0.53	5.0	no data
3/13/2002 11:15	3.694	34.812	90.2	14	6IsA0313021120	3/13/2002	1120		116.0	1067.2	0.07	0.6	0.51	4.7	0.04
3/13/2002 12:15	3.633	34.751	86.9	15	6IsA0313021220	3/13/2002	1220		87.6	776.5	0.07	0.6	0.51	4.5	0.06
3/13/2002 13:15	3.571	34.689	83.7	16	6IsA0313021320	3/13/2002	1320		136.4	1164.5	0.00	0.0	0.51	4.4	0.04
3/13/2002 14:15	3.521	34.639	81.1	17	6IsA0313021420	3/13/2002	1420		127.0	1050.6	0.00	0.0	0.51	4.2	0.04
3/13/2002 15:15	3.472	34.590	78.4	18	6IsA0313021520	3/13/2002	1520		101.0	807.7	0.00	0.0	0.50	4.0	0.03
3/13/2002 16:15	3.425	34.543	75.9	19	6IsA0313021620	3/13/2002	1620		120.6	933.7	0.00	0.0	0.49	3.8	0.03
3/13/2002 17:15	3.384	34.502	73.8	20	6IsA0313021720	3/13/2002	1720		111.8	841.6	0.00	0.0	0.49	3.7	0.04
3/13/2002 18:15	3.344	34.462	71.8	21	6IsA0313021820	3/13/2002	1820		36.4	266.6	0.00	0.0	0.48	3.5	0.03
3/13/2002 19:15	3.31	34.428	70.3	22	6IsA0313021920	3/13/2002	1920		25.8	185.0	0.00	0.0	0.48	3.4	0.02
3/13/2002 20:15	3.276	34.394	68.3	23	6IsA0313022020	3/13/2002	2020		84.0	585.2	0.00	0.0	0.47	3.3	0.02
3/13/2002 21:15	3.256	34.374	67.3	24	6IsA0313022120	3/13/2002	2120		105.8	726.3	0.01	0.1	0.47	3.2	0.02
3/13/2002 22:15	3.234	34.352	66.4	25	6IsA0313022220	3/13/2002	2220		50.6	342.7	0.00	0.0	0.47	3.2	0.02
3/13/2002 23:15	3.203	34.321	64.9	26	6IsA0313022320	3/13/2002	2320		47.4	313.8	0.00	0.0	0.46	3.0	0.02
3/14/2002 0:15	3.177	34.295	64.0	27	6IsA0314020020	3/14/2002	0020		71.4	466.1	0.00	0.0	0.45	2.9	0.02
3/14/2002 1:15	3.147	34.265	62.1	28	6IsA0314020120	3/14/2002	0120		57.6	364.8	0.00	0.0	0.44	2.8	0.02
3/14/2002 2:15	3.116	34.234	60.7	29	6IsA0314020220	3/14/2002	0220		45.4	281.1	0.03	0.2	0.43	2.7	0.01
3/14/2002 3:15	3.092	34.210	59.7	30	6IsA0314020320	3/14/2002	0320		64.0	389.7	0.02	0.1	0.44	2.7	0.01
3/14/2002 4:15	3.065	34.183	58.3	31	6IsA0314020420	3/14/2002	0420		47.6	283.1	0.00	0.0	0.43	2.6	0.01
3/14/2002 5:15	3.041	34.159	57.4	32	6IsA0314020520	3/14/2002	0520		52.2	305.6	0.01	0.1	0.43	2.5	0.01
3/14/2002 6:15	3.018	34.136	56.5	33	6IsA0314020620	3/14/2002	0620		54.8	315.8	0.02	0.1	0.42	2.4	0.01
3/14/2002 7:15	2.995	34.113	55.2	34	6IsA0314020720	3/14/2002	0720		62.2	350.2	0.01	0.1	0.42	2.4	0.01
3/14/2002 8:15	2.971	34.089	54.3	35	6IsA0314020820	3/14/2002	0820		44.0	243.7	0.03	0.2	0.41	2.3	0.01
3/14/2002 9:15	2.951	34.069	53.4	36	6IsA0314020920	3/14/2002	0920		47.4	258.2	0.02	0.1	0.41	2.2	0.01
3/14/2002 10:15	2.929	34.047	52.5	37	6IsA0314021020	3/14/2002	1020		42.8	229.2	0.03	0.2	0.40	2.1	0.01
3/14/2002 11:15	2.913	34.031	51.6	38	6IsA0314021120	3/14/2002	1120		42.6	224.2	0.04	0.2	0.40	2.1	0.01

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Standard Operating Procedures (SOP's) for Bridge Sampling

PURPOSE
To collect storm event stream samples for developing sampling and modeling protocols for determining sediment and nutrient TMDL's.

1. Unlock security gate.
2. Back the crane truck to the center of the bridge near ISCO sampler.
3. For night sampling, start the generator on truck to power the flood lights and prepare for sampling with the DH-59 depth integrated sampler initially followed by the bedload sampling.
4. Sampling with the DH-59 and Bedload sampler shall be conducted at a time interval of 2 hours.

A telephone is located on the bridge rail near the ISCO for sampling team use. The telephone number: 789-2903.

Sampling with the DH-59:
Sampling with the DH-59 depth integrated sampler at this site is conducted by hand with rope attached to sampler. Sample at the same locations as marked on the downstream side of the bridge. This sampler weighs about 25 pounds. Field personnel shall collect samples on the downstream side of the bridge, not to interfere with the intake of the ISCO sampler and YSI multi-probe located on the upstream side of the bridge.

Follow the procedures outlined below to use the manually operated depth-integrated sampler with rope:

1. Secure a rope to sampler.
2. Install the intake nozzle in the sampler. Start with the large (1/4 inch) nozzle. There are five nozzles for use, two of the 1/4 inch, two of the 3/16 inch, and one 1/8 inch diameter bore, threaded for assembly into the sampler head.
3. Place a 1-pint milk bottle into the sampler by pulling the end handle to open, make sure gasket is in position for the sample bottle opening.
4. Move to the marked sampling site on the bridge from the right bank.
5. Lower the DH-59 sampler into the water until the rear fins are just in the water, allow sampler to orient itself with current flow, lower unit into water and start counting (1001-1030 depending on the depth of water), bubbles will appear on the water surface, lower the sampler at a steady speed until the rear of the sampler hits the stream bottom and raise the sampler upwards to the surface of the water to allow the milk bottle to fill, and retrieve the

sampler. Repeat this process, if necessary, until the collected sample is to the required volume between 300 and 400 ml. **DO NOT COMPOSITE SAMPLES**.

6. Record the sampling time, date, and cross stream location on sample bottles and in field log book. See numbering SOP.
7. Empty the milk bottle by swirling the sample and transfer to labeled sample bottles.
8. Store sample on ice in ice chest.
9. Move to next stream cross section, and continue to collect samples at each location for that time interval.

Sampling with crane truck using bedload sampler

1. Back crane truck to the center of the third sampling site (stream cross section locations) marked on bridge from right-edge-of-water (looking downstream) for bedload sampling.
2. Prepare crane for sampling by obtaining the electrically operated remote control for winch behind the seat of the Dodge flatbed truck, 4x4. Plug the remote cord into the side of the crane support stand. Run the winch in reverse to loosen the cable to provide slack for extending the arm to the maximum length and to raise the arm to the 3rd hole so that the winch arm will extend over the bridge top rail. Lift the bedload sampler and lower to ground and stand the sampler in an upright position at the rear of the truck.
3. Install sampling bag on sampler by placing the rubber ring into groove, tighten stainless steel bar clamp with wing nuts. Secure other end of bag to chain.
4. Raise the sampler, loosen the lock handle to allow the crane arm to swing over the top bridge rail.
5. Lower the sampler at the first sampling point (marked on bridge with orange paint) until the rear fins are just in the water, allow sampler to orient itself with current flow and lower unit to stream bottom carefully. Do not drop the sampler too fast to cause bottom disturbance.
6. Sampling time is estimated at 10 minutes for each stream cross section sampling interval **(one composite sample per sampling time)**. Use stop watch to determine the 10 minute sampling interval. The sampler shall be deployed at three to five pre-determined (depending on stream width) equal intervals across the stream section.
7. Retrieve the sampler, lower the sampler to an upright position. Fill a garden sprayer with tap water and wash the sediment attached to the inside of the sampler and bag side walls to concentrate the sediment into the lower corner of the nitex bag.
8. Remove the nitex bag from the sampler.
9. Using a 5-gallon bucket of tap water (about 3- gallons) immerse the sample bag several times to concentrate the sediment into the bottom of the bag for transfer to labeled sample bottle using a large stem funnel.
10. Record the sampling time, date, and cross stream location on sample bottles and in field log book. See numbering SOP.

INTRODUCTION

The balance is the most important single piece of apparatus available to the chemist and is used to determine the mass (weight) of objects. Because the mass (weight) to be determined ranges from kilograms to micrograms, the choice of the balance depends on the total mass (weight) to be determined and the sensitivity required.

PURPOSE

Use of the balance is part of most chemical laboratory procedures. The weight obtained from the weighing process is used in the computation of the respective final result.

GENERAL

The following rules should be observed in caring for and using a balance:

1. Level the balance.
2. Make sure the balance is working properly. Use calibrated and undamaged weights to check.
3. Check the balance zero.
4. Keep the balance clean.
5. Handle all weights and objects with forceps, never with fingers. Place the weight at the center of the pan.
6. Avoid weighing unconditioned objects, hot or cold.
7. Do not overload the balance.
8. Do not place moist objects or chemicals directly on the balance pan.
9. Close the balance case and wait for constant weight.
10. Record weight in notebook for addition. Never add mentally.

ERRORS IN DETERMINING WEIGHTS

1. Changes in moisture or carbon dioxide content. Such materials must be weighed in a closed system.
2. Volatility of sample. Such materials must be weighed in a closed system.
3. Electrification. A charged object is attracted to various parts of the balance. An antistatic brush might help.
4. Temperature. Convection currents of a warm object causes the pan to be buoyed up which makes the object weigh less. An object should be weighed at room temperature.

APPLICATION

All balances at the Field Research Annex are electronic balances. There is the single-pan analytical balance which has a maximum weight capacity of 200 grams and weighs to four places (0.0000g); there is the single-pan top-load balance which has a maximum weight capacity

of 220 grams and weighs to three places (0.000g); there is the single-pan top-load balance which has a maximum weight capacity of 310 grams and weighs to three places (0.000g); and there is the single-pan top-load balance which has two ranges with maximum weight capacities of 16 kg and 3.2 kg and weighs to zero and one places respectively (0g/0.0g).

The operation of each balance is simple:
1. Zero the balance (and open the door).
2. Place the object on the pan (and close the door).
3. Wait for constant weight and take digital readout.

Most of the balances can be coupled directly to computers or recording devices if necessary.

Each individual procedure, whether it is for Total Suspended Solids, for Bedload samples, or for Nutrients, etc., defines which one of the balances is appropriate depending on the maximum weight and the sensitivity required.

PURPOSE
The data of the nutrient analyses will be applied to the modeling of Total Maximum Daily Loads (TMDL).

SUMMARY OF PROCEDURES
ortho-phosphate:

The automated procedure for the determination of ortho- phosphate is based on the colorimetric method in which a blue color is formed by the reaction of ortho- phosphate, molybdate ion and antimony ion followed by reduction with ascorbic acid at an acidic pH. The reduced blue phosphomolybdenum complex is read at 660 nm.

see Bran+Luebbe AutoAnalyzer method No. US-696B-82

Nitrate:
The automated procedure for the determination of nitrate utilizes the reaction whereby nitrate is reduced to nitrite by an alkaline solution of hydrazine sulfate containing a copper catalyst. The stream is then treated with sulfanilamide under acidic conditions to form a soluble dye which is measured colorimetrically. The final product measured represents the nitrite ion originally present plus that formed from the nitrate.

see Bran+Luebbe AutoAnalyzer method No. US-696F-82W

Total phosphorus:
The automated procedure for the determination of total phosphorus takes place in three stages. First, the sample is mixed with persulphate and irradiated in a UV digestor. In this digestion step organic bound phosphorus is released. Second, polyphosphates are converted to ortho-phosphate by acid hydrolysis at 95°C. Third, the ortho-phosphate is determined by reaction with molybdate, antimony and ascorbic acid, producing a phospho-molybdenum blue complex which is measured colorimetrically at 660 or 880 nm.

see Bran+Luebbe AutoAnalyzer method No. G-092-93 Rev.1, multitest MT 17

Ammonia:
The automated procedure for the determination of ammonia utilizes the Berthelot Reaction, in which the formation of a blue colored compound believed to be closely related to indophenol occurs when the solution of an ammonium salt is added to sodium phenoxide, followed by the addition of sodium hypochlorite. A solution of EDTA is added to the sample stream to eliminate

the precipitation of the hydroxides of calcium and magnesium. Sodium nitroprusside is added to intensify the blue color.

see Bran+Luebbe AutoAnalyzer method No. US-696D-82X

Total nitrogen:
Inorganic and organic nitrogen are oxidized to nitrate by sulfate radicals. Sulfate radicals are produced by the photolytic decomposition of persulfate in an on-line UV digestor. The nitrate is reduced to nitrite and then determined using the sulfanilamide/ NEDD reaction with detection at 520 nm.

See Bran+Luebbe AutoAnalyzer method No. G-157-96 Rev. 3, multitest MT17

INTERFERENCES
Phosphorus:
As much as 50 mg Ferric ion/L, 10 mg Copper/L, and 10 mg Silica/L can be tolerated. High silica concentrations cause positive interference.

