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Goodwin Creek Experimental Watershed: Bendway Model Data Report



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Executive Summary

The Goodwin Creek Experimental Watershed is a 21.3 km^2 watershed near Batesville, Mississippi. The watershed is organized and instrumented for conducting extensive research on upstream erosion, stream erosion and sedimentation, and watershed hydrology. Data collection is directed towards providing information needed to test physical concepts and mathematical models of watershed runoff, streamflow, and sediment transport processes.

The Goodwin Creek bendway modeling project was initiated in cooperation with the National Center for Computational Hydroscience and Engineering (NCCHE) at the University of Mississippi in 2004 to simulate the flow along the bendway with 2-dimensional and 3-dimensional free surface flow models using recent cross-sectional geometry and data from an extreme flow event that occurred April 6, 2005. This report focuses on the data compiled for the model simulations. The Goodwin Creek bendway project encompasses many types of instrumentation for measurement of streamflow, sediment transport, streambank stability, and morphological change. The bendway instrumentation consists of numerous tensiometers at various depths within the streambanks to monitor pore-water pressure, pressure transducers for water level (stage) at upstream and downstream ends of the bendway, crest stage gages (at the same location as the pressure transducers) to record peak flow depth, two recording raingages, suspended sediment samplers at upstream and downstream ends of the bendway, and an acoustic sensor (EasyQ) at the downstream end of the model reach to record water level and velocities.

Table of Contents

Executive Summary ii
1. Introduction 1
2. Methods and Materials 4
   2.1 Channel Dimension 4
   2.2 Station 3 and 4 Stream Flow 5
   2.3 Transducer Measurements 7
   2.4 Crest Stage Gage Measurements 7
   2.5 Downstream Boundary Condition 8
      2.5.1 Stage 8
      2.5.2 Velocity 10
   2.6 Boundary Materials and Geotechnical Data 12
      2.6.1 Borehole Shear Testing and Bulk Unit Weights 14
      2.6.2 Submerged Hydraulic Jet Testing 15
   2.7 Pore-Water Pressure in the Banks 18
3. Conclusions 20
4. References 21
5. Appendix 22

List of Figures

Figure 1-1. Map showing location of Goodwin Creek Experimental Watershed..... 3
Figure 2-1. Goodwin Creek bendway model layout of cross sections. 5
Figure 2-2. Discharge data for stations 3 and 4 for the period January 1, 2005 to May 1, 2005..... 6
Figure 2-3. Discharge data for stations 3 and 4 for the April 6, 2005 storm. 6
Figure 2-4. Plot of upstream transducer stage and rainfall for the period December 3, 2004 to August 31, 2005. 7
Figure 2-5. Plot of upstream transducer stage for the April 6, 2005 storm. 8
Figure 2-6. EasyQ water surface elevation measurements at cross section 20..... 9
Figure 2-7. EasyQ water surface elevation for the April 6, 2005 storm. 9
Figure 2-8. EasyQ position within cross section 20 along with initial and current velocity cell locations. 10
Figure 2-9. EasyQ velocity measurements during the period December 3, 2004 to August 31, 2005..... 11
Figure 2-10. EasyQ velocity measurements during the April 6, 2005 storm. 11
Figure 2-11. Schematic representation of borehole shear tester (BST) used to determine cohesive and frictional strengths of *in situ* streambank materials. Modified from Thorne *et al.* (1981). 15
Figure 2-12. Schematic of submerged jet-test device used to measure the erodibility coefficient k, and the critical shear stress τ_c of fine-grained materials. 17
Figure 2-13. Schematic of tensiometer used for pore-water pressure measurements..... 18
Figure 2-14. Pore-water pressure measurements for the period December 3, 2004 to August 31, 2005. 19
Figure 2-15. Pore-water pressure measurements for the April 6, 2005 storm. 19
Figure A1. Station and elevation of survey points collected 5/5/05 for cross section 1..5-1
Figure A2. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 1. 5-1
Figure A3. Station and elevation of survey points collected 5/5/05 for cross section 1a.5-3
Figure A4. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 1a. 5-3
Figure A5. Station and elevation of survey points collected 5/5/05 for cross section 2..5-5
Figure A6. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 2. 5-5
Figure A7. Station and elevation of survey points collected 5/5/05 for cross section 3..5-7
Figure A8. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 3. 5-7
Figure A9. Station and elevation of survey points collected 5/5/05 for cross section 4..5-9
Figure A10. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 4. 5-9
Figure A11. Station and elevation of survey points collected 5/5/05 for cross section 5..5-11
Figure A12. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 5. 5-11

Figure A13. Station and elevation of survey points collected 5/5/05 for cross section 6.. 5-13
Figure A14. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 6. 5-13
Figure A15. Station and elevation of survey points collected 5/5/05 for cross section 7.. 5-15
Figure A16. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 7. 5-15
Figure A17. Station and elevation of survey points collected 5/5/05 for cross section 8.. 5-17
Figure A18. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 8. 5-17
Figure A19. Station and elevation of survey points collected 5/5/05 for cross section 9.. 5-19
Figure A20. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 9. 5-19
Figure A21. Station and elevation of survey points collected 5/5/05 for cross section 10. 5-21
Figure A22. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 10. 5-21
Figure A23. Station and elevation of survey points collected 5/5/05 for cross section 11. 5-23
Figure A24. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 11. 5-23
Figure A25. Station and elevation of survey points collected 5/5/05 for cross section 12. 5-25
Figure A26. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 12. 5-25
Figure A27. Station and elevation of survey points collected 5/5/05 for cross section 12a. 5-27
Figure A28. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 12a. 5-27
Figure A29. Station and elevation of survey points collected 5/5/05 for cross section 13. 5-29
Figure A30. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 13. 5-29
Figure A31. Station and elevation of survey points collected 5/5/05 for cross section 14. 5-31
Figure A32. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 14. 5-31
Figure A33. Station and elevation of survey points collected 5/5/05 for cross section 15. 5-33
Figure A34. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 15. 5-33
Figure A35. Station and elevation of survey points collected 5/5/05 for cross section 16. 5-35

Figure A36. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 16. 5-35
Figure A37. Station and elevation of survey points collected 5/5/05 for cross section 17. 5-37
Figure A38. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 17. 5-37
Figure A39. Station and elevation of survey points collected 5/5/05 for cross section 18. 5-39
Figure A40. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 18. 5-39
Figure A41. Station and elevation of survey points collected 5/5/05 for cross section 19. 5-41
Figure A42. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 19. 5-41
Figure A43. Station and elevation of survey points collected 5/5/05 for cross section 20. 5-43
Figure A44. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 20. 5-43
Figure A45. Station and elevation of survey points collected 5/5/05 for cross section 21. 5-45
Figure A46. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 21. 5-45
Figure A47. Station and elevation of survey points collected 5/5/05 for cross section U1. 5-47
Figure A48. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section U1. 5-47
Figure A49. Station and elevation of survey points collected 5/5/05 for cross section U2. 5-49
Figure A50. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section U2. 5-49
Figure A51. Station and elevation of survey points collected 5/5/05 for cross section U3. 5-51
Figure A52. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section U3. 5-51
Figure A53. Station and elevation of survey points collected 5/5/05 for cross section CF. 5-53
Figure A54. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section CF. 5-53
Figure A55. Station and elevation of survey points collected 5/5/05 for cross section T1. 5-55
Figure A56. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T1 5-55
Figure A57. Station and elevation of survey points collected 5/5/05 for cross section T2. 5-57
Figure A58. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T2 5-57

Figure A59. Station and elevation of survey points collected 5/5/05 for cross section T3. 5-59
Figure A60. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T3 5-59
Figure A61. Station and elevation of survey points collected 5/5/05 for cross section T4. 5-61
Figure A62. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T4 5-61
Figure A63. Station and elevation of survey points collected 5/5/05 for cross section T5. 5-63
Figure A64. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T5 5-63
Figure A65. Station and elevation of survey points collected 5/5/05 for cross section T6. 5-65
Figure A66. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T6 5-65
Figure A67. Station and elevation of survey points collected 5/5/05 for cross section T7. 5-67
Figure A68. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T7 5-67
Figure A69. Station and elevation of survey points collected 5/5/05 for cross section T8. 5-69
Figure A70. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T8 5-69
Figure A71. Station and elevation of survey points collected 5/5/05 for cross section T9. 5-71
Figure A72. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T9 5-71
Figure A73. Station and elevation of survey points collected 5/5/05 for cross section T10. 5-73
Figure A74. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T10 5-73
Figure A75. Station and elevation of survey points collected 5/5/05 for cross section T11. 5-75
Figure A76. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T11 5-75
Figure A77. Station and elevation of survey points collected 5/5/05 for cross section T12. 5-77
Figure A78. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T12 5-77
Figure A79. Station and elevation of survey points collected 5/5/05 for cross section T13. 5-79
Figure A80. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T13 5-79

List of Tables

Table 2-1. Bed material composition of the bendway. 12
Table 2-2. Bank material composition of the bendway. 13
Table 2-3. BST measurements of shear strength of bendway sediments. 14
Table 2-4. Jet test measurements of bendway sediments. 16
Table A1. Station and elevation data for cross section 1. 5-2
Table A2. Station and elevation data for cross section 1a. 5-4
Table A3. Station and elevation data for cross section 2. 5-6
Table A4. Station and elevation data for cross section 3. 5-8
Table A5. Station and elevation data for cross section 4. 5-10
Table A6. Station and elevation data for cross section 5. 5-12
Table A7. Station and elevation data for cross section 6. 5-14
Table A8. Station and elevation data for cross section 7. 5-16
Table A9. Station and elevation data for cross section 8. 5-18
Table A10. Station and elevation data for cross section 9. 5-20
Table A11. Station and elevation data for cross section 10. 5-22
Table A12. Station and elevation data for cross section 11. 5-24
Table A13. Station and elevation data for cross section 12. 5-26
Table A14. Station and elevation data for cross section 12a. 5-28
Table A15. Station and elevation data for cross section 13. 5-30
Table A16. Station and elevation data for cross section 14. 5-32
Table A17. Station and elevation data for cross section 15. 5-34
Table A18. Station and elevation data for cross section 16. 5-36
Table A19. Station and elevation data for cross section 17. 5-38
Table A20. Station and elevation data for cross section 18. 5-40
Table A21. Station and elevation data for cross section 19. 5-42
Table A22. Station and elevation data for cross section 20. 5-44
Table A23. Station and elevation data for cross section 21. 5-46
Table A24. Station and elevation data for cross section U1. 5-48
Table A25. Station and elevation data for cross section U2. 5-50
Table A26. Station and elevation data for cross section U3. 5-52
Table A27. Station and elevation data for cross section CF. 5-54
Table A28. Station and elevation data for cross section T1. 5-56
Table A29. Station and elevation data for cross section T2. 5-58
Table A30. Station and elevation data for cross section T3. 5-60
Table A31. Station and elevation data for cross section T4. 5-62
Table A32. Station and elevation data for cross section T5. 5-64
Table A33. Station and elevation data for cross section T6. 5-66
Table A34. Station and elevation data for cross section T7. 5-68
Table A35. Station and elevation data for cross section T8. 5-70
Table A36. Station and elevation data for cross section T9. 5-72
Table A37. Station and elevation data for cross section T10. 5-74
Table A38. Station and elevation data for cross section T11. 5-76
Table A39. Station and elevation data for cross section T12. 5-78
Table A40. Station and elevation data for cross section T13. 5-80

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1. Introduction

The Goodwin Creek Experimental Watershed (GCEW) was established in north- central Mississippi as a part of the Stream-Bank Erosion Control Evaluation and Demonstration Project authorized by Section 32 of U.S. Public Law 93-251. This 21.3 km^2 watershed near Batesville, Mississippi was chosen for its mixed land use, excessive upland erosion, and steep degrading channels with unstable banks. The watershed is located in the bluff hills of the Yazoo River basin of northern Mississippi (Figure 1-1), with terrain elevation ranges from 71 to 128 meters above mean sea level (MASL), and an average channel slope of 0.004. The watershed is organized and instrumented for conducting extensive research on upstream erosion, stream erosion and sedimentation, and watershed hydrology. Data collection is directed towards providing information needed to test physical concepts and mathematical models of watershed runoff, streamflow, and sediment transport processes. The watershed is divided into fourteen nested subcatchments with a flow measuring flume constructed at each of the drainage outlets. The drainage areas above these stream gaging sites range from 1.6 to 21.3 km^2. Thirty two standard recording rain gages are uniformly located within and just outside the watershed. Instrumentation at each gaging site includes an electronic data acquisition and radio telemetry system that collects, stores and transmits the data to a central computer at the NSL for processing and archival. Measurements collected at each site and transmitted through the telemetry system include water stage, accounting of automatically pumped sediment samples, air and water temperature, precipitation, and climatological parameters. Periodic acquisition of aerial photography and satellite data contribute to complete aerial coverage of land use and surface conditions. Geographic Information Systems are used to incorporate the spatially distributed data in relational databases. These systems provide a convenient and accessible database for use in watershed analysis and modeling. A comprehensive documentation of the Goodwin Creek Experimental Watershed and the database compiled for the period 1982-2002 are available for downloading at the following link:

http://ars.usda.gov/Business/docs.htm?docid=5120

Many streams in agricultural watersheds are characterized by unstable channel boundaries. Erosion in these unstable channels destroys valuable agricultural land, and also degrades the stream habitat for fish and other aquatic organisms. Determining the velocity and area of the flows in a stream that are responsible for maintaining the channel and the aquatic habitat are essential information for use by river engineers to restore impacted channels to a more natural state. Current technologies to predict channel responses are hindered by an incomplete understanding of the processes controlling erosion of streambanks, channel meandering and migration, erosion of cohesive sediment, and the links between bed and bank processes. An eroding bendway is being intensely studied to improve knowledge of these processes. Data collected at this actively eroding streambank includes cross-section surveys, water levels, bank pore-water pressures, and bank-material strength. In addition, information on the role of stream processes on eroding the base of the streambank is collected for use in predicting the type

of flows necessary to steepen the base of the bank and to induce bank failures. Gravitational forces acting on in situ bank material act in concert with hydraulic forces at the bank toe to determine rates of bank erosion and, therefore, bank morphology. The interaction of these forces control streambank mechanics. Hydraulic forces exerted by flowing water on in situ bank-toe material and failed, cohesive material at the bank toe are often sufficient to entrain materials at relatively frequent flows and to maintain steep low-bank profiles. Environmental studies on the GCEW have considered stabilization of eroding streambanks using vegetation, and the use of stone structures to improve aquatic habitats at base flows. A stable bank is transformed into an unstable bank during periods of prolonged rainfall by: (1) increases in soil unit weight, (2) decrease or complete loss of matric suction, and, therefore, apparent cohesion, (3) generation of positive pore-water pressures, and, therefore loss of frictional strength, (4) entrainment of in situ and failed material at the bank toe, and (5) loss of confining pressure during recession of stormflow hydrographs. Data from the GCEW has been used as a prototype for the evaluation of Total Maximum Daily Loads (TMDLs) for clean sediment in streams and rivers. Watershed-scale models employing best management practices have been developed using the GCEW database and are a valuable component for guiding management strategies to rectify impaired streams of the U.S.

The Goodwin Creek bendway modeling project was initiated in cooperation with the National Center for Computational Hydroscience and Engineering (NCCHE), located on the University of Mississippi campus at Oxford, MS, in 2004 to simulate flow along the bendway with 2-dimensional and 3-dimensional free-surface flow models using recent cross-sectional geometry and data from an extreme flow event that occurred April 6, 2005. The goal of the project is to better understand the dynamic nature of the flow in the bendway and gain logistical information concerning points/zones of special interest for more detailed study. This report focuses on the data compiled for the model simulations. These data include: cross-sectional geometry, flow records from Stations 3 and 4 (just upstream of the bendway), flow records at the upstream and downstream ends of the bendway, flow records at the downstream boundary of the model reach, boundary sediment characteristics, and pore-water pressures in the streambank. The geotechnical data was collected as part of an on-going study of streambank mechanics and are included in this report as complimentary data required by stream evolution models.

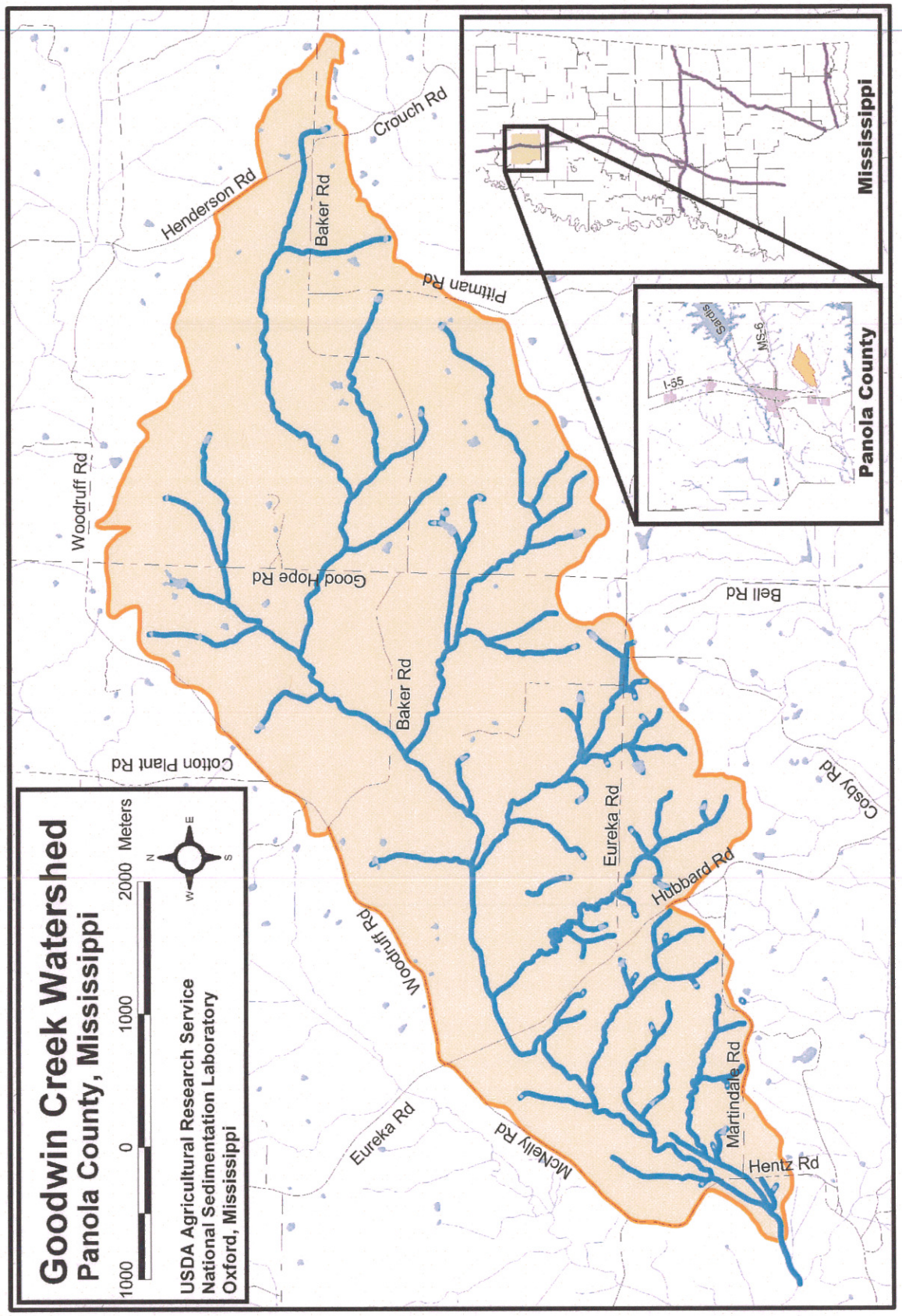


Figure 1-1. Map showing location of Goodwin Creek Experimental Watershed.

2. Methods and Materials

The Goodwin Creek bendway project encompasses many types of instrumentation for measurement of streamflow, sediment transport, streambank stability, and morphological change. The bendway instrumentation consists of numerous tensiometers at various depths within the streambanks to monitor pore-water pressure, pressure transducers for water level (stage) at the upstream and downstream ends of the bendway, crest stage gages (at the same location as the pressure transducers) to record peak flow depth, two recording raingages, suspended sediment samplers at the upstream and downstream ends of the bendway, and an acoustic sensor (EasyQ[1], Nortek AS) at the downstream end of the model reach to record water levels and velocities. The EasyQ serves as the downstream boundary condition for simulations of flow in the bendway. Channel boundary samples, which include bed and bank material, are also collected along with in situ tests of material strength. Erosional resistance of the bed material was determined with a jet test (Hanson, 1990;1991) and shear strength of the bank materials was determined with a bore hole shear tester (Lohnes and Handy, 1968; Thorne *et al.*, 1981).

2.1 Channel Dimension

Goodwin Creek bendway cross-sectional geometry was determined by total station survey. The study site is comprised of 3 upstream cross sections, labeled U1-3 (connection to Station 3); 13 tributary cross sections, labeled T1-13 (connection to Station 4); and 21 main stem cross sections, labeled 1-21. Figure 2-1 shows the layout of cross sections used in model preparation. The contributing area to Station 3 is 868 ha and the contributing area to Station 4 is 362 ha. At each cross section location, photos were taken of the left bank, right bank, upstream and downstream views. Cross-section profiles, survey data, and photos are supplied in the appendix.

[1] Mention of trade names or commercial products in this document is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

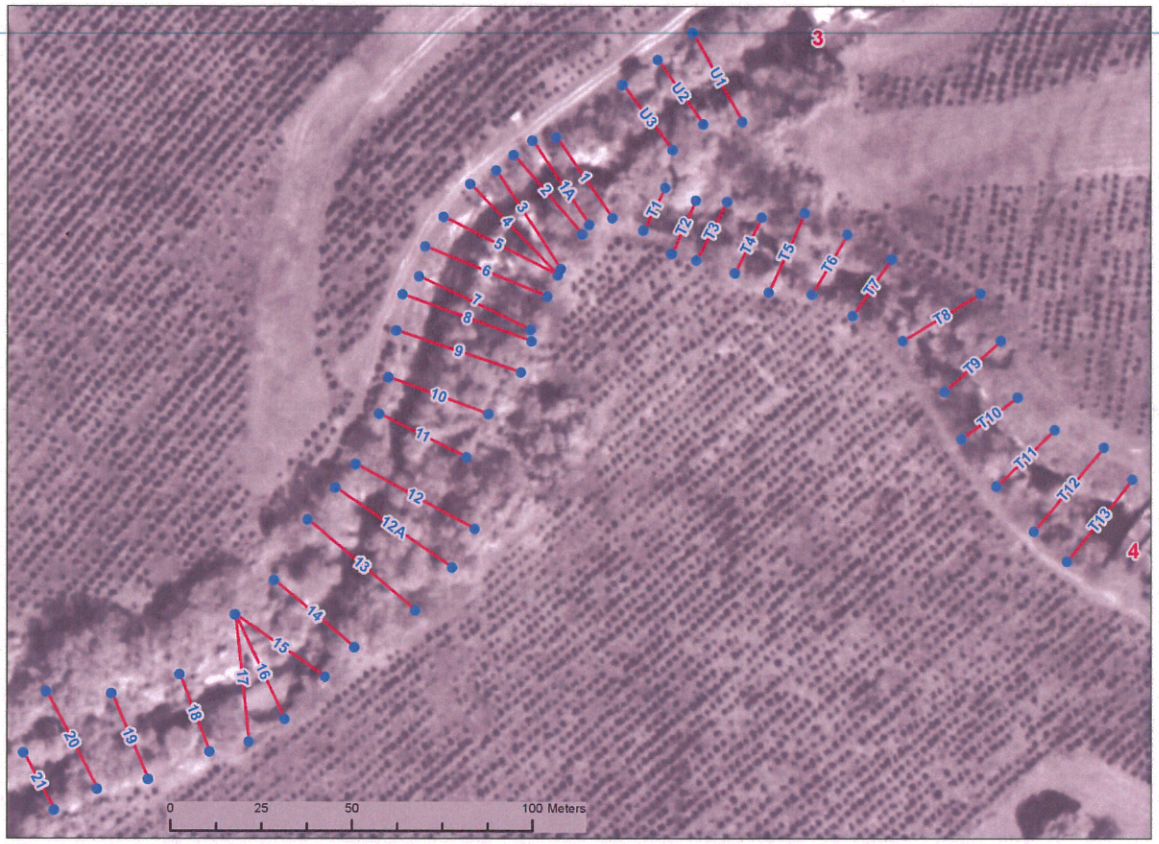


Figure 2-1. Goodwin Creek bendway model layout of cross sections.

2.2 Station 3 and 4 Stream Flow

Stream flow at GCEW is gaged at 14 locations. Here, we are concerned with the stream flow records at Station 3 and Station 4 (see Figure 2-1). The measured discharge from Station 3 (January 1, 2005 through July 5, 2005) and Station 4 (January 1, 2005 through April 20, 2005) is shown in Figure 2-2. Currently, the stage at both stations is measured by an acoustic sensor. Due to the shape of the supercritical flume (V-shape) at Station 4, stage measurements below 35 cm are not accurately measured. The beam from the acoustic sensor bounces off the sidewalls creating an echo which the sensor reads as stage although the water level may be well below the detected echo. Figure 2-3 shows the discharge data for the April 6, 2005 storm for Stations 3 and 4. The data presented in Figures 2-2 and 2-3 for the discharge through Station 4 is reliable for peaks only.

