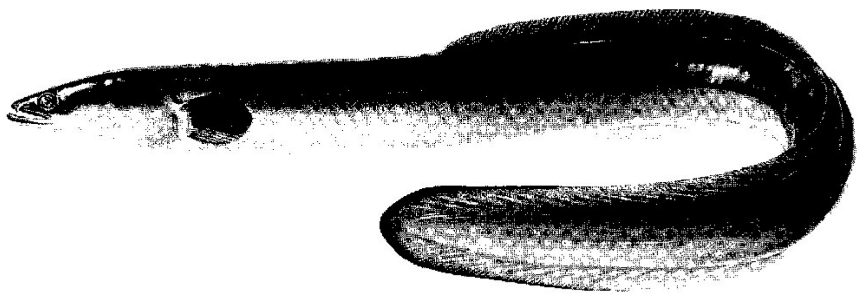
Fort Dupont Subwatershed Restoration: 1999 Baseline Stream Assessment Study – Physical, Chemical and Biological Conditions



American Eel *Anguilla rostrata*

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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 Anacostia River Watershed Restoration Agreement and formation of the Anacostia Watershed Restoration Committee (AWRC) in 1987 marked the beginning of a concerted and focused effort to restore and protect the river and its tributaries. Since its inception, the AWRC has worked closely with Federal natural resource agencies and landowners such as the National Park Service (NPS), the U.S. Fish and Wildlife Service, the U.S. Geological Survey (USGS) and others to integrate their related programmatic responsibilities and resources into the overall restoration effort.

In 1997 staff of the Metropolitan Washington Council of Governments (COG) were hired by the U.S. Army Corps of Engineers to conduct an ecological impact assessment of Federally-owned lands within the Anacostia, which comprise 15 percent of the total drainage area. As part of that work, COG staff developed a technical analysis of ecological problems and an associated suite of conceptual designs targeted for their correction. Included in the study was the Fort Dupont tributary, which was identified as experiencing stormwater-related runoff problems in its headwaters, and for which conceptual restoration designs were developed.

With funding from USGS, COG staff was again contracted in December 1998 to: 1) conduct a comprehensive baseline assessment of existing physical, chemical and biological conditions in the Fort Dupont tributary, 2) perform detailed hydrologic and hydraulic modeling of both the Fort Dupont and adjacent Fort Chaplin drainage networks for the purpose of evaluating various stormflow diversion and in-line pipe stormwater retrofit storage options and 3) assess aquatic community restoration potential in the portion of the Fort Dupont tributary which flows through National Park Service land.

1.1 Problem Assessment

Decades of uncontrolled stormwater runoff, particularly from two urbanized catchment areas draining to separate outfall points in the headwaters of the Fort Dupont tributary, have adversely impacted the stream and its biota. The upstream catchment, which drains approximately 16 acres of older, single family residential land use, is served by a storm drain system that outfalls in the park at a single discharge point immediately downstream of the intersection of Ridge and Burns Roads. The uncontrolled runoff, in combination with: 1) highly erosive stream bank and streambed materials and 2) a high stream gradient, have created a condition of extreme channel downcutting (with locally sheer vertical streambanks approaching heights of 10 feet), associated mature deciduous tree loss and sedimentation, with attendant habitat loss in the Fort Dupont tributary mainstem. The second storm drain system collects runoff from approximately four acres of mixed land uses (draining a portion of the Ridge Road Recreation Center and a portion of Ridge

Road). It also discharges directly into the Fort Dupont tributary approximately 800 feet downstream of the previously described outfall. The chronic erosion problem is so severe that the concrete outfall apron (designed to dissipate erosive storm drain outfall velocities) has been completely undermined and, along with the first few sections of reinforced concrete pipe, lies in the middle of the channel uselessly detached from the balance of the storm drain line. This additional four acres of uncontrolled stormwater runoff (from a much more impervious catchment area) further exacerbates the stream channel erosion problems.

1.3 Fort Dupont Subwatershed

The Fort Dupont tributary is a small third-order stream tributary to the Anacostia River, draining a 443.0 acre (0.69 mi^2) watershed area within the District of Columbia (Figure 1)[1]. The Fort Dupont subwatershed is located within the Coastal Plain Province. This geologically complex subwatershed is underlain by sedimentary gravel, sand and clay materials associated with the Cretaceous Patapsco Formation, Arundel Clay, Miocene Potomac Group and Pliocene Brandywine Gravel (Johnson, 1964). Soils in the study area include a broad mix of both unaltered native sand and silt loams, clayey soils and highly disturbed urban soil associations. Major soil groups present in the subwatershed are as follows: Muirkirk Varient Complex, Chillum silt loam, Beltsville silt loam, Galestown-Urban Land Complex, Iuka sandy loam, and several Udorothent (fill soil) associations (USDA, 1976).

The stream originates in the vicinity of Alabama Avenue and Burns Road, Southeast, and flows in a northwesterly direction for approximately 1.9 miles before entering the Anacostia River. The lower two-thirds of the stream cuts through ancient river terrace deposits. Along the way the stream flows under Fort Davis Drive, Minnesota Avenue and the CSX rail line area. Approximately 2,240 linear feet of the stream system (14.7 percent) is piped. A seven-foot high vertical drop associated with the lower CSX culvert precludes the normal movement and exchange of fish between river and stream. Stream gradient for the Fort Dupont mainstem is at 1.9 percent, relatively high for a Coastal Plain stream. This high gradient is largely a function of the stream's river terrace-influenced morphology.

Climate in the Anacostia watershed is generally referred to as being continental. Annual precipitation averages around 39 inches. Mean Fort Dupont tributary baseflow during the March-December 1999 study period was on the order of 0.1 cubic feet per second (cfs). It is important to note that this study coincided with a prolonged and severe drought which began in summer 1998 and continued through the 12 month long study period.

The Fort Dupont tributary is atypical of District of Columbia streams in that most of its drainage area is undeveloped, wooded parkland. Approximately 376 acres (85 percent) are owned and managed by the United States Department of the Interior, National Park

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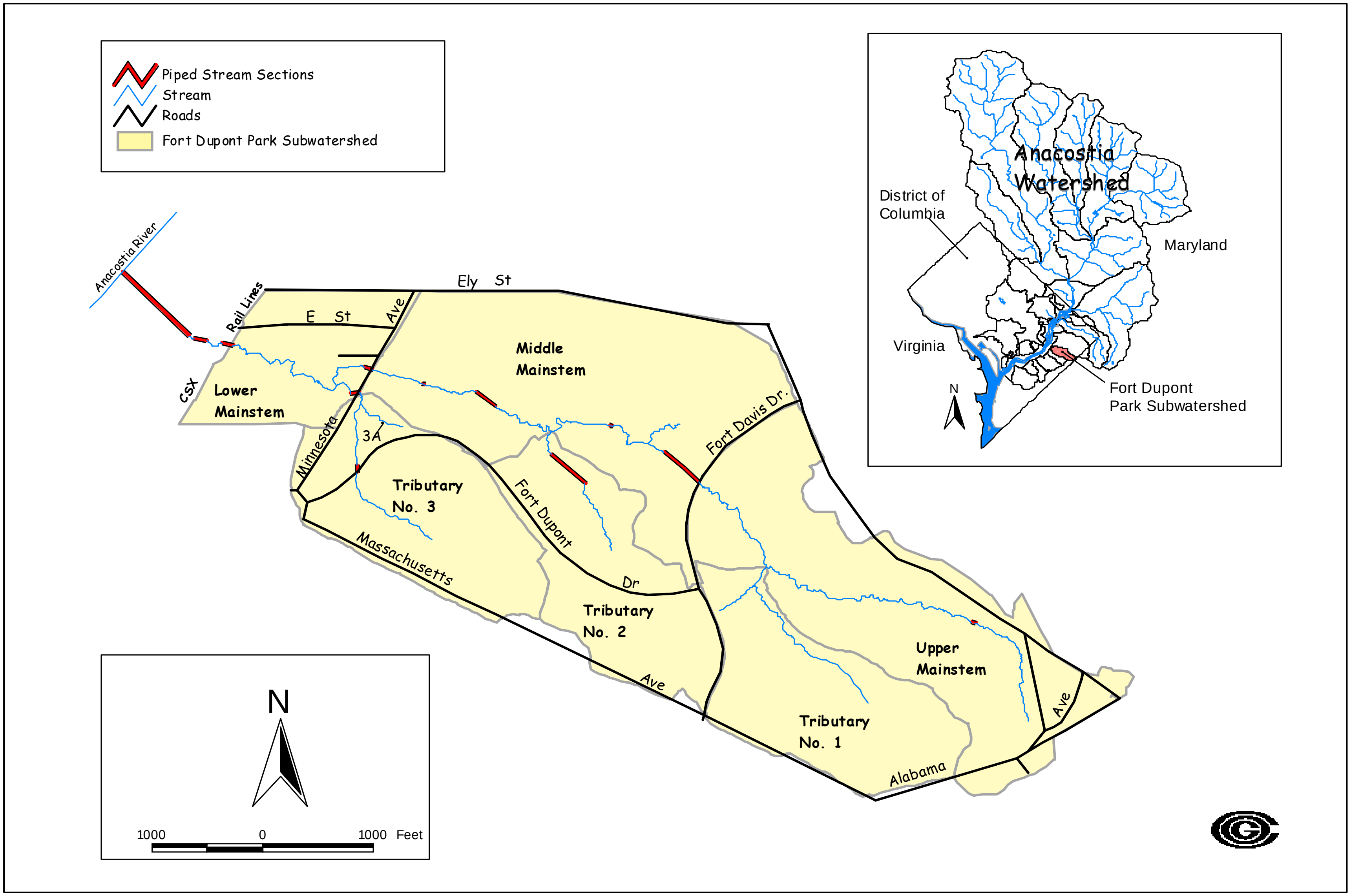
[1] Stream order determination made using 200-foot scale topographic maps

Figure 1. Fort Dupont Park Study Area



Service-National Capital Parks East (NPS). Current park uses and facilities include tennis and basketball courts, athletic fields, a softball diamond, an ice skating rink, an activity center, Park Police stables, maintenance yard, amphitheater, picnic areas and a community garden. It should be noted that the park formerly included an 18-hole golf course, which was abandoned around 1970. Since then, much of the former golf course area has been allowed to naturally reforest itself.

Impervious surfaces in the Fort Dupont subwatershed such as rooftops, roads and parking lots comprise only 13.3 percent of the catchment (Table 1). This level of imperviousness is among the lowest for any of the Anacostia's major subwatersheds (Warner et al., 1997). It is important to note that the stream has been designated by the District of Columbia Department of Health Environmental Health Administration (DC-DOH/EHA) as a class 'C' stream (i.e., protection and propagation of fish, shellfish and wildlife).

2.0 Study Design/Methods

2.1 Fort Dupont Study Area

On March 5, 1999 COG staff performed a preliminary reconnaissance field survey of the Fort Dupont tributary system in which a total stream channel network length of 2.9 miles was identified for the Fort Dupont mainstem and its three small feeder tributaries (Figure 2). As part of this survey, a total of 33 permanent stream transects (spaced on average 400 to 500 feet apart) were established for the Rapid Stream Assessment Technique (RSAT) evaluation portion of the study (Figure 3). However, due to the severity of the drought which effectively dried up riffle and run habitat areas in both Tributary Nos. 1 and 3 prior to the actual RSAT survey dates, only the Fort Dupont mainstem and Tributary No. 2 were RSAT surveyed.

Figure 2. March 5, 1999: Fort Dupont Middle Mainstem (X-12)

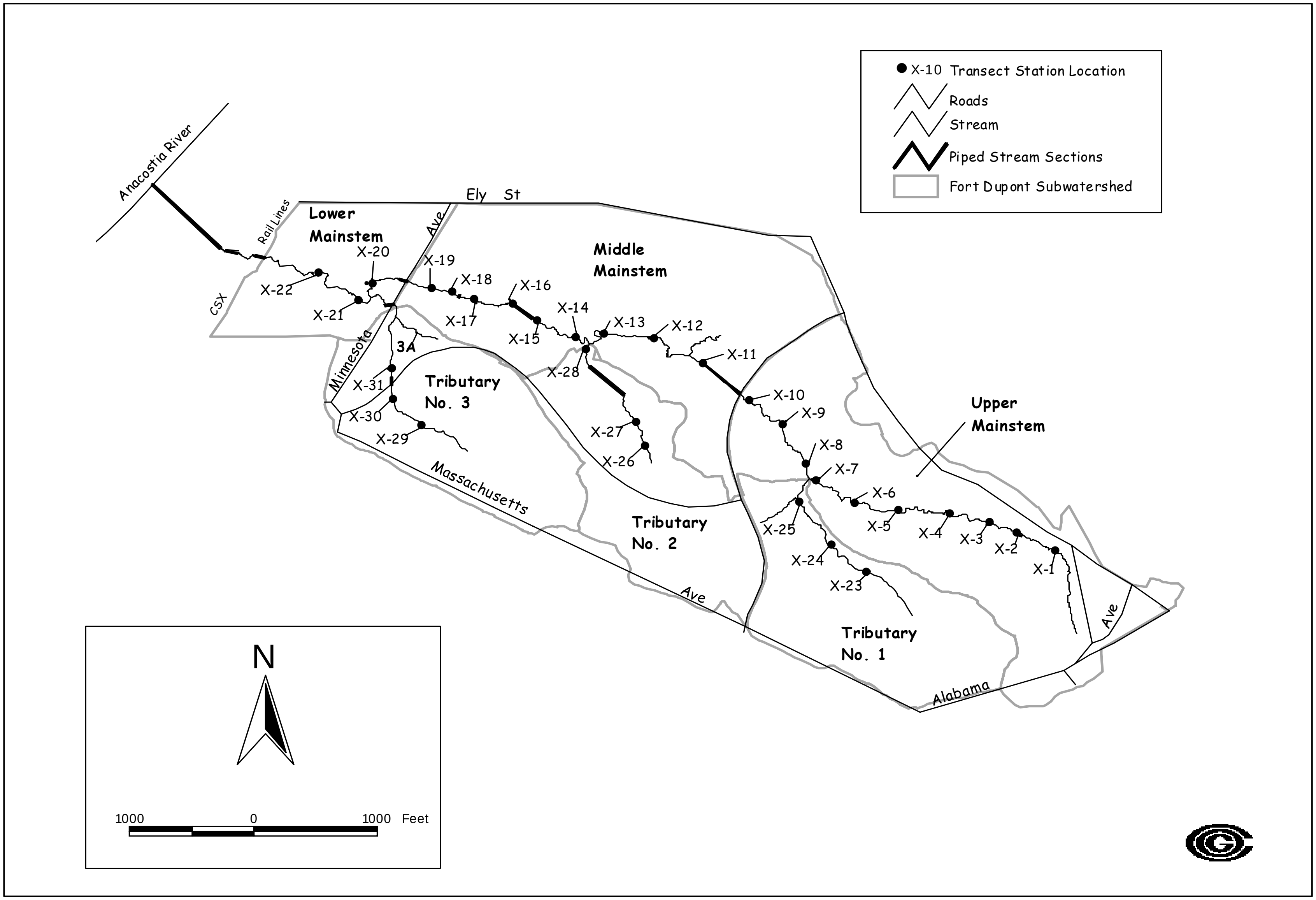
For study purposes, the 1.9 mile-long Fort Dupont mainstem was divided into three major segments (i.e., upper, middle and lower). Of the 22 total mainstem RSAT transects 10 were located upstream of Fort Davis Drive (i.e., upper mainstem), nine were located between Fort Davis Drive and Minnesota Avenue (i.e., middle mainstem) and three were located between Minnesota Avenue and the CSX Railroad culvert (i.e., lower mainstem). In addition, the 973 feet long open channel associated with Tributary No. 2 was surveyed.

Table 1. Fort Dupont - General Study Area Information

Stream Segment	Drainage Area (ac)	Est. Existing Imperviousness (%)	Stream Order[1]	Stream Length		Stream Gradient (%)	Mean Baseflow (cfs)	No. of RSAT Transects	Corresponding 200-Foot Scale Topographic Maps
				Feet	Miles				
Mainstem									
Upper	106.8	12.5	2	4,857	0.9	4.10	-----	10	6268, 6269
Middle	116.0	8.5	3	3,142	0.6	1.90	0.10	9	6962, 6169
Lower[2]	39.2	14.2	3	2,091	0.4	0.70	-----	3	6268, 6269, 6169
Tributaries									
No. 1	59.1	9.8	1	2,208	0.4	0.30	-----	3	6268
No. 2	58.3	12.1	1	973	0.2	0.53	0.009	3	6269, 6268
No. 3[3]	63.6	27.5	2	1,939	0.4	0.37	-----	3	6169, 6168
Total	443.0	13.3	-----	15,210	2.9	-----	-----	31	-----

[1] Stream order is a method of classifying streams in which first-order streams have no tributaries, second-order streams are formed by the junction of any two first-order streams, third-order stream are formed by the junction of any two second-order streams. Stream order determined through use of 200’ scale topographic maps.
[2] Steam length shown is to main CSX culvert.
[3] Does not include Tributary No. 3A (feeder spring).

Figure 3. Fort Dupont – RSAT Transect Station Locations



Data collected from all 25 transects were used to evaluate overall stream quality conditions as well as to allow for direct comparisons between each surveyed reach. Each RSAT stream transect site was permanently marked in the field with a corresponding numbered aluminum tag (which was nailed to a nearby tree). Later, with direct assistance from District of Columbia Department of Health Environmental Health Administration (DC-DOH/EHA) staff, the same transect locations were field plotted using latitude/longitude coordinates obtained through the use of a Trimble Global Positioning System (GPS) unit. These GPS-derived latitude/longitude coordinates have been included as Appendix 1.

It should be noted that due to the high gradient, river terrace nature of the Fort Dupont tributary, 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.[2] Consequently, both MBSS-based Coastal Plain data and COG staff's prior survey experience with other Coastal Plain stream systems were relied upon for evaluation purposes.

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 one-meter square ($1m^2$) streambed sampling for macroinvertebrate metric calculations and MBSS macroinvertebrate IBI 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 is as follows.

[2] Note: results from COG's Spring 1999 Maryland Biological Stream Survey (MBSS) macroinvertebrate index of biological integrity (IBI) analyses for two comparably sized prospective Anacostia reference streams in the Upper Beaverdam Creek and Little Paint Branch subwatersheds are provided in Appendix 2.

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.[3] 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 sewer lines and nickpoints.[4]

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.[5] 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.[6] Diverse depths of flow and velocities through riffles are important to the sustainability of diverse macroinvertebrate communities. Two other important criteria include the quality of both riffle substrate material and pools. For

[3] 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.

