CHEMICAL, BIOLOGICAL, AND PHYSICAL CHARACTERIZATION OF THE CHURCH CREEK AND PAROLE PLAZA NPDES MONITORING STATIONS: 2016 - 2017

FINAL REPORT

Prepared for

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1 INTRODUCTION

In 1998, Anne Arundel County began implementing a long-term monitoring program that satisfies requirements for its Countywide National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Discharge Permit. Monitoring has continued to be required as part of the terms of each renewed permit. Currently, monitoring is required to satisfy conditions outlined in Section F: Assessment of Controls of the County's new permit issued in February 2014. The monitoring program includes chemical, biological, and physical monitoring in the Church Creek subwatershed located within the larger South River watershed. This document describes the monitoring effort undertaken from July 2016 through June 2017.

Biological and physical monitoring take place at monumented locations along the study reach, as described in more detail below. The chemical monitoring activities take place at two stations in the Church Creek subwatershed:

- Downstream of two high-imperviousness, commercial land use outfalls, called the Parole Plaza monitoring station
- An instream station downstream of the Route 2 culvert, called the Church Creek monitoring station

The basic permit requirements for storm event monitoring include sampling a target of 12 storms per year (three in each quarter) that are characterized by three representative (rising, peak, and falling limbs of the hydrograph) discrete samples per storm event, the collection of baseflow samples during extended dry periods, laboratory analysis of water quality parameters specified in the permit, biological and physical characterizations of the study reach, and continuous flow monitoring.

The County is interested in determining the extent to which the redevelopment of the Parole Plaza site (now known as the Annapolis Towne Centre at Parole) has affected the quality of the stormwater effluent from the site. Construction began in 2004, and the bulk of the site work was completed by late 2008. Stream restoration construction took place on a portion of Church Creek, as well as a tributary, from late 2015 into early 2016. This restoration included reengineering of stream channel and resulted in minor changes in the profile of the stream from 2015 to 2016.

During 2016, the South River Federation, in cooperation with Anne Arundel County, undertook restoration of a portion of Church Creek behind the Annapolis Harbor Center and nearby the County's existing biological and physical monitoring sites. This work consisted of 1,500 linear feet of stream restoration and implementation of step-pool storm conveyance, riffle weirs, and grade control structures to improve habitat and increase floodplain connectivity. The County's existing biological and physical monitoring locations downstream of this restoration will be useful in assessing the effects of this work.

2 METHODS

2.1 CHEMICAL MONITORING

During the 2017 sampling period, July 2016 through June 2017, twelve storm events were sampled and analyzed. This section describes the equipment and techniques used in this sampling program. It includes discussions of sample collection, sample analysis, flow data collection, and basin rainfall characterization. A summary of maintenance activities is also included. Data and quarterly data reports (Versar 2017a, 2017b, and 2017c) were used to prepare this annual summary report.

2.1.1 Monitoring Sites

The long-term chemical monitoring program is performed at one outfall station, Parole Plaza, and one instream station, Church Creek. The two stations are described below:

Parole Monitoring Station. This station is a restoration station located at the head of the Parole Tributary to Church Creek. There are two outfalls draining to the sampling station. The first is a 60” corrugated metal pipe (CMP) that has been the historical sampling location for the monitoring of this station. The second is a 54” reinforced concrete pipe (RCP) that was connected to the drainage network during the summer of 2007.

Church Creek Monitoring Station. This station is an instream station on the mainstem of Church Creek. It is located approximately 500 feet downstream of the confluence of the tributary that carries the runoff from the Parole Plaza monitoring station. The samples are collected in the 96” CMP culvert that carries Church Creek underneath Maryland State Highway 2 (Solomons Island Road). The bottom of this culvert is lined with concrete that extends 1.8 feet in height up the sides of the corrugated metal culvert.

Location information and land use data were taken from the *Annapolis Towne Centre @ Parole Stormwater Management Report* (Greenhorne & O’Mara 2005), and summarized for each site in Tables 2-1 and 2-2.

Table 2-1. Drainage areas and site locations of monitoring stations in Church Creek watershed

Monitoring Station	Station Type	Location	Area (acres)
Parole Plaza	Restoration/Outfall	Southwest corner of Forest Drive and MD State Highway 2	60.41
Church Creek	Instream	Downstream (east) of MD State Highway 2	279.09

Table 2-2. Land use summary for the monitoring stations in the Church Creek subwatershed				
Land Use	**Land Use Area (acres)**		**Percent of Total Acreage**	
	Parole Plaza	**Church Creek**	**Parole Plaza**	**Church Creek**
Impervious	52.81	191.37	87.4	68.6
Open Space	7.60	87.72	12.6	31.4
TOTAL	**60.41**	**279.09**	**100**	**100**

2.1.2 Water Sample Collection and Data Analysis

The sample period for this reporting cycle extended from July 2016 through June 2017. Samples are analyzed for the presence of the pollutants listed in Table 2-3.

Table 2-3. Analytes, detection limits, and analytical methods for the Church Creek and Parole Plaza Monitoring stations		
Parameter	**Detection Limit (mg/L)**	**Analytical Method**
Biochemical Oxygen Demand (5 Day)	2.0	SM 5210 B-01
Total Kjeldahl Nitrogen	0.5	SM 4500-NH3 C97
Nitrate + Nitrite	0.05	SM 4500-NO3 H00
Total Phosphorus	0.01	SM 4500-P E99
Total Suspended Solids	1.0	SM 2540 D-97
Total Copper (µg/L)	2.0	EPA 200.8
Total Lead (µg/L)	2.0	EPA 200.8
Total Zinc (µg/L)	20.0	EPA 200.8
Total Petroleum Hydrocarbons	5.0	EPA 1664
E. coli (MPN/100 ml)	10.0	SM 9223 B
Hardness	1.0	SM 2340 C

During the sampling period, twelve storm samples were collected; no baseflow samples were taken in lieu of storm samples.

Below is a discussion of the storm events that were sampled during the monitoring period. Additional discussion of each event can be found in Appendix A.

- July 28, 2016 Storm - The total rainfall for this event was 0.34” and lasted approximately 3.0 hours, based on data from the Church Creek rain gauge.

- September 19, 2016 Storm - The total rainfall for this event was 1.22” and lasted 3.0 hours, based on data from the Church Creek rain gauge.

- September 27, 2016 Storm - The total rainfall for this event was 1.79” and lasted 4.5 hours, based on data from the Church Creek rain gauge.

- November 9, 2016 Storm - The total rainfall for this event was 0.11” and lasted 7.0 hours, based on data from the Church Creek rain gauge.

- November 29, 2016 Storm - The total rainfall for this event was 0.08” and lasted approximately 7.0 hours, based on data from the Church Creek rain gauge. Because October and November were very dry months with a total rainfall of only 2.8 inches, this storm was accepted by Anne Arundel County though it did not meet the 0.1” minimum rainfall requirement.

- December 6, 2016 Storm - The total rainfall for this event was 0.78” and lasted 12 hours, based on data from the Church Creek rain gauge.

- January 23, 2017 Storm - The total rainfall for this event was 0.49” and lasted 12.0 hours, based on data from the Church Creek rain gauge.

- February 28, 2017 Storm - The total rainfall for this event was 0.33” and lasted approximately 9.0 hours, based on data from the Church Creek rain gauge.

- March 31, 2017 Storm - The total rainfall for this event was 1.12” and lasted 10 hours, based on data from the Church Creek rain gauge.

- April 25, 2017 - The total rainfall for this event was 0.39” and lasted approximately 5.0 hours, based on data from the Church Creek rain gauge.

- May 12, 2017 - The total rainfall for this event was 0.98” and lasted approximately 21.0 hours, based on data from the Church Creek rain gauge.

- June 19, 2017 - The total rainfall for this event was 0.36” and lasted approximately 4.0 hours, based on data from the Church Creek rain gauge.

Approximately 30.44 inches of precipitation was recorded at the Church Creek station during the 2017 reporting period. Rainfall was measured using a tipping bucket rain gage located at the Church Creek station. Due to branches hanging over the rain gauge, potentially interfering with accurate rainfall data collection and clogging the rain gauge, some rain data are missing from June 28, 2016 through July 13, 2016.

Table 2-4 lists the total rainfall for each sampled event. Hydrographs are provided in Appendix A. These data, along with stream level readings collected at 5 minute intervals from a permanently mounted pressure transducer, were logged into an ISCO 6712FR automated sampler.

Table 2-4. Rainfall data for sampled storm events	
Date	**Rainfall (inches)**
28 July 2016	0.34
19 September 2016	1.22
27 September 2016	1.79
9 November 2016	0.11
29 November 2016	0.08
6 December 2016	0.78
23 January 2017	0.49
28 February 2017	0.33
31 March 2017	1.12
25 April 2017	0.39
12 May 2017	0.98
19 June 2017	0.36

The ISCO sampler located at the Church Creek station is configured to hold 24 one-liter polyethylene bottles, and can be used to collect samples directly from the 96" CMP. However, this station is generally manned for the entire duration of each event. Therefore, samples are typically taken as grabs from the culvert outfall. Total petroleum hydrocarbon and *E. coli* samples are always collected as manual grab samples. The grab sample location is approximately six feet downstream of the intake for the automated sampler and therefore is considered effectively the same sampling location as for the other parameters using the automated sampler.

When the 54" RCP was put in service at Parole Plaza in the summer of 2007, portions of the drainage that had historically been passing through the 60" CMP began flowing through the new pipe. In order to maintain consistency in the characterization of the watershed, it was determined that samples were required from both pipes. Pressure transducers were permanently mounted in the 60" CMP and 54" RCP. These measured water depth at 5-minute intervals, and stored data for up to three months. Data were downloaded bi-weekly. Stage/discharge relationships were developed for each pipe, to determine the discharge from the pipes based on depth measurements from the pressure transducer. The relationships are based on a combination of field measurements and extrapolated values. The extrapolation is necessary to characterize major storm events where directly measured values are not currently available. The rating tables are included in Appendix A.

A spreadsheet was developed to allow the field sampling crews to input field-measured level data. The spreadsheet interpolated the corresponding flow from the rating curves developed as described above. The flows from the 60" CMP and the 54" RCP were totaled and the resulting combined hydrograph for each event was plotted real-time. This method allowed the field crews to determine when the rising, peak, and falling limbs for the combined hydrograph occurred. The spreadsheet also calculated the percentage of the combined flow that each pipe was contributing. Using volumetric containers, the sampling team prepared composite samples using these percentages, and distributed them to the sample containers. Because of a strong sewage smell during several storm events, the field crew has been sampling *E. coli* separately from each pipe at Parole Plaza. A Technical Memorandum describing the composite sampling procedures in detail was submitted to the Maryland Department of the Environment in May 2008, and is included in Appendix A.

Water quality instruments for measuring pH, temperature, and conductivity were used at both stations. At Parole, an In-Situ Troll 9500 unit mounted within each pipe was used to obtain measurements during storm events; providing measurements every 5 minutes. Measurements for these parameters were not available when personnel were not present due to the low flow conditions at this station. Permanently installed probes would likely dry out and need to be replaced often, thus these units are engaged only during storm events. At the Church Creek station, a YSI 600 XL multiparameter sonde was permanently mounted within the culvert and was connected directly to the ISCO automated sampler, providing measurements every 5 minutes. This unit operates continuously.

Samples were distributed into bottles provided by Martel Laboratories JDS, Inc. From the beginning of the sampling until the March 31, 2017 storm event *E. coli* samples were delivered to Chesapeake Environmental Lab for processing within six hours of being collected. Beginning with the April 25, 2017 storm event, *E. coli* samples were delivered to Water Testing Labs of Maryland. All other samples were delivered to Martel Laboratories within 48 hours.

Event Mean Concentrations (EMCs) for each parameter were calculated for each storm and applied to total stormflow discharges to calculate stormflow pollutant loads for each site. An EMC is a statistical parameter used to represent the flow-weighted average concentration of a given parameter during a storm event (USEPA 2002). The EMC for a storm event where discrete samples have been collected (i.e., samples collected during the rise, peak, and falling limb of a storm event), was calculated using the following formula:

$$EMC = \frac{\sum_{i=1}^{n} V_i C_i}{\sum_{i=1}^{n} V_i}$$

where,

V: volume of flow during period *i*, which is determined from the interval associated with the samples collected during each limb

C: analytical result associated with period *i*

n: total number of limbs taken during event

The stormflow pollutant load for each parameter was calculated as:

$$Load = EMC_j V_j$$

where,

V: total volume of flow during period *j* (entire storm event).

Average annual EMCs were calculated by taking the arithmetic average of EMCs calculated when non-detects were set to zero and when non-detects were set to the detection limit. Since the true concentration of non-detect samples falls somewhere between the detection limit and the null value, this calculation represents a more accurate estimate than using EMCs with non-detects set to either zero or the detection limit. Seasonal loads (also referred to as quarterly loads) for monitored events were calculated by summing all monitored event loads for a specific season. Total seasonal loads were calculated by multiplying the average seasonal EMC by the total volume for the season. Annual loads were calculated by summing all seasonal loads.

2.1.3 Monitoring Station Maintenance

Maintenance was conducted at each sampling station on a biweekly basis. Maintenance included calibration of all probes, inspection of the sampling equipment, intake lines, and programming, and an overall cleaning and organization of the stations. A few issues concerning the replacement of monitoring equipment and the loss of data occurred during the monitoring period; below is a summary of these issues:

- On July 7, Anne Arundel County notified Versar that branches were hanging over the rain gauge, potentially interfering with accurate rainfall data collection. During the next maintenance trip, field staff clipped the branches, and cleared the rain gauge of any debris. To avoid future clogging, on September 2, Versar field staff cut the branches that were hanging over the rain gauge. Before sampling the storm on July 28, field staff noticed the submerged probe was not accurately recording level at the Church Creek station, so it was adjusted for the storm. After the storm, the level continued to drift higher; therefore, on August 18, an Onset HOBO stage logger was installed in the stream to replace the malfunctioning Teledyne ISCO submerged probe. On September 13, the HOBO logger was removed, and a working Teledyne ISCO submerged probe was installed and reattached to the 720 module. Field staff verified that the ISCO was accurately recording level before leaving the site. Staff noted that the ISCO data had begun to drift on July 22, so Versar's data analyst corrected the data by factoring out the drift using linear regressions. The HOBO logger data were post-processed and substituted into the Church Creek Continuous Flow Data_07-09_16 Excel spreadsheet during the period of August 18, 2016 at 5 p.m. until September 13, 2016 at 1 p.m.

- On November 21, field staff replaced the YSI 600XL sonde at Church Creek with a spare provided by Anne Arundel County. All probes subsequently properly recorded water quality except for conductivity, which was inadvertently set by field staff to record specific conductivity. During the routine maintenance on November 28 at 3:00 p.m., the field team corrected the sonde settings to record conductivity. The specific conductivity readings are highlighted in the "Church Creek Continuous Flow Data_10-12_16" file. Versar will convert specific conductivity to conductivity and provide revised data in an addendum. Note that in the continuous flow data file, on December 30, higher ambient temperature readings caused ice and snow melt which resulted in a period of higher flow and conductivity readings. At Parole Plaza after the storm on November 9, the Global Water loggers were adjusted to record data using a time stamp set to daylight savings time.

- During the routine maintenance at Church Creek on February 7, field staff noticed erroneous temperature readings (e.g., 101 degrees Fahrenheit) recorded by the YSI 600XL sonde. The problematic temperature data likely affected conductivity values. The temperature/conductivity probe was removed immediately and Anne Arundel County was informed that a new probe was needed. Also, during that visit, field staff removed leaves, trash, and debris from the sonde and level logger area of the stream. On February 23, staff installed the new temperature/conductivity probe and confirmed that all probes properly logged water quality. After reviewing the data, staff concluded that high conductivity readings did not result from salted road runoff, but from the malfunctioning probe. Erroneous conductivity measurements were removed from the data file where Versar determined the problem began. The incorrect data included the storm event on January 23, so there are no temperature and conductivity data for this storm on the EMC spreadsheet.

- The CMP Global Water logger was calibrated on May 24, 2017 because the level on the logger was not reading accurately with the actual measurement taken by the field staff. During the routine maintenance on June 8 at Parole Plaza both of the Global Water loggers were adjusted to record data using a time stamp set to daylight savings time.

2.2 BIOLOGICAL MONITORING

All biological assessment data were collected in accordance with the Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan (Anne Arundel County 2010), which incorporates many elements of Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS). Geomorphic assessment data were collected in accordance with the standard operating procedures (SOPs) approved for the County's NPDES Program. All methods are consistent with previous years' methods (with applicable updates) to ensure data comparability between years. Collection methods are summarized below. Field data were collected in 2017 by Versar, Inc., a consultant to Anne Arundel County.

2.2.1 Sampling Locations

The study area is located in the northern portion of the Church Creek subwatershed, within the larger South River watershed in Anne Arundel County, Maryland (Figure 2-1). A total of four 75-meter biological monitoring sites are positioned along the study reach and are monitored annually. Three sites were established and first monitored in 2006; one site is located on the Parole Plaza Tributary just below Forest Drive, and two sites are located along the Church

Creek mainstem, on either side of Solomons Island Road (Maryland State Highway 2). A fourth site, located just upstream of the confluence with the Parole Plaza Tributary, was added in 2007 to monitor the effects of runoff from the Festival at Riva shopping center.