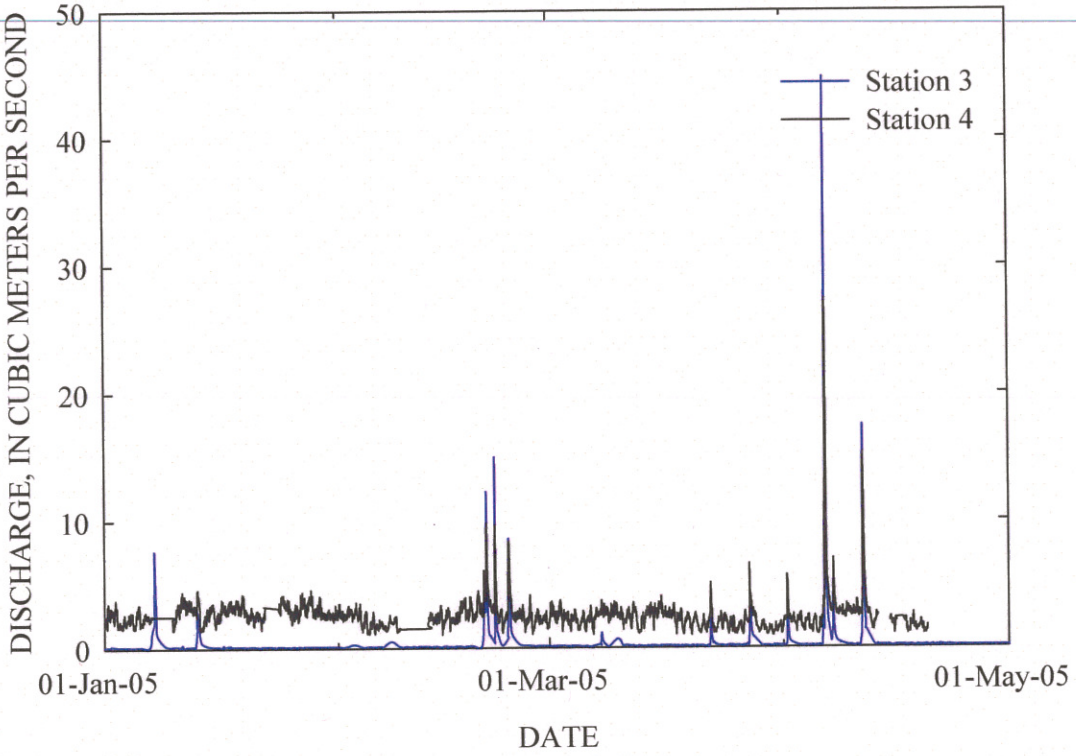


Figure 2-2. Discharge data for stations 3 and 4 for the period January 1, 2005 to May 1, 2005.

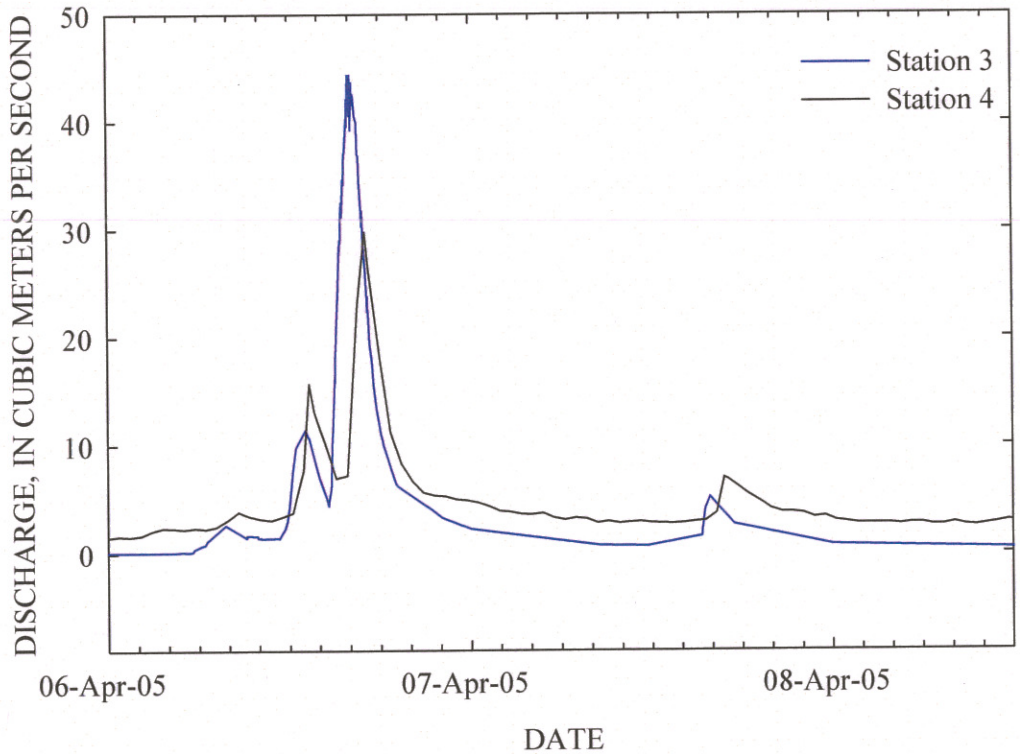


Figure 2-3. Discharge data for stations 3 and 4 for the April 6, 2005 storm.

2.3 *Transducer Measurements*

Cross sections 1 and 12 have pressure transducers for water level (stage) measurement. A pressure transducer is a transducer that converts pressure into an analog electrical signal. Although there are various types of pressure transducers, one of the most common is the strain-gage base transducer. The conversion of pressure into an electrical signal is achieved by the physical deformation of strain gages which are bonded into the diaphragm of the pressure transducer and wired into a wheatstone bridge configuration. Pressure applied to the pressure transducer produces a deflection of the diaphragm which introduces strain to the gages. The strain will produce an electrical resistance change proportional to the pressure. When a precision excitation voltage is applied, the electrical resistance varies with changing liquid pressure. Figure 2-4 shows the upstream transducer data for the period December 3, 2004 to August 31, 2005. Figure 2-5 shows the upstream transducer data for the April 6, 2005 storm.

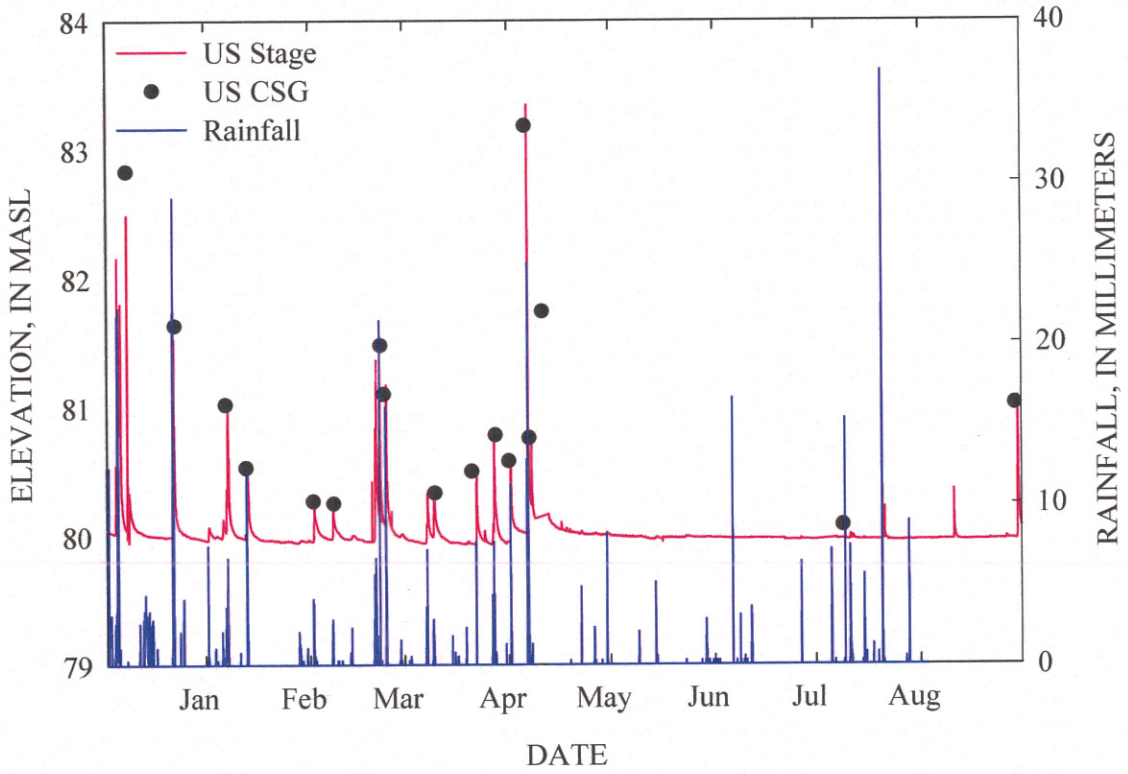


Figure 2-4. Plot of upstream transducer stage and rainfall for the period December 3, 2004 to August 31, 2005.

2.4 *Crest Stage Gage Measurements*

Crest stage gages are installed at cross sections 1 and 12. The crest stage gage consisted of PVC pipe and was installed vertically along the bank. The bottom of the pipe was perforated to allow water entry to the pipe. A graduated stick was placed inside the pipe. At the bottom of the stick, a small container was attached containing cork. As water rises in the channel during a rain event, cork in the small container moves with the rising water

in the pipe, as the water recedes in the channel, some of the cork remains as residue on the stick at the elevation of the peak. A technician makes a site visit following the storm and records the position of the cork, cleans the stick and replaces the cork in the small container at the bottom of the stick. These measurements primarily serve to validate pressure transducer peak values at the specified locations. Figure 2-4 shows crest stage gage readings for the period December 3, 2005 to August 31, 2005.

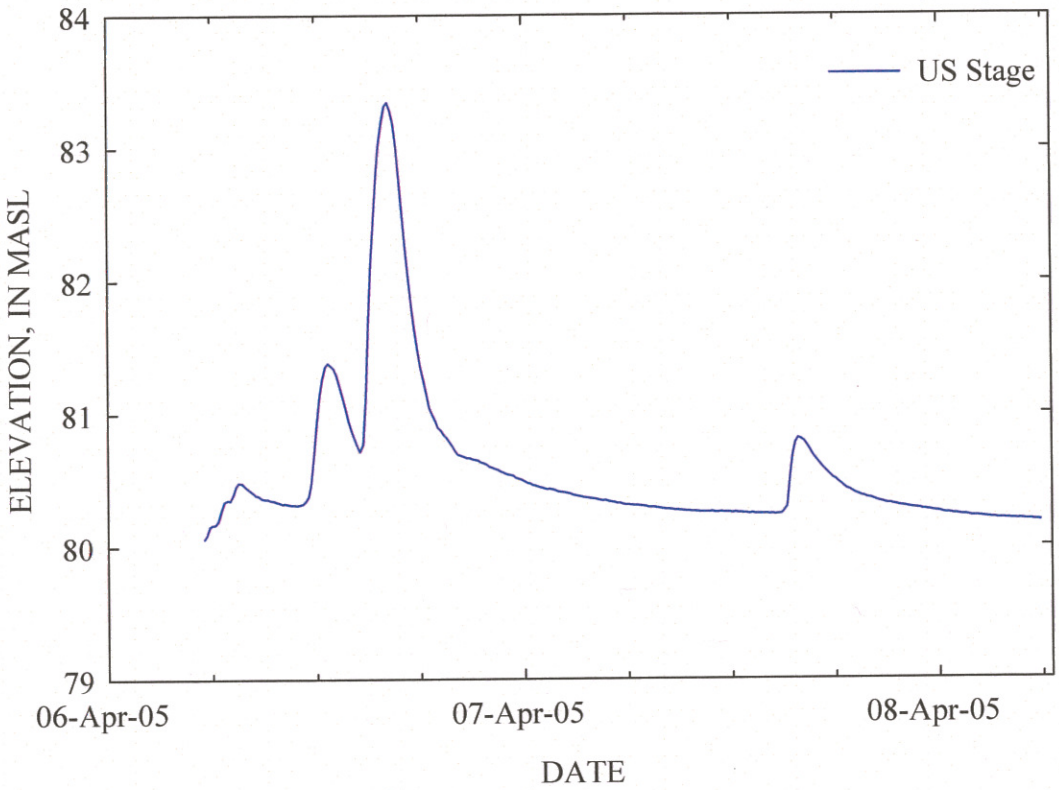


Figure 2-5. Plot of upstream transducer stage for the April 6, 2005 storm.

2.5 Downstream Boundary Condition

2.5.1 Stage

The EasyQ is a small acoustic sensor used in rivers and streams, which monitors both water level and horizontal velocity in three consecutive measurement cells. Water level or stage measurement is made by transmitting a short pulse to the surface, then listening to the echo from the surface. The stage algorithm identifies peaks by the size of a quality parameter – the better an echo matches the expected shape of a surface echo, the higher the quality value. A pressure sensor is used in combination with the stage sensor to separate surface echoes generated by debris in the water from realistic water surface echoes. The elevation of the EasyQ within cross section 20 is 79.61 MASL. Stage measurements for the period December 3, 2004 (installation) to August 31, 2005 are shown in Figure 2-6. Stage at cross section 20 below 79.61 meters is not recorded because the instrument is out of the water. Stage measurements for the April 6, 2005 storm are shown in Figure 2-7.

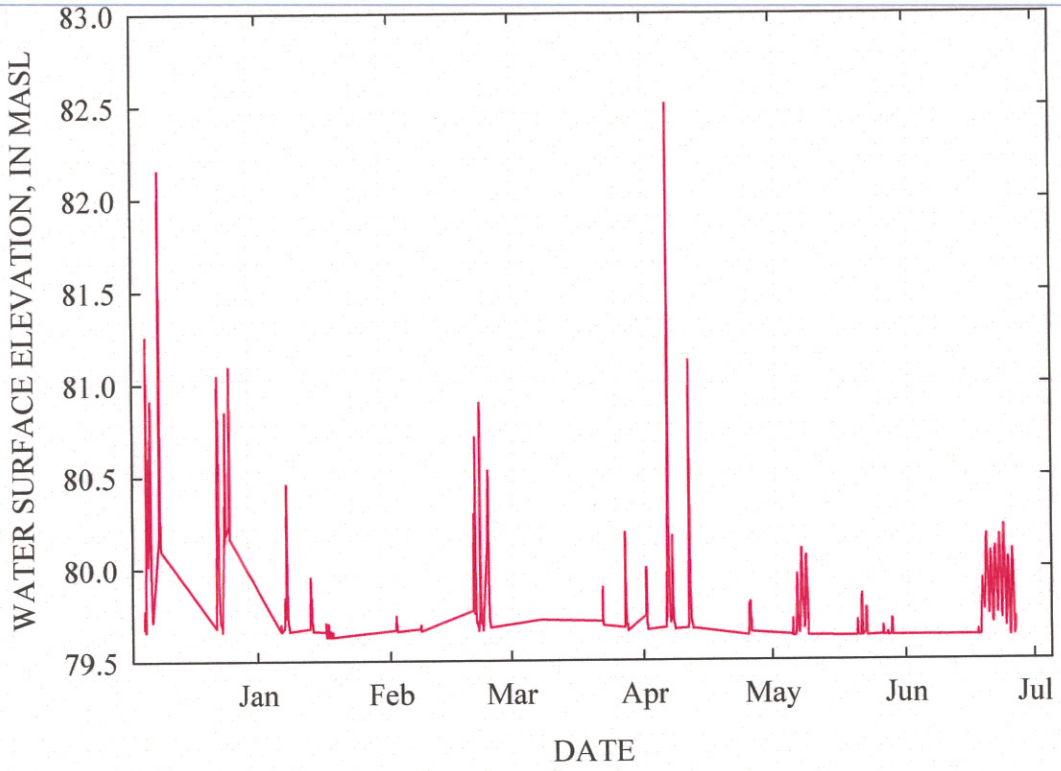


Figure 2-6. EasyQ water surface elevation measurements at cross section 20.

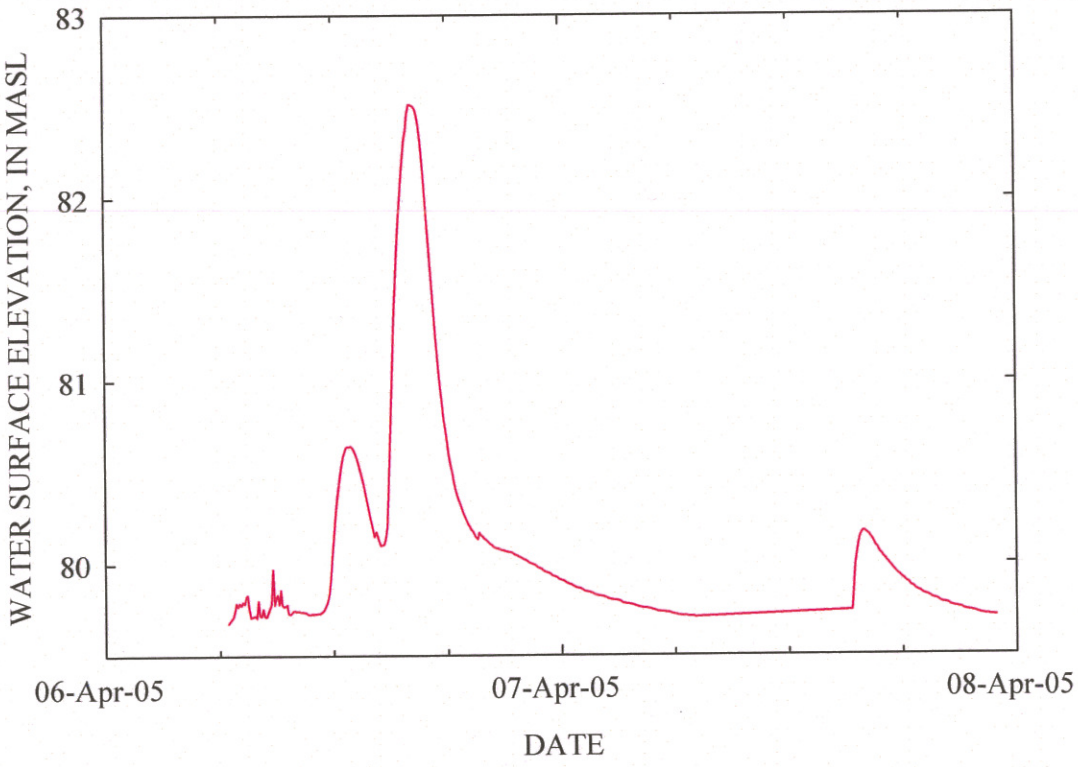


Figure 2-7. EasyQ water surface elevation for the April 6, 2005 storm.

2.5.2 Velocity

The Doppler velocity meter of the EasyQ has two beams that look sideways into the flow and measure the 2-dimensional water velocity in three adjacent measurement cells. The velocity meter has 0.5 meter blanking (distance from sensor to first measurement cell) and equal separation (user specified) for each subsequent measurement cell. Figure 2.8 shows the deployment position of the EasyQ within cross section 20 of Goodwin Creek. Two components of velocity are recorded by the EasyQ, stream-wise and cross-stream. A quality parameter is used for characterization of the velocity signal strength. Initially, velocity cell locations were 0.5, 1.5 and 2.5 meters from the left bank. Currently, velocity cell locations are 0.5, 2.5 and 4.5 meters from the left bank. Velocity cell locations were adjusted to achieve more representative velocity sampling of the cross section. Figure 2-9 shows the velocity measurements from the EasyQ during the period December 3, 2004 (installation) to August 31, 2005. Figure 2-10 shows the velocity measurements for the April 6, 2005 storm. Velocities in Figures 2-9 and 2-10 are plotted as resultant velocities (that is, the square root of the sum of the squared stream-wise and cross-stream velocity components).

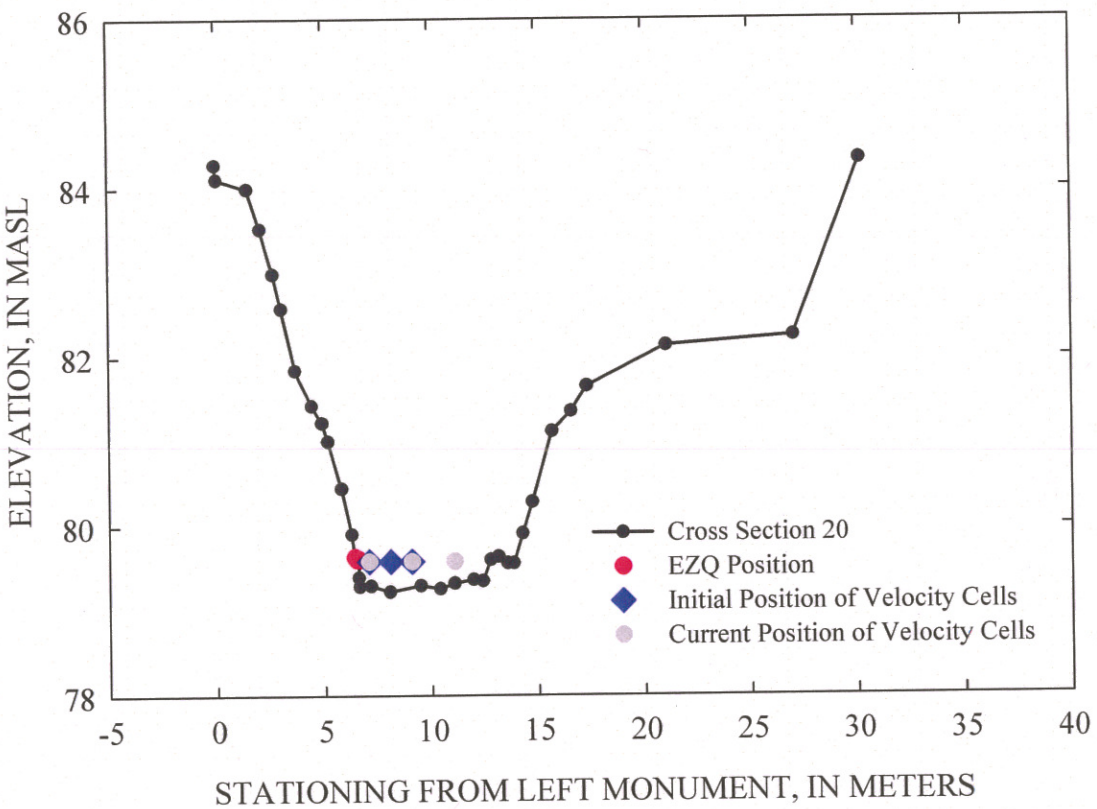


Figure 2-8. EasyQ position within cross section 20 along with initial and current velocity cell locations.

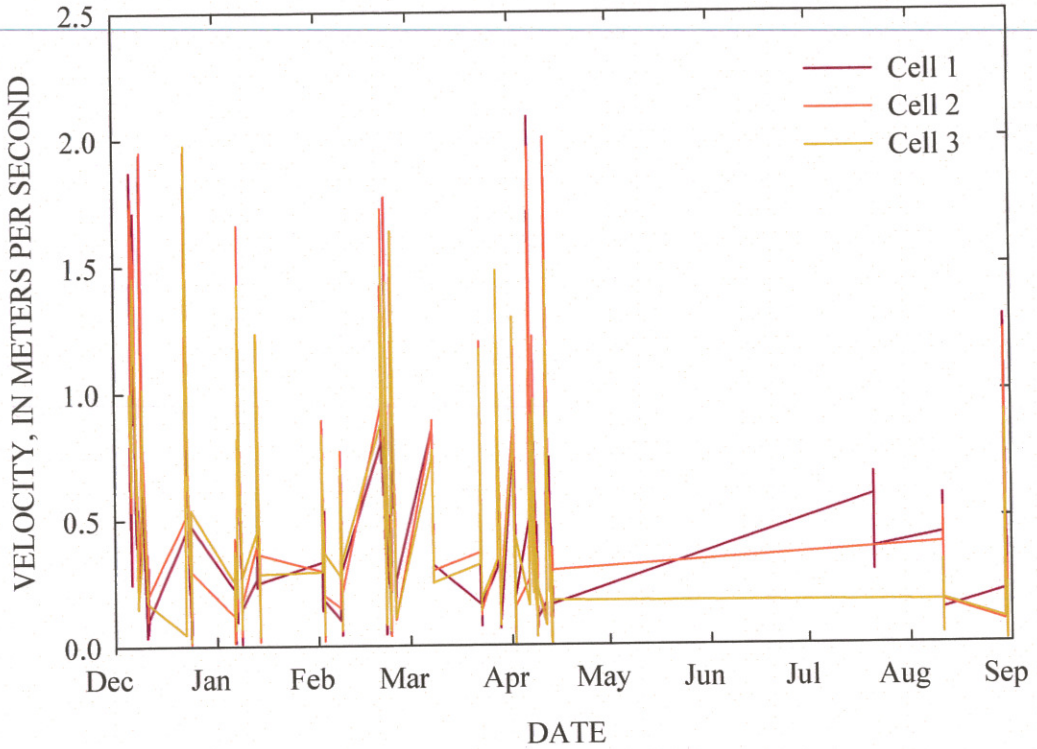


Figure 2-9. EasyQ velocity measurements during the period December 3, 2004 to August 31, 2005.