[4] 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 nickpoint is an erosional feature in the streambed, marked by an abrupt drop in elevation, which is caused by stream headcutting.

[5] 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.

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

higher gradient Coastal Plain streams such as the Fort Dupont tributary, 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, 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.[7]

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.[8] 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 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.

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[7] 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).

[8] 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 three mainstem segments and all three tributaries were also quantitatively sampled by compositing nine 30-second kick samples and 5-jabs from a 1.0 m^2, multiple habitat streambed area. As previously stated, 1 m^2 samples were used for MBSS macroinvertebrate IBI scoring evaluations. RSAT biological indicators 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 2. As seen in Table 2, the channel stability evaluation category was 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."

2.3 Water and Sediment Chemistry Characterization

2.3.1 Baseflow and Stormflow Grab Sampling

In addition to the RSAT water quality grab sampling, five baseflow and five stormflow water chemistry grab samples were collected between August and December, 1999 for the purpose of conducting EPA priority pollutant scans. Both baseflow and stormflow water-grab samples were collected at X-16 (middle mainstem) which corresponds to the stage-discharge characterization site. Each water sample included three types of collection containers:

- Two one-gallon clear wide-mouth glass containers,
- One 40 ml volatile organic analysis (VOA) glass vial with hydrochloric acid preservative, and
- One 100 ml sterile fecal coliform bottle.

For stormflow grab samples, storm events that were likely to produce 0.25 inches of rainfall or greater were tracked using local weather and radar maps provided by AccuWeather.com, Intellicast.com and WeatherNet.com. 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

Table 2. 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)				

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 Martell Laboratories$_{JDS}$ Incorporated in Baltimore, Maryland within six hours. Both sample types were collected between 0700 and 1800 hours. Additionally, the Horiba U-10 water quality meter was used to 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 both the upper and middle Fort Dupont mainstem areas. In order to have enough material to perform an EPA priority pollutant scan, a total of eight liters (approximately two gallons) 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 a sterilized glass sample container, appropriately labeled and placed in an ice cooler. The cooled sample was then delivered to Martell Laboratories$_{JDS}$ Incorporated in Baltimore, Maryland within six hours for analysis.

2.4 Physical/Hydrological Condition Monitoring

2.4.1 Baseflow Discharge

Baseflow discharges were measured 16 times at RSAT transect X-16 using a Global water flow probe, propeller-driven velocity meter. Measurements were taken from different dates (i.e., at least once a month between June 15 and November 25). 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. Discharge was not measured between July 26th and August 24th, as the Fort Dupont Park tributary system riffle areas had dried up leaving mostly standing pools.

2.4.2 Rainfall Measurement

For the May-December 1999 portion of the study, rainfall was measured at the NPS Fort Dupont Activity Center building (located in the vicinity of X-19) via the use of an ISCO Model 3220 recording tipping bucket rain gauge on loan from DC-DOH/EHA. The rain gauge was calibrated to measure, at 15-minute intervals, every hundredth of an inch (0.01 inches) of rainfall. Precipitation data from the recording rain gauge was used in the development of the stage-discharge curve for the Fort Dupont tributary, as well as in the characterization of stormflow water quality.

2.4.3 Stormflow Discharge

Stormflow discharges were measured for storms that produced between 0.26 and 3.69 inches of rainfall. At least one and up to four discharge measurements were taken per storm, for a total of 14 measurements from seven storms. Importantly, date and time were recorded for each discharge measurement to correspond with the information recorded by the water level data logger. Due to stream dewatering associated with the drought, discharge measurements were not made for the period of July 26th to August 24th. The severity of the drought resulted in the pool at RSAT transect No. 16 being dry between August 1st and August 24th.

2.4.4 Stage-Discharge Curve Development

A stage-discharge curve, which characterizes and predicts flows according to water depths, was established for the Fort Dupont Park tributary middle mainstem area. These measurements were conducted at X-16 in late spring to early fall via two Global Water instruments, the automated water level logger and a manually operated flow probe. 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 June 6th to December 31st to record various pools stages (ft) at 20-minute intervals. The installation entailed carefully burying the data logger cylinder, housed in a two-gallon bucket, into the top of an approximately 7.0 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 20.0 inches deep. Finally, the terminal sensor, housed in a 3.0 inch diameter, 15 inch long perforated PVC pipe, was submerged approximately 5.0 inches from the pool bottom and cabled to steel rebars that were driven into the stream bottom. It should be noted that the sensor tip was pointed downstream to reduce silt deposition and clogging of the sensor. The discharge flow probe, which is a propeller-type stream flow current meter, was used to measure mean stream velocity at the riffle immediately upstream of the water level logger pool site. Parameters such as average stream velocity, the wetted perimeter width and riffle depths were measured at the permanent riffle cross-section. 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 that of the baseflow and stormflow water chemistry grab sampling location. 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 97's 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 six mainstem and tributary locations: upper mainstem (X-7), middle mainstem (X-12), middle mainstem (X-16), lower mainstem (X-21), Tributary No. 2 (X-20) and Tributary No. 3 (X-31). At each preceding station location, ¾ inch diameter rebar was driven into the top of each bank. A 100-foot long steel tape measure was next secured to the higher of the two rebars (flush to the ground), drawn tautly across the channel, resecured to the opposite bank and leveled. Cross-sectional elevational differences were then recorded, at one-foot intervals, via the employment of a plumb bob hung from the overlying steel tape and an adjustable 11 foot-long fiberglass surveyor's rod. Channel measurements were made to the nearest 100^{th} of an inch. Permanent channel cross-sections are included in Appendix 3. of the report.

2.4.6 Pebble Count

A modified Wolman (1954) pebble count was performed at the following representative stream locations: upper mainstem (X-7), middle mainstem (X-13), lower mainstem (X-22) and Tributary No. 2 (X-28). At each site, 100 particles total were counted along a tape measured, 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 1999 Summer Thermal Regime Characterization

Characterization of the "summer" thermal regime within key representative portions of the upper, middle and lower Fort Dupont mainstem and Tributary No. 2 was accomplished via the systematic employment of Ryan Temp Mentor recording thermograph thermometers. The four station temperature monitoring network employed in the study included the following stream sites keyed to RSAT transect locations: upper mainstem (X-7 area), middle mainstem (X-14 area), lower mainstem (X-21 area) and Tributary No. 2 (X-28 area).

At each station, the thermograph thermometer was placed into a waterproof Ryan Temp Mentor plastic case and buried. The units were carefully buried, six to eight inches below ground level, in an overbank area to reduce the risk of damage or loss from flooding and/or vandalism. Actual stream water temperature readings were made via an associated 15-foot long sensor cable that extended from the buried unit into the stream. The buried sensor cables were attached to steel rebars driven into the stream bottom. All cables were located in well-shaded undercut bank areas of the stream where the depth of flow was sufficient to keep the sensor tip completely submerged at all times. Temp Mentors were deployed from May 17, 1999 to September 24, 1999 and programmed to record water temperature every 20 minutes. Data were downloaded into a PC and statistically analyzed using Microsoft Excel '97. Climatological information used during the study period was obtained from NOAA (1999) for Washington National Airport, as well as from the Fort Dupont recording rain gauge.

2.5 Biological Monitoring

2.5.1 RSAT Macroinvertebrate Voucher Sample

RSAT Level III surveys of both the Fort Dupont mainstem and Tributary No. 2 were conducted on May 19, 20, and June 2, 1999. For each RSAT riffle transect area, taxa were collected from representative riffle, run and pool habitat via the previously stated two one-square foot 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 1999 1m^2 Macroinvertebrate Sampling

Included as part of the RSAT Level III evaluation were spring and fall 1999 1m^2 macroinvertebrate sampling of the following Fort Dupont mainstem and tributary transect sites: upper mainstem (X-7), middle mainstem (X-13), lower mainstem (X-21), Tributary No. 1 (X-25), Tributary No. 2 (X-28) and Tributary No. 3 (X-31). Spring samples were collected on April 14th, whereas fall samples were collected on November 22nd. In addition, 1m^2 spring and fall collections were performed for the two prospective third-order Anacostia reference stream sites (i.e., the Silverwood tributary located in Little Paint Branch and an unnamed tributary to Upper Beaverdam Creek). The 1m^2 collection is a quantitative survey that combines samples from multiple habitats using both the kick and jab techniques. The total survey area encompassed approximately one-meter-square of the streambed. Again, organisms were collected from representative habitat areas such as riffles, runs and pools using a 600-micron mesh D-frame net.

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 1m^2 surveys were counted and identified in the lab 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 1m^2 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 Dupont biosurvey scoring.

2.5.5 One-Pass Electrofishing Survey

In a cooperative effort between COG and the DC-DOH/EHA, the electrofishing survey for the Fort Dupont upper and middle mainstem areas was a single day event performed in December 1998. It employed a single one-pass or "sweep pass" technique that determined the existing population and distribution of the resident fish community. One-pass electrofishing was performed in an upstream direction, and included the following stream reaches: 1) the entire middle mainstem between Minnesota Avenue and Fort Davis Drive (approx. 0.6 miles) and 2) the upper mainstem from Fort Davis Drive to 0.2 miles upstream. For the Fort Dupont survey, a single Smith-Root Model XII backpack electrofisher with two people netting was employed. All fish were collected, identified, enumerated, observed for general condition and released unharmed back into the stream.

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. The preceding information was mapped onto 1 in. = 200 ft. horizontal scale topographic maps, photographed, logged on field survey forms and subsequently entered into a Microsoft Excel '97 spreadsheet database for further analysis.

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 five feet suggest that downcutting on the order of two to three feet has probably occurred. Other reliable indicators included the presence of nickpoints and exposed concrete footers for retaining walls, weirs, culverts and other anthropogenic instream structures. A comparison of representative riffle transect stream channel cross-sections for the three Fort Dupont mainstem areas, as well as for Tributary No. 2 is presented in Figure 5. General stream channel erosion-related indicators are summarized in Figure 6. The approximate locations of severe and moderated stream bank areas are depicted in Figure 7. Summary stream channel erosion-related information has been included as Tables 3 and 4.

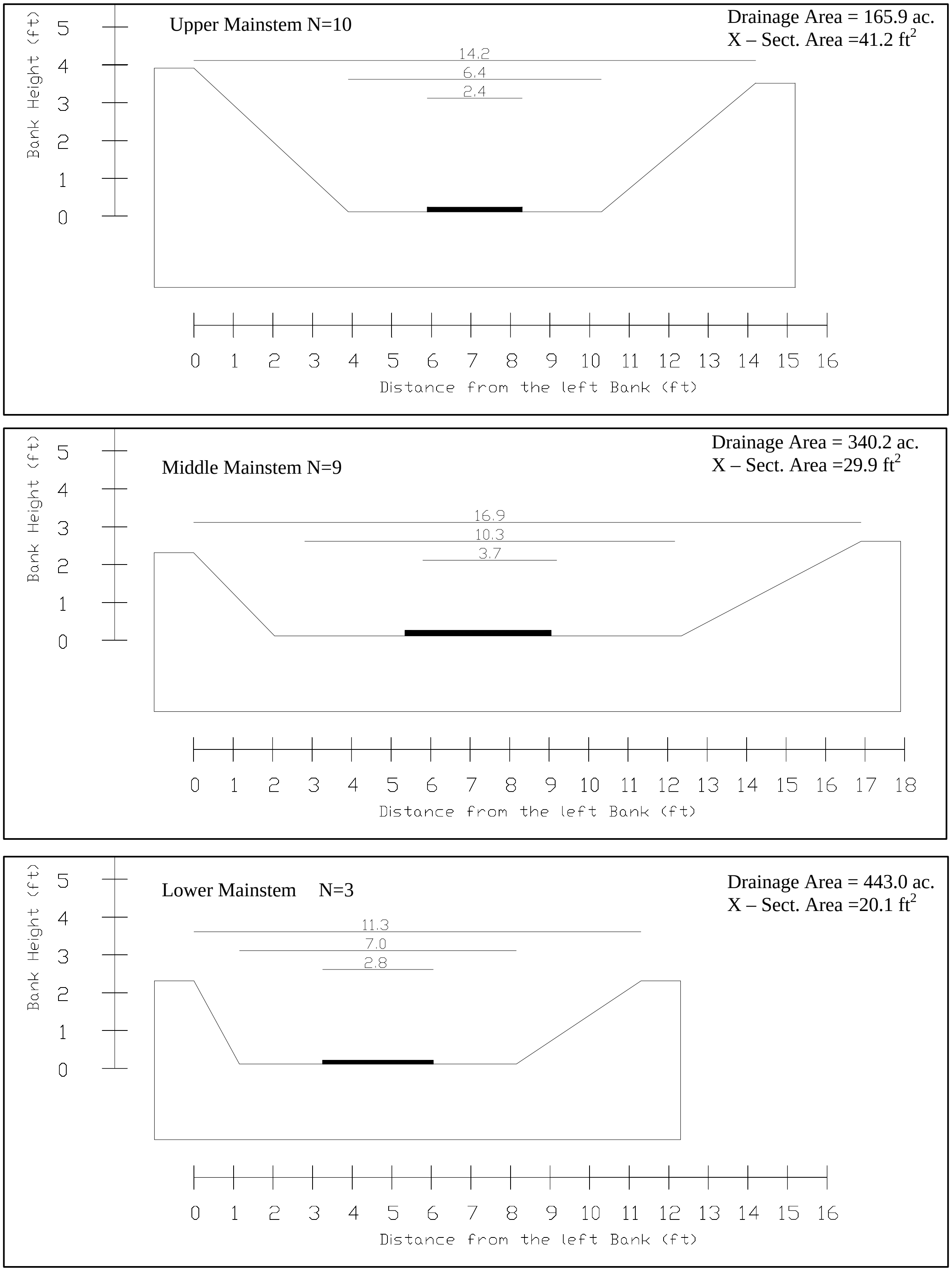
3.1.2 General Findings

With the exception of the first 3,000 linear feet of the upper mainstem, the Fort Dupont tributary appears to be relatively stable. Results from the channel stability portion of the study revealed that out of a total RSAT-surveyed stream length of 11,088 feet, only 116 linear feet, representing approximately 1.0 percent is experiencing severe bank erosion. An additional 1,285 linear feet (15.9 percent) exhibited moderate stream bank erosion conditions. No pockets of moderate/severe erosion were observed during the RSAT survey. Stream areas experiencing moderate or severe stream bank erosion conditions were generally limited to fairly short (i.e., typically 50-100 feet), isolated pockets. As illustrated by Figure 4, these pockets were frequently associated with the outside banks of meanders and/or with recent tree falls. Cross-sectional analysis results (Figure 5) indicated that the mean cross-sectional area of the upper mainstem (41.2 ft^2) is, relative to those of the middle mainstem (29.9ft^2) and lower mainstem (20.1 ft^2), 37.87 percent and 105.0 percent greater, respectively.

Figure 4. Upper Mainstem: Moderate Stream Channel Erosion (X - 9)

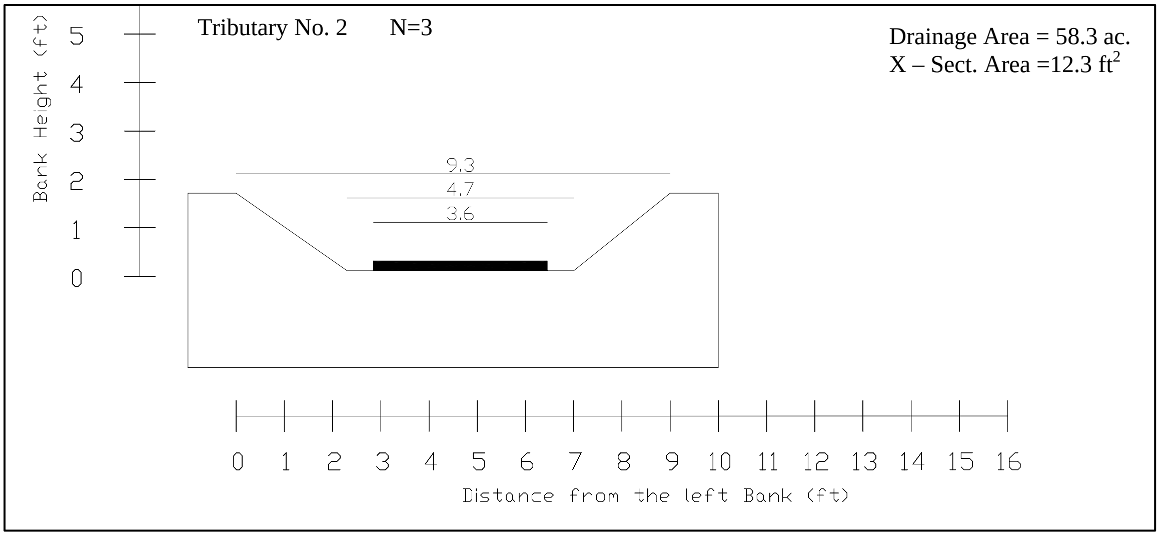
Based on previous COG staff surveys of comparably-sized Coastal Plain and Piedmont streams in the Washington metropolitan area, the generally expected Fort Dupont mainstem bank height and channel width ranges are on the order of one to three feet and 10 to 12 feet, respectively (Galli et al., 1999; Trieu et al., 1998; Galli et al., 1996b; Corish et al., 1996; Galli and Trieu, 1994). The preceding results confirm that decades of uncontrolled stormwater runoff, particularly in the upper and middle mainstem areas, has produced a Fort Dupont stream channel which is with respect to forested, reference stream conditions, markedly wider and more incised.

Figure 5. Representative Channel Cross-Sections[1]



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

Figure 5: Continued



Additional stream channel stability results (Figures 6 and 7 and Table 3), revealed that the upper mainstem had the highest moderate stream bank erosion rate (1287 lf/mi). As seen in Table 3, both the number (8 total) and rate of recent tree falls (8.7/mi) was highest in the upper mainstem. No recent tree falls or erosional log jams were recorded in either the lower mainstem or Tributary No. 2.