Nitrate
Chloride, sulfide, ferric ion and phosphate ion interfere.

Ammonia:
Calcium and magnesium ions in sea water concentrations will precipitate if EDTA is not used.

INSTRUMENT
The Bran+Luebbe AutoAnalyzer 3 is a modern wet-chemistry analyzer that is used in industrial laboratories for automation of complex chemical reactions. Most types of aqueous samples can be analyzed, such as water, solid extracts, beverages, or chemicals.

It uses the principle of air-segmented continuous-flow analysis (CFA) for fully automatic sample analyses. Samples are mixed with reagents in a continuously flowing stream. The individual sample segments are kept separate by means of air bubbles.

With more than 700 chemical methods, the AutoAnalyzer 3 combines the advantages of proven methodology with state-of-the-art technology.

Due to its modular design, the AutoAnalyzer 3 can be easily adapted to the specific requirements of a laboratory. The main system components include Sample, Pump, Chemistry Module and Digital Colorimeter.

System control is provided by the Bran+Luebbe AACE software. AACE stands for Automated Analyzer Control and Evaluation Software and is designed to control all Bran+Luebbe AutoAnalyzer 3 systems. It also provides comprehensive and easy-to-use tools to process and evaluate the data collected from the analyzer. Designed as control software for Bran+Luebbe Continuous Flow analyzers, AACE provides all the necessary tools for communication with the AutoAnalyzer modules, easy run programming, and data processing and retrieval.

AACE is characterized by the following features:

- Windows 95 operating system
- Easy analyzer control
- Real-time information
- Post-run reporting
- Customer-specific quality control
- Network connection and LIMS
- Fast and reliable data storage

The AutoAnalyzer 3 modules are completely controlled by the AACE software. The programming of a run is divided into five menus. The File menu, the Configure menu, the Set Up menu, the Run menu, and the Retrieve menu. Each one is programmed to satisfy the requirements of a run. See Bran+Luebbe Operation Manuals for the AutoAnalyzer 3 and for the AACE software.

METHODOLOGY

The present setup consists of two parameters running simultaneously. First, ortho-phosphate and nitrate, followed by total phosphorus and ammonia. Total nitrogen is run by itself. All five parameters are mixed in one stock standard with equal concentrations. This set up only requires the changing of reagents between runs.

The Set Up programming requires a run to start with the highest standard to adjust the concentration range from zero to 100%, followed by five standards to establish the calibration curve. Baseline and lamp intensity are set automatically. If the baseline is too noisy, a run will not start. A high standard and a zero standard are inserted periodically for auto corrections.

Once a run is finished, the system shuts down automatically and prints a complete report of peaks, concentrations and calibration curves including the correlation coefficients.

METHOD CALIBRATION

Method calibration is discussed under Methodology.

Quality Control

Quality control measures should include:

a. Analysis of a duplicate sample every 10 to 15 samples if sample volume is available.
b. Analysis of a standard every 10 to 15 samples.
   Samples for duplicate analysis will be marked with red tape. If QA samples are not identified, check with log in personnel. The duplicate sample for QA shall be labeled with a Q in back of the label. The following is an example label:
   2IsB0125011215Q
c. Calibration of the analytical balance once a year and weekly checks of the accuracy of the balance by the analyst.

SAMPLE COLLECTION

Sample Collection is discussed in a separate SOP.

SAMPLE HANDLING AND PRESERVATION

When samples are collected, they should be put on ice, delivered to the laboratory as soon as possible and stored under refrigeration until analysis. The time between collection and analyses should be less than 48 hours. Preservation of the sample with acid should be avoided to minimize the handling and preserve the integrity of the sample.

SAMPLE PREPARATION FOR ANALYSIS

The refrigerated sample is poured into a 15- mL labeled polypropylene centrifuge tube and centrifuged at 4000 rpm for 20 minutes. It is then poured into a 5-mL AutoAnalyzer sample cup and inserted into the sample tray according to the programmed Set Up.

TROUBLESHOOTING

Troubleshooting sections are included in both manuals, the AutoAnalyzer 3 manual and the AACE manual.

PERSONNEL QUALIFICATIONS

The AutoAnalyzer 3 is a highly sophisticated instrument and requires knowledge of chemistry and computer literacy. It can be operated by experienced technicians who have gone through a hands-on training period until they are thoroughly familiar with the many different aspects of mechanical, hydraulic, and computer programming handling of the system.

INTRODUCTION

Solids refers to matter suspended or dissolved in water or wastewater. Total suspended solids is the portion of total solids retained by a filter. Dissolved solids is the portion of solids that passes through a filter of 2.0 µm (or smaller) nominal pore size under specified conditions (1). Because flows and concentrations in streams are usually unsteady, samples represent conditions only at the time and location of sample collection. This method implies sand concentrations of less than about 10,000 mg/L and clay concentrations of less than 200 mg/L. If the concentration in the sample is greater than these limits, a factor must be applied to convert the concentration from mg/L to mg/kg. The density of the sample will be larger than 1.000 g/mL at the higher concentration and must be considered in the final calculation. A specific gravity of 2.65 g/mL is generally assumed for sediment.

PURPOSE

The data of the total suspended solids (TSS) analysis will be applied to the modeling of Total Maximum Daily Loads (TMDL).

SUMMARY OF PROCEDURE

A well-mixed sample is filtered through a weighed standard glass-fiber filter and the residue retained on the filter is dried to a constant weight at 103 to 105°C. The increase in weight of the filter represents the total suspended solids.

INTERFERENCES

Exclude large floating particles or submerged agglomerates of nonhomogeneous materials from the sample if it is determined that their inclusion is not representative.
Because excessive residue on the filter may form a water-entrapping crust, limit the sample size to that yielding no more than 200 mg residue.

EQUIPMENT

2-L filter suction flask with sidearm.
Coors porcelain filter funnel with 90-mm diameter perforated plate.
90-mm diameter glass-fiber filter disk #934AH (Whatman).
Forceps for handling glass-fiber filter.
90-mm diameter watch glass.
Filter trap.
One liter graduated cylinder.
Vacuum pump developing a vacuum of 27-28 inches of mercury.
Drying oven, for operation at 103 to 105°C.
Desiccator, provided with a desiccant containing a color indicator of moisture concentration.
Analytical balance, capable of weighing to 0.1 mg.

METHODOLOGY

Preparation of glass-fiber filter disk:
Because of the huge number of samples to be analyzed, a large number of glass-fiber filter disks should be washed and stored in a desiccator before the sampling event.
Insert glass-fiber filter disk with wrinkled side up in filtration apparatus using forceps. Apply vacuum and wash disk with three successive 20-50 mL portions of deionized (DI) water after wetting disk with a small volume of DI water to seat it. Continue suction to remove all traces of water, turn vacuum off, and discard washings. Transfer disk to a watch glass and dry in oven at 103-105°C for one hour. Cool in desiccator to condition to temperature for one hour. Conditioned disks can be stacked in desiccator for future use.

Sample analysis:
Transfer washed disk to a watch glass using forceps and keep in desiccator for 30-60 minutes to condition if disks were prepared and stacked in desiccator. Weigh watch glass with disk. Transfer disk to filtering apparatus using forceps, turn pump on, and wet disk with a small volume of DI water to seat it. Shake the sample bottle for several seconds to suspend all the solids and immediately pour all the sample into a one liter graduated cylinder. **Record the sample volume.** Pour about 50 mL of DI water into the sample bottle, shake well and immediately pour into the one liter grad. cylinder. Repeat this washing two more times or until all the solids have been transferred to the one liter grad. cylinder. Filter the sample and washings. Partially invert the one liter grad. cylinder over the filter funnel and rinse all the remaining solids with a wash bottle into the filter funnel. Wash disk with three successive 20-50 mL portions of DI water, allowing complete drainage between washings. Continue suction to remove all traces of water. Disconnect pump quick-disconnect. Remove disk and transfer to its watch glass (watch glasses must be numbered for easy identification). Dry in oven at 103-105°C for 1.5 hours. Transfer watch glass with disk to desiccator to balance temperature for 1.5 hours and weigh.

As filtering proceeds, inspect the filtrate. If it is turbid, pour the filtrate back through the filter a second and possibly a third time. If the filtrate is still turbid, the filter may be leaking, in which case a new filter must be used and the process repeated. If the filtrate is transparent but discolored, a natural dye is present and refiltration is not necessary.

Calculation: report results in mg to one decimal point

$$\text{mg TSS/L} = \frac{(A - B) \times 1000}{\text{Sample volume, mL}}$$

where: A = weight of watch glass and disk + dried residue
B = weight of watch glass and disk empty, mg

The yield should be between 2.5 and 200 mg dried residue.

REFERENCES

1. Standard Methods for the Examination of Water and Wastewater, 20th Edition 1998, pp. 2-54 to 2-58.
2. Ecosystems Research Division Laboratory Research Notebook #979 of Heinz P. Kollig, pp. 7 to 8.

MODIFICATION TO THE REFERENCE METHODOLOGY

The reference methodology calls for repeating the cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained or until the weight change is less than 4% of the previous weight or 0.5 mg, whichever is less. This repetition of the cycle was eliminated because of the huge number of samples to be analyzed. The time of drying and desiccating, however, was increased from 1 hour to 1.5 hours. In addition, a study was performed to explore the weight change of the disk in repeating the cycle (2). 24 disks were washed, dried, desiccated, and weighed twice. The mean weight change was 0.2 mg and the 95% confidence interval was 0.2 ± 0.06.

QUALITY CONTROL

Analysis of a duplicate sample is not possible because all of the sample has been used for the analysis. Collection of more (another) sample is impractical because it would represent a different sample.

Calibration of the analytical balance once a year and weekly checks of the accuracy of the balance by the analyst.

SAMPLE COLLECTION

Sample collection is discussed in a separate SOP.

SAMPLE HANDLING AND PRESERVATION

When samples are collected, they should be put on ice, delivered to the laboratory as soon as possible and stored under refrigeration until analysis. Begin analysis as soon as possible because of the impracticality of preserving the sample. The time between collection and analysis should be less than 48 hours. In no case should samples be held for more than 7 days.

SAMPLE PREPARATION FOR ANALYSIS

The refrigerated sample should be brought up close to room temperature before filtering.

SOURCES OF ERROR AND VARIABILITY

Sample not mixed adequately.
Torn or holes in fiber-glass filter disk.
Improper vacuum.
Wrong oven temperature.
Desiccant exhausted.
Balance malfunctioning.
Mistake in calculation.

PERSONNEL QUALIFICATIONS

The analysis of total suspended solids is a fairly straight forward process. The analyst should have knowledge of chemistry and be experienced with general laboratory operations. A short hands-on introduction and training period should be required.

Field Standard Operating Procedures
Cableway System
Highway 172 Site

PURPOSE

To collect storm event stream samples for developing sampling and modeling protocols for determining sediment and nutrient TMDL's.

When the sampling team arrives at the site, unlock and open the fence gate underneath the cableway platform. This site has direct utility power from Georgia Power. On the right side of the door is a light switch that will turn on flood lights underneath, lights on side of the building platform at access ramp and light above the main entrance doors. Inside the building on the right side near door there are two light switches, the first switch will turn on the overhead light (look for rodents and snakes), the second switch will turn on the big sports light underneath building platform to light up river view for cableway sampling at night. Once sampling is complete, reverse the steps for turning off lights.

Sampling with the DH-59 and Bedload sampler shall be conducted at a time interval of 2 hours.

A telephone is located on the inside back wall of the cableway house for sampling team use. The telephone number 788-3046.

Operating the cableway system

1. Open the control panel along the back wall of the cableway, turn on, push start button, and the cableway is ready for operation. The speed is controlled by the rheostat in the control box. Start with the speed control at mid range and increase or decrease as desired.
2. Controls for operating the cableway system for positioning the samplers are as follows:

    a. toggle switch located on the support post arm:
        i. reverse position takes the sampler out and lowers the sampler (down/out).
        ii. forward position raises the sampler and brings the sampler into the platform (up/in).
    b. lever on the winch assembly shifts the double drum from one drum to two drum operation:
        i. **up position** raises and lowers the sampler, direction being controlled by the toggle switch located on the support post arm. Forward position of the toggle raises the Cableway sampler and reverse lowers the sampler.
        ii. **down position** controls the transverse motion of the sampler, direction also being

controlled by the toggle switch. Forward position of the toggle brings the sampler in and reverse takes the sampler out.

iii. speeds of the directions are controlled by the rheostat on the control box.

iv. The winch is equipped with an automatic Weston brake system that will allow the sampler to be held in any position even with the loss of generator power. A loud clicking sound will be heard as the sampler is raised. **Do not adjust the brake control knobs.**

v. It is very important at the beginning of each shift for the mechanism of the Weston brake system to be cleaned. Place Kimwipes under the mechanism and then apply a liberal amount of WD-40 to the brake while the winch system is in motion. At the termination of the sampling event, run the winch and tighten the cables so that the sampler attachment (on end of cable) is pulled to the traveler block such that the small cables have minimum slack over the river and the traveler is within the confines of the fence. Do not overtighten the cables.

The winch has two counters to provide the distance that the sampler has traveled. The counter on the right side facing the river registers in feet and the counter on the left side registers in tenth's of feet. These are the counters to be used in positioning the samplers at selected distances from the platform for sampling.