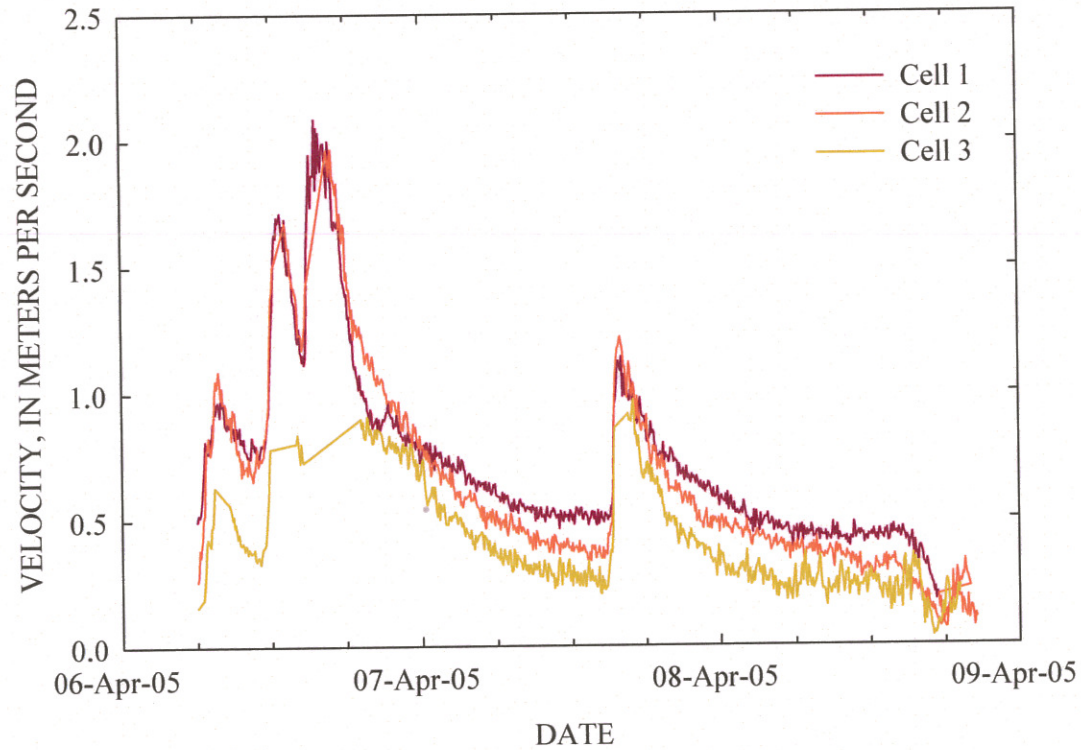


Figure 2-10. EasyQ velocity measurements during the April 6, 2005 storm.

2.6 *Boundary Materials and Geotechnical Data*

Physical properties of each cross section are defined in terms of those variables that describe the forces and resistance acting on each surface of that cross section.
Bed- and bank-material composition and geotechnical properties at each cross section were provided by testing and sampling conducted by the ARS. Simulation models require information on sediment texture to determine sediment routing and sorting processes. Bulk samples of bed and bank materials were collected at the bendway to be analyzed in the laboratory for particle-size distributions. If the bed was dominated by gravel-sized material a count of a minimum of 100 particles was made to determine the distribution of particle sizes. In cases where streambeds were composed of a bi-modal mixture of sediment sizes with coarser-grained gravels, particle-size distributions were weighted by the percentage of the bed covered by each type of sample (i.e., bulk and particle count). Bed-material particle-size distributions for each cross section are shown in Table 2-1. Bank-material particle-size distributions are shown in Table 2-2.

Table 2-1. Bed material composition of the bendway.

Cross Section	Percentage class sizes				D_{50} in millimeters
	Boulders/Cobbles > 64.0 mm	Gravel 2.00 - 64.0 mm	Sand 0.063 - 1.99 mm	Silt and clay < 0.063 mm	
XS01	0.00	55.0	45.0	0.00	4.00
XS02	0.00	65.0	34.9	0.115	9.00
XS03	0.00	45.0	55.0	0.00	0.500
XS04	0.00	20.0	80.0	0.00	0.515
XS05	15.75	45.0	35.0	4.20	8.00
XS06	1.00	99.0	0.0	0.00	17.0
XS07	0.00	86.0	7.0	7.00	13.0
XS08	0.00	98.0	2.0	0.00	13.0
XS09	1.00	89.0	10.0	0.00	15.0
XS10	0.00	30.0	70.0	0.00	0.700
XS11	0.00	25.0	73.4	1.55	0.485
XS12	0.00	17.6	80.7	1.68	0.500
XS13	0.00	35.0	62.6	2.42	0.410
XS14	0.00	91.0	9.0	0.00	15.0
XS15	0.00	70.0	29.7	0.30	6.00
XS16	1.00	88.0	11.0	0.00	17.0
XS17	0.00	89.0	11.0	0.00	17.0

Table 2-2. Bank material composition of the bendway.

Cross Section	Sample location depth m	Percentage class sizes				D_{50} in millimeters
		Boulders/Cobbles > 64.0 mm	Gravel 2.00 - 64.0 mm	Sand 0.063 - 1.99 mm	Silt and clay < 0.063 mm	
XS02	1.7 m RB	0.00	14.38	80.4	5.24	0.503
XS02	0.62 m RB	0.00	7.90	55.3	36.77	0.245
XS02	2.60 m RB	0.00	24.11	48.0	27.88	0.490
XS04	0.91 m RB	0.00	3.30	43.9	52.77	0.060
XS04	1.81 m RB	0.00	3.17	60.2	36.60	0.208
XS04	2.20 m RB	0.00	7.89	69.3	22.79	0.290
XS06	0.8 m RB	0.00	2.29	56.7	40.97	0.150
XS06	1.5 m RB	0.00	37.32	55.0	7.65	0.865
XS06	1.92 m RB	0.00	1.98	74.1	23.91	0.215
XS08	0.9 m RB	0.00	3.62	48.02	48.36	0.0730
XS08	1.74 m RB	0.00	6.33	74.3	19.37	0.408
XS08	2.4 m RB	0.00	8.38	88.8	2.79	0.375
XS10	1.88 m RB	0.00	0.58	73.7	25.70	0.260
XS10	0.83 m RB	0.00	0.71	45.3	54.00	0.060
XS10	1.55 m RB	0.00	2.12	57.2	40.67	0.155
XS14	1.32 m LB	0.00	25.77	47.0	27.21	0.408
XS14	0.9 m LB	0.00	14.08	41.2	44.68	0.102

Conceptual models of bank retreat and the delivery of bank sediments to the flow emphasize the importance of interactions between hydraulic forces acting at the bed and bank toe, and gravitational forces acting on *in situ* bank materials (Carson and Kirkby, 1972; Thorne, 1982; Simon *et al.*, 1991). Failure occurs when erosion of the bank toe and the channel bed adjacent to the bank have increased the height and angle of the bank to the point that gravitational forces exceed the shear strength of the bank material. After failure, failed bank materials may be delivered directly to the flow and deposited as bed material, dispersed as wash load, or deposited along the toe of the bank as intact blocks, or as smaller, dispersed aggregates (Simon *et al.*, 1991). Analysis of streambank stability is based on measured field data using *in situ* devices such as the borehole shear test device (Figure 2-11) and the submerged jet-test device (Figure 2-12).

2.6.1 Borehole Shear Testing and Bulk Unit Weights

To properly determine the resistance of cohesive materials to erosion by mass movement, data must be acquired on those characteristics that control shear strength; that is cohesion, angle of internal friction, pore-water pressure, and bulk unit weight. Cohesion and friction angle data can be obtained from standard laboratory testing (triaxial shear or unconfined compression tests), or by *in-situ* testing with a borehole shear-test (BST) device (Lohnes and Handy, 1968; Thorne *et al.*, 1981; Little *et al.*, 1982; Lutenegger and Hallberg, 1981). The BST provides direct, drained shear-strength tests on the walls of a borehole (Figure 2-11). Advantages of the instrument include:

1. The test is performed *in situ* and testing is, therefore, performed on undisturbed material;
2. Cohesion and friction angle are evaluated separately with the cohesion value representing apparent cohesion (c_a). Effective cohesion (c') is then obtained by adjusting c_a according to measured pore-water pressure and φ^b (φ^b = rate of increase in strength with matric suction).
3. A number of separate trials are run at the same sample depth to produce single values of cohesion and friction angle based on a standard Mohr-Coulomb failure envelope.
4. Data and results obtained from the instrument are plotted and calculated on site, allowing for repetition if results are unreasonable; and
5. Tests can be carried out at various depths in the bank to locate weak strata (Thorne *et al.*, 1981).

BST results for the Goodwin Creek bendway are shown in Table 2-3.

Table 2-3. BST measurements of shear strength of bendway sediments.

Layer	Depth Below Surface (m)	Effective Cohesion c' (Pa)	Effective Friction Angle φ' (^{o})	Angle φ^b (^{o})	Unit Weight (kN/m^3)
1	0-0.5	1,410	33.1	17.0	16.9
2	0.5-1.7	2,700	28.1	10.2	19.3
3	1.7-3.2	6,300	27.0	17.0	19.9
4	> 3.2	1,000	35.0	17.0	21.0

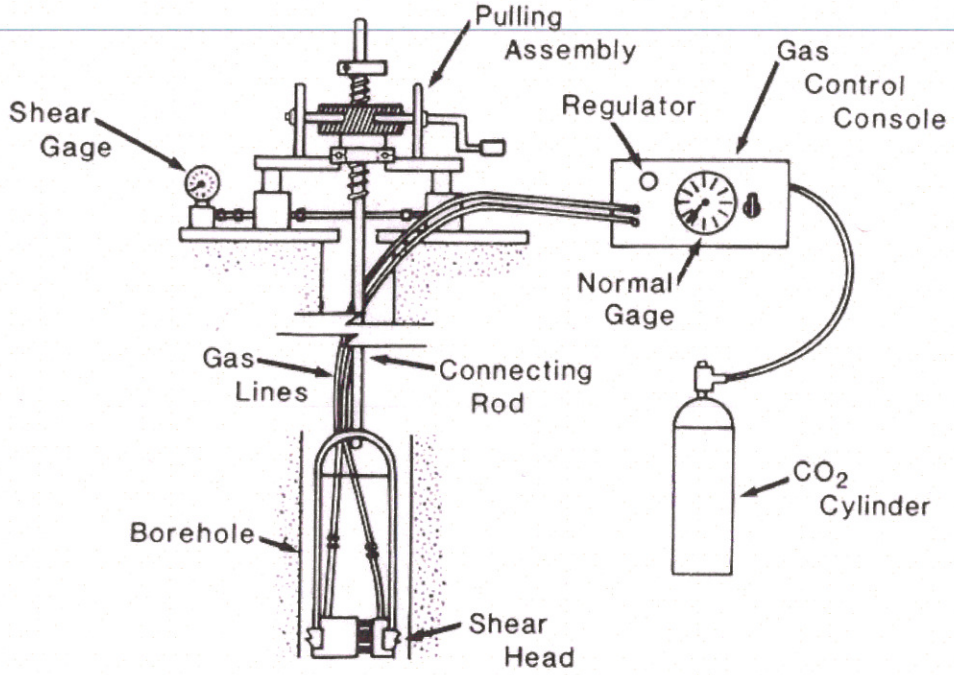


Figure 2-11. Schematic representation of borehole shear tester (BST) used to determine cohesive and frictional strengths of *in situ* streambank materials. Modified from Thorne *et al.* (1981).

2.6.2 Submerged Hydraulic Jet Testing

The submerged jet-test device is used to estimate erosion rates due to hydraulic forces in fine-grained *in situ* materials (Hanson 1990; 1991; Hanson and Simon, 2001) (Figure 2-12). The device shoots a jet of water at a known head (stress) onto the streambed causing it to erode. As the bed erodes, the distance between the jet and the bed increases, resulting in a decrease in the applied shear stress; theoretically, the rate of erosion beneath the jet decreases asymptotically with time to zero. A critical shear stress for the material can then be calculated from the field data as that shear stress where there is no erosion.

The rate of erosion ε (m/s) is assumed to be proportional to the shear stress in excess of a critical shear stress and is expressed as:

$$\varepsilon = k\,(\tau_o - \tau_c)^{\,a} = k\,(\tau_e)^{\,a} \qquad (1)$$

where k = erodibility coefficient (m^3/N-s); τ_o = average boundary shear stress (Pa); τ_c = critical shear stress; a = exponent assumed to equal 1.0 and τ_e = excess shear stress (Pa). An inverse relation between τ_c and k occurs when soils exhibiting a low τ_c have a high k or when soils having a high τ_c have a low k. The measure of material resistance to hydraulic stresses is a function of both τ_c and k. This is generalized to (Hanson and Simon, 2001):

$$k = 0.1\,\tau_c^{\,-0.5} \qquad (2)$$

Two jet tests were conducted at each site where cohesive bed or bank-toe material was present. Values for the Goodwin Creek bendway are shown in Table 2-4.

Table 2-4. Jet test measurements of bendway sediments.

Test Location	τ_c (Pa)	k (cm^3/N-s)
Bed	1.027	0.117
Failure Block	8.07	0.468
Bank face	7.54	0.382

The jet test performed on the bed was carried out on a section of the channel where local scour reached a resistant clay material. The bed of the bendway is predominantly characterized by sand and gravel (Table 2-1), on which the jet test can not be performed. Jet tests were carried out on failed block material located along the toe of the outside bend which were originally located on the bank top. These failure blocks dominate the near-toe region of the outside bend and currently behave as a buffer to the bank-toe. Values given for the bank face represent critical shear stress of materials located above the height of the failure blocks and become critical as flow height increases.

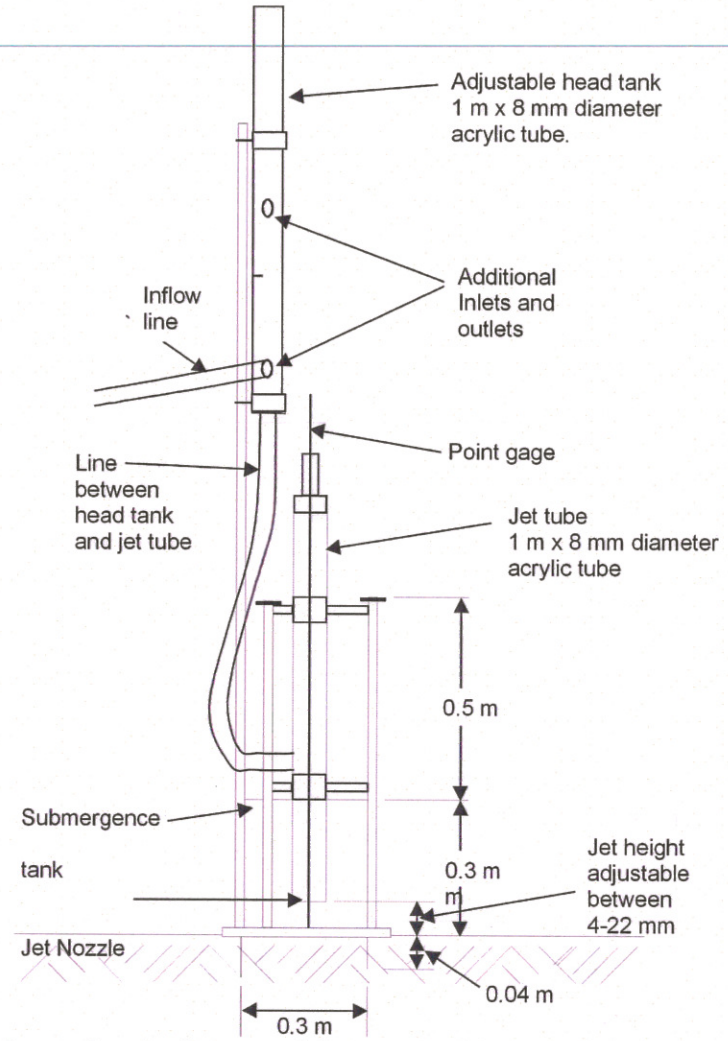


Figure 2-12. Schematic of submerged jet-test device used to measure the erodibility coefficient k, and the critical shear stress τ_c of fine-grained materials.

2.7 Pore-Water Pressure in the Banks

Tensiometers measure soil water potential or tension, which is a measure of the amount of energy required for a plant to overcome capillary and gravitational forces to extract water from a soil. Tensiometers do not measure the osmotic component of soil water potential, which is due to soil salinity. When it is placed in the soil, the water in the instrument comes to equilibrium with the water in the soil by flowing through a ceramic cup. At equilibrium, the water tension in the instrument is equal to the water tension in the soil. Figure 2-13 shows a schematic of a tensiometer.

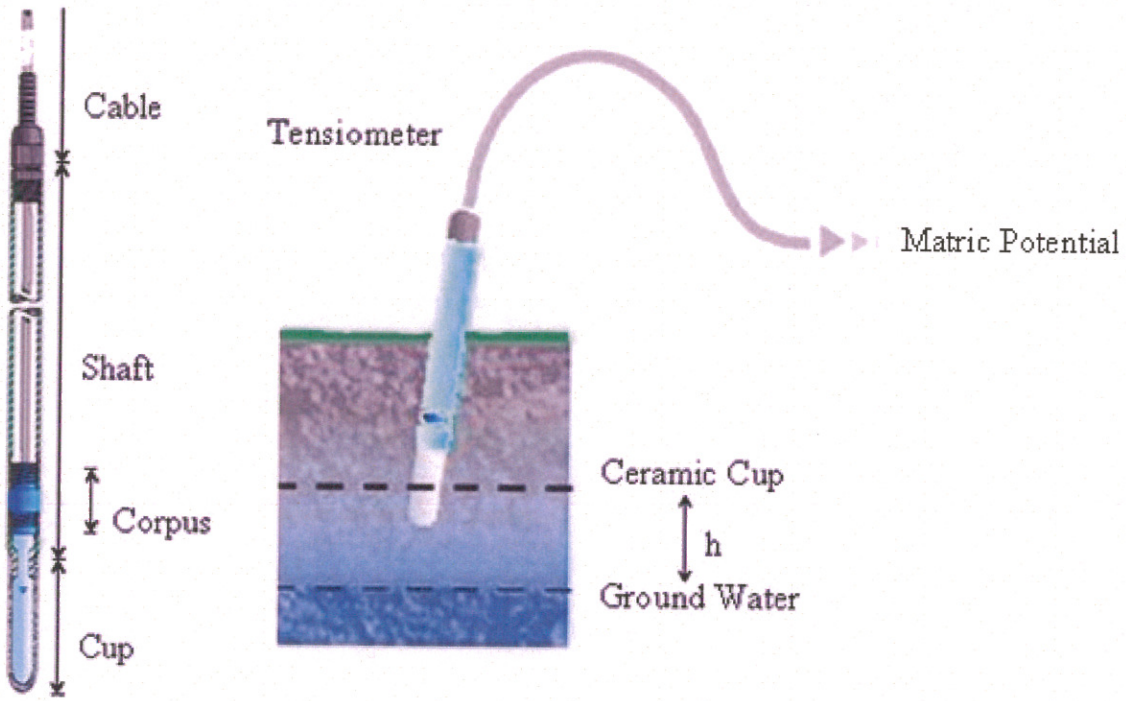


Figure 2-13. Schematic of tensiometer used for pore-water pressure measurements.

The measuring range does not cover the complete range of possible water tension; thus, in the saturated zone tensiometers operate as piezometers or level probes and in the unsaturated zones, they operate up to 85 kPa. Tensiometers produce point measurements; therefore, measured values cannot describe the overall status of an area. An interpretation is largely dependable on type and structure of the soil.

At the bendway study area, tensiometers have been installed at 30 cm, 100 cm, 148 cm, 200 cm, and 270 cm below the ground surface. Pore-water pressures within the streambank at the bendway are shown in Figure 2-14 for the period December 3, 2004 to August 31, 2005. Figure 2-15 shows the pore-water pressures in the streambank for the April 6, 2005 storm.

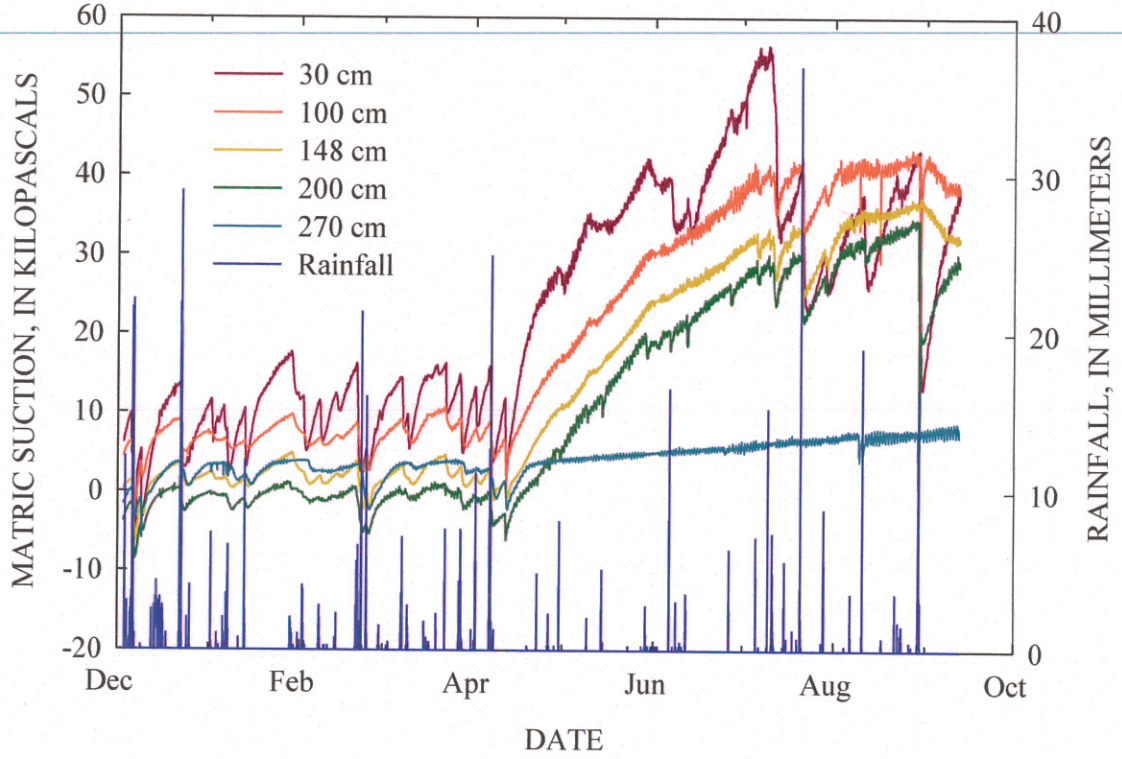


Figure 2-14. Pore-water pressure measurements for the period December 3, 2004 to August 31, 2005.

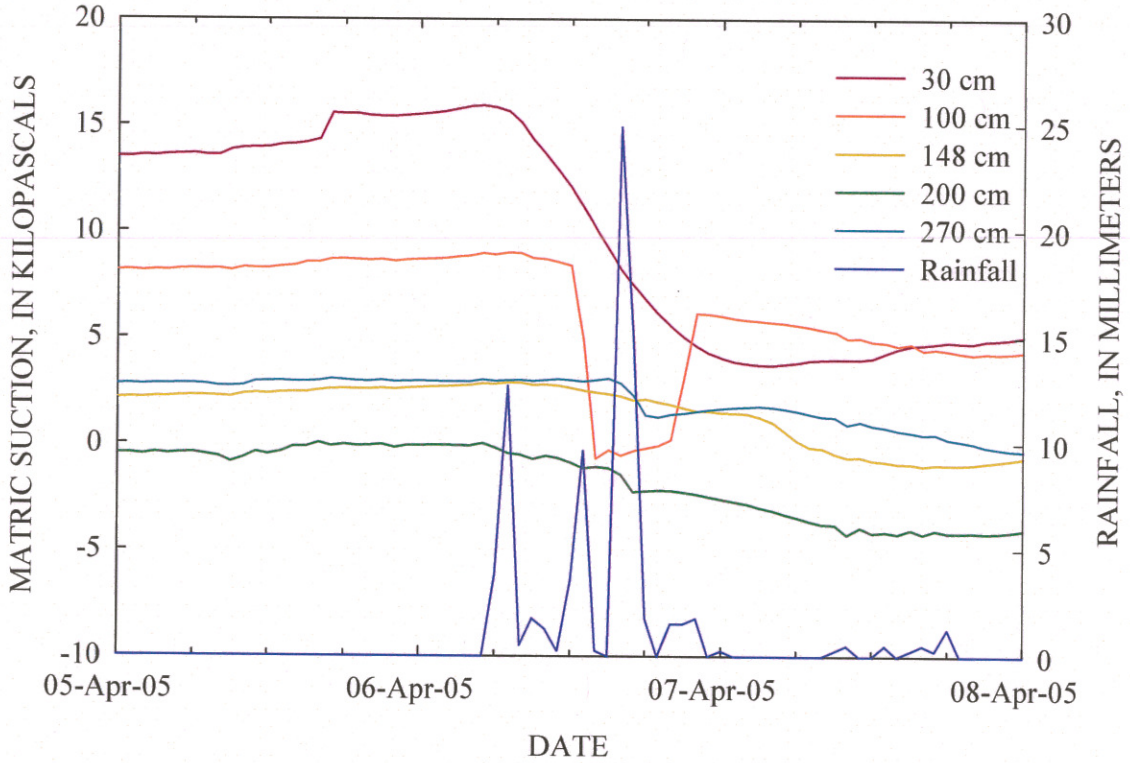


Figure 2-15. Pore-water pressure measurements for the April 6, 2005 storm.