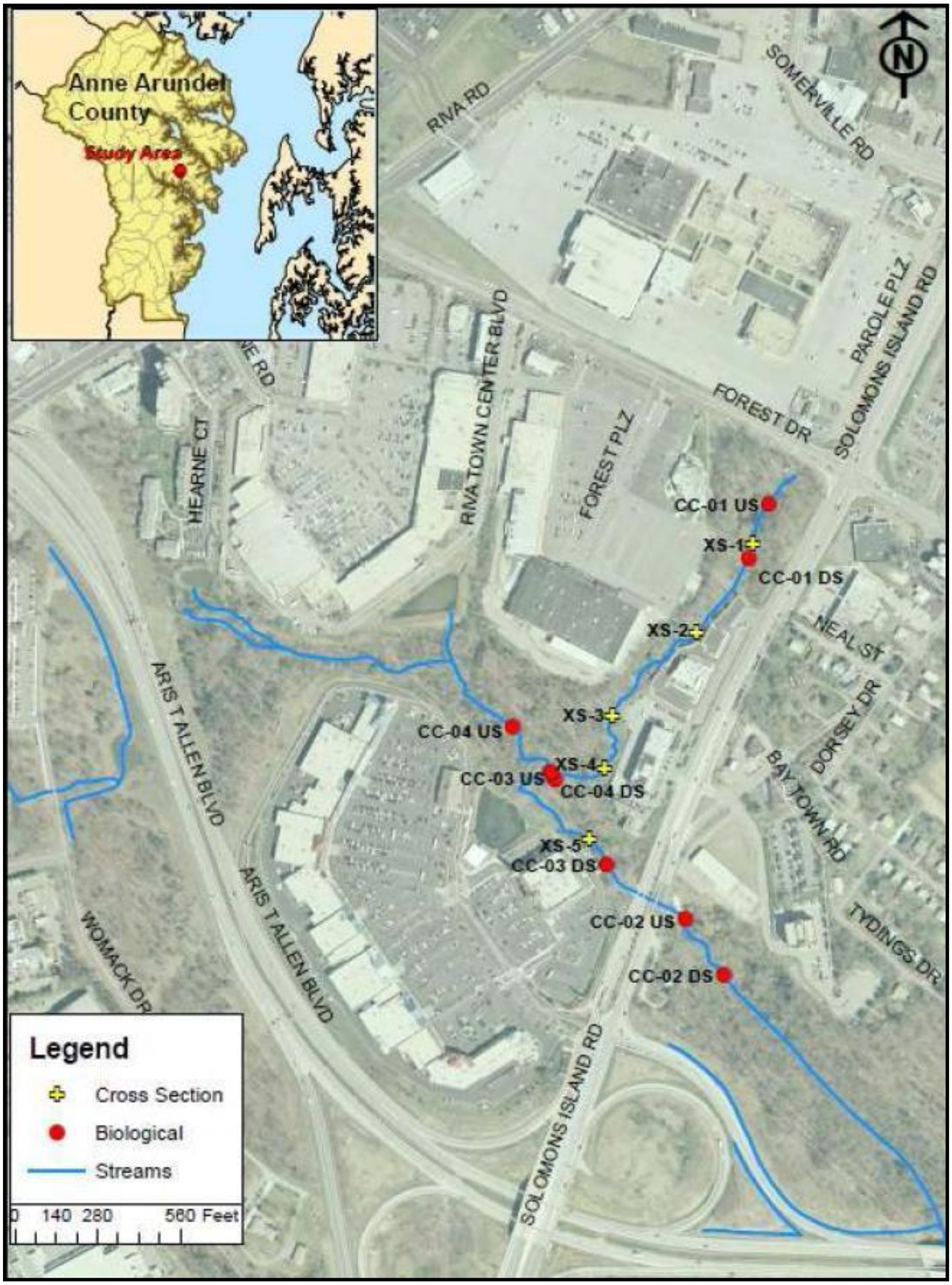

Figure 2-1. Church Creek study area and stream monitoring locations

2.2.2 Stream Habitat Evaluation

To support the biological monitoring, a visual assessment of physical habitat was completed at each monitoring site to evaluate the reach's ability to support aquatic life. Both the MBSS Physical Habitat Index (PHI; Paul et al. 2003) and the U.S. Environmental Protection Agency (U.S. EPA) Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al. 1999) were used to visually assess the physical habitat at each site in conjunction with the spring benthic monitoring. Both habitat assessments consist of a review of biologically significant habitat parameters that evaluate a stream's ability to support an acceptable level of biological health.

To calculate PHI at each site, six parameters were given a numerical score and a categorical rating: instream habitat, epibenthic substrate, remoteness, instream woody debris and rootwads, shading, and bank stability. The raw scores are then transformed into a scaled score (0-100 scale) as described in Paul et al. (2003), and the six scaled scores are averaged into an aggregate final PHI score. Narrative condition descriptions and scoring ranges for the PHI are displayed in Table 2-5.

Table 2-5. Maryland Biological Stream Survey PHI scoring

Score	**Narrative**
81-100	Minimally Degraded
66-80.9	Partially Degraded
51-65.9	Degraded
0-50.9	Severely Degraded

The Rapid Bioassessment Protocol (RBP) habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health: Epifaunal substrate/available cover, Embeddedness, Velocity/depth regime, Sediment deposition, Channel flow status, Channel alteration, Frequency of riffles/ bends, Bank stability, Vegetative protection, and Riparian vegetative zone width. In the field, each parameter was given a numerical score from 0-20 (20=best, 0=worst), or 0-10 (10=best, 0=worst) for individual bank parameters, and a categorical rating of optimal, suboptimal, marginal or poor (Barbour et al. 1999). As overall habitat quality increases, the total score for each site typically increases. The individual RBP habitat parameters for each reach were summed to obtain an overall RBP assessment score. Because adequate reference conditions currently do not exist for Anne Arundel County, the percent comparability was calculated based on western coastal plain reference site conditions obtained from work done in Prince George's County streams (Stribling et al. 1999). The percent of reference score, or percent comparability score, was then used to place each site into corresponding narrative rating categories. The ranges are shown in Table 2-6.

Table 2-6. EPA Rapid Bioassessment Protocol (RBP) scoring	
Percent of Reference Score	**Narrative**
90 - 100	Comparable to Reference
75.1 - 89.9	Supporting
60.1 - 75	Partially Supporting
0 - 60	Non-Supporting

2.2.3 Water Quality Measurement

In situ water quality was measured at each site with a YSI 6820 multiparameter water quality sonde. Turbidity was measured once at the upstream end of the site, all other parameters were measured from three locations within each sampling reach (upstream end, mid-point, and downstream end) and results were averaged to minimize variability and better represent water quality conditions throughout the entire sampling reach. Data were compared to the standards listed in the Code of Maryland Regulations (COMAR) 26.08.02.03-3 – Water Quality (MDE 2010) and shown in Table 2-7.

Table 2-7. Maryland COMAR water quality standards for use I Streams	
Parameter	**Standard**
pH	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (µS/cm)	No existing standard
Turbidity (NTU)	Maximum of 150 NTU and maximum monthly average of 50 NTU
Temperature (°C)	Maximum of 32 °C (90 °F) or ambient temperature, whichever is greater
Source: Code of Maryland Regulations (COMAR) 26.08.02.03-3-Water Quality	

2.2.4 Biological Sample Collection

Benthic macroinvertebrate samples were collected in April 2017 following the MBSS Spring index period protocols (MD DNR 2017) and as specified in *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (QAPP; Anne Arundel County 2010). This methodology emphasizes the community composition and relative abundance of benthic macroinvertebrates inhabiting the most taxonomically diverse, or productive, instream habitats. In this sampling approach, a total of twenty jabs are distributed among the most productive habitats present within the 75-meter reach and sampled in proportion to their occurrence within the segment. The most productive stream habitats are riffles followed by rootwads, rootmats and woody debris and associated snag habitat; leaf packs; submerged macrophytes and associated substrate; and undercut banks. Other less preferred habitats include gravel, broken peat, clay lumps and detrital or sand areas in runs; however, of the aforementioned habitat types, those that are located within moving water are preferred over those in still water.

2.2.5 Biological Sample Processing and Identification

Benthic macroinvertebrate samples were processed and subsampled according to Maryland Biological Stream Survey methods described in the MBSS laboratory methods manual (Boward and Freidman, 2000) and as briefly summarized in the Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan (Anne Arundel County 2010). Subsampling is conducted to standardize the sample size and reduce variation caused by field collection methods. In brief, the sample was washed of preservative in a 0.595 mm screen and spread evenly across a tray comprised of 100 numbered 5cm x 5cm grids. A random number between one and 100 was selected and the selected gird was picked entirely of macroinvertebrates under a bright light source. This process was repeated until a count of 120 was reached. The 120 organism target was used following MBSS methods to allow for specimens that are missing parts or are early instars, which cannot be properly identified.

The samples were taxonomically identified by Versar taxonomists certified by the Society for Freshwater Science (SFS) (formerly known as the North American Benthological Society, NABS). The taxonomic hierarchical level for most organisms was genus level when possible with the exception of Oligochaeta, which were identified to the family level. Early instars or damaged specimens were identified to the lowest possible level. Oligochaeta and Chironomidae specimens were permanently slide mounted for identification. Counts and identifications were recorded on a laboratory bench sheet and entered into a master database for analysis. A list of all taxa identified is provided in Appendix B: Master Taxa List.

2.2.6 Biological Data Analysis

Benthic macroinvertebrate data were analyzed using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (Southerland et al. 2005). The Benthic Index of Biotic Integrity (BIBI) approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. The metrics selected fall into five major groups including taxa richness, composition measures, tolerance to perturbation, trophic classification, and habit measures. Tolerance values were obtained from Bressler et al. (2005).

Raw values from each metric are given a score of 1, 3, or 5 based on ranges of values developed for each metric. The results are combined into a scaled BIBI score ranging from 1.0 to 5.0 and a corresponding narrative rating is assigned. Table 2-8 shows the thresholds for the determination of the metric scoring. Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions: Coastal Plain, Piedmont and Combined Highlands. The Coastal Plain and Piedmont regions are divided by the Fall Line. The current study area is located within the Coastal Plain region. The metrics calculated for Coastal Plain streams are as follows:

> ***Total Number of Taxa*** – Equals the richness of the community in terms of the total number of genera at the genus level or higher. A large variety of genera typically indicate better overall water quality, habitat diversity and/or suitability, and community health.

Number of EPT Taxa – Equals the richness of genera within the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). EPT taxa are generally considered pollution sensitive, thus higher levels of EPT taxa would be indicative of higher water quality.

Number of Ephemeroptera Taxa – Equals the total number Ephemeroptera Taxa in the sample. Ephemeroptera are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate lower disturbances in water quality.

Percent Intolerant Urban – Percentage of sample considered intolerant to urbanization. Equals the percentage of individuals in the sample with a tolerance value of 0-3 out of 10. As impairment increases the percent of intolerant taxa decreases.

Percent Ephemeroptera – Equals the percent of Ephemeroptera individuals in the sample. Ephemeroptera are generally considered pollution sensitive, thus communities dominated by Ephemeroptera usually indicate lower disturbances in water quality.

Number Scraper Taxa – Equals the number of scraper taxa in the sample, those taxa that scrape food from the substrate. As the levels of stressors or pollution rise there is an expected decrease in the numbers of Scraper taxa.

Percent Climbers – Equals the percentage of the total number of individuals who are adapted to living on stem type surfaces. Higher percentages of climbers typically represent a decrease in stressors and overall better water quality.

All of the metric scores are summed and then averaged to obtain the final BIBI score. Table 2-9 shows the scores and narrative rankings of the MBSS BIBI. The biological assessment results are included in Appendix C. The QA/QC information is included in Appendix D.

Table 2-8. Biological condition scoring for the coastal plains metrics

Metric	**Score**		
	5	**3**	**1**
Total Number of Taxa	≥ 22	14-21	< 14
Number of EPT Taxa	≥ 5	2-4	< 2
Number of Ephemeroptera Taxa	≥ 2	1.9-1.0	< 1.0
Percent Intolerant Urban	≥ 28	10-27	< 10
Percent Ephemeroptera	≥ 11	0.8-10.9	< 0.8
Number of Scraper Taxa	≥ 2	1.9-1.0	< 1.0
Percent Climbers	≥ 8.0	0.9-7.9	< 0.9

Table 2-9. Maryland Biological Stream Survey BIBI scoring

BIBI Score	Narrative Ranking	Characteristics
4.0-5.0	Good	Comparable to reference conditions, stream considered to be minimally impacted, biological metrics fall within upper 50th percentile of reference site conditions.
3.0-3.9	Fair	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of minimally impacted streams.
2.0-2.9	Poor	Significant deviation from reference conditions, indicating some degradation. On average, biological metrics fall below the 10th percentile of reference site values.
1.0-1.9	Very Poor	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of minimally impacted streams, indicating severe degradation. On average, most or all metrics fall below the 10th percentile of reference site values.

2.3 PHYSICAL MONITORING

2.3.1 Monitoring Sites

Five cross-sections (XS), four of which were established in 2003 and one which was established in 2007, have been measured annually through 2017. Four of these cross-sections are located along the Parole Plaza Tributary, and one cross-section is located on the Church Creek mainstem, just upstream of Solomon's Island Road (Maryland State Highway 2; Figure 2-1). Cross-section monuments, placed on each bank, consist of capped steel reinforcement bars set within six inches of the ground surface. Field data collected by Versar, Inc. during 2017 were used to prepare this annual summary report.

2.3.2 Physical Data Collection and Analysis

Geomorphic assessments include a longitudinal profile survey, cross-section surveys, and representative pebble counts. A spreadsheet tool called *The Reference Reach Spreadsheet* version 4.3L (Mecklenburg 2006) was used to facilitate data entry and analyses. This spreadsheet was used to compile, manipulate, and plot field data and to analyze dimension, profile, and channel material characteristics of the Church Creek study area.

Data from geomorphic assessments were used to determine the stream type of each reach as categorized by the Rosgen Stream Classification methodology (Rosgen 1996). In this classification methodology, streams are categorized based on their measured field values of entrenchment ratio, width/depth ratio, sinuosity, water surface slope, and channel materials according to the table in Appendix E. As illustrated in Appendix E, the Rosgen Stream Classification categorizes streams into broad stream types, which are identified by the letters Aa, A, B, C, D, DA, E, F, and G. Table 2-10 includes general descriptions of each Rosgen stream type. A summary of the stream types identified within this study is included in Appendix F.

Table 2-10. Rosgen stream classification types

Channel Type	General Description
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.
B	Moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools. Moderate width/depth ratio. Narrow, gently sloping valleys. Very stable plan and profile. Stable banks.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients. Narrow valleys. Unstable, with grade control problems and high bank erosion rates.
Source:	Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado

The cross-section surveys were performed at the five permanent cross-section locations, and photos were taken of upstream, downstream, left bank, and right bank views at each cross-section location. Cross-section surveys consisted of measuring the topographic variability of the associated stream bed, floodplains, and terraces, including:

- Monument elevations
- Changes in topography
- Top of each channel bank
- Elevations of bankfull indicators
- Edge of water during the time of survey
- Thalweg or deepest elevation along active channel
- Depositional and erosional features within the channel

During the cross-sectional survey, the following measurements and calculations of the bankfull channel, which are critical for determining the Rosgen stream type of each reach, also were collected:

- Bankfull Width (Wbkf): the width of the channel at the elevation of bankfull discharge or at the stage that defines the bankfull channel.
- Mean Depth (dbkf): the mean depth of the bankfull channel.
- Bankfull Cross-sectional Area (Abkf): the area of the bankfull channel, estimated as the product of bankfull width and mean depth.
- Width Depth Ratio (Wbkf/dbkf): the ratio of the bankfull width versus mean depth.
- Maximum Depth (dmbkf): the maximum depth of the bankfull channel, or the difference between the thalweg elevation and the bankfull discharge elevation.
- Width of Floodprone Area (Wfpa): the width of the channel at a stage of twice the maximum depth. If the width of the floodprone area was far outside of the channel, its value was visually estimated or paced off.
- Entrenchment Ratio (ER): the ratio of the width of the floodprone area versus bankfull width.
- Sinuosity (K): ratio of the stream length versus the valley length or the valley slope divided by the channel slope. Sinuosity was visually estimated or the valley length was paced off so that an estimate could be calculated.

To quantify the distribution of channel substrate particles sizes within the study area, a modified Wolman pebble count (Rosgen 1996) was performed at each cross-section location. Reach-wide proportional counts were used. Each pebble count consists of stratifying the reach based on the frequency of channel features in that reach (e.g., riffle, run, pool, glide) and measuring 100 particles across ten transects (i.e., 10 particles in each of 10 transects). The transects are allocated across all feature types in the proportion at which they occur within the reach. The intermediate axis of each measured pebble is recorded. The goal of the pebble count is to measure 100 particles across the bankfull width of the channel and calculate the median substrate particle size (i.e., D50) of the reach. This value is used for categorizing the sites into the Rosgen Stream Classification (Rosgen 1996). If a channel was clearly a sand or silt bed channel with no distinct variation in material size, the pebble count was not performed, and the D50 was visually estimated. However, if the channel did have variation in bed material size from feature to feature, a full pebble count was performed.

