# EVALUATION OF THE LONG-TERM IMPACTS OF URBANIZATION ON THE PHYSICAL CHARACTERISTICS OF PIEDMONT HEADWATER STREAMS: INTERIM RESULTS

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**Abstract.** As reported in the 1999 Conference Proceedings (Bourne and Mikalsen, 1999), a field study was initiated in 1996 to evaluate the response of a segment of Proctor Creek in Cobb County to the impact of rapid urbanization in the watershed over time and in comparison to a segment of a physically comparable but almost fully developed urban watershed. The objectives of the study are to measure and evaluate long-term changes in channel cross-sections, bank and channel scouring, streambed composition, longitudinal reach profiles, plan-form dimensions, biological habitats and communities, water chemistry, and land cover to determine the timing and response of the stream to urbanization within the watershed and compare them with corresponding measurements of the developed urban watershed.

These interim results describe measured and observed changes in the Proctor Creek study reach. Since the onset of physical observations in 1996, when increased sedimentation was the only evident indication of increased upstream development in the study reach, there has been a decline in the diversity of the macroinvertebrate community, enlargement of channel cross-sections and extensive bank undercutting and cantilever failure in the lower portion of the reach, scouring and undercutting of an outside bank and downstream migration of a cobble deposit in the middle section, and scouring of root-armored banks in the upper portion of the reach, and extensive silt and sediment deposition over the entire reach.

## INTRODUCTION

Since 1996 an expanding suite of Physical, biological, and water quality measurements have been taken to evaluate the anticipated response of a segment of the upper portion of Proctor Creek to rapid development in this northwest Cobb County watershed. The 3.1 $km^2$ portion of the Proctor Creek above Baker Road, more fully described in Bourne and Mikalsen (1999), was estimated to be 18.6 impervious in 1995, with new commercial and residential development concentrated in the upper portion of the watershed. The developed control stream, labeled Northwoods Branch, is an unnamed tributary to the North Fork of Peachtree Creek below Aztec Road in Doraville, which drains a 3.2 $km^2$ 46% impervious watershed. It began to develop in the early 1960's and is now almost completely developed with retail and office uses, limited access highways, and single and multi-family residential areas.

## SITE MEASUREMENTS

Since the initial habitat assessment and measurement of Proctor Creek channel cross-sections in 1996, additional measurements have been added to evaluate the potential impacts of upstream development on the study reach. Measurements include watershed physical characteristics and the physical, biological, and water quality characteristics of each watershed and stream segment.

This interim report describes the visual indications of stream and bank response to increased upstream development and changes in channel geometry, slope, plan-form dimensions, habitat evaluations, aquatic biology, bed composition, and land cover over time and in comparison to the control stream.

### Reach Measurements

After initial assessment, the following measurements were taken (with methods referenced in parenthesis) for each reach: 1) channel mapping: 2) documentary photography; 3) survey of streambed material composition (Rosgen, 1996); 4) stream habitat assessment (GAEPD, 1997); 5) estimates of bankfull flow stage (Rosgen, 1996 and Henson, et al., undated;)) longitudinal profiles including water surface slope (Rosgen, 1996); and 7) plan-form dimensions

including sinuosity, pool and riffle spacing, meander length and belt width. (Rosgen, 1996).

**Channel Cross-section Measurements**

At least four channel cross-sections have been permanently located in every stream reach. Scour chains were embedded in the streambed to show aggradation or degradation and bank pins to measure the amount of bank recession have been installed and referenced to channel cross-sections (C.C. Harrelson, et al., 1994).

The following measurements were made approximately annually 1) channel cross-sections and area; 2) bankfull cross-sections, area, mean and maximum depth, width to depth ratio, flood prone stage and width, and entrenchment ratio (Rosgen, 1996); 3) stream bed aggregation or degradation; and 4) the amount of bank enlargement at selected locations.

**Other Measurements**

Quarterly water column samples and annual benthic macroinvertebrate surveys (GAEPD, 1997) are collected at Proctor Creek by the Cobb County Water Authority. Quarterly visual observations and measurements of bank or streambed changes were made at Proctor Creek and Northwoods Branch.

## EVALUATION AND ANALYSIS

**The Study Reach**

The Proctor Creek study reach (See Figure 1) is a 333-foot (as measured along the thalweg) segment, beginning 100 feet above Baker Road. Four initial and one alternative cross-sections--with cross-section #1 located furthest downstream--have been established.