3. Summary and Conclusions

The GCEW bendway study sought to gather cross-sectional geometry information, flow records from Stations 3 and 4 (just upstream of the bendway), flow records at the upstream and downstream ends of the bendway, flow records at the downstream boundary of the model reach, boundary sediment characteristics, and pore-water pressures in the streambank for a specific period (April 6, 2004) in time which characterizes the dynamic nature of a channel bendway. The site has been under investigation by Andrew Simon and his staff since 1997. The data presented in this report is intended for flow and channel evolution modelers. The authors are interested in defining critical areas/zones for further study. New instrumentation has been acquired which will enable laboratory scale investigation of the hydraulic processes within the bendway but these resources could prove cumbersome if not implemented in an area/zone of importance. This study represents a small window of time in the evolution of a bendway from which the authors hope to extract meaningful logistical information to assist in the design of further experiments.

4. References

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5. Appendix

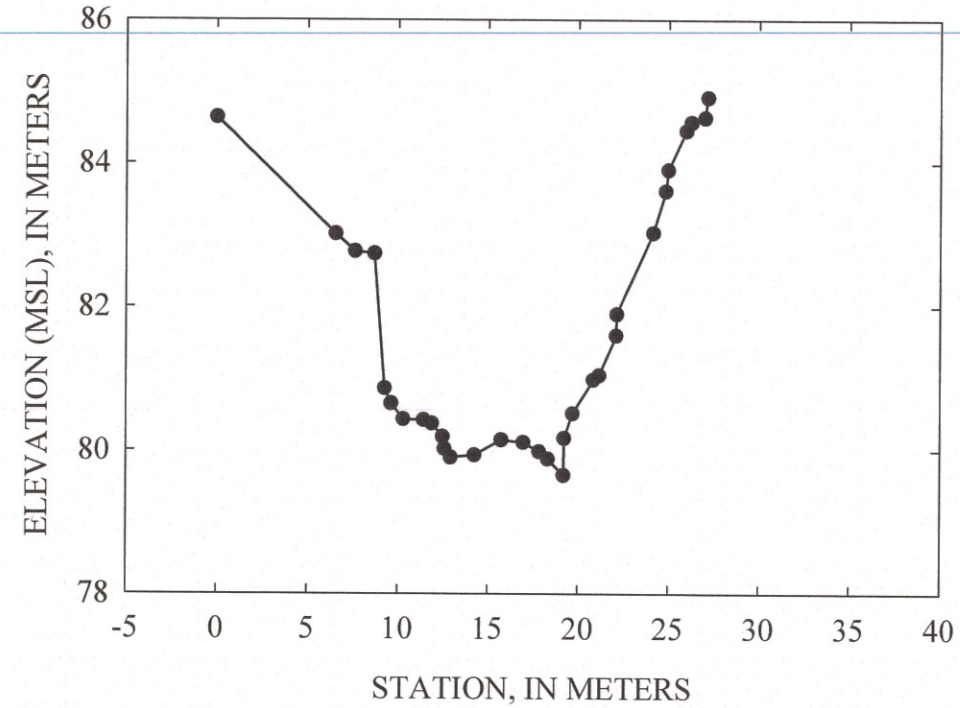


Figure A1. Station and elevation of survey points collected 5/5/05 for cross section 1.



Figure A2. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 1.

Table A1. Station and elevation data for cross section 1.

Northing	Easting	Elevation (m)
416876.82	194576.49	84.92
416876.84	194576.33	84.64
416876.09	194577.03	84.57
416875.87	194577.21	84.45
416875.11	194577.87	83.91
416874.99	194577.95	83.61
416874.35	194578.23	83.03
416872.67	194579.32	81.90
416872.74	194579.47	81.60
416871.94	194579.97	81.04
416871.66	194580.16	80.98
416870.65	194580.71	80.51
416870.24	194580.91	80.17
416870.18	194580.89	79.65
416869.47	194581.39	79.88
416869.06	194581.64	79.98
416868.41	194582.26	80.11
416867.47	194583.02	80.15
416866.19	194583.80	79.93
416865.05	194584.48	79.90
416864.80	194584.72	80.02
416864.79	194584.86	80.19
416864.25	194585.15	80.37
416863.88	194585.41	80.42
416862.87	194585.95	80.43
416862.37	194586.41	80.65
416862.05	194586.58	80.86
416861.54	194586.84	82.74
416860.57	194587.32	82.77
416859.74	194588.01	83.01
416854.82	194592.41	84.64

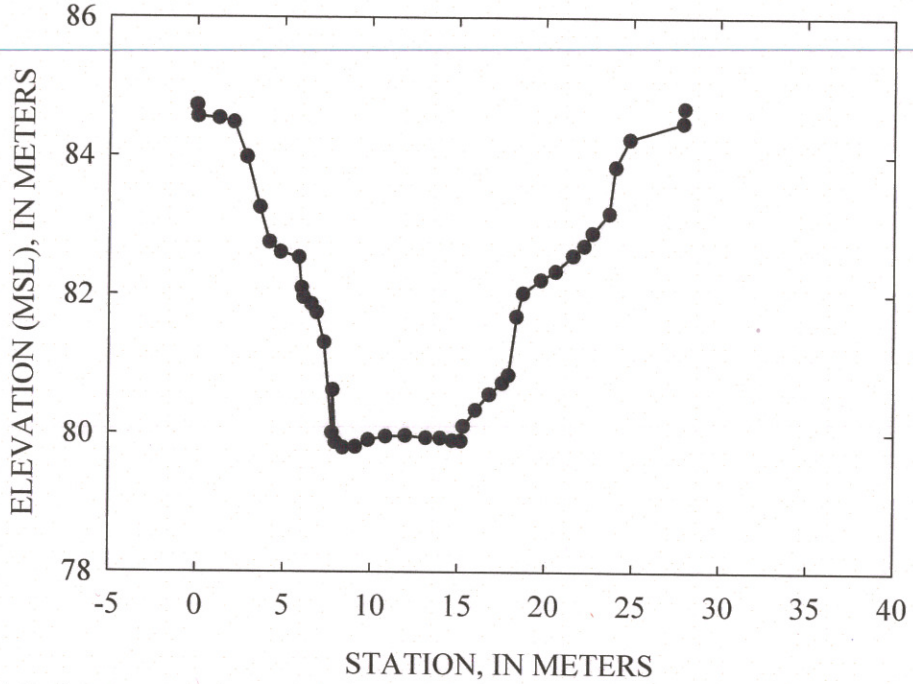


Figure A3. Station and elevation of survey points collected 5/5/05 for cross section 1a.



Figure A4. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 1a.

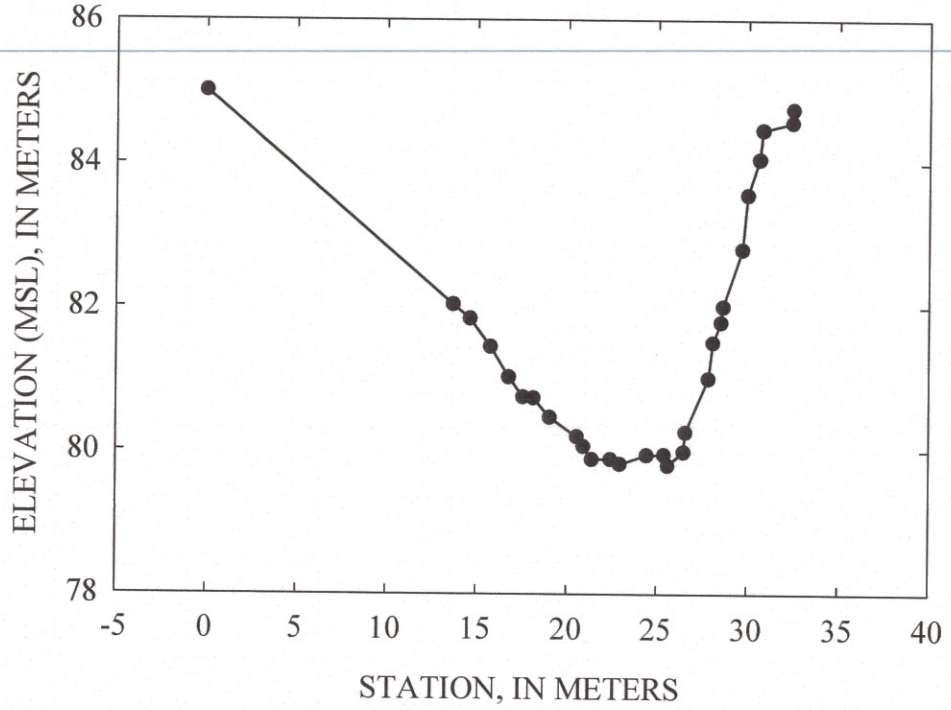


Figure A7. Station and elevation of survey points collected 5/5/05 for cross section 3.



Figure A8. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 3.

Table A2. Station and elevation data for cross section 1a.

Northing	Easting	Elevation (m)
416875.80	194569.91	84.69
416875.75	194569.96	84.49
416873.21	194571.70	84.25
416872.60	194572.23	83.84
416872.33	194572.45	83.18
416871.46	194572.91	82.89
416871.10	194573.20	82.71
416870.61	194573.61	82.57
416869.80	194574.16	82.34
416869.12	194574.67	82.22
416868.28	194575.25	82.02
416867.99	194575.47	81.69
416867.62	194575.73	80.84
416867.26	194575.84	80.73
416866.57	194576.13	80.57
416865.90	194576.56	80.34
416865.31	194576.96	80.11
416865.22	194577.03	79.90
416864.84	194577.35	79.90
416864.29	194577.79	79.94
416863.67	194578.36	79.94
416862.74	194579.09	79.97
416861.84	194579.76	79.96
416861.04	194580.36	79.90
416860.41	194580.75	79.81
416859.86	194581.21	79.79
416859.51	194581.48	79.87
416859.38	194581.61	80.01
416859.38	194581.55	80.62
416859.06	194581.97	81.31
416858.66	194582.18	81.74
416858.33	194582.21	81.86
416857.95	194582.47	81.96
416857.86	194582.56	82.09
416857.68	194582.56	82.54
416856.86	194583.22	82.61
416856.34	194583.59	82.75
416855.86	194583.88	83.26
416855.27	194584.33	83.98
416854.68	194584.81	84.48
416854.00	194585.33	84.54
416853.00	194585.99	84.57
416852.97	194586.03	84.72

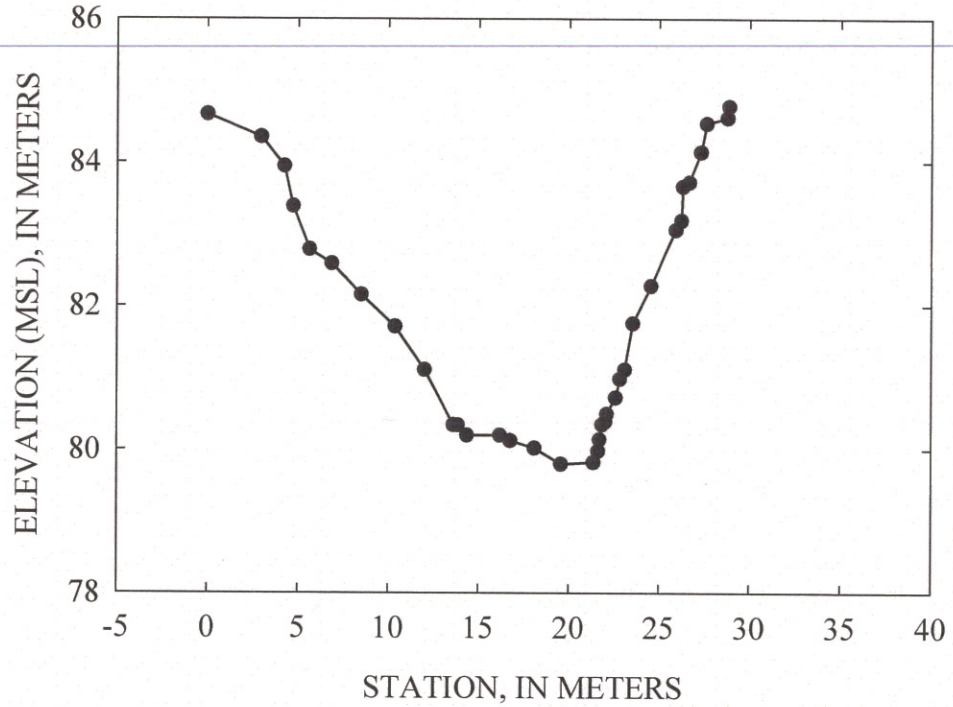


Figure A5. Station and elevation of survey points collected 5/5/05 for cross section 2.



Figure A6. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 2.

Table A3. Station and elevation data for cross section 2.

Northing	Easting	Elevation (m)
416871.70	194564.76	84.78
416871.63	194564.72	84.62
416870.75	194565.55	84.54
416870.57	194565.83	84.14
416870.11	194566.29	83.72
416869.90	194566.58	83.66
416869.79	194566.57	83.19
416869.55	194566.77	83.06
416868.33	194567.47	82.28
416867.37	194567.88	81.76
416866.96	194568.05	81.11
416866.75	194568.24	80.98
416866.60	194568.43	80.72
416866.18	194568.70	80.49
416866.14	194568.77	80.39
416865.99	194568.89	80.35
416865.86	194568.94	80.14
416865.78	194568.96	79.98
416865.54	194569.05	79.82
416864.50	194570.66	79.79
416863.52	194571.77	80.02
416862.58	194572.73	80.12
416862.16	194573.13	80.19
416860.67	194574.18	80.20
416860.26	194574.47	80.34
416860.03	194574.59	80.34
416858.77	194575.60	81.11
416857.60	194576.71	81.71
416856.23	194578.00	82.15
416855.23	194579.35	82.58
416854.35	194580.21	82.78
416853.83	194580.98	83.38
416853.55	194581.40	83.94
416852.62	194582.29	84.35
416850.34	194584.17	84.66
416850.34	194584.17	84.66

Table A4. Station and elevation data for cross section 3.

Northing	Easting	Elevation (m)
416867.39	194559.94	84.76
416867.37	194559.90	84.57
416866.06	194560.93	84.47
416865.91	194561.02	84.06
416865.39	194561.40	83.56
416865.19	194561.60	82.80
416864.33	194562.20	82.00
416864.21	194562.24	81.79
416863.86	194562.50	81.51
416863.72	194562.73	81.00
416862.68	194563.44	80.26
416862.65	194563.56	79.98
416862.00	194564.14	79.79
416861.83	194564.28	79.94
416861.14	194564.98	79.94
416859.83	194565.74	79.81
416859.46	194566.10	79.88
416858.61	194566.68	79.88
416858.21	194566.96	80.06
416857.95	194567.20	80.19
416856.69	194568.04	80.46
416855.88	194568.45	80.73
416855.34	194568.71	80.74
416854.62	194569.05	81.02
416853.70	194569.50	81.44
416852.56	194569.82	81.83
416851.78	194570.35	82.03
416840.62	194578.27	85.00

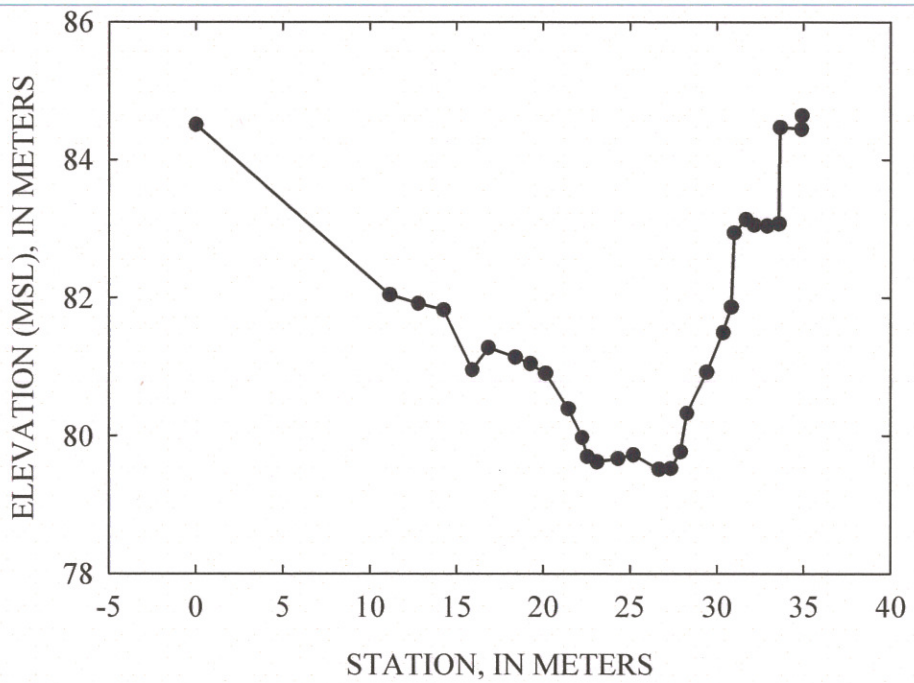


Figure A9. Station and elevation of survey points collected 5/5/05 for cross section 4.

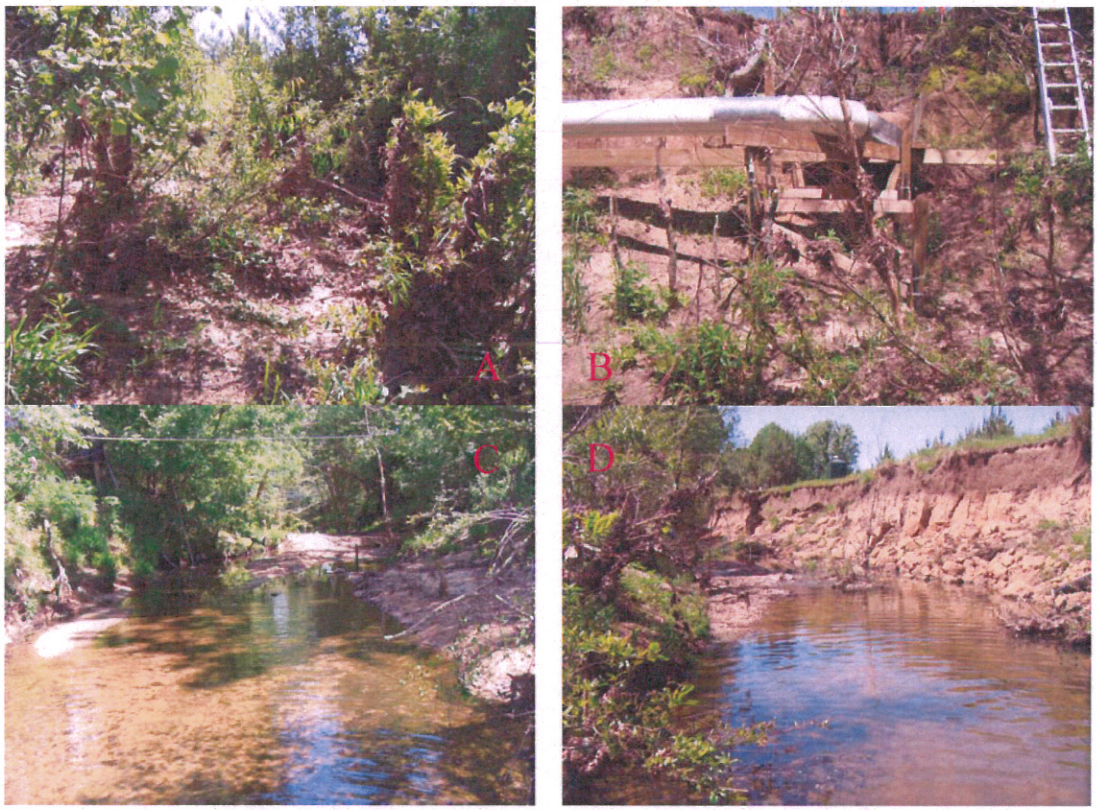


Figure A10. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 4.

Table A5. Station and elevation data for cross section 4.

Northing	Easting	Elevation (m)
416863.62	194552.81	84.64
416863.59	194552.85	84.45
416862.73	194553.71	84.47
416862.61	194553.68	83.08
416862.08	194554.09	83.04
416861.57	194554.67	83.05
416861.28	194555.05	83.14
416860.91	194555.65	82.94
416860.76	194555.74	81.87
416860.30	194555.93	81.50
416859.58	194556.54	80.92
416858.93	194557.52	80.33
416858.75	194557.86	79.76
416858.41	194558.31	79.52
416857.97	194558.81	79.51
416856.92	194559.86	79.72
416856.37	194560.56	79.67
416855.23	194561.13	79.62
416854.83	194561.52	79.70
416854.62	194561.74	79.97
416854.01	194562.27	80.39
416853.05	194563.15	80.90
416852.45	194563.76	81.04
416851.83	194564.37	81.14
416850.89	194565.63	81.28
416850.15	194566.24	80.96
416848.91	194567.33	81.83
416847.76	194568.24	81.92
416846.56	194569.37	82.04
416838.95	194577.52	84.51

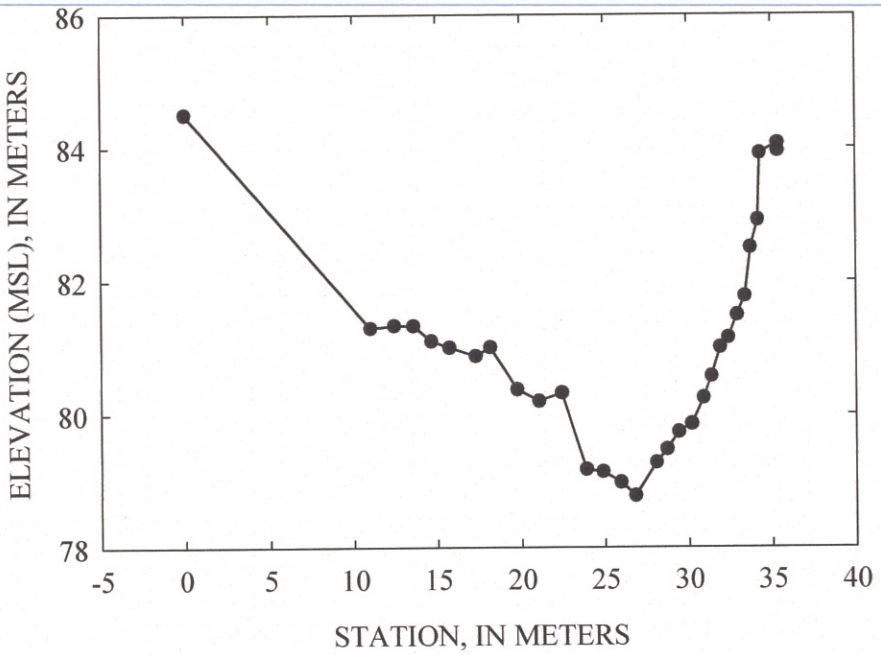


Figure A11. Station and elevation of survey points collected 5/5/05 for cross section 5.



Figure A12. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 5.

Table A6. Station and elevation data for cross section 5.