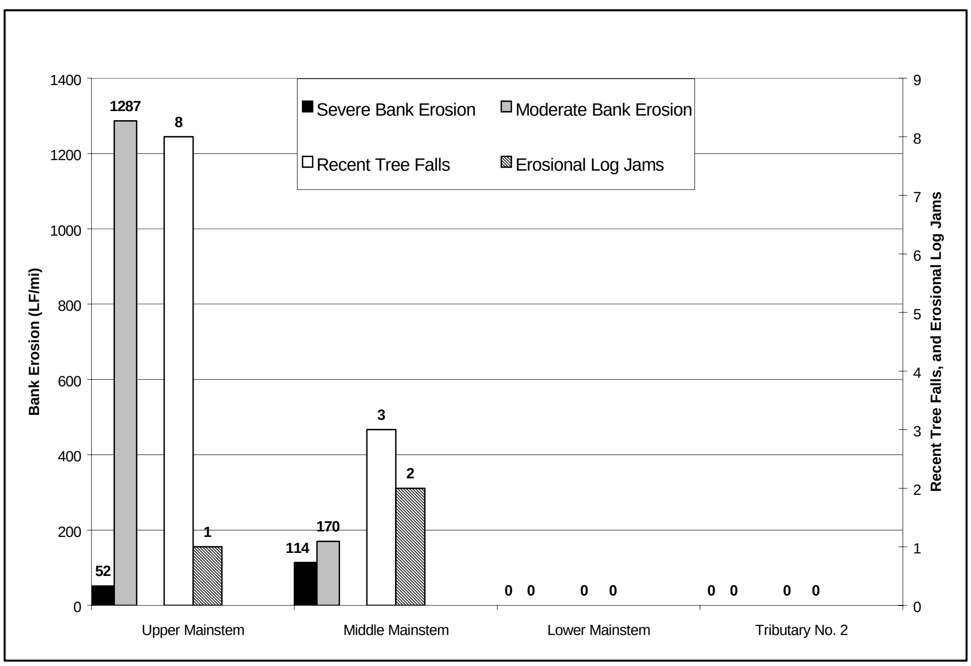


Figure 6. Fort Dupont Stream Channel Erosion-Related Conditions[1]

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

The preceding results indicate that, in aggregate, the Fort Dupont stream channel network is quite stable. However, the upper mainstem has and continues to experience higher levels of active stream channel erosion. This is particularly the case in the higher gradient reach located between the Ridge and Burns Road storm drain outfall and the Tributary No. 1 confluence (Figure 7).

3.1.3 Stream Bank Stability and Relative Erodibility

Both stream bank and soil texture survey data were examined to provide a reconnaissance-level assessment of mean stream bank stability and relative erodibility of existing bank materials (Figure 8). As seen in Figure 8, all RSAT surveyed stream areas were rated as having good or excellent average bank stability. Mean stream bank stability ranged from a low of 76.7 percent (upper mainstem) to a high of 94.7 percent (Tributary No.2).

3.1.4 Major Stream Channel Downcutting

Stream channel downcutting results (Table 4) revealed that both the middle and lower mainstem, as well as Tributary No. 2 fell either within or very close to the expected or reference condition bank height range. On the other hand, mean bank heights for the upper mainstem (3.6 feet) were approximately 1.6 feet higher than expected. As seen in Table 4, the upper mainstem also had the highest total number of nick points (4). The preceding results strongly suggest that: 1) roughly 60 percent of the Fort Dupont mainstem has experienced relatively little or no degradation of its streambed, 2) approximately 32 percent of the channel network is moderately incised (i.e., bank heights 1.0-2.0 feet higher than the RSAT standard range) and 3) as graphically shown in Figure 9, channel headcutting has historically been far more pronounced in the upper mainstem.

Figure 7. Fort Dupont – Moderate and Severe Stream Bank Erosion Areas

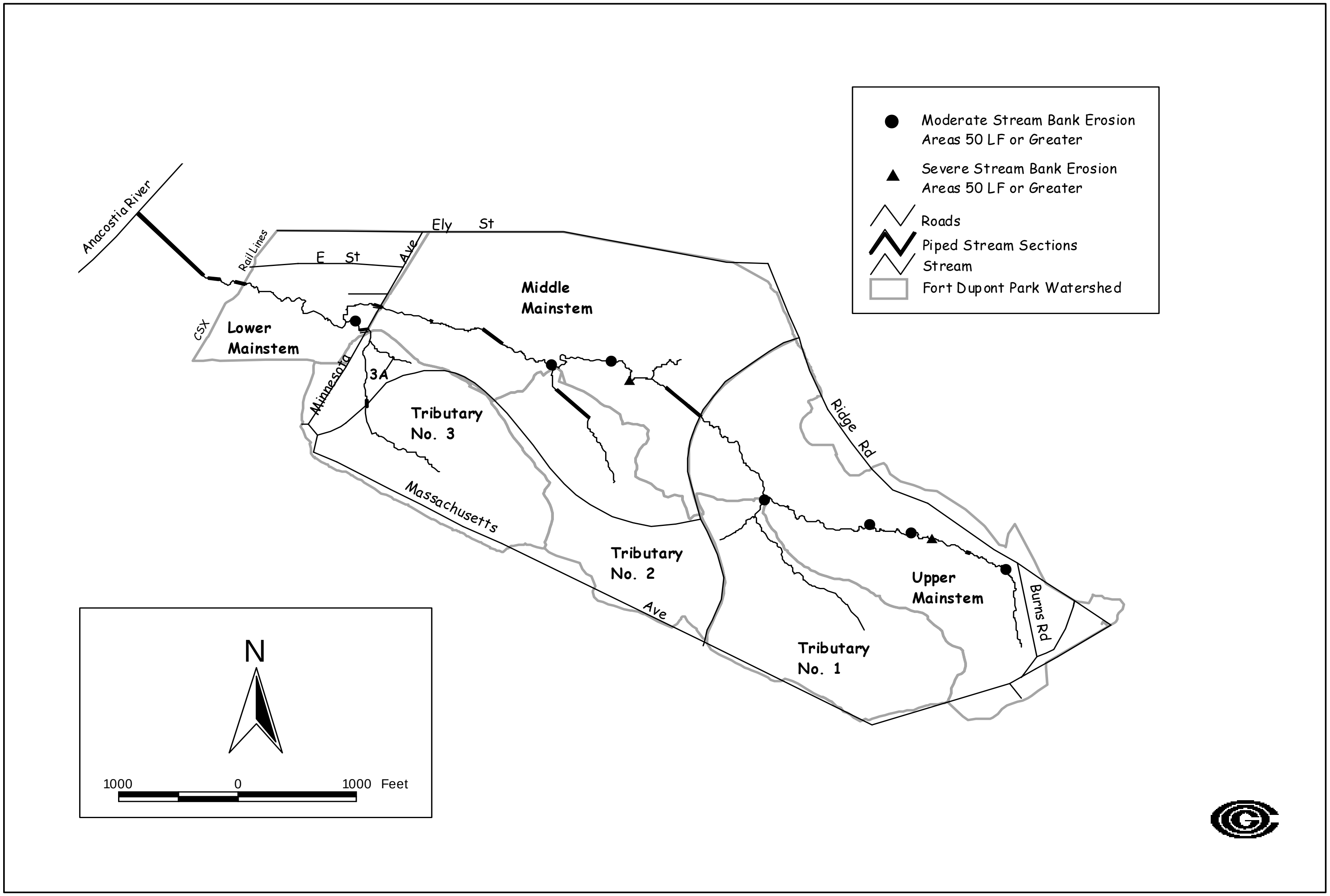


Table 3. Summary: Fort Dupont - Stream Bank Erosion Conditions

RSAT Stream Segment	Segment Length	Bank Erosion Conditions: Severe		Bank Erosion Conditions: Moderate		No. Recent Tree Falls[1]		Number Of Erosional Log Jams	Mean Bank Stability[2] (%)
	(mi.)	(LF)	(LF/mi.)	(LF)	(LF/mi.)	No.	No./mi.		
Mainstem									
Upper	0.92	48	52	1184	1287	8	8.7	1	76.7
Middle	0.60	68	114	101	170	3	5.0	2	86.1
Lower	0.40	0	0	0	0	0	0.0	0	86.0
Tributaries									
No.1	0.42	----	----	----	----	----	----	----	----
No.2	0.18	0	0	0	0	0	0.0	0	94.7
No.3	0.37	----	----	----	----	----	----	----	----
Total	2.88	116	55.2[3]	1285	611.9	11	----	3	85.8[4]

[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] Minimum RSAT stream segment length used to determine bank erosion condition rates totaled 2.1miles which is the total combined segment length for the upper, middle and lower mainstems and Tributary No.2.
[4] Weighted mean.

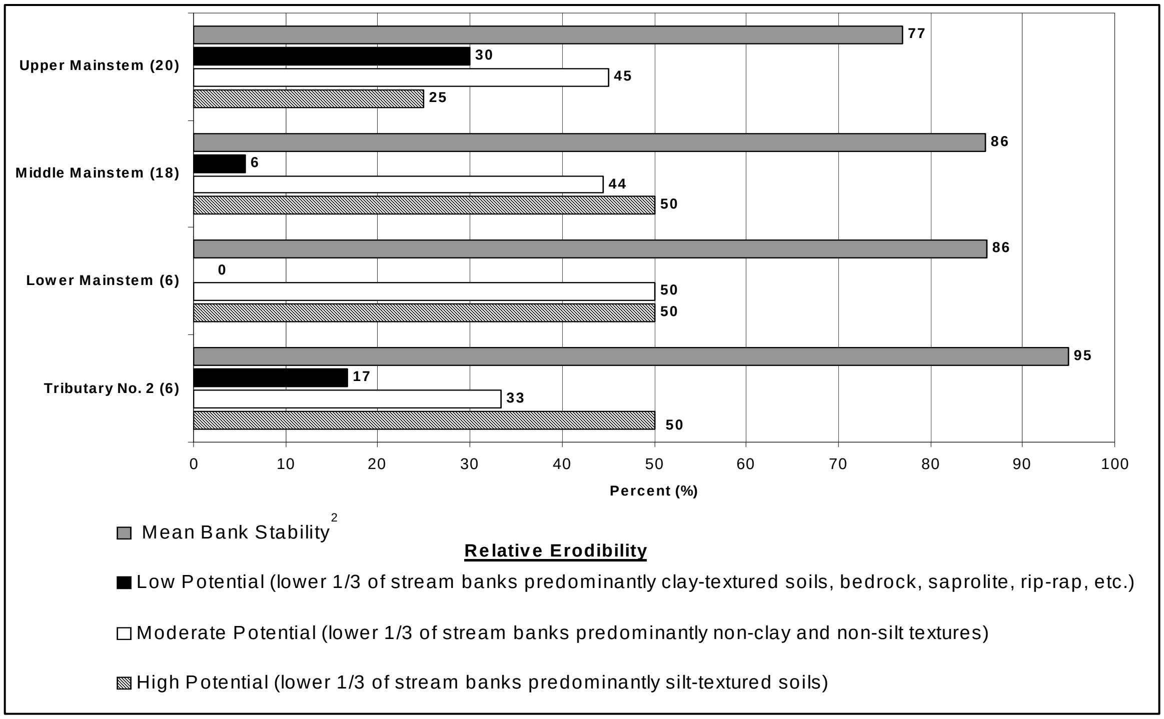


Figure 8. Summary: Mean Stream Bank Stability and Relative Erodibility (%)[1]

Figure 9. Upper Mainstem: Broken Concrete Storm Drain Outfall Apron (X-2 area)

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

Table 4. Summary: Fort Dupont - Stream Channel Downcutting[1]

RSAT Stream Segment	Drainage Area (ac)	Segment Length (ft)	Mean Bank Height R[2] (ft)	Mean Bank Height L[3] (ft)	Mean Bank Height (ft)	Expected Bank Height Range (ft)	Number of Nick Points
Mainstem							
Upper	106.8	4,857	3.8	3.4	3.6	1- 2	4
Middle	116.0	3,142	2.2	2.5	2.3	1- 2	1
Lower	39.2	2,091	2.2	2.2	2.2	2- 3	1
Tributaries							
No.1	59.1	2,208	----	----	----	1- 2	----
No.2	58.3	973	1.6	1.6	1.6	1- 2	0
No.3	63.6	1,939	----	----	----	1- 2	----
Total	443.0	15,210	2.5[4]	2.4[2]	2.4[2]	----	6

[1] RSAT survey not conducted for Tributary No.1 and 3 due to dry riffle areas observed during study period.
[2] Right bank looking downstream.
[3] Left bank looking downstream.
[4] Weighted mean.

3.1.5 Channel Scouring and Sediment Deposition

Figure 10. Upper Mainstem: In-Channel Sand Deposit (X-6 area)

Not surprisingly, the lowest number and rate of large, unstable point bars (i.e., devoid of any vegetation), as well as the lowest observed level of in-channel sand deposits were recorded in the highly stable Tributary No. 2 (Table 5). As depicted by Figure 10, vis-à-vis Tributary No. 2 and both the middle and lower mainstem, slightly higher levels of in-channel sand deposits (i.e., low/moderate range) were noted in the upper mainstem. This finding is consistent with earlier observations which indicated that, overall, the upper mainstem is generally experiencing higher levels of stream channel erosion. It is also worth noting that the middle mainstem's lower embeddedness level (Figure 11) in combination with its low level of in-channel sand deposits suggest that sandy sediment loads are generally lower there and are more efficiently transported downstream.

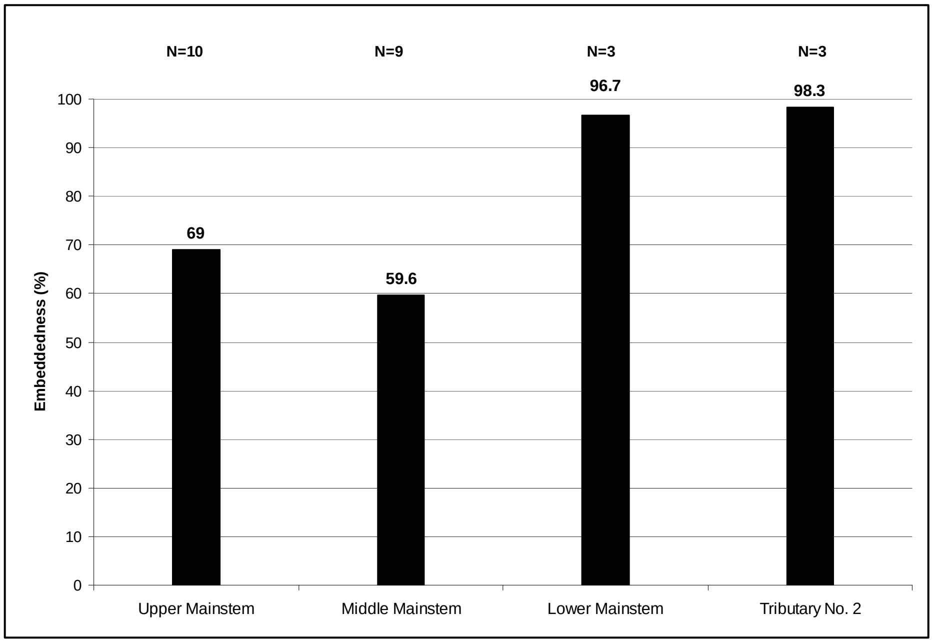


Figure 11. Fort Dupont - Mean Riffle Embeddedness Levels[1] (%)

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

Table 5. Summary: Fort Dupont – 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.**	
Mainstem									
Upper	4,857	0.92	40-100	69	36	20	56	21.7	Low/Moderate
Middle	3,142	0.60	45-80	59	44	15	34	25.0	Low
Lower	2,091	0.40	90-100	97	6	5	83	12.5	Low
Tributary									
No.1	2,208	0.42	----	----	----	----	----	----	----
No.2	973	0.18	95-100	98	3	1	33	5.6	Low
No.3	1,939	0.37	----	----	----	----	----	----	----
Total	**15,210**	**2.88**	----	----	**89**	**41**	**52**[1]	**16.2**[1]	----

[1] Weighted mean.

3.2 Physical Aquatic Habitat

General physical aquatic habitat conditions for the Fort Dupont mainstem and Tributary No. 2 are summarized in Tables 6 and 7 and in Figures 12 and 13. As seen in Table 6, overall RSAT aquatic habitat scores for the Fort Dupont mainstem fell within the fair range, whereas that for Tributary No. 2 was rated at the lower end of the good range. Major contributing factors for the fair mainstem ratings included sub-optimal riffle substrate quality, moderate to high embeddedness levels, a general scarcity of pools greater than or equal to 15 inches in depth, and the presence of numerous fish barriers.

As seen in Figure 12, mainstem riffle substrate quality was marginally better in the middle mainstem, whereas pool quality remained relatively equal throughout the mainstem.

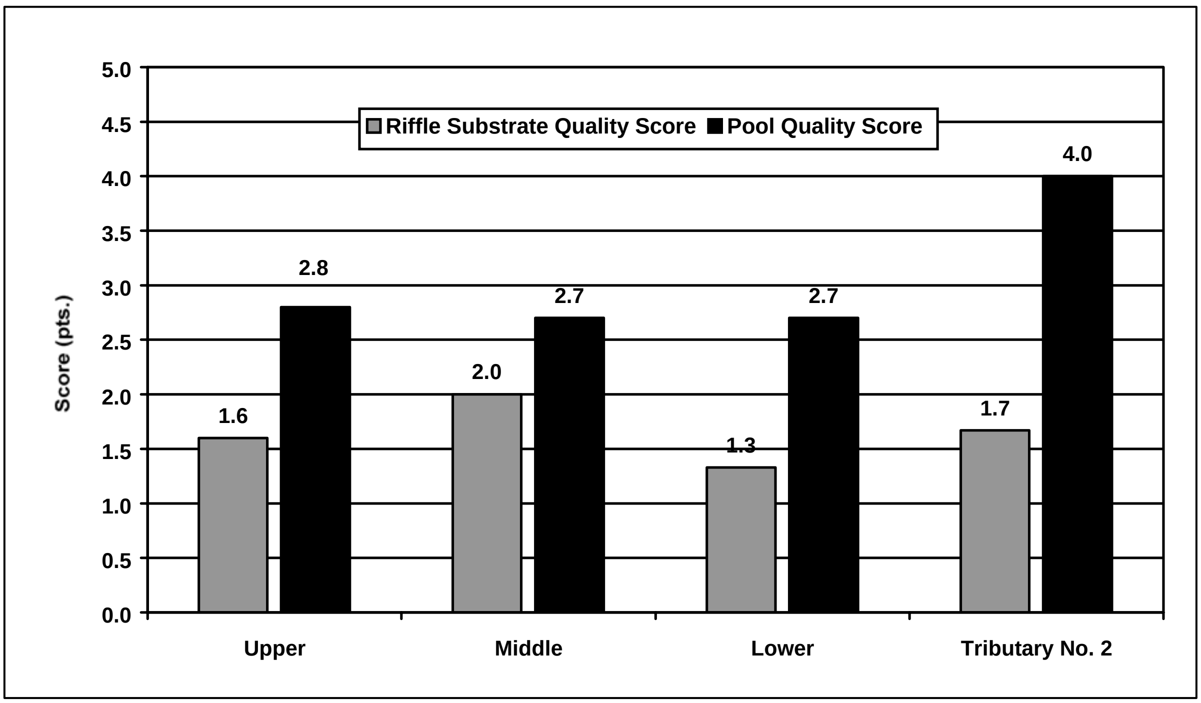


Figure 12. Fort Dupont: Mean Riffle Substrate[1] and Pool Quality[2]

[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.