2.4 LAND USE AND STORMWATER MANAGEMENT ASSESSMENT

2.4.1 Church Creek Watershed Land Use

A previous report (Versar 2013) provided information on land use, based on field reconnaissance conducted during 2013. As seen in an aerial photograph and stormwater best management practice (BMP) facilities map (Figure 2-2), the watershed is predominantly

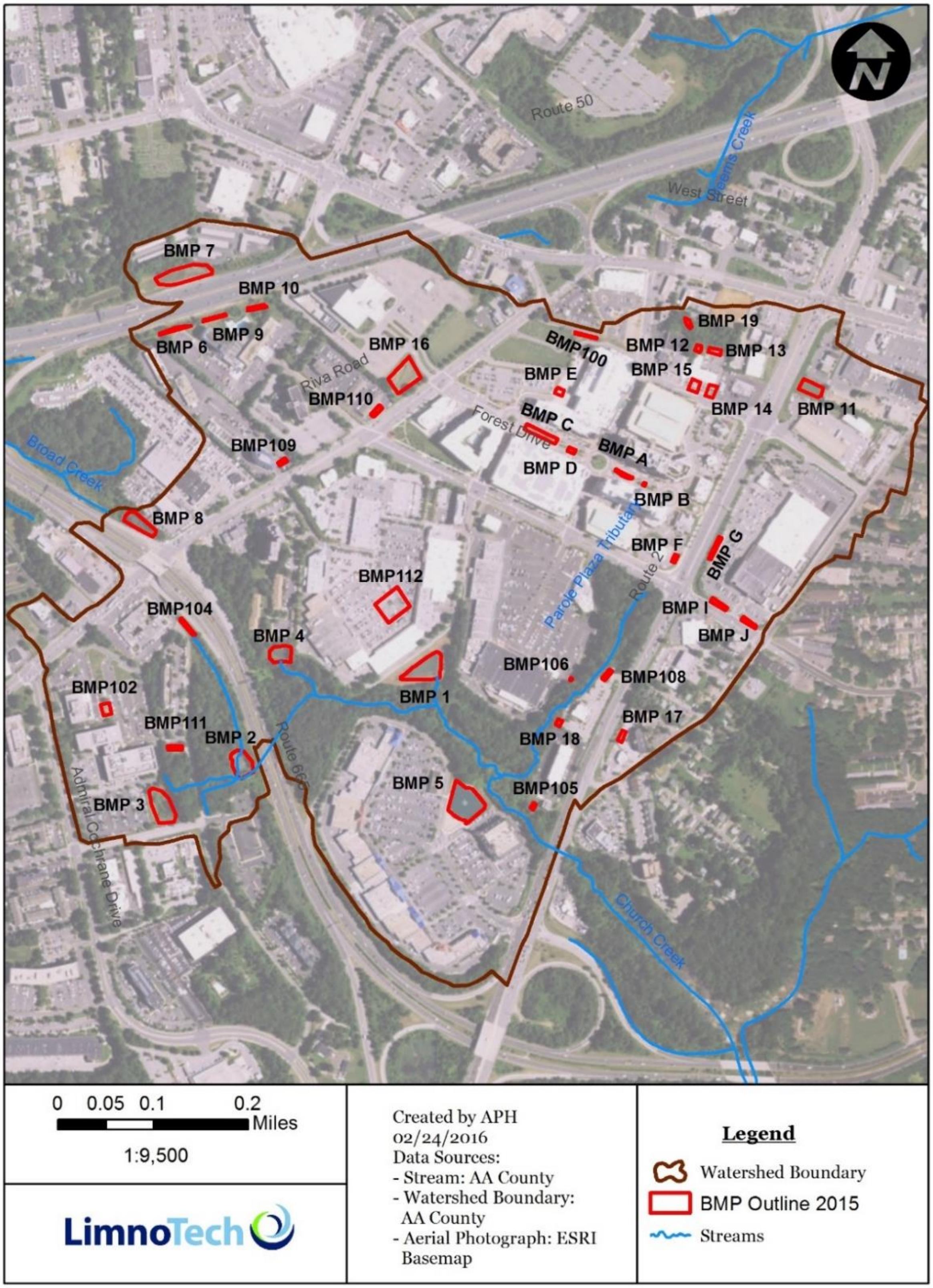

Figure 2-2. Church Creek BMPs

commercial with open space area adjacent to the stream channels. There is little available area for further development in the watershed except for areas that are being redeveloped. Anecdotal information indicates there has been no change in land use in this watershed since the 2013 land use evaluation.

2.4.2 Church Creek Watershed BMP Inspections

The Church Creek watershed contains 40 BMPs as shown in Figure 2-2 and Table 2-11. Inspections were conducted on December 9 and 12, 2015 and January 13, 2016. Inspection and maintenance information is currently being updated in the County's BMP database. Inspection reports are maintained at the County's offices. Appendices H and I contain BMP codes and acronyms.

Table 2-11. Church Creek BMP overview

Church Creek BMP	AA County Urban BMP Database ID[a]	Current BMP Type in Data-base[b]	Recommended Updated BMP Type	Drainage Area (acres)[c]	Location	Address	Presumed Owner	County Follow-up Completed
1	AA001128	PWED	PWED	26.95	Festival at Riva Shopping Center	Riva Road and Forest Drive	County	---
2	Not found in 2015 database	N/A	DP	-	Forested Area	Between Aris T. Allen Boulevard and Womack Drive	SHA	---
3	AA001962	XDPD	XDPD	1.15	ARINC Parking Lot	Spruill Road and Admiral Cochrane Drive	County	---
4	AA000074	XDPD	XDPD	4.47	Forest Garden Apartments	130 Hearne Court	County	---
5	AA001042	PWED	PWED	18.8	Annapolis Harbour Center	Solomons Island Road	County	---
6	Not found in 2015 database	N/A	IBAS	-	Double Tree by Hilton Hotel Parking Lot	Route 50	SHA	---
7	AA001069	XDPD	WP	9.7	Annapolis Self Storage	Route 50 near East Classic Court	SHA	No action taken – current location of feature within BMP inventory database is outside of Church Creek drainage area
8	Not found in 2015 database	N/A	IBAS	-	Sheehy Nissan of Annapolis	Aris T. Allen Boulevard and Riva Road	SHA	---

(a) Numbering system carried over from the 2013 BMP inspection report.

(b) The 2015 Anne Arundel County Urban BMP database was used to identify the BMP type data for the 2015 inspections (See List of Acronyms in Appendix A). Thus BMP type data may be different from the 2013 BMP type data for the same BMP. In addition, LimnoTech has recommended that some of these BMP types be changed based on what was observed in the field.

(c) The 2015 Anne Arundel County Urban BMP database was used to update drainage areas for the 2015 inspections. Some drainage areas are missing in the Urban BMP database.

Table 2-11. (Continued)

Church Creek BMP	AA County Urban BMP Database ID[a]	Current BMP Type in Database[b]	Recommended Updated BMP Type	Drainage Area (acres)[©]	Location	Address	Presumed Owner	County Follow-up Completed
9	Not found in 2015 database	N/A	IBAS	-	Double Tree by Hilton Hotel Parking Lot	Route 50	SHA	---
10	Not found in 2015 database	N/A	IBAS	-	Double Tree by Hilton Hotel Parking Lot	Route 50	SHA	---
11	AA001446	PWED	XDPD	1.13	Second National Federal Savings Bank	2045 West Street	City of Annapolis	---
12	AA012015	MSGW	MSGW	1.94	AAA Mid Atlantic Car Care	2054 Somerville Road	County	---
13	AA012014	APRP	APRP	0.03	AAA Mid Atlantic Car Care	2054 Somerville Road	County	---
14	AA012013	SPSC	MMBR	0.26	AAA Mid Atlantic Car Care	2054 Somerville Road	County	---
15	AA012012	SPSC	MMBR	0.21	AAA Mid Atlantic Car Care	2054 Somerville Road	County	---
16	AA000071	XDED	XDED	3.71	Nationwide Insurance	2453-2499 Riva Road	County	---
17	AA006493	ITRN	ITRN	1.00	Annapolis Station	2431 Solomons Island Road	County	
18	AA001872	ITRN	ITRN	-	Two Restaurant Sites	2436 Solomons Island Road	County	County removed feature from its BMP dataset during completion of the BMP inspection report

Table 2-11. (Continued)

Church Creek BMP	AA County Urban BMP Database ID[a]	Current BMP Type in Data-base[b]	Recommended Updated BMP Type	Drainage Area (acres)[c]	Location	Address	Presumed Owner	County Follow-up Completed
19	Not found in 2015 database	N/A	DP	-	Capitol One Bank	2200 Somerville Road	County	
A	AA008471	FSND	FBIO	0.3	Annapolis Towne Center at Parole	Towne Center Boulevard	County	Feature type corrected and relocated according to grading plan
B	AA008472	XOGS	XOGS	0.53	Annapolis Towne Center at Parole	Towne Center Boulevard	County	Feature relocated according to grading plan
C	AA008475	FBIO	FBIO	0.4	Annapolis Towne Center at Parole	Towne Center Boulevard	County	Feature relocated according to grading plan
D	AA008473	SF/SFND	XOGS	1.88	Annapolis Towne Center at Parole	Towne Center Boulevard	County	Feature type corrected and relocated according to grading plan
E	AA008474	SF/SFND	XOGS	5.63	Annapolis Towne Center at Parole	Towne Center Boulevard	County	Feature type corrected and feature relocated according to grading plan
F	AA008470	FSND	FSND	4.78	Annapolis Towne Center at Parole	2398 Solomons Island Road	County	Feature relocated according to grading plan
G	Not found in 2015 database	N/A	FBIO	-	Shoppers Food Warehouse	2371 Solomons Island Road	County	---
H	*There is no BMP H, please refer to the 2012 BMP inspection report for further explanation*							
I	Not found in 2015 database	N/A	FBIO		Shoppers Food Warehouse	2371 Solomons Island Road	County	---
J	Not found in 2015 database	N/A	FBIO		Shoppers Food Warehouse	2371 Solomons Island Road	County	---
100	AA006819	NDRR	NDRR	0.2	Holiday Inn Express & Suites	2451 Riva Road	Private	---
101	AA008115	IMPP	IMPP	-	Annapolis Towne Center	2348 Forest Drive	Private	Not found on grading plan, BMP removed from dataset

Table 2-11. (Continued)

Church Creek BMP	AA County Urban BMP Database ID[(a)]	Current BMP Type in Data-base[(b)]	Recommended Updated BMP Type	Drainage Area (acres)[©]	Location	Address	Presumed Owner	County Follow-up Completed
102	AA031422	SPSC	FBIO	0.3	ARINC	2551 Riva	Private	---
103	Not found in 2015 database	N/A	ITRN	-	Spruill Rd and Womack Drive Intersection	Womack Drive	Unknown	---
104	AA010516	ODSW	ODSW	0.14	Highway 665 On Ramp	2525 Riva Road	SHA	---
105	Not found in 2015 database	N/A	ITRN	-	Wainwright Avenue	2441 Solomons Island Road	Private	---
106	AA005932	ITRN	ITRN	6.73	South Annapolis Forest Drive Home Depot	Forest Drive	Private	---
108	AA001180	ITRN	ITRN	0.53	Two Restaurant Site	2436 Solomons Island Road	Private	---
109	AA000335	ITRN	ITRN	9.16	Sovran Building	-	Private	---
110	AA000058	XDPD	XDED	2.07	Parole Professional Building	132 Holiday Court	Private	---
111	AA002384	ITRN	ITRN	2.23	Hampton Inn & Suites	124 Womack Drive	Private	---
112	AA002634, AA003322, AA003350, AA003388	ITRN	ITRN	0.5 (all)	Festival at Riva	Riva Road & Forest Drive	County	All four trenches relocated according to grading plan

3 RESULTS

3.1 POLLUTANT CONCENTRATIONS

During this sampling period, 72 water chemistry samples were analyzed. In a few instances, analyte concentrations fell below the specified detection limits. Table 3-1 shows the percentage of samples that were below the detection limit.

Table 3-1. The percentage of non-detects by parameter

Parameter	Detection Limit	Wet Weather
BOD_5 (mg/L)	2.0/4.0	31
TKN (mg/L)	0.5	12
Nitrate + Nitrite (mg/L)	0.05	0
Total Phosphorus (mg/L)	0.01	0
TSS (mg/L)	1.0	0
Total Copper (µg/L)	2.0	0
Total Lead (µg/L)	2.0	23
Total Zinc (µg/L)	20	0
TPH (mg/L)	5.0	56
E. coli (MPN/100 ml)	1.0, 10.0, 100.0	6
Hardness (mg/L)	1.0	0

Table 3-2 shows the maximum values observed for wet weather samples for both stations. The maximum value for each parameter during wet weather monitoring, station of occurrence, and storm date of observation are listed in Table 3-3. Church Creek had the highest values for seven of the thirteen parameters measured during wet weather sampling in 2017. Most of the maximum wet weather values for the parameters were measured during the June 19 storm event. The maximum *E. coli* concentration at Church Creek was 91,000 MPN/100 ml and was observed during the September 27 storm. Chemical monitoring summaries can be found in Appendix G.

Table 3-2. Maximum wet weather values observed during sampling period		
Parameter	**Church Creek**	**Parole Plaza**
Water Temperature (°F)	80.4	81.4
pH	7.5	8.92
BOD_5 (mg/L)	23	25
TKN (mg/L)	4.4	3.0
Nitrate + Nitrite (mg/L)	1.70	3.0
Total Phosphorus (mg/L)	2.60	0.49
TSS (mg/L)	400	530
Total Copper (µg/L)	408	200
Total Lead (µg/L)	401	55
Total Zinc (µg/L)	3600	1810
TPH (mg/L)	12	10
E. coli (MPN/100 ml)	91,000	65,044
Hardness (mg/L)	230	400
BDL: Below Detection Limit		

Table 3-3. Storm dates for wet weather maximum values			
Parameter	**Date of Storm**	**Site**	**Maximum Value**
Water Temperature (°F)	6/19/17	Parole Plaza	81.4
pH	12/6/16	Parole Plaza	8.92
BOD_5 (mg/L)	4/25/17	Parole Plaza	25
TKN (mg/L)	9/27/16	Church Creek	4.4
Nitrate + Nitrite (mg/L)	9/27/16	Parole Plaza	3.0
Total Phosphorus (mg/L)	11/29/16	Church Creek	2.6
TSS (mg/L)	6/19/17	Parole Plaza	530
Total Copper (µg/L)	6/19/17	Church Creek	408
Total Lead (µg/L)	6/19/17	Church Creek	401
Total Zinc (µg/L)	6/19/17	Church Creek	3600
TPH (mg/L)	6/19/17	Church Creek	12
E. coli (MPN/100 ml)	9/27/16	Church Creek	91,000
Hardness (mg/L)	6/19/17	Parole Plaza	400

3.2 EVENT MEAN CONCENTRATIONS AND POLLUTANT LOADINGS

Flow-weighted stormflow event mean concentrations (EMCs) values are presented in Table 3-4. EMCs for BOD, TKN, total phosphorus, lead, and TPH were higher at Church Creek than at Parole Plaza.

Table 3-4. Average EMCs observed during July 2016 to June 2017		
Parameter	**Church Creek**	**Parole Plaza**
Water Temperature (°F)	54.3	57.3
pH	7.04	7.73
BOD_5 (mg/L)	3	2
TKN (mg/L)	0.69	0.68
Nitrate + Nitrite (mg/L)	0.33	0.37
Total Phosphorus (mg/L)	0.14	0.12
TSS (mg/L)	38	47
Total Copper (µg/L)	13.1	19.7
Total Lead (µg/L)	5.1	2.2
Total Zinc (µg/L)	83	137
TPH (mg/L)	0.14	0.46
E. coli (MPN/100 ml)	5,597	7,366
Hardness (mg/L)	43	44

Summed loads for the sampled events monitored during the July 2016 to June 2017 sampling period are shown in Table 3-5. Church Creek per-acre loading rates for monitored events were higher than Parole Plaza for all parameters.

Table 3-5. Estimated pollutant loadings for observed events, in pounds, for the July 2016 to June 2017 sampling period				
Parameter	**Church Creek**		**Parole Plaza**	
	Total	**Per Acre**	**Total**	**Per Acre**
BOD_5	1,358	4.87	111.30	1.84
TKN	268.71	1.03	30.86	0.51
Nitrate + Nitrite	124.01	0.44	15.46	0.26
Total Phosphorus	52.91	0.19	4.93	0.08
TSS	14,267.97	51.12	1,934.02	32.01
Total Copper	4.96	0.018	0.82	0.014
Total Lead	2.20	0.008	0.12	0.002
Total Zinc	31.35	0.112	5.71	0.095
TPH	979.61	3.51	108.48	1.80
Hardness	16,116.07	57.75	1,844.82	30.54

3.3 BIOLOGICAL ASSESSMENT

Biological and physical habitat assessments were completed on April 12 and 17, 2017. Presented below are the summary results for each assessment site. For full bioassessment data and results, refer to Appendix C. A complete taxonomic list can be found in Appendix B. QA/QC information is in Appendix D. As introduced in Section 1, the South River Federation, in cooperation with the County, undertook restoration of Church Creek in the vicinity of the existing biological and physical monitoring sites beginning in late January, 2016. This work consisted of 1,500 linear feet of stream restoration and implementation of step-pool storm conveyance, riffle weirs, and grade control structures to improve habitat and increase floodplain connectivity. All of the CC-04 and part of the CC-03 biological monitoring sites were within the restored reach of stream.

Physical habitat quality was evaluated using the MBSS PHI, and rated "Partially Degraded" for three sites and " Degraded" for one site (Table 3-6). Index scores ranged from a low of 70.0 at CC-02 to a high of 67.9 at CC-04. All sites received very low scores for remoteness due to the proximity of the stream channel to roads and development. Generally, instream woody debris scored high for all the sites. Individual parameter results are listed in Appendix C. Overall, PHI scores throughout the study area indicate habitat conditions may be limiting the potential for healthy biological communities.

The RBP was also used to evaluate the physical habitat quality and rated "Partially Supporting" for three sites and "Supporting" for one site (Table 3-6). Scores ranged from 61 at CC-02 to 78 at CC-04. Generally, epifaunal substrate/cover, velocity/depth regime, sediment deposition, and vegetative protection scored low for all the sites. Overall, RBP scores throughout the study area indicate that physical habitat conditions could limit the potential for healthy, stable biological communities, similar to what was found using the PHI.

Table 3-6. PHI and RBP physical habitat assessment results - 2017

Site	PHI Score	PHI Narrative Rating	RBP Score	RBP Narrative Rating
CC-01	67.4	Partially Degraded	74	Partially Supporting
CC-02	61.0	Degraded	61	Partially Supporting
CC-03	71.7	Partially Degraded	70	Partially Supporting
CC-04	67.9	Partially Degraded	78	Supporting

For biological conditions, three stations received a rating of "Poor" and one station was rated as "Very Poor", indicating a highly impaired benthic macroinvertebrate community. Low BIBI scores are driven by low metric scores at all sites for Number of EPT taxa, Number of Ephemeroptera, Percent Ephemeroptera, and Percent Intolerant Urban. The Percent Climbers metric and Number of Scrapers both received average to high scores for all sites while the Percent Intolerant to Urban metric received low scores (< 5% per subsample) at all sites. Poor habitat conditions and marginal water quality parameters may contribute to low BIBI scores at the Church Creek sites. BIBI scores and ratings are summarized in Table 3-7.