Northing	Easting	Elevation (m)
416854.44	194545.72	84.06
416854.42	194545.71	83.95
416853.95	194546.67	83.91
416853.96	194546.81	82.91
416853.80	194547.23	82.50
416853.79	194547.63	81.77
416853.62	194548.06	81.49
416853.46	194548.57	81.15
416853.09	194548.93	81.00
416852.88	194549.42	80.57
416852.51	194549.78	80.25
416852.12	194550.36	79.86
416851.64	194550.99	79.73
416851.26	194551.58	79.47
416851.09	194552.20	79.27
416850.64	194553.39	78.77
416850.27	194554.19	78.98
416849.81	194555.17	79.14
416849.38	194556.06	79.18
416848.73	194557.36	80.33
416848.11	194558.58	80.20
416847.54	194559.74	80.38
416846.69	194561.09	81.01
416846.37	194561.89	80.88
416845.68	194563.30	81.01
416845.21	194564.28	81.10
416844.84	194565.29	81.33
416844.42	194566.37	81.34
416844.02	194567.76	81.30
416838.95	194577.52	84.51

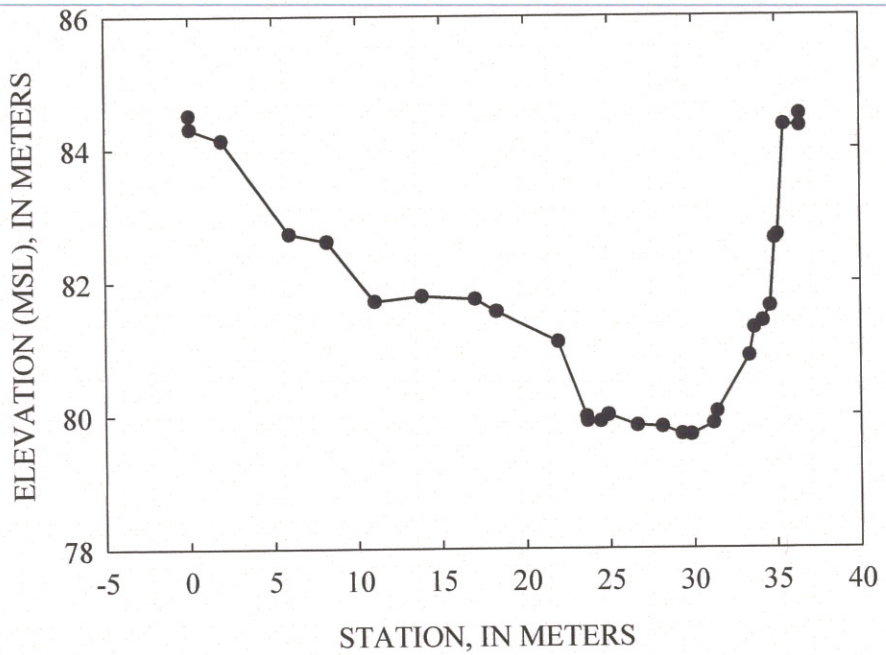


Figure A13. Station and elevation of survey points collected 5/5/05 for cross section 6.



Figure A14. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 6.

Table A7. Station and elevation data for cross section 6.

Northing	Easting	Elevation (m)
416833.07	194574.67	84.52
416833.05	194574.63	84.31
416833.99	194572.96	84.14
416835.31	194569.18	82.73
416836.04	194567.06	82.62
416837.00	194564.38	81.72
416838.36	194561.90	81.80
416840.29	194559.29	81.75
416840.92	194558.18	81.56
416841.08	194554.27	81.11
416841.54	194552.64	79.98
416841.55	194552.60	79.91
416841.84	194551.86	79.91
416842.05	194551.47	80.00
416842.67	194549.84	79.84
416843.10	194548.39	79.82
416843.49	194547.29	79.71
416843.68	194546.78	79.70
416844.36	194545.59	79.87
416844.42	194545.37	80.05
416844.83	194543.45	80.88
416844.75	194543.09	81.31
416844.92	194542.60	81.41
416844.95	194542.16	81.63
416845.54	194542.06	82.65
416845.60	194541.90	82.70
416845.73	194541.52	84.35
416846.33	194540.73	84.33
416846.29	194540.72	84.51

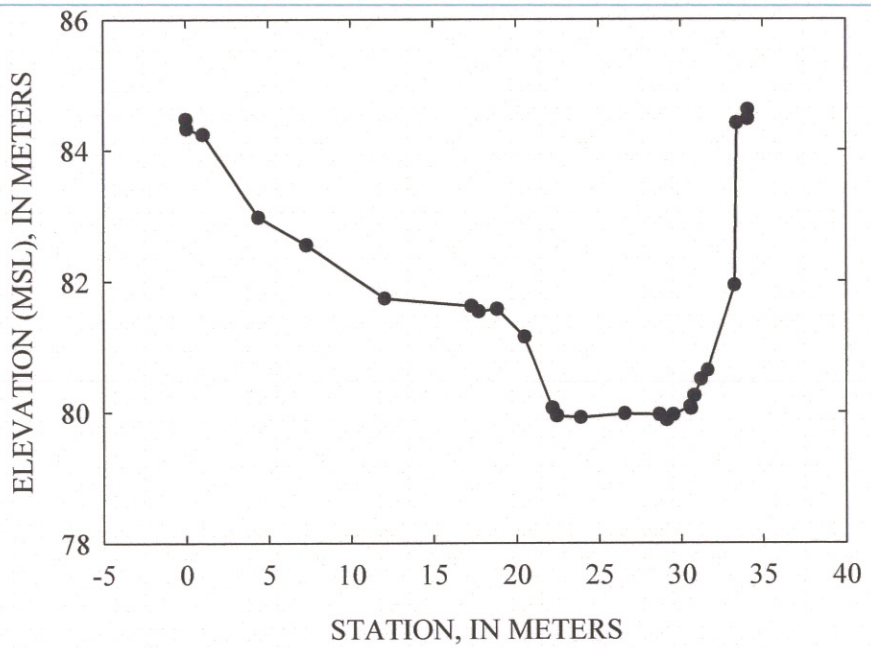


Figure A15. Station and elevation of survey points collected 5/5/05 for cross section 7.



Figure A16. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 7.

Table A8. Station and elevation data for cross section 7.

Northing	Easting	Elevation (m)
416838.04	194539.16	84.61
416838.03	194539.18	84.47
416837.64	194539.74	84.41
416837.73	194539.93	81.93
416837.23	194541.51	80.64
416837.19	194541.95	80.50
416837.07	194542.36	80.25
416836.98	194542.58	80.08
416837.00	194542.54	80.05
416836.29	194543.42	79.96
416836.09	194543.75	79.88
416835.84	194544.12	79.96
416834.90	194546.01	79.97
416834.04	194548.56	79.92
416833.43	194549.86	79.95
416833.39	194550.14	80.06
416832.74	194551.68	81.15
416832.12	194553.24	81.57
416831.76	194554.29	81.54
416831.53	194554.65	81.62
416829.18	194559.37	81.74
416826.96	194563.57	82.56
416825.68	194566.18	82.98
416824.27	194569.21	84.24
416823.89	194570.14	84.33
416823.90	194570.18	84.47

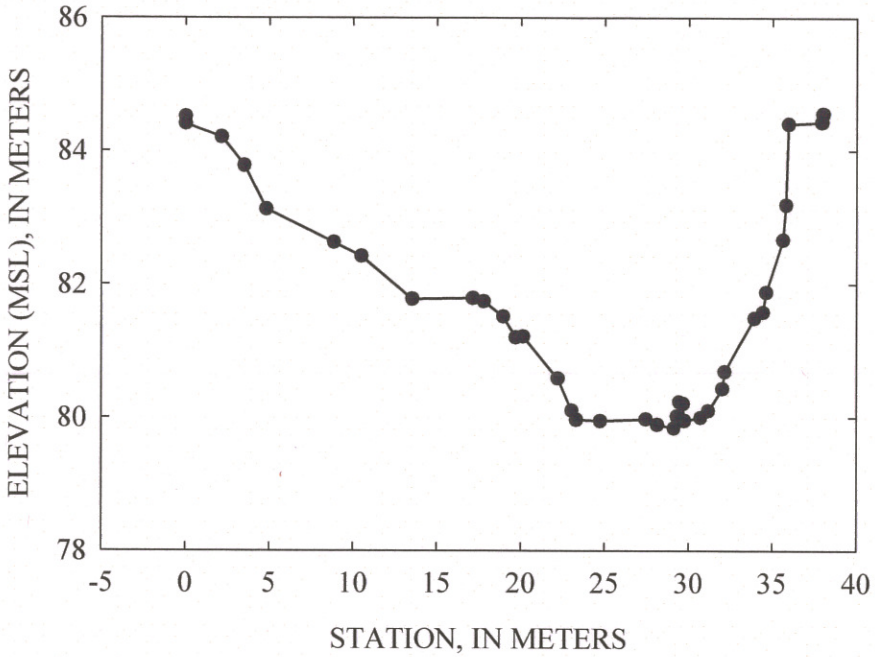


Figure A17. Station and elevation of survey points collected 5/5/05 for cross section 8.



Figure A18. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 8.

Table A9. Station and elevation data for cross section 8.

Northing	Easting	Elevation (m)
416832.97	194534.57	84.56
416832.92	194534.61	84.43
416832.30	194536.51	84.41
416832.15	194536.61	83.19
416832.09	194536.78	82.67
416831.55	194537.64	81.88
416831.58	194537.85	81.58
416831.49	194538.37	81.49
416831.14	194540.13	80.69
416831.16	194540.29	80.43
416830.88	194541.07	80.10
416830.68	194541.50	80.00
416830.57	194542.48	79.96
416830.61	194542.58	80.21
416830.55	194542.79	80.24
416830.49	194542.93	80.02
416830.48	194543.11	79.84
416830.29	194544.07	79.90
416830.19	194544.75	79.98
416829.24	194547.32	79.95
416828.68	194548.64	79.97
416828.54	194548.89	80.11
416828.17	194549.64	80.59
416827.20	194551.49	81.22
416826.99	194551.88	81.20
416826.79	194552.61	81.51
416826.33	194553.68	81.74
416826.13	194554.29	81.79
416824.80	194557.63	81.78
416824.18	194560.63	82.42
416823.73	194562.23	82.63
416822.48	194566.06	83.13
416822.21	194567.34	83.78
416821.72	194568.62	84.21
416820.64	194570.50	84.41
416820.67	194570.53	84.52

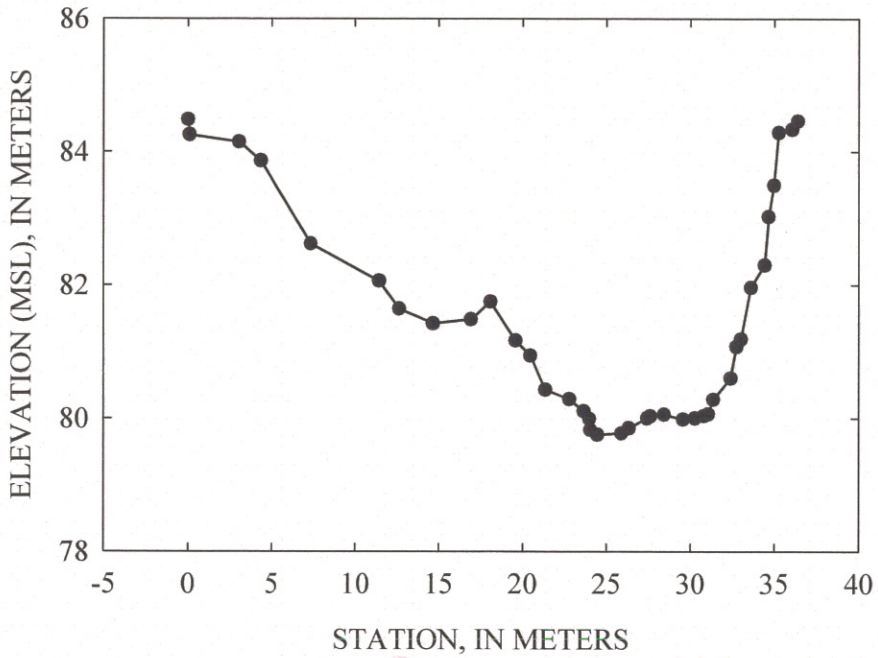


Figure A19. Station and elevation of survey points collected 5/5/05 for cross section 9.



Figure A20. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 9.

Table A10. Station and elevation data for cross section 9.

Northing	Easting	Elevation (m)
416823.04	194533.02	84.46
416823.35	194533.14	84.34
416822.89	194534.14	84.29
416822.80	194534.42	83.50
416822.73	194534.73	83.03
416822.64	194534.95	82.30
416822.24	194535.70	81.97
416822.04	194536.25	81.19
416821.89	194536.47	81.08
416821.72	194536.79	80.60
416821.45	194537.80	80.28
416821.29	194538.07	80.07
416821.21	194538.30	80.04
416821.13	194538.85	80.01
416820.93	194539.52	79.99
416820.63	194540.63	80.06
416820.34	194541.39	80.04
416820.27	194541.56	80.01
416820.21	194542.69	79.85
416820.06	194543.11	79.78
416819.83	194544.53	79.76
416819.79	194544.96	79.83
416819.77	194545.01	79.99
416819.76	194545.36	80.11
416819.68	194546.22	80.29
416819.37	194547.62	80.43
416818.90	194548.41	80.94
416818.47	194549.22	81.17
416817.87	194550.59	81.75
416817.37	194551.67	81.49
416816.87	194553.87	81.42
416816.55	194555.88	81.65
416816.17	194557.00	82.06
416814.61	194560.83	82.62
416813.69	194563.69	83.87
416813.23	194564.91	84.15
416812.20	194567.66	84.26
416812.13	194567.74	84.48

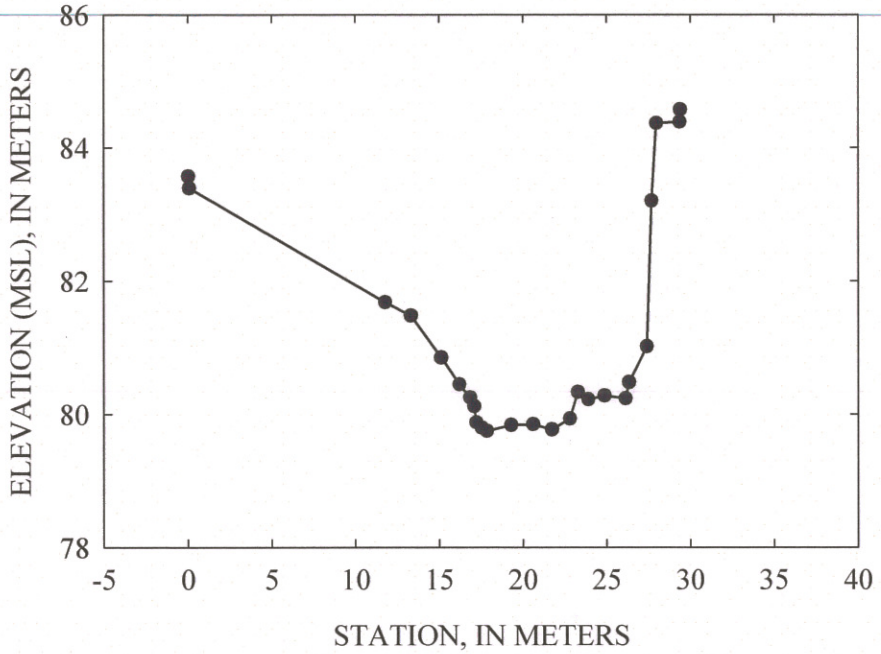


Figure A21. Station and elevation of survey points collected 5/5/05 for cross section 10.



Figure A22. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 10.

Table A11. Station and elevation data for cross section 10.

Northing	Easting	Elevation (m)
416800.48	194558.88	83.57
416800.46	194558.94	83.40
416804.06	194547.66	81.68
416804.60	194546.21	81.48
416805.37	194544.58	80.85
416805.75	194543.56	80.45
416805.88	194542.93	80.25
416806.04	194542.72	80.12
416806.17	194542.64	79.88
416806.32	194542.35	79.80
416806.47	194542.08	79.75
416806.88	194540.69	79.84
416807.37	194539.48	79.85
416807.60	194538.38	79.77
416807.91	194537.36	79.94
416808.05	194536.90	80.33
416808.12	194536.26	80.23
416808.81	194535.46	80.28
416809.21	194534.28	80.24
416809.18	194534.05	80.48
416809.35	194532.98	81.02
416809.76	194532.80	83.20
416809.83	194532.54	84.37
416810.12	194531.15	84.39
416810.15	194531.13	84.57

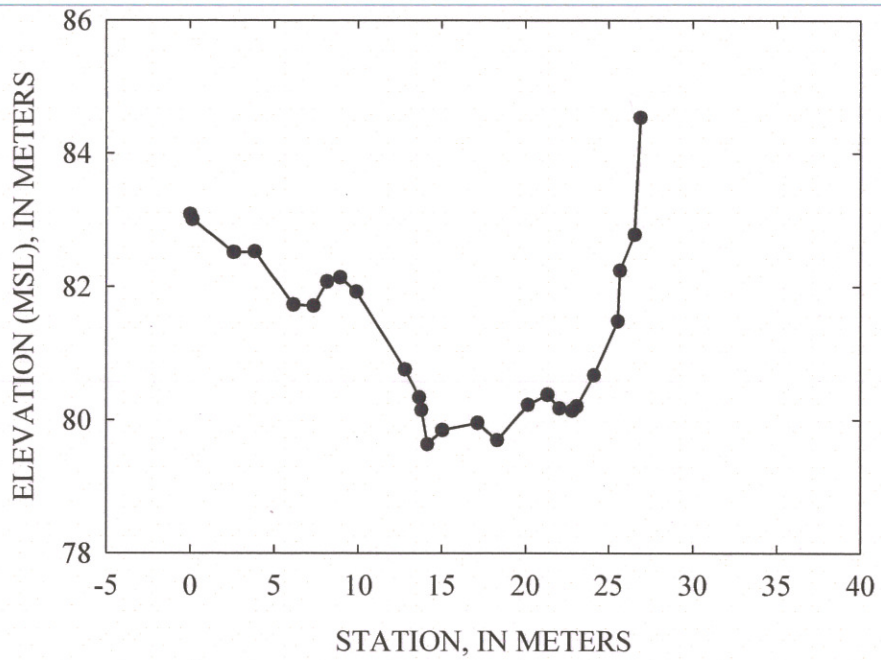


Figure A23. Station and elevation of survey points collected 5/5/05 for cross section 11.



Figure A24. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 11.

Table A12. Station and elevation data for cross section 11.

Northing	Easting	Elevation (m)
416800.11	194528.74	84.54
416799.98	194529.05	82.78
416799.84	194529.93	82.24
416799.77	194530.04	81.48
416799.39	194531.41	80.67
416799.06	194532.42	80.21
416798.93	194532.65	80.14
416798.60	194533.35	80.17
416798.33	194533.99	80.38
416797.80	194535.06	80.23
416797.12	194536.76	79.70
416796.42	194537.74	79.96
416795.46	194539.62	79.85
416795.09	194540.43	79.63
416794.88	194540.73	80.15
416794.83	194540.86	80.34
416794.53	194541.67	80.76
416793.28	194544.29	81.92
416792.71	194545.09	82.14
416792.21	194545.72	82.08
416791.80	194546.41	81.71
416791.36	194547.55	81.73
416790.28	194549.56	82.53
416789.57	194550.61	82.52
416788.60	194552.87	83.01
416788.59	194553.02	83.09

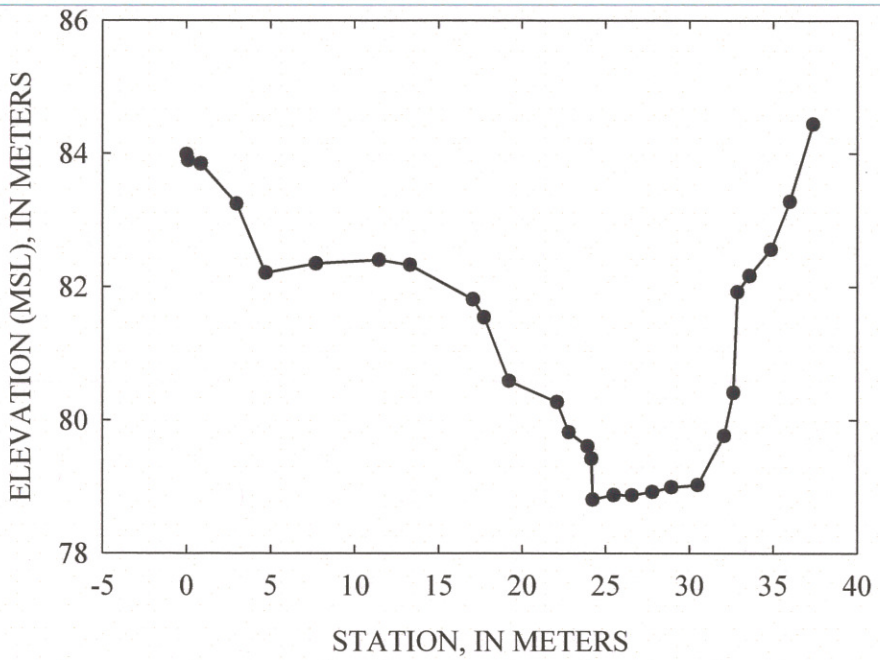


Figure A25. Station and elevation of survey points collected 5/5/05 for cross section 12.



Figure A26. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 12.

Table A13. Station and elevation data for cross section 12.

Northing	Easting	Elevation (m)
416768.91	194555.52	83.99
416768.82	194555.50	83.90
416769.17	194554.71	83.85
416770.17	194552.84	83.25
416770.97	194551.31	82.21
416772.27	194548.60	82.35
416774.20	194545.40	82.41
416775.05	194543.73	82.33
416776.83	194540.43	81.81
416777.24	194539.89	81.54
416777.90	194538.55	80.59
416779.24	194536.00	80.27
416779.52	194535.35	79.82
416779.93	194534.31	79.61
416780.02	194534.10	79.42
416780.07	194534.04	78.81
416780.54	194532.88	78.87
416781.05	194531.92	78.87
416781.73	194530.89	78.92
416782.40	194529.95	78.99
416783.23	194528.61	79.03
416784.04	194527.27	79.76
416784.36	194526.80	80.42
416784.06	194526.36	81.93
416784.23	194525.65	82.17
416784.87	194524.54	82.56
416785.49	194523.59	83.28
416786.18	194522.40	84.44

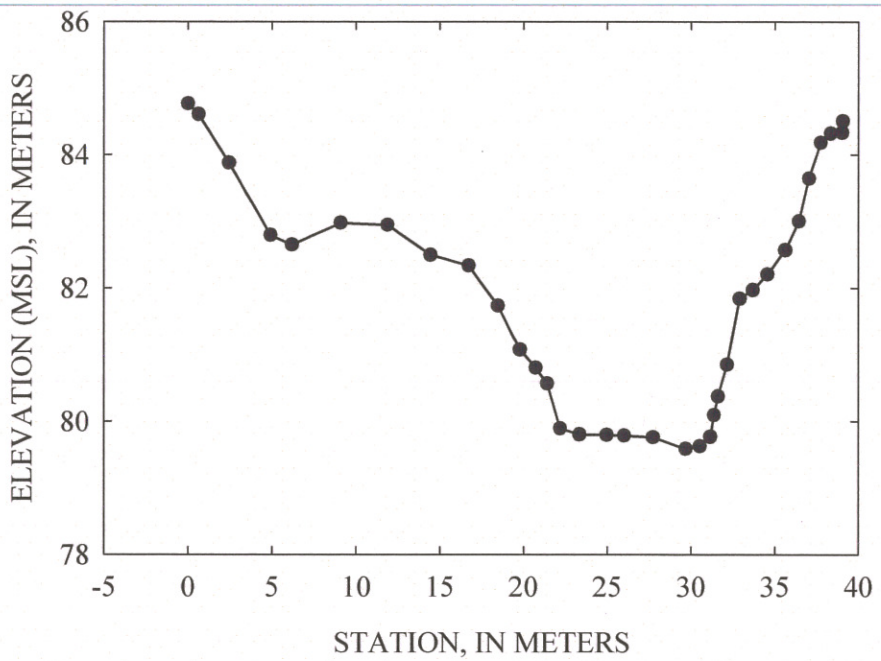


Figure A27. Station and elevation of survey points collected 5/5/05 for cross section 12a.



Figure A28. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 12a.

Table A14. Station and elevation data for cross section 12a.

