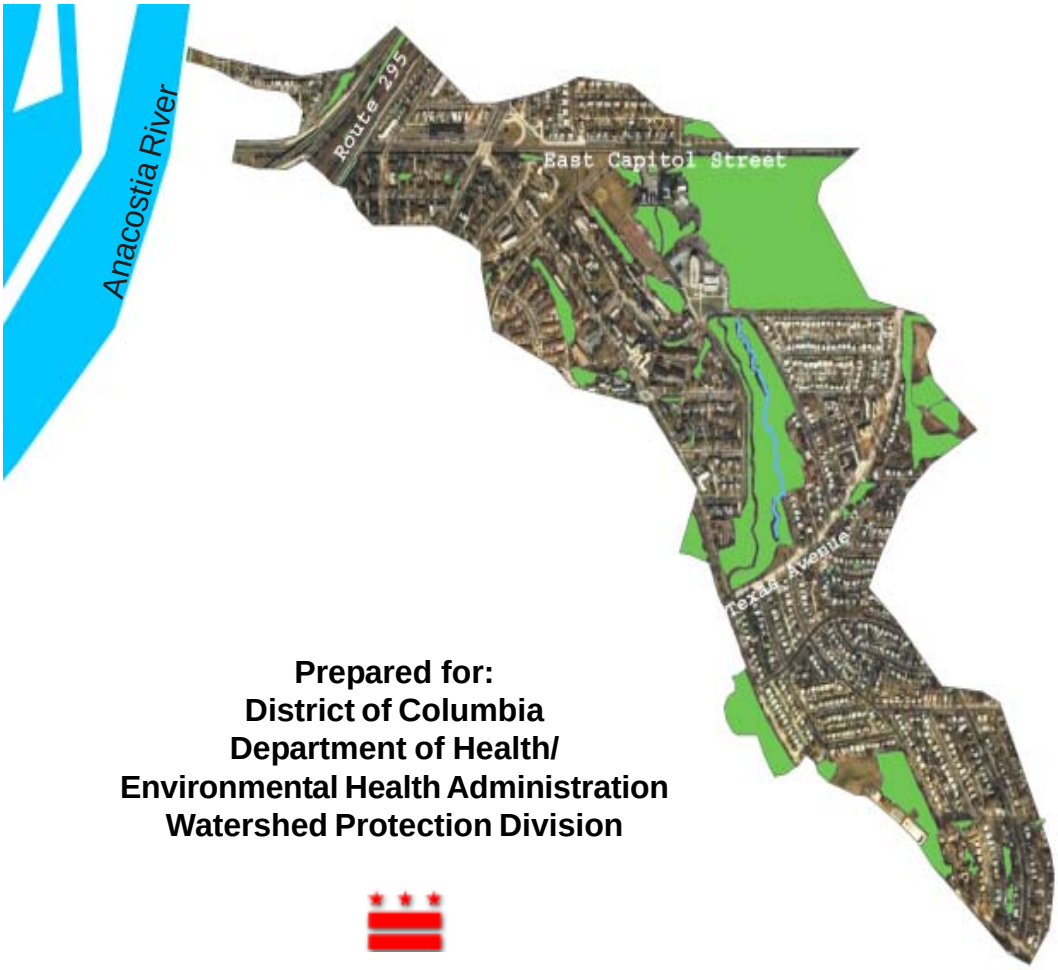
Fort Chaplin Subwatershed Restoration: 2003 Baseline Stream Assessment Study – Physical, Chemical, and Biological Conditions



Prepared for:
District of Columbia
Department of Health/
Environmental Health Administration
Watershed Protection Division

Prepared by:
Department of Environmental Programs
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Executive Summary

With funding support from the District of Columbia Department of Health/Environmental Health Administration (DC-DOH/EHA), the Metropolitan Washington Council of Governments (COG) was contracted in August 2002 to: 1) conduct a comprehensive baseline assessment of existing physical, chemical and biological conditions in Fort Chaplin, and 2) assess aquatic community restoration potential in Fort Chaplin. The 26 month-long Fort Chaplin stream baseline assessment study, described herein consisted of nine parts: 1) employment of the Rapid Stream Assessment Technique (RSAT Level III) to evaluate a total of 0.36 miles (i.e., 1,900.8 feet) of the Fort Chaplin system, 2) the establishment of permanent channel cross-section stations, 3) continuous water temperature monitoring, 4) baseflow and stormflow water chemistry grab sampling, 5) sediment chemistry characterization, 6) an electrofishing survey to qualitatively document both the present composition and relative abundance of fish species, 7) baseflow and stormflow discharge characterization, 8) fish community restoration potential evaluation and 9) development of restoration-related recommendations based on study results.

The results of this study generally support the findings from previous investigations (Johnson, 1989; Banta, 1993) that Fort Chaplin's biological community is severely impaired. Not surprisingly, decades of uncontrolled stormwater runoff in combination with poor water quality and major channel alterations have: 1) created a characteristically 'flashy', urban stream flow regime; 2) modified channel morphology and increased levels of stream channel erosion,; 3) exposed one utility line area; 4) increased stormflow levels of Cu and various other pollutants; 5) reduced both streambed stability and physical aquatic habitat quality; and 6) eliminated all resident fishes from the stream.

Despite the aforementioned problems, Fort Chaplin's macroinvertebrate community still continues to support 23 taxa. Not surprisingly, pollution intolerant stoneflies, flathead mayflies and cased caddisflies have long since been eliminated from the stream. Furthermore, the number of individuals that represent these taxa were extremely low.

Additional major findings and recommendations of the study are described in the following sections.

1. Stream Channel Erosion

A. Fort Chaplin moderate, moderate/severe and severe streambank erosion conditions totaled 448, 1,057 and 690 linear feet, respectively. This total represents approximately 57.7 percent of the entire 3,801.6 feet of the Fort Chaplin streambank channel network (i.e., represents the total of 1,900.8 feet for each right and left streambank length). The total number of recent tree falls, for the 1,900.8 feet of open channel, observed was 14 (i.e., poor range) and the associated rate per mile was 38.5. A total of three erosional log jams were also recorded. The preceding results indicate that the majority of the Fort Chaplin stream channel network is actively eroding.

B. Mean bank height for the entire length of the Fort Chaplin tributary was 9.3 feet, which is approximately six feet higher than the expected streambank height (i.e., 2-3 feet). Mean bank heights for the three study reaches exceeded the expected streambank height on the order of five to eight feet. Only one nick point, and two exposed utility lines were observed. The nick point, which appeared to be actively forming in the Middle reach, was created as a result of a recent large woody debris dam. The exposed utility lines that cross the stream are located in the Upper and the Middle reaches. Although the Upper reach utility pipe appears to be abandoned, the Middle reach utility line appears to be an active ductile iron 10" diameter pipe. Figure 11 illustrates the high stream downcutting rate during a five month period (i.e., May to October 2004). The location of this Middle reach utility line is immediately upstream of both the east and west 'D' Street storm drain system outfalls.

2. Channel Scouring/Sediment Deposition

A. Overall, the channel scouring and sediment deposition condition was rated as fair. There were a total of 24 observed point bars and of that total, five (21 percent) were rated as being both large and unstable. Overall mean embeddedness was rated as being fair. Both the Upper and Lower reaches were rated as being good, whereas the Middle reach was rated as having embeddedness in the fair range. It should also be noted that at transect X-9, both the highest embeddedness value (100 percent) and the largest unstable point bar were recorded. Transect X-9 is located immediately upstream of the 'C' Street 48" RCP culvert, which features a large steel bar trash rack.

3. Physical Aquatic Habitat

A. The overall habitat score fell in the fair range. Major contributing factors for the fair ratings included sub-optimal riffle substrate quality, shallow depth of flow in riffle areas and the predominant presence of unstable finer material (i.e., sand and silt) in the pools below the Upper reach.

B. Pebble count results indicated that the Fort Chaplin median (i.e., D-50) particle size is medium to coarse gravel (i.e., 8.00-31.99mm). In addition, the D-84 sized particle in all three surveyed reaches was very coarse gravel (i.e., 32.00 – 63.99 mm).

C. Only one fish blockage was identified during the RSAT survey, and was classified by COG staff as being a complete barrier. The structure is described as a 5,000 foot (0.95 miles) long piped stream section that extends from the 'C' Street 48" RCP culvert opening and daylights at the east bank sea wall of the Anacostia River.

4. Water Quality

A. Based on both RSAT and laboratory water chemistry grab sampling results, Fort Chaplin baseflow water quality was rated poor. Out of a total of 19 DO measurements taken, 10 (53 percent) were below the minimum 5.0 mg/l criterion recommended by DC-DOH/EHA for the support of a healthy aquatic community. The median fluoride (F^-) concentration for Fort Chaplin is 0.49 mg/l which is 0.19 and 0.29 mg/l greater than that recorded for the neighboring Pope Branch and Fort Dupont tributary, respectively. It should be noted that local naturally occurring fluoride concentrations generally range from 0.1 to 0.2 mg/l and that District of Columbia treated water F^- concentrations are typically 0.4 mg/l (DC-WASA, 2001). Copper (Cu) was not detected in the water samples at levels less than the 0.005 mg/l detection limits. Of the three fecal coliform baseflow samples taken, one sample (2,400 MPN) violated the DC-DOH/EHA 1,000 MPN criterion for class 'C' waters. Furthermore, the relatively low number of E. coli bacteria present (range: 20 - 1,300 MPN) in the three baseflow samples taken suggest that the sources are more likely animal than humans. It should be noted that there were no sewer lines crossing the stream or paralleling the stream within the riparian buffer zone.

B. Stormflow grab sampling results revealed that median total phosphorus (TP) concentration (i.e., 0.24 mg/l) was, compared to baseflow levels (i.e., 0.12 mg/l), approximately two times higher. The median nitrate level (NO_3^-) was surprisingly seven times less than baseflow concentrations (i.e., 0.51 mg/l compared to 3.60 mg/l median baseflow concentration). Stormflow Iron (Fe) concentrations ranged from 1.2 mg/l to 29.0 mg/l, with a median of 5.1 mg/l. Copper (Cu) concentrations ranged from 13.0 µg/l to 64.0 µg/l, with a median of 14.0 µg/l. Based on the limited stormflow monitoring results, it appears that Cu may be limiting to Fort Chaplin's benthic community. Fecal coliform stormflow samples showed that all five samples violated the DC-DOH/EHA 1,000 MPN criterion for class 'C' waters. E. coli bacteria numbers for the five samples ranged from 280 to 11,000 MPN, with an average of 3,676 MPN, suggesting a probable human component.

5. Riparian Habitat Conditions

A. Based on RSAT riparian buffer survey results, overall Fort Chaplin riparian habitat conditions were rated as being good. Overall mean stream canopy coverage was rated in the excellent range (i.e., 60-79 percent). In addition, the riparian buffer zone was on average 150 feet or wider dominated by mature deciduous hardwood forest.

6. Biological Indicators-Benthic Macroinvertebrate Survey

A. Under the RSAT system, the Fort Chaplin mainstem was rated as having poor macroinvertebrate conditions. The taxa richness for the Upper and Lower reaches were both rated as poor (i.e., < 7 taxa) and the taxa richness for the entire Fort Chaplin mainstem, which totaled nine, was rated as fair (i.e., 8-15 taxa). In addition, the biological community was comprised entirely of pollution tolerant species, with characteristically low number of individuals present.

B. The absence of individuals belonging to representative pollution intolerant groups (e.g., stoneflies, flathead mayflies and cased caddisflies) provides additional evidence of generally moderate levels of stream quality impairment. The only representative caddisflies collected were pollution tolerant individuals belonging to the Hydropsychidae family.

C. Both spring 2002 -2003 and fall 2002 MBSS IBI scores for the Upper and Lower reaches were verbally rated as being very poor (i.e., IBI scores < 2.0). The associated verbal ratings for individual metrics fell into either the poor or fair categories. According to Stribling et al. (1998), the general response for all seven metrics to increasing perturbation is a decrease in number, percent or score.

7. Fort Chaplin One-Pass Electrofishing Survey

A. A single pass electrofishing survey was conducted on May 11, 2004 and was a complete sweep of all representative habitat types (i.e., riffles, runs and pools) in a continuous 1,100 foot stream reach. Not surprisingly, no fish were collected or observed during the survey. The preceding results confirmed that: 1) the Fort Chaplin system is currently not supporting a resident fish community and 2) the ~ 5,000 foot long pipe section from 'C' Street down to the Anacostia River is a complete fish blockage which precludes normal exchange with and repopulation from Anacostia River fish stock.

8. Summer 2002, Temperature Regime Characterization

A. Major results from the 41 day monitoring period are as follows: 1) summer maximum stream temperatures in the Fort Chaplin monitoring reaches (i.e., Upper and Lower) were well below the DC-DOH/EHA Class 'C' 32.2 °C (90 °F) standard; 2) both stream reach stations had maximum summer daily temperatures that exceeded the 24 °C (75 °F) MDE Use IV temperature criterion; 2) Upper and Lower reach mean stream temperatures were 27.91 °C and 22.87 °C, respectively (which suggests a downstream temperature decrease); 3) the percent of time that the Upper and Lower reaches maximum summer daily temperatures exceeded the 20 °C MDE Use III temperature criterion was 97 and 88 percent, respectively; 4) the number of days that the Upper and Lower reaches exceeded the 24 °C MDE Use IV temperature criterion were 13 and seven, respectively and 5) the maximum daily water temperature recorded during the temperature study (28.3 °C) was measured in the Upper reach on July 9, 2002, and coincided with an afternoon thunderstorm where the maximum air temperature reached 37.0 °C (98.0 °F) .

9. Flow Regime Characterization

A. Mean mainstem baseflow during the study period was 0.46 cfs.

10. Fish Community Restoration Potential

A. It is believed that, historically, Fort Chaplin may have once supported 6-10 resident fish species. Current limiting factors include episodic water quality problems, the presence of a major fish barrier, the relatively low number of deep quality pools and the general lack of stormwater management controls in the subwatershed. Despite these problems, Fort Chaplin should (in COG staff's opinion) be capable of supporting pollution tolerant, pioneer fish species such as the blacknose dace, *Rhinicthys atratulus,* and northern creek chub, *Semotilus atromaculatus.* Therefore, an experimental reintroduction of these two native species, using individuals collected from other Anacostia tributaries, should be considered after the water quantity and quality problems have been satisfactorily addressed. If the two preceding species survive as expected, then other pollution tolerant species could subsequently be reintroduced using a phased approach.

Recommendations

In an effort to comprehensively address both existing problems and restoration opportunities for Fort Chaplin, COG staff developed the following suite of recommendations. Importantly, it is understood that the comprehensive restoration of Fort Chaplin is dependent upon District of Columbia Depratment of Health/ Environmental Health Administration (DC-DOH/EHA), the U.S. Army Corps of Engineers (USACE), District of Columbia - Water and Sewer Authority (DC-WASA), National Park Service (NPS), District of Columbia Department of Public Works (DC-DPW), and District of Columbia Office of Planning (DC-OP) and the local community working together to pursue a variety of stormwater management, storm drainage, and stream restoration options which will significantly reduce erosive stormflows, improve water quality and enhance aquatic and terrestrial habitat conditions throughout the subwatershed. Therefore, COG staff suggest that those agencies responsible for current and/or planned future Fort Chaplin restoration-related activities, carefully review the more specific recommendations which follow:

1) DC-DOH/EHA, DC-WASA and NPS should continue to work together to pursue stormwater control options, which will significantly reduce erosive stormflow conditions and improve water quality in the Fort Chaplin mainstem for the following storm drain systems:

   • Texas Avenue storm drain system - An in-line flow splitting weir to separate erosive stormflow and convey it, for approximately 1,900 feet to 'C' Street, via a parallel pipe located along the left hand bank;

   • East 'D' Street storm drain system - Disconnect the 27" RCP from directly discharging into the stream and connect this pipe into the proposed parallel pipe system; and

   • West 'D' Street storm drain system - An in-line flow splitting weir to separate erosive stormflow and convey it, for approximately 700 feet to 'C' Street, via a parallel pipe located along the right hand bank.

2) At a minimum, the two following storm drain system outfall locations are either in need of major repair and/or the installation of more effective velocity dissipation features (i.e., east and west 'D' Street).

3) Given the major technical, institutional and financial challenges associated with the implementation of subwatershed-wide, stormwater management controls which significantly reduce runoff volumes entering Fort Chaplin, a Rosgen-based stream channel restoration project for the entire length of open channel (i.e., approximately 1,900 feet) is recommended.

4) DC-WASA should conduct a Fort Chaplin watershed sewer line integrity evaluation.

5) To the greatest practical extent, the employment of various stormwater management water quality control techniques (such as but not limited to Low Impact Development (LID), DC-DOH/EHA approved water quality inserts and inlets, sand filters, porous pavement, green roofs, etc.) are needed throughout the Fort Chaplin subwatershed. This is especially true for the watershed area above Texas Avenue.

6) To address the high trash conditions within the stream channel, investigate the possibility for the employment of either an in-line or end-of-the-pipe trash collection device (i.e., Fresh Creek Trash Netting System, or equivalent) at the terminus of the Texas Avenue storm drain system.

7) Create vernal pools for amphibian habitat in the following general area: Upper Reach (immediately below Texas Avenue) - excavate to deepen the existing vernal pools along left hand bank. Note: several of these vernal pool sites can be excavated by hand using Earth Conservation Corps or other local volunteer labor. Also, in all likelihood the reintroduction of native amphibians such as spotted salamanders (*Ambystoma maculatum*), wood frogs (*Rana sylvatica*) and spring peepers (*Hyla crucifer*) will require the physical transplantation of eggs and/or larvae from other Anacostia sites.

8) The concrete slabs located along the right hand bank near the Upper Reach X-2 area has slipped into the stream. In COG staff's opinion, the concrete slabs should be removed and a geotechnical study should be undertaken of this area to determine its potential long-term stability.

9) The loamy clay fill slope located along the right hand bank near the Upper Reach X-3 area is exhibiting signs of localized slope failure. In COG staff's opinion, a geotechnical study should also be undertaken in this area to determine its potential long-term stability.

10) A community-based clean up of trash and debris from the entire Fort Chaplin stream valley park system is needed. Major trash/dump sites include the stream valley park property that abuts 40th Place, 'C' Street and Burbank Street.

11) Appropriate "No Dumping" signage along 'C' Street is recommended to complement existing signs along Burns and Burbank Streets and 40th Place. In addition, the stenciling of all storm drain inlets in the Fort Chaplin subwatershed with a "No Dumping - Drains to Fort Chaplin Tributary " message should be made a high priority.

12) A volunteer-based exotic/invasive plant management initiative modeled after Montgomery County's "Weed Warrior" program should be seriously considered for the Fort Chaplin stream valley park system. Specifically, the left hand bank area immediately below Texas Avenue has been identified by COG staff as a high priority area as both English ivy and Euonymus sp. vines cover both the forest floor and the mature hardwood trees present.

13) Based on recent success in the neighboring Fort Dupont Tributary, reintroduce native fishes (after the scouring stormflow and poor water quality problems have been addressed) into the entire mainstem of Fort Chaplin. The recommended species and approach are described below:

- Using COG's previous stream restoration experience in the Anacostia's Sligo Creek subwatershed and Table 17 as reference, the following six pollution tolerant species should be considered for reintroduction: blacknose dace (*Rhinichthys atratulus*), northern creek *chub (Semotilus atromaculatus*), white sucker (*Catostomus commersoni*), tessellated darter (*Etheostoma olmstedi*), swallowtail shiner (*Notropis procne*) and satinfin shiner (*Notropis analostanus*). The preceding species may be easily collected in good numbers from various Anacostia streams, including the Northeast and Northwest Branches, Lower Beaverdam Creek, Watts Branch, etc.

- Stocking should be phased, with the hardiest pioneer species, such as the blacknose dace and northern creek chub, being introduced first. As a rough stocking density guide, COG staff recommend that approximately 10-12 blacknose dace and two to four northern creek chub individuals be stocked per high quality pool (i.e., approximately 120-150 blacknose dace and 25-35 northern creek chubs, total). If the two preceding species survive as expected, then the four remaining recommended species should be reintroduced; with white suckers being introduced last and only after overall post restoration physical aquatic habitat conditions have markedly improved. Additional future stockings beyond the recommended six target species should only occur after both stream restoration and stormwater retrofitting work have been completed and monitoring results indicate a recovering stream system.

14) DC-DOH/EHA should continue to work with the DC-Department of Public Works to maintain a relatively clean trash rack at the 'C' Street culvert.

15) Continue periodic physical, chemical and biological monitoring of Fort Chaplin so as to evaluate stream recovery from both the recent drought and future restoration projects.

16) COG staff recommends that the current "Adopt a Block" neighborhood trash-free program already in place for Burbank Street be expanded to include Burns and 'C' Streets, as well as 40th Place.

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1.0 Introduction

1.1 Project Background

Over the past 300 years, farming, urbanization, loss of wetland and forest habitat, erosion, sedimentation and toxic pollution have all taken a tremendous toll on the 176 square mile Anacostia River watershed. After centuries of neglect, the signing of the historic 1987 Anacostia River Watershed Restoration Agreement and formation of the Anacostia Watershed Restoration Committee (AWRC) marked the beginning of a concerted and focused effort to restore and protect the river and its tributaries. Over the past 17 years, the AWRC has worked closely with local, State and Federal resource agencies and landowners such as the District of Columbia Department of Health/ Environmental Health Administration (DC-DOH/EHA), Montgomery County Department of Environmental Protection (MCDEP), Prince George's County Department of Environmental Resources (PGDER), Maryland Department of Natural Resources (MDDNR), Maryland Department of the Environment (MDE), the National Park Service (NPS), the U.S. Army Corps of Engineers (USACE), the U.S. Environmental Protection Agency (EPA) the U.S. Geological Survey (USGS), and the U.S. Fish and Wildlife Service (USFWS), and others to integrate their related programmatic responsibilities and resources into the overall restoration effort.

This report is the final part of a three-phase, multi-year study that involves the assessment of three adjacent Anacostia subwatersheds (i.e., Fort Dupont tributary, Pope Branch and Fort Chaplin tributary) all located within the District of Columbia's east bank of the Anacostia River. Having completed both the extensive Fort Dupont Subwatershed Restoration: 1999 Baseline Stream Assessment Study – Physical, Chemical and Biological Conditions report (Galli and Trieu, 2000) and Pope Branch Subwatershed Restoration: 2002 Baseline Stream Assessment Study – Physical, Chemical and Biological Conditions, the Metropolitan Washington Council of Governments (COG) was contracted by DC-DOH/EHA in August 2002 to: 1) conduct a comprehensive baseline assessment of existing physical, chemical and biological conditions in Fort Chaplin, and 2) assess aquatic community restoration potential for the stream in its entirety.

1.2 Fort Chaplin Subwatershed

Fort Chaplin is a small first-order tributary[1] to the Anacostia River, draining a 344.8-acre (0.54 mi^2) watershed area within the southeast quadrant of the District of Columbia (Figure 1). There are two open stream channels that combine for an approximate total length of 2,900 feet. The first open channel is an intermittent stream that originates downstream of Ridge Road. The channel heads in a northwesterly direction for approximately 1,000 feet whereupon it enters an approximately 1,800 feet long 24" RCP pipe storm drain system which terminates immediately below Texas Avenue. At this point, the stream is considered to be perennial. The perennial stream portion also flows in a slight northwesterly direction for approximately 1,900 feet whereupon it enters a 48" RCP pipe immediately upstream of 'C' Street. This enclosed stream section is approximately 5,100 feet in length and outfalls at the sea-wall of the east bank of the Anacostia River. It effectively precludes the normal movement and exchange of fishes between river and

[1] Stream order determination made using 200-foot scale topographic maps

stream. Both piped sections total 7,000 linear feet (1.3 miles) representing approximately 71.0 percent of the total stream length. The mean open stream channel gradient for Fort Chaplin is, approximately 1.4 percent and is considered slightly high for a Coastal Plain stream. In comparison, the mean stream gradient for the adjacent Fort Dupont and Pope Branch tributaries were 1.9 and 2.6 percent, respectively. These higher than average stream gradients are a function of the river terrace-influenced morphology in this portion of the Anacostia watershed.

For the purposes of this study, the baseline RSAT stream survey was conducted only for the opened stream channel portion located between Texas Avenue and 'C' Street. Figure 1 and Table 1 highlight and summarize the Fort Chaplin drainage area and the surveyed open channel portion of the catchment. It should be noted that the open stream channel segment was subdivided into three areas for selected project task evaluation. These three stream reaches are defined as follows:

1. Upper - 739.2 foot-long reach that starts downstream of Texas Avenue and extends downstream to transect X-3;
2. Middle - 528.0 foot-long reach that starts at transect X-3 and extends downstream to transect X-7; and
3. Lower - 633.6 foot-long reach that starts at transect X-7 and extends downstream to transect X-9.

Table 1 - Fort Chaplin - General Study Area Information

RSAT Study Area	Drainage Area (ac)	Estimated Existing Imperviousness (%)	Stream Order	Open Stream Length		Stream Gradient (%)	Flow Condition/ Mean Baseflow (cfs)	No. of RSAT Transects
				Feet	Miles			
Above Texas Avenue	113.0	31.9	-	-	-	-	-	-
RSAT Stream Segment								
Upper	131.4	29.8	1	739.2	0.14	1.8	--	3
Middle	160.0	30.5	1	528.0	0.10	1.2	--	3
Lower	164.8	29.6	1	633.6	0.12	1.1	0.46	3
Subtotal	164.8	29.6	1	1900.8	0.36	1.4		9
Below 'C' Street	180.0	42.4	-	-	-	-	-	-
Total	344.8	36.3	-	-	-	-	-	-

It is important to note that the stream has been designated by the DC-DOH/EHA as a class 'C' stream (i.e., protection and propagation of fish, shellfish and wildlife).

The Fort Chaplin subwatershed is located entirely within the Coastal Plain Province. This geologically complex subwatershed is underlain by sedimentary gravel, sand and clay materials associated with the geologic Cretaceous Potomac Group, Miocene Calvert Formation, and Pliocene river terrace deposits. The unaltered soil groups in the study area include Beltsville, Chillum, Christiana, and Matapeake silt loams; Muirkirk loamy sands; Croom, Iuka, Keyport, Sassafras, Sunnyside, and Woodstown sandy loams; and four Udorothent urban soils (fill soil). However, in much of the study area these soils have been altered/disturbed by construction grading associated with urban development. Consequently, the preceding soil groups are generally classified with Urban Land (i.e., Christiana-Urban Land, Chillum-Urban Land, etc.; USDA, 1976), since topographical and soil characteristics such as relief and drainage have changed.

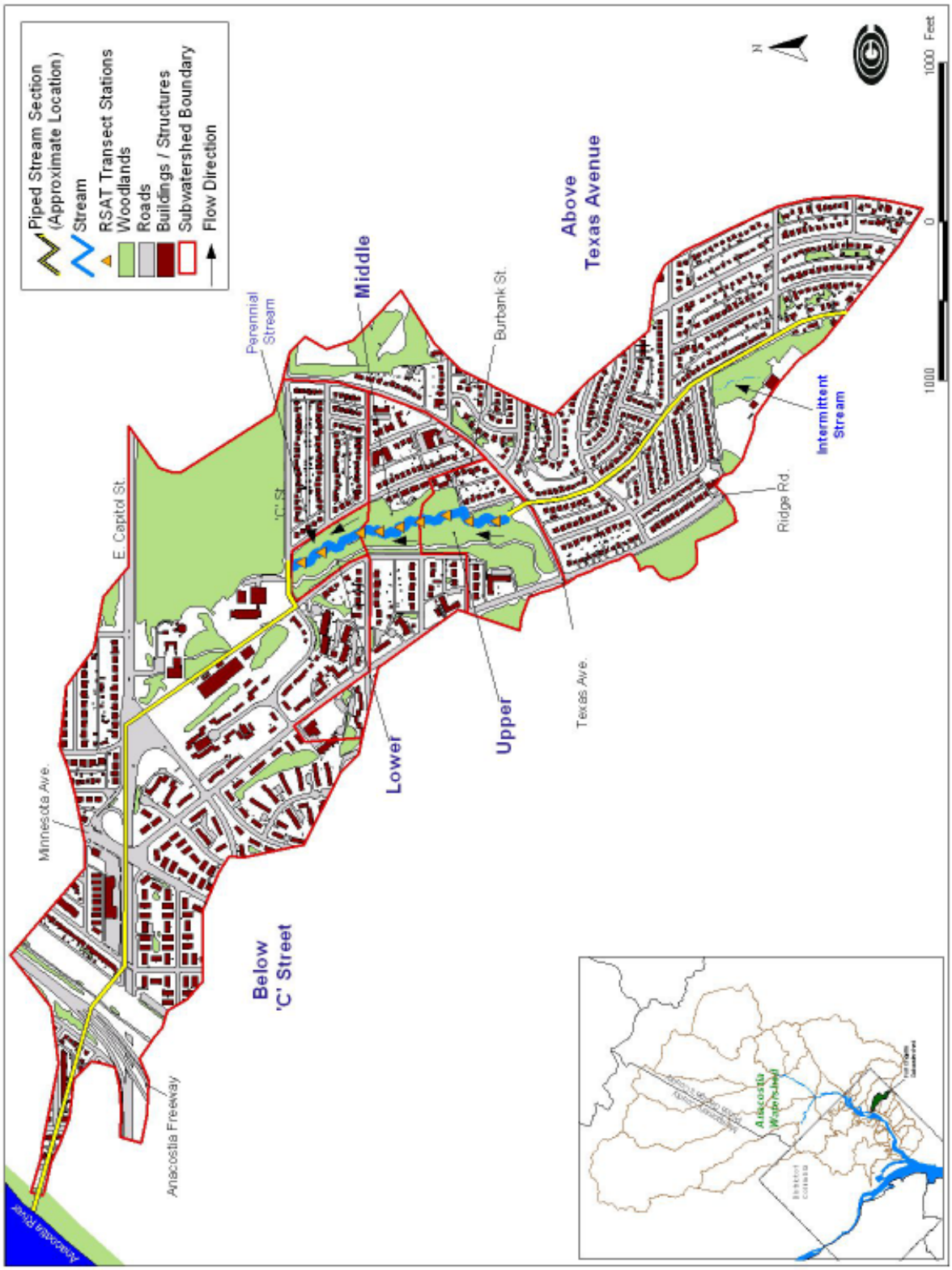


Figure 1 - Fort Chaplin Tributary Study Area

Low level altitude aerial photography together with a limited drive-by road survey was used to verify general land use and land cover types for Fort Chaplin. As seen in Table 2, the predominant land uses for the Fort Chaplin subwatershed include a mix of residential, institutional and commercial areas. The land uses for the drainage area above the Texas Avenue are predominantly single family and row house residential. This area drains approximately 113.0 acres, with 97.8 acres (86.5 percent) associated with the previously mentioned land use types and the remaining 15.2 acres (13.5 percent) is deciduous forest. Heading downstream, the catchment area between Texas Avenue and 'C' Street (the RSAT stream survey portion of the watershed), drains 51.8 acres. Of the 51.8 acres, 35.2 acres (78.0 percent) is associated with single-family, row house residential and, garden apartment land uses. There is also an area occupied by a church and a convenience grocery store located at the corner of Texas Avenue and Chaplin Road. The remaining 16.6 acres (32.1 percent) is deciduous forest. The watershed area below 'C' Street drains 180.0 acres. Approximately 141.7 (78.7 percent) of the 180 acres is a mix of single family, row house residential, garden apartment, institutional and commercial land uses. Overall, the mean Fort Chaplin imperviousness level is 36.3 percent, which is nearly three times that of the adjacent Fort Dupont Tributary (13.3 percent).