Table 3-7. Benthic macroinvertebrate assessment results - 2017

Site	BIBI Score	Narrative Rating
CC-01	2.14	Poor
CC-02	2.14	Poor
CC-03	2.43	Poor
CC-04	1.86	Very Poor

To supplement the biological assessment data, *in situ* water quality parameters were measured at each biological monitoring site prior to sample collection. Table 3-8 shows the water quality data for each site. pH at two sites, CC-01 and CC-04, were also slightly less than the minimum pH of 6.5 specified for Use class I streams. Church Creek site conductivity values were elevated, particularly at CC-01, compared to most coastal plain streams, and exceeded the 75th percentile of values (i.e., 307 µS/cm) measured during Round One (2004-2008) of the Countywide Biological Monitoring and Assessment Program (Hill and Pieper, 2011), as well as higher than the range of those found in other urban, or highly impervious, drainage areas in Maryland (MD DNR, 2001, 2003, 2005; KCI, 2009; Hill and Crunkleton, 2009). Stream conductivity is affected by inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations, many of which are generally found at elevated concentrations in urban streams (Paul and Meyer, 2001). Increased stream ion concentrations (measured as conductivity) in urban systems are typically a result of runoff over impervious surfaces, passage through pipes, and exposure to other infrastructure (Cushman 2006). Seasonal use of road salt has most likely caused conductivity values to be high.

Table 3-8. *In situ* water quality results - 2017

Site	pH	Temperature	Dissolved Oxygen	Turbidity	Conductivity
	SU	°C	mg/L	NTU	µS/cm
CC-01	6.29	17.6	13.86	17.5	2319
CC-02	7.04	15.4	7.86	16.2	468
CC-03	6.67	17.0	6.08	15.7	479
CC-04	6.49	19.3	5.58	13.2	392

3.4 GEOMORPHIC ASSESSMENT

Due to the highly altered conditions of the drainage area (i.e., high imperviousness, altered flow regime, numerous stormwater outfalls) and stream channel (i.e., channelization, stabilization) in the study area, reliable bankfull indicators were often difficult to locate in the field. In the absence of reliable bankfull indicators, bankfull elevations were adjusted to match the predicted values for bankfull area provided by the bankfull channel geometry relationship for urban streams developed specifically for Anne Arundel County (AADPW 2002). Furthermore, categorization of segments into the Rosgen Classification scheme for natural rivers required a fair amount of professional judgment to interpret the data. When assigning the stream classification types, values for some parameters would often fit into the prescribed ranges according to the Rosgen Classification while others would not. Many of the features at the existing cross-section locations have shifted from riffle features to pool features, which can skew the channel dimensions since classifications are based on riffle dimensions. Consequently, it was often necessary to apply best professional judgment and incorporate supplemental information (e.g., presence of depositional features) in order to assign the most appropriate stream classifications. The Rosgen classification system is summarized in Appendix E and 2017 data for Church Creek sites are in Appendix F. Also noteworthy, prior to the 2016 geomorphic survey, stream restoration occurred downstream of XS-4, on an unnamed tributary, and upstream of XS-5 on the mainstem Church Creek in the vicinity of the Annapolis Harbor Center. Thus, longitudinal profile length has shortened between the 2015 and 2016 surveying as a result of the stream restoration construction and channel reengineering. The 2017 geomorphic survey gives a first look at any changes a year after the restoration was completed between XS-4 and XS-5.

The most upstream reach on the Parole Plaza Tributary, XS-1, has been undergoing a transition from a Rosgen C4/5 channel to a F4 channel, as evidenced by changes in the width/ depth and entrenchment ratios. Previous monitoring in 2010 suggested that this reach was shifting from an E to a C channel as evidenced by channel degradation along the right bank and a notable increase in sediment deposition and point bar formation along the right bank just downstream. Additional degradation between 2010 and 2012 suggest that the channel had lost connectivity to the floodplain and had likely shifted to an F stream type. Mid-channel degradation continued between 2014 and 2017 showing approximately a 0.8 feet difference. In 2017, geomorphic assessment parameters continue to support the classification of this reach as an F4 channel. The channel evolution is supported by a 61.3% increase in channel cross-sectional area since 2003 and considerable widening and mid-channel bar formation immediately downstream, which is indicative of a channel that it not stable and is undergoing a widening and degradation phase. From 2014 to 2017, the cross-sectional area continues a steady increase. Left bank widening was also apparent between 2013 and 2014 monitoring years and remained consistent during 2015 and through 2017. However, it is also important to acknowledge that this cross-section is no longer located in a riffle feature and is now in a pool feature, which affects the channel dimensions and complicates classification using the Rosgen system.

The next site downstream on the Parole Plaza Tributary, XS-2, was classified as a Rosgen G4c channel based on its continued low width/depth ratio, low slope, and gravel substrate. From 2016 to the 2017 survey, the substrate size decreased slightly. Since 2012 its entrenchment ratio was slightly higher than those typical of G streams, but in 2017 the ratio of entrenchment was shown to decrease. This reach was previously classified as an E type channel; however, it was noted that the reach was actively degrading and widening. While E streams are typically more sinuous, this segment has been noticeably straightened and stabilized by a retaining wall and rubble/fill along the left bank (facing downstream). The lack of sinuosity in the channel has likely resulted in instability, and consequently resulted in a shift to a less-stable form.

Site XS-3, located along the restored segment of Parole Plaza Tributary, was not classified until 2013, after allowing 3 years of stabilization after restoration. In 2013 and 2014 it was classified as a Rosgen G4c channel based on its low entrenchment ratio, low width/depth ratio, and low slope. In 2015 XS-3 remained a G type channel; however, the substrate had become coarser resulting in a G4/3c classification. Variable coarseness caused XS-3 to return to a G4c during the 2016 survey and it has maintained that classification in 2017. Before restoration, this cross-section was classified as a Rosgen G5c channel; however, since the Rosgen scheme was developed to classify natural channels, or those that are shaped naturally by fluvial processes, it was deemed inappropriate to classify immediately after construction. This section is still heavily armored and reliable bankfull indicators are not easily identified. Not much change has been documented at XS-3 but during the 2017 survey the right bank has begun to erode behind the armored bank.

The most downstream site on the Parole Plaza Tributary, XS-4, has transitioned from a Rosgen E5 channel to a C5/4 back to an E5/4 channel and now an E4/5 channel due to increased substrate size and fluctuations in width/depth ratio. A large woody debris jam located just downstream of the cross-section location has resulted in a considerable accumulation of fine sediment and debris across the channel and, consequently, has led to aggradation and a reduction in the cross-sectional area up until 2016. In 2016, before the cross-section survey was performed, restoration on the reach began and was completed just downstream of XS-4. Construction activities included the removal of the woody debris jam. A year after the construction it is likely the fine sediment that was behind the debris jam has cleared resulting in the increase substrate size. Between 2011 and 2015 cross-sectional area has consistently been lower than baseline monitoring in 2003. Restoration in 2016 has caused cross-sectional area to increase by 9.8% from 2003 monitoring. Subsequently, in 2017 the cross-sectional area decreased from 2016 by 15.3% and has decreased by 7.0 % since the 2003 monitoring.

Located on the mainstem of Church Creek, upstream of the MD Rt. 2 culvert, XS-5 has transformed from a Rosgen C3/5 channel into a F4 channel due to a significantly decreased entrenchment ratio from 4.0 to 1.7 between 2012 and 2017. Between 2015 and 2016 this portion of the reach has become slightly less coarse from a D50 of 61 mm to 24 mm. In 2017, this reach maintained the same D50 particle size. This segment shows evidence of previous alteration in the form of cobble-sized riprap armoring along the bed and lower banks to protect a sewer line crossing and obvious channel straightening, which explains the lack of sinuosity typical of F type streams. The substantial amount of cobble-sized rip-rap in the stream channel has resulted in a bi-modal distribution of substrate particles within this reach, with a predominance of gravel in the pools and artificial cobbles in the riffles. In 2017, the cross-sectional area and the width/depth ratio decreased slightly.

4 DISCUSSION

Results from the July 2016-June 2017 study period are discussed in the following section. Water quality, biological, and geomorphological data are interpreted, presented and compared to previous data. A discussion of the characteristics of the watershed is also included.

4.1 WATER CHEMISTRY

Water quality criteria are presented in Table 4-1. The measured data are compared, where possible, to these criteria to assess the extent of the pollution in this tributary.

Table 4-1. State and Federal water quality criteria available for parameters sampled at Church Creek

Parameter (mg/L, except as noted)	Chronic	Acute	Reference
Lead (µg/L)	2.5	65	COMAR 26.08.02.03-2
Copper (µg/L)	9	13	COMAR 26.08.02.03-2
Zinc (µg/L)	120	120	COMAR 26.08.02.03-2
Total P	0.0225		USEPA 2000
BOD_5	7		USEPA 1986
Nitrate + Nitrite	0.095		USEPA 2000
TSS	500		USEPA 1974
TKN	None		
TPH	None		
*E. coli** (MPN/100ml)	235		COMAR 26.08.02.03-3.
Hardness	None		

* Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.

Criteria are used to protect against both short-term and long-term effects. Numeric criteria are important where the cause of toxicity is known or for protection against pollutants with potential human health impacts or bioaccumulation potential. Narrative criteria can be the basis for limiting toxicity in discharges where a specific pollutant can be identified as contributing to the toxicity. Biological criteria can be used to complement traditional, chemical-specific criteria as indicators of aquatic health and impacts to the aquatic ecosystem.

Table 4-2 compares storm event results to the Federal and State acute criteria. Comparison and interpretation of Church Creek pollutant concentrations to Federal and State water quality criteria, and relating these conditions to ultimate ecological outcomes in the system, however, are difficult. Criteria do not exist for all parameters measured at the monitoring stations. In addition, a clear cause and effect relationship between water quality and ecological condition is difficult to determine. However, these comparisons can be used as general indicators of water quality impairment. Both State and Federal criteria are based on ambient stream conditions. Chronic criteria consider the maximum levels at which aquatic life can survive if continuously subjected to a pollutant concentration. Acute criteria reflect the maximum level at which an aquatic organism can survive if periodically subjected to a pollutant concentration. Since storm events represent a periodic condition, wet-weather samples are compared only to acute criteria.

Table 4-2. Maximum concentrations observed for wet weather samples compared to appropriate criteria

Parameter (mg/L, except as noted)	Acute	Church Creek	Parole Plaza
Lead (µg/L)	65	401*	55
Copper (µg/L)	13	408*	200*
Zinc (µg/L)	120	3600*	1810*
Total P	0.0225	2.6*	0.49*
BOD_5	7	23*	25*
Nitrate + Nitrite	0.095	1.70*	3*
TSS	500	400	530*
TKN	None	4.4	3
TPH	None	12	10
*E. coli*** (MPN/100ml)	235	91,000*	65,044*
Hardness	None	230	400

* Criterion exceeded
** Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.

As in prior years, comparisons to water quality criteria continue to indicate elevated pollutant concentrations in the Church Creek watershed. In particular, copper, zinc, total phosphorous, BOD_5, nitrate-nitrite, and *E. coli* frequently exceeded criteria at both sampling stations. During the June 19, 2017 storm event, at Church Creek, lead exceeded its corresponding criterion along with TSS at Parole Plaza. Table 4-2 (above) shows the maximum concentrations for each sampling site, and compares these to the criteria.

Table 4-3 shows the percentage of wet weather samples for which criteria were exceeded. Water quality criteria for the pollutants listed above were more frequently exceeded at the Parole Plaza station than at the Church Creek station for all contaminants except lead. *E. coli* concentrations also remained high at both stations throughout the 2017 monitoring period, exceeding water quality criteria 72 percent of the time at Church Creek and 81 percent of the time at Parole Plaza. Note that prior to site stabilization, total suspended solids concentrations had been particularly high due to construction activity at Annapolis Towne Centre. Following stabilization of the site in Fall 2008, the event mean concentrations for total suspended solids have dropped significantly. However, during the June 19 storm event, total suspended solids concentrations exceeded the water quality criterion during the rising limb at Parole Plaza, but the event mean concentration for the storm remained low. At Church Creek TSS did not exceed the criterion, but there was a higher concentration (400 mg/L) during the September 27, 2017 storm event.

Table 4-3. Percentage of all wet weather samples that exceed appropriate criteria

Parameter	**Criteria (mg/L, except as noted)**	**Church Creek (%)**	**Parole Plaza (%)**
Lead (µg/L)	65	3	0
Copper (µg/L)	13	36	81
Zinc (µg/L)	120	22	69
Total P	0.0225	100	100
BOD_5	7	31	42
Nitrate + Nitrite	0.095	100	100
TSS	500	0	3
TKN	None	NA	NA
TPH	None	NA	NA
*E. coli** (MPN/100ml)	235	72	81
Hardness	None	NA	NA

* Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.

Table 4-4 shows the annual average event mean concentrations that exceeded water quality criteria. As can be seen from the table, copper, total phosphorous, nitrate-nitrite, and *E. coli* consistently exceeded their corresponding criteria at both stations. At both sites, the annual average event mean concentrations for copper exceeded both the chronic and acute criteria.

High levels of pollutants observed in the watershed are typical for commercial and retail land uses that are coupled with high levels of automobile traffic and impervious surface area (U.S. EPA 1983). As shown in Table 2-2, 87% of the watershed to the Parole monitoring station and 69% of the watershed to the Church Creek station is impervious.

In 2007, loading rates (Tables 4-5 and 4-6) increased sharply at both stations. Loading rates in 2008 were still high, when compared to historical values, but dropped dramatically from the 2007 levels. During the 2009 reporting year, loading rates dropped further, and aligned more closely with historical values. High loading rates in 2007 likely resulted from construction activity that was underway immediately upstream of the Parole Plaza station. Since the majority of the site was stabilized by the end of 2008, the cessation of construction likely caused pollutant loads to decrease.

Table 4-4. Annual average event mean concentrations and criteria (parameters that exceeded appropriate criteria are indicated)

Parameter (mg/L, except as noted)	Chronic Criteria	Acute Criteria	Church Creek	Parole Plaza
Lead (µg/L)	2.5	65	5.1[a]	2.2
Copper (µg/L)	9	13	13.1[a,b]	19.7[a,b]
Zinc (µg/L)	120	120	83	137[a,b]
Total P	0.0225		0.14[a]	0.12[a]
BOD_5	7		3	2
Nitrate + Nitrite	0.095		0.33[a]	0.37[a]
TSS	500		38	47
TKN	None		0.69	0.68
TPH	None		0.14	0.46
*E. coli** (MPN/100ml)	235		5,597[a]	7,366[a]
Hardness	None		43	44

[a] Chronic or general criterion exceeded
[b] Acute criterion exceeded
* Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.

Table 4-5. Total annual loading rates, in pounds, observed at the Parole Plaza Sampling Station from 2002 to 2017

Year	BOD	TSS	TP	TKN	NO_3+NO_2	Zinc	Lead	Copper	Hardness	Fecal Coliform[a]
2002	2,912	26,585	1,178	388	323	58	14	1	NA	1,152,001
2003	21,665	86,385	372	1,477	714	176	69	15	NA	5,350,164
2004	8.025	57,447	293	655	391	57	7	8	NA	402,127
2005	4,573	33,015	184	483	350	50	12	8	NA	665,232
2006	13,562	94,306	650	1,867	410	177	13	25	NA	3,360,952
										E. coli[a]
2007	40,009	848,116	1,649	2,328	1,401	349	26	162	NA	11,017
2008[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	2,175	11,787	59	490	117	56	0.8	6.5	NA	2,115
2010	2,209	17,609	89	309	120	40	1.2	4.1	NA	1,740
2011	2,114	13,894	42	371	131	58	1.1	6.3	6,987	2,682
2012	3,660	15,335	62	284	214	57	1.0	6.6	14,578	10,209
2013	1,481	6,079	34	155	108	34	0.5	4.9	8,586	16,041
2014	2,040	18,953	54	536	497	50	1.0	8.1	36,945	12,716
2015	940	14,606	45	232	162	38	1.1	5.3	29,023	3,333
2016	1,308	10,887	29	218	103	36	1.0	9.3	14,779	18,268
2017	1,120	19,913	50	318	161	57	1.2	8.3	18,876	7,366
2002-2006 Mean	8,544	59,548	535	974	438	104	23	11	NA	2,186,095
2009-2017 Mean	1,894	14,340	52	324	179	47	1	7	18,539	8,274
2002-2017 Mean	6,652	84,994	319	674	347	86	10	19	18,539	8,549

[a] Units of Fecal Coliform and *E. coli* are MPN/100 mL.
[b] In 2008, monitoring was conducted for both outfalls at Parole Plaza, but continuous level monitoring was not available for the 54" RCP; therefore, loads could not be calculated.
[c] Mean *E. coli* value, does not include pre-2007 Fecal Coliform data.

Table 4-6. Total annual loading rates, in pounds, observed at the Church Creek Sampling Station from 2002 to 2017

Year	BOD	TSS	TP	TKN	NO_3+ NO_2	Zinc	Lead	Copper	Hard-ness	Fecal Coliform*
2002	6,408	58,501	2,593	854	711	127	32	3	NA	2,534,970
2003	47,673	190,090	818	3,250	1,571	387	151	32	NA	11,773,001
2004	17,660	126,411	645	1,441	860	126	19	18	NA	884,887
2005	10,062	72,648	405	1,062	771	109	27	16	NA	1,463,839
2006	29,844	207,520	1,431	4,109	902	390	29	54	NA	7,395,753
										E. coli*
2007	265,499	3,312,794	8,381	20,330	436,206	3,663	277	652	NA	1,755
2008	60,843	458,185	3,037	12,468	4,444	693	37	36	NA	3,857
2009	35,521	206,184	1,296	9,377	2,505	531	30	57	NA	3,912
2010	49,256	341,877	2,066	9,561	2,912	739	39	77	NA	3,358
2011	42,883	214,820	1,340	7,410	3,606	704	30	41	259,076	3,995
2012	40,145	150,490	1,103	3,714	3,018	551	20	31	250,747	5,549
2013	43,980	180,946	899	3,326	2,782	558	27	57	314,179	2,399
2014	31,969	299,830	1,065	12,177	6,019	551	27	78	646,801	8,638
2015	19,643	344,419	1,057	5,743	3,148	665	35	99	455,627	2,100
2016	46,587	335,422	1,026	6,648	3,081	818	41	92	344,729	8,049
2017	23,557	230,599	855	4,699	2,044	468	34	71	257,816	5,597
2002-2006 Mean	22,329	131,034	1,178	2,143	963	228	52	25	NA	4,810,490
2009-2017 Mean	37,060	256,065	1,190	6,962	3,235	621	31	67	361,282	4,844
2002-2017 Mean	48,221	420,671	1,751	6,636	29,661	693	53	88	361,282	**4,474

* Units of Fecal Coliform and *E. coli* are MPN/100 mL.
** Mean *E. coli* value, does not include pre-2007 Fecal Coliform data.