Cableway Calibration Check
DH-59

Zero the cableway using the DH-59 sampler. Attach the DH-59 to the cableway using the shackle pins and clips. Suspend the sampler using the lifting mode of the mechanism and allow it to travel to the edge of the platform. Lower the sampler to a point slightly below the platform then bring the vertical cable back even with the platform. Once this position has been achieved, bring the sampler up to the shackle mechanism on the traveler cable. This is point "0" and should be indicated on both counters located on opposite sides of the winch system. If not at "0", manually set both counters to "0" at this time.

BEDLOAD

Calibrate the cableway for the bedload sampler by lowering the sampler to the edge of the platform floor and position it in the center of the 6-inch sample intake. Once this position has been achieved, bring the sampler up to the shackle mechanism on the traveler cable. This is point "0" and should be indicated on both counters.

Sediment Sampling with Cableway

Depth Integrated Sampling using DH-59

The DH-59 depth-integrating sampler accumulates a water-sediment mixture throughout the depth of the water column. If the 1-pint bottle becomes completely filled during a sampling operation, it is not representative and must be discarded. The time it takes to lower and raise the sampler in the water column shall be sufficient to produce a sample volume between 300 and 400 ml.

1. Install the intake nozzle in the sampler. Start with the large (1/4 inch) nozzle. Check each nozzle and sampler intake hole to make sure it is free of debris and not clogged. There are five nozzles for use, two of the 1/4 inch, two of the 3/16 inch, and one 1/8 inch diameter bore, threaded for assembly into the sampler head.
2. Place a 1-pint bottle into the sampler by pulling the end handle to open, make sure gasket is in position for the sample bottle opening.
3. Beginning on the far-side (right side facing downstream) of the stream from the platform, sampling points are designated A through E and are located at counter readings of 79, 71, 63, 55 and 47 foot, respectively (8-foot increments between sites with 5-foot from each side of the stream bank). In the event of exceedingly high water levels above bank full, two additional sample sites are located at 94 and 14 feet when the water depth at these sites is 6-inches or greater. The sampling site locations are provided on a chart located on the wall of the cableway platform. Beginning at the79 foot interval, position the sampler consecutively at each of these locations on the cableway.
4. After positioning the sampler at the designated locations, allow the sampler to descend to the bottom of the river under controlled speed. First lower the sampler until the rear fins are just in the water, allow the sampler to orient itself with current flow and then lower the unit to the
   stream bottom. As the unit decends into the water, start counting from 1001- 1030 depending on the depth of water. Bubbles will appear on the water surface indicating that the sample is entering the bottle. Lower the sampler at a steady speed until the rear of the sampler hits the stream bottom, (look for a slight upward deflection of the traveler) then raise the sampler at the same steady speed upwards to obtain the sample. Retrieve the sampler and check the volume collected. If necessary, repeat this process until the collected volume is between 300 and 400 ml. **DO NOT COMPOSITE THE SAMPLES**. The DH-59 are individual samples of each stream cross section.
5. Record the site number, sampling time, date, and cross stream location on sample bottles and in field log book See numbering SOP.
6. Empty the sample bottle by swirling the contents and then transfer to the labeled sample bottles.

7. Store samples on ice in ice chest.
8. Move to next stream cross section, and continue to collect samples at each location for that time interval.

Helley Smith Bedload Sampler

Bedload sampling is collecting sediment that is being transported along the stream bottom during a storm event. The sampler weighs 170 pounds, consists of a 6-inch opening and a nitex bag for the collection of sediment.

Attach the bedload sampler to the cableway and raise to an upright position so that it is standing on its fins.

1. Install nitex sampling bag on the sampler by placing the rubber ring into groove with the two pleats at bottom of sampler for alignment, tighten stainless steel bar clamp with wing nuts. Secure other end of bag to chain.
2. Beginning at the 79 foot interval, lower the sampler to the bottom of the river until the rear fins are just in the water. Allow the sampler to orient itself with current flow and lower to stream bottom, being careful not to disturb the stream bottom by dropping the sampler too fast. When the sampler makes contact with the stream bottom there is a slight upward deflection of the traveler. Allow the sampler to remain at that stream cross sectional location for 10 minute (if the water depth is 6-inches or greater). Use stop watch to determine the 10 minute sampling interval. After the 10 minutes is complete, move to the next cross section by raising the sampler above the water and determining the distance to travel to the next location.
3. Retrieve the sampler and lower it to an upright position on the platform. Keep the cable secured to the sampler. Use the garden sprayer filled with tap water to wash the sediment from the inside surface of the sampler and the side walls of the bag so that the sediment is concentrated in the lower corner of the nitex bag.
4. Remove the nitex bag from the sampler.
5. Using a 5-gallon bucket with about 3-gallons of tap water, immerse the sample bag several times to clean the bag and to concentrate the sample in the bottom of the bag for ease of transfer to sample bottles.
6. Transfer the bedload sediment sample into a one-liter widemouth Nalgene bottle by using a large stem funnel.
7. Label the sample bottle and record in the field log book the sampling time, date, and cross section locations that were sampled. See numbering SOP.
8. Place the **composite sample** on ice for transport to the laboratory.
9. Reattach the bag to the sampler for the next sampling time interval.

10. Remove the bedload sampler from the cableway and attach the DH-59 sampler for the next sampling time interval.

Standard Operating Procedures
Cableway System
Clouds Creek Site, SFBR60
Located in Watson Mill Bridge State Park

PURPOSE
To collect storm event stream samples for developing sampling and modeling protocols for determining sediment, nutrient and pathogen TMDL's.

When the sampling team arrives at the primitive camp area road inside the park, unlock the EPA lock at gate for entry. Keep the park gate closed at all times. Drive the vehicle to an area with trash cans at top of hill and stop. Unload the 4 x 4 mule from trailer and transport supplies and sampling team to the site. Secure vehicle and trailer doors. Unlock the gate and doors to the cableway platform and generator door. Check oil level in the generator. Open the propane gas valve to the generator. Start the generator by switching to run and close door. On the right side of the back entrance gate is a light switch that will turn on flood lights on side of the building platform, inside and at the generator. Inside the building on the back wall is an electrical raceway. Turn on the big sports light (mounted on roof) that provides light across the river at the electrical raceway for night time sampling.

Once sampling is complete, reverse the steps for securing the sampling site, turning off lights, then open the door of generator and turn off and lock and lock all gates. **Be sure to turn off propane gas valve.**

Located on the inside back wall of the cableway house is a telephone for sampling team use. The telephone number 783-2201.

Operating the cableway system
1. Open the control panel along the back wall of the cableway, turn on, push start button, and the cableway is ready for operation. The speed is controlled by the rheostat in the control box. Start with the speed control at mid range and increase or decrease as desired.
2. Controls for operating the cableway system for positioning the samplers are as follows:
   a. toggle switch located on the support post arm:
      i. reverse position takes the sampler out and lowers the sampler (down/out).
      ii. forward position raises the sampler and brings the sampler into the platform (up/in).
   b. lever on the winch assembly shifts the double drum from one drum to two drum operation:
      i. **up position** raises and lowers the sampler, direction being controlled by the toggle

ii. switch located on the support post arm. Forward position of the toggle raises the sampler and reverse lowers the sampler.
iii. **down position** controls the transverse motion of the sampler, direction also being controlled by the toggle switch. Forward position of the toggle brings the sampler in and reverse takes the sampler out.
iv. speeds of the directions are controlled by the rheostat on the control box.
v. The winch is equipped with an automatic Weston brake system that will allow the sampler to be held in any position even with the loss of generator power. A loud clicking sound will be heard as the sampler is raised. **Do not adjust the brake control knobs.**
vi. It is very important at the beginning of each shift for the mechanism of the Weston brake system to be cleaned. Place Kimwipes under the mechanism and then apply a liberal amount of WD-40 to the brake while the winch system is in motion. At the termination of the sampling event, run the winch and tighten the cables so that the sampler attachment (on end of cable) is pulled to the traveler block such that the small cables have minimum slack over the river and the traveler is within the confines of the fence. Do not overtighten the cables.

The winch has two counters to provide the distance that the sampler has traveled. The counter on the right side facing the river registers in feet and the counter on the left side registers in tenth's of feet. These are the counters to be used in positioning the samplers at selected distances from the platform for sampling.

Cableway Calibration Check
DH-59

Zero the cableway using the DH-59 sampler. Attach the DH-59 to the cableway using the shackle pins and clips. Suspend the sampler using the lifting mode of the mechanism and allow it to travel to the edge of the platform. Lower the sampler to a point slightly below the platform then bring the vertical cable back even with the platform. Once this position has been achieved, bring the sampler up to the shackle mechanism on the traveler cable. This is point "0" and should be indicated on both counters located on opposite sides of the winch system. If not at "0", manually set both counters to "0" at this time.

BEDLOAD

Calibrate the cableway for the bedload sampler by lowering the sampler to the edge of the platform floor and position it in the center of the 6-inch sample intake. Once this position has been achieved, bring the sampler up to the shackle mechanism on the traveler cable. This is point "0" and should be indicated on both counters.

Sediment Sampling with Cableway

Depth Integrated Sampling using DH-59

The DH-59 depth-integrating sampler accumulates a water-sediment mixture throughout the depth of the water column. If the 1-pint bottle becomes completely filled during a sampling operation, it is not representative and must be discarded. The time it takes to lower and raise the sampler in the water column shall be sufficient to produce a sample volume between 300 and 400 ml.

1. Install the intake nozzle in the sampler. Start with the large (1/4 inch) nozzle. Check each nozzle and sampler intake hole to make sure it is free of debris and not clogged. There are five nozzles for use, two of the 1/4 inch, two of the 3/16 inch, and one 1/8 inch diameter bore, threaded for assembly into the sampler head.
2. Place a 1-pint bottle into the sampler by pulling the end handle to open, make sure gasket is in position for the sample bottle opening.
3. Beginning on the far-side (right side facing downstream) of the stream from the platform, sampling points are designated A through E and are located at counter readings of 88, 76, 64, 52 and 40 foot, respectively (12-foot increments between sites with 5-foot from each side of the stream bank). In the event of exceedingly high water levels above bank full, three additional sample sites are located at 100, 28 and 16 feet designated as AA, E1 and E2, respectively. Sample only when the water depth at these sites is 6-inches or greater. The sampling site locations are provided on a chart located on the wall of the cableway platform. Beginning at the79 foot interval, position the sampler consecutively at each of these locations on the cableway.
4. After positioning the sampler at the designated locations, allow the sampler to descend to the bottom of the river under controlled speed. First lower the sampler until the rear fins are just in the water, allow the sampler to orient itself with current flow and then lower the unit to the stream bottom. As the unit decends into the water, start counting from 1001- 1030 depending on the depth of water. Bubbles will appear on the water surface indicating that the sample is entering the bottle. Lower the sampler at a steady speed until the rear of the sampler hits the stream bottom, (look for a slight upward deflection of the traveler) then raise the sampler at the same steady speed upwards to obtain the sample. Retrieve the sampler and check the volume collected. If necessary, repeat this process until the collected volume is between 300 and 400 ml. **DO NOT COMPOSITE THE SAMPLES**. The DH-59 are individual samples of each stream cross section.
5. Record the sampling time, date, and cross stream location on sample bottles and in field log book See numbering SOP.

6. Empty the sample bottle by swirling the contents and then transfer to the labeled sample bottles.
7. Store samples on ice in ice chest.
8. Move to next stream cross section, and continue to collect samples at each location for that time interval.

Helley Smith Bedload Sampler

Bedload sampling is collecting sediment that is being transported along the stream bottom during a storm event. The sampler weighs 170 pounds, consists of a 6-inch opening and a nitex bag for the collection of sediment.

Attach the bedload sampler to the cableway and raise to an upright position so that it is standing on its fins.

1. Install nitex sampling bag on the sampler by placing the rubber ring into groove with the two pleats at bottom of sampler for alignment, tighten stainless steel bar clamp with wing nuts. Secure other end of bag to chain.
2. Beginning at the 88 foot interval, lower the sampler to the bottom of the river until the rear fins are just in the water. Allow the sampler to orient itself with current flow and lower to stream bottom, being careful not to disturb the stream bottom by dropping the sampler too fast. When the sampler makes contact with the stream bottom there is a slight upward deflection of the traveler. Allow the sampler to remain at that stream cross sectional location for 10 minute (if the water depth is 6-inches or greater). Use stop watch to determine the 10 minute sampling interval. After the 10 minutes is complete, move to the next cross section by raising the sampler above the water and determining the distance to travel to the next location.
3. Retrieve the sampler and lower it to an upright position on the platform. Keep the cable secured to the sampler. Use the garden sprayer filled with tap water to wash the sediment from the inside surface of the sampler and the side walls of the bag so that the sediment is concentrated in the lower corner of the nitex bag.
4. Remove the nitex bag from the sampler.
5. Using a 5-gallon bucket with about 3-gallons of tap water, immerse the sample bag several times to clean the bag and to concentrate the sample in the bottom of the bag for ease of transfer to sample bottles.
6. Transfer the bedload sediment sample into a one-liter widemouth Nalgene bottle by using a large stem funnel.
7. Label the sample bottle and record in the field log book the sampling time, date, and cross section locations that were sampled. See numbering SOP.

8. Place the **composite sample** on ice for transport to the laboratory.
9. Reattach the bag to the sampler for the next sampling time interval.
10. Remove the bedload sampler from the cableway and attach the DH-59 sampler for the next sampling time interval.