Climate in the Anacostia watershed is generally referred to as being continental. Annual precipitation averages around 39 inches. Mean Fort Chaplin tributary baseflow during the July through September 2003 monitoring period was approximately 0.46 cubic feet per second (cfs). It is important to note that this 2003 study coincided with an extremely wet year where the annual rainfall totaled 60.8 inches, a surplus of 21.5 inches above the annual average. Climatological data was summarized from the National Oceanic and Atmospheric Administration - the National Weather Service (NOAA-NWS) Ronald Reagan National Airport rainfall gauging station.

Table 2 - Summary: Fort Chaplin - General Land Use / Land Cover And Associated Imperviousness

Study Area	Associated Drainage Area (ac)	General Land Use / Land Cover	Associated Developed Areas (ac)	Estimated Imperviousness (Percent)
Above Texas Avenue	113.0	Single Family and Row House Residential	97.8	31.9
RSAT Stream Segment				
Upper	18.4	Single Family and Row House Residential and Garden Apartment	--	17.5
Middle	28.6	Single Family and Row House Residential, Garden Apartment, Institutional and Commercial	--	33.5
Lower	4.8	Forest	--	0.0
Sub-total	164.8		35.2	24.8
Below 'C' Street	180.0	Single Family and Row House Residential, Garden Apartment, Institutional and Commercial	141.7	42.4
Subwatershed Total	**344.8**		**--**	**36.3**

1.3 Problem Assessment

Decades of uncontrolled stormwater runoff from this urbanized catchment have adversely impacted the stream and its biota. In older urbanized watersheds, stormwater runoff is generally efficiently conveyed directly to the receiving stream via a network of enclosed storm drainage systems. In Fort Chaplin, there are a total of three storm drain systems that discharge directly into the stream (Figure 2). The largest of these is the Texas Avenue system, which drains approximately 113 acres of single family and/or row house residential landuses. This system discharges runoff directly into the open, perennial flowing stream section via a four foot-high and eight foot-wide concrete culvert. Further downstream, there are two additional systems that also discharge runoff directly into the stream. The east and west 'D' Street storm drain systems discharge stormwater runoff via 48" and 27" reinforced concrete pipes (RCP's), respectively. The large volumes of uncontrolled runoff in combination with moderate to high erosive streambank and streambed materials and a slightly high stream gradient have: 1) accelerated both channel widening and downcutting, 2) resulted in the loss of numerous mature deciduous trees, and 3) increased pollutant and sediment loads and deliveries, with attendant aquatic habitat and biological community loss in Fort Chaplin.

Figure 2 - Fort Chaplin Tributary - A. Texas Avenue Storm Drain Outfall (4' high by 8' wide concrete box culvert); B. East 'D' Street Storm Drain Outfall (48" RCP); C. West 'D' Street Storm Drain Outfall (27" RCP)

2.0 Study Design/Methods

2.1 Fort Chaplin Study Area

On December 17, 2002, COG staff performed a preliminary reconnaissance field survey of Fort Chaplin tributary in which a total open, perennial flow stream channel network length of 0.36 (i.e., 1900.8 feet) miles was identified. As part of this survey, a total of nine permanent stream transects (spaced on average 200 to 300 feet apart) were established for the Rapid Stream Assessment Technique (RSAT) evaluation portion of the study (Figure 3). The entire perennial flowing portion of Fort Chaplin between Texas Avenue and 'C' Street was RSAT surveyed. Furthermore, the streambank stability condition survey evaluated both the left and right streambank (i.e., a total of 3,801.6 linear feet).

As previously stated, for RSAT study purposes, the 0.36 mile-long Fort Chaplin channel network was subdivided into three distinct reaches (i.e., Upper, Middle and, Lower). There were a total of three transects established within each reach.

Each RSAT stream transect site was geo-referenced using a Trimble GEO-XT global positioning satellite (GPS) receiver. The associated GPS-derived latitude/longitude coordinates for each transect have been included as Appendix 1.

It should be noted that due to the moderately high gradient, river terrace nature of Fort Chaplin, COG staff were unable to find a comparable, unimpaired Coastal Plain reference stream within either the 176 square mile Anacostia watershed or immediate Washington metropolitan area. Consequently, COG staff's prior survey experience in the adjacent Fort Dupont tributary and other Coastal Plain stream systems, and MBSS-based Coastal Plain data were relied upon for evaluation purposes[3].

2.2 RSAT Level III Survey

The Rapid Stream Assessment Technique (RSAT) was developed by COG in 1992 to provide a simple, rapid reconnaissance-level assessment of stream quality conditions. Since its inception, RSAT has undergone a series of revisions and upgrades. The RSAT Level III method used in this study features quantitative macroinvertebrate community metric calculations, greater use of hand-held water quality meters for enhanced baseflow water quality characterization, pebble counts and the capacity to assess both Piedmont and Coastal Plain streams. RSAT employs both a reference stream and an integrated numerical scoring and verbal ranking approach.

The following six standard RSAT survey evaluation categories were assessed to compute the overall RSAT stream evaluation scores: 1) Bank Stability, 2) Channel Scouring/Sediment Deposition, 3) Physical Instream Habitat, 4) Water Quality, 5) Riparian Habitat Condition and 6) Biological Indicators. As previously indicated, the Level III evaluation included two-meter square ($2m^2$) streambed sampling for macroinvertebrate metric calculations and MBSS macroinvertebrate IBI

[3] Note: results from COG's fall 2002 and spring 2003 Maryland Biological Stream Survey (MBSS) macroinvertebrate index of biological integrity (IBI) analyses for the Fort Dupont tributary were used for comparison, .

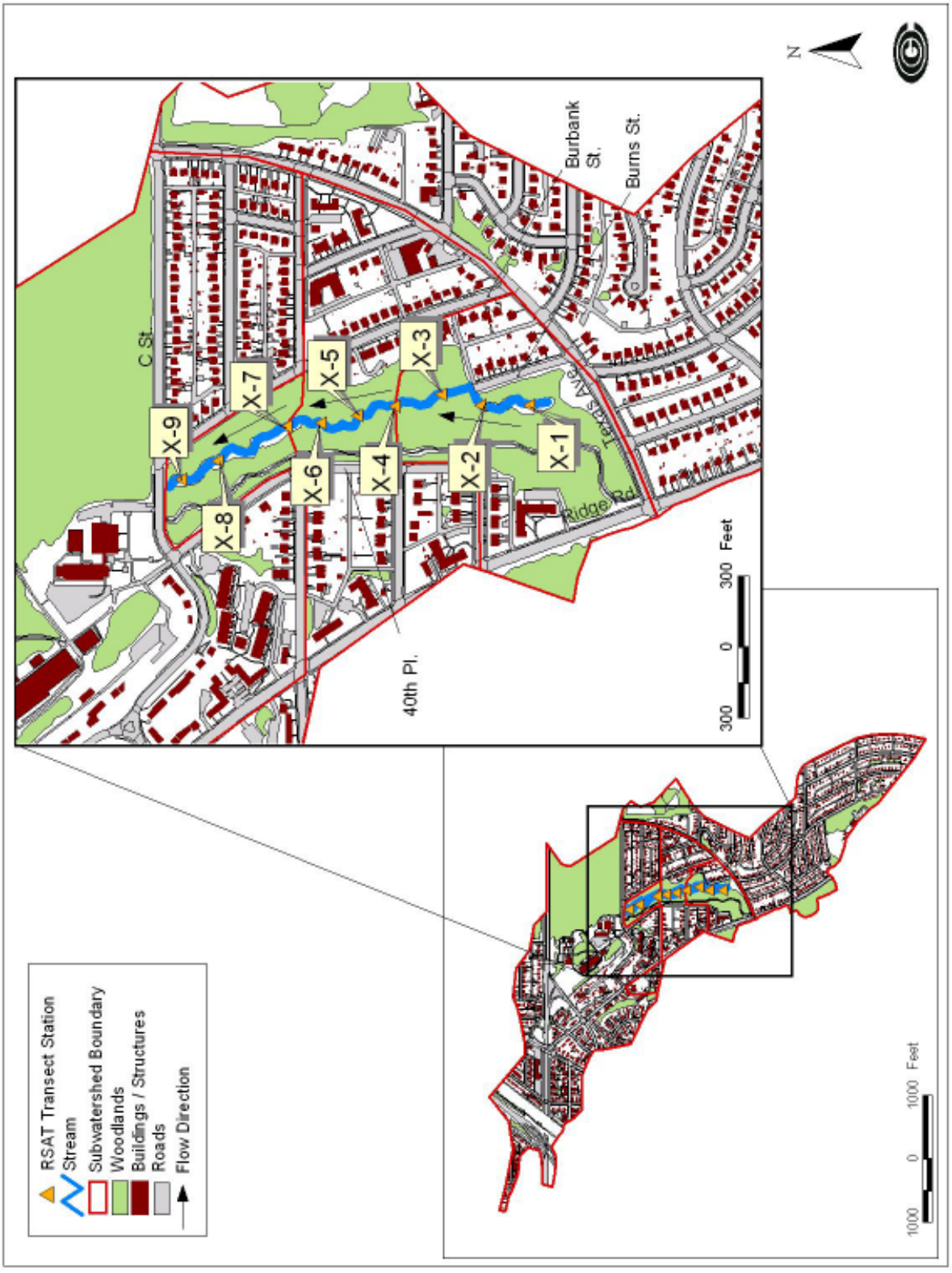


Figure 3 - Fort Chaplin Tributary - RSAT Transect Station Locations

scoring of surveyed stream reaches. Sample metrics included: 1) taxa richness, 2) total number of EPT taxa, 3) percent Ephemeroptera, 4) percent Tanytarsini of Chironomidae, 5) Beck's Biotic Index, 6) number of scraper taxa and 7) percent clingers. A brief overview of the types of field measurements and observations made for each of the preceding six RSAT evaluation categories are as follows.

1. Bank Stability

One of the primary assessments of channel stability is overall bank stability which is evaluated through both a visual estimation of the percentage of bank that is stable along each transect surveyed (expressed as a percentage) and a generalized approximation of the degree of erosion between transects (categorized verbally as stable, slight, slight/moderate, moderate, moderate/severe, or severe). Additional observations factored into the bank stability evaluation include the stability of stream bend areas and the number of recent, large tree falls per stream mile. The relative erodibility of the soil material comprising the bottom one-third of the bank (the area most susceptible to erosion) is also considered.[4] Another factor considered in assessing channel stability is the degree of channel downcutting, which is evaluated by a set of indicators that includes bank heights, exposed utility lines and nick points.[5]

2. Channel Scouring/Sediment Deposition

A key factor in evaluating the degree of sediment deposition occurring along the stream channel is the mean embeddedness level of riffle substrate material.[6] Other important indicators of sediment load and transport include pool depths and the amount of silt and sand in pools; sand and silt deposits within run areas and along the tops of banks; and the number of large, unstable point bars. Point bars also provide insight into the degree of channel scouring. For example, point bars armored by cobble-sized materials generally reflect frequent, intense storm flows unlike point bars comprised of smaller, gravelly or sandy material. Scouring is also sometimes evidenced by riffle areas where lower-lying resistant streambed materials such as bedrock or clay have been exposed and the upper layers of loose substrate material have been stripped away.

3. Physical Instream Habitat

One of the first criteria considered in evaluating physical instream habitat is the stream channel's wetted perimeter at riffle areas.[7] Diverse depths of flow and velocities through riffles

[4] Relative erodibility describes the erosion potential and is classified as low, moderate or high. Low potential denotes predominantly clay-textured soils, bedrock, saprolite and rip-rap; moderate potential characterizes non-silt or non-clay dominant soil textures; and high potential describes predominantly silt-textured soils.

[5] Mean bank heights of one to two feet for small first and second-order Coastal Plain streams and two to three feet for third-order streams approximate reference conditions. Sewer lines are typically laid three to four feet below the bottom of the streambed; therefore, their exposure offers insight into the depth of downcutting that has occurred. A nick point is an erosional feature in the streambed, marked by an abrupt drop in elevation, which is caused by stream headcutting.

[6] Embeddedness is the amount of sand and/or silt that surrounds or covers larger riffle materials such as gravel, cobble, and rubble; it is expressed as a percentage.

[7] Wetted perimeter is the percentage of the bottom channel width at riffle areas that contains flowing water.

are important to the sustainability of diverse macroinvertebrate communities. Two other important criteria include the quality of both riffle substrate material and pools. For higher gradient Coastal Plain streams such as Fort Chaplin, the ideal riffle substrate includes a mix of coarser gravels and cobble, with some larger rubble or boulder-sized stones and little sand. Gravel and cobble-sized materials should be the dominant and co-dominant materials present, respectively. Poor riffle substrate quality is generally associated with a very high and disproportionate amount of sand, silt and fine gravel. Small riffle substrate, such as sand and fine gravel, provides limited habitat for macroinvertebrates and fish; and is inherently unstable and generally supports a limited biological community. Individual pool quality is assessed relative to its value as fish habitat and is based on five factors: 1) size and maximum pool depth, 2) substrate composition, 3) amount and type of overhead cover, 4) amount and type of submerged cover and 5) proximity to key food producing areas such as the nearest upstream riffle area. Additional factors considered in assessing overall physical instream habitat include: the degree to which riffles, runs and pools are equally represented; channel alteration or significant point bar formation; the riffle/pool ratio and the number of fish barriers (either partial or complete) present.[8]

4. Water Quality

Two key RSAT indicators of baseflow water quality are substrate fouling and total dissolved solids (TDS). Substrate fouling provides a qualitative indirect measure of the chronic nutrient (primarily nitrogen) and organic carbon loading to a stream.[9] TDS levels often increase in response to the introduction of a variety of pollutants such as sewage from septic field/sanitary sewer line exfiltration, road salts, fertilizers, etc. Additional parameters measured include nitrate concentrations (which also provide indirect evidence of potential inputs such as sewage, chemical fertilizers and/or decaying organic matter), orthophosphate (a limiting macro-nutrient for algae), iron, fluoride concentrations (which may indicate the inflow of treated water or sewage), turbidity, water temperature, pH, dissolved oxygen (DO) and conductivity. Water clarity and odor are also documented. Baseflow water quality readings were taken using a Horiba U-10 water quality meter, Hach total dissolved solids (TDS) meter and Hach nitrate, orthophosphate, iron and fluoride pocket colorimeters.

5. Riparian Habitat

The quality of riparian habitat is evaluated based on 1) the width of the vegetated buffer zone on the left and right banks and the type of vegetation (a forested buffer rating highest) and 2) the percent canopy coverage (i.e., shading) over the stream.

[8] Partial barriers denote any obstruction, which would likely prohibit or impede normal upstream-downstream fish movements during certain times of the year (e.g., low summer baseflow conditions). Complete barriers describe obstructions, which totally prevent the normal movement of fish throughout the year (e.g., a perched culvert, which features a three-foot-high vertical drop).
[9] Substrate fouling is defined as the percentage of the underside surface area of a cobble-sized stone (or larger) lying free on the streambed, which is coated with a biological film or growth.

6. Biological Indicators-Benthic Macroinvertebrate Biosurvey

Benthic macroinvertebrates are often used for biological monitoring because they are a ubiquitous diverse group of sedentary and relatively long-lived taxa, which often respond predictably to human watershed perturbations. Importantly, a stream's biological community normally responds to and is reflective of prevailing water quality and physical habitat conditions. The two principal factors considered in evaluating the benthic macroinvertebrate communities are: 1) the number of taxa present (i.e., species richness) and 2) the relative abundances (i.e., total number of individuals) of taxa present. Two types of macroinvertebrate samples were collected. For every survey reach, taxa were collected at each riffle transect area by compositing two one-square foot kick and two one-square foot jab samples. Representative individuals were preserved in ethyl alcohol and placed in the RSAT voucher collection. All reaches with baseflow were also quantitatively sampled by compositing the 20-jabs collected from all representative available habitats (i.e., riffle, runs and pools) that totaled approximately $2m^2$ streambed area. As previously stated, the 20-jab samples were used for MBSS macroinvertebrate IBI scoring evaluations. An RSAT biological indicator scoring is based on both the taxa observed and collected as well as relative abundances over the entire survey reach.

An example of the RSAT scoring system has been included as Table 3. As seen in Table 3, the channel stability evaluation category is weighted slightly more heavily than the other five categories. This was done intentionally to reflect the major influence, which the stream flow regime exerts on all six-evaluation categories. For more detailed information regarding RSAT field protocols the reader is referred to Appendix 'A' of "Technical Memorandum: Rapid Stream Assessment Technique (RSAT) Field Methods, Galli, 1996a".

Table 3 - RSAT Scoring System

RSAT Evaluation Category	General Verbal Rating Categories and Associated Point Range			
	Excellent	Good	Fair	Poor
1. Bank Stability	9-11	6-8	3-5	0-2
2. Channel Scouring/Sediment Deposition	7-8	5-6	3-4	0-2
3. Physical In-Stream Habitat	7-8	5-6	3-4	0-2
4. Water Quality	7-8	5-6	3-4	0-2
5. Riparian Habitat Conditions	6-7	4-5	2-3	0-1
6. Biological Indicators	7-8	5-6	3-4	0-2
Verbal Ranking (based on total score: 42-50 pts = Excellent, 30-41 pts = Good, 16-29 pts = Fair, <16 pts = Poor)				

2.3 Water and Sediment Chemistry Characterization

2.3.1 Baseflow and Stormflow Grab Sampling

In addition to the RSAT water quality grab sampling, three baseflow and five stormflow water chemistry grab samples were collected between August 2003 and April 2004 for the purpose of conducting EPA priority pollutant scans. Both baseflow and stormflow water-grab

samples were collected at transect station location X-9 (Lower reach), which corresponds to the stage-discharge characterization site. Each water sample included 18 separate collection containers, each containing their respective preservative. It should be noted that additional to the water chemistry characterization, both baseflow and stormflow samples also included coliform bacteria (i.e., total, fecal and E. coli) characterization.

For stormflow grab samples, storm events that were likely to produce 0.10 inches of rainfall or greater were tracked using local weather and radar maps provided by AccuWeather.com, Intellicast.com and the National Weather Service (NWS). From such storms, water chemistry grab samples were collected by completely submerging the collection containers into a pool to collect the initial runoff associated with the rising limb of the hydrograph (i.e., first flush). Baseflow water grab samples were collected using the same method, but from an undisturbed pool. Both baseflow and stormflow water samples were iced and transferred to CT&E Environmental Services, Incorporated in Baltimore, Maryland within six hours. Both sample types were collected between 0700 and 1800 hours. In addition, when possible, the Horiba U-10 water quality meter was used to further measure DO, water temperature, conductivity, pH and turbidity levels.

2.3.2 Sediment Chemistry

One composite sediment grab sample was collected from a total of eight pool sites located in the Upper, Middle and Lower Fort Chaplin reaches. In order to have enough material to perform an EPA priority pollutant scan, a total of 32 ounces of fine sediment was collected using a long-handled, polyethylene dipper which featured a 500 ml bowl set at a 45° angle. The composite was homogenized in a large porcelain mixing bowl, transferred into eight sterilized four ounce glass sample containers, appropriately labeled and placed in an ice cooler. The cooled sample was then delivered to CT&E Environmental Services, Incorporated in Baltimore, Maryland within six hours for analysis.

2.4 Physical/Hydrological Condition Monitoring

2.4.1 Baseflow Discharge

Baseflow discharges were measured at a riffle near transect X-9 (Figure 4). A total of 11 measurements were conducted using a Marsh-McBirney Incorporated, model 2000 Flowmate flow probe. Measurements were taken from different dates (i.e., at least three times a month between July and September 2003). Again, the time was recorded for each discharge measurement that corresponded to the time that a stage height was recorded by the water level data logger.

Figure 4 - Lower reach - COG Staff Measuring Baseflow

2.4.2 Rainfall Measurement

For the June-October 2003 portion of the study, rainfall was measured at the NPS Fort Dupont Activity Center building via the use of a RainWise® RGEL Tipping Bucket Recording Rain Gauge. However, organic debris had severely clogged the instrument. After a data quality check, it was deemed that the data from the rain gauge could not be used. Therefore, daily rainfall data was obtained from the rain gauge station located at the NWS Reagan National Airport weather station.

2.4.3 Stormflow Discharge

Stormflow discharges were measured for storms that produced between 0.17 and 1.93 inches of rainfall. Measurements were taken in the Lower reach stream channel section at transect X-9. It should be noted that near peak stormflow discharge measurements were extremely limited due to the dangerous stormflow conditions during first-flush events. Therefore, one to two discharge measurements per storm were conducted during the rising limb of the hydrograph curve for a total of eight. Date and time were recorded for each discharge measurement to correspond with the information recorded by the water level data logger.

2.4.4 Stage-Discharge Curve Development

In an attempt to develop a stage-discharge curve, which characterizes and predicts flows according to water depths, COG staff deployed the Global Water automated water level logger and manually operated the Marsh-McBirney Incorporated model 2000 Flowmate flow probe in a pool to riffle sequence located in close proximity to transect X-9 (i.e., Lower reach). The stage level logger, which features a data logger encased in a waterproof cylinder connecting to a 15 foot cable that terminates at a pressure transducer sensor, was deployed from July 11th to November 20th, 2003 to record various pools stages (ft) at 20-minute intervals. The installation entailed carefully burying the data logger cylinder, housed in a PVC pipe, into the top of an approximately four foot high bank to reduce the risk of damage or loss from flooding and/or vandalism. The sensor cable was also buried and snaked through the roots down the embankment to a pool approximately 15.0 inches deep. Finally, the terminal sensor, housed in a 3.0 inch diameter, 15 inch long perforated PVC pipe, was submerged. It should be noted that the sensor tip was pointed downstream to reduce silt deposition and clogging of the sensor.

The discharge flow probe was used to measure mean stream velocity in a riffle immediately downstream of the water level logger pool site. Parameters such as average stream velocity; the wetted perimeter width and riffle depths were measured. Again, date and time were noted and recorded to correspond with the information recorded by the water level data logger. It should be noted that the stage-discharge measurement site corresponds to those of the baseflow and stormflow water chemistry grab sampling locations. Discharge was calculated using the following simple formula: Discharge (ft^3/sec) = riffle cross-sectional area (ft^2) * mean stream velocity (ft/sec). The stage and discharge data were downloaded and statistically analyzed using Microsoft Excel 2003 linear regression to test for a significant relationship between the stage and discharge data.

2.4.5 Permanent Channel Cross-Sections

As part of the channel morphology characterization portion of the study, COG staff established permanent channel cross-section stations at the following three locations: Upper (X-3), Middle (X-7), Lower (X-9) reaches. To permanently mark each preceding station location, a 0.5 inch diameter rebar was driven into the top of each bank (left side looking downstream), latitude and longitude coordinates were acquired using the Trimble Geo-XT satellite receiver and photographs were taken to provide additional cross-reference information for future follow-up channel measurements. Cross-sectional elevational differences were then recorded, at one-foot intervals, via an 11 foot-long fiberglass surveyor's rod with a leveler attached and the LEICA Total Station model number TCR110. Channel measurements were made to the nearest 100th of an inch. Permanent channel cross-sections are included in Appendix 2 of the report.

2.4.6 Pebble Count

A modified Wolman (1954) pebble count was performed at representative stream locations within all three Upper, Middle and Lower reaches. At each site, 100 particles total were counted along a tape measure, 100 foot-long longitudinal transect. At three-foot intervals along the tape line, three to four particles were measured across the entire 'wetted perimeter' width of the channel. The intermediate axis of each randomly chosen particle was measured to the nearest millimeter (mm) and recorded. For each preceding site, representative riffle, run and pool habitat types were sampled on a proportional basis. Pebble count data were summed for each location to obtain D-15, D-34, D-50 and D-84 particle size distributions.

2.4.7 Rosgen Level I and II – Steam Channel Morphological Description

The Fort Chaplin stream channel types were classified using the both the Level I Rosgen Stream Channel Classification Method. In addition, a Level II morphological assessment was performed at the following representative stream locations: Upper (X-3), Middle (X-7), Lower (X-9) reaches. Measurements to characterize Level I (e.g., Stream Type B, moderately entrenched, moderate gradient, riffle dominated channel with stable banks, width/depth ratio > 1.2, etc.) and Level II (e.g., bankfull width, mean depth, bankfull cross-section area, width/depth ratio, maximum depth of the bankfull cross-section, width of flood prone area, entrenchment ratio, water surface slope, etc.) conditions were performed employing the LEICA Total Station model number TCR110. For further Rosgen Level I and II method descriptions, the reader is referred to "*Applied Stream Morphology*" (Rosgen, 1996).

2.4.8 2002 Summer Thermal Regime Characterization

Characterization of the "summer" thermal regime within key representative portions of Fort Chaplin was accomplished via the systematic employment of HOBO® temperature probes. The two temperature monitoring station network employed in the study included the following stream sites keyed to RSAT transect locations: Upper reach (X-1 area) and Lower reach (X-9 area).

At each station, the temperature probe was placed into a waterproof HOBO® clear submersible plastic case and submerged in pools approximately 12 inches deep. The units were carefully cabled

to trees in the overbank area so as to reduce the risk of damage or loss from flooding. Both units were located in well-shaded areas of the stream where the depth of flow was sufficient to keep the unit completely submerged. HOBO® temperature probes were deployed from June 26, 2003 to August 6, 2003 and programmed to record water temperature every 15 minutes. Data were downloaded into a personal laptop computer and statistically analyzed using Microsoft Excel 2003. Climatological information used during the study period was obtained from NWS (2003) for Washington Reagan National Airport.

2.5 Biological Monitoring

2.5.1 RSAT Macroinvertebrate Voucher Sample

RSAT Level III surveys of Fort Chaplin were conducted on February 19-20, 2004. In addition, on May 20, 2004, the following two RSAT categories; Riparian Habitat Conditions and Biological Indicators were completed. For each RSAT riffle transect area, taxa were collected from representative riffle, run and pool habitat via the previously stated two one-square foot kick and two one-square foot jab protocol. A D-frame net with a 600-micron mesh was used to collect macroinvertebrates. In addition, macroinvertebrates were collected at each transect from the bottom side of 10 cobble-sized stones and included in the voucher collection.

2.5.2 Spring and Fall 2002 20-Jab Macroinvertebrate Sampling

Included as part of the RSAT Level III evaluation were spring and fall 2002, and spring 2003; 20-jab macroinvertebrate sampling of the following Fort Chaplin transect sites: Upper (X-1 area), and Lower reaches (X-9 area). Fall 2002 samples were collected on December 12th. Spring samples were collected were collected on March 25, 2002 and May 11, 2003. In addition, for comparison purposes, 20-jab collections were also performed for the Fort Dupont Tributary system (i.e., middle mainstem and lower Tributary 2 areas). The 20-jab collection is a quantitative survey that combines samples from multiple, representative habitats (i.e., riffles, runs, and pools). The total survey area encompassed an approximately 2m^2 area of the streambed. Organisms were collected from representative habitat areas such as riffles, runs and pools using a 600-micron mesh D-frame net and field sorted using a 60-minute long sorting or a 200 organisms collected limit.

2.5.3 Taxonomy

RSAT voucher samples were identified in the field to the family level and preserved for laboratory identification to the lowest possible level via the following taxonomic references: Harper and Hynes, 1971; Merritt and Cummins, 1996; Pennak, 1989; Stewart and Stark, 1993; and Wiggins, 1998. All preserved organisms collected via the 20-jab surveys were counted and identified by COG staff to the lowest possible taxonomic level. For aquatic insects, identification was, with few exceptions, to the genus level.

2.5.4 Macroinvertebrate Biosurvey Scoring

RSAT biosurvey scoring is based on the taxa observed and collected in the field as well as from the voucher collection for the entire survey reach. The 20-jab scoring is based on the seven

metrics currently employed by the Maryland Biological Stream Survey (Stribling et al., 1998) for Coastal Plain streams (i.e., taxa richness, total EPT taxa, percent Ephemeroptera, percent Tanytarsini, Beck's Biotic Index, number of scraper taxa, and percent clingers). It should be noted that the MBSS used these metrics to develop the Maryland Index of Biological Integrity (IBI) for Coastal Plain streams. This IBI was employed for the Fort Chaplin biosurvey scoring.

2.5.5 One-Pass Electrofishing Survey

COG staff performed a single day May 2004 single pass or "sweep pass" electrofishing survey of Fort Chaplin. The purpose of the survey was to determine the existing Fort Chaplin resident fish population and distribution. A Smith-Root Model XII backpack eletrofisher with two people netting was employed. The survey, which started from the 'C' Street 48" RCP, was a complete sweep of all representative habitat types (i.e., riffles, runs and pools) in a continuous 1,100 foot stream reach (approximately 0.2 miles). It should be noted that the electrofishing effort concentrated sampling in pool habitats.