Northing	Easting	Elevation (m)
416779.62	194516.84	84.51
416779.59	194516.85	84.34
416779.30	194517.48	84.33
416779.04	194518.03	84.19
416778.59	194518.59	83.65
416778.22	194519.08	83.01
416777.69	194519.70	82.58
416777.02	194520.52	82.21
416776.49	194521.22	81.98
416776.15	194521.94	81.84
416775.72	194522.54	80.86
416775.34	194522.94	80.38
416775.21	194523.14	80.10
416775.05	194523.30	79.77
416774.79	194523.87	79.63
416774.43	194524.66	79.59
416773.58	194526.42	79.76
416772.57	194527.84	79.79
416771.97	194528.69	79.80
416771.08	194530.04	79.81
416770.41	194530.97	79.90
416770.00	194531.65	80.57
416769.61	194532.22	80.81
416769.21	194533.07	81.08
416768.35	194534.08	81.74
416767.47	194535.58	82.34
416766.33	194537.56	82.50
416765.07	194539.79	82.95
416763.64	194542.21	82.98
416761.83	194544.48	82.65
416761.17	194545.57	82.80
416759.54	194547.47	83.88
416758.45	194548.90	84.61
416758.22	194549.51	84.77

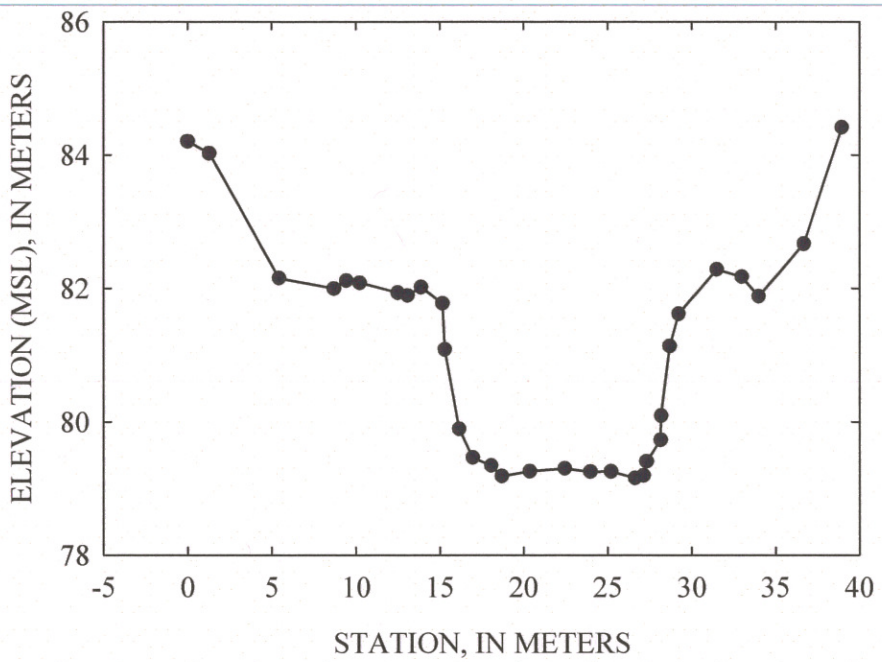


Figure A29. Station and elevation of survey points collected 5/5/05 for cross section 13.



Figure A30. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 13.

Table A15. Station and elevation data for cross section 13.

Northing	Easting	Elevation (m)
416746.29	194539.60	84.21
416747.09	194538.60	84.03
416749.88	194535.52	82.16
416751.90	194532.98	82.00
416752.29	194532.34	82.12
416752.77	194531.69	82.09
416754.18	194529.92	81.94
416754.49	194529.41	81.90
416755.16	194528.93	82.02
416756.04	194528.01	81.78
416756.24	194527.98	81.09
416756.86	194527.40	79.90
416757.30	194526.69	79.46
416758.01	194525.85	79.34
416758.36	194525.31	79.19
416759.25	194523.91	79.26
416760.61	194522.31	79.30
416761.46	194521.04	79.25
416762.27	194520.13	79.26
416763.05	194518.93	79.15
416763.70	194518.80	79.20
416763.74	194518.61	79.41
416764.07	194517.81	79.73
416763.91	194517.63	80.09
416764.18	194517.19	81.14
416764.53	194516.80	81.62
416766.23	194515.24	82.29
416767.04	194513.98	82.18
416767.75	194513.25	81.88
416769.23	194510.98	82.67
416770.74	194509.29	84.42

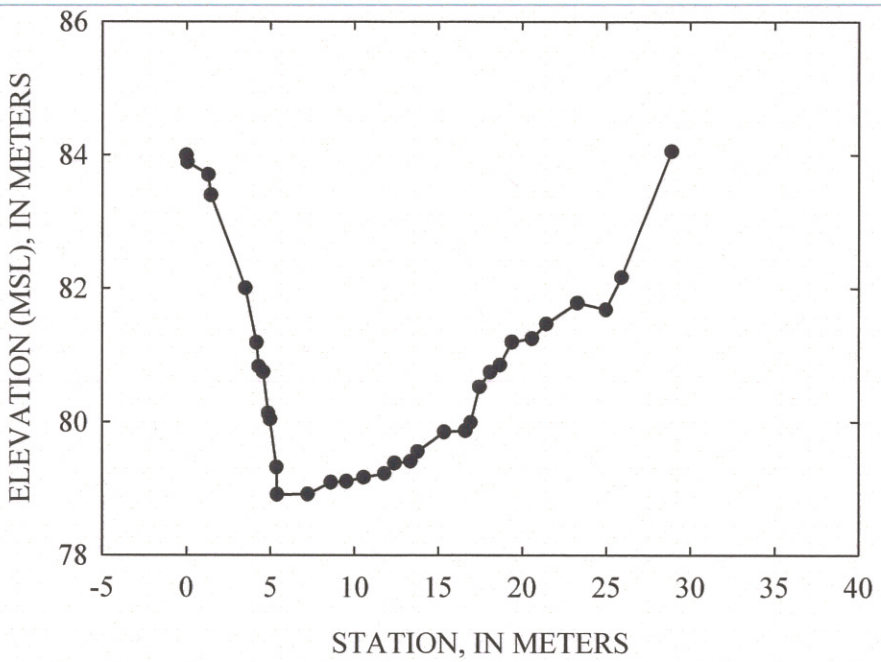


Figure A31. Station and elevation of survey points collected 5/5/05 for cross section 14.



Figure A32. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 14.

Table A16. Station and elevation data for cross section 14.

Northing	Easting	Elevation (m)
416735.81	194522.80	84.00
416735.79	194522.86	83.89
416736.88	194522.09	83.71
416737.00	194521.97	83.40
416738.54	194520.63	82.00
416738.91	194520.03	81.19
416739.00	194519.93	80.83
416739.24	194519.80	80.75
416739.44	194519.58	80.13
416739.46	194519.42	80.04
416739.69	194519.11	79.32
416739.70	194519.07	78.91
416740.88	194517.67	78.91
416741.53	194516.37	79.09
416742.12	194515.66	79.10
416742.74	194514.83	79.17
416743.41	194513.80	79.22
416743.85	194513.36	79.38
416744.38	194512.57	79.41
416744.65	194512.26	79.55
416745.67	194511.04	79.85
416746.38	194509.99	79.87
416746.58	194509.75	79.99
416746.91	194509.34	80.52
416747.40	194508.91	80.75
416747.75	194508.45	80.85
416748.11	194507.84	81.20
416748.78	194506.84	81.25
416749.43	194506.26	81.47
416750.64	194504.90	81.78
416751.62	194503.50	81.68
416752.14	194502.71	82.17
416753.93	194500.33	84.06

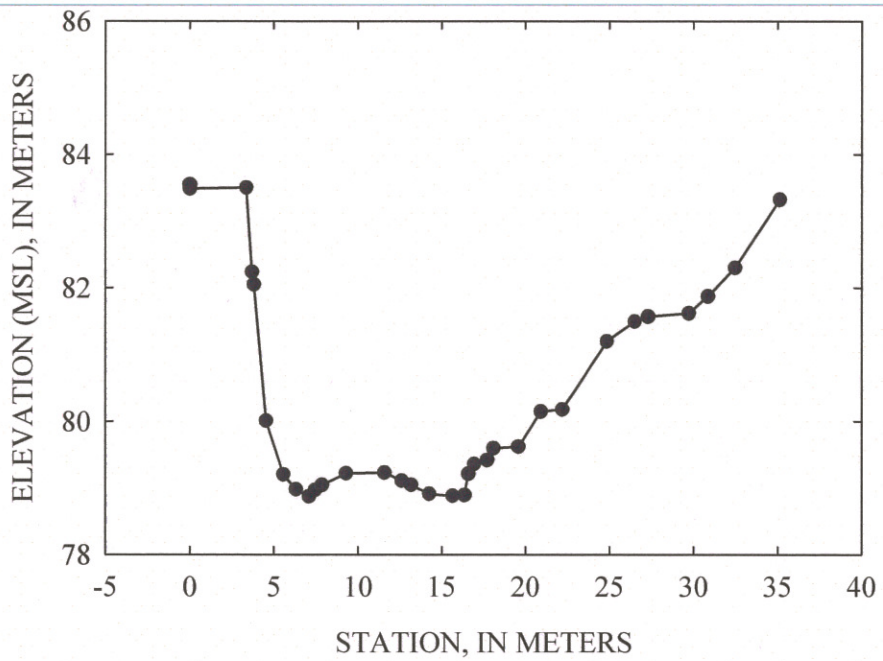


Figure A33. Station and elevation of survey points collected 5/5/05 for cross section 15.



Figure A34. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 15.

Table A17. Station and elevation data for cross section 15.

Northing	Easting	Elevation (m)
416727.62	194514.83	83.71
416727.68	194515.03	83.64
416728.69	194513.56	83.59
416728.74	194513.43	82.84
416729.08	194513.22	82.00
416729.50	194512.67	80.34
416729.78	194512.29	79.42
416730.42	194511.61	79.25
416731.05	194510.33	78.98
416731.33	194509.41	78.90
416731.85	194508.50	78.90
416732.37	194507.62	78.94
416733.51	194505.78	78.95
416733.94	194505.14	79.01
416734.49	194504.26	79.38
416735.37	194502.56	79.42
416736.11	194501.75	80.23
416736.66	194500.85	80.73
416737.01	194500.32	80.80
416737.61	194499.16	80.76
416738.80	194498.18	81.13
416739.53	194497.04	81.32
416740.06	194496.53	81.58
416740.82	194495.25	81.52
416741.78	194493.66	81.97
416744.30	194489.80	83.33

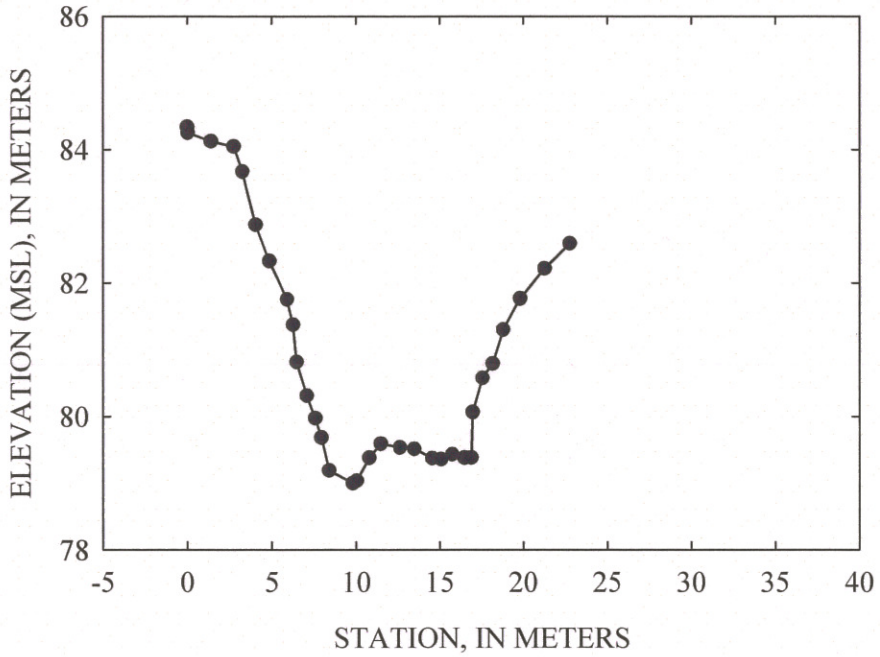


Figure A35. Station and elevation of survey points collected 5/5/05 for cross section 16.



Figure A36. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 16.

Table A18. Station and elevation data for cross section 16.

Northing	Easting	Elevation (m)
416715.86	194503.87	83.57
416715.84	194503.88	83.53
416716.40	194503.53	83.47
416716.61	194503.40	82.88
416717.28	194503.30	82.23
416718.05	194502.95	81.76
416718.82	194502.29	80.97
416719.45	194501.77	79.72
416720.84	194501.08	79.25
416721.37	194500.78	79.33
416722.37	194500.17	79.27
416724.04	194499.34	79.15
416724.51	194499.09	79.20
416726.75	194498.18	79.02
416727.70	194497.74	78.91
416728.49	194497.18	79.00
416728.69	194497.08	79.12
416729.29	194496.63	79.32
416730.52	194496.00	79.56
416731.93	194495.11	80.39
416732.76	194495.10	80.57
416733.74	194494.18	80.54
416737.08	194492.87	81.63
416738.12	194492.32	81.70
416738.61	194492.01	81.47
416741.87	194490.66	82.26
416744.30	194489.77	83.33

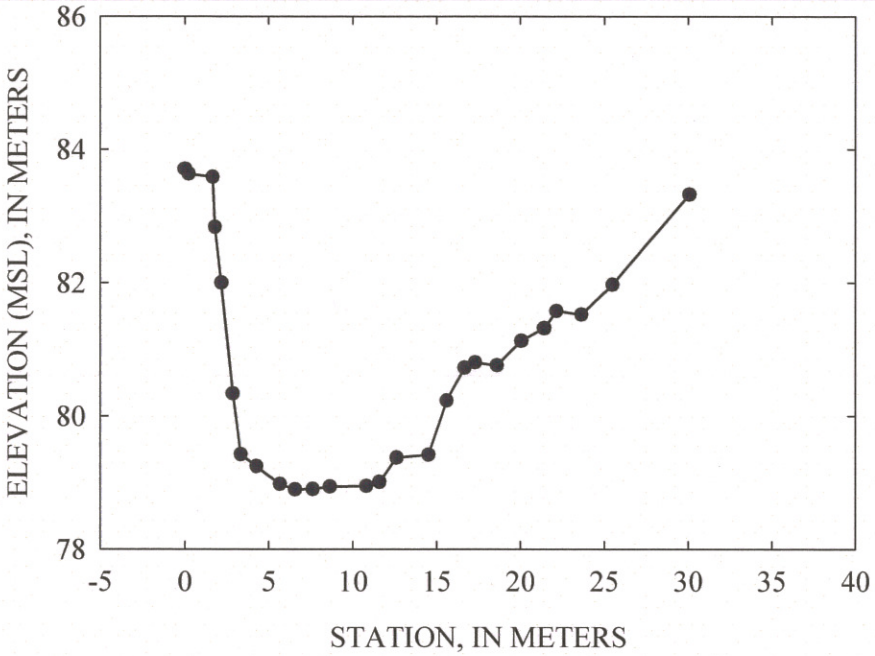


Figure A37. Station and elevation of survey points collected 5/5/05 for cross section 17.



Figure A38. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 17.

Table A19. Station and elevation data for cross section 17.

Northing	Easting	Elevation (m)
416709.52	194494.08	83.55
416709.53	194494.09	83.49
416712.79	194493.32	83.51
416713.10	194493.10	82.24
416713.20	194493.08	82.05
416713.94	194493.07	80.01
416714.94	194492.81	79.20
416715.64	194492.50	78.98
416716.39	194492.30	78.87
416716.75	194492.19	78.97
416717.27	194492.74	79.04
416718.70	194492.62	79.22
416720.97	194492.30	79.23
416721.97	194492.12	79.11
416722.53	194492.07	79.05
416723.57	194491.71	78.91
416724.96	194491.41	78.88
416725.64	194491.20	78.89
416725.85	194491.13	79.21
416726.20	194491.07	79.36
416726.95	194490.85	79.42
416727.31	194490.77	79.60
416728.80	194490.69	79.62
416730.16	194490.67	80.15
416731.45	194490.69	80.18
416734.10	194490.57	81.20
416735.79	194490.65	81.50
416736.61	194490.70	81.57
416739.05	194490.71	81.62
416740.20	194490.79	81.88
416741.79	194490.54	82.30
416744.38	194489.83	83.33

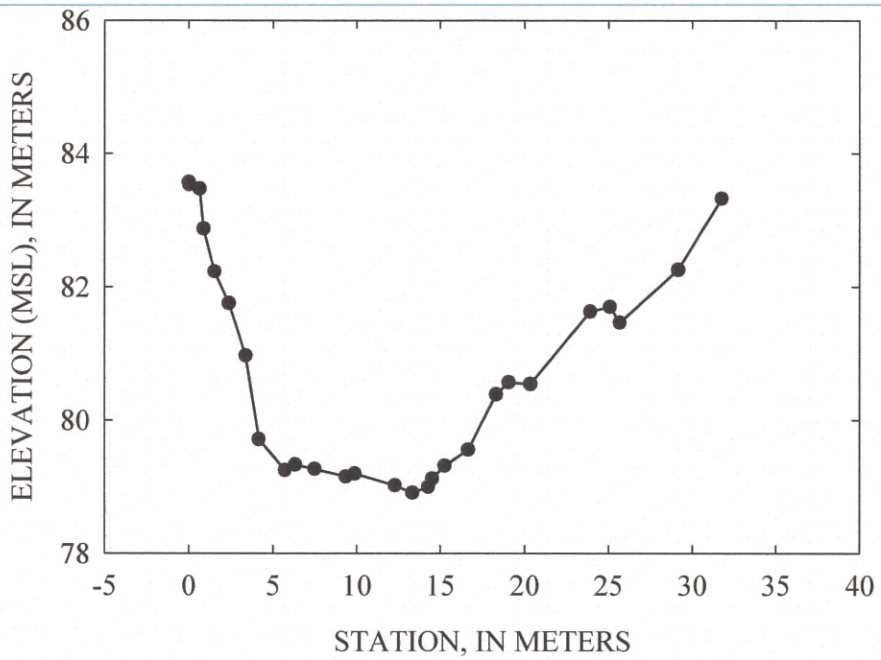


Figure A39. Station and elevation of survey points collected 5/5/05 for cross section 18.



Figure A40. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 18.

Table A20. Station and elevation data for cross section 18.

Northing	Easting	Elevation (m)
416706.60	194483.31	84.34
416706.62	194483.29	84.26
416707.93	194482.86	84.13
416709.17	194482.36	84.05
416709.65	194482.15	83.67
416710.37	194481.86	82.88
416711.14	194481.63	82.33
416712.13	194481.26	81.76
416712.45	194481.12	81.38
416712.64	194481.02	80.82
416713.22	194480.85	80.31
416713.41	194480.04	79.98
416713.82	194480.03	79.68
416714.39	194480.21	79.19
416715.58	194479.38	79.00
416715.84	194479.38	79.04
416716.56	194479.17	79.38
416717.18	194478.88	79.59
416718.20	194478.34	79.54
416718.98	194477.96	79.52
416719.95	194477.54	79.38
416720.44	194477.32	79.36
416721.09	194477.16	79.43
416721.91	194477.20	79.38
416722.28	194477.03	79.38
416722.35	194477.00	80.07
416722.70	194476.32	80.58
416723.28	194476.11	80.79
416723.86	194475.92	81.30
416724.86	194475.62	81.77
416726.23	194475.14	82.22
416727.68	194474.75	82.60

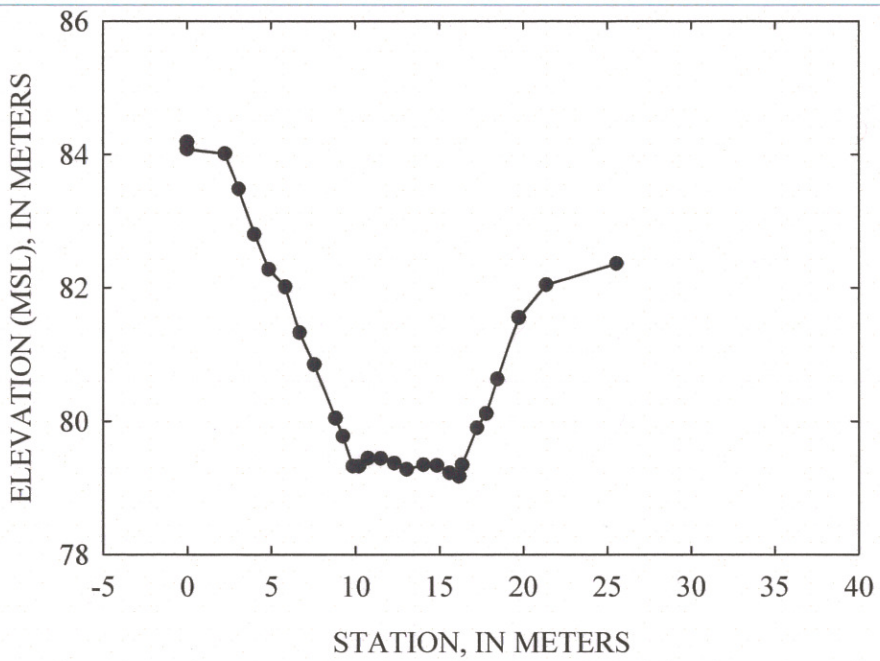


Figure A41. Station and elevation of survey points collected 5/5/05 for cross section 19.



Figure A42. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 19.

Table A21. Station and elevation data for cross section 19.

Northing	Easting	Elevation (m)
416698.81	194466.65	84.19
416698.82	194466.65	84.08
416700.86	194465.74	84.01
416701.64	194465.47	83.48
416702.48	194465.08	82.80
416703.23	194464.66	82.28
416704.11	194464.20	82.02
416704.85	194463.77	81.33
416705.61	194463.35	80.85
416706.82	194462.96	80.05
416707.37	194463.11	79.77
416707.92	194462.89	79.32
416708.26	194462.79	79.33
416708.78	194462.62	79.45
416709.47	194462.34	79.44
416710.21	194462.00	79.37
416710.87	194461.66	79.28
416711.84	194461.36	79.35
416712.56	194461.00	79.33
416713.18	194460.56	79.22
416713.68	194460.27	79.17
416713.85	194460.22	79.35
416714.60	194459.71	79.90
416715.09	194459.45	80.12
416715.71	194459.21	80.63
416716.94	194458.86	81.55
416718.40	194458.09	82.05
416722.11	194456.19	82.36

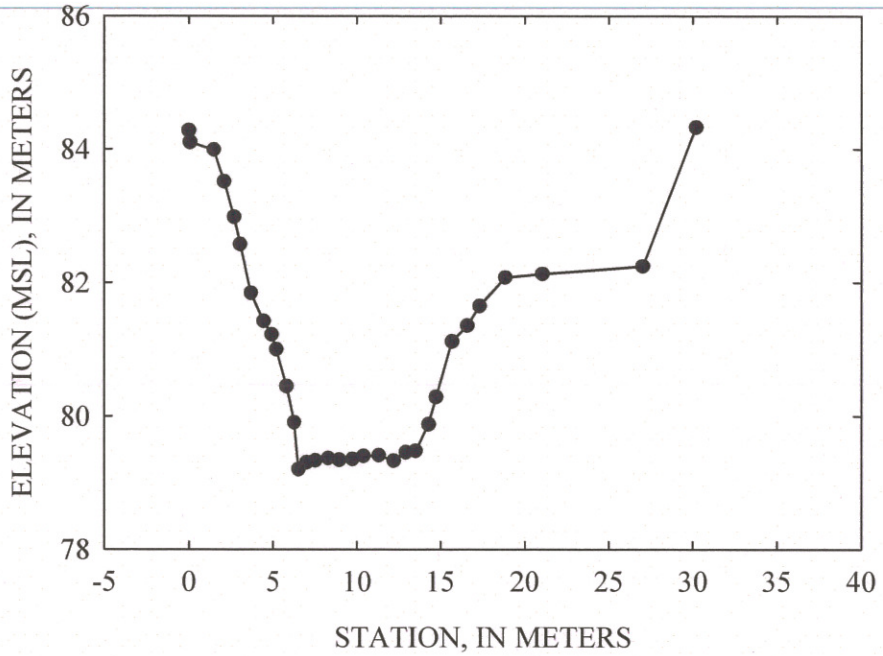


Figure A43. Station and elevation of survey points collected 5/5/05 for cross section 20.



Figure A44. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 20.

Table A22. Station and elevation data for cross section 20.

Northing	Easting	Elevation (m)
416695.87	194452.54	84.28
416695.94	194452.56	84.11
416697.15	194451.78	83.99
416697.68	194451.50	83.52
416698.25	194451.33	82.99
416698.51	194451.03	82.58
416699.20	194450.98	81.85
416699.90	194450.65	81.43
416700.24	194450.28	81.22
416700.51	194450.22	81.00
416701.12	194450.06	80.45
416701.51	194449.81	79.91
416701.52	194449.29	79.20
416702.00	194449.12	79.31
416702.42	194448.81	79.33
416703.11	194448.49	79.37
416703.66	194448.15	79.34
416704.43	194447.89	79.35
416705.07	194447.69	79.40
416705.94	194447.39	79.41
416706.76	194447.03	79.33
416707.47	194446.80	79.46
416707.92	194446.40	79.48
416708.61	194446.05	79.88
416708.85	194445.55	80.29
416709.68	194445.12	81.12
416710.50	194444.71	81.36
416711.13	194444.36	81.65
416712.47	194443.64	82.08
416714.48	194442.73	82.13
416719.82	194440.05	82.25
416722.37	194438.10	84.33

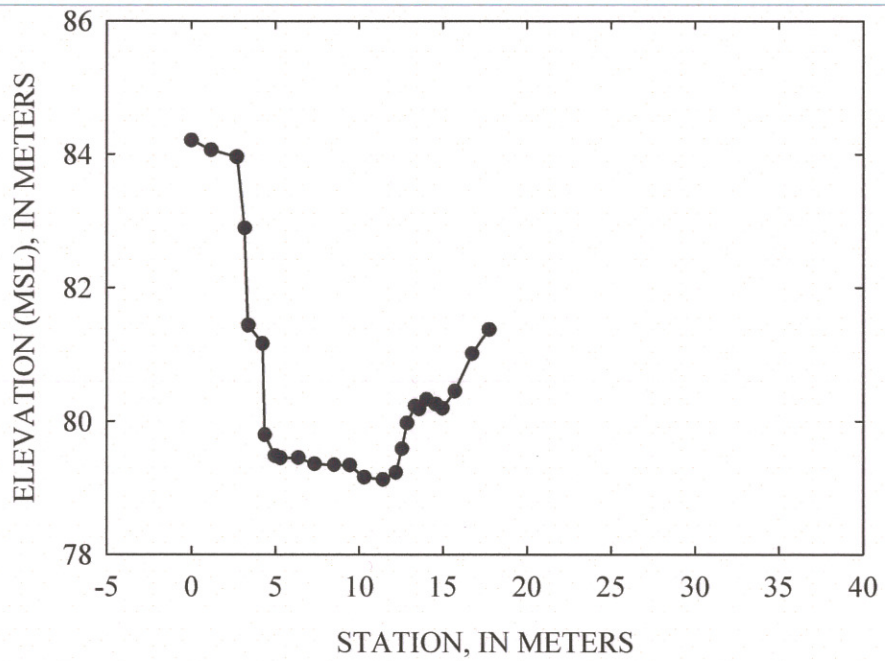


Figure A45. Station and elevation of survey points collected 5/5/05 for cross section 21.