**Changes in Land Use**

Rapid development has continued in the Proctor Creek watershed. Existing single-family developments have continued to grow and new single-family development has occurred in the watershed above the study reach. New houses have been constructed on a steep hillside above the approximately 50-75' riparian corridor adjacent to the study reach and an extensive area just above the reach has been mass graded. One of the upstream developments has been subject to enforcement actions for failure to comply with the local erosion and sediment control ordinance. Extensive sediment deposits cover the stream bottom above the sampling reach. Changes in land cover and the estimated 18.6% impervious cover in 1995 will be evaluated when Atlanta Regional Commission 2000 land cover data becomes available. A new bridge with four 8-foot box culverts was constructed at Baker Road in 1997. The bridge has been associated with visible increases in pooling in the lower portion of the study reach but more potential for bank scouring during high flows, since the greatly expanded capacity of the new opening will accommodate higher flow through velocities and amounts.

**Changes in Plan Form and Longitudinal Profile**

Visual observations and mapping conducted on March 12, 1999 and September 11, 2000 revealed no substantial changes in the measured sinuosity (reach/valley length) of 1.2 and the mean entrenchment ratio (flood prone/bankfull width) of 1.3 for the Proctor Creek study reach. The initial measured surface slope was 0.01. In comparison, December 2000 mapping of Northwoods Branch, the developed stream, revealed a higher sinuosity of 1.6 and measurements of channel profiles revealed a mean entrenchment ratio of 1.1. Changes revealed by the Proctor Creek maps include a reduction in the length of the riffles and increased pooling in the lower portion of the reach, which completely covered an earlier riffle. The cobble bed of the largest riffle area has migrated downstream toward Cross-section #2 and the former bed of smooth, diatom-coated cobble has been displaced by scoured, rough-surfaced cobble.

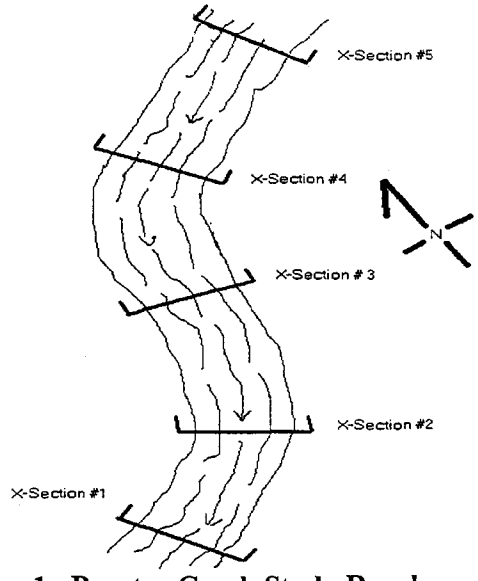



**Figure 1. Proctor Creek Study Reach.**

**Changes in Streambanks**

Changes in streambanks since 1995 ranged from new scouring of the streambank closest to the thalweg

in the upstream relatively straight riffle-run segment above Cross-section #4, to new moderate to severe bank under-cutting along the outside between Cross-sections # 2 and 3, to increased undercutting and cantilever failure of the almost vertical banks of the outside bends of the lower portion of the study reach between Cross-sections # 1 and 2. Increased deposition as well as bank scouring was observed on the inside bends of the lower portion of the study reach.

While bank pins set in 1998 in the banks of the upstream riffle-run segment have not revealed any bank recession, the bank closest to the thalweg has begun to show signs of scouring of the partially root-armored bank, including the removal of moss and shallow-rooted vegetation, and exposure of small plant roots. In the middle portion of the reach, below Cross-section #3, severe undercutting has been observed along a sweeping outside bend in the channel, where four bank pins have revealed bank recession of 0.25 to 0.55 feet. In the lower portion of the reach, the extent of the vertical exposed banks on the outside bends have increased and undercutting and cantilever failure has continued, depositing new soil at the toe of the banks. A portion of the inside bend at Cross-section #2 has been scoured and collapsed, depositing soil and sediment on the inside bar.

**Channel Cross-Sections**

Channel cross-sections were measured in 1996, 1997, 1998, and 2000. Estimates of bankfull stage were made using procedures described by Rosgen (1996) and Henson, et al. (undated) and, since such indicators tend to be obscured by changes in flow conditions associated with urbanization, the authors also identified a "channel full" cross-sectional area which included the portion of the stream channel below a horizontal line projected across the channel from the lowest bank. The mean bankfull and "channel full" cross-sectional areas of Proctor Creek's four cross-sections in 1996 were 32.4 and 80.8 sq ft, respectively. These were respectively 81 and 55% smaller than the 47.2 and 176.0 sq ft bankfull and channel full cross-sections of Northwoods Branch control stream (measured in 1999).