3.0 Results

3.1 Stream Channel Erosion

3.1.1 Background

Under the RSAT system, the following channel morphology-related data were collected at each riffle transect: top channel width, bottom channel width, average right and left bank height, general right and left bank material type and right and left bank stability. In addition, between each transect station, COG staff noted and recorded both the general level of bank stability in the channel network and the presence of recent tree falls, exposed sewer lines, perched road culverts or other tell-tale signs of lateral stream channel erosion and degradation. Bank stability conditions between transect stations were visually rated and placed into one of the following six categories:

1) Stable - Over 90 percent of bank network is stable, with no signs of major lateral bank erosion problems present;
2) Slight - 81 to 90 percent of bank network is stable and signs of major lateral bank erosion problems are rarely observed;
3) Slight/Moderate - 71 to 80 percent of bank network is stable and signs of major lateral bank erosion problems are uncommon to common;
4) Moderate – 61 to 70 percent of bank network is stable and signs of lateral bank erosion problems are common;
5) Moderate/Severe – 50 to 60 percent of bank network is stable and signs of lateral bank erosion problems are very common;
6) Severe – Less than 50 percent of bank network is stable and major portions of banks are unraveling.

To accurately document these streambank channel conditions, COG staff employed the

Trimble GEO-XT GPS receiver to register and georeference linear streambank distances that exhibited the preceding characteristics. As a result, COG staff categorized a total of 3,801.6 (i.e., 1,900.8 feet for each right and left streambank length) feet of the streambank network. In addition, photographic documentation of these conditions were captured and logged on field survey forms.

As the stream channel was walked, particularly close attention was paid to evidence of major channel downcutting or degradation. Again, average bank heights provided a good indication. For example, bank heights averaging four feet suggest that downcutting on the order of one to three feet has probably occurred. Other reliable indicators included the presence of nickpoints and exposed sewer lines crossing the stream, and undercut and/or collapsed concrete road culverts. A comparison of representative riffle transect stream channel cross-sections for Fort Chaplin, is presented in Figure 6. General stream channel erosion-related indicators are summarized in Figure 8. The approximate locations of severe, moderate/severe and moderate streambank erosion areas are depicted in Figure 9. Summary stream channel erosion-related information has also been included as Table 4 and 5.

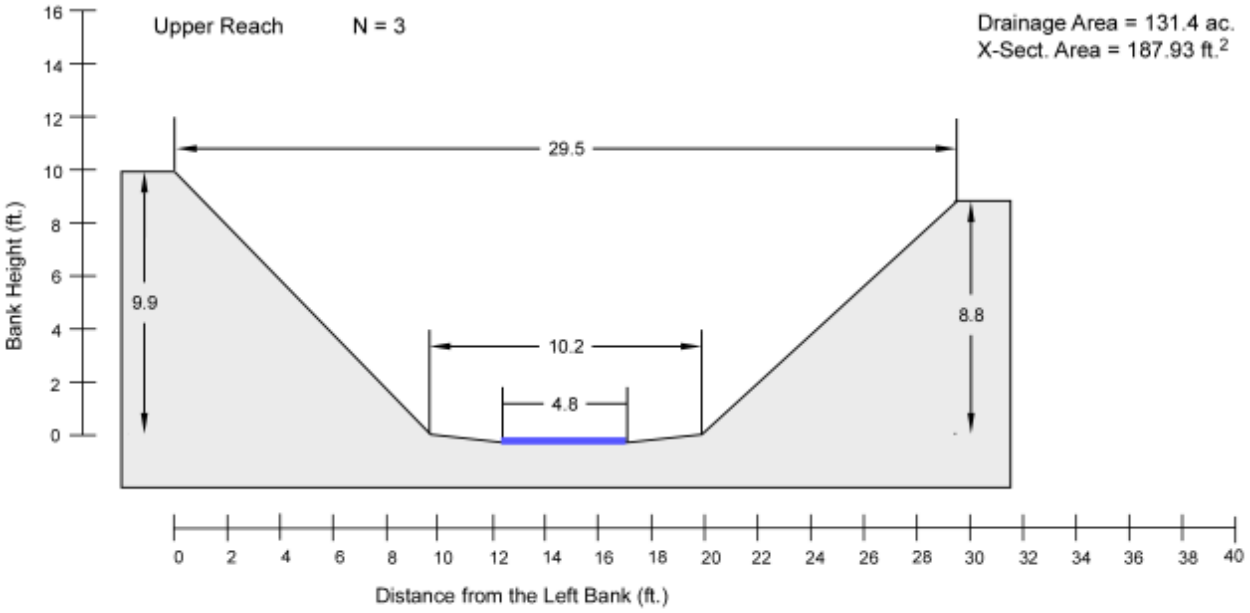
3.1.2 General Findings

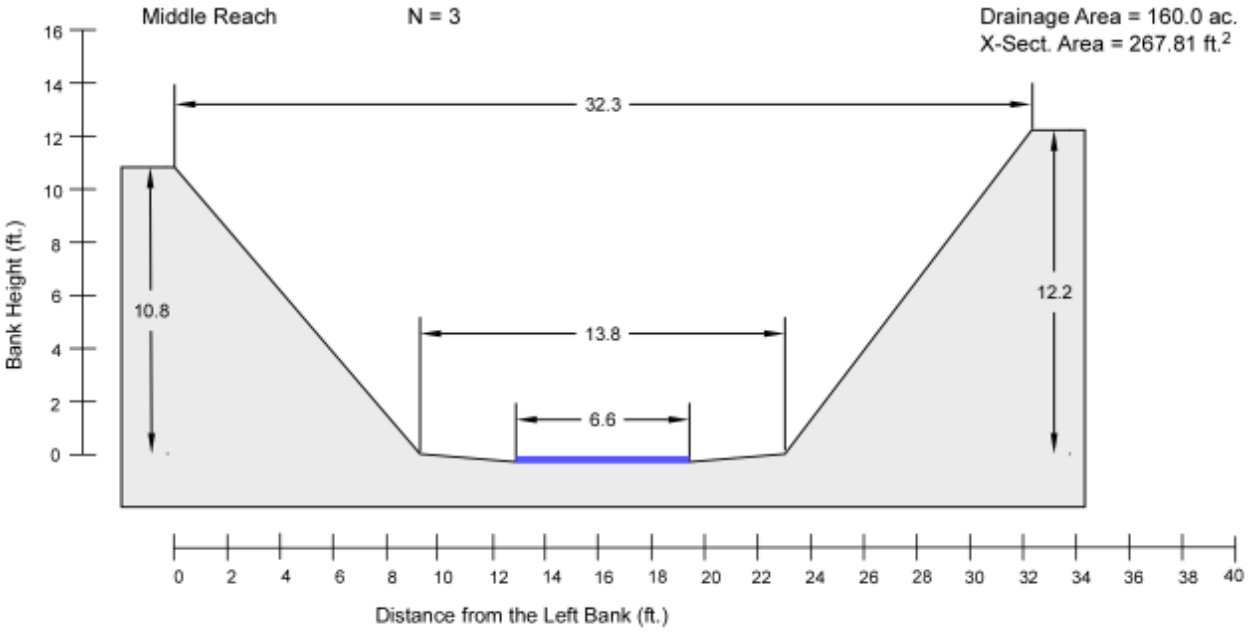
The Fort Chaplin streambank network appears to be actively eroding in its remaining open channel sections. Results from the channel stability portion of the study revealed that out of a total of 3,801.6 feet of RSAT-surveyed streambank network length (i.e., total length for both right and left bank areas combined), 690 linear feet, representing approximately 18.2 percent is experiencing severe erosion. Approximately 1,057 linear feet (27.8 percent) exhibited moderate/severe streambank erosion conditions. An additional 448 linear feet (11.2 percent) exhibited moderate bank erosion conditions (Figure 5). Stream areas experiencing moderate, moderate/severe or severe streambank erosion conditions were observed in both straight and meandering sections. As illustrated by Figure 5, these sections were frequently associated with recent tree falls lying across the stream channel. Cross-sectional analysis results (Figure 6) indicated that the mean cross-sectional area of both the Upper (187.9 ft^2) and Lower (178.3 ft^2) reaches are similar in area; whereas, the wider and more entrenched Middle reach cross-sectional area (267.81 ft^2) is approximately forty percent greater.

Figure 5 - Upper reach - Severe Streambank Erosion

Based on previous COG staff surveys of comparably-sized Coastal Plain and Piedmont streams in the Washington metropolitan area, the generally expected Fort Chaplin bank height and channel width ranges are on the order of one to three feet and 10 to 12 feet, respectively (Galli et al., 1999; Trieu et al., 1998; Galli et al., 1996b; Corish et al., 1996; Galli and Trieu, 1994). The

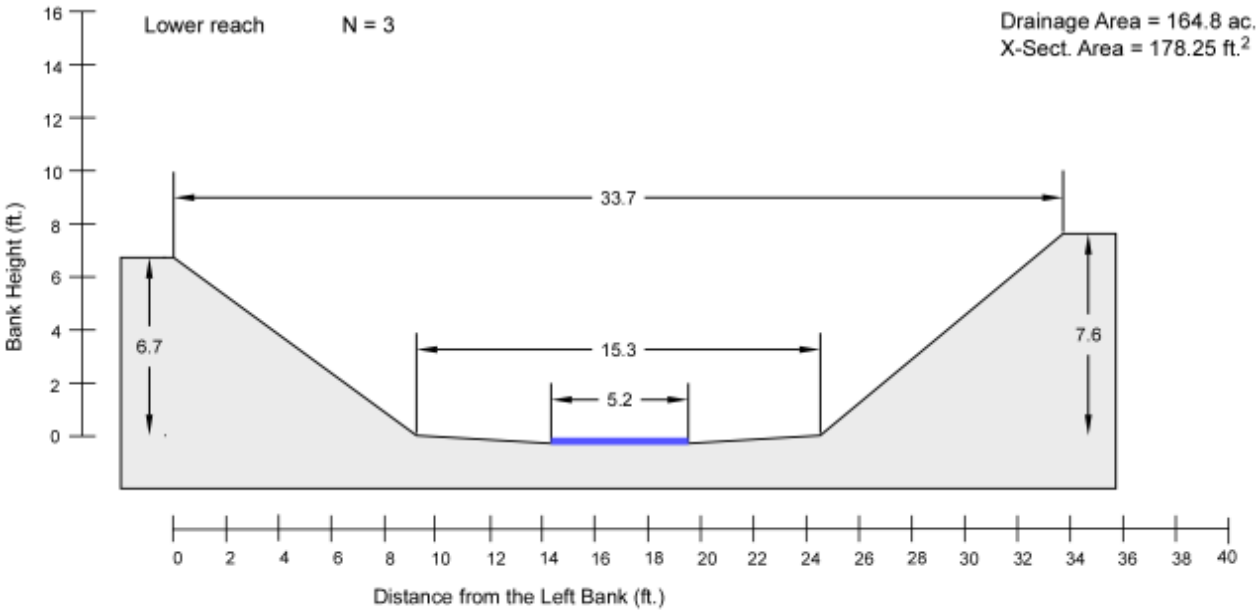
Figure 6 - Representative Channel Cross-Sections [1]

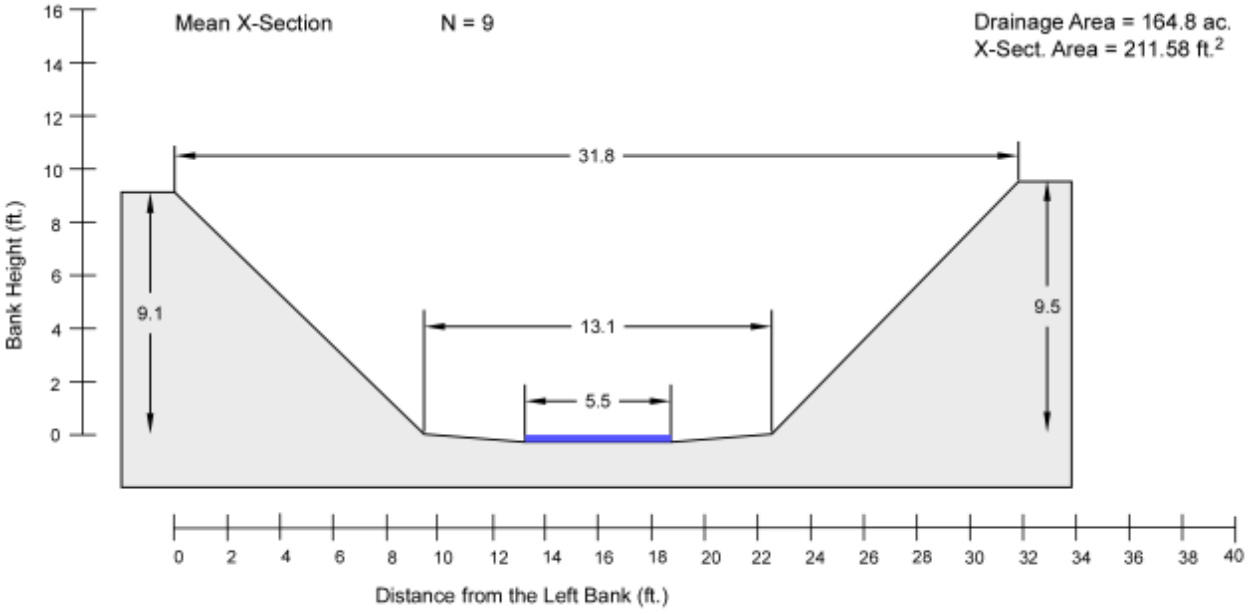




[1] Top channel width, bottom channel width and wetted perimeter area (heavy black line) depicted.

Figure 6 - Continued [1]





[1] Top channel width, bottom channel width and wetted perimeter area (heavy black line) depicted.

preceding results confirm that decades of uncontrolled stormwater runoff, beginning downstream of Texas Avenue (Figure 7) and extending all the way downstream to the piped entrance at 'C' Street has produced a Fort Chaplin stream channel, which is with respect to forested, reference stream conditions, markedly wider and more incised.

Figure 7 - Lower Reach ('C' Street Area) - Severe Channel Erosion

Additional stream channel stability results (Figures 8 and 10 and Table 4) revealed that the Middle reach had the highest amount of severe streambank erosion, totaling 313 feet. This total represents approximately 8.2 percent of the streambank network length (i.e., 3,801. 6 feet for both right and left streambank lengths). Moderate/severe and moderate streambank erosion conditions totalling 545 and 352 feet, respectively, were observed in the Lower reach. The highest severe and moderate/severe streambank erosion condition rates were observed in both the Middle and Lower reaches (i.e., 1,566.6 lf/mi and 2,269.0 lf/mi, respectively). Severe streambank erosion in the Upper reach totalled 98 feet, representing approximately 6.5 percent of the reach's streambank network.

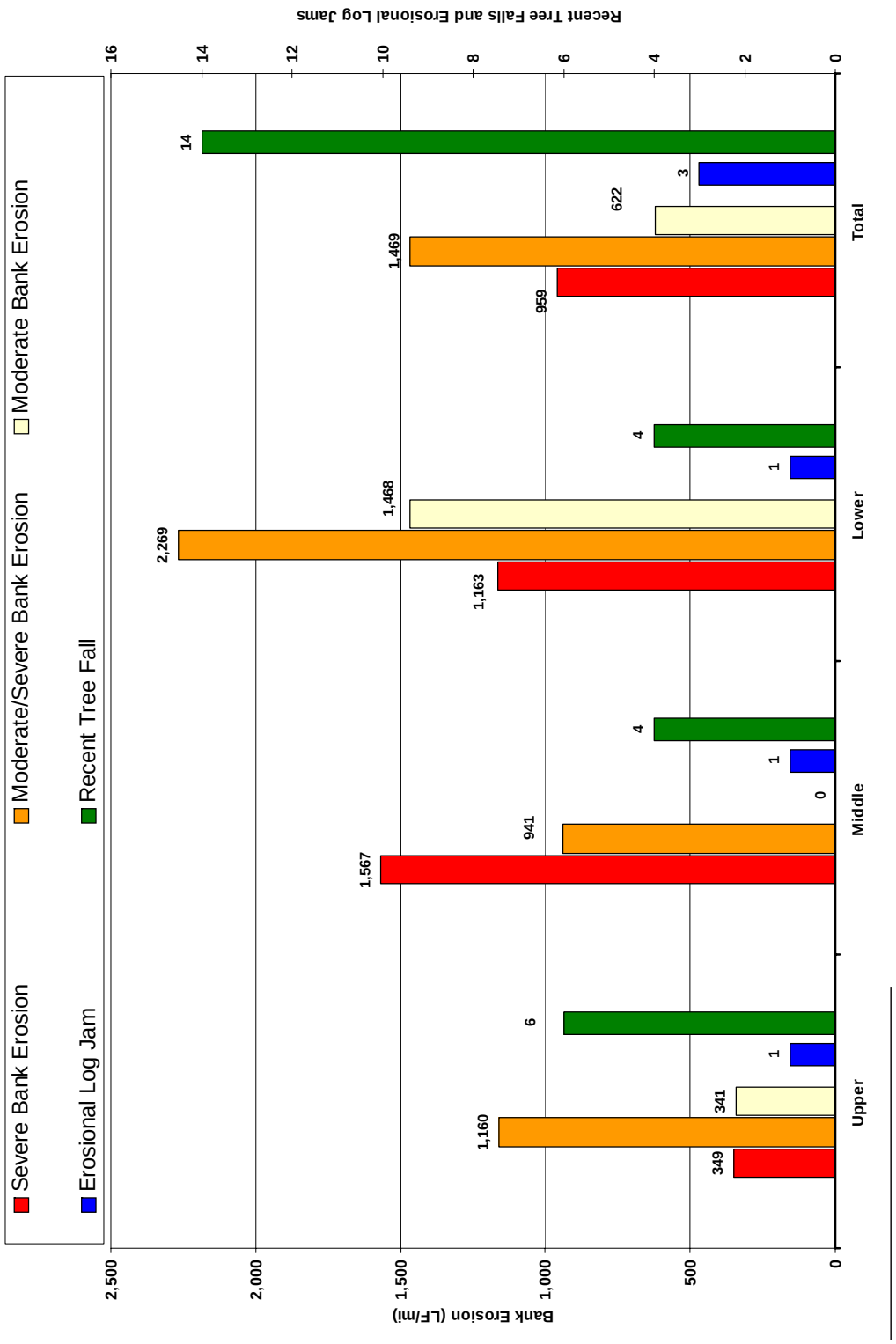
The total number of recent tree falls observed in the entire stream channel survey length (i.e., 1900.8 feet) was 14 (i.e., 38.5 tree falls/mile). Both the number of tree falls and associated rate were extremely high.

In summary, Fort Chaplin moderate, moderate/severe and severe streambank erosion conditions totaled 448, 1,057 and 690 linear feet, respectively (Figure 9 and Table 4). This total represents approximately 57.7 percent of the entire Fort Chaplin streambank network length (i.e., 3,801. 6 feet for both left and right streambank lengths). As previously mentioned, the total number of recent tree falls observed was 14 and the associated rate per mile was 38.5. A total of three erosional log jams were also recorded. The preceding results indicate that the majority of the Fort Chaplin open stream channel is actively eroding.

3.1.3 Streambank Stability and Relative Erodibility

Overall, mean bank stability for Fort Chaplin (59 percent) was rated as fair. Mean bank stability for the RSAT reaches ranged from 53 (Upper reach) to 65 (Lower reach) percent placing it in the fair range (i.e., 50 to 70 percent). Based on soil textural survey results (Figure 10), relative streambank soil erodibility was rated as follows: 1) low/moderate in the Upper reach, 3) low/moderate in the Middle reach, and 3) moderate/high in the Lower reach. It is important to note that clay textured soils were frequently the major component within the streambank areas of the Upper and Middle reaches. Whereas, silt was the primary streambank soil texture in the Lower reach.

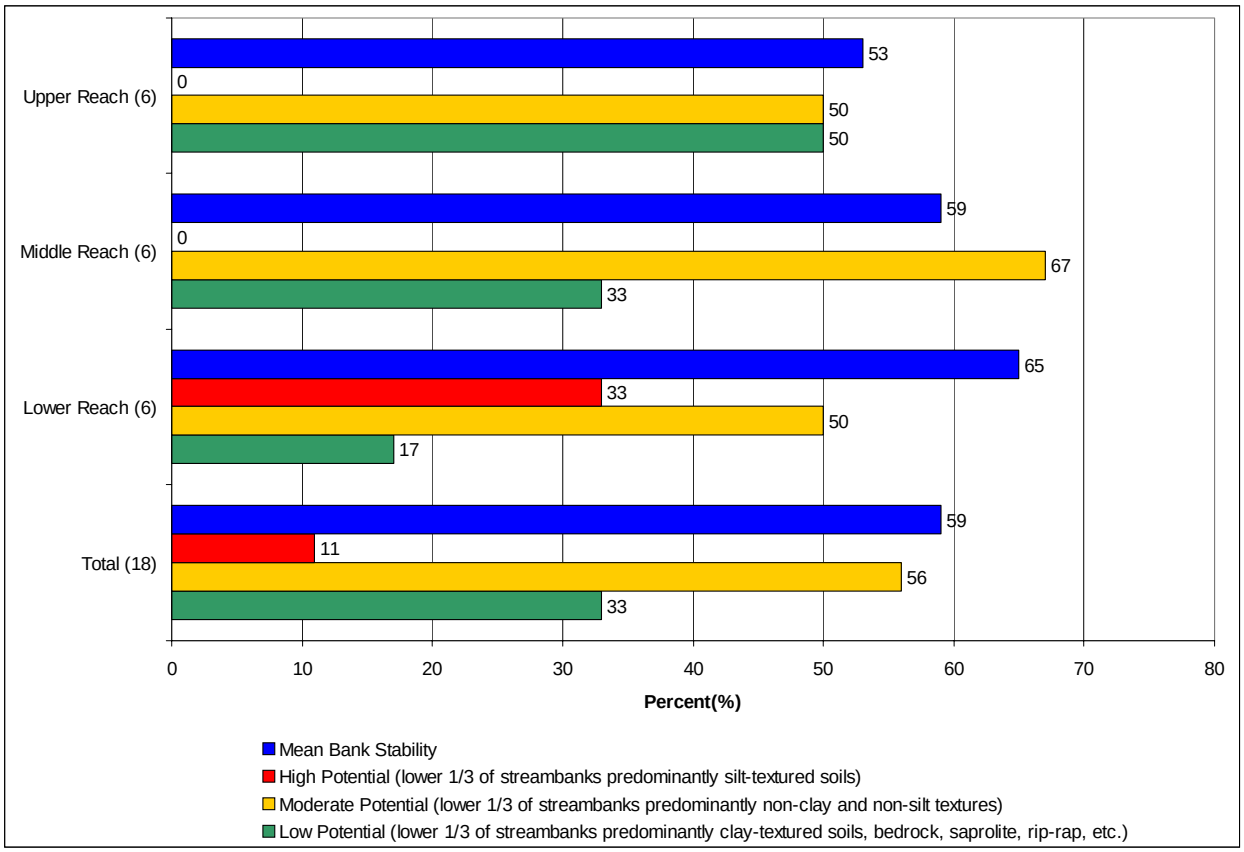
Figure 8 - Fort Chaplin Tributary Stream Channel Erosion-Related Conditions[1]



[1] Actual numbers appear above each bar for recent tree falls and erosional log jams. lf/mi. rate shown above each bar for severe severe/moderate and moderate streambank erosion.

Figure 9 - Fort Chaplin - Moderate, Moderate/Severe and Severe Streambank Erosion Areas

Figure 10 - Summary - Fort Chaplin Mean Streambank Stability[1] and Relative Erodibility (%)[2]



[1] Mean bank stability interpretation: >80% = Excellent, 71-80% = Good, 50-70% = Fair, <50% = Poor
[2] Total number of observations to determine average bank stability and relative erodibility appear in parentheses

Table 4 - Summary: Fort Chaplin - Streambank Erosion Conditions

RSAT Stream Segment	Segment Length (mi.)	Streambank Network Segment Length (mi.)	Bank Erosion Conditions						No. of Recent Tree Falls [1]		No. of Erosional Log Jams	Mean Bank Stability [2] (%)
			Severe		Mod/Severe		Moderate		No.	No./mi		
			(LF)	(LF/mi.)	(LF)	(LF/mi.)	(LF)	(LF/mi.)				
Upper	0.14	0.28	98	349.1	325	1,159.6	96	341.1	6	42.8	1	65
Middle	0.10	0.20	313	1,566.6	188	940.9	0	0.0	4	40.0	1	59
Lower	0.12	0.24	279	1,162.8	545	2,269.0	352	1,468.1	4	33.3	1	53
Total	0.36	0.72	690	958.5	1,057	1,468.7	448	622.0	14	38.5	3	59[3]

Note: Streambank network segment length is the total distance of both the surveyed right and left streambank lengths. Bank erosion condition rate is per the streambank network segment length, whereas the rate for number of recent tree falls is per segment length.

[1] Tree fall interpretation: 0-1/mi. = Excellent, 2-3/mi. = Good, 4-5/mi. = Fair, ≥6 = Poor.
[2] Bank stability interpretation: >80% = Excellent, 71-80% = Good, 50-70% = Fair, <50% = Poor.
[3] Weighted Mean.

3.1.4 Major Stream Channel Downcutting

As seen in Table 5, mean bank height for the entire length of Fort Chaplin was 9.3 feet, which is approximately six feet higher than the expected streambank height (i.e., 2-3 feet). As expected, mean bank heights for the reaches exceeded the expected streambank height on the order of eight feet (Middle reach). Also as seen in Table 5, one nick point, and two exposed utility lines were observed within the stream channel network. The nick point, which appeared to be actively eroding in the Middle reach, is the result of a recently created large woody debris dam. The exposed utility lines that cross the stream are located in the Upper and the Middle reaches. Although the Upper reach utility pipe appears to be abandoned, the Middle reach utility line appears to be an active, 10" diameter ductile iron pipe (DIP). Figure 11 illustrates the high stream downcutting rate during a five month period (i.e., May to October 2004). The location of this Middle reach utility line is immediately upstream of both the east and west 'D' Street storm drain system outfalls.

Table 5 - Summary: Fort Chaplin - Stream Channel Downcutting

RSAT Stream Segment	Drainage Area (ac)	Segment Length (ft)	Mean Bank Height Right [1] (ft)	Mean Bank Height Left [2] (ft)	Mean Bank Height (ft)	Expected Bank Height Range (ft)	Number of Nick Points	Number of Exposed Sewer Lines Within The Stream Channel
Upper	18.4	739.2	8.8	9.9	9.4	2-3	--	1
Middle	28.6	528.0	12.2	10.8	11.5	2-3	1	1
Lower	4.8	633.6	7.6	6.7	7.2	2-3	--	0
Total	51.8	1900.8	9.5[3]	9.1[3]	9.3[3]	2-3	1	2

Figure 11 - A. Middle Reach - Exposed Three Foot Long 10" DIP Section, May 2004; B. Middle Reach - Exposed Eight Foot Long 10" DIP, October 2004

[1] Right bank looking downstream.
[2] Left bank looking downstream.
[3] Weighted mean.

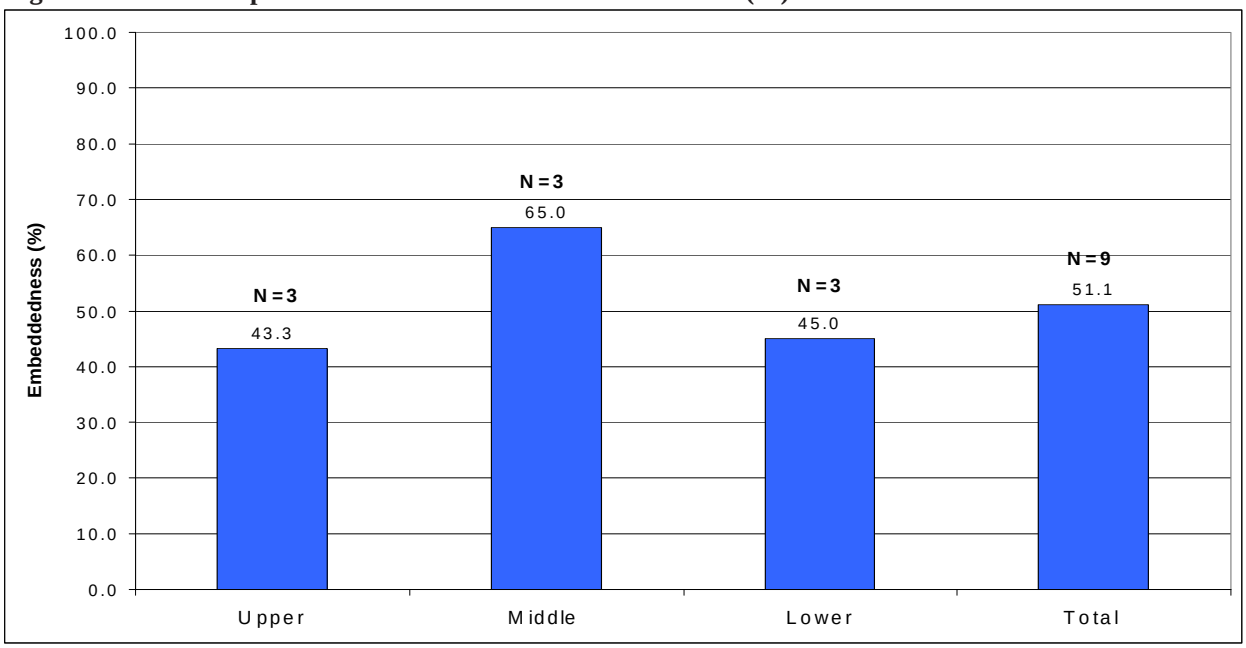
3.1.5 Channel Scouring and Sediment Deposition

Overall, the channel scouring and sediment deposition condition was rated as fair. There were a total of 24 observed large point bars and of that total, five (21 percent) were categorized as being unstable. As seen in Table 6, both the Middle and the Lower reaches recorded the highest total number of unstable point bars at two and two, respectively. The rate of unstable point bars generally increased in a downstream fashion (Table 6). In addition, overall mean riffle embeddedness (an additional measure of sediment deposition conditions) for Fort Chaplin, at 51.1 percent, was rated as being fair. Specifically, both the Upper and Lower reaches were rated as being good; whereas, the Middle reach was rated as fair (Figure 12). It should also be noted that at transect X-9, the highest embeddedness value (100 percent) together with the largest unstable point bar was recorded. Transect X-9 is located immediately upstream of the 'C' Street 48" RCP culvert.