Figure A46. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section 21.

Table A23. Station and elevation data for cross section 21.

Northing	Easting	Elevation (m)
416690.02	194440.87	84.21
416691.08	194440.36	84.07
416692.38	194439.58	83.96
416692.79	194439.35	82.90
416692.93	194439.17	81.44
416693.72	194438.80	81.16
416693.85	194438.79	79.79
416694.46	194438.63	79.48
416694.34	194437.82	79.45
416695.34	194437.37	79.45
416696.14	194436.81	79.36
416697.13	194436.21	79.34
416697.93	194435.70	79.34
416698.59	194435.15	79.16
416699.68	194434.77	79.12
416700.30	194434.31	79.23
416700.65	194434.19	79.59
416701.21	194434.53	79.97
416701.66	194434.36	80.22
416701.89	194434.27	80.18
416702.27	194434.05	80.33
416702.74	194433.78	80.26
416703.06	194433.53	80.19
416703.71	194433.17	80.45
416704.57	194432.61	81.01
416705.46	194432.14	81.37

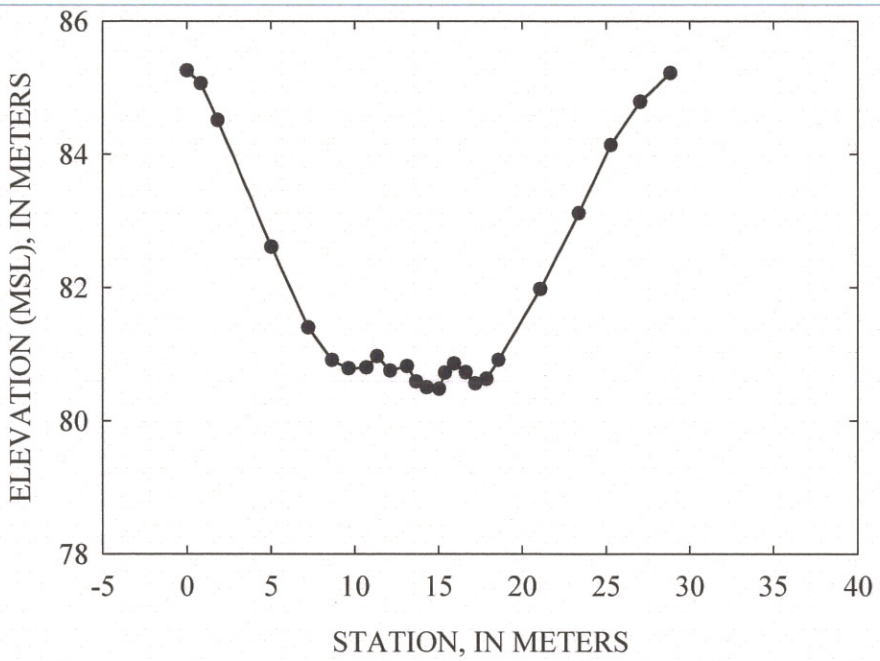


Figure A47. Station and elevation of survey points collected 5/5/05 for cross section U1.



Figure A48. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section U1.

Table A24. Station and elevation data for cross section U1.

Northing	Easting	Elevation (m)
416881.07	194628.44	85.26
416881.79	194628.05	85.06
416882.69	194627.58	84.51
416885.62	194626.31	82.61
416887.37	194624.92	81.40
416888.68	194624.35	80.91
416889.54	194623.83	80.79
416890.46	194623.33	80.80
416891.01	194623.02	80.97
416891.68	194622.58	80.75
416892.54	194622.06	80.82
416893.00	194621.77	80.59
416893.55	194621.44	80.50
416894.19	194621.09	80.48
416894.41	194620.77	80.72
416894.90	194620.51	80.86
416895.49	194620.16	80.73
416895.99	194619.90	80.56
416896.61	194619.64	80.63
416897.14	194619.12	80.91
416899.30	194617.87	81.98
416901.30	194616.77	83.12
416903.01	194615.90	84.14
416904.45	194614.83	84.79
416906.01	194613.96	85.22

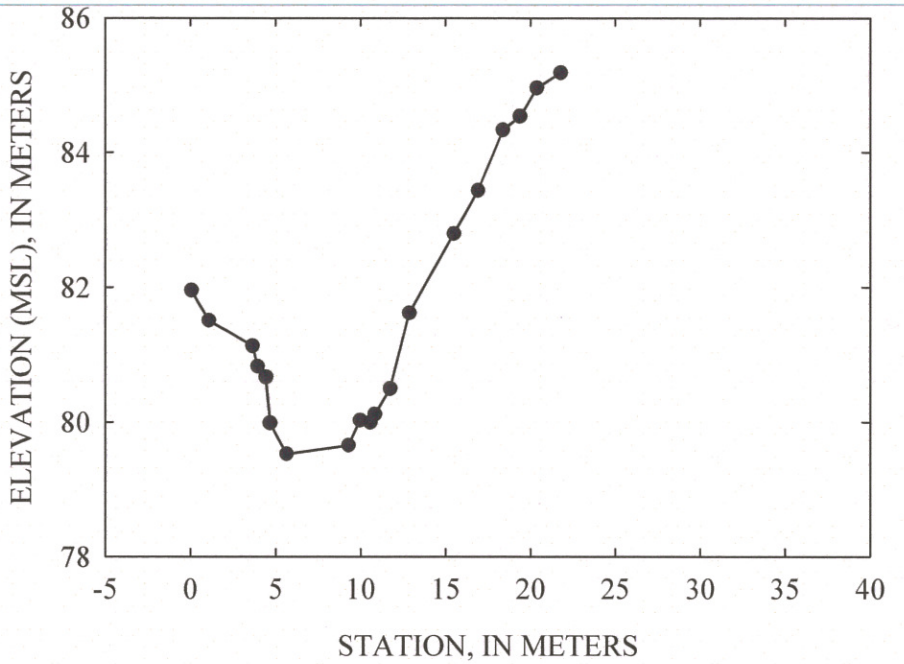


Figure A49. Station and elevation of survey points collected 5/5/05 for cross section U2.



Figure A50. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section U2.

Table A25. Station and elevation data for cross section U2.

Northing	Easting	Elevation (m)
416880.97	194617.27	81.96
416881.86	194616.56	81.51
416883.86	194614.95	81.13
416884.08	194614.76	80.83
416884.46	194614.46	80.67
416884.64	194614.28	79.99
416885.48	194613.78	79.53
416888.17	194611.30	79.66
416888.95	194611.17	80.03
416889.33	194610.71	80.00
416889.54	194610.52	80.12
416890.30	194610.05	80.50
416891.22	194609.40	81.62
416893.37	194607.91	82.80
416894.42	194606.96	83.44
416895.71	194606.23	84.34
416896.45	194605.53	84.54
416897.28	194604.97	84.96
416898.45	194604.18	85.18

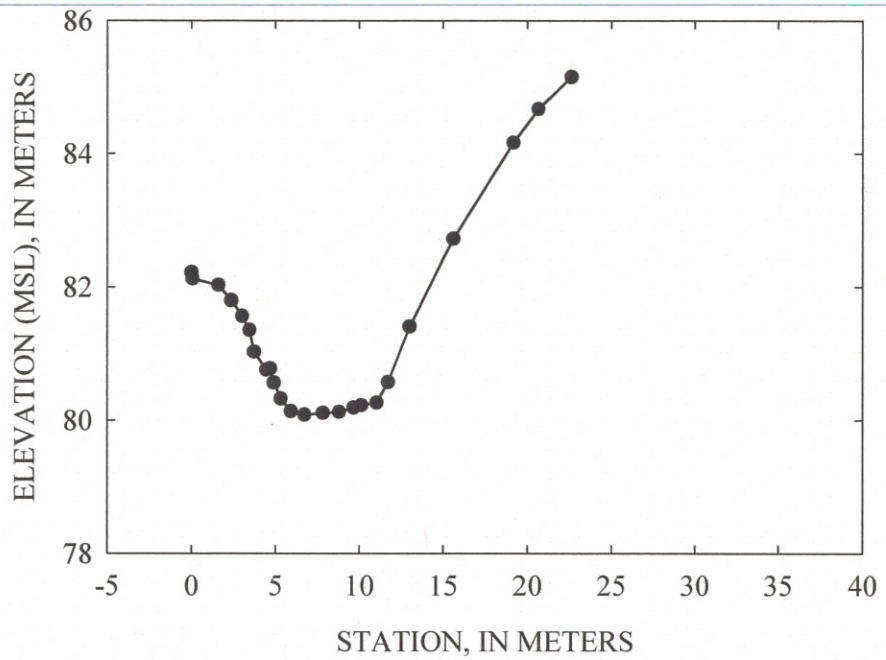


Figure A51. Station and elevation of survey points collected 5/5/05 for cross section U3.



Figure A52. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section U3.

Table A26. Station and elevation data for cross section U3.

Northing	Easting	Elevation (m)
416873.74	194608.83	82.22
416873.78	194608.78	82.13
416875.04	194607.88	82.03
416875.61	194607.39	81.80
416876.12	194606.99	81.56
416876.48	194606.74	81.35
416876.72	194606.59	81.03
416877.31	194606.18	80.76
416877.48	194606.02	80.78
416877.64	194605.87	80.56
416877.95	194605.59	80.33
416878.39	194605.17	80.14
416878.99	194604.62	80.09
416879.81	194603.87	80.11
416880.56	194603.27	80.13
416881.18	194602.63	80.19
416881.63	194602.47	80.23
416882.31	194601.87	80.26
416882.87	194601.48	80.57
416883.93	194600.75	81.41
416885.99	194599.17	82.73
416888.64	194596.76	84.17
416889.83	194595.87	84.67
416891.41	194594.70	85.15

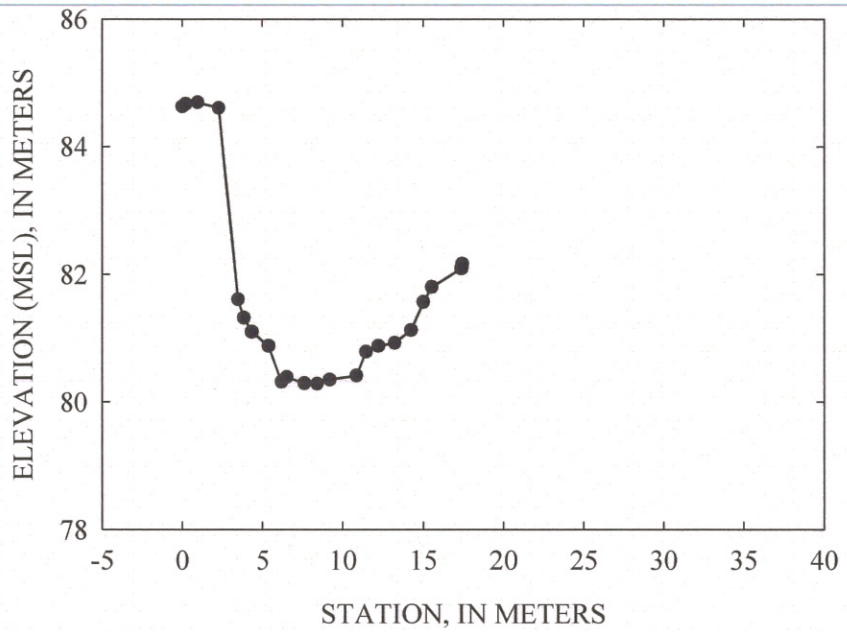


Figure A53. Station and elevation of survey points collected 5/5/05 for cross section CF.



Figure A54. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section CF.

Table A27. Station and elevation data for cross section CF.

Northing	Easting	Elevation (m)
416869.13	194602.41	82.16
416869.08	194602.40	82.09
416867.40	194601.63	81.80
416867.02	194601.23	81.57
416866.41	194600.77	81.13
416865.57	194600.20	80.93
416864.72	194599.67	80.88
416864.05	194599.30	80.79
416863.54	194598.95	80.41
416862.14	194598.08	80.35
416861.41	194597.78	80.29
416860.66	194597.45	80.29
416859.76	194596.85	80.39
416859.49	194596.65	80.32
416858.78	194596.26	80.88
416858.02	194595.49	81.10
416857.66	194595.13	81.32
416857.42	194594.84	81.61
416856.12	194594.63	84.61
416854.92	194594.10	84.69
416854.37	194593.54	84.67
416854.84	194592.44	84.63

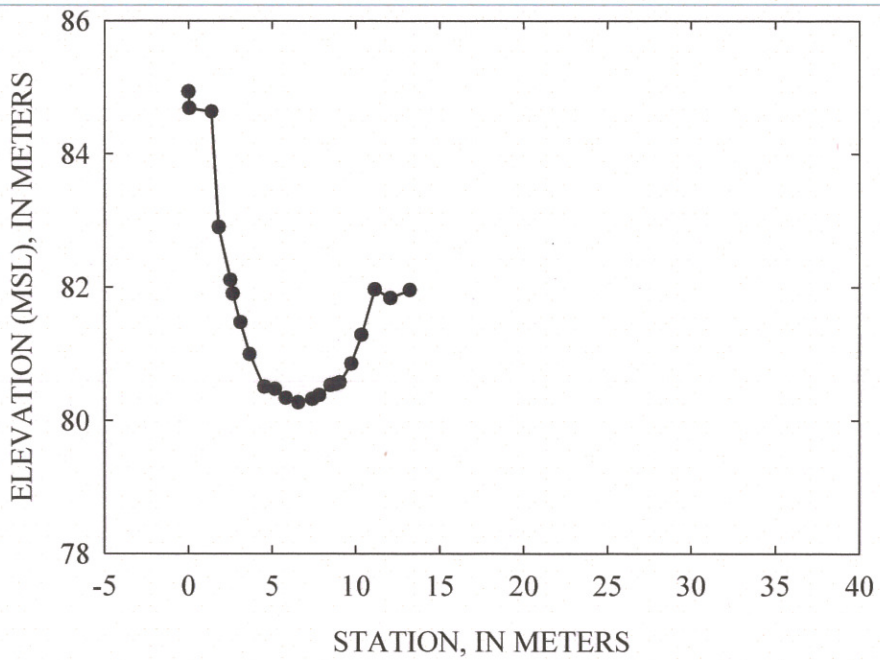


Figure A55. Station and elevation of survey points collected 5/5/05 for cross section T1.



Figure A56. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T1.

Table A28. Station and elevation data for cross section T1.

Northing	Easting	Elevation (m)
416851.53	194601.03	84.94
416851.48	194601.03	84.69
416852.76	194601.69	84.63
416853.11	194601.95	82.90
416853.80	194602.11	82.11
416854.08	194601.75	81.90
416854.58	194601.58	81.47
416855.01	194602.16	81.00
416855.92	194602.21	80.51
416856.49	194602.53	80.48
416857.01	194603.03	80.34
416857.70	194603.35	80.27
416858.42	194603.77	80.32
416858.76	194604.06	80.38
416859.32	194604.45	80.53
416859.59	194604.58	80.55
416859.71	194604.93	80.57
416860.28	194605.34	80.85
416860.83	194605.59	81.29
416861.53	194605.97	81.97
416862.34	194606.42	81.84
416863.39	194606.90	81.96

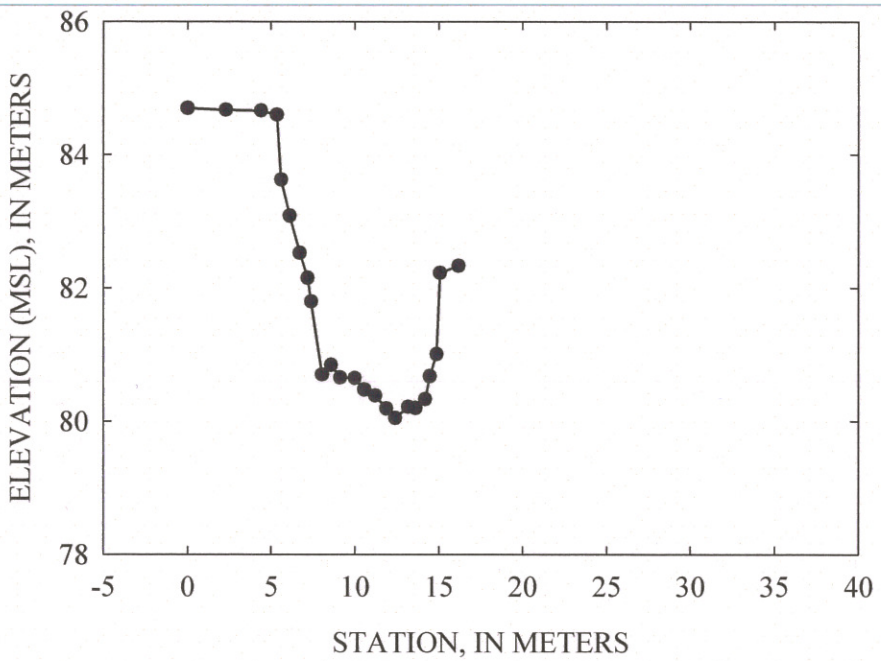


Figure A57. Station and elevation of survey points collected 5/5/05 for cross section T2.



Figure A58. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T2.

Table A29. Station and elevation data for cross section T2.

Northing	Easting	Elevation (m)
416845.26	194608.93	84.70
416847.15	194610.19	84.67
416849.30	194610.66	84.66
416850.20	194610.98	84.60
416850.35	194611.24	83.63
416850.85	194611.38	83.08
416851.49	194611.40	82.53
416852.00	194611.41	82.15
416852.14	194611.67	81.80
416852.78	194611.81	80.70
416852.49	194613.55	80.85
416853.10	194613.59	80.66
416853.96	194613.85	80.65
416854.53	194614.01	80.48
416855.14	194614.22	80.39
416855.83	194614.36	80.19
416856.41	194614.36	80.05
416857.03	194614.87	80.22
416857.44	194614.99	80.20
416858.09	194614.99	80.33
416858.40	194614.96	80.68
416858.78	194615.08	81.01
416859.05	194615.00	82.23
416860.04	194615.50	82.34

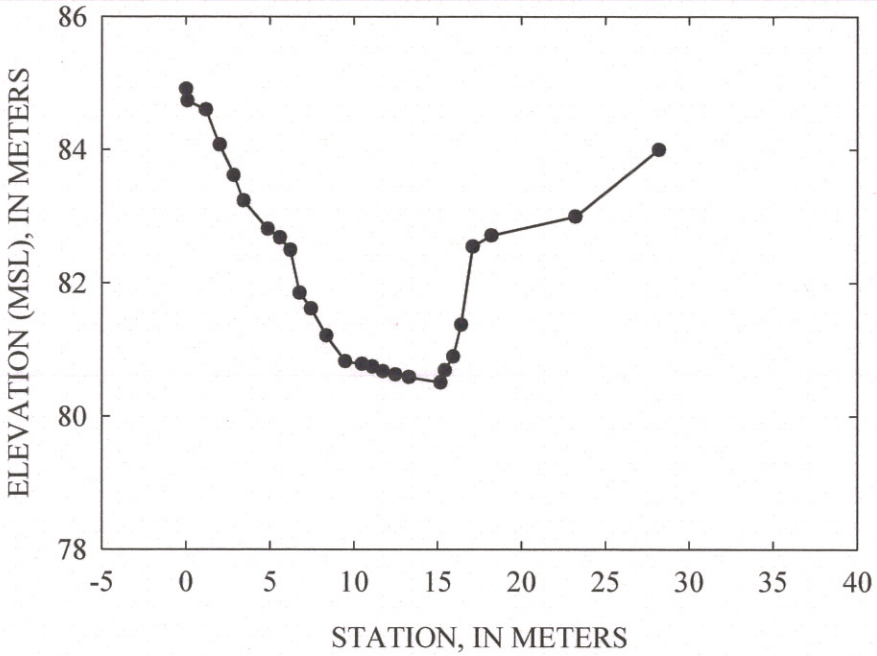


Figure A59. Station and elevation of survey points collected 5/5/05 for cross section T3.



Figure A60. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T3.

Table A30. Station and elevation data for cross section T3.

Northing	Easting	Elevation (m)
416843.61	194615.83	84.91
416843.59	194615.91	84.74
416844.58	194616.55	84.60
416845.20	194617.06	84.07
416845.88	194617.52	83.62
416846.42	194617.79	83.24
416847.78	194618.33	82.81
416848.42	194618.69	82.68
416849.04	194618.86	82.50
416849.51	194619.15	81.85
416850.09	194619.49	81.62
416850.93	194619.87	81.21
416851.97	194620.28	80.82
416851.92	194622.22	80.79
416852.57	194622.43	80.74
416853.25	194622.52	80.68
416854.02	194622.71	80.63
416854.93	194622.80	80.59
416856.86	194623.24	80.51
416857.27	194623.02	80.69
416857.66	194623.36	80.90
416858.06	194623.63	81.38
416858.73	194623.82	82.55
416859.76	194624.22	82.71

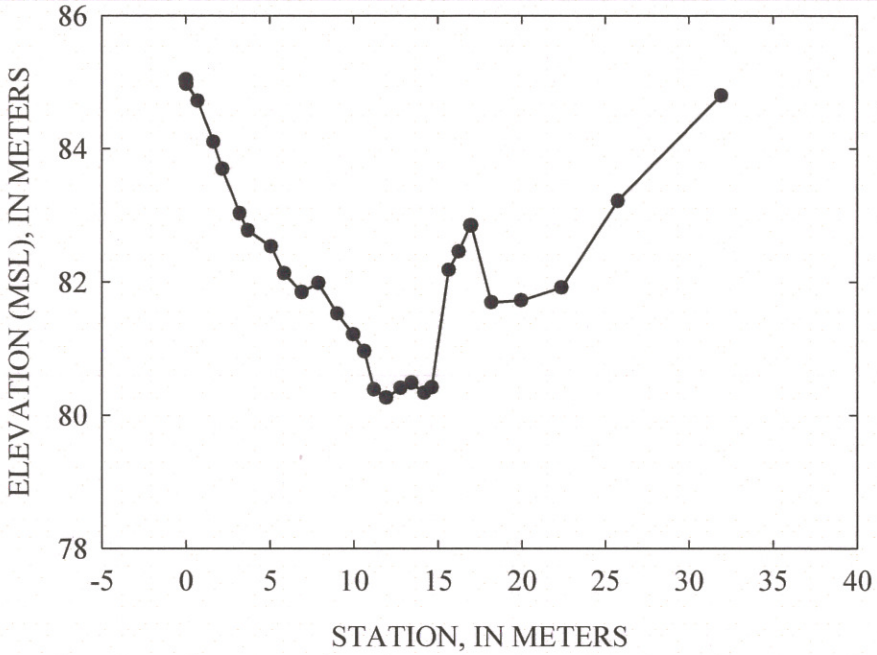


Figure A61. Station and elevation of survey points collected 5/5/05 for cross section T4.



Figure A62. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T4.

Table A31. Station and elevation data for cross section T4.