Field Standard Operating Procedures
Cableway System
Carlton Site

PURPOSE
To collect storm event stream samples for developing sampling and modeling protocols for determining sediment and nutrient TMDL's.

When the sampling team arrives at the site, unlock entrance gate, and turn on light switch (raise lid cover) located on outside wall of building as you start up the access ramp. This switch will light flood lights going up ramp and back of building. Unlock main entrance doors and turn on first light switch for the overhead light (look for rodents and snakes). The second switch turns on the sports light facing the river for cableway sampling at night. This site has two power sources, one being utility power (Rayle EMC) and the other a Kohler 11KW generator. In the event of power loss from utility power, the transfer switch will automatically switch to generator power. It will take about 2 minutes until full power is restored to the light. For emergency lighting, a battery powered light will come on as soon as power is up from the generator. This light will turn off automatically. The sports light that is being used for cableway sampling is a 400 watt halide lamp. When power is turned off manually or due to power failure, it will not come back on for about 10 minutes since it has to cool off before igniting again. Do not cut off switches thinking something is wrong, be patient and wait. The generator is fueled by propane gas (100 pound tank) and a second tank will be available for replacement. The propane fuel tank will remain on at all times. In case the propane gas tank is empty, the generator will try to start itself 3 times before shutting down. In the event it does not start call Charlie Smith for directions. The generator system is all automatic and does not require assistance from the sampling teams. **IMPORTANT: DO NOT CUT OFF ANY SWITCHES WITH THE GENERATOR SYSTEM INCLUDING THE TRANSFER SWITCH (GE Zenith Control Box) ON BACK WALL.** Every two weeks the generator will run automatically 15 minutes for warmup to keep operational.

Once sampling is complete, reverse the steps for securing the sampling site and turning off lights. **Be sure to disconnect the 9-V battery in the green power control box along back wall**.

Located on the inside right wall there is a telephone for sampling team use. The phone number is797-3206.

The installation of a new OTT cableway system and support equipment for securing the ISCO strainers and the YSI multi-probe in the center of a 180 foot wide river was a difficult challenge

since the stream bed consisted of loose sand (2-feet deep) overlying bedrock. The site was made operational with the ISCO and YSI multi-probe May 16, 2002.

Operating the cableway system

1. Open the green power control box along the back wall of the cableway and install the 9-V battery that powers the digital read out on the remote control. Close door.
2. Turn on cableway by the yellow switch key and then press green "ON" button.
3. Connect the DH-59 sampler to cableway for first stream sampling.
4. Remove the cableway remote control from wall and lift the DH-59 sampler from the floor.
5. Zero the cableway by bringing the sampler to the stop switch (located at top of cableway system) and press the distance measurement to zero the system.
6. Collect 5-samples located at 10 meter intervals apart including 10, 20, 30, 40 and 50. The edge of the river's right bank facing downstream is 7 meters from zero and the far side bank facing downstream is 59 meters.

Depth Integrated Sampling using DH-59

The DH-59 depth-integrating sampler accumulates a water-sediment mixture throughout the depth of the water column. If the 1-pint bottle becomes completely filled during a sampling operation, it is not representative and must be discarded. The time it takes to lower and raise the sampler in the water column shall be sufficient to produce a sample volume between 300 and 400 ml.

1. Install the intake nozzle in the sampler. Start with the large (1/4 inch) nozzle. Check each nozzle and sampler intake hole to make sure it is free of debris and not clogged. There are five nozzles for use, two of the 1/4 inch, two of the 3/16 inch, and one 1/8 inch diameter bore, threaded for assembly into the sampler head.
2. Place a 1-pint bottle into the sampler by pulling the end handle to open, make sure gasket is in position for the sample bottle opening.
3. Beginning on the far-side (left side facing downstream) of the stream from the platform, on a chart located on the wall of the cableway platform. Beginning at the 50 meter interval, position the sampler consecutively at each of these locations on the cableway.
4. After positioning the sampler at the designated locations, allow the sampler to descend to the bottom of the river under controlled speed. First lower the sampler until the rear fins are just in the water, allow the sampler to orient itself with current flow and then lower the unit to the stream bottom. As the unit decends into the water, start counting from 1001- 1030 depending on the depth of water. Bubbles will appear on the water surface indicating that

the sample is entering the bottle. Lower the sampler at a steady speed until the rear of the sampler hits the stream bottom, (look for a slight upward deflection of the traveler) then raise the sampler at the same steady speed upwards to obtain the sample. Retrieve the sampler and check the volume collected. If necessary, repeat this process until the collected volume is between 300 and 400 ml. **DO NOT COMPOSITE THE SAMPLES**. The DH-59 are individual samples of each stream cross section.

5. Record the sampling time, date, and cross stream location on sample bottles and in field log book See numbering SOP.
6. Empty the sample bottle by swirling the contents and then transfer to the labeled sample bottles.
7. Store samples on ice in ice chest.
8. Move to next stream cross section, and continue to collect samples at each location for that time interval.

Helley Smith Bedload Sampler

Bedload sampling is collecting sediment that is being transported along the stream bottom during a storm event. The sampler weighs 170 pounds, consists of a 6-inch opening and a nitex bag for the collection of sediment.

Attach the bedload sampler to the cableway and raise to an upright position so that it is standing on its fins.

1. Install nitex sampling bag on the sampler by placing the rubber ring into groove with the two pleats at bottom of sampler for alignment, tighten stainless steel bar clamp with wing nuts. Secure other end of bag to chain.
2. Beginning at the 50 meter interval, lower the sampler to the bottom of the river until the rear fins are just in the water. Allow the sampler to orient itself with current flow and lower to stream bottom, being careful not to disturb the stream bottom by dropping the sampler too fast. When the sampler makes contact with the stream bottom there is a slight upward deflection of the traveler. Allow the sampler to remain at that stream cross sectional location for 10 minute (if the water depth is 6-inches or greater). Use stop watch to determine the 10 minute sampling interval. After the 10 minutes is complete, move to the next cross section by raising the sampler above the water and determining the distance to travel to the next location.
3. Retrieve the sampler and lower it to an upright position on the platform. Keep the cable secured to the sampler. Use the garden sprayer filled with tap water to wash the sediment from the inside surface of the sampler and the side walls of the bag so that the sediment is concentrated in the lower corner of the nitex bag.

4. Remove the nitex bag from the sampler.
5. Using a 5-gallon bucket with about 3-gallons of tap water, immerse the sample bag several times to clean the bag and to concentrate the sample in the bottom of the bag for ease of transfer to sample bottles.
6. Transfer the bedload sediment sample into a one-liter widemouth Nalgene bottle by using a large stem funnel.
7. Label the sample bottle and record in the field log book the sampling time, date, and cross section locations that were sampled. See numbering SOP.
8. Place the **composite sample** on ice for transport to the laboratory.
9. Reattach the bag to the sampler for the next sampling time interval.
10. Remove the bedload sampler from the cableway and attach the DH-59 sampler for the next sampling time interval.

Standard Operating Procedures
Field Sample Numbering System

PURPOSE

To label storm event stream samples, sediment cores collected from stream cross sections and monthly grab samples for analysis. Data will be used to develop sampling and modeling protocols for determining sediment and nutrient TMDL's.

Each sampling team shall have a team leader or designee who will be responsible for making sure all samples are collected, properly labeled, recorded and taken to the Field Research Annex (FRA) for analysis.

As Isco samples are logged in at the FRA, approximately, every 10th sample shall be identified with red tape to indicate a QA sample for duplicate analysis in the laboratory. The QA designated samples shall have a Q located at the end of the sample ID. For field and laboratory duplicate samples, a Q shall be located at the end of the sample ID. For all other samples, an X shall be placed at the end of the sample ID as a place holder.

SUMMARY OF PROCEDURE

Record Keeping:

For record keeping use "rite in the rain" notepads and record the site number, sample type (bedload, depth integrated, grab), stream cross section location (if appropriate) or Isco sampler letter (if sample is from one of the Iscos), the date, and time (military).

Label the depth integrated and bedload sample bottles using a Sharpie permanent marking pen using the following instructions:

Each container shall be labeled with the following numbering system:

Site Number (first number of label, 1 digit):

1 = Ila
2 = Double Branch
3 = Highway 172 (cableway)
4 = Brush Creek
5 = Highway 22 (cableway proposed)
6 = Clouds Creek (cableway)
7 = Carlton (cableway proposed)

Sample Type (next three letters of label):

DI = vertically water depth-integrated samples, segregated by cross-section (collected with the DH48 hand-held sampler or line/cable-delivered DH59 for non-wadeable streams) with the third place designated as the cross-sectional position (see below).
Bd = bedload (taken with 6-inch bedload samplers (whether taken by wading or withcrane and largest sampler) will be sampled at appropriate cross-sectional locations but all cross-sectional sub-samples *will be combined into a composite sample with the third space occupied by the letter X*
IsG = baseline grab samples taken with Isco
GRB = baseline grab samples taken by wading into stream

Cross section (third sample type letter):
(designated with depth integrated suspended sediment samples **(DI only)**:

A = first sampling site located on right side facing downstream
B = next interval equally spaced facing downstream
C = next interval equally spaced facing downstream
D = next interval equally spaced facing downstream
E = next interval equally spaced facing downstream
F = next interval equally spaced facing downstream
G = next interval equally spaced facing downstream
H = next interval equally spaced facing downstream

Date (next six numbers of sample label): = month, day, year

Time (next four numbers in the label): = military time

Last letter in the label: = X is a place holder indicating a regular sample for analysis
Q represents a field or laboratory duplicate sample for Quality Assurance (QA) analysis.

EXAMPLE LABELS USING:

Site Number = 1-7

Sample Type = bedload (BdX)
Depth integrated [DI (sections A-H)]
Stream cross section location = A through H (for depth integrated suspended sediments)

Sample Type	= Grab, baseline samples only; IsG, or GRB, (if taken manually)
	Isco (appropriately labeled from the respective Isco sampler as IsA or IsB)
Date	= month, day, year without slashes (020201)
Time	= military time in hours and minutes without punctuation (2330)
Q	= QA sample analysis
X	= regular sample analysis

EXAMPLE LABELING

Background Samples for suspended sediment and nutrients prior to event:

1IsG0125010900X
Ila site, grab sample collected using the Isco sampler, on Jan. 25, 2001, at 9:00 AM

1IsG0125010900**Q**
Ila site, grab sample collected using the Isco sampler, on Jan, 25, 2001, at 9:00 AM (QA sample)

1GRB0202011630X
Ila site, manually acquired grab sample, collected in sample bottle on February 2, 2001, at 4:30 PM

Bedload Samples:

3BdX0125010100X
Hwy 172 site, bedload sediment sample composite of all cross-sections sampled, on Jan. 25, 2001, at 1:00 AM

3BdX0125010100**Q**
Hwy 172 site, bedload sediment sample composite of all cross-sections sampled, on Jan. 25, 2001, at 1:00 AM (QA sample)

Isco Samples:

2IsB0125011215X
Double Branch site, Isco sampler B, Jan. 25, 2001, at 12:15 PM

2IsB0125011215Q
Double Branch site, Isco sampler B, Jan. 25, 2001, at 12:15 PM (QA sample)

Depth Integrated Samples:

2DIC0125011445X

Double Branch site, depth integrated water sample @ cross-section position C, Jan. 25, 2001, at 2:45 PM

2DIC0125011445**Q**

Double Branch site, depth integrated water sample @ cross-section position C, Jan. 25, 2001, at 2:45 PM (QA sample)

3DIA0607012400X

Highway 172, depth integrated water sample @ cross-section position A, June 7, 2001 @ 12 mid-night

Standard Operating Procedures
Stream Cross Section Sample Numbering System

PURPOSE
To label stream cross section samples collected for analysis. Data will be used to develop sampling and modeling protocols for determining sediment TMDL's.

SUMMARY OF PROCEDURE
Record Keeping:
For record keeping use "rite in the rain" notepads and record the site number, stream cross section location, sample depth, the date, and time (military).

Label the sample bottles using a Sharpie permanent marking pen using the following instructions:

Each container shall be labeled with the following numbering system:

Storm Event Sampling Site Number (first number of label, 1 digit):
1 = Ila
2 = Double Branch
3 = Highway 172 (cableway)
4 = Brush Creek
5 = Highway 22 (cableway proposed)
6 = Clouds Creek (cableway)
7 = Carlton (cableway proposed)

Continue the numbering system for the remainder of the selected stream cross section sites (total is about 300)

Stream Cross section (second sample type letter):

A = first sampling site located on right side facing downstream (i.e. right bank)
B = next interval equally spaced facing downstream
C = next interval equally spaced facing downstream
D = next interval equally spaced facing downstream
E = next interval equally spaced facing downstream (i.e. left bank)

Date (next six numbers of sample label): = month, day, year

Time (last four numbers in the label): = military time

EXAMPLE LABELS USING:

Site Number = 1-300
Stream cross section location = A through E
Date = month, day, year without slashes (020201)
Time = military time in hours and minutes without punctuation (2330)

PURPOSE

The data of the particle size analysis will be applied to the modeling of Total Maximum Daily Loads (TMDL).

SUMMARY OF PROCEDURE

Particle size analysis measures the size distribution of particles suspended in a liquid or suspended in air. Particle size analysis at the Environmental Research Division requires analysis of particles suspended in water only.