Table 6. Summary: Fort Dupont - General Physical Aquatic Habitat Conditions[1]

	Riffle Characteristics:				Pool Characteristics:					Fish Barriers		
RSAT Stream Segment	No. of Riffles	Mean Riffle Depth (in.)	Mean Riffle Substrate Quality (pts.)[2]	Mean Riffle Embedded -ness[3] (%)	No. of Pools	Mean Max. Depth (in.)	Mean Pool Quality[4] (pts.)	Number of Quality Pools	Riffle/ Pool Ratio[5]	Total No.	Per mile	RSAT Physical Habitat Score[6] (pts.)
Mainstem												
Upper	103	1.2	1.6	69.0	33	9.9	2.1	6	3.1	5	5.4	3
Middle	54	1.5	2.0	59.6	34	12.9	2.5	12	1.6	4	6.7	4
Lower	10	0.8	1.3	96.7	9	16.4	2.6	9	1.1	3	7.5	3
Sub-total	167	1.2	----	75.1	76	13.1	2.4	27	----	12	13.8	----
Tributary												
No. 1	----	----	----	----	----	----	----	----	----	----		----
No. 2	16	2.0	1.7	98.3	7	12.7	4.0	3	2.3	1	5.6	5
No. 3	----	----	----	----	----	----	----	----	----	----		----

[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: 6.5-8.0 = Excellent, 4.5-6.4 = Good, 2.5-4.4 = Fair, 1.0-2.4 = Poor.

It should, however, be noted that: 1) the middle mainstem had the highest number (5 total) of "deep" pools rated good or better (Table 7), 2) pool depths measured during the study were, owing to the drought, probably one to two inches shallower than under more normal baseflow conditions, 3) the majority of the pools surveyed featured large amounts of highly unstable sandy material and 4) as illustrated in Figure 13, approximately one-half of the deep pools observed were associated with large, woody debris such as tree falls.

Figure 13. Upper Mainstem: High Quality 2-Foot Deep Pool (X-7 area)

With further regard to substrate quality, pebble count results (Figure 14) indicated that the median (i.e., D-50) Fort Dupont tributary particle size is medium to coarse gravel (i.e., 8.0-31.00 mm). In addition, the D-84 sized particle in all four surveyed reaches was very coarse gravel (i.e., 32.00-63.99 mm). The preceding findings confirm that the Fort Dupont streambed is made up of predominantly gravel-sized material, whose typically small diameter and round shape is inherently unstable and prone to rolling during stormflows. This is particularly so in the upper mainstem, where D-15, D-50 and D-84 sized particles were the smallest of the four surveyed reaches.

3.2.1 Fish Barriers

A total of 13 fish blockages were identified during the RSAT survey. Of these, nine were classified by COG staff as being complete barriers, with the remaining four classified as partial blockages. A brief description of each blockage is provided as Table 8. In addition, the general location of each barrier is shown in Figure 15.

As depicted by Figure 16, the majority (92 percent) of the observed fish barriers were associated with either culverts (6 total; 46 percent) or nick points (also 6 total; 46 percent). Without question, the single largest barrier to fish movement and migration within the Fort Dupont tributary is the seven foot vertical drop associated with the lower CSX railroad culvert (Figure 15; Site No. 12). As previously stated, this blockage precludes, with the lone exception of the American eel (*Anguilla rostrata*), the exchange of fish species between river and stream.[9]

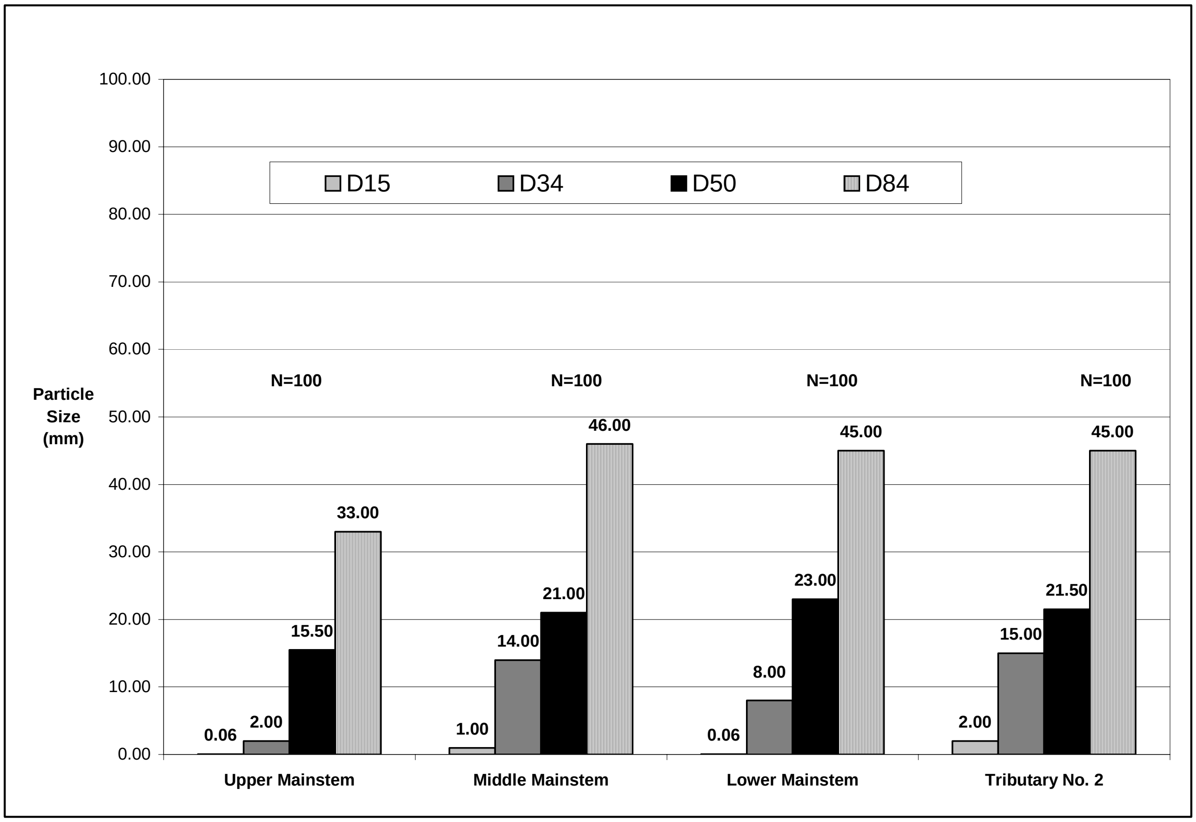
[9] American eels (particularly young elvers), are renowned for their ability to temporarily leave the water and slither over moist terrain when migrating up streams.

Table 7. Summary: Fort Dupont Mainstem Pool Quality[1] (Fall, 1999)

Mainstem Segment	Pool Number	Pool Depth (in.)	RSAT Pool Quality Score[2]	Verbal Ranking	Location
Upper	1.	20	3	Good	Approximately 100 feet above transect 7
	2.	18	2	Fair	Approximately 75 feet above transect 7
	3.	28	5	Excellent	Approximately 300 feet above transect 8
	4.	19	2	Fair	25 feet above Tributary No. 1
	5.	19	2	Fair	10 feet below Tributary No. 1
	6.	19	3	Good	100 feet below Tributary No. 1
Mean		18.2	2.8		
Middle	1.	15	2	Fair	15 feet below the first footbridge
	2.	15	2	Fair	35 feet above the first culvert
	3.	30	5	Excellent	50 feet above transect 14 (i.e.,"Eel Pool")
	4.	17	2	Fair	@ the confluence with Tributary No. 2
	5.	17	3	Good	50 feet below Tributary No. 2
	6.	16	2	Fair	150 feet below Tributary No. 2 or 40 feet above Transect 14
	7.	18	3	Good	@ transect 14
	8.	22	4	Very Good	@ second footbridge
	9.	15	2	Fair	@ transect 16
	10.	17	3	Good	Approximately 100 feet above the Fort Dupont Amphitheater
	11.	17	2	Fair	@ 18 inch RCP stormdrain outfall
	12.	16	2	Fair	Approximately 30 feet above the chain link fence that crosses the stream
Mean		17.9	2.7		
Lower	1.	15	2	Fair	Approximately 80 feet below the confluence with Tributary No. 3
	2.	17	2	Fair	Approximately 20 feet above transect 21
	3.	27	5	Excellent	Approximately 10 feet below transect 21
	4.	21	3	Good	Approximately 100 feet above transect 22
	5.	15	2	Fair	Approximately 50 below transect 22
	6.	15	2	Fair	Approximately 250 feet above the CSX railroad culvert
	7.	16	2	Fair	Approximately 150 feet above the CSX railroad culvert
	8.	23	4	Very Good	Approximately 80 feet above the CSX railroad culvert
	9.	15	2	Fair	Approximately 40 feet above the CSX railroad culvert
Mean		18.2	2.7		
Total	27				

[1] Quality pools were determined to be at least 15.0 inches deep.
[2] Quality pool point scale interpretation: 5 = Excellent, 4 = Very Good, 3 = Good, 2 = Fair, 1 = Poor.

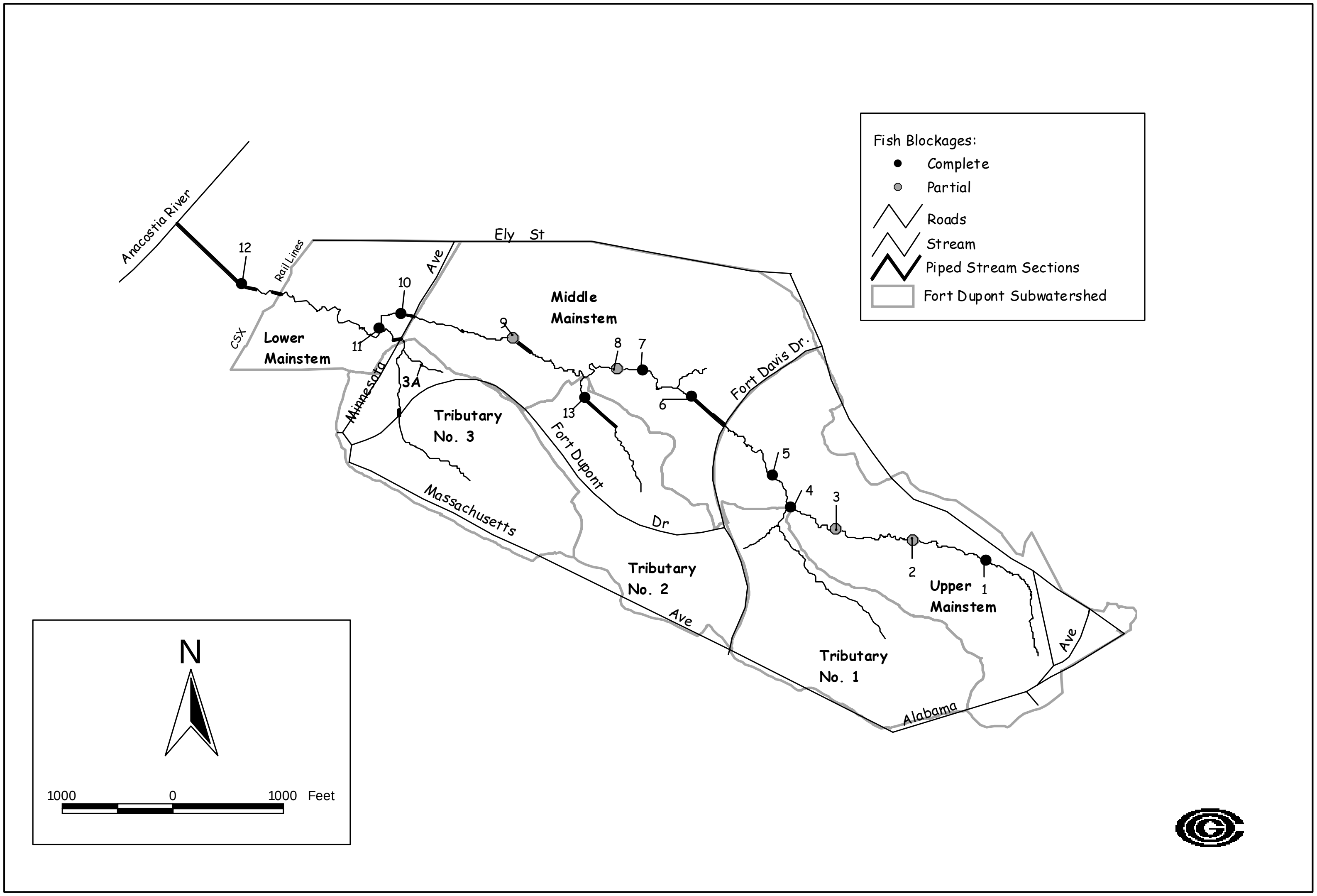
Figure 14. Fort Dupont: Substrate Particle Size Distribution[1] - D15, D34, D50, and D84



1

Very Fine Sand	0.06 – 0.13
Coarse Sand	1.00 – 1.31
Very Coarse Sand	1.01 – 1.99
Very Fine Gravel	2.00 – 7.99
Medium gravel	8.00 – 15.99
Coarse Gravel	16.00 – 31.99
Very Coarse Gravel	32.00 – 63.99
Small Cobble	64.00 – 127.99
Large Cobble	128.00 - 255.99
Boulder	256.00 – 4095.99
Bedrock	≥4096.00

Figure 15. Fort Dupont - Fish Blockages[1]



[1] Numbers next to fish blockages correspond to Table 8.

Table 8. Summary: Fort Dupont - Existing Fish Blockages

Fort Dupont Mainstem	Fish Blockage Type[1]	Blockage Height (in)	Description	Location					
				Latitude			Longitude		
				Deg.	Min.	Sec.	Deg.	Min.	Sec.
Upper									
1.	Complete	15	Perched 48" CMP culvert @ X-2	38	52	30.90	76	56	25.44
2.	Partial	12	Nick point approx. 150' below X-5	39	52	35.94	76	56	48.19
3.	Partial	12	Nick point approx. 370' below X-6	40	52	38.93	76	56	50.17
4.	Complete	24	Nick point approx. 150' below X-7	49	52	33.78	76	56	42.79
5.	Complete	31	Nick point/debris jam approx. 245' below X-8	50	52	32.77	76	56	33.79
Middle									
6.	Complete	0	Laminar flow assoc. w/ 436' (L), conc. box & pipe culvert @ Fort Davis Dr.	41	52	46.38	76	56	59.53
7.	Complete	36	A 3.0' drop at the 78" CMP (24' long) @ X-12	42	52	48.83	76	57	65.29
8.	Partial	10	Nick point/debris jam approx. 250' below X-12	43	52	48.97	76	57	68.06
9.	Partial	0	Laminar flow assoc. w/ 218' (L), 84" CMP culvert @ X-15	48	52	51.89	76	57	80.20
Lower									
10.	Complete	36	A 3.0' drop @ Lower Mainstem and Tributary No. 3 confluence @ Minnesota Ave.	45	52	54.26	76	57	93.30
11.	Complete	18	Nick point/Log Jam	46	52	52.79	76	57	95.78
12.	Complete	84	7' drop assoc. with the CSX rail road culvert	47	52	57.07	76	57	111.80
Tributary No. 2									
13.	Complete	18	Perched 36" RCP – Approx. 395' long	44	52	46.24	76	57	71.92

[1] Two types of physical fish barriers are noted: 1) partial barriers, defined as any obstruction which would likely prohibit or impede normal upstream-downstream fish movement during certain times of the year (e.g., low summer baseflow conditions); and 2) complete barriers, described as 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).
Note: numbers in column one correspond to Figure 14 (Fish Barriers).

3.3 RSAT Water Quality

As part of the RSAT survey, one-time baseflow grab sampling was conducted to provide a snap-shot of water quality conditions in the Fort Dupont mainstem and Tributary No. 2. The following 13 parameters were measured at approximately every fourth or fifth transect station: 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 parameters, TDS, nitrate and substrate fouling were selected for stream reach comparisons. Results are summarized in Figure 17 and Appendix 4.

Figure 16. 78" CMP with 3' Drop at Upstream End (X-12)

As seen in Figure 17, TDS levels in all four stream reaches surveyed were in the fair range (i.e., 101-150 mg/l). TDS levels were lowest in the middle mainstem (105 mg/l) and highest in the lower mainstem (140 mg/l).

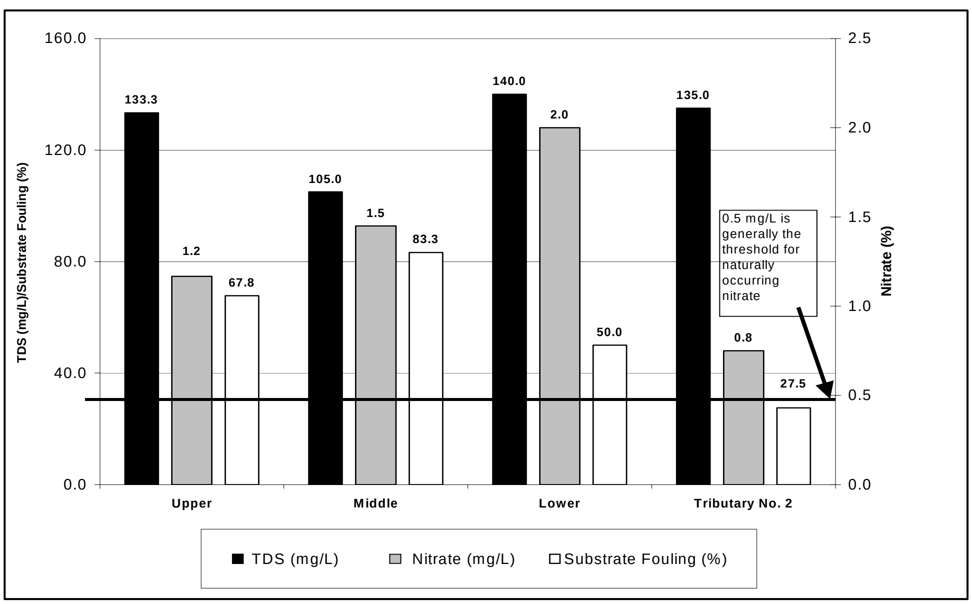


Figure 17. Fort Dupont: Mean TDS[1], Substrate Fouling[2] and Nitrate[3]

[1] TDS interpretation: <50 mg/L = Excellent, 50-100 mg/L = Good, 101-150 mg/L = Fair, >150mg/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.