When compared to the 2016 reporting year, 2017 loading rates increased for all sampled parameters at the Parole Plaza Station with the exception of BOD_5, copper, and *E. coli*. At the Church Creek Station, 2017 reporting year loading rates decreased for all sampled parameters when compared to 2016. The reduction in loads at the Church Creek Station may indicate that the stream restoration provided immediate benefit. The change in loading may also be due to natural variability in stream pollutant concentrations coupled with a 17% decline in annual discharge because of lower total rainfall in 2017 compared to 2016.

During the post-construction period (2009 to 2017), average loading rates at Parole Plaza have been lower than the levels existing prior to the redevelopment of the Towne Centre. However, at the Church Creek station, all average post-construction parameters except for lead and *E. coli* have exceeded average pre-construction (2002-2006) monitoring levels, and continued to do so in 2017.

Seasonal pollutant loads in 2017 are provided in Table 4-7. At Church Creek, the highest pollutant loads were recorded in the summer, except for copper and zinc which were highest in the winter. The highest loads of all parameters at Parole Plaza were recorded in the winter, except for *E. coli* (spring). At Parole Plaza, hardness was much higher in the winter, likely due to the use of salt to deice local roads and sidewalks associated with the extensive residential and shopping areas in this drainage area. TSS was distinctly higher, probably due to scraping action of plows on driving surfaces and the breakup of asphalt after several freeze-thaw cycles caused by the swings in temperature observed during the 2017 winter. At Parole Plaza in the winter, metal and total phosphorus loads increased and were likely associated with high seasonal TSS load.

Table 4-7. Seasonal loading rates, in pounds, observed at the Church Creek and Parole Plaza sampling stations in 2017

Season	BOD	TSS	TP	TKN	NO_3+NO_2	Zinc	Lead	Copper	Hardness	*E. coli**
Church Creek										
Summer	10,878	103,527	295	1,641	691	133	14	17	76,274	10,021
Fall	4,912	25,049	181	1,142	514	65	2	8	61,669	2,222
Winter	3,548	55,872	207	1,200	447	167	11	28	63,794	2,282
Spring	4,219	46,150	172	716	392	105	7	19	56,080	7,489
Parole Plaza										
Summer	217	1,347	9	61	43	8	0.1	1	1,607	4,895
Fall	191	1,362	8	59	27	8	0.1	1	2,487	2,504
Winter	462	15,354	25	146	67	30	0.8	5	12,060	3,971
Spring	251	1,850	9	52	24	12	0	1	2,722	16,530

* Units of *E. coli* are MPN/100 mL.

Annual average EMCs were plotted for each monitoring year. Plots were constructed to illustrate the impact that construction activity and redevelopment of the Annapolis Towne Centre site has had on water quality within the study reach. Figures 4-1 through 4-5 show how EMCs have changed from 2004 to 2017 at the Parole Monitoring Station. Nearly every concentration rose substantially between 2006 and 2007 when the majority of the site work took place at the Towne Centre. These concentrations fell notably in 2008, as the site stabilized. This downward trend continued in 2009. The reduction in pollutant concentrations stabilized in 2010 and 2011 possibly indicating that the stream has reached a post-construction baseline. The 2013 rise in TPH was due to an increase in the detection limit, and may not be associated with an actual increase in concentration, as greater than 95% of TPH concentrations fell below the detection limit. It is important to note that the 2013 data included in these plots do not include summer season data, which is often the season that produces the highest EMCs for many of the parameters. At Parole Plaza in 2017, most parameters were highest during the winter compared to other seasons, except *E. coli* which was highest during the spring. Annual pollutant concentrations in 2017 slightly decreased for most parameters, and substantially decreased for *E. coli*, compared to those from 2016. Total zinc, TKN, and TSS slightly increased in 2017 at Parole Plaza.

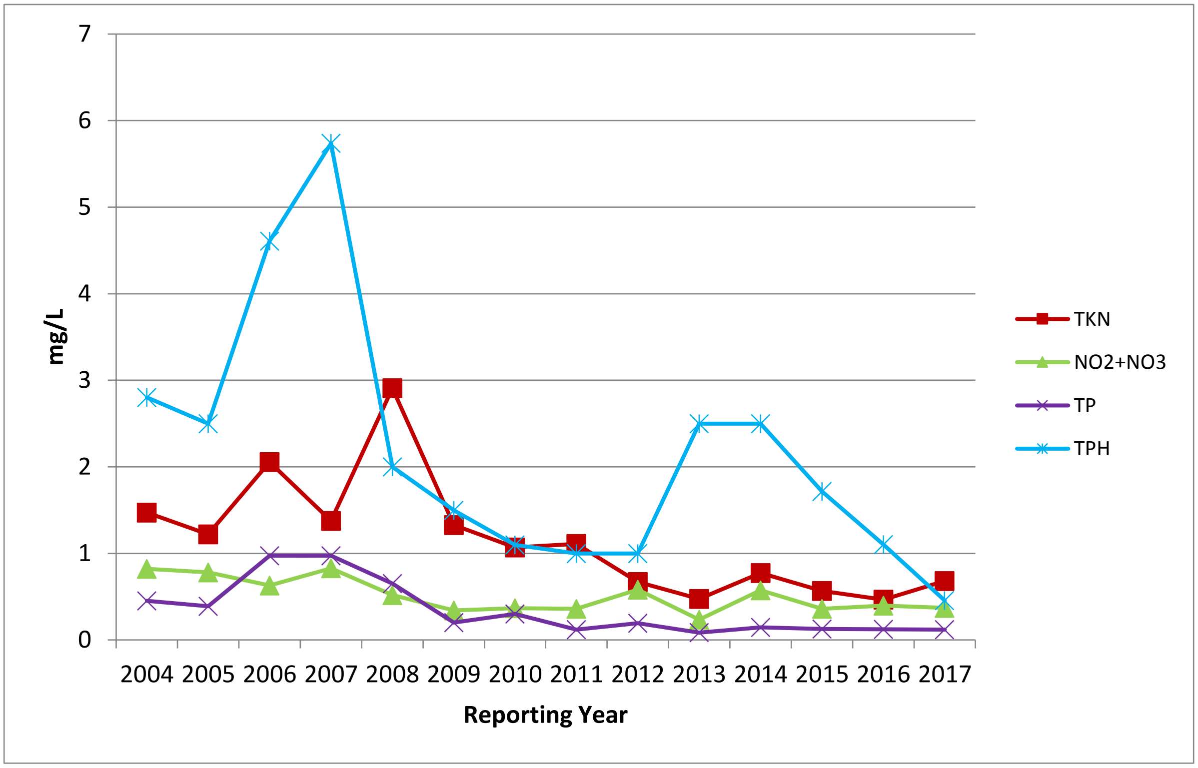

Figure 4-1. Parole Plaza station long-term monitoring: annual EMCs (TKN, NO_2+NO_3, TP, TPH; mg/L)

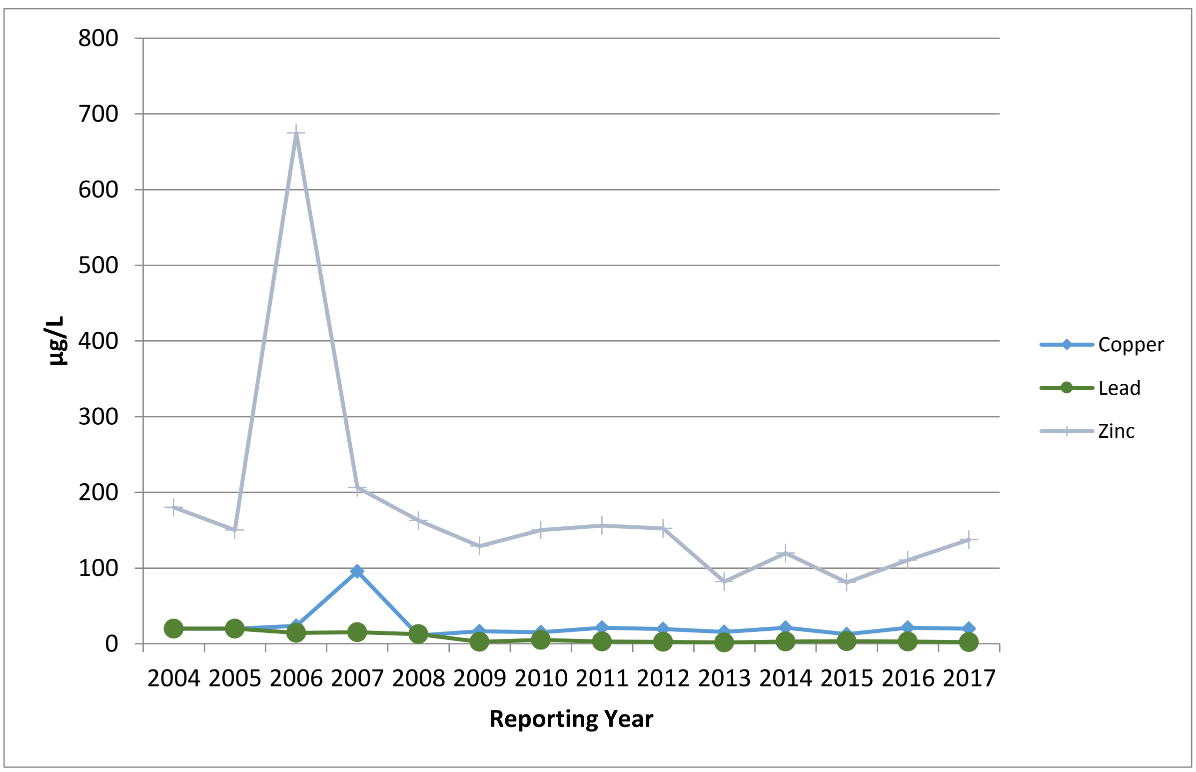

Figure 4-2. Parole Plaza station long-term monitoring: annual EMCs (Cu, Pb, Zn; mg/L)

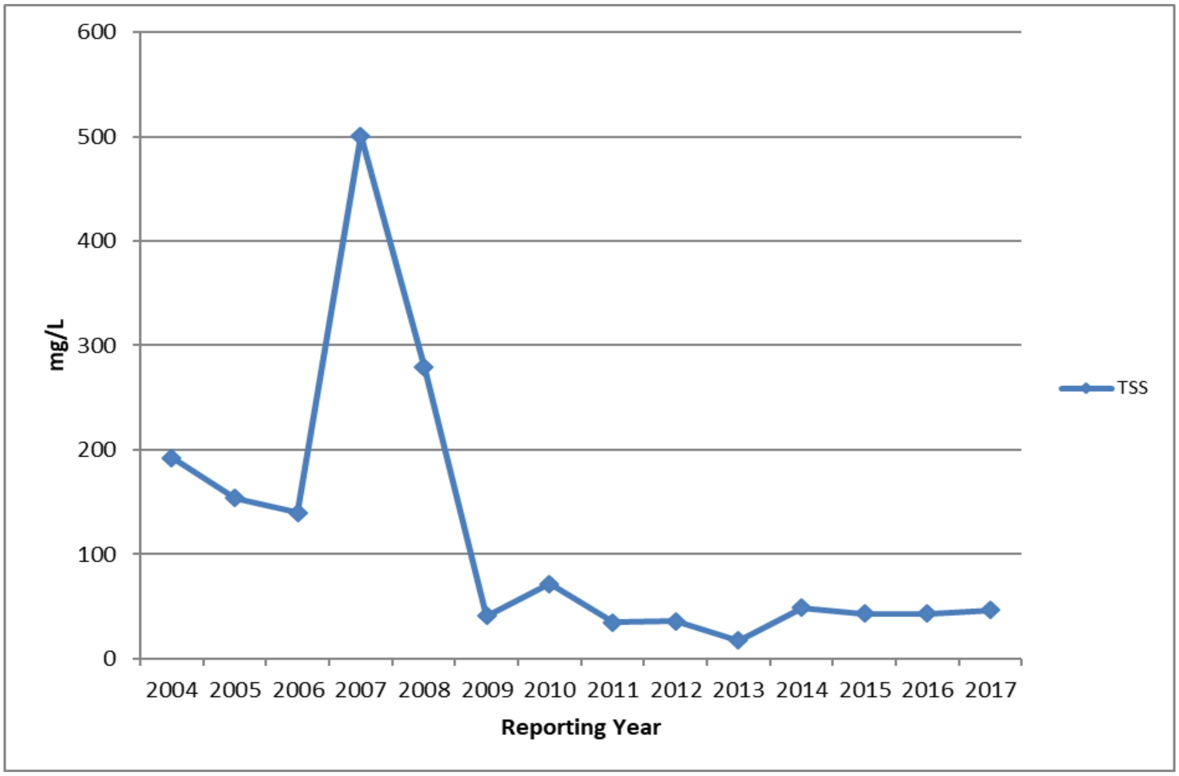

Figure 4-3. Parole Plaza station long-term monitoring: annual EMCs (TSS; mg/L)

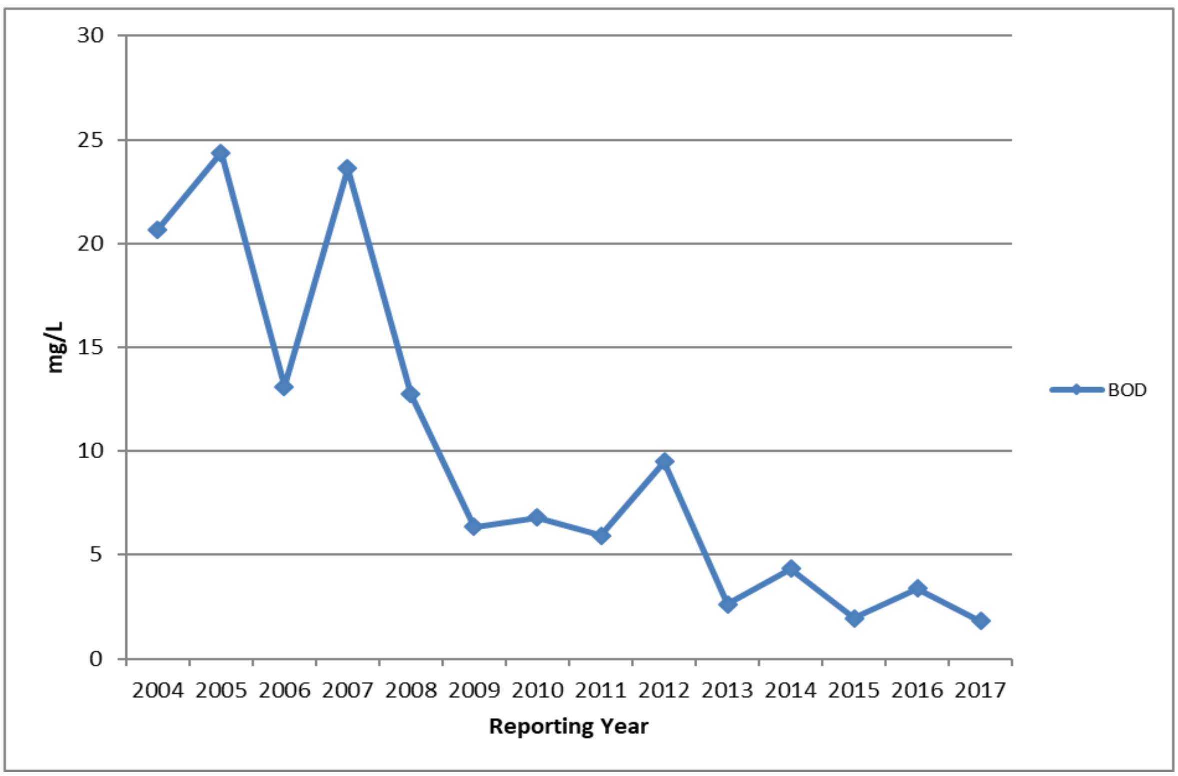

Figure 4-4. Parole Plaza station long-term monitoring: annual EMCs (BOD_5; mg/L)

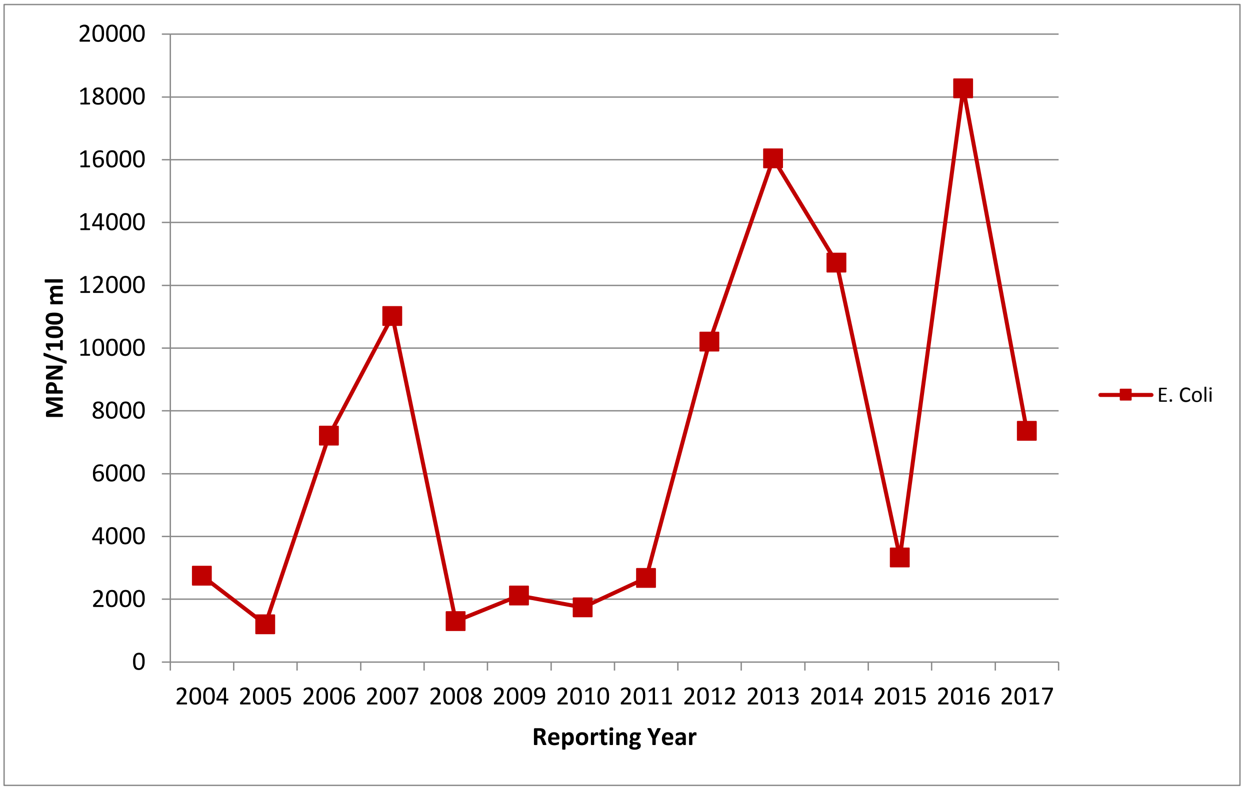

Figure 4-5. Parole Plaza station long-term monitoring: annual EMCs (*E. coli*; MPN/100 mL)

Figures 4-6 through 4-10 show a slight change in the trend in EMCs for the Church Creek monitoring station. A decrease in pollutant concentrations at Church Creek was observed in 2017 for most parameters when compared to 2016 EMCs except for total phosphorus and total copper which slightly increased. Note that the apparent rise in TPH at Church Creek in 2013 was due to an increase in the detection limit. Also, summer season concentrations were not included with the 2013 EMC data. In 2017, at Church Creek total zinc and copper were highest during the winter but all other parameters were highest during the summer. The restoration work conducted during the prior monitoring period (FY2016) could not be directly connected to the observed pollutant concentrations at Church Creek in the 2017 monitoring period. Changes in annual EMCs between the prior and current monitoring period appear to be within the normal variability of historical values or continuations of already decreasing trends (e.g., BOD_5 and TPH), although the influence of the stream restoration work cannot be ruled out.