About one gram of dispersing agent is added to the soil sample and mixed (stirred) for several minutes to enhance separation or dispersion of aggregates. The sample is then poured and washed into a stack of sieves for separation: 8mm, 4mm, and 2mm. Each one of the four size groups is dried in a drying oven at 103°C to 105°C to get the Dry Weight followed by ignition in a muffle furnace at 550°C to get the weight of Loss on Ignition (LOI).
Before drying, a subsample of the less than 2-mm size sample is injected into a particle size analyzer to get the distribution of sand, silt, and clay. An identical size sample is pipetted into an empty preweighed 50-mL crucible to obtain the equivalent weight injected into the particle size analyzer.

INTERFERENCES

There should not be any major interferences since each of the phases of separation is simple and straight forward.

EQUIPMENT

The particle size analysis is divided into two major parts. Part one consists of the manual separation (sieving) and part two consists of the particle size analysis of the less than 2-mm fraction using a particle size analyzer.

Part One: Three sieves, 2 inches high and 8 inches in diameter, with sieve openings of 2mm, 4mm, and 8mm. One sieve collection pan.
Pint wash bottle.
Sodium metaphosphate.
Sink with water faucet sprayer.
250-mL porcelain crucibles.
Spoon scraper.
Balance (top loader) weighing to one decimal place in grams.
Drying oven (103°C to 105°C).
Muffle furnace (550°C).

Part Two: One five-inch diameter sieve with 2-mm sieve openings.
Particle Size Analyzer, Coulter LS200 Series instrument with a Fluid Module and Printer.
Most of the equipment in Part One.
Three sizes of plastic pipets: 1mL, 5mL, and 10mL. Each of the pipets has the tip cut off.
50-mL porcelain crucibles.
Balance (top loader) weighing to three decimal places in grams.

METHODOLOGY

The sample is submitted to the laboratory usually in a one-quart plastic bottle. Add one gram of dispersing agent (sodium metaphosphate) and stir for several minutes to enhance separation of the aggregates. Pour and rinse the bottle clean in a stack of sieves with the 8-mm openings on the top followed by the 4-mm and 2-mm sieves. All three sieves sit in a sieve receiver pan. Use the pint wash bottle and the spoon scraper to wash the sample through the 8-mm sieve. Pour the content of the 8-mm sieve (larger than 8mm) into a preweighed empty and marked 250-mL porcelain crucible. Do the same with the 4-mm and 2-mm sieves. Pour the content of the receiver pan (less than 2mm) back into the original sample bottle. Dry the 250-mL crucible plus content overnight in a drying oven at 103°C to 105°C. Cool in a desiccator til conditioned (several hours). Reweigh crucible. The weight difference is the Dry Weight. Put the crucible in a muffle furnace and heat at 550°C for one hour. Cool and condition in a desiccator for several hours. Reweigh crucible. The loss in weight from the Dry Weight is the Loss on Ignition (LOI). Calculate the LOI in percent by:

$$\text{LOI (\%)} = (\text{LOI weight} \times 100)/\text{Dry Weight}$$

The less than 2-mm sample should settle over night in the refrigerator before analyzing with the Coulter LS200. The analyst must estimate which size pipet to use for sampling. If the sample appears to contain much clay, use the small pipet. If the sample appears to contain much sand, use the larger pipets. The analyst should be familiar with the general operation of the Coulter LS200. The following details the operation of the LS200 for the TMDL Project's Bedload and Core samples:

PARTICLE SIZE ANALYZER OPERATION
COULTER LS200

Turn water on and let air out (both gauges should have 30 psi or less).
The instrument stays on all the time. If it is turned off, it needs to be on for about four hours before use. The main switch is on the lower left.

Turn the computer on, click: Cancel.
Click: Use Optical Module at start of screen (this is mandatory).
Click: ok.
Click: Control. Click: Turn pump on.
Many things can be done under Control.
Click: File. Under "Change Directory", click either bedload samples or core samples or create directory. The selected directory should appear in the lower left corner of the screen.
Click: Preferences and load Preferences.

Click: Run.
Click: Run Cycle.
Click: New Sample.
Click: Start (on run cycle).
The instrument will go through its routine checks. Have the small 2-mm sieve sitting on top of the water reservoir.
When zero obscuration is shown, add sample to between 8 and 12 % obscuration using the proper size pipette. Add an equivalent amount of sample into a 50-mL preweighed crucible.
Click: Done.
Type in required information (sample ID, etc.).
Click:ok. Sample will be analyzed and the result printed out.
Shut down:
Click: Control. Click: Turn pump off.
Click: Shut off Optical Module under Run.
Click: File. Click Exit (always exit under File).
Turn water off and bleed pressure off. Turn the computer off.
Dry the 50-mL crucible in the oven at103°C to 105°C over night. Cool in the desiccator til conditioned and reweigh.
Pour and wash the less than 2-mm sample from the original sample bottle into a preweighed 250-mL porcelain crucible after having poured off most of the supernatant water. Continue weighing and heating as explained under Part One.

METHOD CALIBRATION
Generally, the LS200 instrument performs its own calibration before each analysis. A sand standard is prepared in the laboratory from sand that is sieved through a 500-um sieve followed by a 250-um sieve. The standard is called Sand Standard 250-500um and is run every 10 to 15 samples. A statistical analysis was done with the Sand Standard as follows:

n	=	15
mean	=	482.8um
standard deviation	=	4.92um
3 x standard deviation	=	14.8um
mean	=	482.8 +/- 14.8um

When the Sand Standard falls within the range of the mean, the instrument's performance is assumed to be acceptable.

QUALITY CONTROL
Quality control measures should include:

a. Analysis of a duplicate sample every 10 to 15 samples if sampling permits.
b. Analysis of a standard every 10 to 15 samples.
   Samples for duplicate analysis will be marked with red tape. If QA samples are not identified, check with log-in personnel. The duplicate sample for QA shall be labeled with a Q in back of the label. The following is an example label: 2IsB0125011215Q
c. Calibration of the analytical balances once a year and weekly checks of the accuracy of the balances by the analyst.

Each run's data are stored on the instrument's chem-station. However, back-up copies will be made to floppy or zip disk at regular intervals.

SAMPLE COLLECTION
Sample collection is discussed in a separate SOP.

SAMPLE HANDLING AND PRESERVATION
When samples are collected they should be put on ice, delivered to the laboratory as soon as possible and stored in a freezer until analysis if storage requires more than seven days. Otherwise store under refrigeration. Preservation of the sample with acid should be avoided to minimize the handling and preserve the integrity of the sample.

SAMPLE PREPARATION FOR ANALYSIS
The preparation of the sample for analysis is discussed under Methodology.
The frozen or refrigerated sample should be brought up close to room temperature before processing.

SOURCES OF ERROR AND VARIABILITY

Because of the crude way of processing the sample, there will be a larger variability in the reproducibility. However, the Sand Standard should not be affected.

PERSONNEL QUALIFICATIONS

The sieving process is a straight forward one and can be learned quickly by a technician. The operation of the LS200 instrument requires primarily computer literacy. It can be operated by an experienced technician who has gone through a hands-on training period until he/she is thoroughly familiar with the many different aspects of the LS200 instrument.

REFERENCES

Coulter Corporation. 1994. Coulter LS Series Product Manual. Coulter Corporation, Miami, Florida.

Standard Methods for the Examination of Water and Wastewater, 20th Edition 1998, pp. 2-61 to 2-69.

PURPOSE

The data of the carbon analyses will be applied to the modeling of Total Maximum Daily Loads (TMDL).

SUMMARY OF PROCEDURES

The total carbon (TC) combustion tube is filled with oxidation catalyst and heated to 680°C. The carrier gas is high purity air, TOC grade, and flows through the tube at a rate of 150 mL/min. The component in the sample is decomposed to become CO_2 and flows through an Inorganic Carbon (IC) reaction vessel and through a halogen scrubber into the Non-Dispersive Infrared gas analyzer (NDIR) where CO_2 is detected. The measurement of non-purgeable organic carbon (NPOC) is performed by pretreating the sample with acid, 2 N hydrochloric, and sparging with carrier gas before sending sample to the detector.

INTERFERENCES

Carrier gas containing more than 1ppm of CO_2, CO and HC would interfere in accurate measurements.

INSTRUMENTATION

The instrument is a Shimadzu Total Organic Carbon Analyzer model TOC-5050A with an ASI-5000A autosampler. These are controlled by a Windows based TOC Control software.

METHODOLOGY

The previously refrigerated sample is poured into a 15-mL centrifuge tube and centrifuged for 20 minutes at 4000 rpm. About 5 mL of sample is poured into a 10-mL sample vial and the remainder of the sample is used for other analyses. The sample is automatically acidified with 25 uL of 2 N HCl to give a pH of about 2 and is then sparged for five minutes with high quality, TOC grade, compressed air. The instrument automatically injects with a 250-uL syringe the amount of sample needed for correct peak size and concentration. The measurement is of Non-purgeable Organic Carbon (NPOC) and is substituted for the TOC/TC method which requires each sample to be run twice. The NPOC method is approved in TOC-related standard methods and referred to in water quality-related test methods.

CALIBRATION METHOD

Stock solution of standards are made according to instructions on page 54 in the instruction manual. Desired concentrations will be made from this standard and new standard curves will be run before each sampling event. The output signal of the NDIR is linearized for all ranges. Neither the combustion system nor the reaction system provides factors causing the concentration-output characteristics to be deviated from linearity. Therefore one or two point calibration curve is satisfactory for measurement according to the Shimadzu manual. A three point curve will be used in our laboratory.

SAMPLE COLLECTION

Sample Collection is discussed in a separate SOP.

SAMPLE HANDLING AND PRESERVATION

When samples are collected, they should be put on ice, delivered to the laboratory as soon as possible and stored under refrigeration until analysis. The time between collection and analysis should be less than 48 hours.

TROUBLESHOOTING AND MAINTENANCE

Troubleshooting and maintenance will be performed according to the Instruction Manual and the TOC Control Software Manual.

PERSONNEL QUALIFICATIONS

The Total Organic Carbon analyzer can be operated by experienced technicians who have gone through a hands-on training period until they are thoroughly familiar with the different aspects of the analysis and the computer programming handling of the system and automatic sampler.

SCOPE AND APPLICATION

The membrane filter technique is a basic procedure used in the detection of coliform bacteria. The fecal coliform test may be applicable to investigations of drinking water, stream pollution, raw water sources, wastewater treatment systems, bathing waters, sea waters, and general water quality monitoring.

SUMMARY OF METHOD

The procedure involves filtering three different volumes of a sample, which is determined by referring to table 9222:III of SM 9222 D, plating the filter on m-FC medium, and then incubating the sample at the desired temperature of 44.5 ± 0.2°C for 24 ± 2 hours. The standard volume of drinking water to be analyzed is 100 mL. This may be distributed among multiple membranes.

The best readable plate is one that contains 20-60 BLUE colonies per plate.

INTERFERENCES

Water samples containing colloidal or suspended particulate material can clog the membrane filter, thereby preventing filtration, or cause spreading bacterial colonies which could interfere with the identification of target colonies.

Turbidity caused by the prescence of algae may not permit testing of a sample volume sufficient to yield significant results.

Low coliform estimates may be caused by the presence of high numbers of noncoliforms or toxic substances.

HEALTH AND SAFETY PROCEDURES

Adherence to laboratory safety procedures described in the *SESD Safety, Health and Environmental Management Program (SHEM) Procedures and Policy Manual*, Section 2.5 is required.

SPECIAL PROCEDURES

Residual chlorine in chlorinated samples should be neutralized with 0.1 mL of 10% sodium thiosulfate ($Na_2S_2O_3$).

When less than 10 mL of a sample is used, add approximately 10 mL of sterile dilution water to the funnel before filtration to aid in dispersing the bacterial suspension over the entire filtering surface.

ANALYST TRAINING

An Initial Demonstration of Capability/Performance (IDC or IDP) shall be performed prior to the analysis of any samples, and with a significant change in instrument type, personnel, matrix, or test method where applicable.

Analysts must demonstrate the ability to generate acceptable test results with this method by preparing and analyzing a minimum of four aliquots of a quality control sample either concurrently or over a period of days.

The capability of the analyst to produce acceptable results will be determined by their ability to obtain a percent recovery of 80-120% and to obtain a relative standard deviation of ≤20%.

REAGENTS AND STANDARDS

Dehydrated, and commercially prepared medium may be used.

Laboratory prepared media should be batched tested for performance with positive and negative culture controls before it is used for analysis and should be prepared in accordance with *SM 9050.*

Dilution water should be prepared in accordance with *SM 9050 B and C.*

APPARATUS AND MATERIALS

Culture dishes, pre-sterilized disposable plastic dishes with tight fitting lids.

Filtration units- Wrap the assembly in heavy aluminum foil, sterilize by autoclaving, and store until use. Alternately, expose all surfaces of the previously cleaned assembly to ultraviolet radiation (2 minutes) for the initial sanitization before use in the test procedure, or before reusing units between successive filtration series.

Pre-sterilized and certified membrane filters and absorbent pads.

Incubator, set at 44.5 ± 0.2°C.

Sample and dilution bottles.

Pipets and graduated cylinders.

Smooth flat forceps, without corrugations on the inner sides of the tips. Sterilize before use by dipping in 95% ethyl alcohol and then pass through a flame.

Apparatus should be maintained in accordance with *SM 9030.*

SAMPLE COLLECTION AND PRESERVATION

Collect samples in clean wide-mouth plastic bottles with non-leaking caps and non-toxic liners containing sodium thiosulfate.

Hold samples at <10°C during a maximum transport time of 6 hours.

Refrigerate samples upon arrival in the laboratory and be processed within 2 hours of arrival.