Table 6 - Summary: Fort Chaplin - Channel Scouring/Sediment Deposition Conditions

RSAT Stream Segment	Segment Length		Percent Riffle Embeddedness			Large Point Bars			Relative Level of In-Channel Sand Deposits
	(ft)	(Mi)	Observed Range	Mean	Total Number Observed	No. Unstable	Percent Unstable (%)	No. of Unstable/Mi.	
Upper	739.2	0.14	20-60	43.3	18	1	25	7.14	Low
Middle	528.0	0.10	50-70	65.0	9	2	20	20.0	Low-Moderate
Lower	633.6	0.12	15-100	45.0	7	2	20	16.7	Low-Moderate
Total	1,900.8	0.36	15-100	51.1	34	5	21	13.9	Low-Moderate

Figure 12 - Fort Chaplin - Mean Riffle Embeddedness Levels[1] (%)



[1] General Embeddedness Interpretation 0-24% = Excellent, 25-50% = Good; 51-75% = Fair; >76% = Poor.

Figure 13 - Lower Reach - High In-Channel Sand Deposition at Transect X-9

In summary, the general low to moderate levels of in-channel sand deposition suggests that the transport of sand and other small diameter materials is very efficient within Fort Chaplin. However, during the study, high in-channel sand deposition was observed in a 70 foot-long channel section downstream of transect X-9 (Figure 13). Apparently, the level of sand deposition in the Lower reach is dependent on the relative amount of trash/debris that has accumulated on the trash rack at the opening of the 'C' Street 48" RCP. It should be noted that the DC Department of Public Works (during the spring and summer seasons) removes the trash and debris from this rack at least once a week. However, when high levels of trash/debris accumulate on the rack, a large backwater area extending approximately 70 to 100 feet upstream is created, thereby trapping large quantities of sand and silt.

3.2 Physical Aquatic Habitat

General physical aquatic habitat conditions for Fort Chaplin are summarized in Table 7 and Figures 14 and 15. As seen in Table 7, the overall habitat score fell in the fair range. Major contributing factors for the fair ratings included sub-optimal riffle substrate quality, shallow depth of flow in riffle areas and the predominant presence of unstable finer material (i.e., sand and silt) in the pools.

As seen in Figure 14, the overall the riffle substrate quality was rated as poor, whereas the pool quality was rated fair. With the exception of the Upper reach, the riffle substrate quality and the pool quality were rated poor. However, it should be noted that the pools in the Upper reach were rated excellent; being uncharacteristically deep and featuring good to excellent overhead cover for fish.

Pebble count results (Figure 15) indicated that the Fort Chaplin median (i.e., D-50) particle size is medium to coarse gravel (i.e., 8.00-31.99 mm). In addition, the D-84 sized particle in all three surveyed reaches was very coarse gravel (i.e., 32.00 – 63.99 mm). The preceding findings confirm that the Fort Chaplin streambed is made up of predominantly gravel-sized material. Typically, gravel-sized materials with small diameters and round shapes, such as those recorded in Fort Chaplin, are inherently unstable and prone to rolling during stormflows.

Table 7 - Summary: Fort Chaplin - General Physical Aquatic Habitat Conditions [1]

RSAT Stream Segment	Riffle Characteristics:				Pool Characteristics:					Fish Barriers		RSAT Physical Habitat Score (pts.)[6]
	No. of Riffles	Mean Riffle Depth (in.)	Mean Riffle Substrate Quality (pts.)[2]	Mean Riffle Embedd-edness (%)[3]	No. of Pools	Mean Max. Depth (in.)	Mean Pool Quality (pts.)[4]	Number of Quality Pools	Riffle/Pool Ratio[5]	Total No.	Per mile	
Upper	18	1.3	2.0	43.3	5	19.7	3.3	4	3.60	0	0.0	--
Middle	9	0.9	1.7	65.0	6	14.7	1.7	1	1.50	0	0.0	--
Lower	7	1.7	1.7	45.0	7	11.0	1.7	3	1.00	1	8.3	--
Total	34	1.3	1.8	51.1	18	15.1	2.2	8	1.88	1	1.8	4

[1] Mean values shown are weighted means.
[2] Riffle substrate quality rating scale: 3.25 - 4.00 = Excellent, 2.50 - 3.24 = Good, 1.75 - 2.49 = Fair, 1.00- 1.74 = Poor.
[3] Riffle embeddedness rating scale: <25% = Excellent, 25-50% = Good, 51-75% = Fair, >75% = Poor.
[4] Quality pool point scale interpretation: 5 = Excellent, 4 = Very Good, 3 = Good, 2 = Fair, 1 = Poor.
[5] Riffle/pool ratio rating scale: 0.9 - 1.1:1 = Excellent, 0.70 - 0.89:1 or 1.11 - 1.3:1 = Good, 0.5 - 0.69 or 1.31 - 1.5:1 = Fair, 0.49:1≤ or ≥1.51:1 = Poor.
[6] Physical habitat rating scale:7 - 8 = Excellent, 5 - 6 = Good, 3 - 4 = Fair, 0 - 2 = Poor.

Figure 14 - Fort Chaplin Mean Riffle Substrate[1] and Pool Quality[2] Scores

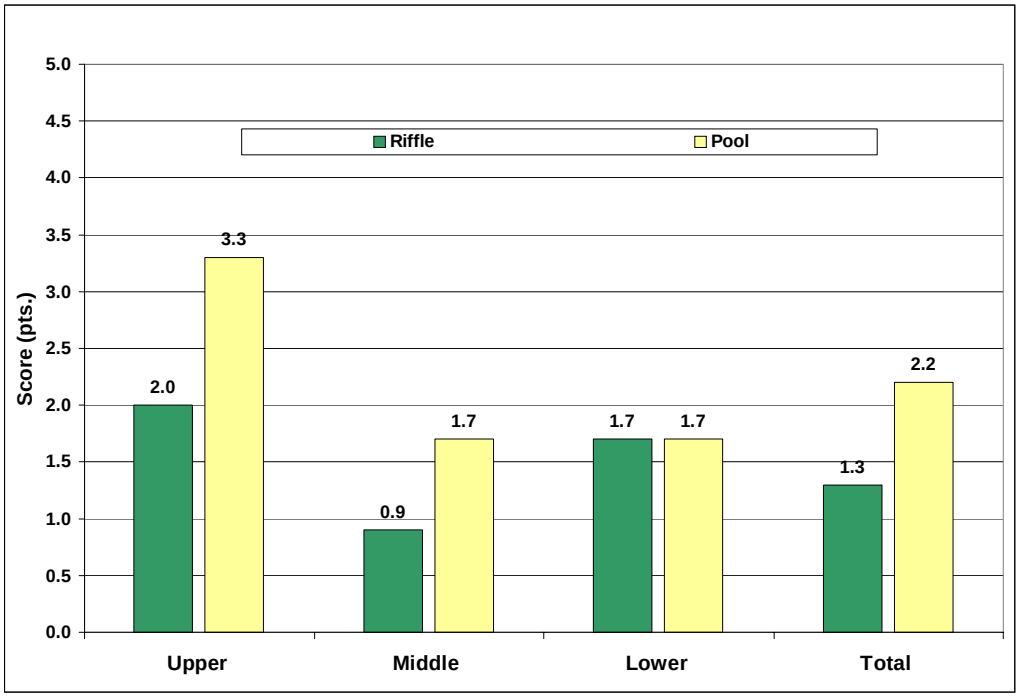
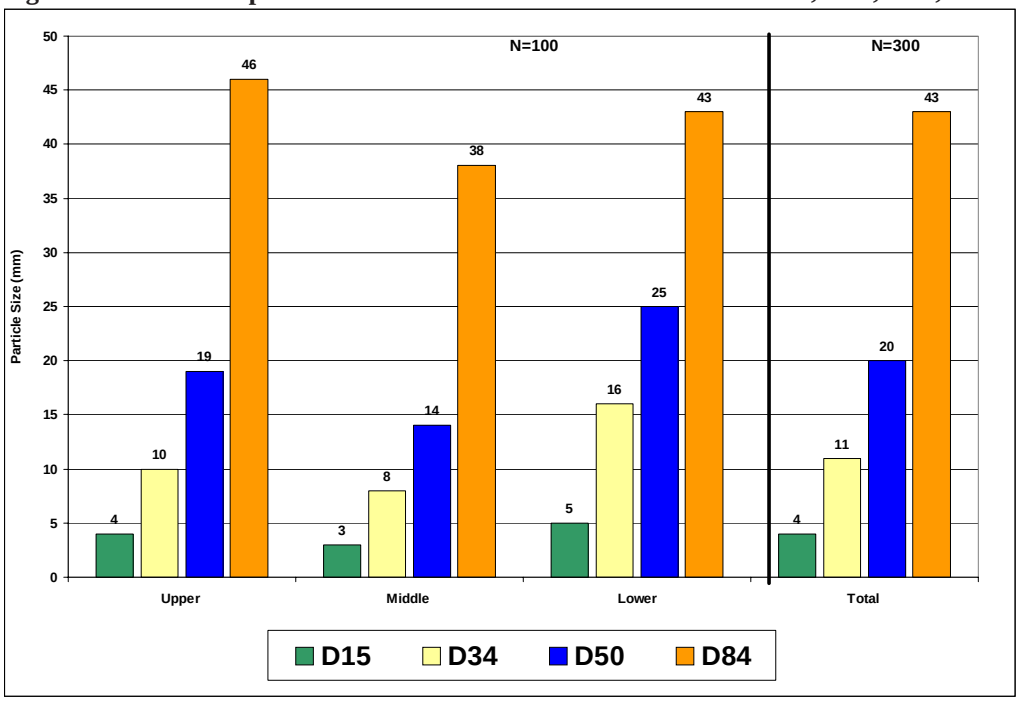


Figure 15 - Fort Chaplin - Substrate Particle Size Distribution[3] - D15, D34, D50, and D84



[1] Riffle substrate quality point scale interpretation: 3.25-4.00 = Excellent, 2.50-3.24 = Good, 1.75-2.49 = Fair, 1.00-1.74 = Poor.
[2] Pool quality point interpretation: 4.5-5.0 = Excellent, 4.0-4.4 = Very Good, 3.0-3.9 = Good, 2.0-2.9 = Fair, 1.0-1.9 = Poor.
[3]

Substrate Class (AGI, 1982)	Very Fine Sand	Coarse Sand	Very Coarse Sand	Very Fine Gravel	Medium Gravel	Coarse Gravel	Very Coarse Gravel	Small Cobble	Large Cobble	Boulder	Bedrock
Size Range (mm)	0.06 – 0.13	1.00 – 1.31	1.01– 1.99	2.00 – 7.99	8.00 – 15.99	16.00 – 31.99	32.00 – 63.99	64.00 – 127.99	128.00 – 255.99	256.00 – 4095.99	>= 4096.00

3.2.1 Fish Blockages

Only one fish blockage was identified during the RSAT survey and was classified by COG staff as being a complete barrier. The structure is described as a 5,000 foot (0.95 miles) long piped stream section that extends from the 'C' Street 48" RCP opening to the east bank sea wall of the Anacostia River. As previously stated, this piped section precludes any normal movement of fish between the river and Fort Chaplin. A brief description of the blockage is provided in Table 8 and its general location is shown in Figure 16.

Table 8 - Summary: Fort Chaplin Tributary - Existing Fish Blockage

RSAT Stream Segment	Fish Blockage Type[1]	Blockage Height (ft)	Description	Location					
				Latitude			Longitude		
				Deg.	Min.	Sec.	Deg.	Min.	Sec.
Lower	Complete	---	~5,000 foot long piped stream section below 'C' Street	76	56	43.81	38	53	11.03

3.3 RSAT Water Quality

As part of the RSAT survey, baseflow grab sampling was conducted for both the Upper and Lower reaches to provide a snap-shot of water quality conditions in the Fort Chaplin stream. Generally, the following 13 parameters were measured: air temperature, water temperature, dissolved oxygen (DO), pH, conductivity, turbidity, total dissolved solids (TDS), water color and odor, substrate fouling, nitrate-nitrogen (NO_3^-), orthophosphate and fluoride (F^-). Of the preceding 13 water quality parameters, TDS, nitrate and substrate fouling were selected for stream reach comparisons. Results are summarized in Figure 17 and Appendix 5.

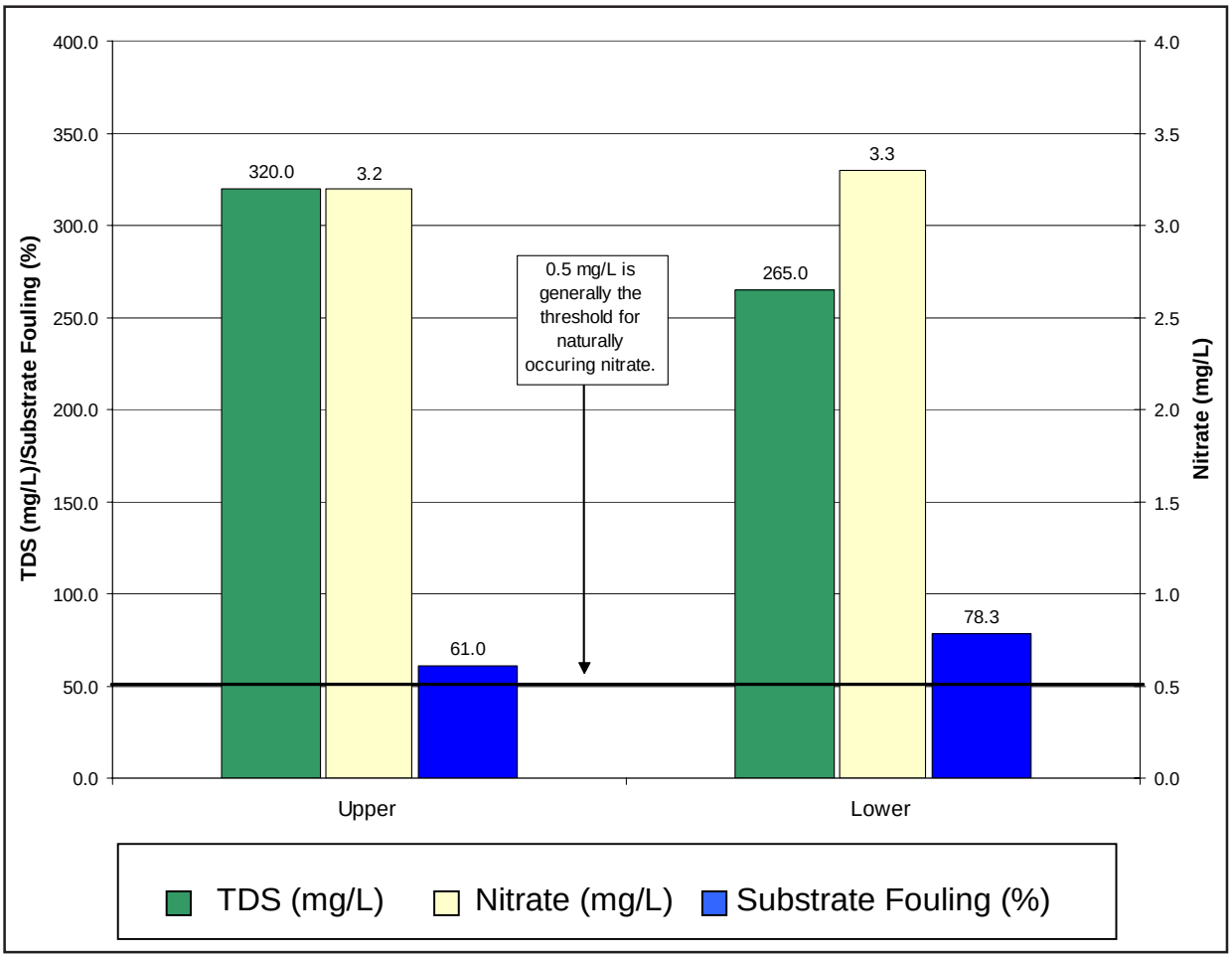
As seen in Figure 17, mean TDS levels in both stream reaches surveyed were in the poor range (i.e., >=150 mg/l). Mean TDS levels decreased in a downstream fashion. It should be noted that one high TDS instantaneous reading of > 600 mg/l was recorded during the RSAT survey. This high February, 2004 reading was associated with snow melt runoff after an application of road salt.

With regard to nitrate levels, the instantaneous nitrate measurements ranged from 1.1 to 4.4 mg/l placing it in the moderate to high range (i.e., 1.1 - >3.0 mg/l). The mean nitrate levels for the Upper and Lower reaches (i.e., 3.2 and 3.3 mg/l, respectively) were in the high range (i.e., > 3.0 mg/l) indicating increasing levels in a downstream direction. In addition, substrate fouling levels were rated as being in the poor range in all stream reaches (i.e., > 50 percent of the bottom side of cobble-sized stones were covered by an organic film). As seen in Figure 17, mean substrate fouling levels for both reaches were comparable and ranged from 61.0 percent (Upper) to 78.3 percent (Lower). It should be noted that the substrate fouling range was 20 to 80 percent in the Middle reach. The overall Fort Chaplin mean substrate fouling level was 55 percent (poor range).

[1] A complete barrier is described as an obstructions which totally prevent the normal movement of fish throughout the year (e.g., a 5,000 foot long piped stream section).

Figure 16 - Fort Chaplin Tributary - Fish Blockage

Figure 17 - Fort Chaplin - Mean TDS[1], Substrate Fouling[2] and Nitrate[3]



[1] TDS interpretation: <50 mg/L = Excellent, 50-100 mg/L = Good, 101-150 mg/L = Fair, >150 mg/L = Poor.
[2] Substrate fouling interpretation: 0-10% = Excellent, 11-20% = Good, 21-50% = Fair, >50% = Poor.
[3] Nitrate interpretation: 0.0-1.0 mg/L= Low, 1.1-2.9 mg/L = Moderate, >3.0 mg/L = High.

The preceding results suggest high levels of organic loading/nutrient enrichment throughout Fort Chaplin. It should also be noted that spot fluoride readings revealed that both the Upper and Lower Reaches periodically exceeded 0.3 mg/l (Appendix 5, Table 3). The highest fluoride reading (1.02 mg/l) occurred on July 24, 2002 in the Upper reach. Typically, natural background levels for fluoride in local surface waters are approximately 0.1 – 0.2 mg/l or less (Hannon, 1996; Thomas, 1966; Woll 1978; Otten and Hilleary, 1985), whereas concentrations of 0.3 mg/l or greater suggest the possible influence of either treated drinking water[9] or sewage.

3.4 Riparian Habitat Conditions

As previously mentioned, forests within the Fort Chaplin subwatershed cover approximately 20.3 percent of the watershed and the majority of this land cover type is located within the Fort Circle hiker/biker park system. Similarly, the entire Fort Chaplin stream channel is also located within this wooded park system. Consequently, with wide buffer widths (i.e., on average greater than 150 feet) and good mean canopy coverage[10] (i.e., 66.5 percent), RSAT riparian habitat conditions were rated as being good (Table 9). It should be noted that existing major canopy gaps in the Middle reach were generally associated with large recent tree falls along the stream channel.

Figure 18 - Middle Reach - Mature Hardwood Forest

With the exception of the short stream length (i.e., ~ 360 feet) in the Upper reach along Burns Street, the riparian corridor was relatively wide (i.e., average 150 feet or greater) and heavily forested. As seen in Figure 18, a mature deciduous hardwood forest was the dominant vegetative community in the stream valley. In general, the mean left bank riparian buffer width (172 feet) was slightly wider that of the right bank (149 feet). It should be noted that a 200 feet plus wide riparian buffer was recorded in the vicinity of transect X-5. Unfortunately, throughout the RSAT surveyed riparian areas, signs of illegal dumping of bulk trash items (i.e., mattresses, residential water heaters, sofas, yard waste, old 5-gallon paint buckets, etc.,) were observed. In addition, non-native invasive plants such as porcelain berry, Euonymus sp. and English ivy are widespread, particularly in the Upper reach where they are most abundant.

[9] Typically, fluoridated drinking water contains 0.4 to 0.5 mg/l of fluoride.
[10] Canopy coverage percentages are based on visual estimates.

Table 9 - Summary: Fort Chaplin – Upper, Middle and Lower Riparian Habitat Conditions

RSAT Stream Segment	Segment Length (mi.)	Number of Observations	Mean Canopy Coverage (%) [1]	Riparian Habitat Condition	
				RSAT Score [2]	Verbal Ranking
Upper	0.14	7	78.6	--	--
Middle	0.10	5	48.0	--	--
Lower	0.12	5	65.0	--	--
Total	0.36	17	66.5[3]	5	Good

3.5 Biological Condition – Benthic Macroinvertebrate Biosurvey

3.5.1 Background

Macroinvertebrates are generally defined as animals without backbones that are large enough to be retained on a U.S. Standard No. 30 sieve (0.595 micron mesh openings). Benthic macroinvertebrates have long been used for biological monitoring purposes because they are a ubiquitous diverse group of sedentary and relatively long-lived species, which often respond predictably to human watershed perturbations. Importantly, a stream's biological community normally responds to and is reflective of prevailing water quality and physical habitat conditions. As part of the RSAT evaluation, an in-depth biosurvey of the stream's macroinvertebrate community was performed using both the RSAT voucher collection and more quantitative 20-jab samples from an approximately $2m^2$ streambed area. The purpose of the biosurvey was two-fold: 1) to characterize macroinvertebrate community composition and the relative abundance of major representative taxonomic groups, and 2) to quantify, through the employment of a suite of metrics, general stream quality/level of impairment. As previously described, the RSAT Level III RSAT voucher collection protocol employed in the study involved turning over 10 cobble-sized stones (or larger) and taking a combination of two one-square-foot kick and two one-square-foot jab samples per transect from representative riffle, run and pool habitat areas. Representative macroinvertebrate organisms collected at each transect were first identified in the field to family level and then composited and placed into an RSAT voucher for each individual stream segment. The D-nets used for the biosurvey featured 600-micron mesh.

In addition, companion spring 20-jab multiple-habitat sampling was performed at the following two sites:

- Upper Reach (X-2 area), and
- Lower Reach (X-8 area).

The preceding 20-jab macroinvertebrate collection work was conducted for fall (December 2002) and spring (March 2003, and May 2004) seasons. It should be noted that at each 20-jab sampling location, macroinvertebrates were similarly collected from multiple habitats (via a D-net). All 20-

[1] Mean canopy coverage interpretations: > 80% = Excellent, 60-79% = Good, 50-59% = Fair, <50% = Poor.
[2] Point Score Interpretation: 6.0-7.0 = Excellent, 4.0-5.9 = Good, 2.0-3.9 = Fair, 0-1.9 = Poor.
[3] Weighted Mean

jab samples and RSAT voucher collection samples were identified in the laboratory, to the lowest taxonomic level, by COG staff using a 60x stereoscope. As previously indicated, the following seven metric calculations were performed for each 20-jab sample: 1) taxa richness, 2) total number of EPT taxa, 3) percent Ephemeroptera, 4) percent Tanytarsini, 5) Beck's Biotic Index, 6) number of scraper taxa and 7) percent clingers. These seven metrics were employed for calculating the MBSS Coastal Plain macroinvertebrate index of biological integrity (IBI). IBI scores were used to help characterize existing biological community conditions, as well as to provide a basis for comparing different stream reaches. Finally, it is recommended that MBSS IBI scores for Fort Chaplin stream sites where the total number of organisms collected was less than 80 should be viewed with caution.

General pollution tolerance for major taxonomic groups was per Bode et. al. (1991), Lenat (1993) and Stribling et al. (1998). Macroinvertebrate relative abundance categories used in the biosurvey are comparable to EPA's Rapid Bioassessment Protocol (RBP) Level I and are as follows: absent/no group found, scarce, scarce/common, common, common/abundant and abundant. Relative abundance is recorded, based on the investigator's experience and judgement, at each transect. In addition, the four generalized macroinvertebrate community condition-rating categories employed by the RSAT voucher collection are presented in Table 10. The general macroinvertebrate community condition for the entire Fort Chaplin stream channel is summarized in Figure 19.

In addition, the mean relative abundance of observed macroinvertebrate taxa is presented in Figure 20. Macroinvertebrate taxa richness for both RSAT voucher and 20-jab samples are included in Table 11. For additional tributary-specific macroinvertebrate survey results, the reader is referred to Appendix 4.

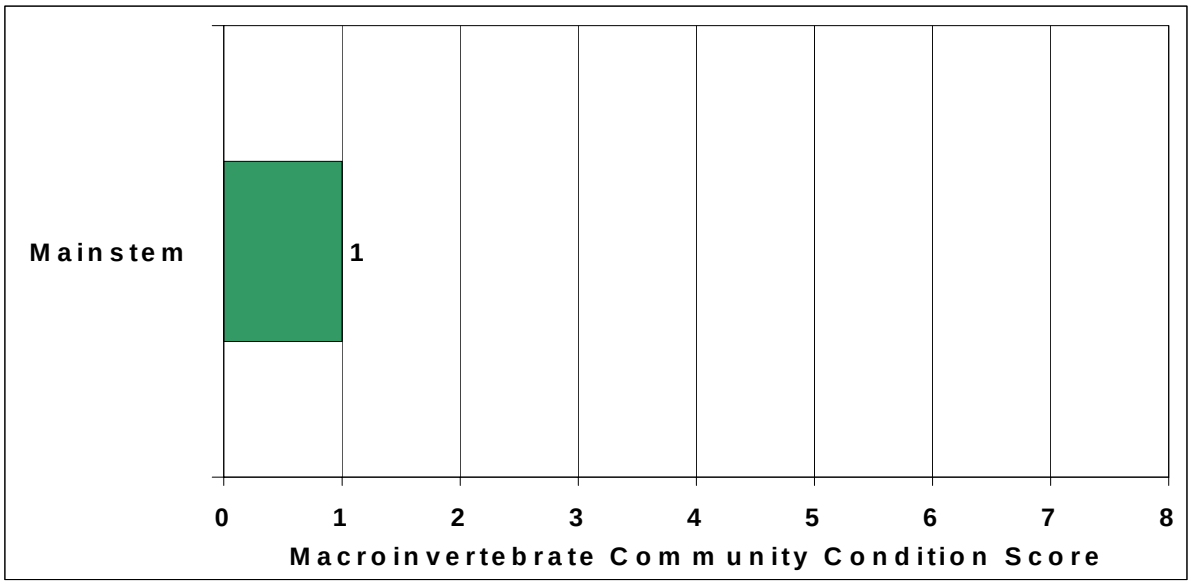
3.5.2 General RSAT Voucher Collection Findings

As seen in Figure 19, the Fort Chaplin stream was rated as having poor macroinvertebrate community conditions. Individuals from the more pollution intolerant groups (i.e., stonefly, mayfly and caddisfly) were all conspicuously absent. Only one caddisfly individual belonging to the

Table 10 - RSAT Macroinvertebrate Community Condition

Verbal Rating Category and Representative Conditions			
Excellent	**Good**	**Fair**	**Poor**
- diverse macroinvertebrate community present, dominated by flathead mayflies, stoneflies and cased caddisflies, very few snails and/or leeches present;	- mayflies and caddisflies present (stoneflies absent, good overall diversity;	- pollution-tolerant caddisflies, snails, midgeflies, aquatic worms dominant;	- poor diversity generally dominated by midgeflies, aquatic worms and snails;
- moderate-high number of individuals.	- moderate-high number of individuals.	- low-moderate number of individuals.	-depauperate population-low number of individuals.

Figure 19 - Fort Chaplin Tributary - RSAT Voucher Collection Macroinvertebrate Community[1] Condition



more pollution tolerant family (i.e., Hydropsychidae) was collected. Overall, the number of individuals collected in Fort Chaplin was extremely low. Based on the RSAT system, the relative abundances of these macroinvertebrates were rated as being generally scarce, or in a few instances, scarce/common.

3.5.3 Macroinvertebrate Relative Abundance and Taxa Richness

Relative Abundance

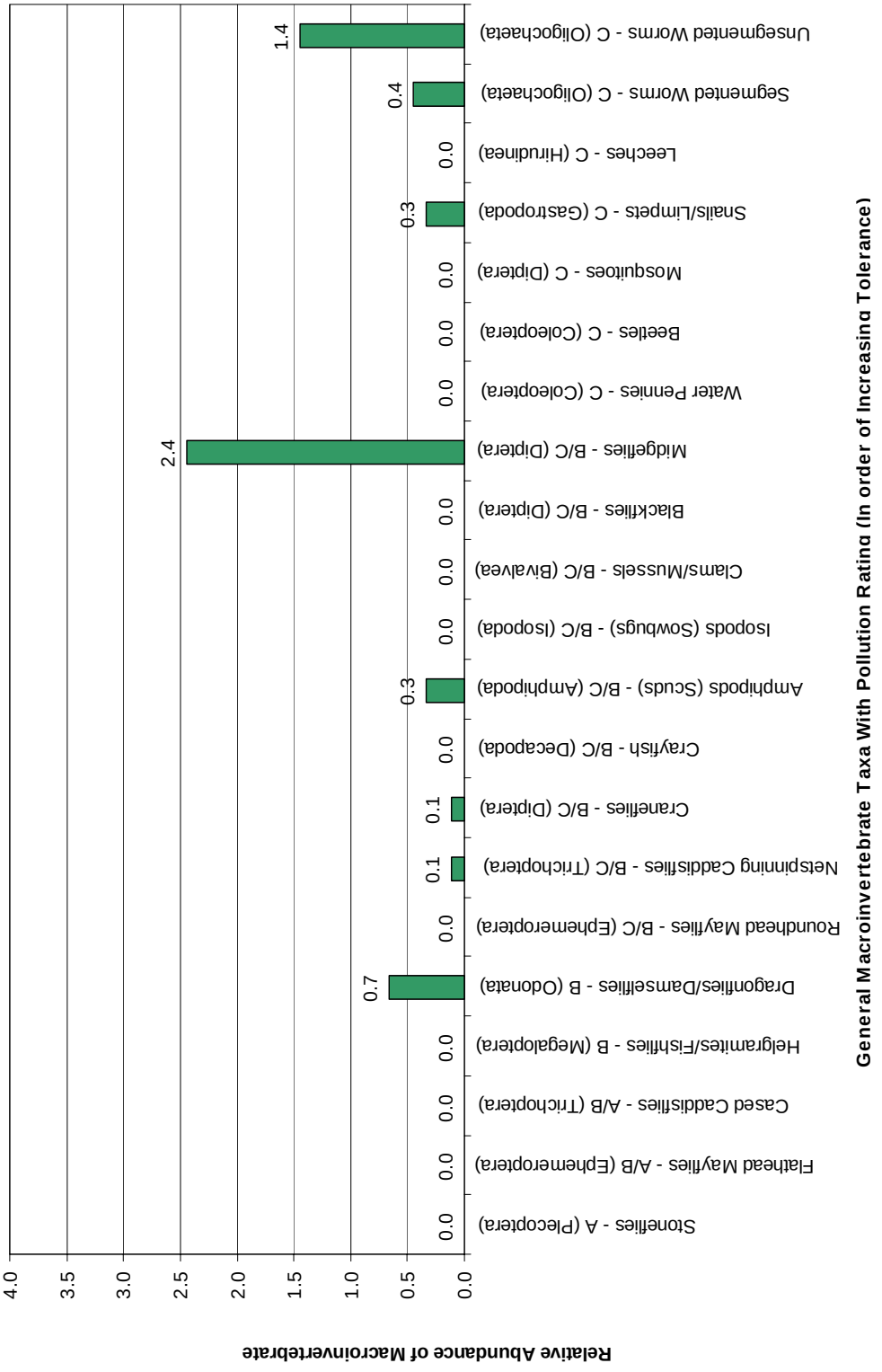
The absence of individuals belonging to representative pollution intolerant groups (e.g., stoneflies, mayflies and caddisflies) provided additional evidence of generally moderate to high levels of stream quality impairment in Fort Chaplin. As seen in Figure 20, pollution intolerant stoneflies, flathead mayflies and cased caddisflies were conspicuously absent throughout. As previously mentioned, the only representative caddisfly (i.e., one collected at transect X-2) collected was pollution tolerant. Furthermore, with the exception of midgeflies and aquatic worms, all other taxa were present in low numbers. It should be noted that aquatic worms are often associated with sluggish flowing to stagnant aquatic habitats and can tolerate both high nutrient loads and low dissolved oxygen levels.