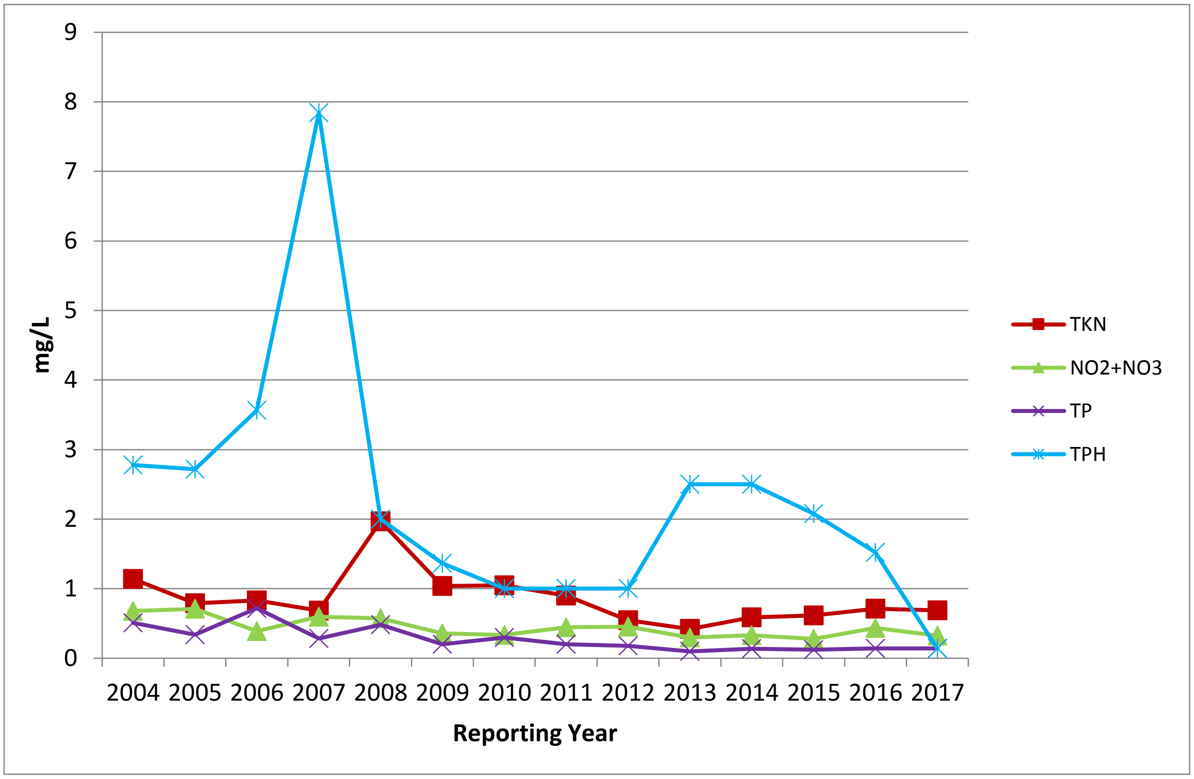

Figure 4-6. Church Creek station long-term monitoring: annual EMCs (TKN, NO_2+NO_3, TP, TPH; mg/L)

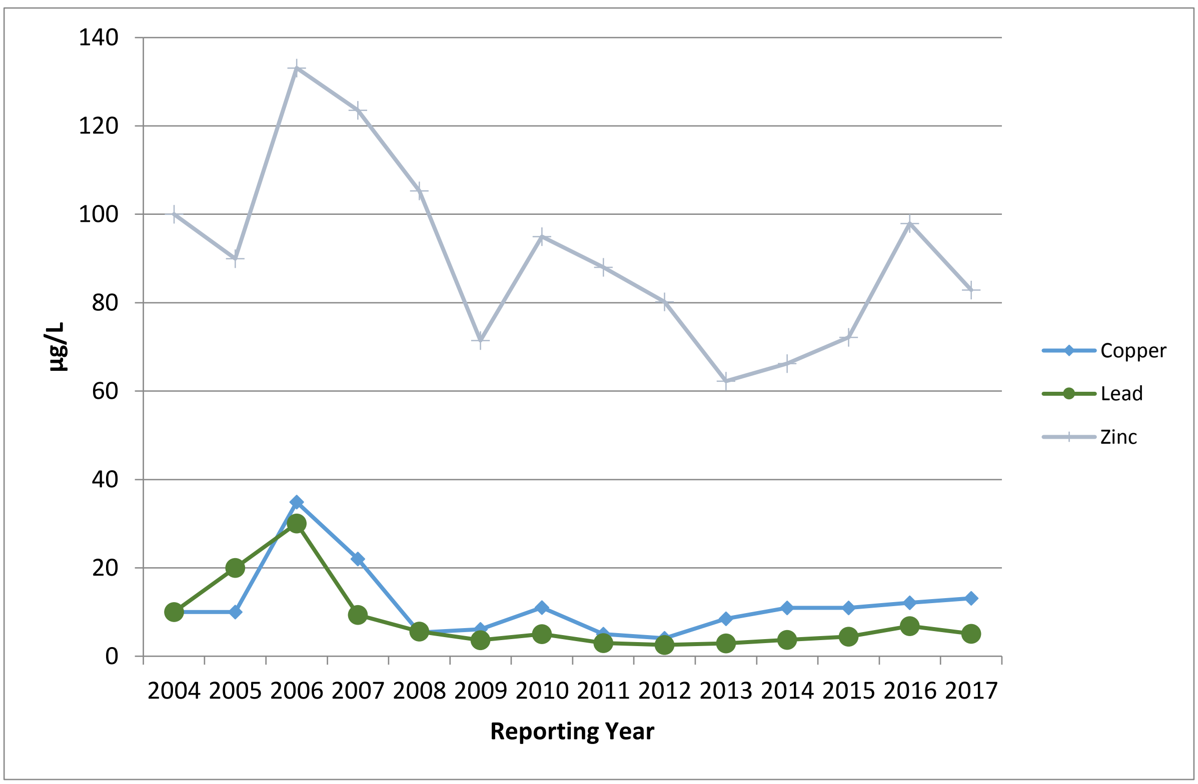

Figure 4-7. Church Creek station long-term monitoring: annual EMCs (Cu, Pb, Zn; mg/L)

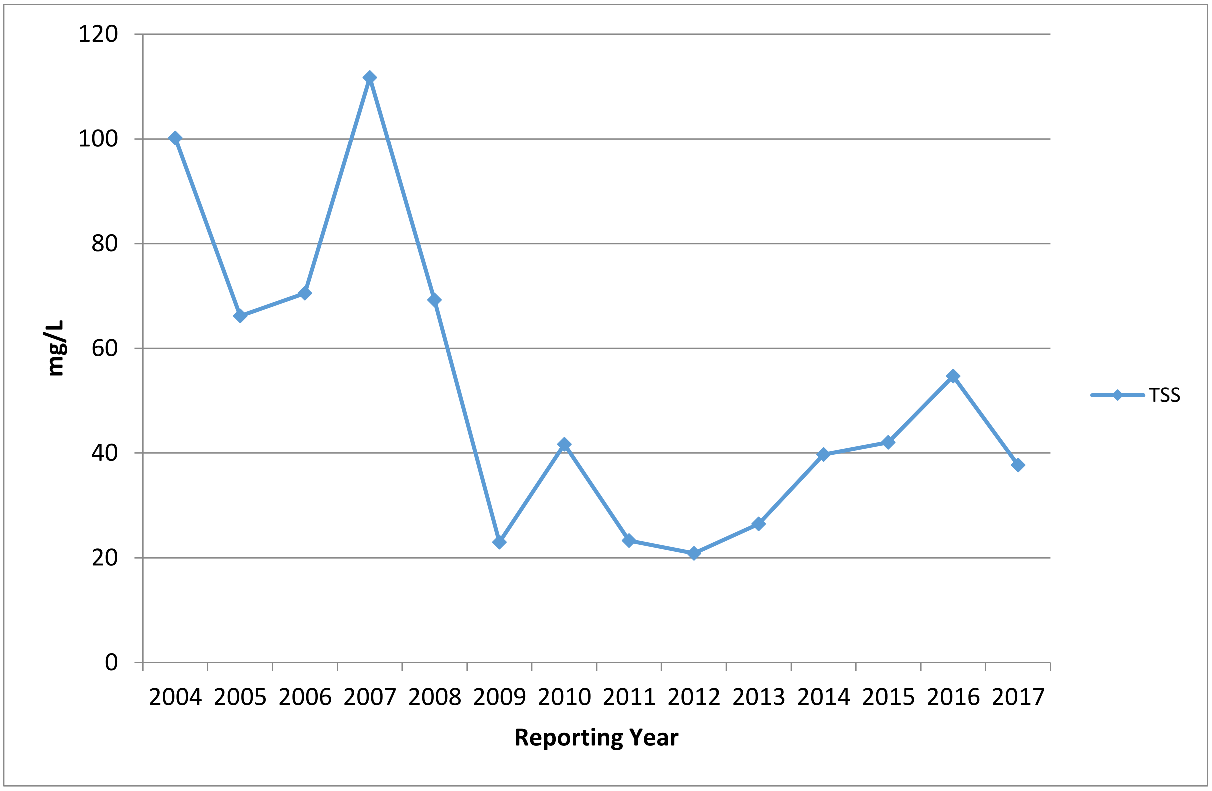

Figure 4-8. Church Creek station long-term monitoring: annual EMCs (TSS; mg/L)

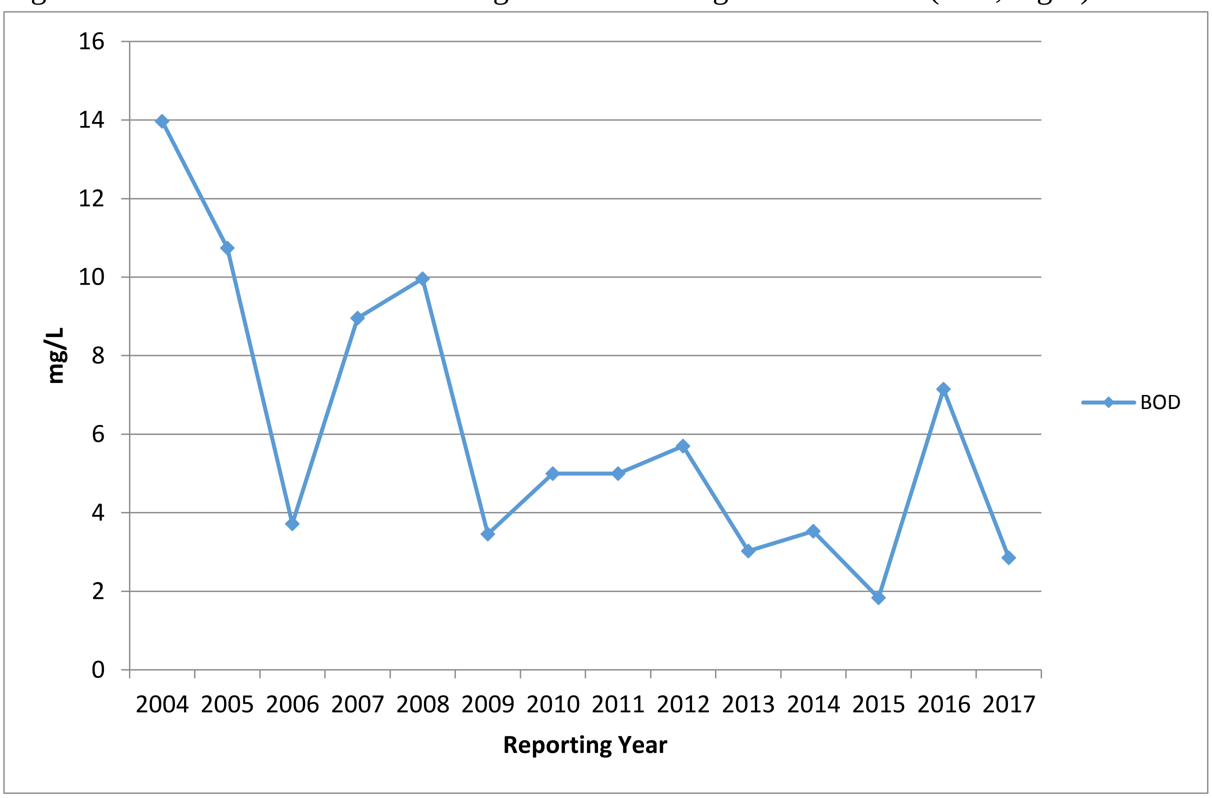

Figure 4-9. Church Creek station long-term monitoring: annual EMCs (BOD_5; mg/L)

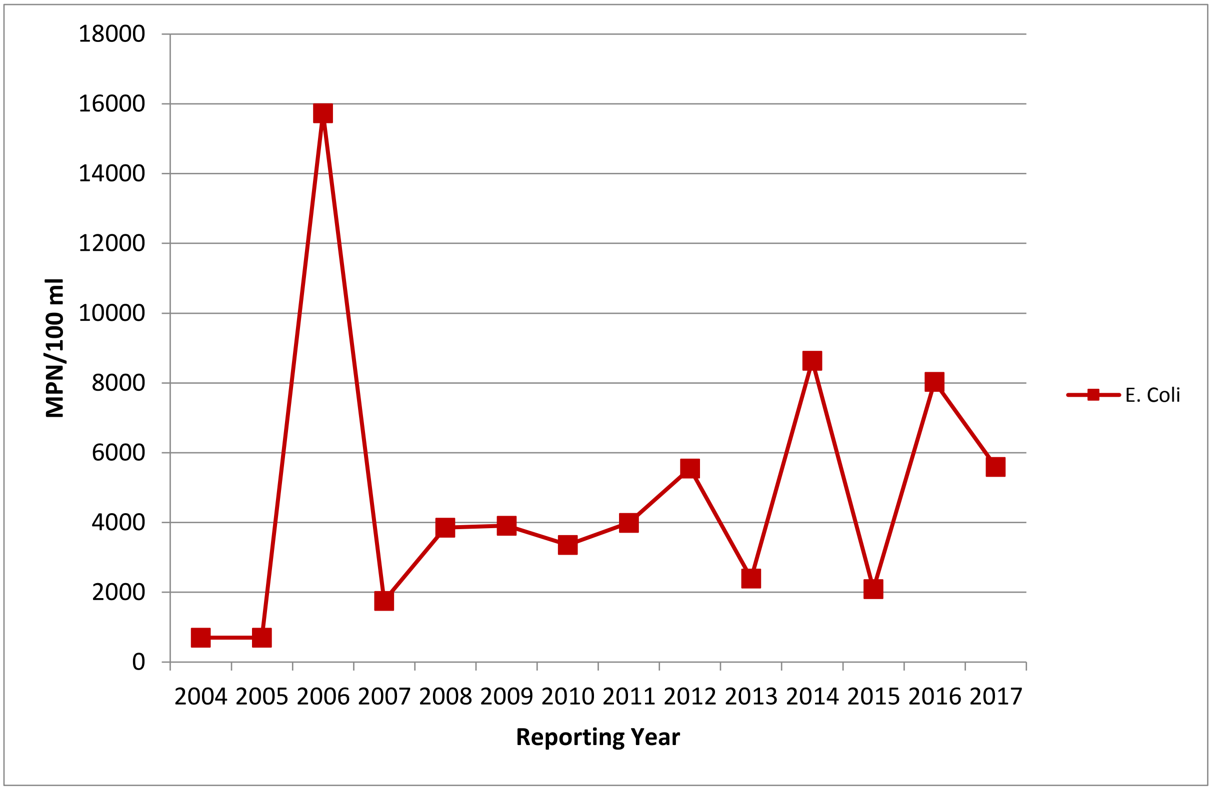

Figure 4-10. Church Creek station long-term monitoring: annual EMCs (*E. coli*; MPN/ 100 mL)

4.2 PHYSICAL HABITAT AND BIOLOGICAL CONDITIONS

Physical habitat and biological conditions within the Church Creek study area continue to be impaired by urbanization within the surrounding watershed. Stream physical habitat remains degraded throughout the entire study reach (Table 4-8, Figure 4-11). While scores at all sites increased in 2017, the change in score was sufficient to shift the associated narrative rating for CC-01 and CC-04 into a higher category, ‘Partially Degraded’, than that observed in 2016, ‘Degraded’. Nonetheless, urban stressors such as hydrologic alteration (i.e., increased runoff, increased frequency of peak flows, reduced infiltration) within the watershed have resulted in a reduction of stable instream habitat as well as increased channel erosion and sedimentation. A general lack of a stable epifaunal substrate further limits the capacity of the stream to support a diverse and healthy macroinvertebrate community. In addition, elevated conductivity levels reflect high levels of dissolved solids during baseflow conditions, which typically indicate the presence of water quality stressors.