When transport conditions necessitate delays in delivery of samples longer than 6 hours, consider using field laboratory facilities located near the site of collection.

Samples should be collected in accordance with SM *9060 A and B.*

SAMPLE HOLDING TIME

Source samples should be not be held more than 6 hours from time of collection to the time analyses are initiated.

Drinking water samples should be analyzed within 30 hours of collection.

METHOD CALIBRATION

There are no calibrations associated with this method.

Check the temperatures in the incubator twice daily to insure that it is functioning properly.

Maintain sterility with equipment media and technique.

SAMPLE ANALYSIS AND PROCEDURE

Place a pad in the culture dish and saturate with at least 2.0 mL m-FC medium. Carefully remove excess medium by decanting the plate.

Place the prepared filter directly on the pad, filter the appropriate volumes of sample, place the top on the dish, invert the dish and incubate for 24 ± 2 hours at 44.5 ± 0.2°C.

After filtering a series of 10 samples, filter 100 mL of sterile rinse water to check for possible cross-contamination or contaminated rinse water, and incubate under the same conditions as the samples.

QUALITY CONTROL

Laboratory Reagent Blanks (LRB) will be performed at a frequency of at least one per batch. The batch may or may not consist of 20 or more samples which will be analyzed together as a group.

Laboratory control samples shall be performed at a frequency of one per batch.

At least one sample must be analyzed in duplicate at a frequency of one in 10 samples.

DATA ANALYSIS AND CALCULATION

Direct plating methods such as the membrane filter procedure permit a direct count of coliform colonies.

The best readable plate is counted for its colonies, the colonies are verified, and the density is calculated using the count and the volume of sample filtered. The coliform density is reported conventionally as membrane filter count per 100 mL.

POLLUTION PREVENTION

See *SESD Safety, Health and Environmental Management Program (SHEM) Procedures and Policy Manual*, Section 5.8.

WASTE MANAGEMENT

Waste management and disposal procedures are described in the *SESD Safety, Health and Environmental Management Program (SHEM) Procedures and Policy Manual*, Section 2.5.

REFERENCES

American Public Health Association. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, 1998.

Science and Ecosystem Support Division, Region 4, U.S. Environmental Protection Agency. September, 2000. *Ecological Assessment Branch Laboratory Operations and Quality Assurance Manual*.

Science and Ecosystem Support Division, Region 4, U.S. Environmental Protection Agency. May, 1998. *Safety, Health and Environmental Management Program Procedures and Policy Manual.*

Procedural Section

Scope and Application

This enzyme substrate test utilizes hydrolyzable substrates for the simultaneous detection of total coliform bacteria and *Escherichia coli* enzymes. The MI Broth used in this analysis, contains a nutritive lactose-based medium containing inhibitors to eliminate the growth of non-coliform bacteria. This method is recommended for the analysis of drinking and source water samples, chemical processing and pharmaceutical manufacturing waters.

Summary of Method

The procedure involves filtering three different volumes of a sample, which may be determined by referring to table 9222:III of SM 9222 D, plating the filter on a selective and differential medium, and then incubating the sample at the desired temperature of

$35 \pm 0.5^{\circ}C$ for 22 to 24 hours.

The standard volume of drinking water to be analyzed is 100 milliliters. This may be distributed among multiple membranes.

Total coliform bacteria present will produce fluorescent colonies upon exposure to longwave ultraviolet light (366 nm) after primary culturing on MI agar and *E. coli* will produce blue colonies under ambient light after primary culturing on MI agar.

Interferences

Water samples containing colloidal or suspended particulate material can clog the membrane filter, thereby preventing filtration, or cause spreading bacterial colonies which could interfere with the identification of target colonies.

Turbidity caused by the prescence of algae may not permit testing of a sample volume sufficient to yield significant results.

Low coliform estimates may be caused by the presence of high numbers of non coliforms or toxic substances.

Health and Safety Procedures

Adherence to laboratory safety procedures described in the *SESD Safety, Health and Environmental Management Program (SHEM) Procedures and Policy Manual*, Section 2.5 is required.

Special Procedures

Residual chlorine in chlorinated samples should be neutralized with 0.1 mL of 10% sodium thiosulfate ($Na_2S_2O_3$).

When less than 10 mL of a sample is used, add approximately 10 mL of sterile dilution water to the funnel before filtration to aid in dispersing the bacterial suspension over the entire filtering surface.

Analyst Training

An Initial Demonstration of Capability/Performance (IDC or IDP) shall be performed prior to the analysis of any samples, and with a significant change in instrument type, personnel, matrix, or test method where applicable.

Analysts must demonstrate the ability to generate acceptable test results with this method by preparing and analyzing a minimum of four aliquots of a quality control sample either concurrently or over a period of days.

The capability of the analyst to produce acceptable results will be determined by their ability to obtain a percent recovery of 80-120% and to obtain a relative standard deviation of $\leq$20%.

Reagents and Standards

Commercially prepared media in liquid form (MI Broth) may be used.

Laboratory prepared media should be batched tested for performance with positive and negative culture controls before it is used for analysis and should be prepared in accordance with *SM 9050.*

Dilution water should be prepared in accordance with *SM 9050 B and C.*

Apparatus and Materials

Culture dishes, pre-sterilized disposable plastic dishes with tight fitting lids.

Filtration units- Wrap the assembly in heavy aluminum foil, sterilize by autoclaving, and store until use. Alternately, expose all surfaces of the previously cleaned assembly to ultraviolet radiation (2 minutes) for the initial sanitization before use in the test procedure, or before reusing units between successive filtration series.

Presterilized and certified membrane filters and absorbent pads.

Incubator, set at 35 ± 0.5°C.

Sample and dilution bottles.

Pipets and graduated cylinders.

Smooth flat forceps, without corrugations on the inner sides of the tips. Sterilize before use by dipping in 95% ethyl alcohol and then pass through a flame.

Apparatus should be maintained in accordance with *SM 9030.*

Sample Collection and Preservation

Collect samples in clean wide-mouth plastic bottles with non-leaking caps and non-toxic liners containing sodium thiosulfate

Hold samples at <10°C during a maximum transport time of 6 hours.

Refrigerate samples upon arrival in the laboratory and be processed within 2 hours of arrival.

When transport conditions necessitate delays in delivery of samples longer than 6 hours, consider using field laboratory facilities located near the site of collection.

Samples should be collected in accordance with SM *9060 A and B.*

Sample Holding Time

Source samples should not be held more than 6 hours from time of collection to the time analyses are initiated.

Drinking water samples should be analyzed within 30 hours of collection.

Method Calibration

There are no calibrations associated with this method.

Check the temperatures in the incubator twice daily to insure that it is functioning properly.

Maintain sterility with equipment media and technique.

Sample Analysis and Procedure

Place a pad in the culture dish and saturate with at least 2.0 mL of medium. Carefully remove excess medium by decanting the plate.

Place the prepared filter directly on the pad, filter the appropriate volumes of sample, place the top on the dish, invert the dish and incubate for 22 to 24 hours at 35 ± 0.5°C.

After filtering a series of 10 samples, filter 100 mL of sterile rinse water to check for possible cross-contamination or contaminated rinse water, and incubate under the same conditions as the samples.

Quality Control

Laboratory Reagent Blanks (LRB) will be performed at a frequency of at least one per batch. The batch may or may not consist of 20 or more samples which will be analyzed together as a group.

Laboratory control samples shall be performed at a frequency of one per batch.

At least one sample must be analyzed in duplicate at a frequency of one in 10 samples.

Intralaboratory quality assurance and control should be in accordance with *SM 9020*.

Data Analysis and Calculation

Direct plating methods such as the membrane filter procedure permit a direct count of coliform colonies.

The best readable plate is counted for its colonies, the colonies are verified, and the density is calculated using the count and the volume of sample filtered. The coliform density is reported conventionally as membrane filter count per 100 mL.

Pollution Prevention

See *SESD Safety, Health and Environmental Management Program (SHEM) Procedures and Policy Manual*, Section 5.8.

Waste Management

Waste management and disposal procedures are described in the *SESD Safety, Health and Environmental Management Program (SHEM) Procedures and Policy Manual*, Section 2.5.

References

American Public Health Association. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, 1998.

Science and Ecosystem Support Division, Region 4, U.S. Environmental Protection Agency. September, 2000. *Ecological Assessment Branch Laboratory Operations and Quality Assurance Manual*.

Science and Ecosystem Support Division, Region 4, U.S. Environmental Protection Agency. May, 1998. *Safety, Health and Environmental Management Program Procedures and Policy Manual.*

Procedural Section

Scope and Application

This test utilizes Enterolert to detect and quantify enterococci in both marine and recreational fresh water with results in 24 hours.

Summary of Method

The procedure involves aseptically adding the reagent to the sample, pouring the sample into the Quanti-Tray (counts from 1-200) or Quanti-Tray 2000 (counts from 1-2,419), sealing in the Quanti-Tray Sealer, and then incubating at 41° C for 24 hours.

The standard volume of water to be analyzed is 100 milliliters.

Wells containing enterococci will appear flourescent, and the Most Probable Number (MPN) table will be used to determine the count.

Interferences

Turbidity caused by the presence of algae may not permit testing of a sample volume sufficient to yield significant results.

Low estimates of enterococci may be caused by the presence of toxic substances.

Health and Safety Procedures

Adherence to laboratory safety procedures described in the *SESD Safety, Health and Environmental Management Program (SHEM) Procedures and Policy Manual*, Section 2.5 is required.

Special Procedures

Residual chlorine in chlorinated samples should be neutralized with 0.1 mL of 10% sodium thiosulfate ($Na_2S_2O_3$).

Analyst Training

An Initial Demonstration of Capability/Performance (IDC or IDP) shall be performed prior to the analysis of any samples, and with a significant change in instrument type, personnel, matrix, or test method where applicable.

Analysts must demonstrate the ability to generate acceptable test results with this method by preparing and analyzing a minimum of four aliquots of a quality control sample either concurrently or over a period of days.

The capability of the analyst to produce acceptable results will be determined by their ability to obtain a percent recovery of 80-120% and to obtain a relative standard deviation of $\leq$20%.

Reagents and Standards

Commercially prepared media (Enterolert) may be used.

Dilution water should be prepared in accordance with *SM 9050 B and C*.

8.0 Apparatus and Materials

Quanti-Tray or Quanti-Tray 2000, and Quanti-Tray Sealer

Incubator, set at 41° C

Sample and dilution bottles.

Pipets and graduated cylinders.

9.0 Sample Collection and Preservation

Collect samples in clean wide-mouth plastic bottles with non-leaking caps and non-toxic liners containing sodium thiosulfate.

Hold samples at <10°C during a maximum transport time of 6 hours.

Refrigerate samples upon arrival in the laboratory and be processed within 2 hours of arrival.

When transport conditions necessitate delays in delivery of samples longer than 6 hours, consider using field laboratory facilities located near the site of collection.

Samples should be collected in accordance with SM *9060 A and B.*

Sample Holding Time

Source samples should not be held more than 6 hours from time of collection to the time analyses are initiated.

Drinking water samples should be analyzed within 30 hours of collection.

Method Calibration

There are no calibrations associated with this method.

Check the temperatures in the incubator twice daily to insure that it is functioning properly.

Maintain sterility with equipment, media, and technique.

Sample Analysis and Procedure

Aseptically add pre-weighed reagent to sample.

Pour into Quanti-Tray or Quanti-Tray 2000.

Seal in Quanti-Tray Sealer.

Incubate for 24 hours.

Quality Control

Laboratory Reagent Blanks (LRB) will be performed at a frequency of at least one per batch. The batch may or may not consist of 20 or more samples which will be analyzed together as a group.

Laboratory control samples shall be performed at a frequency of one per batch.
At least one sample must be analyzed in duplicate at a frequency of one in 10 samples.
Intralaboratory quality assurance and control should be in accordance with *SM 9020*.

Data Analysis and Calculation

Detecting and quantifying enterococci is achieved by observing a change in fluorescence in the well of the Quanti-Tray. Colorless results indicate a negative test.

A most probable number (MPN) table is used to determine the enterococci count.

Pollution Prevention

See *SESD Safety, Health and Environmental Management Program (SHEM) Procedures and Policy Manual*, Section 5.8.

Waste Management

Waste management and disposal procedures are described in the *SESD Safety, Health and Environmental Management Program (SHEM) Procedures and Policy Manual*, Section 2.5.

References

American Public Health Association. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition, 1998.

Science and Ecosystem Support Division, Region 4, U.S. Environmental Protection Agency. September, 2000. *Ecological Assessment Branch Laboratory Operations and Quality Assurance Manual*.

Science and Ecosystem Support Division, Region 4, U.S. Environmental Protection Agency. May, 1998. *Safety, Health and Environmental Management Program Procedures and Policy Manual.*

IDEXX. IDEXX Water Testing Method, 2001.