Taxa Richness

During the course of the study, a total of 23 macroinvertebrate taxa were identified from Fort Chaplin (Appendix 4; Table 1). A total of 9 and 12 taxa, were identified for the summer 2004 RSAT voucher and the 20-jab surveys, respectively. As seen in Table 11, the highest number of taxa collected (12, fair range) was associated with the spring 2004 20-jab sample. A total of 9

[1]Macroinvertebrate scale interpretation: 7.0-8.0 pts. = Excellent, 5.0-6.9 pts. = Good, 2.1-4.9 pts. = Fair, 0.0-2.0 pts. = Poor.

Figure 20 - Fort Chaplin Tributary - Relative Abundance of Observed Macroinvertebrates[1] and General Pollution Tolerance[2]



[1] Relative abundance scores were averaged for each mainstem reach. Relative abundance interpretation: 0.1-0.9 = Scarce, 1.0-2.0 = Scarce/Common, 2.1-3.0 = Common, 3.1-4.0 = Common/Abundant, > 4.1– 5.0 = Abundant.

[2] Pollution Tolerance Rating: A = Intolerant, B = Moderately Tolerant, C = Tolerant

Table 11 - Summary: Fort Chaplin Tributary Macroinvertebrate Taxa Richness, Spring and Fall 2002-2004

RSAT Stream Segment	Number of Taxa Collected				Number of Taxa Collected Verbal Rating[1]			
	20-Jabs	20-Jabs	20-Jabs	RSAT Voucher[3]	20-Jabs	20-Jabs	20-Jabs	RSAT Voucher[2]
	December 2002	March 2003	May 2004	May 2004	December 2002	March 2003	May 2004	May 2004
Upper	6	1	6	5	Poor	Poor	Poor	Poor
Lower	5	2	8	5	Poor	Poor	Fair	Poor
Total	**9**	**2**	**12**	**9**	-----	-----	-----	**-----**

and 2 taxa respectively, were collected in the fall 2002 and spring 2003 20-jab samples (i.e., fair and poor range, respectively).

3.5.4 20-Jab Sample Metrics and MBSS IBI Scores

As previously stated, the 20-jab macroinvertebrate sampling includes a more quantitative interpretative approach, featuring the employment of seven individual MBSS Coastal Plain stream metrics. Individual metric calculations were performed and used in developing the overall IBI score for each surveyed stream reach. Results are presented in Table 12. It should be noted that Fort Dupont Tributary fall 2002, and spring 2003 and 2004 20-jab sampling results were intentionally included in Table 12, so as to provide a comparison to the Fort Chaplin macroinvertebrate community.

As seen in Table 12, both spring and fall overall MBSS IBI scores for all three stream reaches were verbally rated as being very poor (i.e., IBI scores < 2.0). In addition, the associated verbal ratings for the individual metrics fell into either the poor or fair categories. According to Stribling et al. (1998), the general response for all seven metrics to increasing perturbation is a decrease in number, percent or score. A narrative description of stream biological integrity associated with the four IBI categories is provided in Table 13.

As seen in Table 12, although expected to be somewhat similar to that of its neighboring Fort Dupont stream system, the Fort Chaplin macroinvertebrate densities were remarkably lower. In the fall of 2002 (near the end of the drought that greatly reduced both the Fort Chaplin and Fort Dupont stream baseflow), the densities in Fort Chaplin were on the order of 4 to 15 times less than those of Fort Dupont. In the spring of 2003, even when normal baseflow conditions resumed, the densities were 2 to 40 times less. Furthermore, approximately one-year after the drought, densities in spring 2004 continued to be on the order of 3 to 18 times less. It should be noted that the Fort Chaplin macroinvertebrate community is comprised mainly of organisms (e.g., aquatic worms and midgeflies etc.,) that can tolerate warm water temperatures and low dissolved oxygen levels;

[1] General RSAT voucher interpretation for the number of taxa: >=25 = Excellent, 16-24 = Good, 8-15 = Fair, 0-7 = Poor.
[2] RSAT voucher protocol surveys an area of 3 m^2/mi versus 1-2 m^2/mi surveyed with the 1m^2 sample.

Table 12 - Summary: Fort Chaplin Tributary and Fort Dupont Tributary - Spring and Fall 2002 20-Jab Macroinvertebrate Sample Metrics and MBSS Coastal Plain IBI Scores

Site	Sampling Date	No. of Organisms/m²	Taxa Richness[1]	Total No. of EPT Taxa[2]	Percent Ephemeroptera[3] (%)	Percent Tantarsini[4] (%)	Beck's Biotic Index[5]	No. of Scraper Taxa[6]	Percent Clingers[7] (%)	MBSS IBI Score[8]	MBSS IBI Verbal Ranking
					Pope Branch Spring						
Upper	12/16/2002	19	6	0	0.0	0.0	0	2	2.6	1.0	Very Poor
Lower	12/16/2002	15	5	0	0.0	0.0	0	1	3.4	0.8	Very Poor
Upper	3/24/2003	1	1	0	0.0	0.0	0	0	0.0	0.8	Very Poor
Lower	3/24/2003	10	2	0	0.0	0.0	0	0	0.0	0.8	Very Poor
Upper	5/11/2004	11	6	0	0.0	0.0	0	0	0.0	0.8	Very Poor
Lower	5/11/2004	28	8	0	0.0	0.0	0	1	1.8	0.8	Very Poor
					Fort Dupont Spring						
Middle	12/13/2002	84	8	0	0.00	0.00	4	0	6.0	1.0	Very Poor
Middle	3/25/2003	18	8	0	0.00	0.00	6	0	5.6	1.0	Very Poor
Middle	5/11/2004	105	10	1	0.00	0.00	10	0	0.0	1.0	Very Poor
					Fort Dupont Fall						
Tributary No. 2	12/13/2002	229	13	1	0.00	0.44	8	0	2.2	1.2	Very Poor
Tributary No. 2	3/25/2003	40	11	0	0.00	0.00	13	0	35.0	1.2	Very Poor
Tributary No. 2	5/11/2004	70	8	1	0.00	0.00	10	0	0.0	1.0	Very Poor

[1] Taxa richness represents the total number of taxa collected and is interpreted by MBSS as follows: >25 = Good, 11-24 = Fair, <11 = Poor.

[2] Counts the distinct taxa considered pollution intolerant within the groups of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). EPT taxa metrics are interpreted as follows: >6 = Good, 3 - 6 = Fair, and <3 = Poor.

[3] Measures the abundance of generally pollution intolerant Ephemeroptera (mayflies) relative to other often more tolerant individuals and is interpreted as follows: >11.4% = Good, 2.0 – 11.4% = Fair and < 2.0% = Poor.

[4] Measures the abundance of generally pollution intolerant Tanytarsini (midgeflies) relative to other more tolerant Chironomidae and is interpreted as follows: >13.0% = Good, 0.0 – 13.0% = Fair and < 0.0% = Poor.

[5] The Beck's Biotic Index is a weighed enumeration of two Class of organic pollution tolerant taxa, the most tolerant and the second most tolerant groups. The index is interpreted as follows: >12 = Good, 4.0-12.0 = Fair and <4.0 = Poor.

[6] The number of herbivorous scrapers is a metric used to reflect available food resources like periphyton and microfauna which may themselves be more abundant under conditions of minimal perturbation. This value is interpreted as follows: >4 = Good, 1-4 = Fair, <1 = Poor.

[7] Measure the organisms that are behaviorally and morphologically adapted to clinging to surfaces in fast moving riffles. Percent ratios are interpreted as follows: >= 62.1% = Good, 38.7 – 62.1% = Fair and <38.7% = Poor.

[8] Index of Biological Integrity developed by Maryland Department of Natural Resources, Maryland Biological Stream Survey (MBSS). MBSS IBI Score interpretation 4.0-5.0 = Good, 3.0-3.9 = Fair, 2.0-2.9 = Poor, <1.9 = Very Poor.

conditions which were frequently recorded during the study. Other factors contributing in major ways to the impairment of the Fort Chaplin macroinvertebrate community include: 1) an unstable streambed associated with frequent scouring stormflows and 2) associated poor water quality.

The preceding MBSS metric and IBI scores generally support RSAT voucher collection findings that the overall Fort Chaplin macroinvertebrate community is, at a minimum, severely impaired. It should be noted that poor water quality may be a major limiting factor. However, other factors such as streambed instability, altered water temperature regime, the possible episodic discharge of toxic products, etc., are also limiting Fort Chaplin's aquatic community.

Table 13 - General IBI Score Interpretation (Stribling et al. 1998)

Verbal Ranking	IBI Score Range	General Description
Good	4.0 - 5.0	Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.
Fair	3.0 - 3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally impacted streams. Fall within the lower portion of the range of reference sites (10th to 50th percentiles).
Poor	2.0 - 2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating some degradation.
Very Poor	1.0 - 2.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating severe degradation.

3.6 RSAT Summary Stream Quality Ratings

A summary breakdown of the six RSAT evaluation categories employed for evaluating overall stream quality in the Fort Chaplin stream is included as Table 14. As seen in Table 14, the entire Fort Chaplin stream channel received a fair overall stream quality rating.

Table 14 - Fort Chaplin Study Summary: Fort Chaplin RSAT Ratings[1]

RSAT Stream Segment	Channel Stability	Channel Scouring/ Sediment Deposition	Physical Instream Habitat	Water Quality	Riparian Habitat Conditions	Biological Indicators	Overall RSAT Stream Quality Rating [2]
Total	Fair (3)	Fair (4)	Fair (3)	Poor (1)	Good (5)	Poor (1)	Fair (17)

[1] Actual point values are shown in parentheses.

[2] Total RSAT score interpretation: 42-50 = Excellent, 30-41 = Good, 16-29 = Fair, <16 = Poor.

3.7 Fort Chaplin One-Pass Electrofishing Survey

As already noted, a single pass electrofishing survey was conducted on May 2004. The survey, which started from the 'C' Street 48" RCP culvert, featured a complete sweep of all representative habitat types (i.e., riffles, runs and pools) in a continuous 1,100 foot stream reach. Not surprisingly, no fish were collected or observed during the survey. The preceding results confirmed that: 1) the Fort Chaplin system is currently not supporting a resident fish community and 2) the ~ 5,000 foot long pipe section from 'C' Street down to the Anacostia River is a complete fish blockage which precludes normal exchange with and repopulation from Anacostia River fish stock.

3.8 Stream Chemistry

As part of the additional non-RSAT water quality grab sampling performed for the study, COG staff collected both baseflow and stormflow samples for water chemistry analysis by CT&E Environmental Services, Incorporated. This analysis was performed for three baseflow and five stormflow samples collected from the Lower reach (X-9) area between July 2003 and April 2004, only. In addition, limited in-situ grab sampling with hand-held meters was conducted for the period July 2003 through February 2004 at the two following locations: 1) Upper reach (X-2) and 2) Lower reach (X-9). Results are summarized in Figure 17 and Table 1 of Appendix 5.

3.8.1 Baseflow DO

During the study period, violations of the District of Columbia's Department of Health (DC-DOH) 5.0 mg/l dissolved oxygen (DO) water quality standard were recorded in both the Upper and Lower reaches. In fact, ten DO measurements (53 percent) out a total of 19 taken were below the minimum 5.0 mg/l criterion recommended for the support of a healthy aquatic community. A further breakdown of the DO violations are as follows: Upper reach (X-2) three out nine (33 percent), and Lower reach (X-9) seven out of ten (70 percent). As seen in Figure 21, DO levels decreased dramatically in a downstream direction. The median DO levels for Upper and Lower reaches were 5.24 and 2.72 mg/l, respectively.

3.8.2 Baseflow Conductivity

Conductivity, which provides an indirect measure of dissolved anions and cations present in water (e.g., carbonates, chlorides, sulfates, nitrates, sodium, potassium, calcium and magnesium), was high throughout Fort Chaplin in downstream fashion[11]. As seen in Figure 21, median baseflow conductivity concentrations for the two stream reaches were nearly identical, and ranged from a low of 344 mS/cm to a high of 579 mS/cm (both in the Upper reach).

Limited water quality surveys of relatively undisturbed Coastal Plain streams in Maryland

[11] Conductivity levels often increase in response to a variety of anthropogenic activities and related pollution such as sewage from sanitary sewer line/septic field leakage, road salting, leaching from recently disturbed soils, application of fertilizers, etc.

and other mid-Atlantic states strongly suggest that Fort Chaplin baseflow conductivity levels should be in the 60-160 mS/cm range (Thomas, 1966; Janicki et al., 1995; Galli et al., 1997, MCDEP, 1998; Stribling et al., 1999). The elevated conductivity readings suggest a variety of possible anthropogenic-related influences including treated water from leaking water or sewer lines, road salting, leaching from recently disturbed soils, application of fertilizers, etc.

3.8.3 Baseflow pH

pH, which is used to indicate the acidity or alkalinity of water, decreased in downstream fashion in Fort Chaplin. As seen in Figure 21, median pH levels ranged from 6.78 (near neutral) for the Upper reach to 6.60 (near neutral) for the Lower reach. In general, unimpaired fresh water streams in the Washington metropolitan area have a pH range on the order of 6.5 to 8.0. This is the pH range favorable for the support of most aquatic organisms. It should be noted that because of treatment-related changes, the pH of tap water is generally higher than background water supply levels. The pH of treated water in District of Columbia is generally around 8.0 (DC-WASA, 2003).

3.8.4 Baseflow Fluoride

Median fluoride (F^-) concentrations in Fort Chaplin increased heading downstream. However, one extremely high instantaneous measurement of 1.02 mg/l was recorded in the Upper reach. As seen in Table 15, the median F^- concentration for Fort Chaplin is 0.49 mg/l (which is 0.19 and 0.29 mg/l greater than that recorded for the neighboring Pope Branch and Fort Dupont Tributary, respectively). It should be noted that local naturally occurring fluoride concentrations generally range from 0.1 to 0.2 mg/l and that District of Columbia treated water F^- concentrations are typically 0.4 mg/l (DC-WASA, 2001).

3.8.5 Middle Reach Baseflow NO_3^-, TP, Fe, Cu, TOC and BOD

Limited baseflow laboratory water chemistry analysis summary results (Figure 22; Appendix 5: Table 2) for Fort Chaplin Lower reach (X-9) revealed that: 1) nitrate (NO_3^-) concentrations were in the moderate range; 2) total phosphorus (TP) concentrations were low; 3) iron (Fe) levels did exceed the DC-DOH/EHA Class 'C' 1.0 mg/l criterion for the protection of aquatic life 100 percent of the time. It should be noted that, during the Fort Chaplin study, COG staff observed the presence of iron-oxidizing bacteria in close proximity to water discharged from seeps as suggested by Robbins and Norden (1994); 4) copper (Cu) was not detected and thus was well below the generally recommended 'acute' concentration limit of 13 µg/l established by EPA (2002) and MDE (2003); 5) total organic carbon (TOC) was slightly elevated; and 6) biochemical oxygen demand[12] (BOD) was not detected (i.e., < 2.0 mg/l).

For reporting purposes, nitrate (NO_3^-) concentrations were grouped, per USGS (1993), into three concentration classes: 1) low, < 1.0 mg/l, 2) moderate, 1.0-3.0 mg/l, and 3) high, >3.0 mg/l.

[12] Bod levels less than the 2.0 mg/l detection limit were not reported by CTE laboratory.

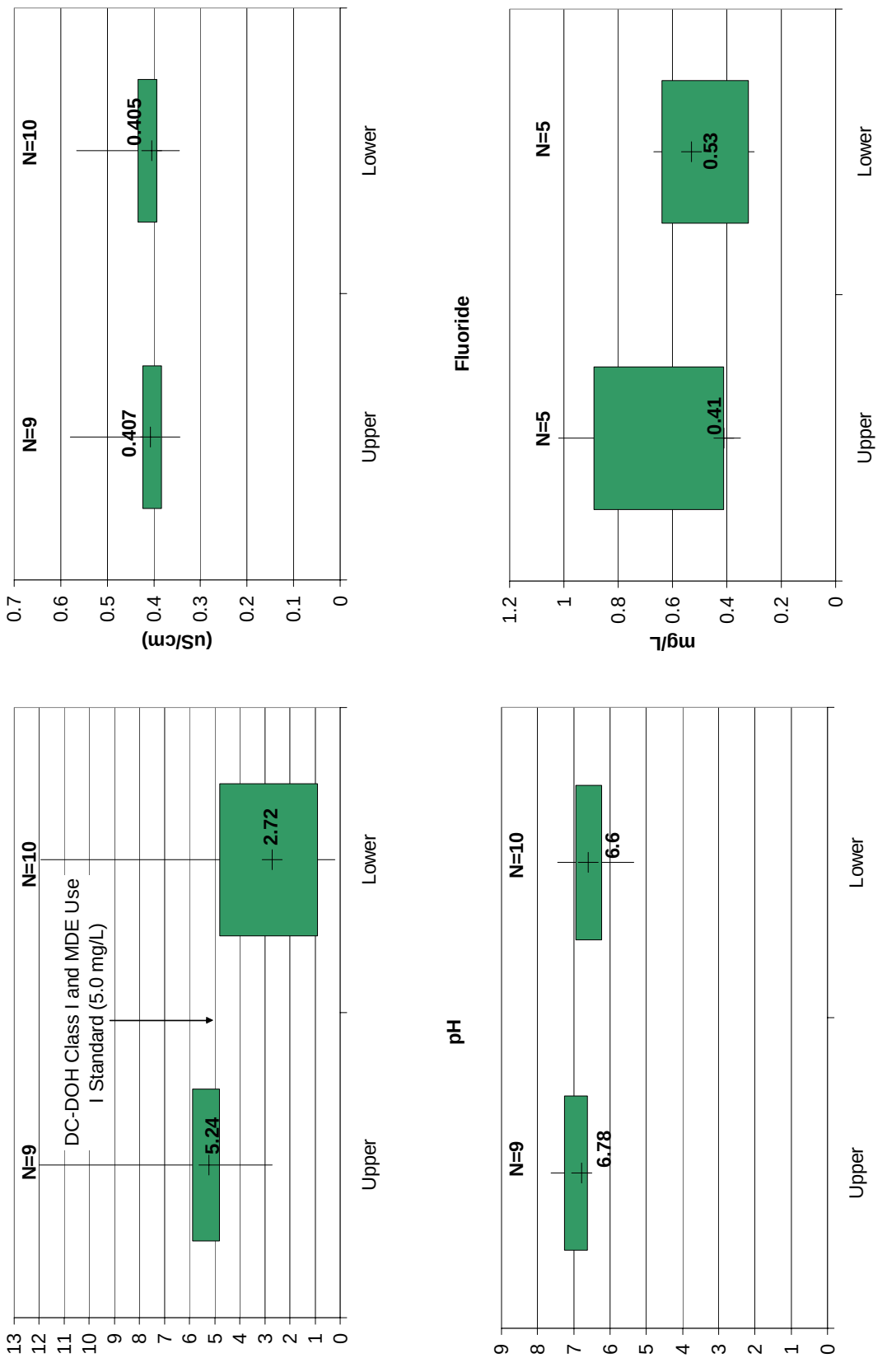
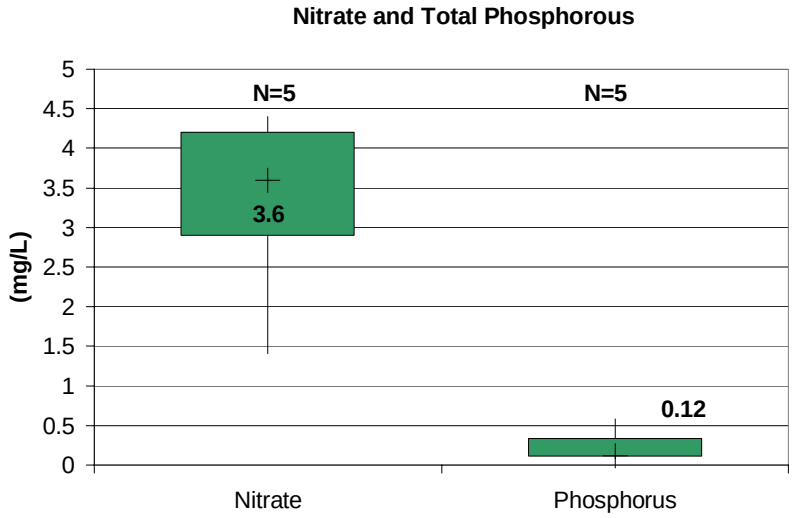
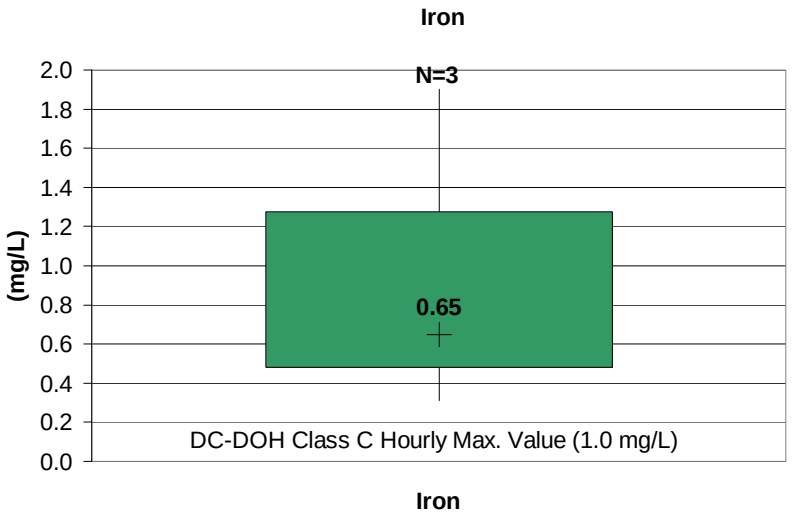
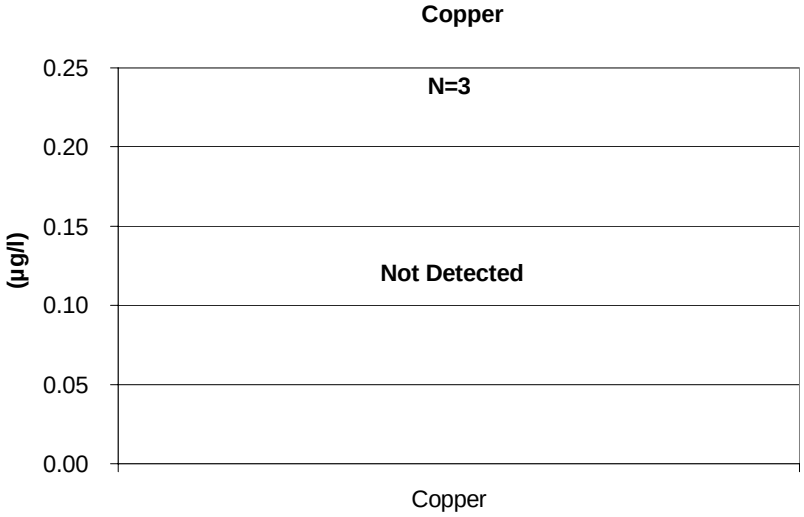


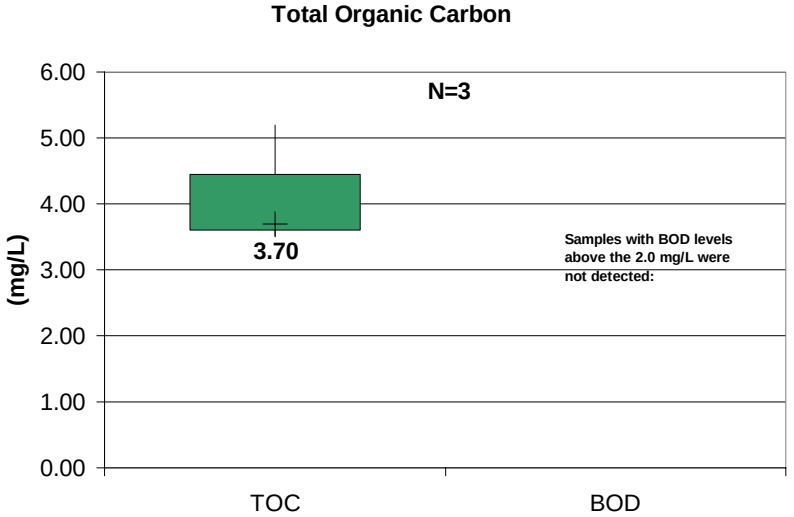
Figure 21 - Fort Chaplin Middle, and Lower Reach Baseflow DO, Conductivity, pH and Fluoride (July - November 2002)

Figure 22 - Fort Chaplin Lower Reach Baseflow Nitrate, Total Phosphorus, Copper, Iron, Total Organic Carbon, and Biochemical Oxygen Demand (July – November 2002)









As seen in Figure 22, the maximum baseflow NO_3^- concentration recorded was 4.4 mg/l. The median baseflow TP level, at 0.12 mg/l, was slightly above the < 0.10 mg/l level recommended by EPA (1986) for the reduction and/or avoidance of nuisance plant growth in streams.

As seen in Figure 22, TOC levels ranged from 3.5 to 5.2 mg/l. During the study, no baseflow BOD concentration was above the CTE, Incorporated 2.0 mg/l detection limit. Finally, of the three fecal coliform baseflow samples taken, one sample (2,400 MPN) violated the DC-DOH/EHA 1,000 MPN criterion for class 'C' waters. Furthermore, the relatively low number of E. coli bacteria present (range: 20 - 1,300 MPN) in the three baseflow samples taken suggest that the sources are more likely animal than humans. It should be noted that there were no sewer lines crossing the stream or paralleling the stream within the riparian buffer zone.

3.8.6 Middle Reach Stormflow NO_3^-, TP, Fe, Cu, TOC and BOD

Among the several stormflow-related observations made by COG staff during the study was that: 1) first flush runoff (i.e., from the ascending limb of the hydrograph) from even relatively small rainfall events (i.e., <0.17 inches rainfall/24 hrs.) produced turbid, dark-brown colored water in Fort Chaplin, 2) turbidity levels (i.e., turbidity reading of 540 NTU on November 19, 2003) did violate the DC-DOH/EHA maximum instantaneous turbidity criterion of 150 NTU, 3) in contrast to the neighboring and more heavily wooded Fort Dupont tributary (where the stormflow hydrograph typically returned to its pre-storm baseflow condition within approximately four to six hours following the cessation of rainfall) the Fort Chaplin stormflow hydrograph typically returned to its pre-storm baseflow condition within approximately two to four hours, and 4) water clarity returned to near baseflow conditions within an approximately three to five hour period.

Not surprisingly, TP, Fe, Cu, and TOC levels all experienced marked increases under stormflow conditions. As seen in Figure 23, TP median stormflow concentrations were twice as high as baseflow. Furthermore, TOC and BOD median stormflow levels, compared to baseflow, were approximately 4 to 9 times higher, respectively. However, somewhat a surprise to COG staff, NO_3^- levels (i.e., range 0.38 - 2.1 mg/l) decreased during stormflow conditions. The median stormflow NO_3^- concentrations, compared to baseflow conditions, was approximately seven times less (i.e., stormflow = 0.51 mg/l and baseflow = 3.6 mg/l).

Fort Chaplin stormflow Fe concentrations ranged from 1.2 mg/l to 29.0 mg/l with a median of 5.1 mg/l. This median concentration was approximately seven times greater than that observed for baseflow conditions. In contrast, Fort Dupont Tributary median baseflow and stormflow Fe concentrations (Table 15) were far higher at 2.4 and 51.0 mg/l, respectively (which are on the order of four and 25 times greater than those recorded for Fort Chaplin). While the preceding Fort Chaplin Fe concentrations and exposure periods may not in themselves be toxic, it has been shown in macroinvertebrate and fish toxicity studies (Gerhardt, 1992, Skyora et al., 1972; Ebeling, 1931; Roback, S. Hart and Fuller, 1974) that high Fe levels (>50 mg/l) could potentially cause reproductive impairment, reduced emergence, decrease motility, reduced growth and even serious injury or death for certain sensitive species. It should, however, be noted that other factors such as pH, hardness, temperature and the presence of ligands affect the solubility of iron, and therefore its toxicity.