By March 2000, the mean bankfull and channel full cross-sectional area of the four Proctor Creek cross-sections had increased approximately 20% to 38.3 and 97.1 sq ft, respectively. The majority of the increase occurred between 1997-98. The most significant changes (Figure 2) were a more than 1 foot degradation of the streambed and a 0.5 to 1.2 foot recession of the right (looking downstream) bank at Cross-section #1, a 0.4 to 1.7 foot recession of the left streambank at Cross-section #2 (Figure 3), and movement of the thalweg toward the right bank. There was no significant change (Figure 4) in the upstream Cross-section #4.

**Sediment Deposition**

While insufficient recent pebble counts are available to quantify changes in sediment deposition, field observations reveal a substantial increase in course sediment between and silt coating the cobble and rocks in the upper riffle-run dominated portion of the study reach. In the middle and lower portion of the reach, substantial increases in the extent and depth of coarse sediment and orange, highly oxidized silt, likely derived from the predominant upland Madison, Gwinnett, and Appling Series soils, were observed in the pools carved in the gray, alluvial Cartecay soils. Long-term trends in suspended solids concentrations and turbidity have not yet been evaluated.

**Habitat Evaluations**

On May 14, 1996, a Georgia EPD staff member and four trainees, using EPD (1997) procedures, assigned a mean habitat assessment rating of 123 (of an optimum 200) to the Proctor Creek study reach. On December 14, 1998, two of the authors, using the same procedures, assigned a slightly higher (more suitable) rating of 127. On September 11, 2000, four investigators, including the same two authors, assigned a lower mean rating of 117. The primary reasons for the lower score were reduced ratings for in-stream cover and sediment deposition.

**Macroinvertebrates**

The U.S. Geological Survey collected a benthic macroinvertebrate sample from Proctor Creek in the fall of 1996 (Peters, 1997). The Cobb County Water system has subsequently conducted approximately annual macroinvertebrate surveys. Historical surveys have revealed the disappearance of sensitive species. Plecoptera Peltoperla sp and Acroneuria sp were last observed in 1995. Corydalidae Corydalus sp was last observed 1998 and Heptagenia Stenomema sp and Aeshnia Boyeria sp were last observed in 1999. There has also been a decline in general taxa richness over the study period. Full metric analysis has yet to be applied Heptagenia Stenomema sp and Aeshnia Boyeria sp were last observed in 1999.

## CONCLUSION

The major changes in the study reach observed since 1996--the decline in the diversity of the