Appendix 2: Storm Event Sampling Data Analysis

Data collected by EPA Region 4 contractors during the storm events of April 7th – April 11th, 2003 were analyzed to answer the following questions:

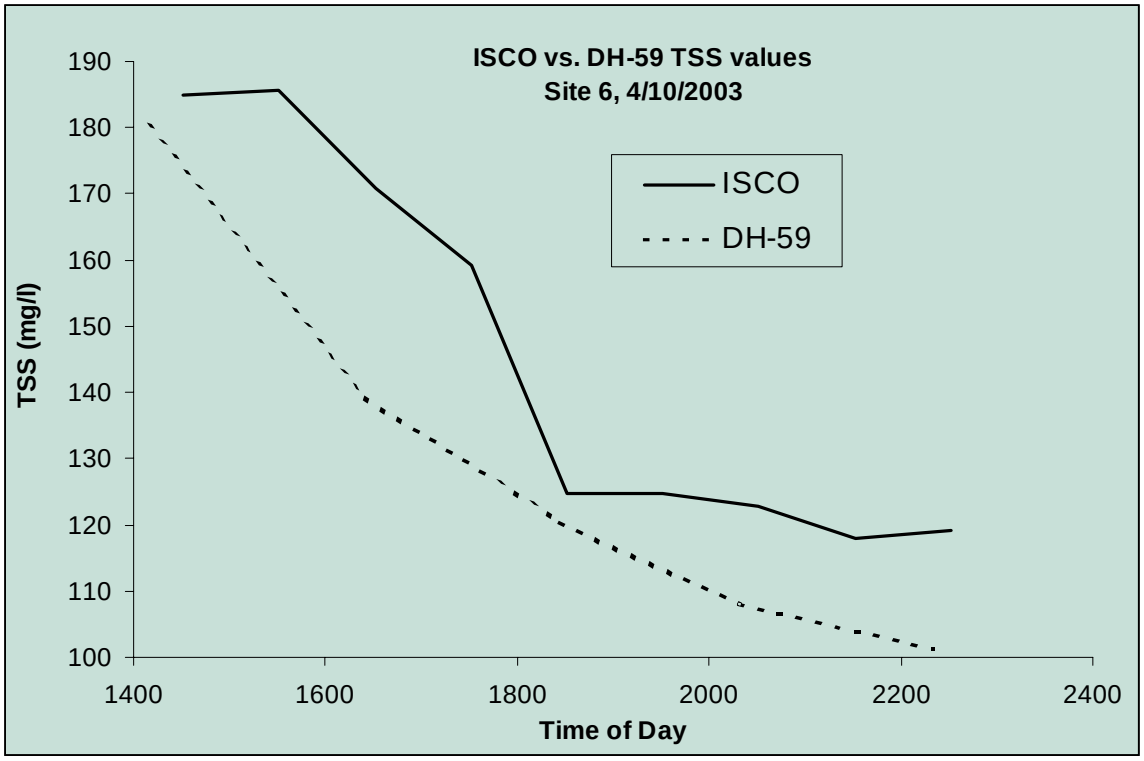
1. How similar are Total Suspended Solids (TSS) measurements gathered using the DH-59 and ISCO samplers? Figures A2.1 and A2.2 address this issue.
2. How much information is lost by adopting a two-hour ISCO sampling interval versus a one-hour interval? Figures A2.3 and A2.4 address this issue.
3. Given that multiple measures are taken across a stream reach when sampling stream TSS using the DH-59, is there a relationship between the mean and standard deviation of these multiple measures. Also, is there a relationship between the Coefficient of Variation (StDev/Mean) and the mean of these measures. The first issue is addressed by Figure A2.5; the second by Figure A2.6.
4. Are there significant differences between DH-59 TSS measurements taken at the edges of the stream versus the center of the stream, versus locations intermediate to the stream edge and center. This issue is addressed in Figure A2.7.

Figure A2.1 shows two example plots of DH-59 versus ISCO TSS measurements. Depth integrated TSS values at both sites tended to be smaller than ISCO TSS measures, and the overall scatterplot showing paired points for all sites across this sampling effort reiterates this point (Figure A2.2). The value of the intercept (11.3) and the overall slope of the relationship (0.8739) indicate that small ISCO TSS measures tended to be lesser than depth integrated measures, but as ISCO TSS values increase, they become greater than corresponding depth integrated TSS measures.

Figures A2.3 and A2.4 indicate a high correlation between actual and estimated ISCO TSS measures. Actual values were taken every hour, and estimated values were derived from these actual values in the following manner: an estimate for hour 2 was calculated by taking the mean of hour 1 and hour 3 values. In the same way, an estimate of the TSS value for hour 4 was derived using the mean of the values at hour 3 and hour 5. In Figure A2.4, estimates for hours 2 and 4 are paired with the actual measured values for hours 2 and 4. The 90% confidence interval on the slope of Figure A2.4 includes the value 1.0, but this fact is less relevant than the percentage of variance explained by the regression line (76%). If ISCO TSS values were taken every two hours instead of every hour, taking a mean to estimate the intermediate hour's TSS value would be unbiased (because the intercept is zero and the slope of the regression line is not significantly different from 1.0), but the accuracy of the estimate would be less than perfect (because R^2 is much less than 1.0).

Figures A2.5 and A2.6 indicate that as in-stream sediment increases, the standard deviation of multiple DH-59 measures of TSS across a stream section increase, but the coefficient of variation (StDev/Mean) of these measures declines. Basically, the standard deviation is increasing as the mean increases, but at a lesser rate, so their ratio declines as the mean increases.

The three plots of Figure A2.7 indicate no significant bias (90% confidence interval on the intercept includes the value 0.0) for TSS measures taken mid-stream, at the stream edge, and at locations between these two. The slope of the relationship between center and intermediate measurements is significantly different than 1.0 at the 90% confidence level, but this is entirely due to two observations with very large negative residuals (shown as triangles in the top-right plot). Without these outliers, the resulting slope is not significantly different from 1.0. All of this information leads us to include that TSS values for the sampled streams are uniform across a stream section.



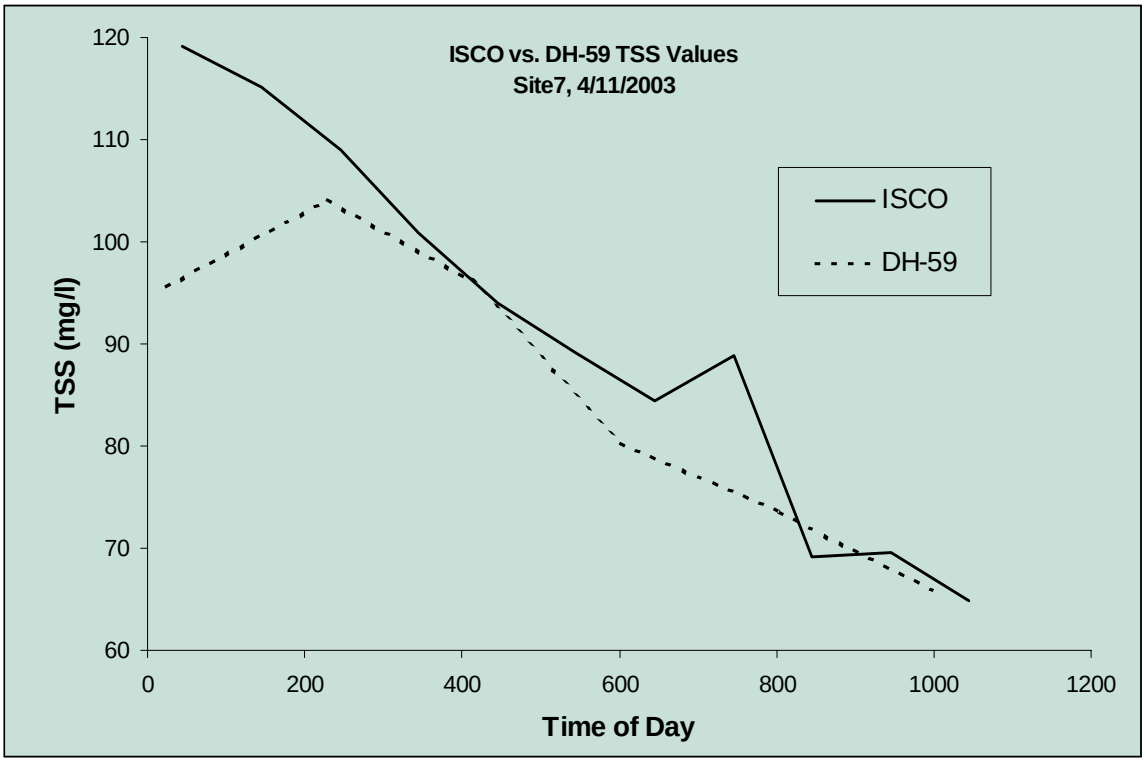


Figure A2.1. Comparison of Total Suspended Solid measurements using Depth-Integrated and ISCO samplers at two sampling sites.

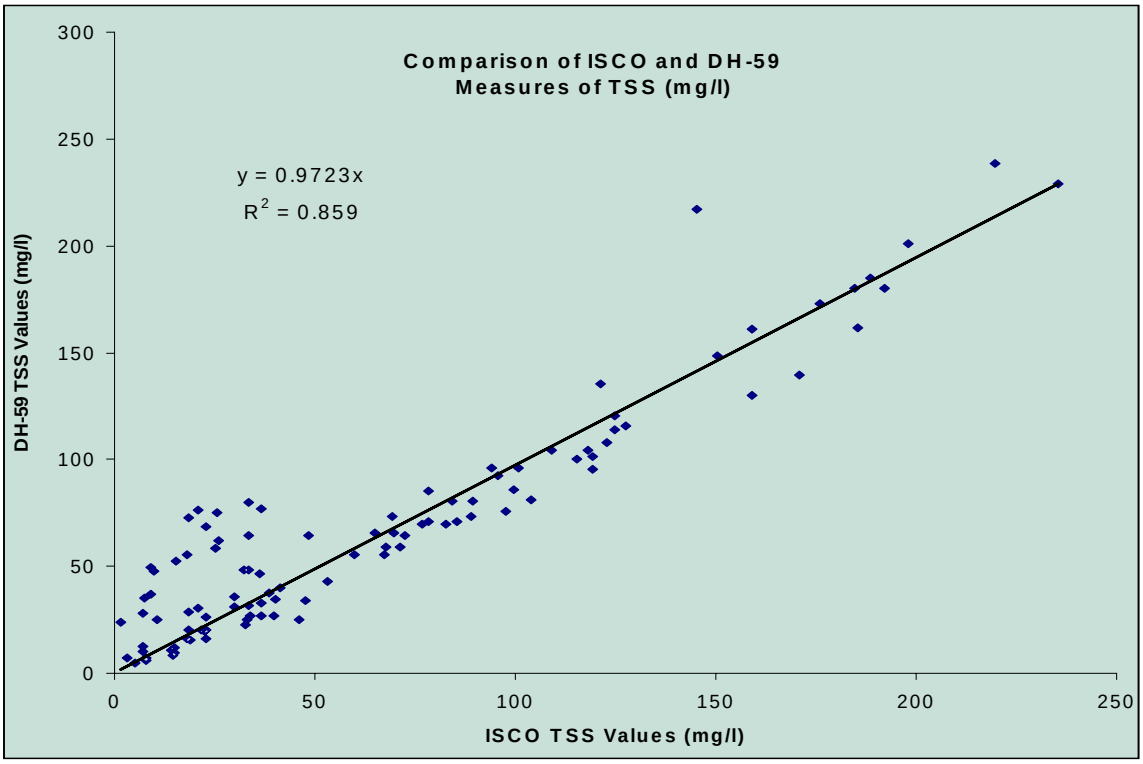


Figure A2.2. Estimated linear relationship between Depth Integrated and ISCO Total Suspended Solid measurements.

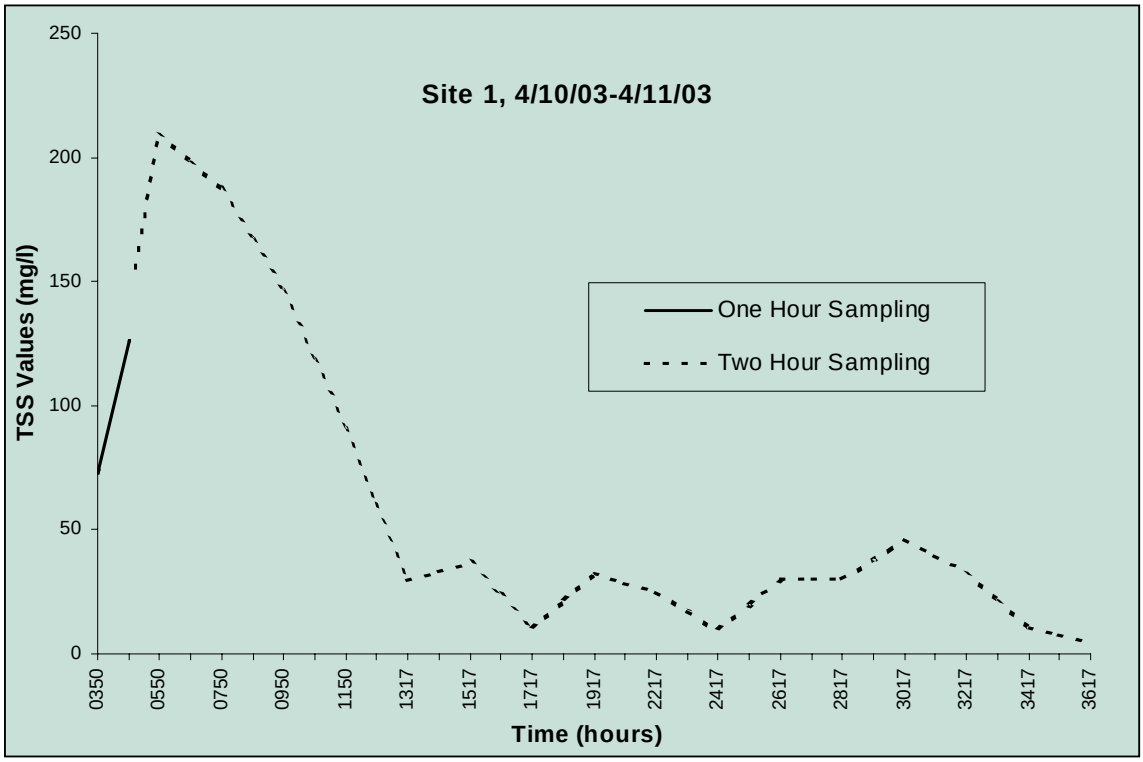


Figure A2.3. Comparison of one hour versus two-hour ISCO Total Suspended Solid measurements.