Northing	Easting	Elevation (m)
416840.27	194626.59	85.04
416840.26	194626.61	84.97
416840.91	194626.85	84.72
416841.76	194627.20	84.10
416842.24	194627.45	83.70
416843.23	194627.74	83.03
416843.74	194627.77	82.78
416845.02	194628.33	82.53
416845.70	194628.74	82.13
416846.62	194629.25	81.85
416847.49	194629.78	81.99
416848.48	194630.28	81.53
416849.33	194630.74	81.22
416849.89	194631.07	80.96
416850.45	194631.22	80.39
416851.15	194631.45	80.27
416851.93	194631.76	80.41
416852.51	194632.07	80.49
416853.14	194632.49	80.34
416853.54	194632.71	80.42
416854.54	194632.95	82.18
416855.07	194633.23	82.46
416855.61	194633.68	82.85
416855.64	194633.78	82.85
416854.40	194633.46	81.70
416853.80	194633.28	81.73
416853.22	194633.12	81.92
416852.24	194632.84	83.22
416849.47	194632.07	84.80

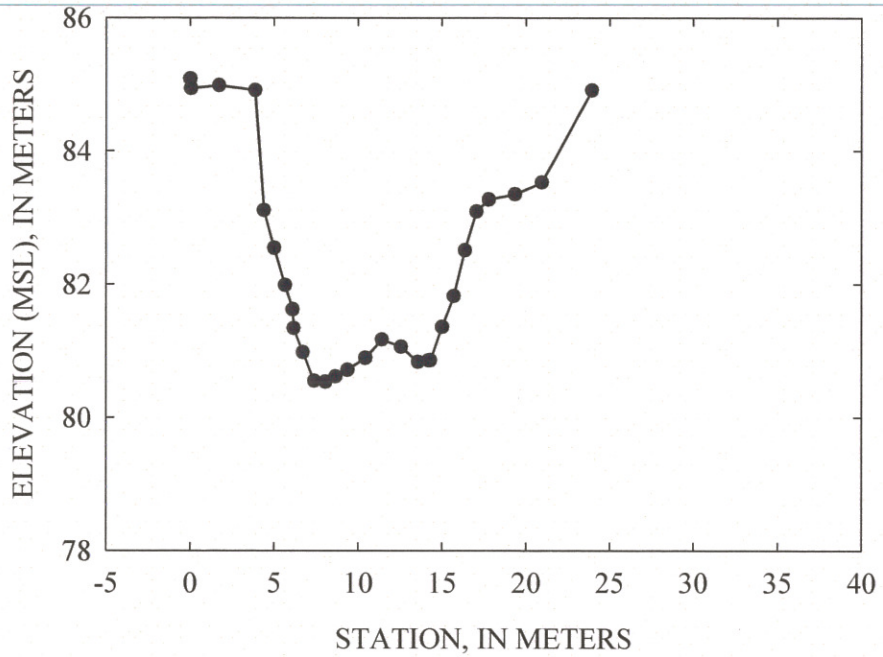


Figure A63. Station and elevation of survey points collected 5/5/05 for cross section T5.



Figure A64. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T5.

Table A32. Station and elevation data for cross section T5.

Northing	Easting	Elevation (m)
416835.14	194636.07	85.08
416835.16	194636.10	84.94
416836.73	194636.69	84.98
416838.65	194637.69	84.91
416839.12	194637.91	83.11
416839.62	194638.27	82.54
416840.21	194638.56	81.99
416840.52	194638.94	81.62
416840.90	194638.24	81.34
416841.40	194638.48	80.98
416841.96	194638.91	80.55
416842.57	194639.20	80.54
416843.06	194639.57	80.62
416843.61	194640.10	80.72
416844.50	194640.67	80.90
416845.35	194641.13	81.17
416846.40	194641.60	81.06
416847.29	194642.12	80.83
416847.88	194642.30	80.86
416848.25	194641.81	80.86
416848.85	194642.16	81.36
416849.46	194642.49	81.82
416850.02	194642.84	82.51
416850.72	194642.99	83.09
416851.38	194643.27	83.27
416852.79	194643.94	83.35
416854.27	194644.56	83.53
416856.99	194645.77	84.91

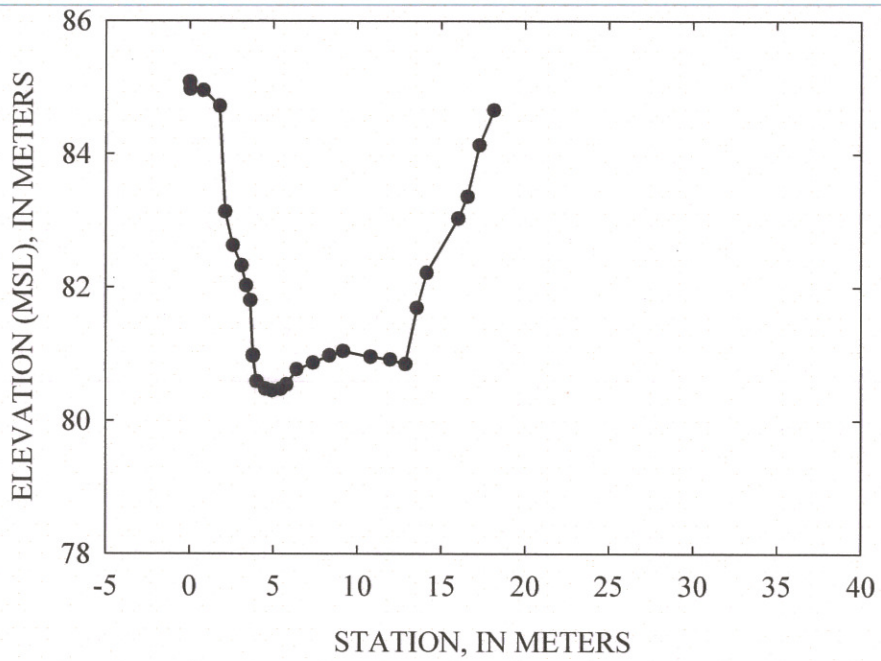


Figure A65. Station and elevation of survey points collected 5/5/05 for cross section T6.



Figure A66. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T6.

Table A33. Station and elevation data for cross section T6.

Northing	Easting	Elevation (m)
416833.64	194646.44	85.08
416833.67	194646.45	84.97
416834.40	194646.72	84.95
416835.30	194647.10	84.72
416835.70	194646.98	83.14
416836.06	194647.39	82.63
416836.50	194647.65	82.33
416836.72	194647.86	82.03
416836.97	194647.87	81.80
416837.15	194647.90	80.98
416837.13	194647.91	80.97
416837.39	194647.87	80.59
416837.87	194648.02	80.48
416838.29	194648.06	80.45
416838.83	194648.17	80.47
416839.10	194648.39	80.54
416839.64	194648.69	80.77
416840.53	194649.04	80.87
416841.40	194649.52	80.98
416842.07	194650.04	81.04
416843.40	194651.06	80.96
416844.42	194651.59	80.92
416845.11	194652.27	80.85
416845.71	194652.58	81.69
416846.10	194653.11	82.22
416847.79	194653.94	83.04
416848.28	194654.19	83.36
416848.64	194655.01	84.13
416849.37	194655.43	84.66
416850.29	194655.63	84.91

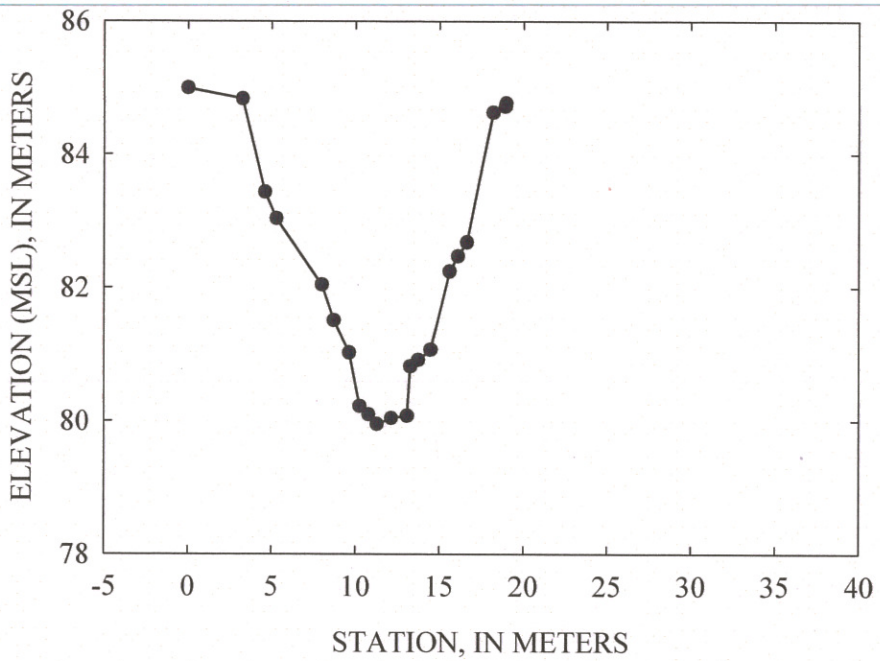


Figure A67. Station and elevation of survey points collected 5/5/05 for cross section T7.



Figure A68. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T7.

Table A34. Station and elevation data for cross section T7.

Northing	Easting	Elevation (m)
416844.04	194668.05	84.77
416844.00	194668.06	84.72
416843.28	194668.04	84.63
416842.06	194666.82	82.68
416841.50	194666.74	82.47
416841.11	194666.39	82.25
416840.66	194665.11	81.07
416839.92	194664.85	80.92
416839.48	194664.68	80.82
416839.31	194664.58	80.08
416838.43	194664.19	80.04
416837.58	194663.89	79.95
416837.08	194663.77	80.10
416836.54	194663.63	80.22
416835.96	194663.38	81.03
416835.56	194662.29	81.51
416835.01	194661.83	82.04
416832.57	194660.59	83.04
416831.98	194660.24	83.43
416830.91	194659.42	84.83
416828.03	194657.85	84.99
416828.06	194657.84	84.99

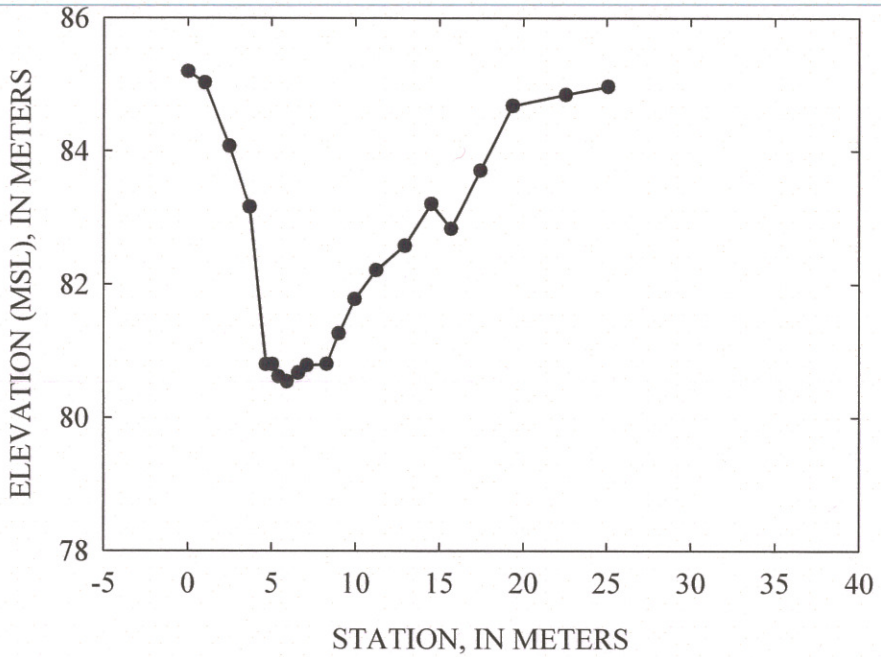


Figure A69. Station and elevation of survey points collected 5/5/05 for cross section T8.



Figure A70. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T8.

Table A35. Station and elevation data for cross section T8.

Northing	Easting	Elevation (m)
416835.35	194692.99	84.97
416833.76	194690.99	84.85
416831.69	194688.59	84.68
416830.32	194687.22	83.71
416829.30	194685.80	82.84
416828.63	194684.83	83.21
416827.87	194683.43	82.58
416827.09	194681.89	82.21
416826.13	194680.99	81.78
416825.70	194680.13	81.27
416825.52	194679.39	80.81
416824.83	194678.43	80.79
416824.52	194678.02	80.67
416824.14	194677.47	80.54
416824.25	194676.76	80.62
416824.14	194676.40	80.80
416824.02	194676.02	80.80
416823.61	194675.11	83.16
416823.00	194674.05	84.08
416822.12	194672.88	85.03
416821.69	194671.95	85.19

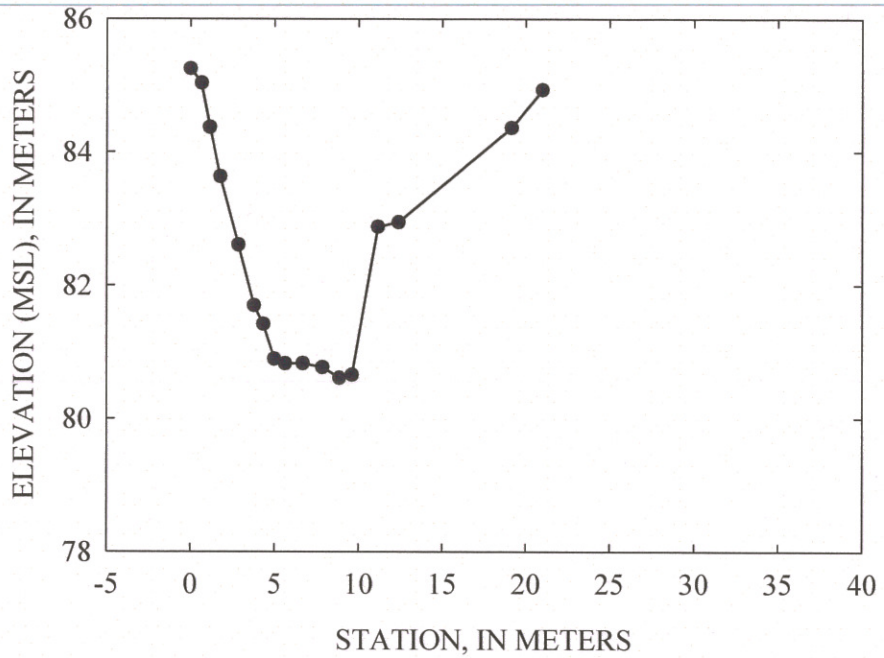


Figure A71. Station and elevation of survey points collected 5/5/05 for cross section T9.



Figure A72. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T9.

Table A36. Station and elevation data for cross section T9.

Northing	Easting	Elevation (m)
416808.14	194683.82	85.25
416808.62	194684.28	85.03
416808.95	194684.66	84.37
416809.33	194685.13	83.63
416809.93	194686.05	82.61
416810.79	194686.52	81.70
416810.96	194687.11	81.42
416811.35	194687.63	80.90
416811.71	194688.19	80.83
416812.35	194689.02	80.83
416813.27	194689.76	80.77
416814.02	194690.43	80.61
416814.58	194690.96	80.66
416815.51	194692.20	82.88
416816.26	194693.19	82.95
416821.19	194697.82	84.36
416822.62	194699.02	84.93

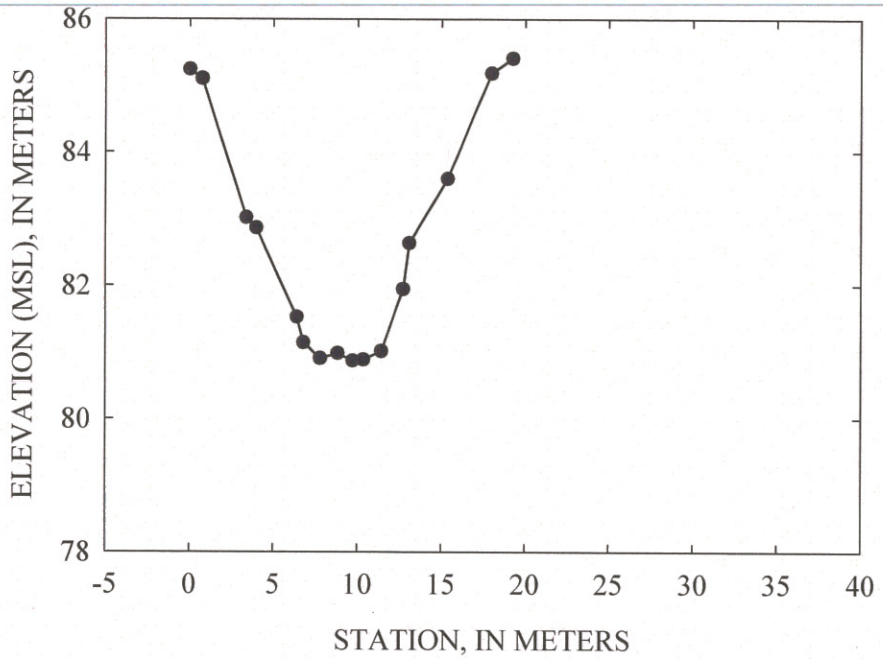


Figure A73. Station and elevation of survey points collected 5/5/05 for cross section T10.



Figure A74. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T10.

Table A37. Station and elevation data for cross section T10.

Northing	Easting	Elevation (m)
416807.26	194704.12	85.41
416806.41	194703.17	85.18
416804.87	194701.07	83.60
416803.44	194699.27	82.64
416803.35	194698.88	81.95
416803.18	194697.44	81.02
416802.50	194696.62	80.89
416801.71	194696.39	80.87
416801.31	194695.57	80.99
416800.79	194694.66	80.91
416800.05	194693.96	81.14
416799.83	194693.64	81.53
416798.01	194691.97	82.86
416797.63	194691.48	83.02
416795.85	194689.55	85.10
416795.35	194689.00	85.24

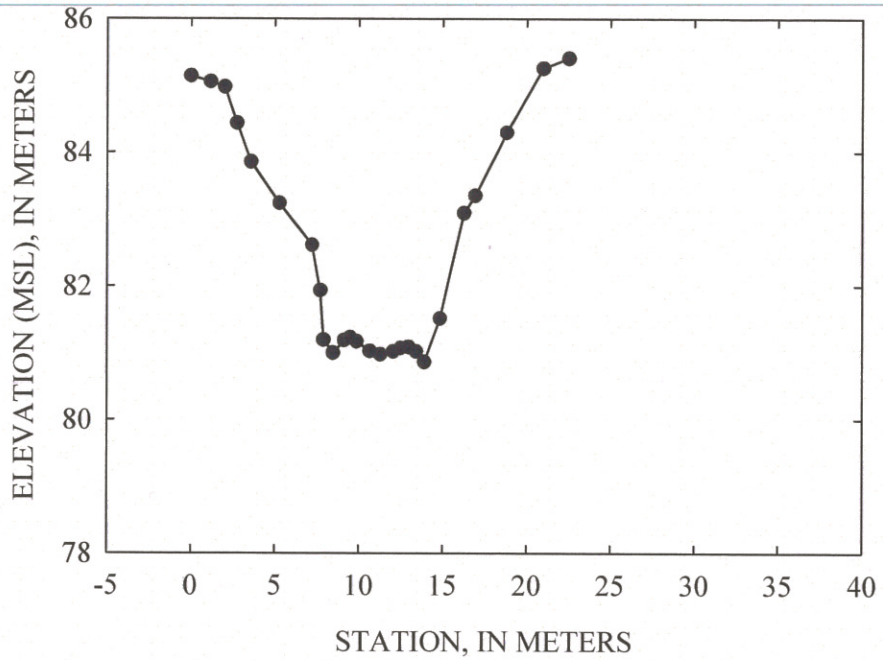


Figure A75. Station and elevation of survey points collected 5/5/05 for cross section T11.



Figure A76. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T11.

Table A38. Station and elevation data for cross section T11.

Northing	Easting	Elevation (m)
416782.54	194699.14	85.14
416783.41	194699.93	85.05
416784.00	194700.53	84.97
416784.47	194701.08	84.43
416785.11	194701.62	83.86
416786.19	194702.95	83.24
416787.34	194704.51	82.61
416787.68	194704.89	81.93
416787.80	194705.04	81.19
416788.30	194705.35	81.00
416788.91	194705.69	81.19
416789.22	194705.90	81.23
416789.51	194706.16	81.17
416790.07	194706.70	81.03
416790.52	194707.11	80.98
416791.10	194707.62	81.02
416791.46	194707.89	81.07
416791.94	194708.08	81.09
416792.34	194708.31	81.02
416792.77	194708.58	80.86
416793.30	194709.38	81.51
416794.00	194710.68	83.09
416794.46	194711.14	83.35
416795.85	194712.39	84.29
416797.37	194713.99	85.26
416798.69	194714.83	85.41

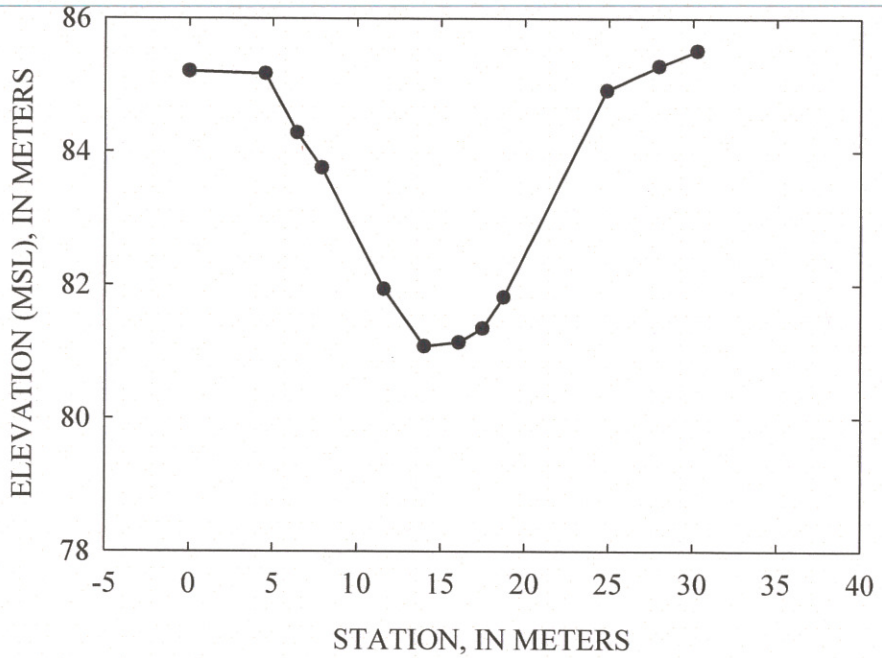


Figure A77. Station and elevation of survey points collected 5/5/05 for cross section T12.



Figure A78. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T12.

Table A39. Station and elevation data for cross section T12.

Northing	Easting	Elevation (m)
416770.53	194709.81	85.21
416774.02	194712.73	85.17
416775.39	194714.00	84.28
416776.44	194715.06	83.76
416779.36	194717.32	81.94
416781.17	194718.94	81.09
416782.38	194720.67	81.14
416783.57	194721.46	81.35
416784.30	194722.53	81.82
416789.77	194725.58	84.92
416792.15	194727.55	85.28
416794.26	194728.57	85.52

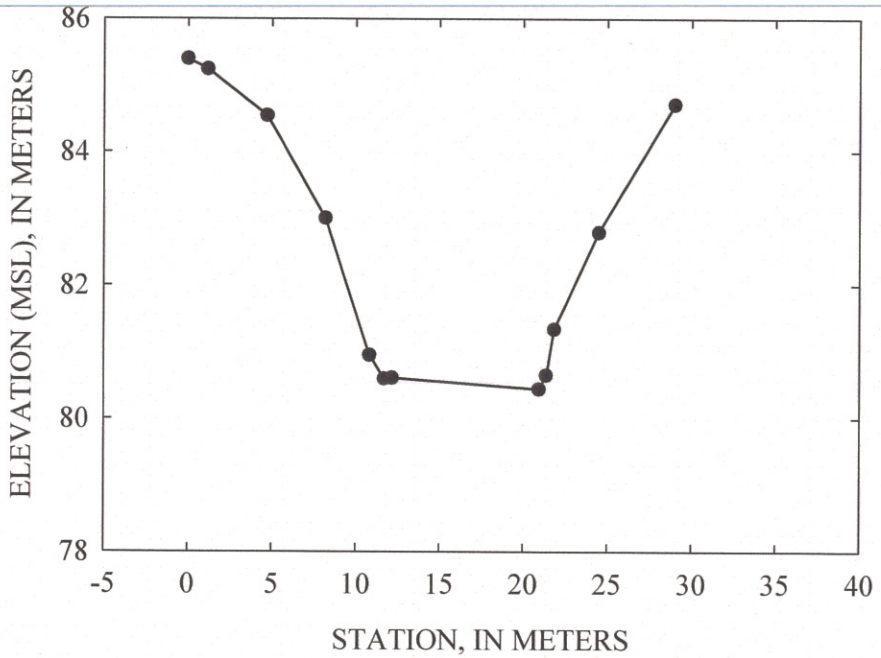


Figure A79. Station and elevation of survey points collected 5/5/05 for cross section T13.



Figure A80. (A) Left bank, (B) right bank, (C) upstream and (D) downstream photos of cross section T13.

Table A40. Station and elevation data for cross section T13.

Northing	Easting	Elevation (m)
416785.74	194736.96	84.71
416782.23	194734.10	82.79
416780.21	194732.38	81.34
416779.93	194731.99	80.65
416779.60	194731.71	80.45
416772.65	194726.37	80.61
416772.46	194725.82	80.60
416771.71	194725.39	80.95
416769.26	194724.24	83.00
416766.29	194722.38	84.54
416763.61	194720.07	85.24
416762.69	194719.35	85.39