Table 4-8. PHI scores from 2006 to 2017

Site		CC-01	CC-02	CC-03	CC-04
2006	PHI Score	51.1	55.4	56.8	No Data
	Rating	Degraded	Degraded	Degraded	Collected
2007	PHI Score	61.2	59.1	65.7	60.8
	Rating	Degraded	Degraded	Degraded	Degraded
2008	PHI Score	57.1	56.8	66.6	62.6
	Rating	Degraded	Degraded	Partially Degraded	Degraded
2009	PHI Score	73.2	59.6	69.2	65.2
	Rating	Partially Degraded	Degraded	Partially Degraded	Degraded
2010	PHI Score	64.3	53.9	65.0	62.3
	Rating	Degraded	Degraded	Degraded	Degraded
2011	PHI Score	67.4	55.3	66.9	61.5
	Rating	Partially Degraded	Degraded	Partially Degraded	Degraded
2012	PHI Score	69.2	51.5	62.5	58.3
	Rating	Partially Degraded	Degraded	Degraded	Degraded
2013	PHI Score	63.0	53.5	66.6	57.5
	Rating	Degraded	Degraded	Partially Degraded	Degraded
2014	PHI Score	65.85	56.16	70.79	61.01
	Rating	Degraded	Degraded	Partially Degraded	Degraded
2015	PHI Score	66.35	52.93	66.68	62.70
	Rating	Partially Degraded	Degraded	Partially Degraded	Degraded
2016	PHI Score	64.80	58.47	68.64	62.70
	Rating	Degraded	Degraded	Partially Degraded	Degraded
2017	PHI Score	67.41	60.97	71.72	67.92
	Rating	Partially Degraded	Degraded	Partially Degraded	Partially Degraded

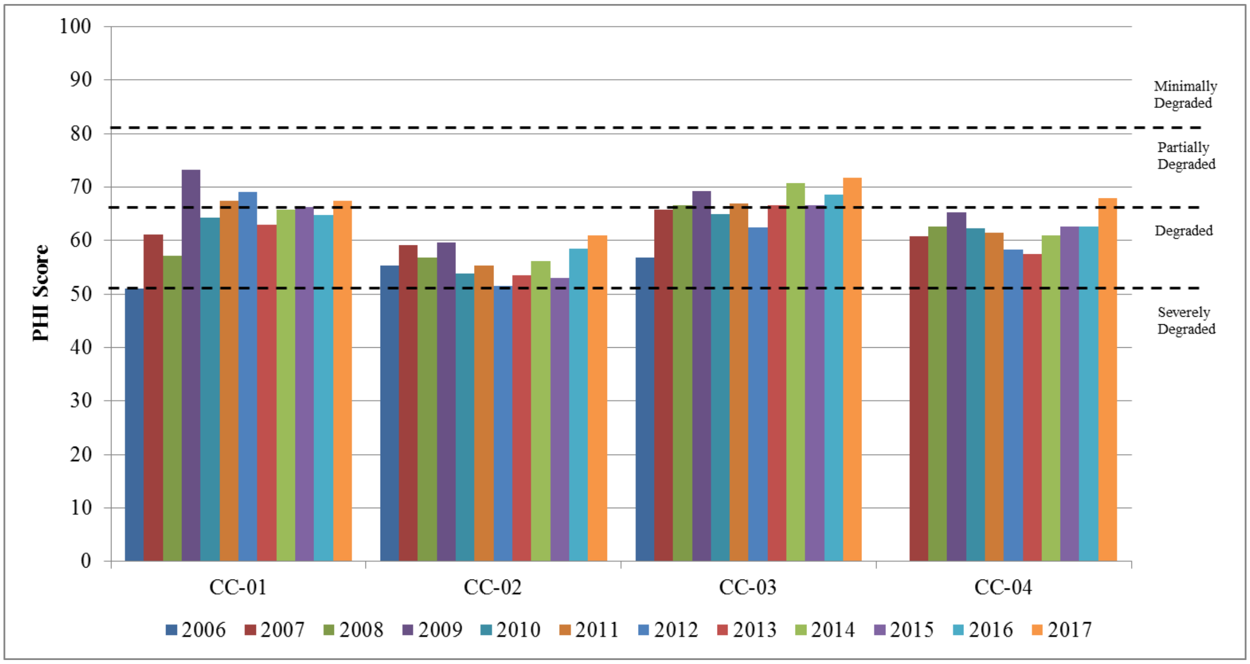

Figure 4-11. Comparison of PHI scores from 2006 to 2017

Beginning in 2013 and 2014, the updated MBSS PHI methods (Paul et al. 2003) were used to calculate PHI instead of the original MBSS methods (Hall et al. 2002) which had been used in the Church Creek watershed reports from prior years. Scores for 2006-2012 shown in Table 4-8 and Figure 4-11 were calculated using the original method, while scores for 2013-2017 were calculated using the updated method.

Biological impairment is evident within this watershed as reflected by the macroinvertebrate communities found throughout the study reach. A comparison of BIBI scores from 2006 through 2017 (Table 4-9) shows no substantial change in biological conditions throughout the study reach. While BIBI scores tend to fluctuate from year to year, overall classifications have changed very little with sites consistently rating either "Poor" or "Very Poor," no clear trends have been established (Figure 4-12). It appears that the biological community continues to be limited by the presence of urban stressors and degraded physical condition of the stream, and annual shifts in BIBI scores are likely related to random and systematic variability inherent in the assessment process.

Table 4-9. BIBI scores from 2006 to 2017

Site		CC-01	CC-02	CC-03	CC-04
2006	BIBI Score	1.86	2.43	1.86	No Data
	Rating	Very Poor	Poor	Very Poor	Collected
2007	BIBI Score	1.00	1.86	2.71	2.71
	Rating	Very Poor	Very Poor	Poor	Poor
2008	BIBI Score	2.43	2.43	2.43	2.14
	Rating	Poor	Poor	Poor	Poor
2009	BIBI Score	1.86	1.86	2.14	2.43
	Rating	Very Poor	Very Poor	Poor	Poor
2010	BIBI Score	1.29	1.86	1.57	2.14
	Rating	Very Poor	Very Poor	Very Poor	Poor
2011	BIBI Score	1.57	1.86	1.57	2.14
	Rating	Very Poor	Very Poor	Very Poor	Poor
2012	BIBI Score	1.86	2.43	1.57	2.43
	Rating	Very Poor	Poor	Very Poor	Poor
2013	BIBI Score	1.57	2.43	1.86	1.29
	Rating	Very Poor	Poor	Very Poor	Very Poor
2014	BIBI Score	1.57	1.86	1.29	1.57
	Rating	Very Poor	Very Poor	Very Poor	Very Poor
2015	BIBI Score	1.57	1.57	2.14	1.86
	Rating	Very Poor	Very Poor	Poor	Very Poor
2016	BIBI Score	1.86	1.57	2.14	2.71
	Rating	Very Poor	Very Poor	Poor	Poor
2017	BIBI Score	2.14	2.14	2.43	1.86
	Rating	Poor	Poor	Poor	Very Poor

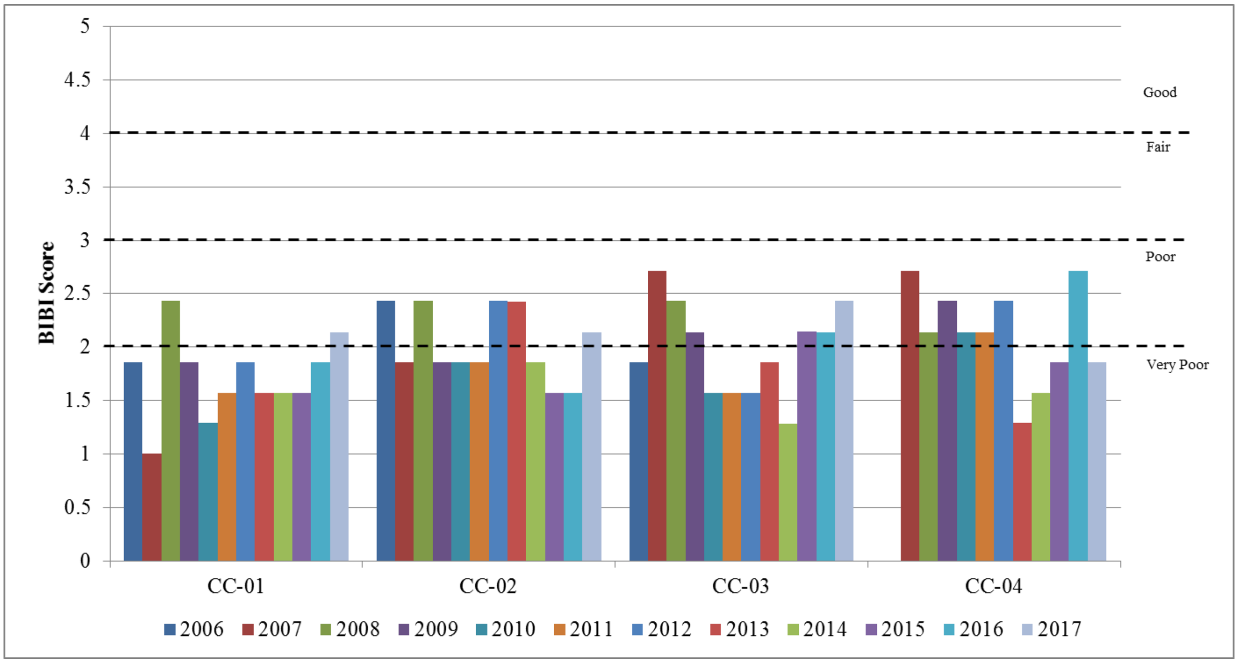

Figure 4-12. Comparison of BIBI scores from 2006 to 2017

4.3 GEOMORPHIC CONDITIONS

The Church Creek study area has a very high percentage of impervious surface cover (approximately 64 percent), and no reach was classified as a C channel, which are generally considered stable stream types due to adequate floodplain connectivity. Four reaches were classified as either F or G channels, which are more entrenched and less stable. The lower end of the Parole Plaza Tributary (XS-4) classified as an E channel and maintains some limited connectivity to its floodplain even though there are significant stormwater inputs feeding into the stream, which typically results in accelerated channel erosion and degradation. Evolution of channel type over the course of the study at each cross-section is presented in Table 4-10. It is likely that current stormwater management and wetland storage on the Church Creek mainstem, as well as the presence of an intact riparian vegetative buffer along much of the stream corridor, contributes to minimizing some of the adverse effects of the high imperviousness in the watershed. Additionally, grade controls such as the culvert at Solomon's Island Road and cobble rip-rap armoring at XS-5 likely prevent some degradation from occurring in the channel upstream. Nonetheless, there are clear indications of channel instability (i.e., degradation, aggradation, widening) in the upper reaches of the Parole Plaza Tributary, and thus, a need for additional stormwater management to prevent further channel erosion.

Table 4-10. Past Rosgen classifications

Cross-section	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
XS-1	E5	C5	E4	E5 → C5	E5 → C4/5	C4/5 → F4/5	F5	F4	F5/4	F4	F4	F4
XS-2	E5	E5	E5	E5	E5	G5c	G5c	G5c	G4c	G4	G4c	G4c
XS-3	G5c	G5c	G5c	G5c	G5c	No Data	No Data	G4c	G4c	G4/3c	G4c	G4c
XS-4	E5	E5	E5	E5	E5	E5	E5	C5	C5	C5	E5/4	E4/5
XS-5	E5b	C5	C5	C5	C3/5	C3/5	C3/5	F4/3	F3	F3/4	F4	F4

Bankfull channel dimensions (cross-sectional area, width, depth) in the Church Creek study area showed significant departure from expected values, as derived from Maryland Coastal Plain regional relationships of bankfull channel geometry (McCandless 2003). Almost all dimensions were generally larger in the Church Creek study area (see Figures 4-13, 4-14, and 4-15), and were often more similar to relationships of bankfull channel geometry derived from gaged urban watersheds located in the Coastal Plain. These relationships were developed for an urban stream restoration project in Anne Arundel County (AADPW 2002). Values measured in 2017 were slightly higher than prior assessment results. This reflects the higher level of imperviousness in the study area, as compared to the lower impervious levels in the drainage areas used to develop the regional relationship data. The results suggest that this stream has become enlarged as a result of the high imperviousness, and is both wider and deeper than stable C and E type channels located in rural/suburban watersheds of the coastal plain. It should be noted, however, that locating bankfull elevations in the field on actively eroding, previously stabilized, or incising channels is difficult and not recommended due to unreliable and/or misleading indicators, and instead bankfull elevations should be estimated using the aforementioned regional curves (Rosgen, personal communication, May 2011). Where bankfull indicators were suspect or questionable, the indicator approximating the rural/suburban regional curve for bankfull area was used to estimate bankfull elevations. Additionally, the Rosgen method is best used on streams that are free to adjust their lateral boundaries under the current discharge regime experienced by the system (Rosgen 1996). Given the high levels of rip rap and/or concrete rubble armoring found in the reaches containing cross-sections 2, 3 and 5, the accurate determination of the bankfull indicators in the field at these locations is problematic.

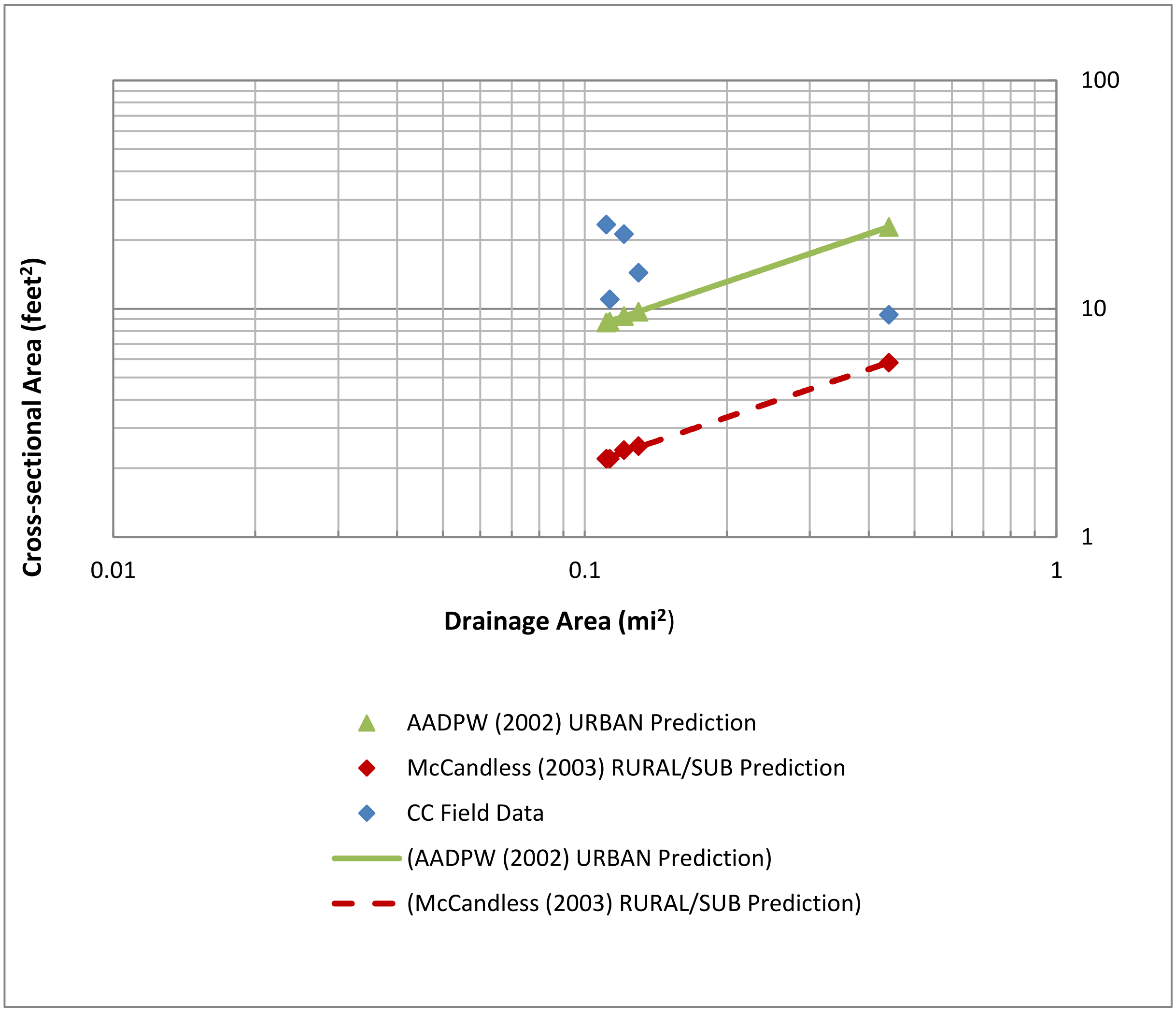

Figure 4-13. Comparison of bankfull channel cross-sectional area to drainage area (CC = Church Creek, 2017 data)