With regard to mainstem nitrate levels, all were in the moderate range (i.e., 1.1-2.9 mg/l). Also, a distinct downstream increase was observed, with NO_3- levels increasing from a low of 1.2 mg/l in the upper mainstem to 1.5 mg/l in the middle mainstem and finally, to 2.0 mg/l in the lower mainstem. Nitrate concentrations in Tributary No. 2 were in the low range (i.e., <1.0 mg/l). Substrate fouling levels were rated as being poor in both the upper and middle mainstem (i.e., >50 percent of the bottom side of cobble-sized stones covered by an organic film) and fair in both the lower mainstem (50 percent fouling) and Tributary No. 2 (27.5 percent fouling).

The preceding results suggest low to moderate levels of organic loading/nutrient enrichment throughout the Fort Dupont tributary system. It should also be noted that spot fluoride readings taken in the upper mainstem on 5/19/99 ranged from 0.4 to 0.6 mg/l (mean 0.5 mg/l). Normally, natural background levels for fluoride in surface waters are on the order of 0.1 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 sewage or treated water.[10] Given the high fluoride readings and higher than average baseflow observed in the upper mainstem and the absence of any obvious signs of sewage input to the stream, in all likelihood the cause was a waterline leak or break in the extreme headwaters (i.e., Burns Road/Ridge Road area).

3.4 Riparian Habitat Conditions

As expected, owing to its heavily forested park setting, Fort Dupont riparian habitat conditions fell within either the good or excellent category (Table 9). As seen in Table 9, the lower mainstem had, at 61 percent, the lowest observed mean canopy coverage.[11] The reason for this is attributable to observed gaps in the forested riparian buffer associated with both the Minnesota Avenue (X-20) and transect station X-22 areas. With few exceptions, the riparian corridors were typically heavily forested and wide. In fact, 17 out of the 25 RSAT transect station sites (68 percent) featured forested riparian buffers 200 feet wide or greater along both banks (excellent range). Notable exceptions where buffer widths were considered fair/poor (i.e., < 50 feet along each bank), included the following middle mainstem sites: X-17, X-18 and X-19. It should be noted that the three preceding sites are located within the vicinity of both the Fort Dupont amphitheater stage and maintenance facility and their associated lawn areas.

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

Table 9. Summary: Fort Dupont – Riparian Habitat Conditions

RSAT Stream Segment	Segment Length (mi.)	No. of Observations	Mean Canopy Coverage (%)[1]	Riparian Habitat Condition	
				RSAT Score[2]	Verbal Ranking
Mainstem					
Upper	0.92	19	88	6	Excellent
Middle	0.60	18	87	5	Good
Lower	0.40	4	61	4	Good
Sub-Total	1.92	41	84.9	5.3[3]	Good
Tributary					
No. 1	---	---	---	---	---
No. 2	0.18	6	89	7	Excellent
No. 3	---	---	---	---	---

[1] Mean canopy coverage interpretation: ≥ 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

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 $1m^2$ samples. 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 $1m^2$ multiple-habitat sampling was performed at the following six sites:

- Upper mainstem (X-10 area),
- Middle mainstem (X-19 area),
- Lower mainstem (X-22 area),
- Tributary No. 1 (X-25 area),
- Tributary No. 2 (X-28), and
- Tributary No. 3 (approx. 100 feet upstream of the Fort Dupont confluence).

The preceding $1m^2$ macroinvertebrate collection work was conducted on April 14, 1999. It should be noted that at each $1m^2$ sampling location, macroinvertebrates were similarly collected from multiple habitats (via a D-net) using both kick and jab techniques. All $1m^2$ 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 $1m^2$ 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 Dupont 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 Fort Dupont Park tributary system is summarized in Figure 18.

In addition, the mean relative abundance of observed macroinvertebrate taxa is presented in Figure 19. Macroinvertebrate taxa richness for both RSAT voucher and $1m^2$ samples are included in Table 11. For additional tributary-specific macroinvertebrate survey results, the reader is referred to Appendix 5.

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; •moderate-high number of individuals.	•mayflies and caddisflies present (stoneflies absent), good overall diversity; •moderate-high number of individuals.	•pollution-tolerant caddisflies, snails, midgeflies, aquatic worms dominant; •low-moderate number of individuals.	•poor diversity generally dominated by midgeflies, aquatic worms and snails; •depauperate population-low number of individuals.

Table 10. RSAT Macroinvertebrate Community Condition

3.5.2 General RSAT Voucher Collection Findings

As seen in Figure 18, all three Fort Dupont mainstem reaches were rated as having fair macroinvertebrate community conditions. However, were it not for the few, scattered stonefly individuals (belonging to the genus *Amphinemura*) present along the entire mainstem length, overall individual scores would have been rated poor. Without exception, the mainstem macroinvertebrate community was depauperate, with characteristically poor to fair taxa richness and scarce relative abundances. The Tributary No. 2 macroinvertebrate community was rated as being good bordering on fair. Again, the good rating was heavily influenced by the scarce to common relative abundance of the stonefly *Amphinemura delosa.*

3.5.3 Macroinvertebrate Relative Abundance and Taxa Richness

Relative Abundance

The extremely low number of individuals collected from the mainstem belonging to representative pollution intolerant groups (e.g., stoneflies, mayflies and caddisflies) provides additional evidence of generally moderate levels of stream quality impairment. As seen in Figure 19, stoneflies were scarce in the Fort Dupont mainstem and scarce/common in Tributary No. 2. In addition, pollution intolerant mayflies and caddisflies were conspicuously absent throughout. Furthermore, with the exception of aquatic flies and midges all other taxa were present in low numbers. It is important to note that *Amphinemura delosa* was the lone stonefly taxon collected during the study. This small, late spring emerging stonefly is a detritivore that feeds primarily on leafy material. *Amphinemura's* life cycle includes an embryonic (egg stage) diapause, which lasts four to six months (Stewart and Stark, 1993). In all likelihood, this prolonged summer/fall diapause stage is an advantageous adaptation for living in small, often intermittent forested stream systems.

Also noteworthy was the presence of the highly pollution tolerant aquatic fly, *Bittacomorpha sp.*, which was common in Tributary No. 2. As reported by Ward (1992), this fly is often found in very shallow water among large sized organic material (i.e., wood and leaf debris).

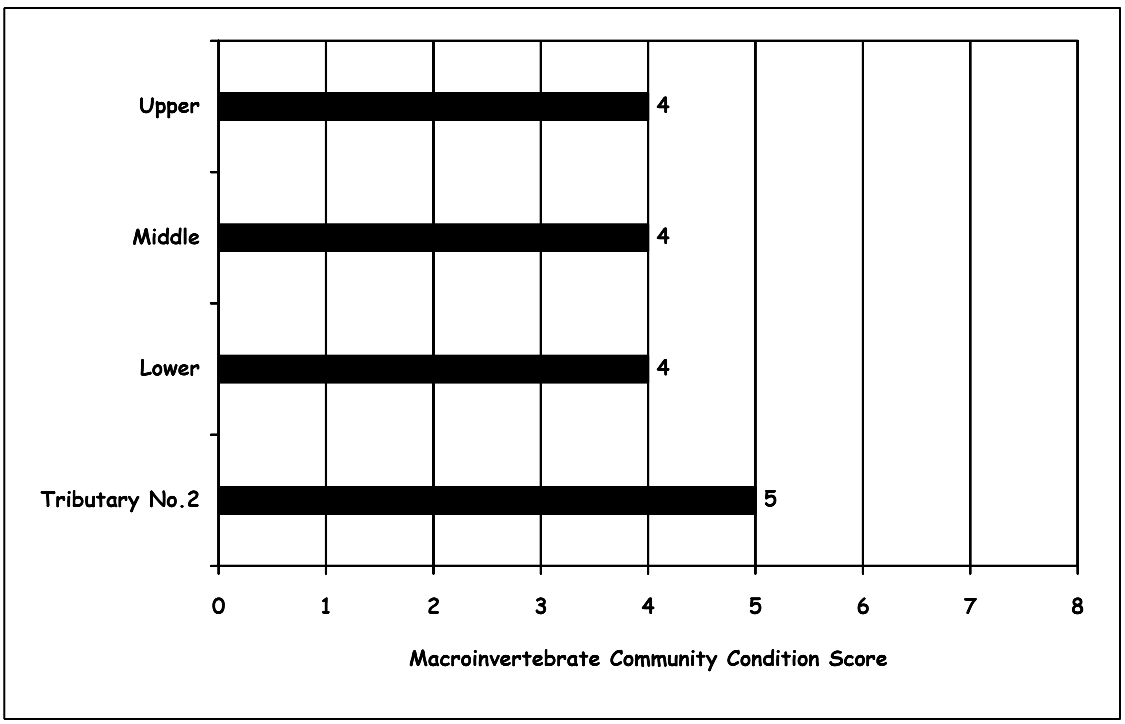


Figure 18. Fort Dupont: RSAT Voucher Collection Macroinvertebrate Community Condition[1]

[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.

Unlike many other aquatic organisms that remove oxygen from the water, *Bittacomopha sp.* uses its extendible tail (a caudal tube) as a respiratory tube to breathe atmospheric air.

Taxa Richness

During the course of the study a total of 36 macroinvertebrate taxa were identified from the Fort Dupont tributary system (Appendix 5; Table 1). As seen in Table 11, the highest number of taxa collected (17, good range) was associated with the Tributary No. 1 $1m^2$ sample. The remaining five stream sites all had between nine and fifteen taxa present and were rated fair.

Table 11. Summary: Fort Dupont - Macroinvertebrate Taxa Richness, Spring 1999

RSAT Stream Segment	Sampling Date		Stream Order[1]	Number of Taxa Collected		Verbal Rating[2]	
	RSAT Voucher	$1m^2$		RSAT Voucher[3]	$1m^2$	RSAT Voucher	$1m^2$
Mainstem							
Upper	May, 1999	April, 1999	2	15	10	Fair	Fair
Middle	May, 1999	April, 1999	3	9	9	Fair	Fair
Lower	May, 1999	April, 1999	3	7	10	Poor	Fair
Mean	----	----	----	10	10	----	----
Tributaries							
Number 1	----	April, 1999	1	N/A	17	N/A	Good
Number 2	June, 1999	April, 1999	1	8	12	Fair	Fair
Number 3	----	April, 1999	2	N/A	9	N/A	Fair
Mean	----	----	----	8	13	----	----

[1] Stream order based on 200-foot scale topographic map interpretation.
[2] General RSAT voucher interpretation for the number of taxa: $25 = Excellent, 16-24 = Good, 8-15 = Fair, 0-7 = Poor.
[3] RSAT voucher protocol surveys an area of 3 m^2/mi versus 1-2 m^2/mi surveyed with the $1m^2$ sample.

3.5.4 $1m^2$ Sample Metrics and MBSS IBI Scores

As previously stated, the $1m^2$ macroinvertebrate sampling was a more quantitative approach, which featured seven individual MBSS Coastal Plain stream metrics. Individual metric calculations were performed and used in developing the overall IBI score for each surveyed stream site. Results are presented in Table 12. It should be noted that fall 1999 $1m^2$ sampling results were intentionally included in Table 12, so as to provide additional insight on the effects of the drought on the Fort Dupont macroinvertebrate community.

As seen in Table 12, both spring and fall MBSS IBI scores for all six stream sites were verbally rated as being very poor (i.e., IBI scores < 2.0). In fact, only one sampling site (Tributary No. 1, spring 1999) had one metric score in the good range (i.e., 39.1 percent clingers). Importantly, the dominant clinger taxon at Tributary No. 1 was the highly pollution tolerant blackfly, *Simulium sp*. The associated verbal ratings for the scores of all other metrics for the five remaining stream sites 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.

Not surprisingly, the severe nature of the drought, which effectively dewatered the mainstem and Tributary No. 1 and No. 3 riffle areas for 30 consecutive days or longer during the study, had a major negative impact on the macroinvertebrate communities. As seen in Table 12, fall $1m^2$ macroinvertebrate densities were, compared to spring samples, markedly lower at each stream site. Hardest hit were Tributary Nos. 2 and 3, where the number of organisms collected in the fall decreased to 15 and 32 individuals, respectively. Similar, though somewhat less dramatic reductions were generally observed for all seven metric categories, at all six stream sites. With further regard to macroinvertebrate densities, all three spring 1999 tributary densities were higher than those reported for the mainstem. This suggests that: 1) the three tributaries may be serving as de facto nursery areas for several of the organisms present in the mainstem and 2) physical habitat, the general availability of food materials and/or water quality may be more limiting in the mainstem. Finally, it should be noted that the pollution intolerant stonefly *Amphinemura delosa* comprised approximately 80 percent (i.e., 631 individuals) of the spring 1999 Tributary No. 2 $1m^2$ sample.

The preceding MBSS metric and IBI scores generally support RSAT voucher collection findings that the overall Fort Dupont tributary biological community is, at a minimum, moderately impaired. While some of this impairment is certainly attributable to the severe drought, the results strongly suggest that both water quality and/or other physical aquatic habitat factors (e.g., streambed instability, altered water temperature regime, the episodic presence of iron floc on the Fort Dupont mainstem streambed, etc.) are responsible.

Table 12. **Summary: Fort Dupont - 1m^2 Macroinvertebrate Sample Metrics and MBSS Coastal Plain IBI Scores**

Site	Sampling Date	No. of Organisms/m^2	Taxa Richness[1]	Total No. of EPT Taxa[2]	Percent Ephemeroptera[3] (%)	Percent Tanytarsini[4] (%)	Beck's Biotic Index[5]	No. of Scraper Taxa[6]	Percent Clingers[7] (%)	MBSS IBI Score[8]	MBSS IBI Verbal Ranking
Mainstem					Spring						
Upper	04/14/1999	40	10	1	0	0	1	0	2.5	1.0	Very Poor
Middle	04/14/1999	66	9	1	0	0	4	0	6.1	1.3	Very Poor
Lower	04/14/1999	123	10	1	0	0	2	1	0.8	1.3	Very Poor
Tributary											
Number 1	04/14/1999	445	17	2	0	0	6	0	39.1	1.9	Very Poor
Number 2	04/14/1999	806	12	2	0	0	5	0	1.6	1.6	Very Poor
Number 3	04/14/1999	843	9	1	0	0	2	0	1.2	1.0	Very Poor
Mainstem					Fall						
Upper	11/22/1999	32	8	0	0	0	3	0	3.1	1.0	Very Poor
Middle	11/22/1999	55	6	0	0	0	1	0	0.0	1.0	Very Poor
Lower	11/22/1999	49	7	0	0	0	1	0	0.0	1.0	Very Poor
Tributary											
Number 1	11/22/1999	140	10	0	0	1.43	2	0	0.0	1.3	Very Poor
Number 2	11/22/1999	15	5	0	0	0	1	0	0.0	1.0	Very Poor
Number 3	11/22/1999	32	5	0	0	0	0	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.

Good	IBI Score 4.0 – 5.0	Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.
Fair	IBI Score 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 (10^{th} to 50^{th} percentiles).
Poor	IBI Score 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	IBI Score 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.

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

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 Dupont mainstem and Tributary No. 2 is included as Table 14. As seen in Table 14, the middle mainstem and Tributary No. 2 were the only stream reaches that received an overall good stream quality rating. Both the upper and lower mainstem areas were rated as being fair. Finally, it should be noted that the good stream quality rating which the middle mainstem received was bordering on fair.

3.7 Fort Dupont Mainstem One-Pass Electrofishing Survey

Due to the severity of the drought, which effectively dried up the Fort Dupont tributary system in August 1999, the planned summer 1999 mainstem electrofishing survey was not performed. However, results from the joint DC-DOH/EHA/COG December 15, 1998 one-pass electrofishing survey of the middle and upper mainstem areas identified the presence of only two small (approximately 8 inches-long) American eel, *Anguilla rostrata*, elvers. Both eels were collected from the large, deep middle mainstem pool located in the vicinity of X-14. The only other vertebrates collected were larvae of the northern two-lined salamander, *Eurycea bislineata*, which were relatively common. The preceding results confirmed that: 1) the Fort Dupont tributary system is currently not supporting a resident fish community and 2) the seven foot vertical drop associated with the lower CSX railroad culvert is a complete fish blockage which precludes normal exchange with and repopulation from Anacostia River fish stock.

Table 14. Fort Dupont Park Tributary Study Summary: Mainstem and Tributary No. 2 RSAT Ratings[1]

RSAT Stream Segment	1. Channel Stability	2. Channel Scouring/ Sediment Deposition	3. Physical Instream Habitat	4. Water Quality	5. Riparian Habitat Conditions	6. Biological Indicators	Overall RSAT Stream Quality Rating[2]
Mainstem							
Upper	Good (6)	Fair (3)	Fair (3)	Fair (3)	Excellent (6)	Fair (4)	**Fair (25)**
Middle	Excellent (9)	Fair (4)	Fair (4)	Fair (4)	Good (5)	Fair (4)	**Good (30)**
Lower	Excellent (9)	Fair (3)	Fair (3)	Fair (4)	Good (4)	Fair (4)	**Fair (27)**
Tributaries							
No. 1	Not Surveyed - Dry riffle area observed during RSAT period						
No. 2	Excellent (10)	Good (5)	Good (5)	Fair (4)	Excellent (7)	Good (5)	**Good (36)**
No. 3	Not Surveyed - Dry riffle area observed during RSAT period						

[1] Actual point values are shown in parentheses.
[2] Total RSAT score interpretation: 42-50 = Excellent, 30-41 = Good, 16-29 = Fair, <16 = Poor.

3.8 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 Martel Laboratories $_{\text{JDS}}$Inc. Due to budgetary constraints, this analysis was performed for five baseflow and five stormflow samples collected from the middle mainstem (X-16 area) between September-December 1999, only. In addition, limited in-situ grab sampling was conducted for the period June-December 1999 at the four following locations: 1) upper mainstem (X-7), 2) middle mainstem (X-16), 3) lower mainstem (X-21) and Tributary No. 2 (X-28). Results are summarized in Figures 16 and 17 and Appendix 6.

Baseflow DO

Despite the prolonged and severe nature of the drought, no violation of the District of Columbia's Department of Health (DC-DOH) 5.0 mg/l criterion was ever recorded. As seen in Figure 20, median DO levels were, on average, 1.1-2.5 mg/l higher in the middle mainstem than elsewhere. This higher observed level may in part be attributable to the middle mainstem's modest gradient, somewhat coarser riffle substrate and the relatively low amount of organic matter associated with the streambed.