With regard to Cu, stormflow concentrations ranged from 13.00 µg/l to 64.00 µg/l. The median

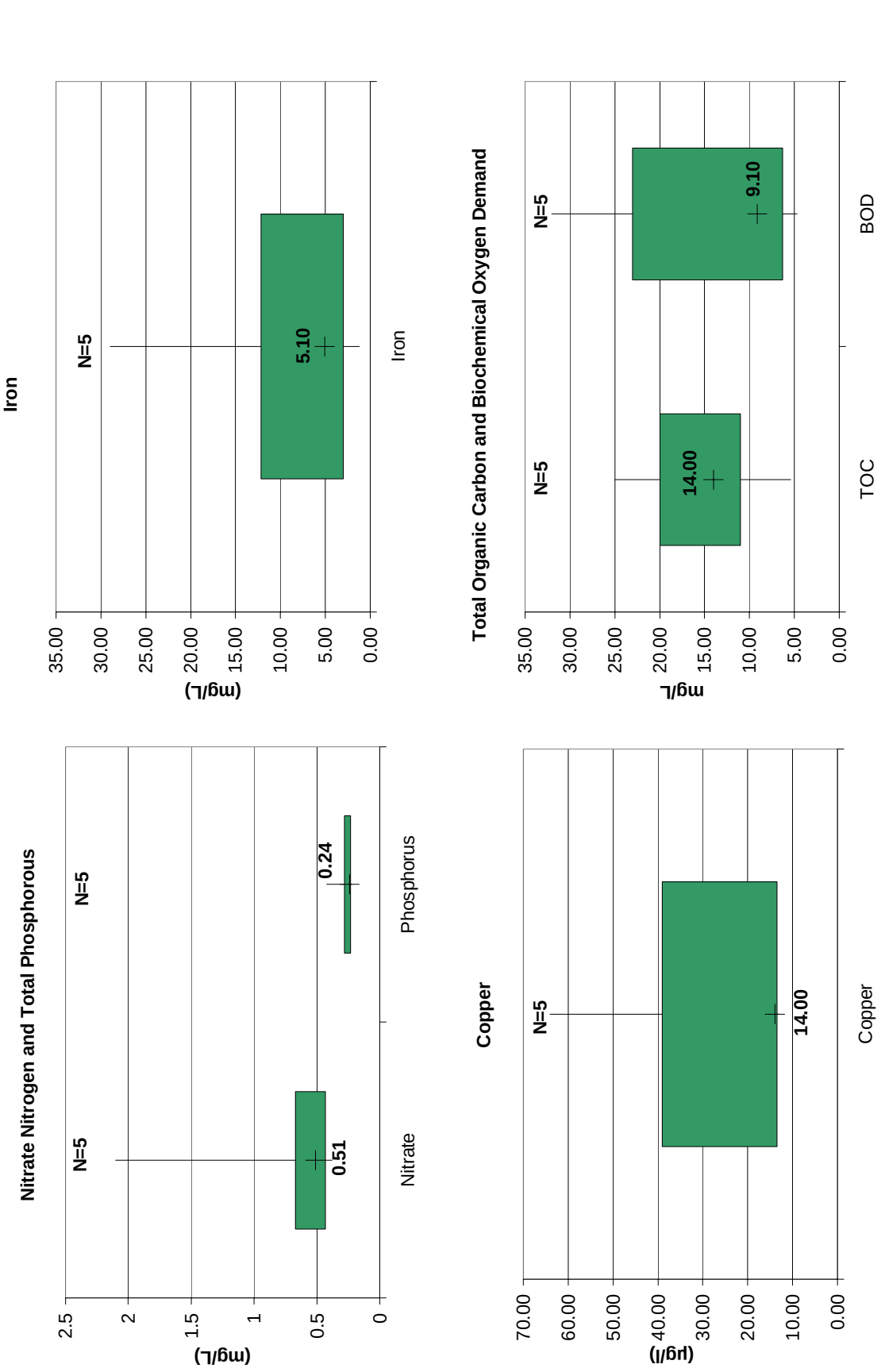


Figure 23 - Fort Chaplin Lower Reach Stormflow Nitrate, Total Phosphorus, Copper, Iron, Total Organic Carbon, and Biochemical Oxygen Demand (July - November 2002)

Table 15 - Select Water Quality Grab Sampling Monitoring Results - Fort Chaplin (2003/2004), Pope Branch (2002) and Fort Dupont (1999)

Parameter	unit	Baseflow and Stormflow Median Values											
		Fort Chaplin (Lower)				Pope Branch (Lower Reach 'A')				Fort Dupont (Middle Mainstem)			
		Baseflow		Stormflow		Baseflow		Stormflow		Baseflow		Stormflow	
		N	Value	N	Value	N	Value	N	Value	N	Value	N	Value
1. DO	mg/l	9	2.64	-	-	10	5.48	-	-	9	10.6	-	-
2. Conductivity	(µs/cm)	9	0.40	-	-	10	338	-	-	9	207	-	-
3. pH	mg/l	3	7.17	5	6.68	10	6.27	-	-	9	6.44	-	-
4. Fl-	mg/l	5	0.49	-	-	10	0.30	-	-	9	0.20	-	-
5. NO3	mg/l	3	1.67	5	0.82	3	1.80	6	0.74	5	0.20	5	0.40
6. TP	mg/l	3	0.26	5	0.28	3	0.05	6	0.21	5	0.01	5	0.36
7. Fe	mg/l	3	0.95	5	10.10	3	0.54	6	1.95	5	2.40	5	51.00
8. Cu	µg/l	3	ND	5	14.00	10	4.00	6	11.50	5	4.00	5	14.00
9. TOC	mg/l	3	4.13	5	15.08	3	3.30	6	7.00	5	6.40	5	18.00
10. BOD	mg/l	3	ND	5	15.02	3	11.00	6	4.25	5	2.00	5	5.00

stormflow Cu concentration was 14.00 µg/l. This median level was significantly greater than the median baseflow concentration, because copper concentration at baseflow conditions was not detected. According to EPA (2002), in order to protect most aquatic organisms, 'acute' copper concentrations should not (at a hardness level of 100 mg/l) exceed 13 µg/l. This 'acute' 13 µg/l level is also currently proposed for use by the State of Maryland for its freshwater copper toxicity criterion (MDE, 2003). It should be noted that Fort Chaplin stormflow hardness concentrations ranged from 38 to 170 µg/l (Appendix 5: Table 3). In addition, DC-DOH/EHA water quality standards currently employ a hardness-adjusted copper criterion. Based on the observed Fort Chaplin stormflow hardness levels, the hourly maximum allowable DC-DOH/EHA Cu concentrations for the five sampled storms would have been 16, 7, 7, and 19 µg/l, respectively. Actual corresponding stormflow Cu concentrations were 13, 14, 14, and 64 µg/l. It should be noted that copper concentrations were not detected during the April 2004 storm sample. The preceding findings suggest that copper concentrations may be limiting to the Fort Chaplin aquatic community.

As seen in Figure 23, stormflow TOC concentrations ranged from 11.0 to 25.0 mg/l, with a median of 14.0 mg/l. Stormflow BOD levels were generally below or within the typical mean 11.9 - 30.0 mg/l concentration range reported by Schueler (1987) and Novotny and Olem (1994) for urban stormwater runoff. The maximum stormflow BOD concentration observed during the study was 32.0 mg/l (Figure 22). High BOD levels may suggest an increase in microbial activities decomposing organic material (i.e., sewage, leafy detritus, etc.). Finally, it should be noted that stormflow fecal coliform concentrations ranged from a low of 7,000 to a high of 50,000 MPN. Additional coliform bacteriological data showed that E. coli concentrations ranged from 280 to 11,000 MPN reflecting moderate input levels of animal and/or human waste.

Table 16 - Fort Chaplin - Select Mainstem Sediment Chemistry Results (2000/2004)

EPA Method Number	Analyte (mg/kg)	Detection Limit (Fort Dupont) (mg/kg)	Detection Limit (Pope Branch) (mg/kg)	Detection Limit (Fort Chaplin) (mg/kg)	Test Value [1] (Fort Dupont)	Test Value[1] (Pope Branch)	Test Value[1] (Fort Chaplin)
	Hydrocarbons						
8270C	Benzo(a) anthracene	1	0.40	0.41	ND	ND	ND
8270C	Benzoflouranthenes[2]	1	0.40	0.41	ND	ND	ND
8270C	Benzo(a)pyrene	1	0.40	0.41	ND	ND	ND
8270C	Benzo(g,h,i)perylene	1	0.82	0.83	ND	ND	ND
8270C	Bis(2-ehtylhexyl)phthalate	10	0.40	0.41	ND	ND	ND
8270C	Chrysene	1	0.40	0.41	ND	ND	ND
8270C	Fluoranthene	1	0.40	0.41	ND	ND	ND
8270C	Indeno-(1,2,3,-cd)-pyrene	10	0.40	0.83	ND	ND	ND
8270C	Phenanthrene	1	0.40	0.41	ND	ND	ND
8270C	Pyrene	1	0.40	0.41	ND	ND	ND
8270C	Di-N-butyl phthalate	1	0.40	0.41	ND	ND	ND
8270C	Phenol	10	0.40	0.41	ND	ND	ND
	Metals						
6010B	Arsenic	50	0.92	0.93	<50	1.2	1.8
6010B	Beryllium	1	0.18	0.18	<1	0.26	0.37
6010B	Chromium	1	0.92	0.93	5.9	7.2	5.6
6010B	Copper	1	0.92	0.93	4.7	4.0	7.1
6010B	Lead	10	0.92	0.93	<10	3.8	6.2
6010B	Nickel	2	0.92	0.93	5.7	4.9	6.5
6010B	Zinc	1	3.70	3.7	21.0	19.0	28

3.9 Sediment Chemistry

Results from the Fort Chaplin sediment grab sample testing are presented in Table 16. As seen in Table 16, none of the major hydrocarbon analytes tested for as part of the EPA priority pollutant scan were present within the detection limits of the analysis. In addition, representative metals (e.g., copper, chromium, lead and zinc) typically present in urban runoff were detected, and were generally higher than the levels observed in the neighboring Fort Dupont Tributary. It should be noted that interpretation of the sediment chemistry data is, because of the current lack of EPA sediment pore water quality criteria and incomplete understanding of the bioavailability of these pollutants, still difficult at this time. However, based on the EPA priority pollutant scan results it does not appear that the pollutants detected pose serious environmental toxic risks to the biological community of Fort Chaplin.

[1] ND indicates not detected.

[2] Detected and reported as the sum of Benzo(b)flouranthene and Benzo(k)flouranthenes.

4.0 Physical/Hydrological Conditions

4.1 Rosgen Level I and II Stream Channel Morphology

Based on both Rosgen Level I and II stream channel morphology results (Table 17), the Fort Chaplin stream channel network may be generally classified as belonging to the following stream types: Upper reach - F_{4b}, and Middle and Lower reaches - F_4. As seen in Table 17, the degree of channel entrenchment decreased in a downstream fashion. The entrenchment ratio ratings for Fort Chaplin are as follows; Upper reach - entrenched (i.e., 1.2), and Middle and Lower Reaches - moderately entrenched (i.e., 1.4). For additional Rosgen Level II analysis results, the reader is referred to Table 17 and Appendix 6.

4.2 2002 Stream Temperature Monitoring

Results from the 6/20/03 to 8/01/03 (41 days) continuous stream temperature monitoring portion of the study are presented in Figures 24 and 25. In addition to the 32.2 °C (90 °F) DC-DOH/EHA Class 'C' temperature standard for the stream, COG staff included both the MDE 24 °C Use IV (recreational trout waters) and 20 °C (68 °F) Use III (natural trout waters) criteria for further comparison.

As seen in Figure 24, stream temperature in both reaches surveyed were well below the 32.2 °C DC-DOH/EHA class "C' standard. Upper and Lower reach mean stream temperatures were 27.91 °C and 22.87 °C, suggesting that stream temperatures decrease in a downstream fashion. Additional results from the monitoring period are as follows: 1) all stream areas had maximum summer daily temperatures that exceeded the 20 °C MDE Use III (natural trout waters) temperature criterion; 2) the number of days that violated the 24 °C MDE Use IV (recreational trout waters) temperature criterion were 13 for the Upper and 7 for the Lower reach and 3) the maximum daily water temperature recorded during the temperature study (28.3 °C) was measured in the Upper reach on July 9, 2002 and coincided with an afternoon thunderstorm where the maximum air temperature reached 37.0 °C (98 °F). Additional analysis (Figure 25) revealed that Lower reach water temperatures were at or below 20 °C 12-16 percent of the time. In contrast, Pope Branch Lower Reach 'B' and Middle Fort Dupont temperatures were below 20 °C 34 and 54 percent of the time, respectively.

Based on the preceding water temperature monitoring results the Fort Chaplin water temperature regime can be generally categorized, per Galli (1990), as being that of a coolwater stream system. Summer temperatures at all three stations regularly exceeded temperature levels considered optimal (i.e., less than 17 to 20 °C) for many stonefly, mayfly and caddisfly species (Gaufin and Nebecker, 1973; Ward and Stanford, 1979; Fraley, 1979). Also, it should be noted that temperatures exceeding 21 °C have been shown to stress most coldwater organisms and that as a group stoneflies (Plecoptera**)** are least temperature tolerant and are restricted to cold to cool flowing waters.

Table 17 - Fort Chaplin - Rosgen Level I and II - Summary Results

RSAT Stream Segment	Drainage Area (ac)[1]	Stream Length		Stream Type Classification		Stream Order	Entrench--ment Ratio[2]	Width/ Depth Ratio[3]	Sinuosity [4]	Channel Slope (%)[5]	Channel Material (D50)[6] Size (mm)
		Feet	Miles	Level I	Level II						
Upper	131.4	739.2	0.14	F	F_{4b}	1	1.2	56.54	1.2	.022	29.27
Middle	160.0	528.0	0.10	F	F_4	1	1.4	31.60	1.2	.012	28.00
Lower	164.8	633.6	0.12	F	F_4	1	1.4	58.32	1.1	.011	26.86
Total	343.3	1900.8	0.36	-	-	-	-	-	-	.015	28.05

[1] Total drainage acreage reflects area draining down to the Anacostia River.

[2] Entrenched = <1.4; Moderately Entrenched = 1.4 – 2.2; Slightly Entrenched = > 2.2

[3] Width /Depth Ratio Interpretation: Very Low to Low = < 12; Moderate to High = > 12; Very High = > 40

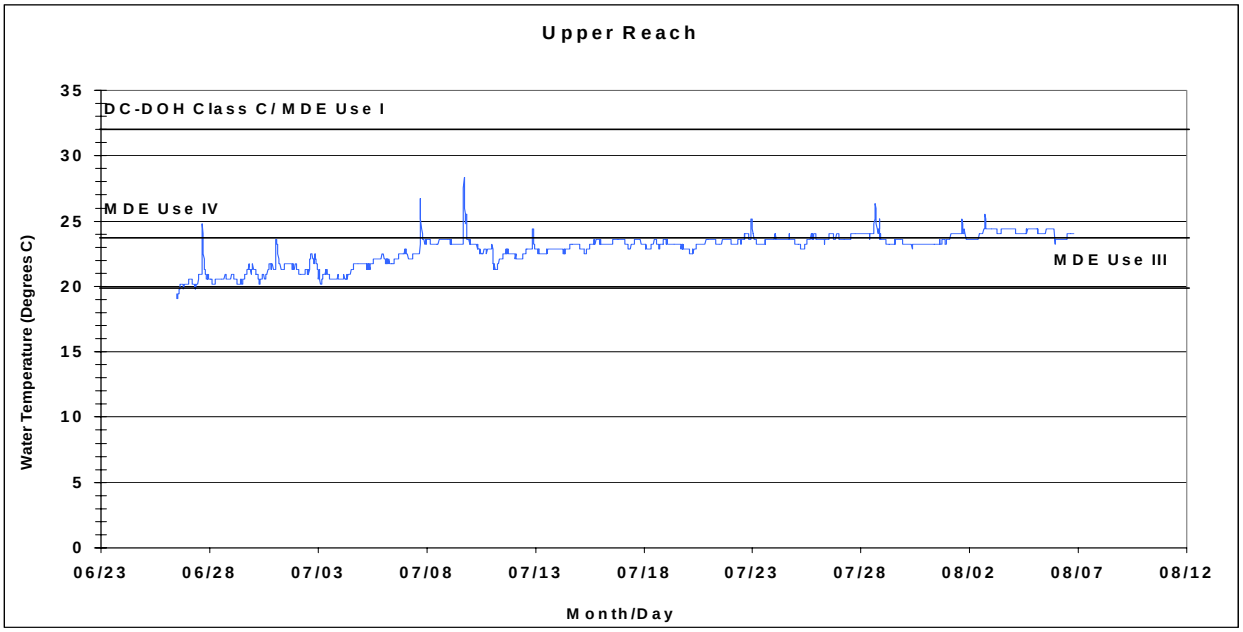
[4] Sinuosity Interpretation: Low = < 1.2; Moderate to High = > 1.2; Very High = > 1.5

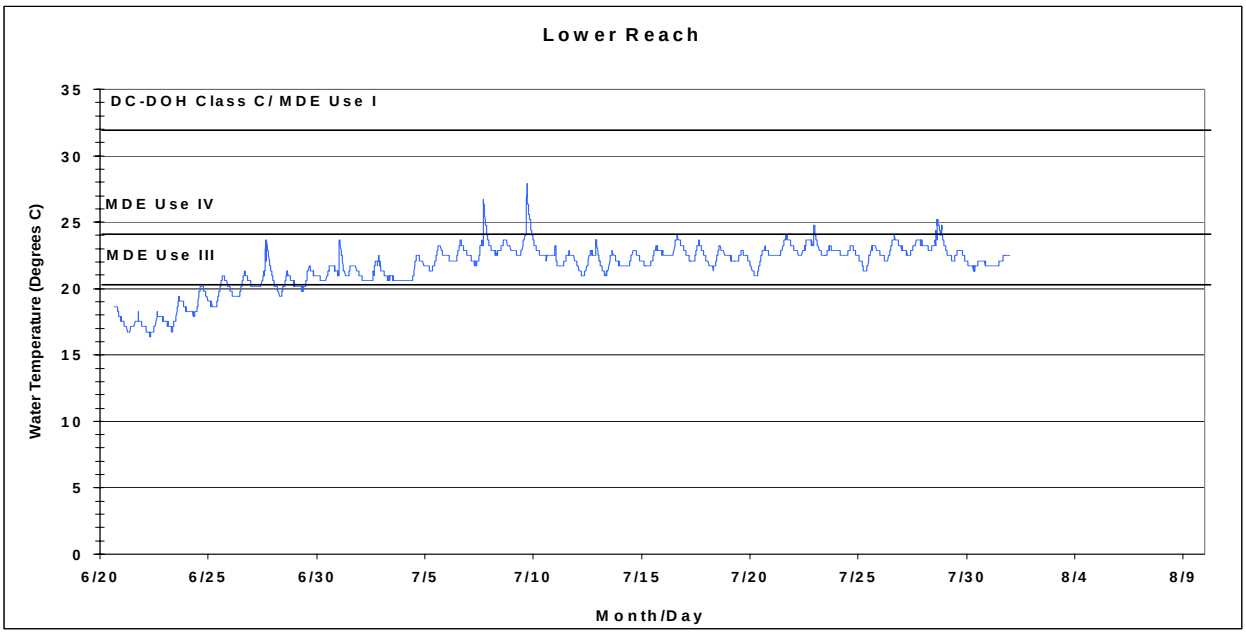
[5] Channel slope calculated from reach riffle-to-riffle measurements (Rosgen, 1996).

[6]

Substrate Class (AGI, 1982)	Very Fine Sand	Coarse Sand	Very Coarse Sand	Very Fine Gravel	Medium Gravel	Coarse Gravel	Very Coarse Gravel	Small Cobble	Large Cobble	Boulder	Bedrock
Size Range (mm)	0.06 – 0.13	1.00 – 1.31	1.01– 1.99	2.00 – 7.99	8.00 – 15.99	16.00 – 31.99	32.00 – 63.99	64.00 – 127.99	128.00 – 255.99	256.00 – 4095.99	>= 4096.00

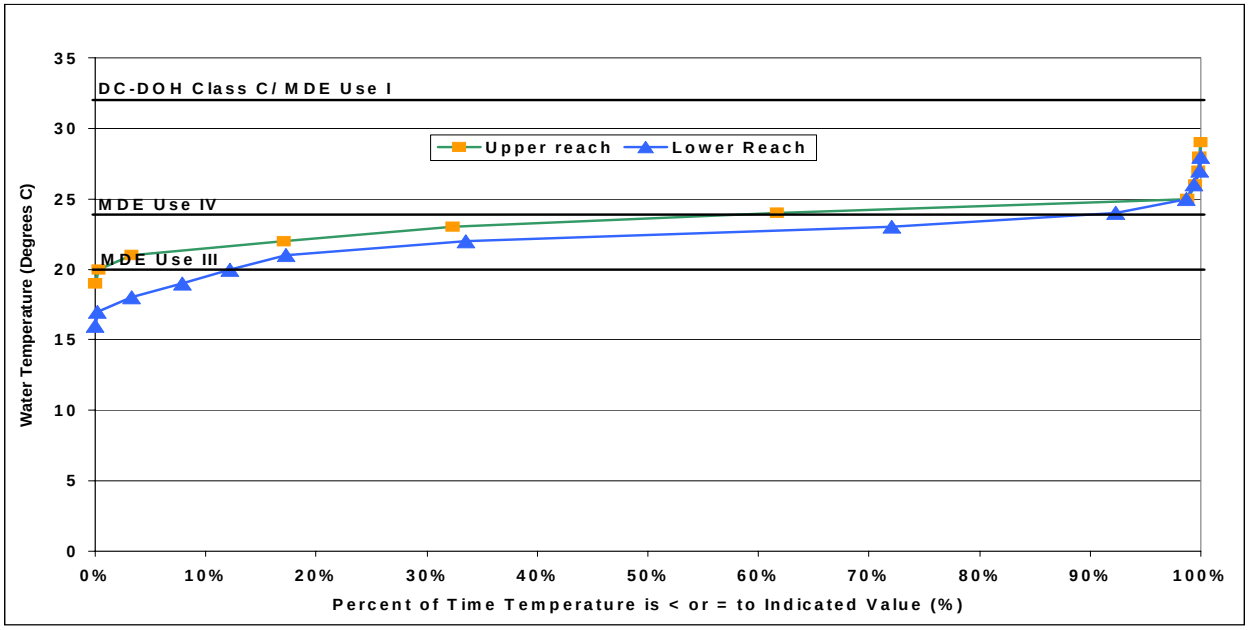
Figure 24 - Fort Chaplin - Upper And Lower Reaches Twenty-Minute Water Temperature Readings[1] (June 26-August 1, 2003)

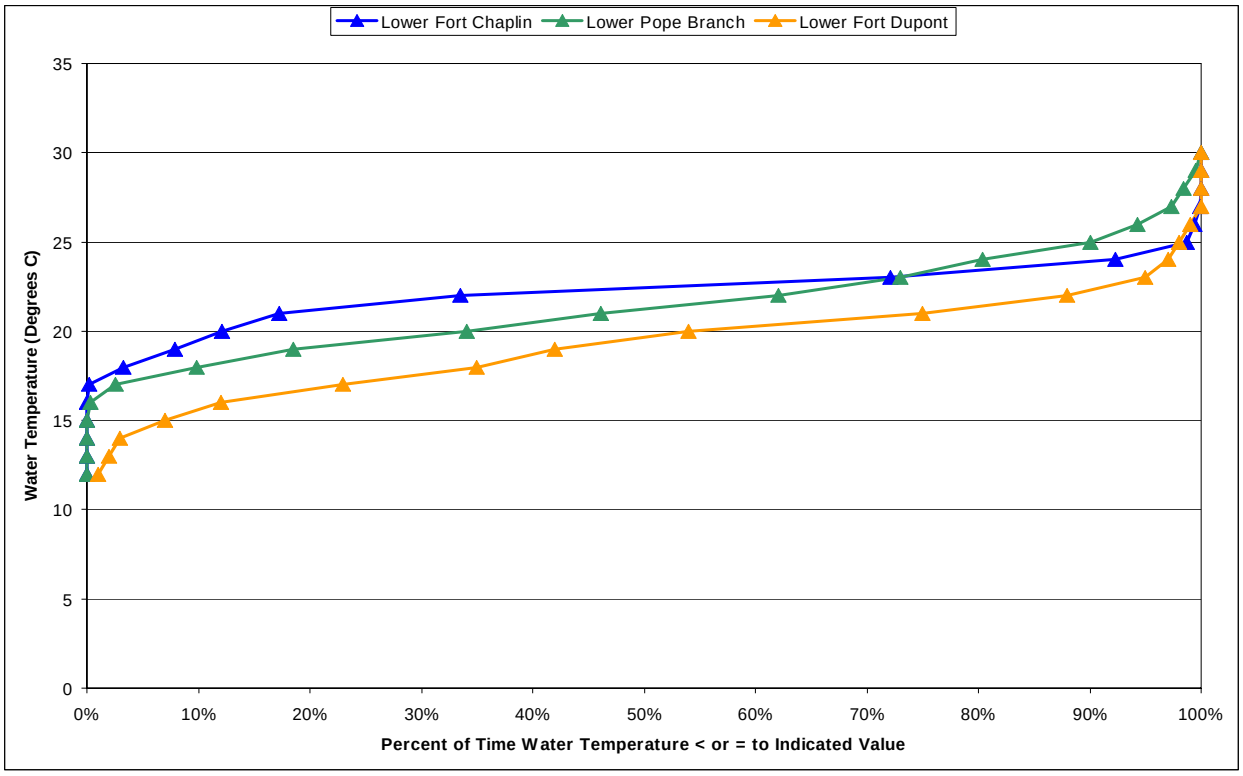




[1] DC-DOH Maximum Water Temperature Standards: Class-Protection and propagation of fish, shellfish and wildlife = 32.2°C. MDE Maximum Water Temperature Standards: Use I (water contact recreation, aquatic life and water supply) = 32°C; Use III (natural trout waters) = 20°C; Use IV (recreational trout waters) = 24°C.

Figure 25 - Fort Chaplin Water Temperature Distribution: Upper and Lower Reaches; Fort Chaplin Tributary, Pope Branch and Fort Dupont Tributary Lower Reaches

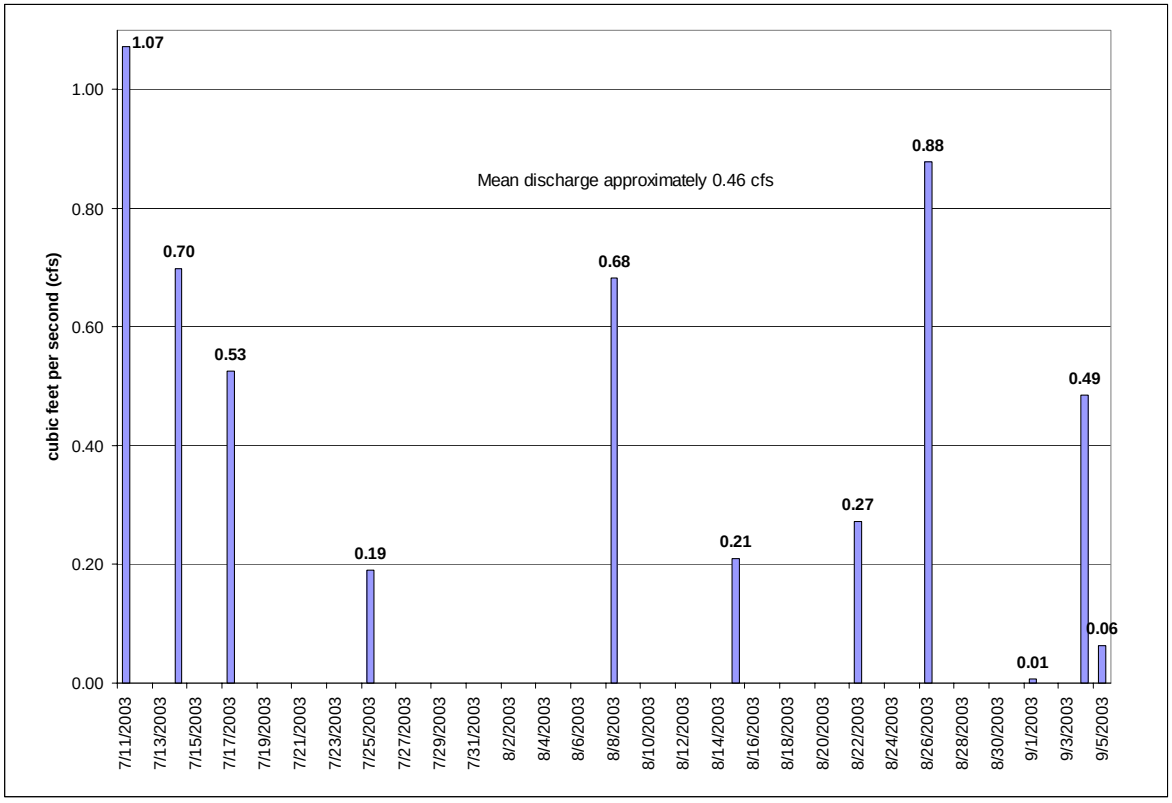




4.3 Baseflow Discharge

As previously indicated, between July 11th, 2003 and September 5th, 2004 COG staff took a total of 11 measurements at the Lower reach (X-9) baseflow monitoring station. Baseflow discharge results are summarized in Figure 26. As seen in Figure 26, Fort Chaplin maintained baseflow throughout the study period and mean baseflow was approximately 0.46 cfs. It should be noted that during the 2003, monthly precipitation was well above normal in 11 out of the 12 months.