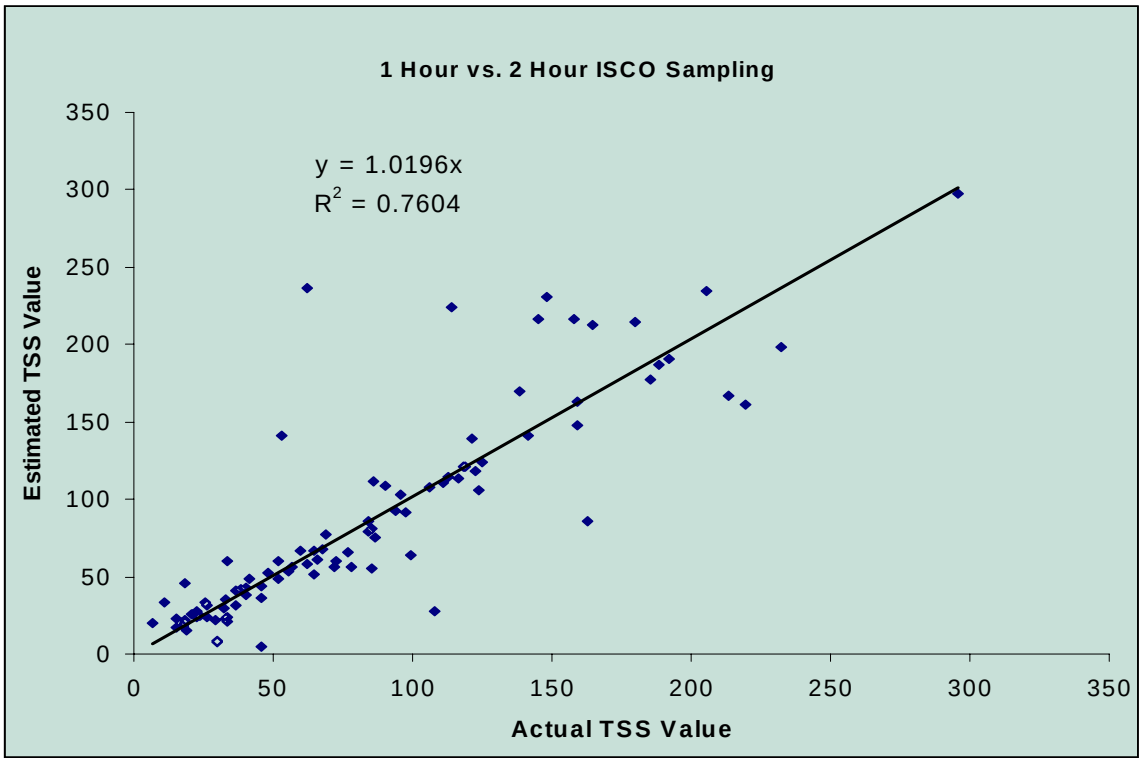


Figure A2.4. Linear relationship between actual and estimated ISCO Total Suspended Solid measurements.

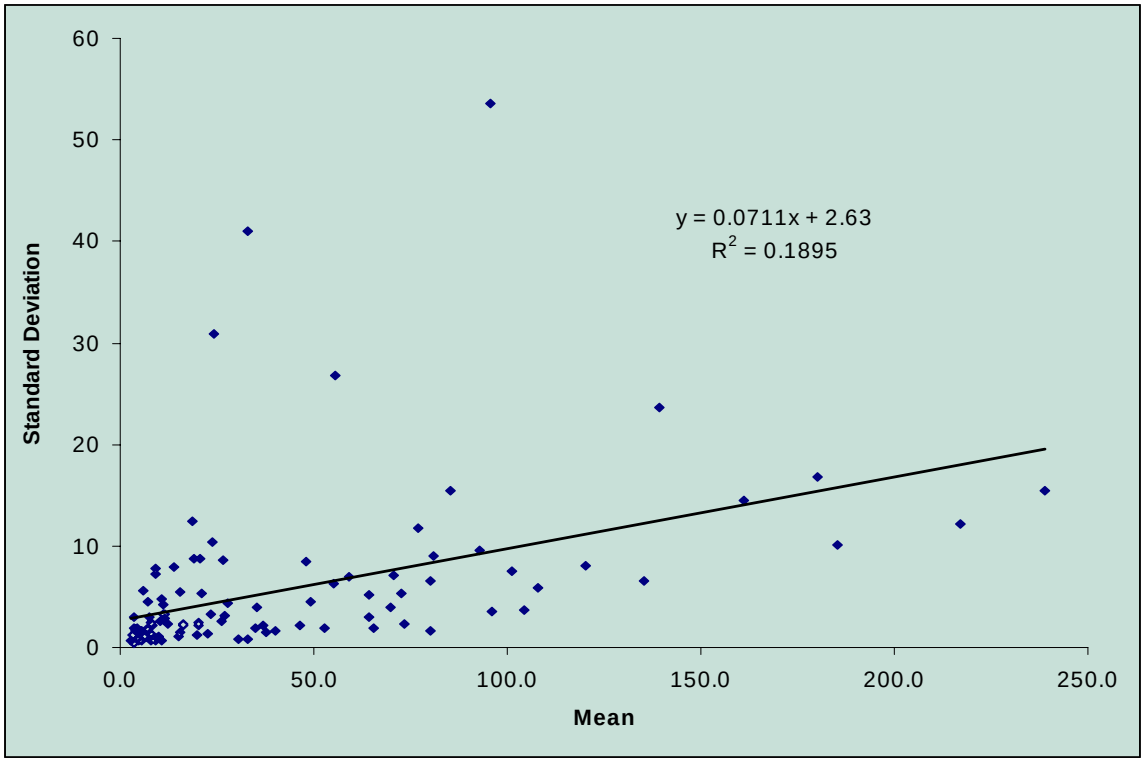


Figure A2.5. Relationship between the standard deviation and the mean of Depth Integrated Total Suspended Solids measurements.

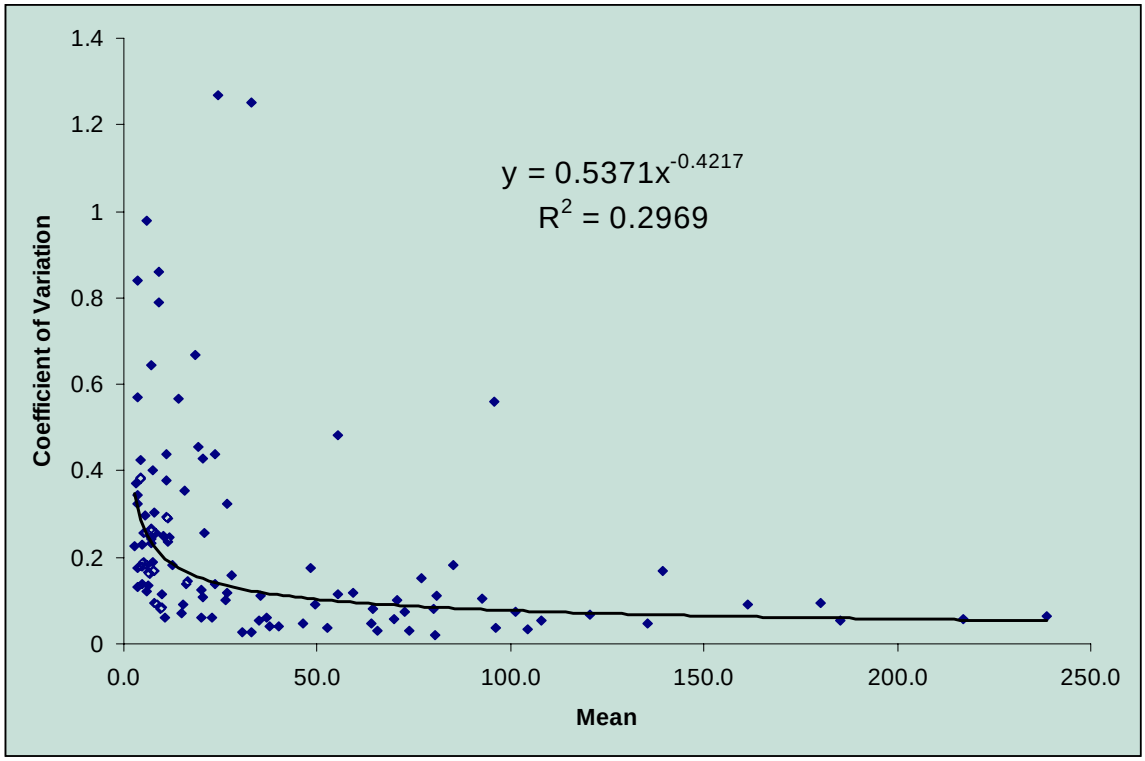


Figure A2.6. Relationship between the coefficient of variation and the mean of Depth Integrated Total Suspended Solids measurements.

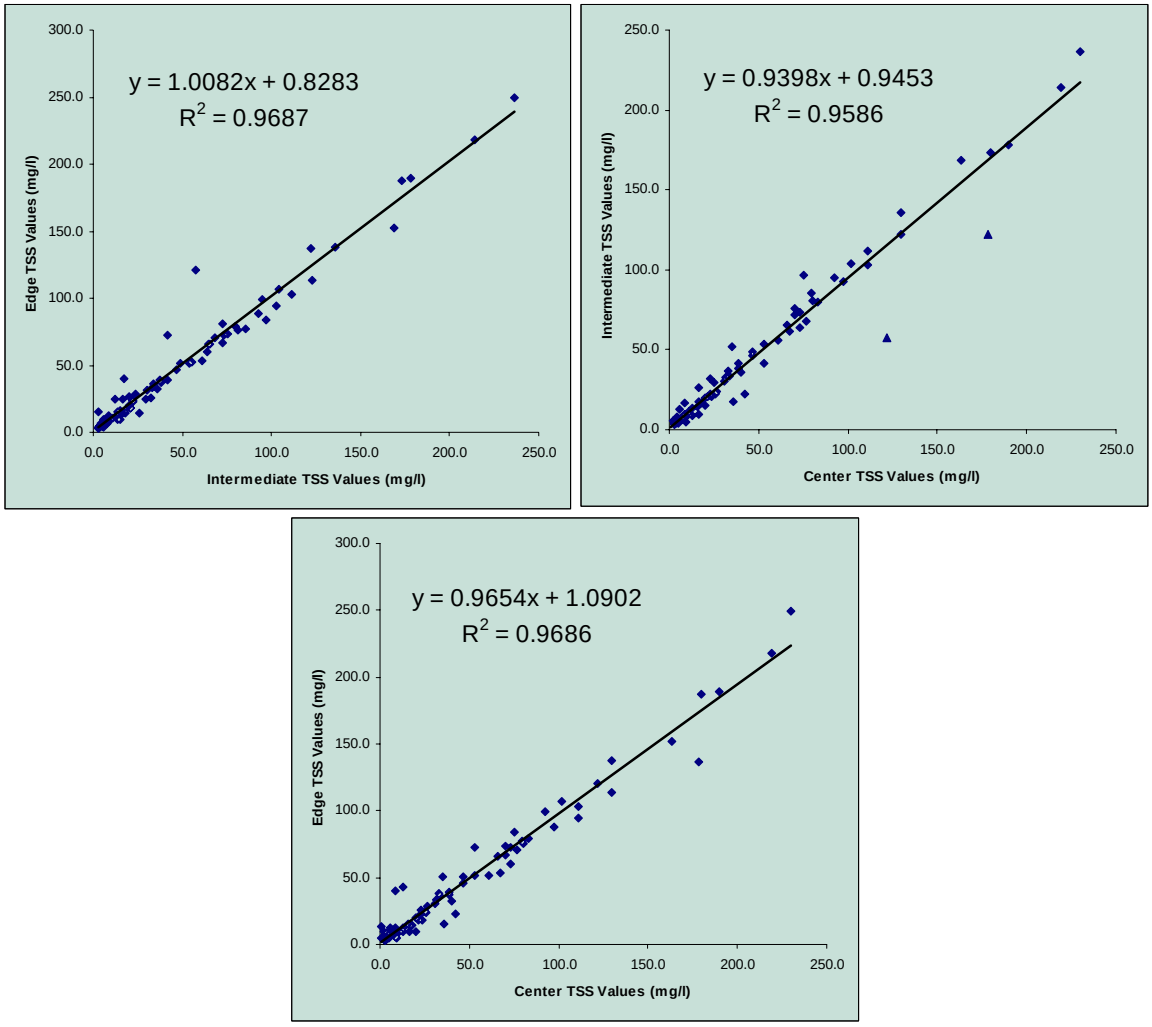


Figure A2.7. Relationships between Depth Integrated Total Suspended Solid measurements taken at the edge, center, and intermediate locations of a stream cross-section.