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), increased in the Fort Dupont mainstem in distinct downstream fashion.[12] As seen in Figure 20, median baseflow conductivity concentrations for the four stream sites ranged from a low of 180 μS/cm in the upper mainstem to a high of 280 μS/cm in the lower mainstem. By comparison, the median conductivity level for Tributary No. 2 was 240 μS/cm.

Limited water quality surveys of relatively undisturbed Coastal Plain streams in Maryland and other mid-Atlantic states strongly suggest that Fort Dupont baseflow conductivity levels should be in the 60-160 μS/cm range (Thomas, 1966; Janicki et al., 1995; Galli et al., 1997, MCDEP, 1998; Stribling et al., 1999). The preceding findings suggest decreasing mainstem water quality conditions with increasing distance from the source. They also suggest low levels of water quality degradation in both the Fort Dupont mainstem and Tributary No. 2.

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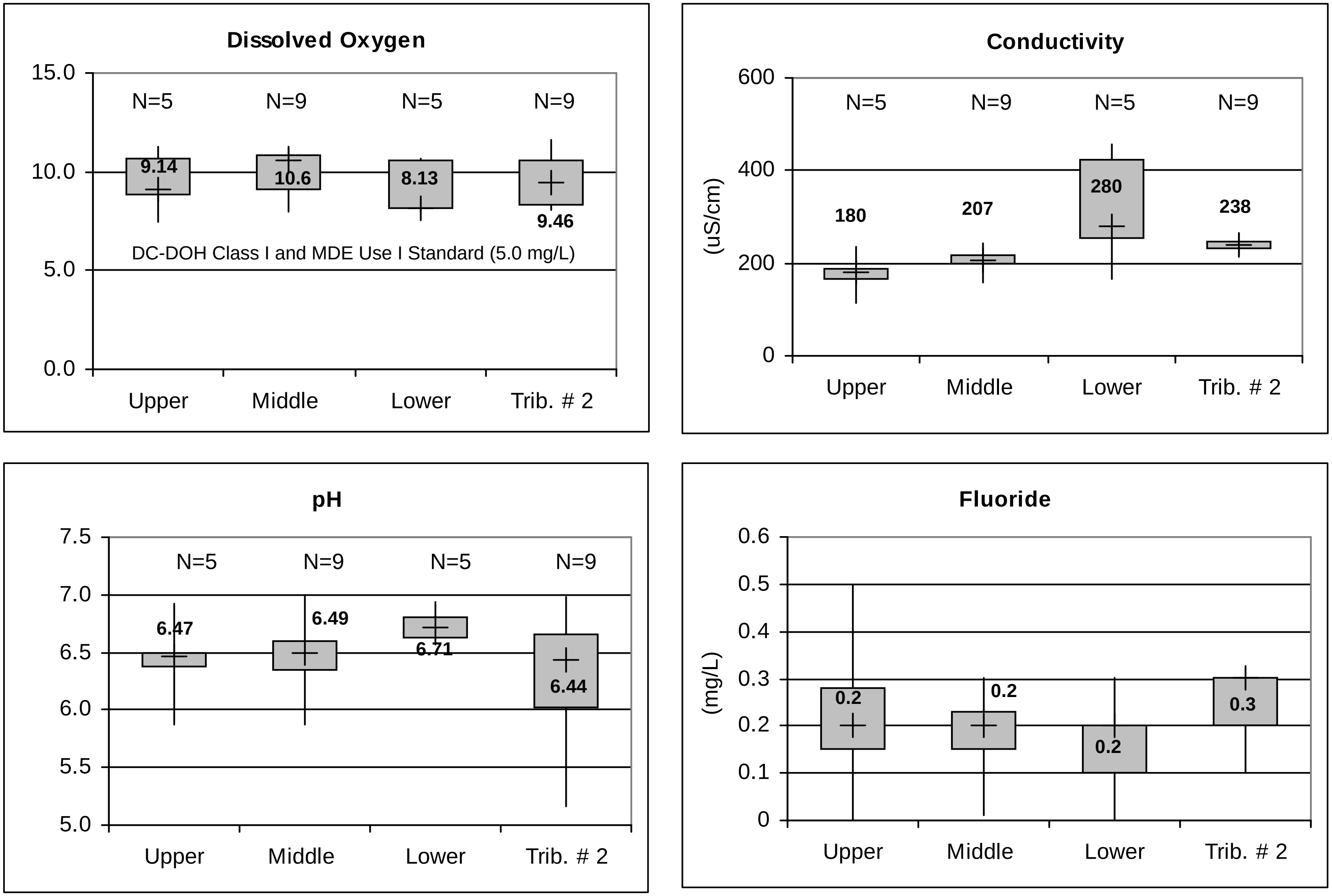
[12] Conductivity levels often increase in response to a variety of anthropogenic activities and related pollution such as sewage from sanitary sewer line/septic field leakage, road salting, leaching from recently disturbed soils, application of fertilizers, etc.

Figure 20. Fort Dupont Upper, Middle and Lower Mainstem and Tributary No. 2 Baseflow DO, Conductivity, pH and Fluoride (May - December 1999)



Middle Mainstem Baseflow NO_3, TP, Fe, Cu, TOC and BOD

Baseflow water chemistry analysis results (Figure 21; Appendix 6: Table 1) for the Fort Dupont middle mainstem (X-16) revealed that: 1) both nitrate (NO_3) and total phosphorus (TP) concentrations were low, 2) iron (Fe) levels violated the DC-DOH/EHA Class 'C' 1.0 mg/l criterion for the protection of aquatic life 71.4 percent of the time, 3) the maximum observed copper (Cu) concentration (6 μg/l) was well below the generally recommended 'instantaneous' concentration limit of 18-20 μg/l established by EPA (1986); and MDE (1995) and 4) both total organic carbon (TOC) and biochemical oxygen demand (BOD) levels were slightly elevated.

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. As seen in Figure 21, the maximum baseflow NO_3 concentration recorded was 0.29 mg/l. Baseflow TP levels were similarly low (i.e., <0.15 mg/l). From the data it is apparent that the 0.10 mg/l TP concentration level recommended by EPA (1986) for the reduction and/or avoidance of nuisance plant growth in streams is infrequently exceeded.

During the course of the study, COG staff routinely observed signs of the presence of iron-oxidizing bacteria (and their associated oily films, flocculates and/or globules) throughout the entire Fort Dupont stream system. Both large globules (Figure 22) and high levels of iron flocculates (which often coated the entire streambed) were commonly associated with mainstem areas, whereas oily films and lower levels of flocculates were more typical of the tributaries.

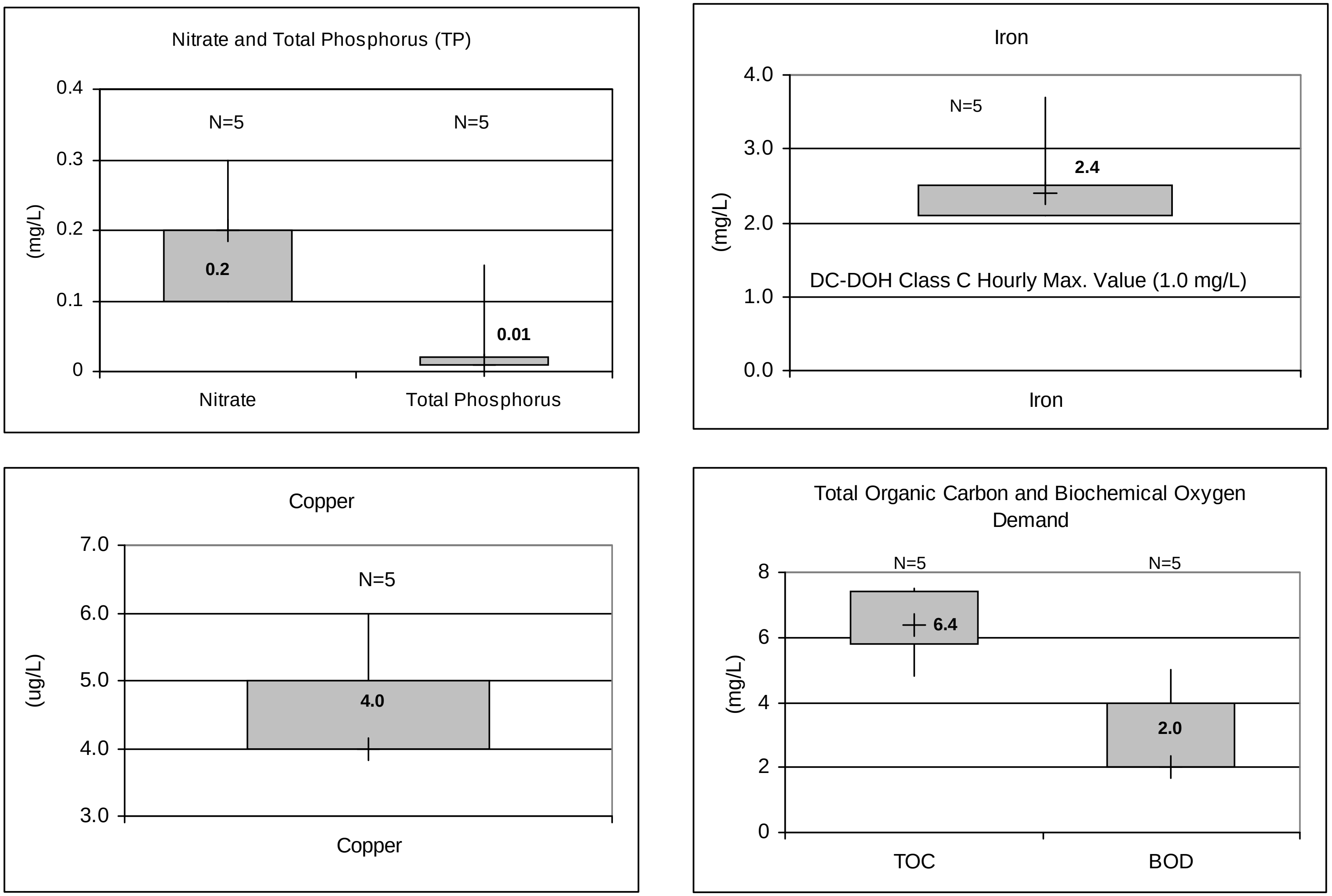
According to Robbins and Norden (1994), iron bacteria are part of the natural flora of iron-rich streams, such as those present in the Atlantic Coastal Plain. From the data (Figure 21 and Appendix 6: Table 1 and Table 3), it is apparent that the Fort Dupont stream system is iron-rich, with baseflow Fe concentrations during the study ranging from 0.32 to 3.7 mg/l. These levels may be unsuitable for certain sensitive macroinvertebrate and fish species (EPA, 1986; Hohreiter, 1980).

As seen in Figure 21, baseflow TOC and BOD levels ranged from 4.8-7.5 mg/l and 2.0-4.0 mg/l, respectively. The somewhat higher than expected TOC concentrations may in part help explain the previously noted moderate to high substrate fouling levels observed throughout the Fort Dupont stream system.

Middle Mainstem 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) runoff from even relatively small rainfall events (i.e., <0.25 inches rainfall/24 hrs) produced highly turbid conditions in the Fort Dupont mainstem (Figure 23), 2) mainstem turbidity levels returned to baseflow condition within approximately six to eight hours following the cessation of rainfall, 3) with the exception of the Hurricane Floyd storm (3.69 inches of rainfall on 9/16/99), Tributary No. 2 always ran clear and 4) water clarity in all three tributaries returned to baseflow condition within the span of approximately one to two hours.

Figure 21. Fort Dupont - Middle Mainstem (X-16) Baseflow Nitrate, Total Phosphorus, Copper, Iron, Total Organic Carbon and Biochemical Oxygen Demand (Sept. - Dec. 1999)



Not surprisingly, NO_3, TP, Fe, Cu, TOC and BOD levels all experienced marked increases under stormflow conditions. In addition, Hurricane Floyd (9/16/99) produced major outlier spikes in associated concentration levels for all six preceding water quality parameters. As seen in Figure 24, median stormflow NO_3 and TP concentrations were, compared to baseflow conditions, approximately two and four times higher, respectively.

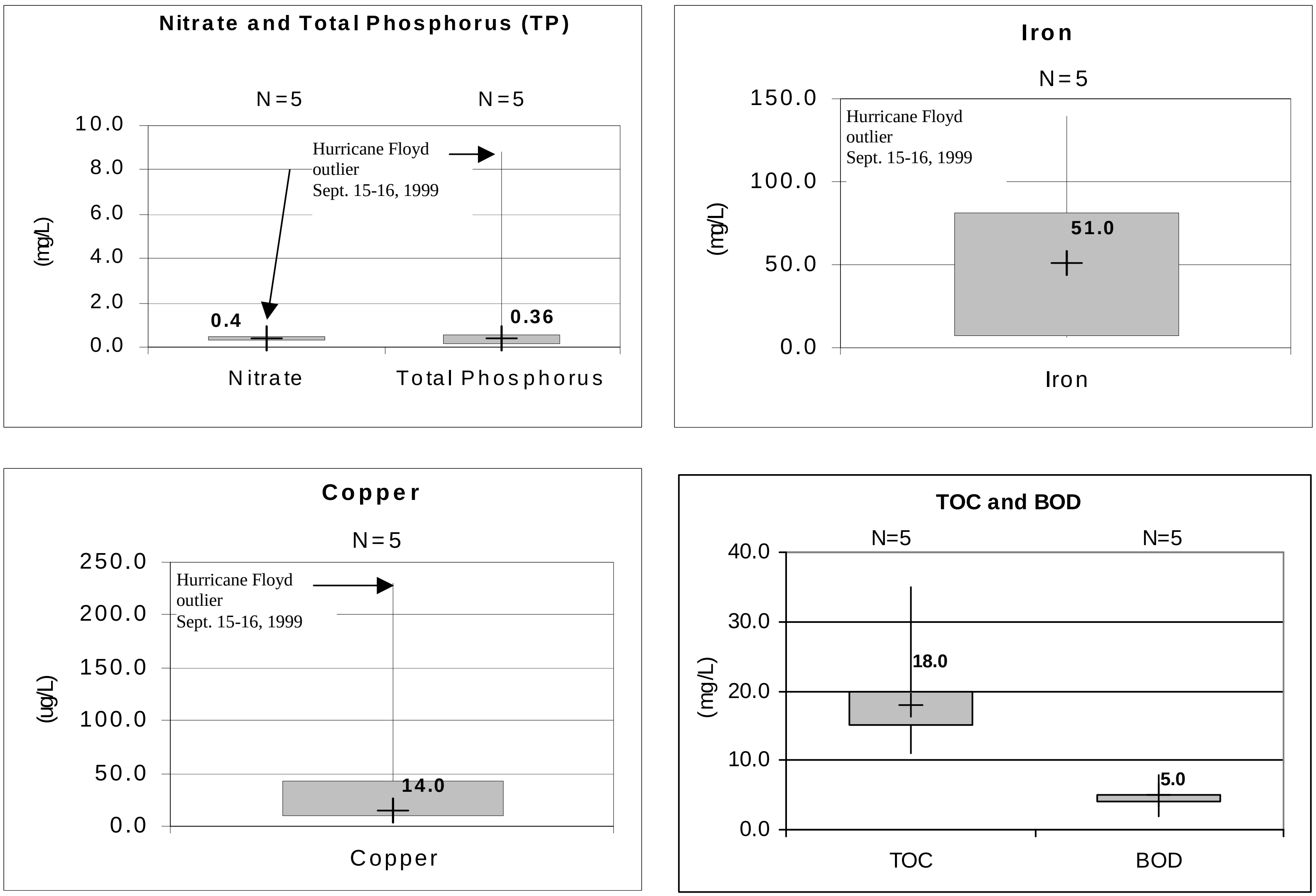
Figure 22. Episodic Iron Floc Coating of Mainstem Streambed (X-13 area)

Stormflow Fe concentrations ranged from 5.8 mg/l to 140 mg/l (Hurricane Floyd), with a median of 51.0 mg/l. This median concentration was approximately 25 times greater than that observed for baseflow conditions, and is reflective of both the high iron content of the soils of the Fort Dupont subwatershed, and their mobility during storm events. While the preceding concentrations and exposure periods may not in themselves be toxic, they would appear to be a major stressor on the Fort Dupont aquatic community. For example, macroinvertebrate and fish toxicity studies (Skyora et al., 1972; Ebeling, 1931; Roback, S. in Hart and Fuller, 1974) suggest that the preceding Fe levels could cause reproductive impairment, reduced emergence, 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.

Figure 23. Fort Dupont Mainstem – Stormflow Runoff

With regard to Cu, stormflow concentrations ranged from 9.0 μg/l to 230.0 μg/l (Hurricane Floyd). The median stormflow Cu concentration was 14.0 μg/l. This median level was more than three times greater than the median baseflow concentration (i.e., 14.0 μg/l versus 4.0 μg/l).

Figure 24. Fort Dupont - Middle Mainstem (X-16) Stormflow Nitrate, Total Phosphorus, Copper, Iron, Total Organic Carbon and Biochemical Oxygen Demand (Sept. - Dec. 1999)



According to EPA (1986), in order to protect most aquatic organisms, hourly copper concentrations should not (at a hardness level of 100 mg/l) exceed 18 μg/l. This 'instantaneous' 18 μg/l level is currently used by the State of Maryland for its acute freshwater copper toxicity criterion (MDE, 1995). It should be noted that Fort Dupont stormflow hardness concentrations ranged from 52 to 91 mg/l (Appendix 6: Table 2). Conversely, DC-DOH/EHA water quality standards currently employ an alkalinity-adjusted copper criterion. Based on the observed Fort Dupont stormflow alkalinity levels, the hourly maximum allowable DC-DOH/EHA Cu concentrations for the five sampled storms would have been 16.0, 9.0, 17.0, 12.5 and 12.5 μg/l, respectively. Actual corresponding stormflow Cu concentrations were 230 (Hurricane Floyd), 43, 9, 10 and 14 μg/l, respectively. While copper is readily adsorbed by suspended matter and does not bioaccumulate, the preceding findings are of concern and suggest that copper concentrations could also be limiting to the Fort Dupont aquatic community. Finally, given that the stormwater samples were collected upstream of the maintenance facility's storm drain outfall, the preceding results indicate an upstream source(s) for Cu, Fe and other pollutants.

As seen in Figure 24, stormflow TOC concentrations ranged from 11 to 35 mg/l, with a median of 18 mg/l. Somewhat to the surprise of COG staff, stormflow BOD levels remained well below the typical mean 11.9-30 mg/l concentration range reported by Schueler (1987) and Novotny and Olem (1994) for urban stormwater runoff. In fact, the maximum stormflow BOD concentration observed during the study was only 8.0 mg/l (Figure 24). The preceding results, together with relatively low fecal coliform concentrations recorded during the study strongly suggest that much of the organic load to the stream is of the natural, background variety as opposed to anthropogenic sources such as sewage.