**Figure 2**
**Proctor Creek X-Section #1**
**1996 and 2000**

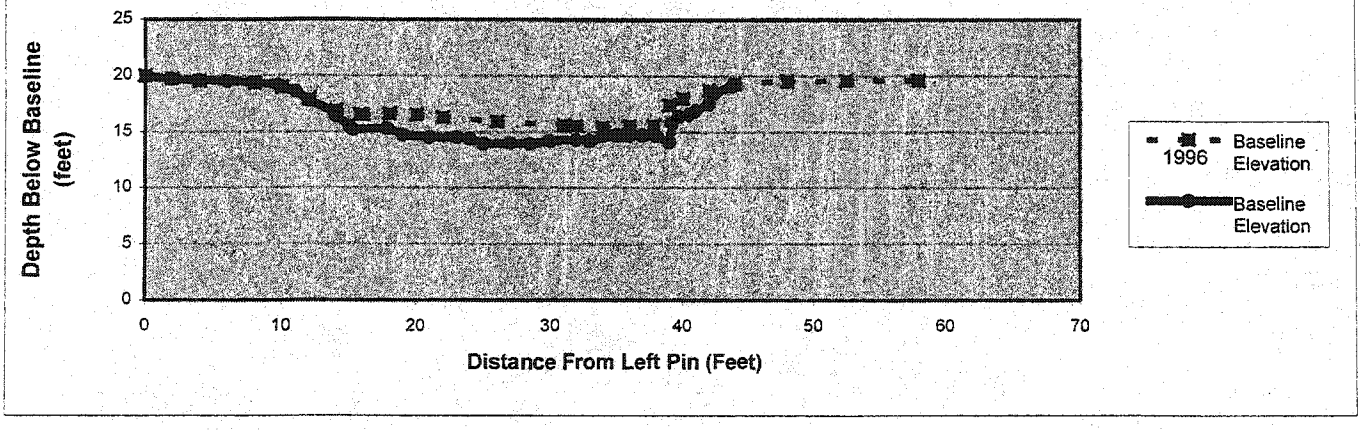



**Figure 3**
**Proctor Creek X-Section #3**
**1996-2000**

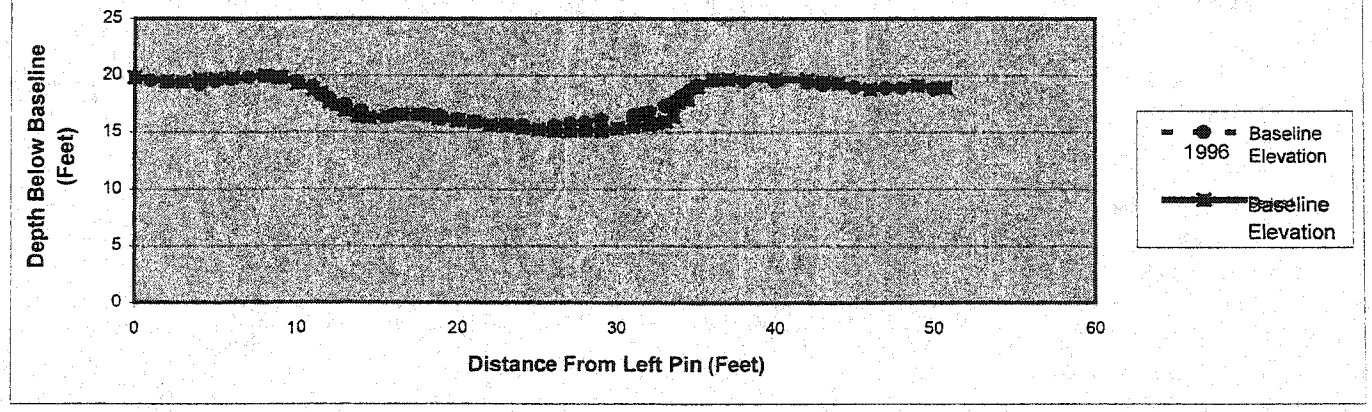
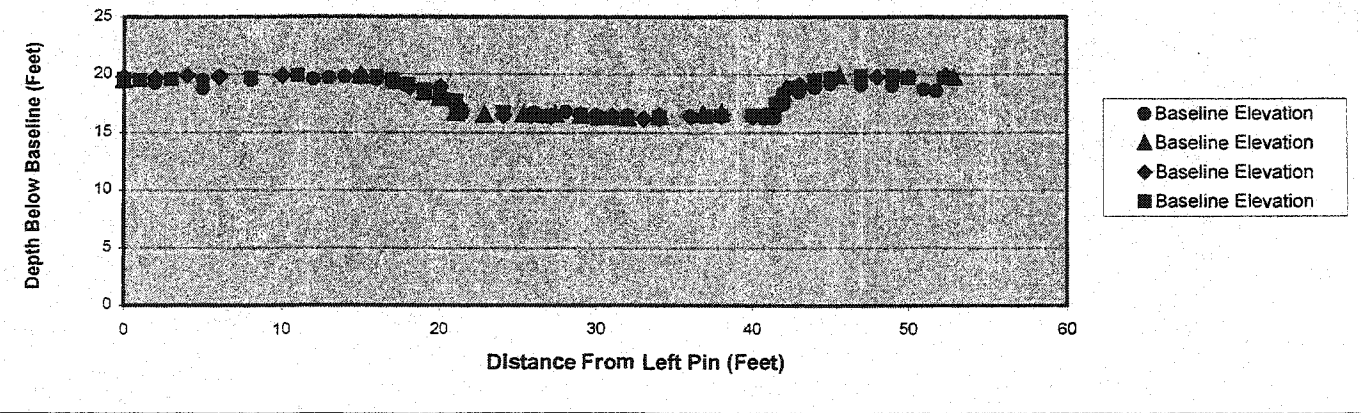



**Figure 4**
**Proctor Creek X-Section #4**
**1996-2000**



macroinvertebrate community, enlargement of channel cross-sections and extensive bank undercutting and cantilever failure in the lower portion of the reach, scouring and undercutting of an outside bank and downstream migration of a cobble deposit in the middle section, and scouring of root-armored banks in the upper portion of the reach, and extensive silt and sediment deposition over the entire reach—are attributed to the impacts of increasing development in the upstream watershed. Sampling, measurements, and field observations will continue and be intermittently reported. The next report will also present graphs of quantitative measures of the Proctor Creek basin and study reach over time, and in comparison to the fully developed Northwoods Branch.

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