Figure 26 - Baseflow Discharge - Lower Reach (Transect X-9)



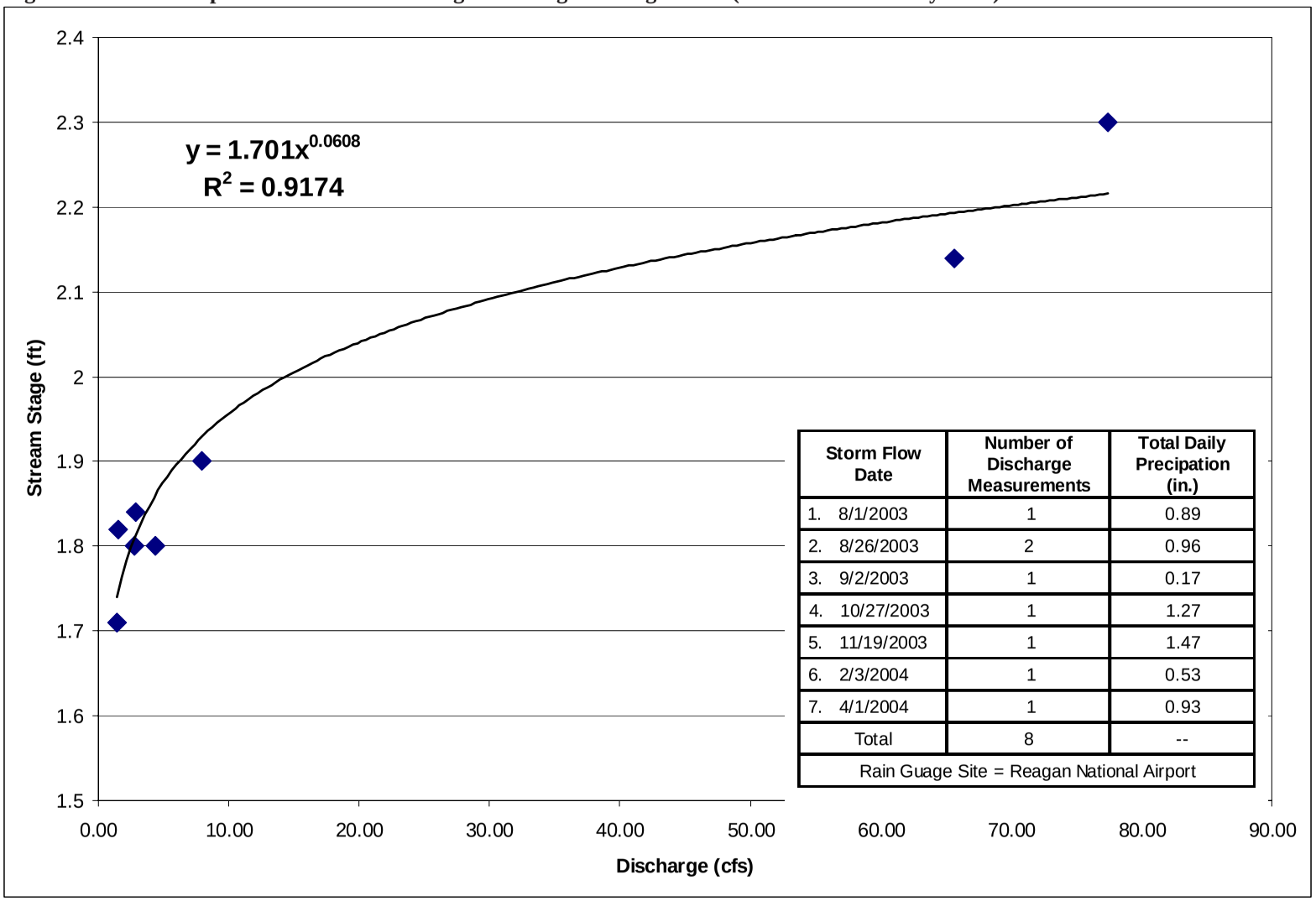
4.4 Lower Reach - Stage - Discharge Rating Curve and Stormflow Response

4.4.1 Rating Curve

In an effort to better predict stormflow discharges in Fort Chaplin, COG staff developed, as previously described, a stage-discharge rating curve (Figure 27). As shown in Figure 26, seven stormflow events (discharge measurements, total, taken during the ascending portion of the hydrograph) were used to generate the rating curve. In addition, using the "Rational Formula", COG staff conservatively calculated the approximate discharge levels for the following storm frequencies:

- weekly (0.25" rainfall/24 hours)= ~31.2 cfs;
- six month (1.65" rainfall/24 hours)= ~205.6 cfs;
- 1-year (2.60" rainfall/24 hours)= ~324.0 cfs;

Figure 27 - Fort Chaplin - Lower Reach - Stage-Discharge[1] Rating Curve (June 2002 - January 2003)



Storm Flow Date	Number of Discharge Measurements	Total Daily Precipation (in.)
1. 8/1/2003	1	0.89
2. 8/26/2003	2	0.96
3. 9/2/2003	1	0.17
4. 10/27/2003	1	1.27
5. 11/19/2003	1	1.47
6. 2/3/2004	1	0.53
7. 4/1/2004	1	0.93
Total	8	--
Rain Guage Site = Reagan National Airport		

[1] Discharge measurements were taken during the ascending limb of the storm hydrograph

Regarding Fort Chaplin's restoration potential, several key limiting factors must be kept in perspective. First, unlike the neighboring Fort Dupont Tributary which has several smaller feeder tributaries and hence, potential refugia areas for aquatic life, Fort Chaplin consists of one single stream channel. Consequently, Fort Chaplin's aquatic community is at far greater risk from toxic spills, leaking sewer/utility lines and other anthropogenic-related mishaps and insults. Second, imperviousness levels and related uncontrolled volumes of stormwater runoff in the Fort Chaplin subwatershed are both relatively high. The stormwater runoff problem is exacerbated by the presence of a network of piped storm drains, which convey runoff directly to the stream. Typical of a very urban subwatershed, the relatively short, open section of Fort Chaplin includes three major storm drain outfalls. Third, the low number of deep, high quality pools and presence of one major fish blockage greatly restricts fish restoration potential.

Among the priority stormwater runoff/storm drainage problem areas to consider for both future stormwater management and storm drain outfall retrofitting are the Texas Avenue (Figure 29) and the east and west 'D' Street sub-catchments. These drainage areas contribute significant volumes of uncontrolled runoff and pollutants to Fort Chaplin. Therefore, a comprehensive stream restoration approach which also includes major reconstruction of Fort Chaplin's stream channel morphology so as to better meet its altered urban stream flow and sediment transport regimes will also be required.

Figure 29 - Upper Reach - Texas Avenue Storm Drain Outfall (4'Hx8'W) Uncontrolled Runoff During a July 11, 2003 Afternoon Thunderstorm

Regarding the potential re-establishment of a Fort Chaplin fish community, the magnitude of the existing fish blockage makes fish reintroduction with native species the most cost-effective and viable option. While in COG staff's opinion, the perennial portion of the stream is presently capable of supporting pollution tolerant pioneer fish species such as blacknose dace, *Rhynicthys atratulus*, and northern creek chub, *Semotilus atromaculatus*, it would be premature to reintroduce these species given the existing scouring stormflows and suspected water quality-related problems. Based on its stream size and direct connection with the tidal Anacostia River, it is estimated that Fort Chaplin may have historically supported 6 to 10 resident fish species. Although no historical fisheries data specific to the Fort Chaplin are known to exist, the list of fishes collected in neighboring Oxon run in 1920 (Table 18) provides both valuable historical insight, as well as potential candidate species for future reintroduction.

- 2-year (3.20" rainfall/24 hours)= ~398.8 cfs; and
- 5-year (4.20" rainfall/24 hours)= ~523.4 cfs.

The preceding results should be of interest for future detailed Fort Chaplin hydraulic geometry, sediment transport, stormwater management, and storm drainage and/or stream restoration evaluations.

4.4.2 Stormflow Response

As is the case with most small urban streams, flows in the Fort Chaplin responded quickly and often unpredictably to small rainfall events. For example, the relatively steady 0.32-inch rainfall on September 3, 2003 resulted in a 0.34-foot increase in stage and a discharge of approximately 2.44 cfs. In contrast, runoff associated with the shorter, more intense 0.39-inch storm on August 10, 2003 produced both a 0.71-foot increase in stage and a discharge of approximately 171 cfs (which is approximately 371 times higher than the mean baseflow discharge).

During the study, COG staff also observed that stormwater runoff associated with even small, 0.15 inch rainfall events was sufficient to move the gravel-sized materials in the Fort Chaplin streambed materials in the. It was additionally noted that runoff from approximately 0.80 inch storms displaced cobble-sized materials in Fort Chaplin; whereas, 1.00 inch storm events produced similar results in neighboring Fort Dupont.

Figure 28 - Lower Reach - Severe Channel Erosion

5.0 Discussion

The results of this study generally support the findings from previous investigations (Johnson, 1989; Banta, 1993) that the Fort Chaplin biological community is severely impaired. Not surprisingly, decades of uncontrolled stormwater runoff in combination with poor water quality (i.e., possible leaking sewer/utility lines) and channel alterations have: 1) created a characteristically 'flashy', urban stream flow regime; 2) modified channel morphology and increased levels of stream channel erosion (Figure 28); 3) exposed a utility line; 4) increased stormflow levels of sediment and various other pollutants; 5) reduced both streambed stability and physical aquatic habitat quality; 6) resulted in the enclosure of 5,100 linear feet of the stream system; and 7) eliminated all resident fishes from the stream.

Even though Fort Chaplin continues to support a macroinvertebrate community with 23 total taxa, it is not surprising that pollution intolerant stoneflies, flathead mayflies and cased caddisflies have long since been eliminated from the stream. Individuals that were collected represent the pollution tolerant groups, only. In fact, only extremely low numbers of pollution tolerant Hydropsychid caddisflies currently remain.

Table 18 - Potential Candidate Fish Species for Fort Chaplin Tributary Reintroduction

Fishes Collected in Oxon Run, 1920 [1]		Origin	Trophic Level	Suitable Volume Flow (cfs)[2]	Adult Habitat	Spawning Strategy	Pollution Tolerance
1.	American Brook Lamprey	Native	Herbivore	No preferred flow	All	Open Substratum	Intolerant
2.	Blacknose Dace	Native	Generalist	0.1 - 5.97	All	Open Substratum	Tolerant
3.	Northern Creek Chub	Native	Generalist	0.1 - 7.89	Pool/Run	Nest Builder	Tolerant
4.	Fallfish	Native	Generalist	1.61 - 21.07	Pool/Run	Nest Builder	Tolerant
5.	White sucker	Native	Omnivore	1.84 - 68.0	Pool/Run	Open Substratum	Tolerant
6.	Northern Hogsucker	Native	Insectivore	1.99 - 39.8	Riffle/Run	Open Substratum	Intolerant
7.	Creek Chubsucker	Native	Invertivore	Larger streams	Pool	Open Substratum	------
8.	Bluntnose Minnow	Native	Omnivore	0.4 - 39.8	Pool/Run	Nest Builder - Guarded	Tolerant
9.	Rosyside Dace	Native	Insectivore	0.1 - 4.96	Pool	Open Substratum	Intolerant
10.	Swallowtail Shiner	Native	Omnivore	0.299 - 68.0	Pool/Run	Crevice Spawner	Tolerant
11.	Satinfin Shiner	Native	Omnivore	0.299 - 40.0	Pool/Run	Open Substratum	Tolerant
12.	Common Shiner	Native	Omnivore	2.58 - 40.79	Pool/Run	Open Substratum	Intermediate
13.	Steelcolor Shiner	Native	Insectivore	Larger streams	Run/Pool	Crevice Spawner	------
14.	Golden Shiner	Native	Omnivore	No preferred flow	Pool	Open Substratum	Tolerant
15.	Eastern Silvery Minnow	Native	Herbivore	Larger streams	Pool/Run	Open Substratum	Tolerant
16.	Silverjaw Minnow	Native	Insectivore	0.7 - 50.7	Pool/Run	Open Substratum	Intermediate
17.	Cutlips Minnow	Native	Omnivore	0.1 - 68.0	Pool/Run	Nest Builder	Intermediate
18.	American Eel	Native	Piscivore	10.04 - 68.0	Pool/Run	Ocean Spawner	Intermediate
19.	Banded Killifish	Native	Invertivore	>= 3.6	Pool/Run	Open Substratum	Tolerant
20.	Redbreast Sunfish	Native	Invertivore	No preferred flow	Pool	Nest Builder - Guarded	Tolerant
21.	Pumpkinseed Sunfish	Native	Invertivore	No preferred flow	Pool	Nest Builder - Guarded	Tolerant
22.	Largemouth Bass	Introduced	Piscivore	No preferred flow	Pool	Nest Builder - Guarded	Tolerant
23.	Tesselated Darter	Native	Insectivore	0.1 - 68.0	Pool/Run	Nest Builder - Guarded	Tolerant

[1] Breder, C.M. and D.R. Crawford, 1922. The Food of Certain Minnows. Zoologica (2): 287-327.
[2] Tsai, C. and M.L. Wiley, 1983. Instream Flow Requirements for Fish and Fisheries in Maryland. Maryland Water Resources Research Center, College Park, MD. 90pp.

6.0 Recommendations

In an effort to comprehensively address both existing problems and restoration opportunities for Fort Chaplin, COG staff developed the following suite of recommendations. Importantly, it is understood that the comprehensive restoration of Fort Chaplin is dependent upon District of Columbia Depratment of Health/ Environmental Health Administration (DC-DOH/EHA), the U.S. Army Corps of Engineers (USACE), District of Columbia - Water and Sewer Authority (DC-WASA), National Park Service (NPS), District of Columbia Department of Public Works (DC-DPW), and District of Columbia Office of Planning (DC-OP) and the local community working together to pursue a variety of stormwater management, storm drainage, and stream restoration options which will significantly reduce erosive stormflows, improve water quality and enhance aquatic and terrestrial habitat conditions throughout the subwatershed. Therefore, COG staff suggest that those agencies responsible for current and/or planned future Fort Chaplin restoration-related activities, carefully review the more specific recommendations which follow:

1) DC-DOH/EHA, DC-WASA and NPS should continue to work together to pursue stormwater control options, which will significantly reduce erosive stormflow conditions and improve water quality in the Fort Chaplin mainstem for the following storm drain systems:

   • Texas Avenue storm drain system - An in-line flow splitting weir to separate erosive stormflow and convey it, for approximately 1,900 feet to 'C' Street, via a parallel pipe located along the left hand bank;

   • East 'D' Street storm drain system - Disconnect the 27" RCP from directly discharging into the stream and connect this pipe into the proposed parallel pipe system; and

   • West 'D' Street storm drain system - An in-line flow splitting weir to separate erosive stormflow and convey it, for approximately 700 feet to 'C' Street, via a parallel pipe located along the right hand bank.

2) At a minimum, the two following storm drain system outfall locations are either in need of major repair and/or the installation of more effective velocity dissipation feature (i.e., east and west 'D' Street outfalls).

3) Given the major technical, institutional and financial challenges associated with the implementation of subwatershed-wide, stormwater management controls which significantly reduce runoff volumes entering Fort Chaplin, a Rosgen-based stream channel restoration project for the entire length of open channel (i.e., approximately 1,900 feet) is recommended.

4) DC-WASA should conduct a Fort Chaplin watershed sewer line integrity evaluation.

5) To the greatest practical extent, the employment of various stormwater management water quality control techniques (such as, but not limited to: Low Impact Development (LID), DC-DOH/EHA approved water quality inserts and inlets, sand filters, porous pavement, green roofs, etc.) are needed throughout the Fort Chaplin subwatershed. This is especially true for the watershed area above Texas Avenue.

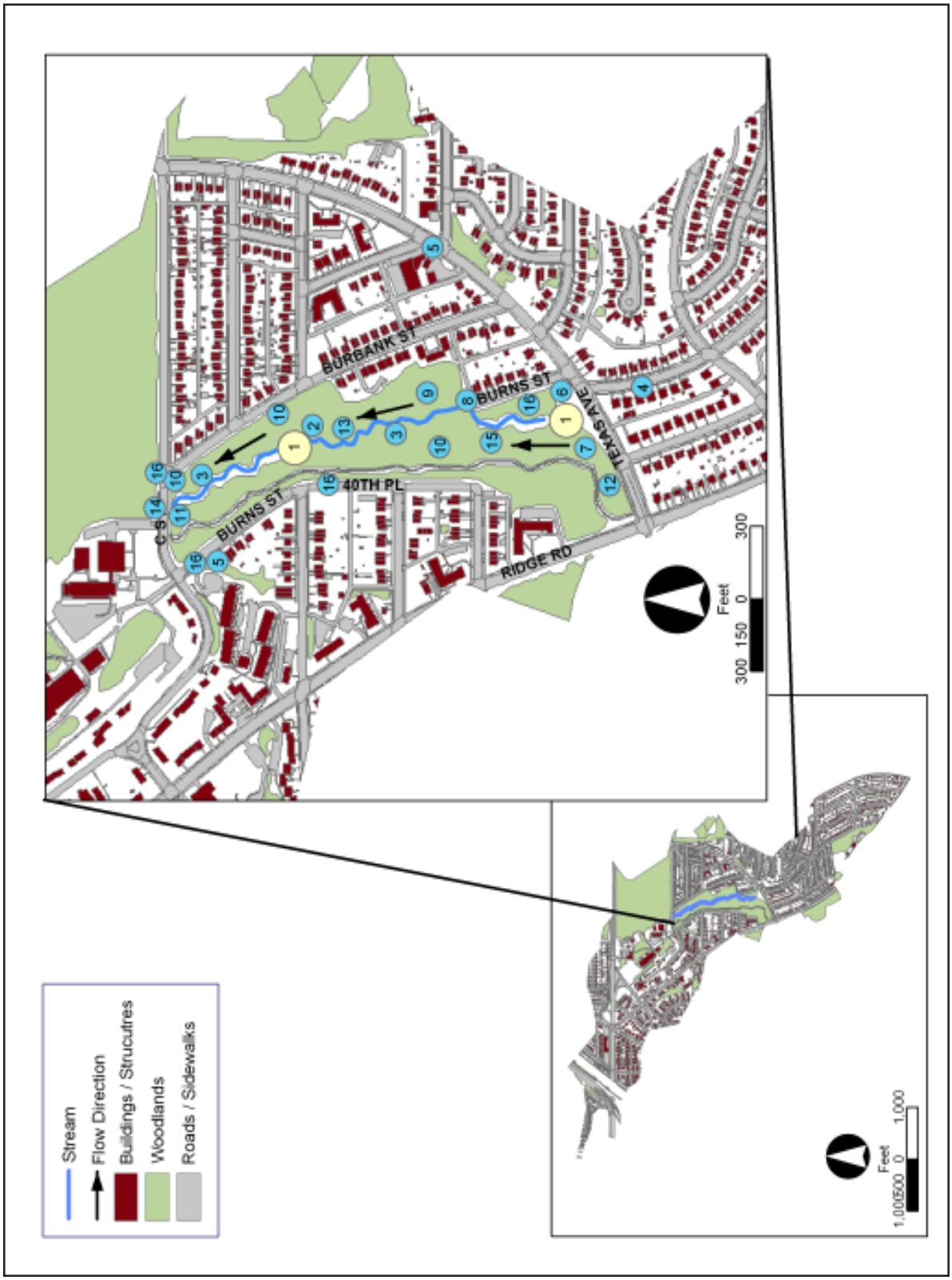


Figure 30 - Fort Chaplin Tributary - Project Recommendation Sites

6) To address the high trash conditions within the stream channel, investigate the possibility for the employment of either of an in-line or end of the pipe trash collection device (e.g., Fresh Creek Trash Netting System, or equivalent) within the Texas Avenue storm drain system.

7) Create one or more vernal pools for amphibian habitat in the following general area: Upper Reach (immediately below Texas Avenue) - excavate to deepen the existing vernal pools along the left hand bank (Figure 31). Note: several of these vernal pool sites can be excavated by hand using Earth Conservation Corps or other local volunteer labor. Also, in all likelihood the reintroduction of native amphibians such as spotted salamanders (*Ambystoma maculatum*), wood frogs (*Rana sylvatica*) and spring peepers (*Hyla crucifer*) will require the physical transplantation of eggs and/or larvae from other Anacostia sites.

Figure 31 - Upper Reach (Texas Avenue Area) - Wetland Enhancement Habitat Area

8) The concrete/asphalt slab filled slope located along the right hand bank near the Upper Reach X-2 area is exhibiting signs of localized slope failure (Figure 32). In COG staff's opinion, a geotechnical study should be undertaken of this area to determine its potential long-term stability.

9) The loamy clay-filled slope located along the right hand bank near the Upper Reach X-3 area is exhibiting signs of localized slope failure. In COG staff's opinion, a geotechnical study should also be undertaken of this area to determine its potential long-term stability.

10) A community-based clean up of trash and debris from the entire Fort Chaplin stream valley park system is needed. Major trash/ dump sites include the stream valley park property that abuts 40th Place, 'C' Street and Burbank Street.

11) Appropriate "No Dumping" signage along 'C' Street, which compliments, existing signs along Burns and Burbank Streets and 40th Place is recommended. In addition, the stenciling of all storm drain inlets

Figure 32 - Upper Reach - Right Bank Slope Failure Area

in the Fort Chaplin subwatershed with a "No Dumping - Drains to Fort Chaplin tributary" message should be made a high priority.

12) A volunteer-based exotic/invasive plant management initiative modeled after Montgomery County's "Weed Warrior" program should be seriously considered for the Fort Chaplin stream valley park system. Specifically, the left hand bank area immediately below Texas Avenue has been identified by COG staff as a high priority area, as both English ivy and Euonymus sp. vines cover both the forest floor and the mature hardwood trees present (Figure 33).

13) Based on recent success in the neighboring Fort Dupont Tributary, reintroduce native fishes (after the scouring stormflow, physical aquatic habitat and poor water quality problems have been satisfactorily addressed) into Fort Chaplin. The recommended species and approach are described below:

Figure 33 - Upper Reach - Recommended Exotic/Invasive Removal Area

• Using COG's previous stream restoration experience in the Anacostia's Sligo Creek subwatershed and Table 17 as reference, the following six pollution tolerant species should be considered for reintroduction: blacknose dace (*Rhinichthys atratulus*), northern creek *chub (Semotilus atromaculatus*), white sucker (*Catostomus commersoni*), tessellated darter (*Etheostoma olmstedi*), swallowtail shiner (*Notropis procne*) and satinfin shiner (*Notropis analostanus*). The preceding species may be easily collected in good numbers from various Anacostia streams, including the Northeast and Northwest Branches, Lower Beaverdam Creek, Watts Branch, etc.

• Stocking should be phased, with the hardiest pioneer species, such as the blacknose dace and northern creek chub, being introduced first. As a rough stocking density guide, COG staff recommend that approximately 10-12 blacknose dace and two to four northern creek chub individuals be stocked per high quality pool (i.e., approximately 120-150 blacknose dace and 25-35 northern creek chubs, total). If the two preceding species survive as expected, then the four remaining recommended species should be reintroduced; with white suckers being introduced last and only after overall post restoration physical aquatic habitat conditions have markedly improved. Additional future stockings beyond the recommended six target species should only occur after both stream restoration and stormwater retrofitting work have been completed and monitoring results indicate a recovering stream system.

14) DC-DOH/EHA should continue to work with the DC-Department of Public Works to maintain a relative trash/debris free rack at 'C' Street (Figure 34).

15) Continue physical, chemical and biological monitoring of Fort Chaplin so as to evaluate stream recovery following completion of restoration projects.

16) COG staff recommends that the established District of Columbia's 'Adopt a Block 'neighborhood clean streets program (Figure 35) be expanded to include Burns and 'C' Streets, as well as 40th Place.

Figure 34 - Lower Reach - 'C' Street 48" RCP - Debris/Trash Filled Rack

Figure 35 - Middle Reach - Burbank Street "Adopt A Block" Signage

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FORT CHAPLIN

APPENDICES

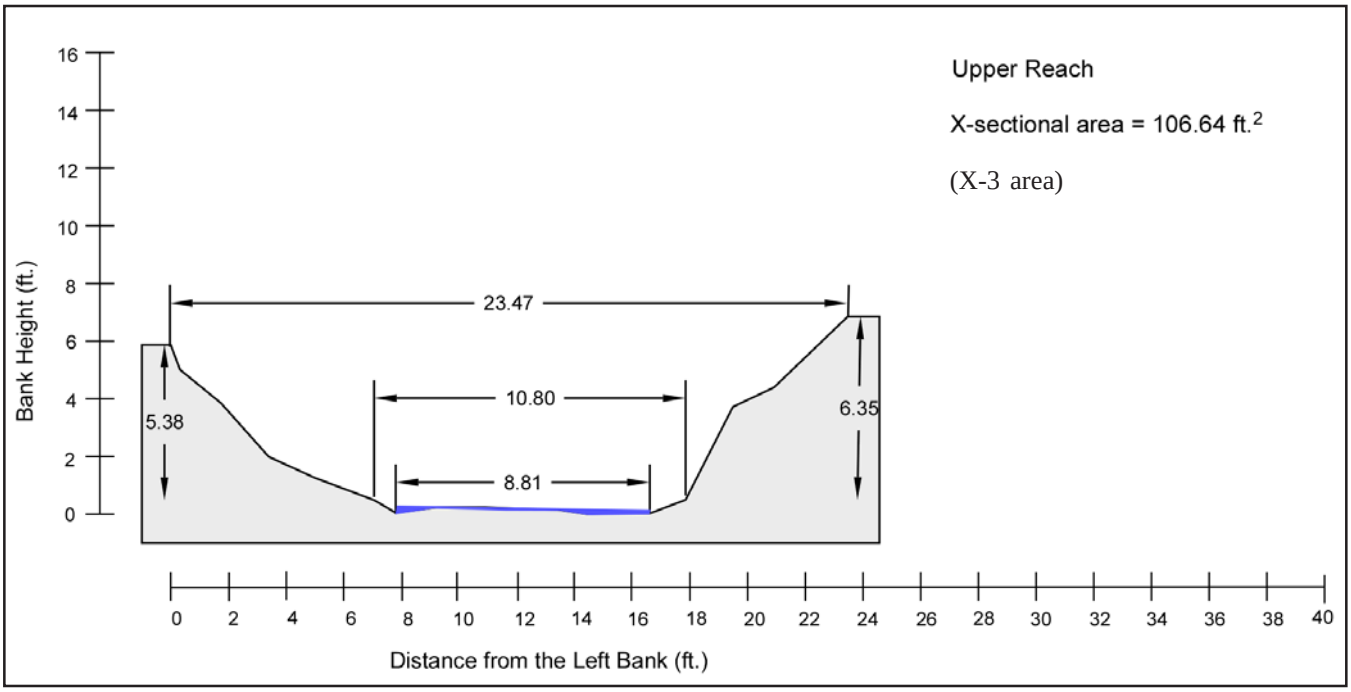
Appendix 1

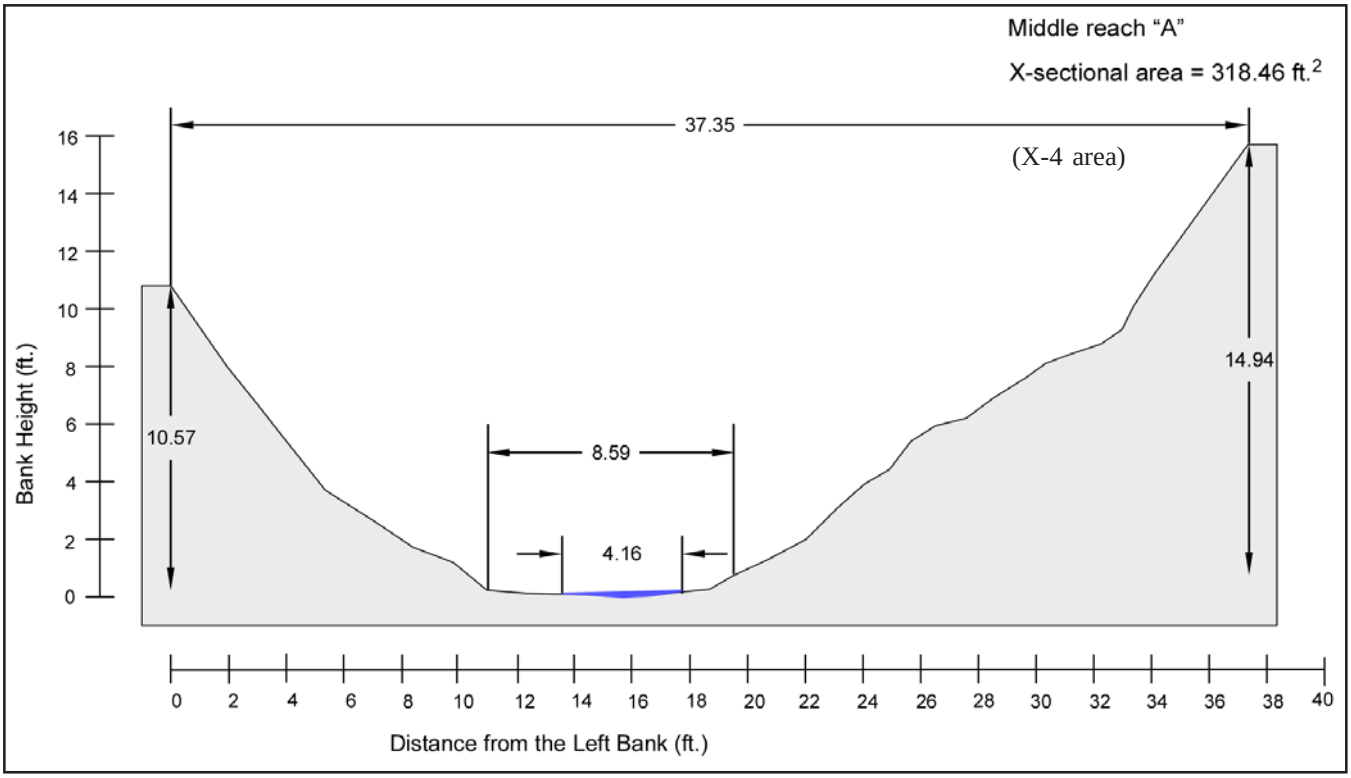
Table 1 - Fort Chaplin - Corresponding Latitude and Longitude Coordinates for RSAT Transects

Transect Number	Latitude	Longitude
Fort Chaplin Upper Mainstem		
X-1	38.88226	-76.94433
X-2	38.88281	-76.94427
X-3	38.88327	-76.94410
Fort Chaplin Middle Mainstem		
X-4	38.88380	-76.94426
X-5	38.88423	-76.94442
X-6	38.88464	-76.94452
Fort Chaplin Lower Mainstem		
X-7	38.88504	-76.94457
X-8	38.88583	-76.94508
X-9	38.88625	-76.94535