3.9 Sediment Chemistry

Results from the Fort Dupont sediment grab sample testing are presented in Table 15. As seen in Table 15, 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 typically present in urban runoff were detected at relatively low levels. It should be noted that interpretation of the sediment chemistry data is, because of the current lack of EPA sediment quality criteria and incomplete understanding of the bioavailability of these pollutants, still quite 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 the Fort Dupont mainstem.

Table 15. Fort Dupont – Select Mainstem Sediment Chemistry Results (October 1999)

EPA Method Number	Analyte (mg/kg)	Detection Limit (mg/kg)	Test Value[1]
	Hydrocarbons		
625	Benzo(a)anthracene	1	ND
625	Benzoflouranthenes[2]	1	ND
625	Benzo(a)pyrene	1	ND
625	Benzo(g,h,i)perylene	1	ND
625	Bis(2-ehtylhexyl)phthalate)	10	ND
625	Chrysene	1	ND
625	Fluoranthene	1	ND
625	Indeno-(1,2,3,-cd)-pyrene	10	ND
625	Phenanthrene	1	ND
625	Pyrene	1	ND
625	Di-N-butyl phthalate	1	ND
	Metals		
200.7	Arsenic	50	<50
200.7	Beryllium	1	<1
200.7	Chromium	1	5.9
200.7	Copper	1	4.7
200.7	Lead	10	<10
200.7	Nickel	2	5.7
200.7	Phenol	10	ND
200.7	Zinc	1	21

[1] ND indicates not detected.
[2] Detected and reported as the sum of Benzo(b)flouranthene and Benzo(k)flouranthenes.

3.10 Physical/Hydrological

3.10.1 1999 Stream Temperature Monitoring

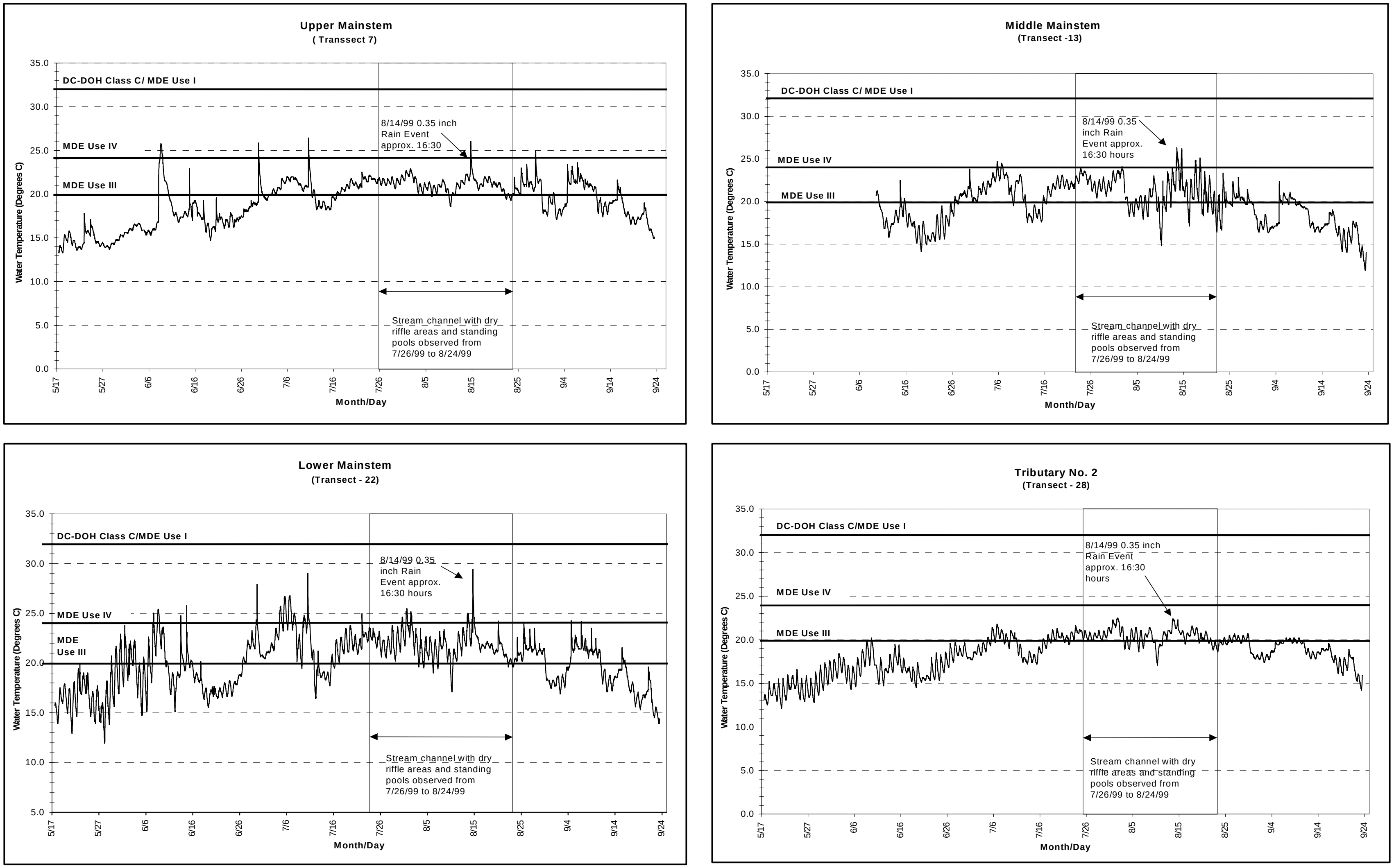
Results from the 5/17/99 to 9/24/99 continuous stream temperature monitoring portion of the study are presented in Figures 25 and 26. In addition to the 32.2 °C (90 °F) DC-DOH/EHA Class 'C' temperature standard for the stream, COG staff have included both the MDE 24 °C Use IV recreational trout and 20 °C (68 °C) Use III natural trout waters criteria for further comparison.

As seen in Figure 25, stream temperatures in all three Fort Dupont mainstem reaches, as well as in Tributary No. 2 were well below the DC-DOH/EHA Class 'C' standard. Importantly, the small spring-like Tributary No. 2 (Figure 25, Panel D) was by far the coldest of the four stream areas monitored.

Unlike the Fort Dupont mainstem, which exhibited water temperature 'spikes' in response to stormflow inputs and high air temperatures, diurnal stream temperature fluctuations in Tributary No. 2 remained relatively constant. Additional results from the 130 day monitoring period are as follows: 1) all three mainstem stations had maximum summer daily temperatures that exceeded both the 20 °C Use III and 24 °C Use IV temperature criteria; 2) mainstem stream temperatures increased in downstream fashion, with the lower mainstem being on average 2 °C warmer than the upper mainstem; 3) the maximum daily water temperature recorded during the study (29 °C) was measured in the lower mainstem and coincided with a 0.35 inch rainfall event on 8/14/99; 4) with the exception of standing pools of water, all four stream reaches were, because of the drought, dry between July 26th and August 24th (i.e., a 30-day period); 5) the thermal regimes of the three mainstem stations were far more strongly influenced by prevailing air temperatures than that of Tributary No. 2 and 6) the maximum daily water temperature recorded for Tributary No. 2 was 22 °C. Additional analysis (Figure 26) revealed that water temperature at Tributary No. 2 was at or below 20 °C 92 percent of the time. By comparison, the upper, middle and lower mainstem were below 20 °C 69, 67 and 55 percent of the time, respectively.

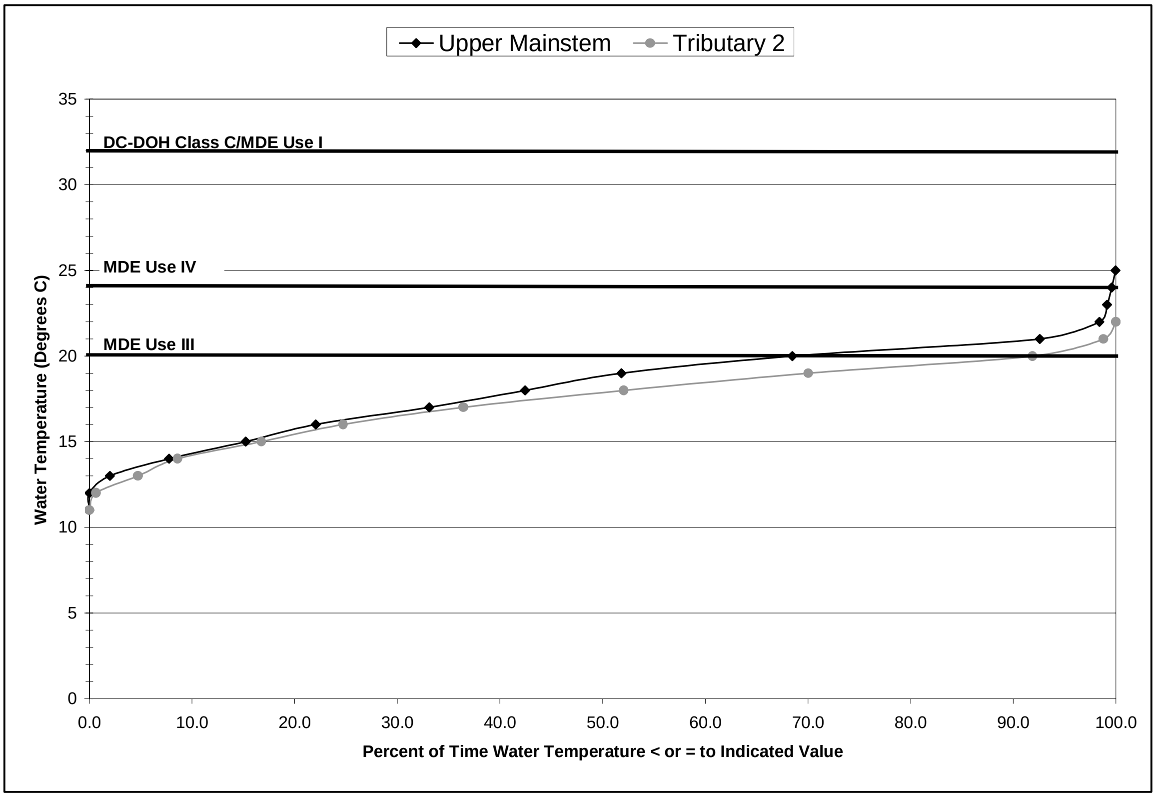
Based on the preceding water temperature monitoring results the temperature regime for the entire Fort Dupont mainstem can be generally categorized, per Galli (1990) as being that of a coolwater stream system, whereas that for Tributary No. 2 may be viewed as a coolwater stream bordering on cold. Summer temperatures at all four 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. This may explain in part why far higher numbers of *Amphinemura delosa* individuals were collected from Tributary No. 2 than anywhere else in the Fort Dupont stream system.

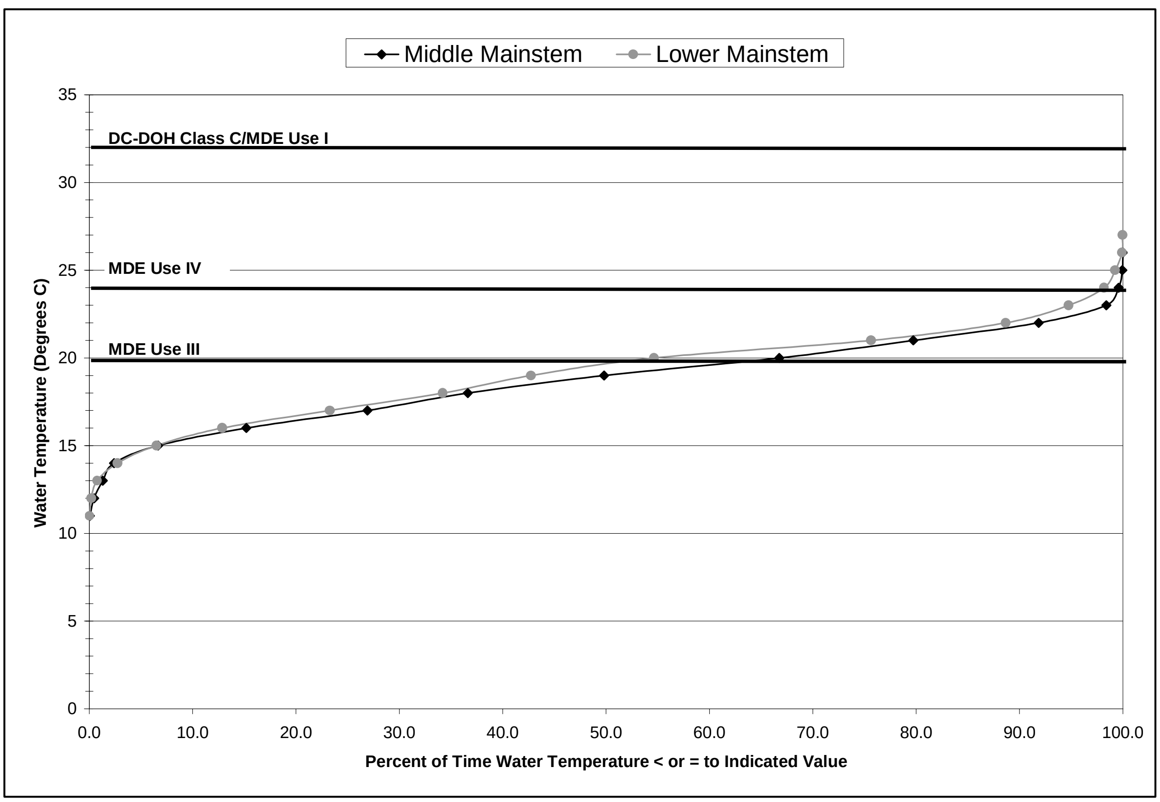
Figure 25. Fort Dupont - Upper, Middle, Lower Mainstems and Tributary No. 2 Twenty-Minute Temperature Readings[1] (May 17 – Sept. 24, 1999)



[1] DC-DOH Maximum Water Temperature Standards: Class C – 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 26. Fort Dupont Water Temperature Distribution: Upper Mainstem versus Tributary Number 2 and Middle versus Lower Mainstem (May17-Sept. 24, 1999)





3.10.2 Baseflow Discharge

As previously indicated, between June 15 and November 25, 1999 COG staff made a total of 16 baseflow measurements at the middle mainstem (X-16) flow monitoring station. Baseflow discharge results are shown in Figure 27. As seen in Figure 27, baseflow between mid-June through the end of September was dramatically reduced by

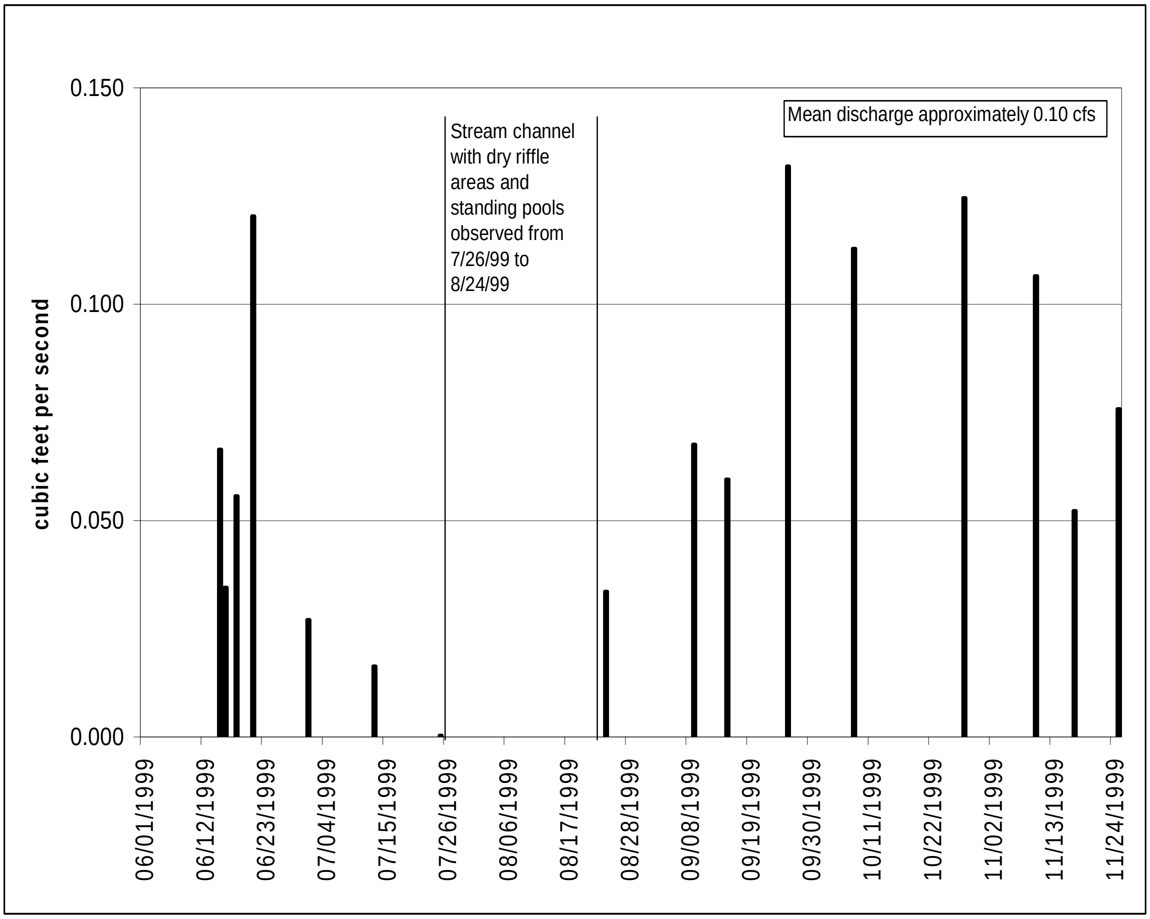


Figure 27. Fort Dupont: Middle Mainstem (X-16) - Baseflow Discharge (June – November, 1999)

the drought. In fact, with the exception of a few, isolated standing pools of water, the Fort Dupont mainstem was dry from 7/26/99 to 8/24/99, a period of 30 days. Following several significant rainfall events in both late August and September, baseflow resumed in the mainstem. Although mean Fort Dupont mainstem baseflow during the study period was 0.10 cfs, in all likelihood this discharge was (based on total "water year", October through September, precipitation levels) some 10-15 percent below the expected 'normal' average. During the 1999 water year, monthly precipitation was well below normal in eight out of the 12 months. Finally, it should be noted that the small spring located along the "valley trail" (a.k.a. Tributary No. 3A) along with Tributary No. 2 were the only stream areas which maintained some measure of baseflow (i.e., trickle flow) throughout the drought.

3.10.3 Middle - Mainstem Stage - Discharge Rating Curve and Stormflow Response

Rating Curve

In an effort to better predict stormflow discharges in the Fort Dupont mainstem COG staff developed, as previously described, a stage-discharge rating curve (Figure 28). As shown in Figure 28, seven stormfall events (14 discharge measurements, total, taken during the ascending portion of the hydrograph) were used to generate the rating curve. Based on stage elevation-related data, the following general storm frequency/discharge levels were additionally calculated:

- weekly (0.25" rainfall/24 hours)= ~5.0 cfs;
- one month (0.75" rainfall/24 hours)= ~9.2 cfs;
- six month (1.65" rainfall/24 hours)= ~33.5 cfs;
- 1-year (2.60" rainfall/24 hours)= ~102.0 cfs;
- 2-year (3.20" rainfall/24 hours)= ~187.0 cfs; and
- 5-year (4.20" rainfall/24 hours)= ~457.0 cfs.

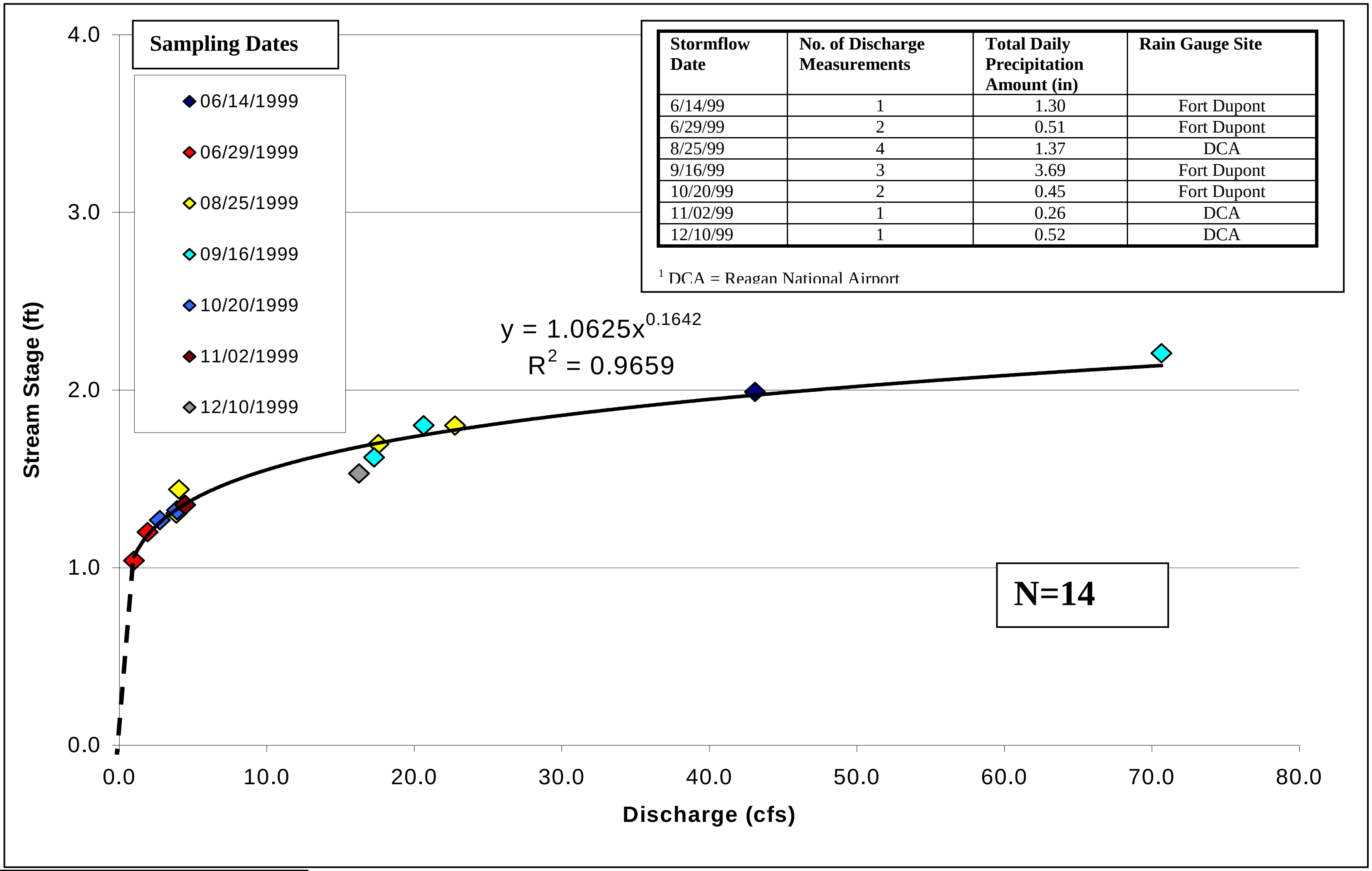
The preceding results should be of interest for future detailed Fort Dupont hydraulic geometry, sediment transport, stormwater management, storm drainage and/or stream restoration evaluations. For example, the 70 cfs discharge measured during the ascending portion of the hydrograph for Hurricane Floyd (3.69" rainfall, 2-year plus frequency storm) was sufficient to cause localized mainstem flooding. As graphically shown in Figures 29 and 30, runoff from Floyd flooded the valley from Minnesota Avenue back upstream to the lower NPS maintenance road. Clearly, the design stormflow capacity for the 16' wide by 3' high Minnesota Avenue box culvert has, over time, been compromised by the major accumulation of sediment and debris.

Stormflow Response

As is the case with most small urban streams, flows in the Fort Dupont tributary responded quickly and often unpredictably to small rainfall events. For example, the relatively steady 0.45 inch rainfall on 11/20/99 resulted in a 1.35 foot increase in stage and a discharge of approximately 5 cfs (Figure 28). In contrast, runoff associated with the shorter, more intense 0.52 inch storm on 10/20/99 produced both a 1.65 foot increase in stage and a discharge of approximately 16 cfs (which, is approximately 160 times higher than the mean baseflow discharge).

During the study, COG staff also observed that stormwater runoff associated with even small, 0.25 inch rainfall events was sufficient to move gravel-sized streambed materials in the mainstem. It was additionally noted that runoff from approximately 1.0 inch storms displaced cobble-sized materials.

Figure 28. Fort Dupont: Middle Mainstem– Stage-Discharge Rating Curve (June – December 1999) [1]



Stormflow Date	No. of Discharge Measurements	Total Daily Precipitation Amount (in)	Rain Gauge Site
6/14/99	1	1.30	Fort Dupont
6/29/99	2	0.51	Fort Dupont
8/25/99	4	1.37	DCA
9/16/99	3	3.69	Fort Dupont
10/20/99	2	0.45	Fort Dupont
11/02/99	1	0.26	DCA
12/10/99	1	0.52	DCA

[1] DCA = Reagan National Airport

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

Figure 29. Hurricane Floyd: NPS Maintenance Road Culvert Looking Downstream (X-19 area)

Figure 30. Hurricane Floyd: Flooding Upstream of Minnesota Avenue

4.0 Discussion

The results of this study generally support the findings from previous investigations (Johnson, 1989; Banta, 1993) that the Fort Dupont tributary biological community is moderately impaired. Not surprisingly, decades of uncontrolled stormwater runoff in combination with major channel modifications have: 1) created a characteristically 'flashy', urban stream flow regime; 2) altered channel morphology and increased levels of stream channel erosion, particularly in the upper mainstem; 3) dramatically increased mainstem stormflow levels of sediment, Fe, Cu and other pollutants; 4) reduced both streambed stability and physical aquatic habitat; 5) resulted in the enclosure of 2,240 linear feet of the stream system and the creation of 13 major fish blockages and 6) with the exception of the American eel, *Anguilla rostrata*, eliminated all resident fish from the stream. In addition, the 1998-99 drought, which effectively dried up all baseflow in the mainstem for a 30-day period during summer 1999, underscored the limited groundwater supply for the stream.

In spite of all of these problems, the Fort Dupont macroinvertebrate community still manages to support 36 taxa, including both the pollution intolerant stonefly, *Amphinemura delosa*, and caddisfly *Ironoquia sp*. Importantly, the more physically stable and biologically diverse Tributary Nos. 1, 2 and 3A are viewed by COG staff as serving as important refugia for the benthic community. Therefore, protection of these three areas is paramount to any future, successful restoration attempt of the Fort Dupont mainstem.

Regarding mainstem restoration potential, several key factors should be kept in perspective. First, because the Fort Dupont subwatershed is relatively undeveloped and major stormwater inputs are concentrated in its headwaters, the stream should respond well to an effective stormflow diversion/stormwater management system located in that portion of the catchment. Thus, it is expected that such a system would improve both mainstem streambed stability and stormflow water quality. This should have an overall positive impact on the macroinvertebrate community. However, it is unlikely that potentially limiting stormflow and/or baseflow concentrations of Fe would be totally eliminated. Second, the episodic coating of major portions of the mainstem streambed with flocculates and globules produced by iron oxidizing bacteria is likely to continue to occur, for the foreseeable future, in this iron-rich stream system. Just what limiting effects this may have on both the quality and quantity of future macroinvertebrate/fish habitat and food supply is unclear. Third, the relatively low mainstem baseflow discharge (i.e., mean 0.10 cfs) together with the low number of deep, quality pools and presence of 13 fish barriers (including the seven foot high CSX culvert blockage), severely restricts fish restoration potential. Given the number and magnitude of fish blockages, fish reintroduction with native species appears to be the most cost-effective and viable means for re-establishing a mainstem fish community.

Based on its stream size and direct connection with the tidal Anacostia River, it is estimated that the Fort Dupont mainstem may have historically supported 12 to 15 resident fish species. While no historical fisheries data specific to the Fort Dupont tributary are known to exist, the list of fishes collected in neighboring Oxon Run in 1920 (Table 16) provides both valuable historical insight, as well as potential candidate species for reintroduction. In COG staff's opinion, even without the previously recommended stormflow diversion/stormwater management system in place, the Fort Dupont tributary should 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 species, using individuals collected from other Anacostia tributaries, should be performed as soon as National Park Service approval can be obtained.

5.0 Recommendations

In an effort to comprehensively address both existing problems and restoration opportunities for the Fort Dupont stream system, COG staff developed the following suite of recommendations which are keyed both to Figure 31 (map) and to Figures 32-36 (photographs).

1. The NPS, USGS and DC- DOH/EHA should continue to work together to pursue stormwater management options, which will significantly reduce erosive stormflow conditions and improve water quality in the headwaters of the Fort Dupont tributary mainstem.

2. The mainstem culvert at Minnesota Avenue is silted-in. Stream flow is now flowing parallel to Minnesota Avenue and proceeding downstream via the Tributary No. 3 culvert (also located at Minnesota Ave.). Therefore, it is strongly recommended that the mainstem culvert be cleaned out as soon as possible. Note: this work needs to be done very carefully to avoid initiating streambed headcutting upstream of the culvert.

3. NPS should develop and implement a park-wide gully erosion control program. Volunteer groups such as the Earth Conservation Corps could perform much of this remedial work. Recommended priority sites include:

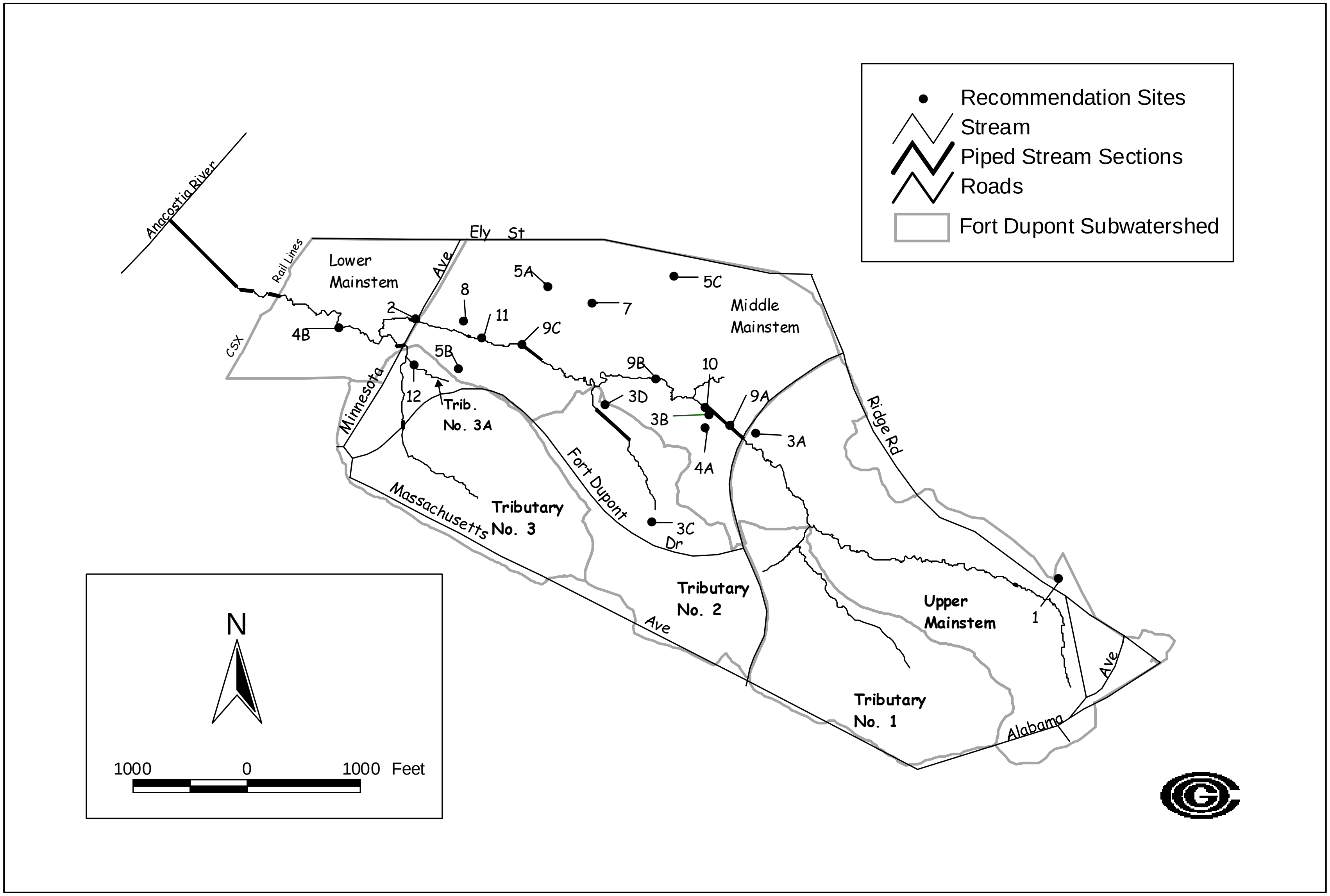
    A. Foot trail system upstream of Fort Davis Dr.;
    B. Unpaved maintenance road below Fort Davis Dr.;
    C. Community Garden (lower one-half); and
    D. Foot path area east of Tributary No. 2.

Table 16. Fort Dupont: Potential Candidate Fish Species for Fort Dupont 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.

Figure 31. Fort Dupont - Project Recommendation Sites



4. The two existing dump sites [i.e., upper, "dedicated" site 'A' located north of the community garden and lower, "illegal" site 'B' below Minnesota Ave. (Figure 32)] should be cleaned up as soon as possible. It is also strongly recommended that soils in the vicinity of dump site 'A' be tested for possible contaminants such as heavy metals, pesticides, etc.

Figure 32. Site 4B. - Dump Site (X-22 area)

5. Provide additional on-site stormwater management controls at the following locations:

    A. Fort Dupont Maintenance Facility [wetland/marsh system (Figure 33) recommended];
    B. Activity Center Parking Lot (bioretention or modified Delaware sand filter recommended); and
    C. Fort Dupont Ice Rink Parking Lot [bioretention recommended (Figure 34)].

Figure 33. Site 5A. - Recommended SWM Wetland Creation Area

Figure 34. Soapy Discharge from Fort Dupont Ice Rink Area (Site 5C)

6. Incorporate a dedicated material storage area into the existing maintenance facility.

7. Fort Dupont Stable – relocate existing paddock area to a flatter site (i.e., possibly east side of existing barn) so as to eliminate the existing gully erosion problems.

8. Reforest the right hand bank (looking downstream) from the maintenance facility area to Minnesota Avenue, so as to create a minimum 50-foot wide, continuous forested buffer.

9. Fish Passage – remove or modify the following culverts:

   A. Fort Davis Drive (grout interior to create deeper baseflow channel);
   B. Remove the 24-foot long 78" CMP culvert (X-12 area) with associated 3-foot drop. Use series of rock vortex weirs to step stream down; and
   C. Remove the 218-foot long 86" CMP culvert (X-15 area). Use series of rock vortex weirs to step stream down.

10. Create a vernal pool along the left bank immediately downstream of the Fort Davis Drive culvert (Figure 35). Note: the vernal pool could be hand excavated using Earth Conservation Corps or other volunteers.

11. Remove approximately 30-feet of downed chain link fence lying across the stream in the vicinity of the Fort Dupont Amphitheater.

Figure 35. Site 4A. - Recommended Vernal Pool Creation Area

12. Enhance and create additional deep pool areas (i.e., > 24" deep) in the upper and middle mainstem areas and Tributary 3A (Figure 36) to provide refugia for aquatic life. The employment of pool forming structures, such as rootwads, log spurs, rock vortex weirs, etc. should be considered.

13. On an experimental basis, reintroduce native fish into the Fort Dupont stream system. More specific details are provided below:

    - Using COG's previous stream restoration experience in the Anacostia's Sligo Creek subwatershed and Table 16 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.

Figure 36. Site 12. - Recommended Pool Refugium Creation Site (Trib. No. 3A Foot Bridge

- Stocking should be phased, with the hardiest pioneer species, such as the blacknose dace and northern creek chub, being introduced first. Using Table 7 (Fort Dupont Mainstem Pool Quality) as a rough stocking density guide, COG staff recommend that approximately 10 blacknose dace and two northern creek chub individuals be stocked per mainstem pool (i.e., approximately 270 blacknose dace and 50 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 mainstem pool quality has markedly improved. Additional future stockings beyond the recommended six target species should only occur after both stormflow diversion/stormwater management controls are operational and monitoring results indicate a recovering stream system.

14. Continue physical, chemical and biological monitoring of the Fort Dupont tributary system to evaluate stream recovery from both the drought and restoration projects.

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