Appendix 2

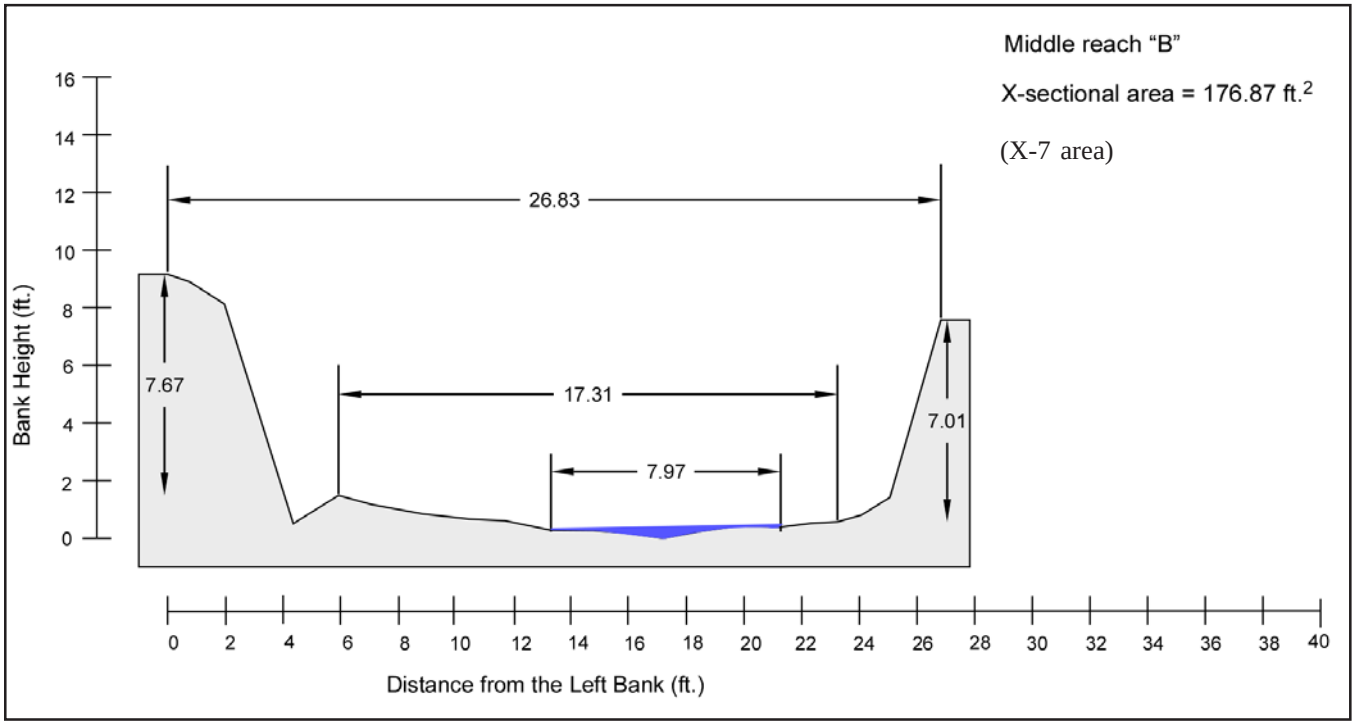
Figure 1 - Fort Chaplin - Permanent Channel Cross Sections[1]

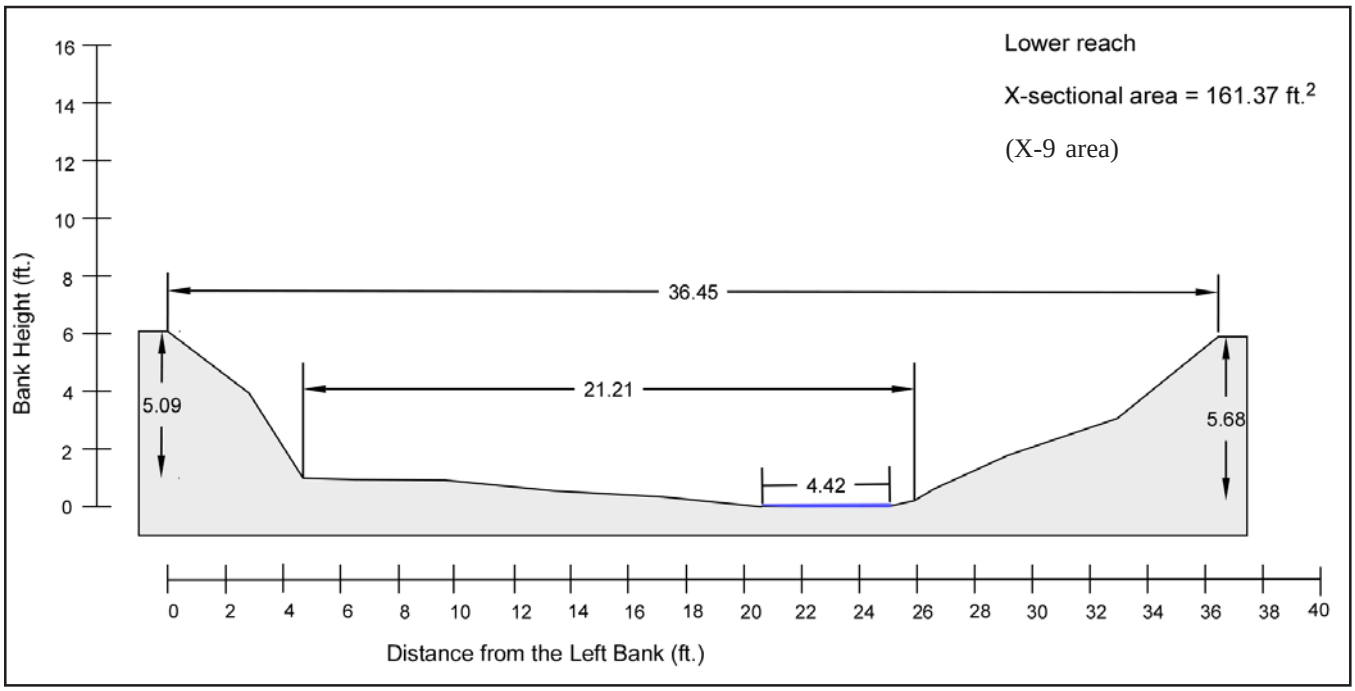




[1] Top Channel width, bottom channel width, and wetted perimeter (heavy blue line) area depicted.

Figure 1: Continued[1]





[1] Top Channel width, bottom channel width, and wetted perimeter (heavy blue line) area depicted.

Appendix 3

Table 1 - Fort Chaplin - RSAT Field Data

Stream: Fort Chaplin **Survey Date: 2/19-20/04**
Reach: Upper

Transect No.	Top Channel Width	Bottom Channel Width	Wetted Perimeter	Mean Riffle Depth	Mean Bank Height R	Mean Bank Height L	Mean Bank Stability R & L	Bank Material Type	Bank Material Type	Riffle Substrate Material Comp.	Mean Riffle Embedd-edness	Mean Substrate Fouling Level	Riparian Veg. Type	Riparian Veg. Type	Buffer Width R	Buffer Width L	Max. Pool Depth	Pool Habitat Quality Score	Time	Air Temp.	Water Temp.	DO	pH	TDS	Cond	Turb	Nitrate-Nitrogen	F-	Phosphate
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	%	R	L		%	%	R	L	(ft)	(ft)	(ft)			C	C	(mg/L)		(mg/L)	(ms/cm)	(NTU)	(mg/L)	(mg/L)	(mg/L)
X-1	36.9	12.9	4.7	1.5	13.4	12.5	68	SL/S	SL/CL	GCSB	20	65	F	F	142	200	1.2	2											
X-2	28.9	7.5	3.2	1.5	7.5	11.4	63	SL/S	L/CL	GSCB	50	65	F	F	24.25	200	1.5	3	14:05	10.9	8.7	12.01	-	610	0.579	7	4	0.35	0.24
X-3	22.8	10.3	6.4	1.0	5.5	5.8	65	L/CL	SL/S	GSCB	60	53	F	F	200	200	2.3	5											
Average	**29.5**	**10.2**	**4.8**	**1.3**	**8.8**	**9.9**	**65.0**	-	-	-	**43.3**	**61.0**	-	-	**122.1**	**200.0**	**1.6**	**3.3**											

Stream: Fort Chaplin **Survey Date: 2/19-20/04**
Reach: Middle

Transect No.	Top Channel Width	Bottom Channel Width	Wetted Perimeter	Mean Riffle Depth	Mean Bank Height R	Mean Bank Height L	Mean Bank Stability R & L	Bank Material Type	Bank Material Type	Riffle Substrate Material Comp.	Mean Riffle Embedd-edness	Mean Substrate Fouling Level	Riparian Veg. Type	Riparian Veg. Type	Buffer Width R	Buffer Width L	Max. Pool Depth	Pool Habitat Quality Score	Time	Air Temp.	Water Temp.	DO	pH	TDS	Cond	Turb	Nitrate-Nitrogen	F-	Phosphate
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	%	R	L		%	%	R	L	(ft)	(ft)	(ft)			C	C	(mg/L)		(mg/L)	(ms/cm)	(NTU)	(mg/L)	(mg/L)	(mg/L)
X-4	25.2	12.5	3.4	1.8	14.5	9.5	62	SL/S	CL/S	GSCRB	70	80	F	F	190	200	1.1	1											
X-5	41.1	18.0	8.1	0.8	12.15	12.8	60	SL/S	S/CL	SCGR	75	65	F	F	200	200	1.0	1											
X-6	30.5	10.8	8.2	0.1	10.01	10.07	54	L/S	SL/S	GCSR	50	50	F	F	200	150	1.6	3											
Average	**32.3**	**13.8**	**6.6**	**0.9**	**12.2**	**10.8**	**58.5**	-	-	-	**65.0**	**65.0**	-	-	**196.7**	**183.3**	**1.2**	**1.7**											

Stream: Fort Chaplin **Survey Date: 2/19-20/04**
Reach: Lower

Transect No.	Top Channel Width	Bottom Channel Width	Wetted Perimeter	Mean Riffle Depth	Mean Bank Height R	Mean Bank Height L	Mean Bank Stability R & L	Bank Material Type	Bank Material Type	Riffle Substrate Material Comp.	Mean Riffle Embedd-edness	Mean Substrate Fouling Level	Riparian Veg. Type	Riparian Veg. Type	Buffer Width R	Buffer Width L	Max. Pool Depth	Pool Habitat Quality Score	Time	Air Temp.	Water Temp.	DO	pH	TDS	Cond	Turb	Nitrate-Nitrogen	F-	Phosphate
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	%	R	L		%	%	R	L	(ft)	(ft)	(ft)			C	C	(mg/L)		(mg/L)	(ms/cm)	(NTU)	(mg/L)	(mg/L)	(mg/L)
X-7	36.4	16.7	6.0	1.2	9.91	7.57	58	SL/S	CL/SL	GCSR	20	75	F	F	200	150	1.3	2											
X-8	29.8	18.8	4.5	0.8	5.28	7.05	63	L/S	SL/S	GCSB	15	80	F	F	100	122	1.4	2											
X-9	35.0	10.4	5.2	3.0	7.5	5.6	40	SL	SL	SGC	100	80	F	F	91	146	0.0	1	13:50	21:36	8	11.93	5.4	600	0.566	7	4.4	0.32	0.42
Average	**33.7**	**15.3**	**5.2**	**1.7**	**7.6**	**6.7**	**53.3**	-	-	-	**45.0**	**78.3**	-	-	**130.3**	**139.3**	**0.9**	**1.7**	-	-	-	-	-	-	-	-			

Appendix 4

Table 1 - Fort Chaplin - Macroinvertebrate 20-Jabs (~2m^2) Feeding Functional Group and Pollution Tolerance Values (Spring and Fall 2002, and Spring 2003 and 2004)

Order	Taxa	Common Name	Pollution Tolerance[1]	Functional Feeding Group[2]
Trichoptera	1. Hydropsychidae	Caddisfly	6	Filterer
Zygoptera	2. Zygoptera	Damselfly	6	Predator
Coleoptera	3. Dytiscidae	Beetle	5	Predator
Diptera	4. Aedes sp.	Mosquito	8	Collector
	5. Chaoborus sp.	Phantom Midges	8	Predator
	6. Chironomidae	Midge	6	Collector
	7. Chironomini	Midge	6	Collector
	8. Chrysogaster sp.	Rattail Maggot	10	Collector
	9. Orthocladiinae	Midge	5	Collector
	10. Phoridae	Scuttlefly	5	Predator
	11. Tanypodinae	Midge	7	Predator
	12. Tipulidae	Caddisfly	6	Shredder
Amphipoda	13. Gammeridae	Scud	6	Shredder
Gastropoda	14. Fossaria sp.	Snail	8	Scraper
	15. Physella vernalis	Snail	8	Scraper
	16. Physidae	Snail	8	Scraper
	17. Physella sp.	Snail	8	Scraper
Lepidoptera	18. Acentria acentropus	Aquatic Butterfly	6	Shredder
	19. Pyralidae	Aquatic Butterfly	6	Shredder
Isopoda	20. Asellidae	Sowbug	8	Collector
	21. Asellus sp.	Sowbug	8	Collector
Hirudinea	22. Hirudinea	Leech	10	Predator
Oligochaeta	23. Oligochaeta	Aquatic Worm	10	Collector

[1] A number assigned to an individual or its group describing the degree to which that individual or group tolerates organic pollution.
[2] Feeding adaptations that classify the nutritional processing method performed by different aquatic insects (Merritt and Cummins 1984).

Table 2 - Fort Chaplin - Macroinvertebrate RSAT Voucher Collection - Relative Abundance[1] (May, 2004)

Order	Taxa	Common Name	Tolerance Value[2]	RSAT Voucher
Trichoptera	1. Hydropsychidae	Caddisfly	B	1
Zygoptera	2. Zygoptera	Damselfly	B	1
Diptera	3. Chironomini	Midge	B	1
	4. Chrysogaster sp.	Rattail Maggot	C	1
	5. Orthocladiinae	Midge	B	3
	6. Tanypodinae	Midge	B/C	1
Amphipoda	7. Gammeridae	Scud	B	1
Isopoda	8. Asellidae	Sowbug	B/C	1
Oligochaeta	9. Oligochaeta	Aquatic Worm	C	2
	Total Taxa			**9**

[1] Relative abundance scores were averaged for each mainstem reach. Relative abundance interpretation: 0.1-0.9 = Scarce, 1.0-2.0 = Scarce/Common, 2.1-3.0 = Common, 3.1-4.0 = Common/Abundant, 4.1-5.0 = Abundant.
[2] Pollution Tolerance Rating: A = Intolerant, B = Moderately Tolerant, C = Tolerant

Table 3 - Fort Chaplin and Fort Dupont - Number of Individuals Macroinvertebrates 20-Jabs (~2m^2)

Order	Taxa	Tolerance Value	Common Name	Collection Season											
				Fort Chaplin						Fort Dupont					
				Upper			Lower			Middle Mainstem			Trib #2		
				F 02	S 03	S 04	F 02	S 03	S 04	F 02	S 03	S 04	F 02	S 03	S 04
Plecoptera	1. Amphinemura sp.	A/B	Stonefly									66			118
Trichoptera	2. Ptilostomus sp.	B	Caddisfly										1		
Megaloptera	3. Nigronia sp.	A	Alderfly								2				
	4. Sialis sp.	B	Fishfly										5		
Odonata	5. Calopteryx sp.	B	Damselfly									3			
	6. Cordulegaster sp.	A/B	Dragonfly											1	
	7. Erythemis sp.	B/C	Dragonfly								1				
Zygoptera	8. Zygoptera	B	Beetle			3									
Coleoptera	9. Agabus sp.	B	Beetle							1			2	1	
	10. Dytiscidae	B	Beetle			1									
	11. Hydaticus sp.	B	Beetle									3			6
	12. Hydrobius sp.	B	Beetle							1	1				
	13. Hydroporus sp.	B	Beetle										6	2	
	14. Uvarus sp.	B	Beetle												2
Diptera	15. Aedes sp.	B/C	Mosquito						2						
	16. Chaoborus sp.	B/C	Phantom Midges						1						
	17. Chironomidae	B	Midge			1									
	18. Chironomini	B	Midge			3			5	1		20	4	4	
	19. Dicranota sp.	B	Cranefly												2
	20. Ormosia sp.	B	Cranefly							1		1	2		
	21. Orthocladiinae	B	Midge			13				48	1		60	6	4
	22. Pericoma sp.	B	Mothfly									1			
	23. Phoridae	B	Scuttlefly				1								
	24. Simulium sp.	B/C	Blackfly								1			28	
	25. Tanypodinae	B/C	Midge						3				7	1	
	26. Tanytarsini	B	Midge										1		
	27. Tipula sp.	B	Cranefly							24	4	6	102	19	2
	28. Tipulidae	B	Cranefly	1										1	
	29. Bittacormorpha sp.	C	False Cranefly									1			
Amphipoda	30. Crangonyx sp.	B	Dobsonfly											10	
	31. Gammarus sp.	B	Scud								4				
Gastropoda	32. Physella sp.	B	Scuttlefly	1											
	33. Physella vernalis	B/C	Snail				1								
Lepidoptera	34. Acentria acentropus	B	Aquatic Butterfly				1								
	35. Pyralidae	B	Aquatic Butterfly						5			1			
Isopoda	36. Asellus sp.	B/C	Sowbug	3											
	37. Gammarus sp.	B	Scud										8		
Mollusca	38. Fossaria sp.	B/C	Snail	1											
	39. Physidae	B/C	Snail						1						
Decapoda	40. Cambaridae	B	Crayfish										1		
Hirudinea	41. Hirudinea	C	Leech	3			2	6	6						
Oligochaeta	42. Oligochaeta	C	Aquatic Worm	29	1	1	24	14	32	8	4	3	30	7	5
			Total	**38**	**1**	**22**	**29**	**20**	**55**	**84**	**18**	**105**	**229**	**80**	**139**

Note: F = Fall Season and S = Spring Season

[1] Pollution Tolerance Rating: A = Intolerant, B = Moderately Tolerant, C = Tolerant
Note: A blank cell indicates the macroinvertebrate group was not found during 20-jab sampling.

Appendix 5

Table 1. Summary: Fort Chaplin – Instantaneous Baseflow Water Chemistry (July 2003-May 2004)

Sample Site	Date	Air Temp C	Water Temp C	DO (mg/L)	pH	TDS (mg/L)	Cond. (uS/cm)	Turb. (NTU)	Nitrate (mg/L)	Fluoride (mg/L)	Ortho Phosphate (mg/L)	Total Phosphorus (mg/L)	Copper (mg/L	Iron (mg/L)
Upper	7/11/2003	26.1	-	-	-	-	-	-	3.1	0.41	0.33	0.11	0.11	0.06
	7/14/2003	24.4	23.5	6.16	6.69	260	0.383	2	-	-	-	-	-	-
	7/17/2003	25.0	23.9	5.89	6.63	270	0.380	0	3.8	0.41	0.76	0.25	0.02	0.06
	7/24/2003	24.4	24.5	4.81	6.60	270	0.400	1	4.0	1.02	0.12	0.04	0.03	0.04
	8/1/2003	25.6	24.9	5.24	6.87	280	0.412	2	-	-	-	-	-	-
	8/8/2003	25.6	24.0	5.13	6.55	300	0.424	1	-	-	-	-	-	-
	8/15/2003	29.4	26.4	4.10	7.20	300	0.407	3	-	-	-	-	-	-
	8/22/2003	29.4	29.3	2.71	7.39	270	0.344	4	-	-	-	-	-	-
	9/5/2003	20.6	-	-	-	-	-	-	1.1	0.89	0.21	0.07	0.07	0.0
	2/20/2004	10.9	8.70	12.00	-	610	0.579	7	4.0	0.35	0.24	0.08	0.22	0.9
	5/11/2004	26.1	17.5	5.67	7.63	-	0.443	5	-	-	-	-	-	-
Lower	7/11/2003	26.1	22.5	5.08	6.64	160	0.359	4	2.9	0.30	1.03	0.34	0.08	0.22
	7/14/2003	24.4	22.8	4.02	6.22	260	0.396	1	-	-	-	-	-	-
	7/17/2003	25.0	23.3	3.75	6.27	280	0.400	1	4.2	0.67	1.78	0.58	0.03	0.07
	7/24/2003	24.4	23.4	0.96	6.21	270	0.410	0	3.6	0.53	0.32	0.10	0.07	0.44
	8/1/2003	25.6	23.7	1.69	6.80	290	0.445	0	-	-	-	-	-	-
	8/8/2003	25.6	22.7	0.22	6.56	280	0.436	2	-	-	-	-	-	-
	8/15/2003	29.4	25.1	0.77	7.00	300	0.426	2	-	-	-	-	-	-
	8/22/2003	29.4	28.1	0.87	7.16	280	0.345	3	-	-	-	-	-	-
	9/5/2003	20.6	-	-	-	-	-	-	1.4	0.64	0.24	0.08	0.16	0.02
	2/20/2004	10.9	8.0	11.90	5.35	600	0.566	7	4.4	0.32	0.42	0.14	0.35	0.61
	5/11/2004	26.1	18.4	6.41	7.45	-	0.393	5	-	-	-	-	-	-

Note: Horiba U-10 mulitprobe water sampler parameters included: Air and Water Temperatures, Dissolved Oxygen (DO), pH, Conductivity (Cond), and Turbidity (Turb). Hach Pocket Colorimeters were used for the following chemical tests: Nitrate , Fluoride, Ortho Phosphate, Total Phosphorus, Copper and Iron.

Table 2 Fort Chaplin Baseflow Grab Sampling Results (July 2003-February 2004[1])

	Unit	Detection Limit	7/29/03	8/22/03	2/20/04
1. Alkalinity, Total (as Ca Co3)	mg/L	2	74	81	56
2. Hardness (total)	mg/L	5	130	140	150
3. pH	--	--	6.97	7.55	6.98
4. Specific Conductance	umhos/cm	1	400	410	840
5. **Dissolved Solids**					
6. Total Suspended Solids	mg/L	5	5	6	46
7. Turbidity	NTU	0.5	4.4	3.5	25
8. Nitrate Nitrogen	mg/L	0.05	1.6	2.0	1.4
9. Ortho Phosphate	mg/L	0.02	ND	ND	ND
10. Total Phosphorous	mg/L	0.02	ND	ND	0.26
11. Total Organic Carbon	mg/L	1	5.2	3.5	3.7
12. Biochemical Oxygen Demand – 5 Day	mg/L	2	ND	ND	ND
13. Cadmium	ug/L	1	ND	ND	ND
14. Copper	mg/L	0.005	ND	ND	ND
15. Iron	mg/L	0.05	0.65	0.31	1.9
16. Total Petroleum Hydrocarbons	mg/L	1	2.5	ND	ND
17. Surfactants (MBAS)	mg/L	0.03	0.03	0.045	0.068
18. Fecal Coliform	MPN	2	2,400	500	20
19. E. coli	MPN	2	1,300	500	20
20. Total Coliform	MPN	2	>16,000	9,000	790

[1] Chemical analysis performed by CT&E Environmental Services Inc.
Note: ND indicates no data reported.

Table 3 Fort Chaplin Stormflow Grab Sampling Results (August 2003-April 2004[1])

	Unit	Detection Limit	8/1/2003	9/3/2003	10/27/2003	11/19/2003	4/1/2004
Rainfall (in.)			**0.89**	**0.32**	**1.27**	**1.47**	**0.93**
1. Alkalinity, Total (as Ca Co3)	mg/L	2	79	53	38	35	29
2. Hardness (total)	mg/L	5	140	58	52	170	38
3. pH	-	-	6.87	6.44	6.87	6.56	6.67
4. Specific Conductance	umhos/cm	1	440	200	160	190	160
5. Dissolved Solids							
6. Total Suspended Solids	mg/L	5	180	160	77	630	58
7. Turbidity	NTU	0.5	76	30	89	540	92
8. Nitrate Nitrogen	mg/L	0.05	2.1	0.43	0.51	0.38	0.67
9. Ortho Phosphate	mg/L	0.02	0.13	0.091	0.19	0.38	0.12
10. Total Phosphorous	mg/L	0.02	0.28	0.23	0.22	0.42	0.24
11. Total Organic Carbon	mg/L	1	11	14	20	25	5.4
12. Biochemical Oxygen Demand – 5 Day	mg/L	2	6.3	23	9.1	32	4.7
13. Cadmium	ug/L	1	ND	ND	ND	0.002	ND
14. Copper	mg/L	0.005	0.013	0.014	0.014	0.064	ND
15. Iron	mg/L	0.05	6.6	3.6	1.2	29	ND
16. Total Petroleum Hydrocarbons	mg/L	1	ND	ND	ND	1.2	ND
17. Surfactants (MBAS)	mg/L	0.03	0.096	0.16	0.18	0.2	0.073
18. Fecal Coliform	MPN	2	28,000	50,000	11,000	23,000	7,000
19. E. Coli	MPN	2	11,000	280	2,800	2,100	2,200
20. Total Coliform	MPN	1	79,000	>160,000	1,800,000	930,000	130,000

[1] Chemical analysis performed by CT&E Environmental Services Inc.
Note: ND indicates not detected.

Appendix 6

Figure 1 - Fort Chaplin - Rosgen Stream Classification- Morphological Description - Level II (Rosgen, 1996)

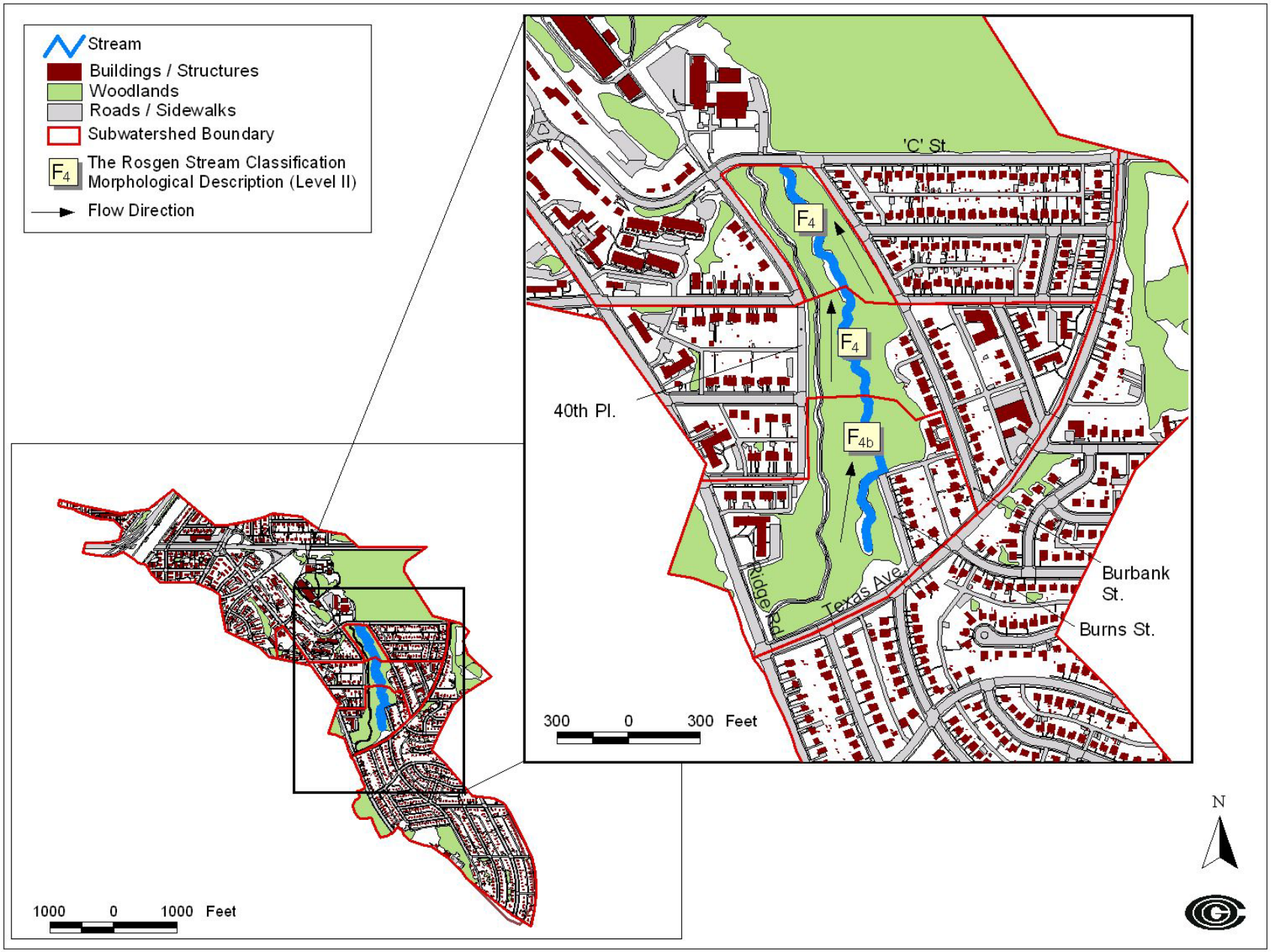


Table 1 – Fort Chaplin Upper Reach, Middle Reach and Lower Reach– Summary - Rosgen Stream Classification (Level II) – Meander Geometry[1,2]

Stream Segment/Transect Location	Meander Geometry				Stream Type Classification	
	Amplitude (ft)	Belt Width (ft)	Wavelength (ft)	Radius (ft)	Level I	Level II
Upper Reach					F	F_{4B}
1	34.0	61.60	126.30	102.30		
2	10.7	34.30	33.60	90.50		
3	10.9	31.00	61.10	95.70		
Middle Reach					F	F_4
4	29.27	38.68	23.16	145.30		
5	9.02	20.60	42.60	70.50		
Lower Reach					F	F_4
6	21.11	32.70	67.98	95.20		
7	15.57	18.09	85.57	97.32		

[1] Descriptions of the meander geometry can be found in chapter five of *Applied Channel Morphology* (Rosgen ,1996)

2 Summary Rosgen Stream Classification is for the open stream length of Fort Chaplin only.

Appendix 7

Figure 1 - Fort Chaplin - Sanitary Sewer Line Systems and Storm Drain Outfall Locations