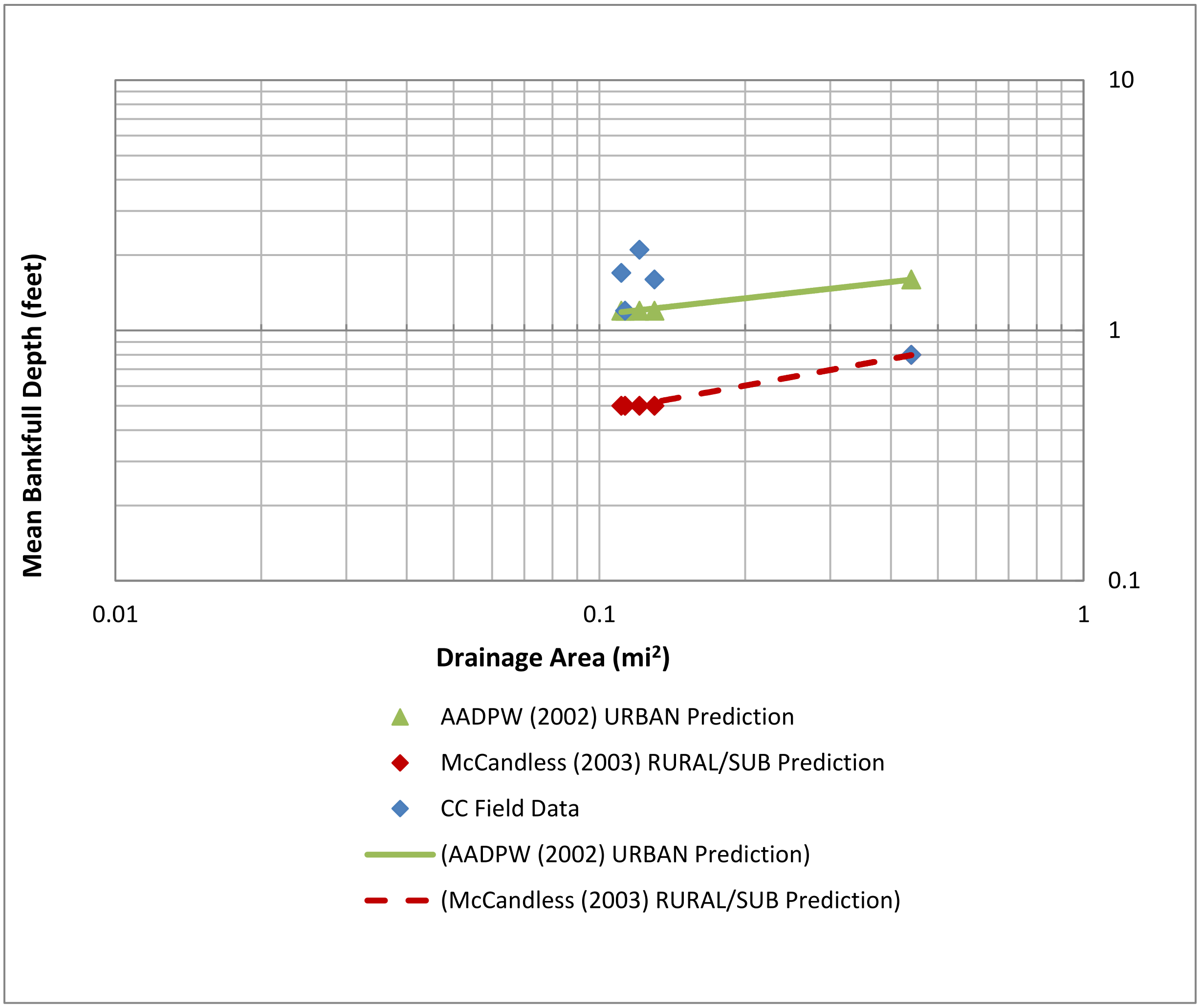

Figure 4-14. Comparison of mean bankfull depth to drainage area (CC = Church Creek, 2017 data)

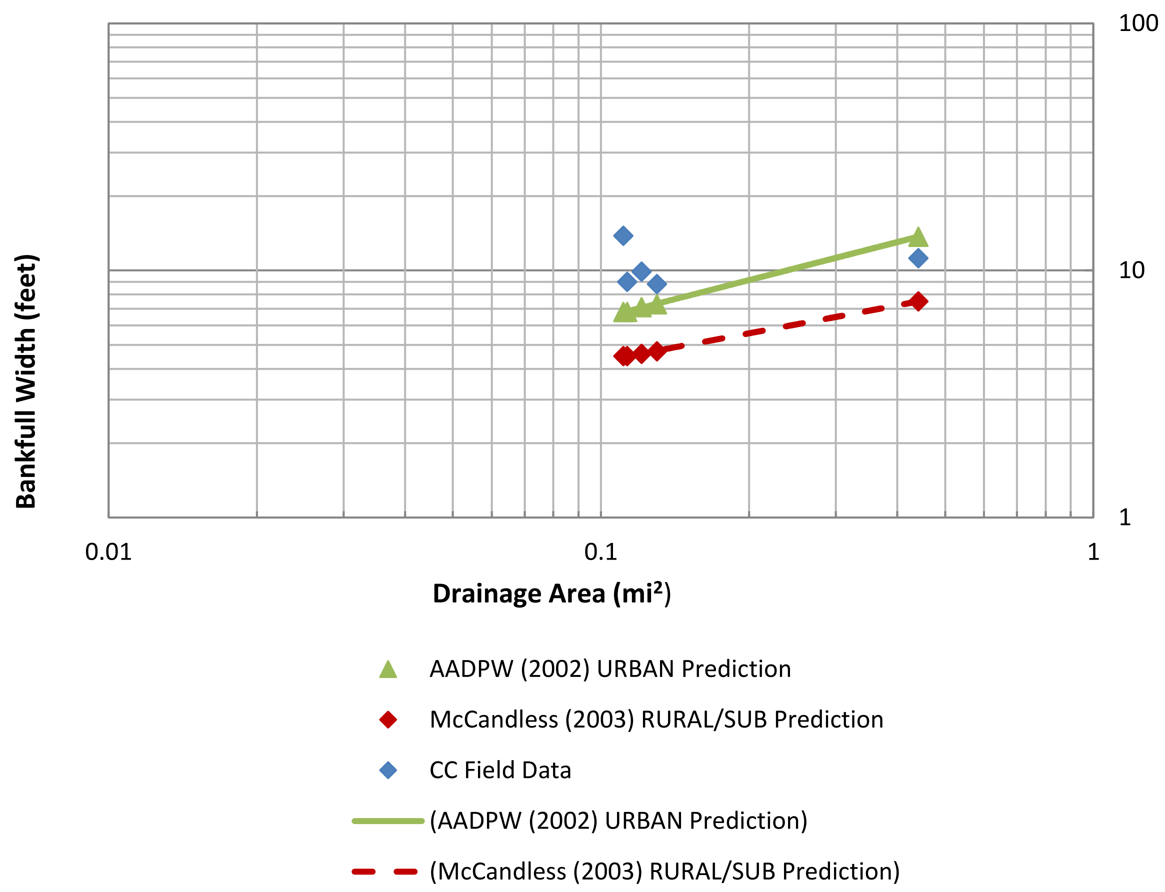

Figure 4-15. Comparison of bankfull width to drainage area (CC = Church Creek, 2017 data)

One of the five cross-sections showed enlargement from channel erosion while the other four showed aggradation as compared to baseline measurements (Table 4-11). Due to the replacement of XS-3 following channel restoration, data were compared to 2007 at this location only, whereas all other comparisons were made to 2003 data. Cross-sectional area from 2011 through 2017 was calculated using the top of bank elevation from the baseline survey in order to standardize comparisons and reduce variability among more subjective bankfull elevation reference points, or even changes that can occur to top of bank elevation from year to year. It is important to note that calculations prior to 2011 did not use the baseline reference elevation, instead they used the corresponding year's top of bank elevation for calculating cross-sectional area, and consequently these values are not directly comparable to the cross-sectional areas reported in 2011 through 2017. Comparison of baseline cross-sectional area is however comparable to 2011 through 2017 since all calculations are made using the same top of bank elevation.

Table 4-11. Summary of cross-sectional area changes over time.

Cross-section[a]	XS-1	XS-2	XS-3	XS-4	XS-5
July 2003	16.8	8.9	ND	14.3	9.7
Jan 2005	20.7	10.0	ND	14.4	9.9
March 2006	19.4	8.0	ND	18.4	9.5
March 2007	19.4	8.9	19.8	17.4	9.0
May 2008	20.1	10.1	16.7	18.0	8.9
July 2009	19.6	9.8	21.0	15.4	8.3
May 2010	19.8	10.3	20.4	16.4	8.5
July 2011[b]	21.3	15.9	20.6	7.8	10.5
April 2012[b]	21.6	15.4	19.2	11.7	5.9
July 2013[b]	21.0	15.5	20.2	11.7	6.9
June 2014 [b]	22.4	16.2	20.6	6.8	6.7
May 2015 [b]	22.6	16.4	18.6	9.2	6.7
March 2016 [b]	25.7	23.0	18.7	15.7	6.6
February 2017 [b]	27.1	18.7	18.2	13.3	6.5
% Change 2003-2017	61.3	110.1	-8.1[c]	-7.0	-33.0
% Change 2011-2017	27.2	17.6	-11.7	70.5	-38.1

[a] All values listed here are for top of bank area and are listed in square feet
[b] Values obtained using reference elevations (top of bank) from baseline measurements
[c] % change from 2007
ND = No Data

Using the current reference elevation comparison method, the upstream cross-sections (XS-1 and XS-2) showed fairly substantial enlargement over time, with increases of approximately 61.3%, and 110.1% respectively, since baseline measurements began in 2003. The bed elevation at XS-1 appears to have dropped almost a foot since 2003 with a noticeable amount of bed scour occurring between 2014 and 2017 (Appendix F). Scouring near the right bank occurred between 2008 and 2009 but has remained stable since. The left bank however, has both widened and deepened since 2012 but looks to be stabilizing as of 2017. The channel at XS-2 has widened notably since 2003, with considerable erosion along the right bank. The left bank has been generally stable showing minimal erosion until 2016. In 2016 the channel had both widened along the left bank and deepened mid channel, although in 2017 the channel returned to more narrow and shallow conditions seen before 2016. Cross-section area comparisons between baseline and 2017 show a substantial increase with a moderate percent change occurring over the last five years of 27.2% increase at XS-1 and 17.6% increase at XS-2.

Cross-section XS-3 has had very minimal changes in cross-sectional area with just a 8.1% decrease since 2007 baseline measurements and -11.7% change between 2011 and 2017. Between 2009 and 2011, the XS-3 channel appeared to be enlarging, as the right bank and bottom of the right bank experienced some erosion and the cross-sectional area increased (Appendix F). However, during the past five years, the right bank has experienced some aggradation (Appendix F). Between 2012 and 2016 monitoring, there has been little change apart from slight aggradation across the stream bed and toe of the right bank. In 2017 erosion began occurring behind the armored right bank and some scouring was evident on both sides of the channel bed. Cross-section XS-3 continues to have yard waste (i.e., grass clippings, leaves, and branches) dumped along the left bank.

Cross-section XS-4 has had the most variation throughout the years. Between 2010 and 2011 cross-section XS-4 had shown moderate signs of aggradation. Within the next year, the channel experienced erosion of the bed, particularly along the right hand side of the stream. In the 2013 survey, signs of aggradation were again present and the stream bed characteristics resemble those of the 2011 survey. In 2014 the stream bed remained elevated as in 2011 and 2013 however there was slight widening along the right bank. The debris jam at XS-4 which formed between 2011 and 2012 and caused sediment accumulation, was removed during stream restoration construction prior to the 2016 surveying. Consequently, the channel scoured significantly and resulted in cross-sectional area increase. This scour slowed by 2017 and the cross-sectional area decreased slightly from 2016. Cross-section XS-4 continues to be larger than in 2011 (70.5%) but is 7.0% smaller than 2003.

Cross-section XS-5 has been armored with cobble-sized rip rap in its bed to protect the sanitary sewer line. Between 2012 and 2013, XS-5 appears to have eroded by several inches of sediment, most notably near the left bank. The cross-sectional area has decreased by 38.1% since 2011. During the past three years, however, there has been little change in both stream bed elevation and bank stability (Appendix F). Cross-sectional area has remained relatively stable from 2014 to 2017 with little to no change year to year.

4.4 GENERAL CONCLUSIONS

Based upon the data collected in 2017, most stream water quality parameters measured have improved when compared to pre-construction and earlier post-construction monitoring years, but biological and physical conditions within the Church Creek study area have not improved and remain in a degraded and impaired condition. Although the stream channel has been stabilized along several reaches, the effects on biota are yet to be seen from such efforts. In 2016, stream restoration occurred downstream of XS-4, on an unnamed tributary of Church Creek, and upstream of XS-5 on the mainstem Church Creek. All of the CC-04 and part of the CC-03 biological monitoring sites were within the restored reach of stream. At Church Creek, annual average EMCs for most pollutants and annual loads for all pollutants were lower in 2017 compared to 2016. The reduced loadings and EMCs may have been the result of stream restoration; however, given the size of the restored area in relation to the overall watershed, water quality improvement may be difficult to discern from natural variations in pollutant levels, especially in the short timespan in which post-restoration data are available. The reduction in loads of pollutants at Church Creek may was also due, in part, to a 17% decline in total discharge as a result of lower annual rainfall between 2016 and 2017. Over time, the restoration project should result in less sediment transported downstream, increased stability at physical monitoring stations, and could positively affect the biota at monitoring stations through habitat improvement. In the year since restoration was completed, cross-section 5, downstream of the restored reach has maintained stability in its geomorphic parameters including consistent cross-sectional area. No considerable changes have been observed in water chemistry, biota, or physical habitat downstream of the restored reach; while increased categorical changes in PHI were observed in 2017, these categorical ratings were still within the historical rankings for the sites. Future monitoring efforts will be used to evaluate the effects of this restoration.

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APPENDIX A

STORM EVENT HYDROGRAPHS, NARRATIVES AND COMPOSITE SAMPLING METHOD TECHNICAL MEMORANDUM

KCI TECHNOLOGIES

TECHNICAL MEMORANDUM

TO:	Janis Markusic, AACO DPW
FROM:	James Tomlinson
DATE:	5/12/08
SUBJECT:	Proposed Modifications to Sampling Procedures Church Creek/Parole Plaza NPDES Monitoring 2008 KCI Job Order No. 01-032333.38

Dear Ms. Markusic,

Monitoring at the Parole Plaza station has historically entailed collecting storm water samples from a 60" corrugated metal pipe (CMP) outfall draining the Parole Plaza site. The rising, peak, and falling limb of each storm event was sampled and analyzed in the lab. In the summer of 2007, a newly-installed 54" reinforced concrete pipe (RCP) was connected to the Church Creek drainage network (refer to Figure 1). The new 54" RCP drains the *Annapolis Towne Center at Parole* construction site and contains portions of the drainage that had historically been passing through the 60" CMP. Based on plan reviews, on-site discussions with County staff /inspectors, and discussions with Mr. Matthew Kelly of Greenhorne & O'Mara Inc. (Head Engineer) it was determined that runoff from the *Annapolis Towne Centre at Parole* site would be discharging from both the 60" CMP and 54" RCP outfalls under post-construction conditions.

In order to maintain consistency in the characterization of the watershed, samples are being collected from both pipes. As in the 2006-2007 reporting year, the 2007-2008 reporting year has also encountered the challenge of determining the active drainage configuration during each sampled event. To address this problem, samples were collected for each limb of an event and taken to the laboratory for each pipe separately. In 2007, storm samples were collected and analyzed for both outfall pipes for three storm events (9/11/07, 10/9/07, and 10/19/07) at the Parole Plaza station. In 2008, storm samples were collected and analyzed for both outfall pipes for two storm events (1/10/08 and 1/17/08) at the Parole Plaza station.

Stage/discharge relationships were developed for both pipes, to determine the discharge from each pipe based on field-measured depths. The rating tables were used to determine discharges and total flow volumes for each limb of the storm. The reported concentrations for each limb were then weighted by the flow for that limb of the storm to determine the event mean concentration for each pipe. The event mean concentrations for each pipe were then flow weighted again for the total discharge through each pipe to determine the total event mean concentration for the *Annapolis Towne Center at* Parole site.

In March 2008, the sampling methodology was modified such that only one flow-weighted composite sample per event limb is collected and analyzed at the lab. The goal of compositing the discharge from both pipes is to ensure a comprehensive analysis of the storm water leaving the *Annapolis Towne Center at Parole* site during and after construction. The flow-weighted composite sample for each limb of an event is determined by the combined discharge of the 60" CMP and 54"RCP outfalls. Stage/discharge relationships were developed for both pipes, to determine the discharge from each pipe based on field-measured depths. The relationships are based on modeled values and are currently being validated by field-measured data. A sample is collected for each limb of a storm by proportioning the appropriate volume of RCP/CMP sample into a sample container, based on each pipes contribution to the total runoff. To determine the appropriate amount of sample to collect from each pipe for each limb, the discharge from the CMP and RCP is computed and totaled. The CMP and RCP discharge is then divided by the total discharge to determine the percent contribution to the total discharge. Once the percent contribution is determined, then volumetric containers are utilized to proportion each pipe sample to create one composite sample. The composite sample is then distributed into the laboratory bottles.

At this time, three storm events (3/19/08, 4/20/08, and 4/26/08) have been sampled utilizing the flow-weighted composite method. Currently, no automated equipment is available for the RCP. Level, pH, and temperature are taken manually during sampled events. All of the flow data and discharge characteristics for each outfall pipe are recorded during the storm event into a laptop spreadsheet that automatically calculates the correct sample proportions. General notes, field-measured velocity data, and a hydrograph are also recorded on the laptop spreadsheet during the storm event (see Figure 2).

As discussed in the field on April 10, 2008, KCI feels that this is an appropriate method for maintaining consistency with the historical data, while reducing the costs of sampling and testing both outfalls individually.

If you have any questions or comments, please feel free to contact me at the number below.

Sincerely,

James A. Tomlinson, PE
Project Manager
(410) 316-7864

ND/jt

cc: Christopher Victoria, AACo DPW
Nathan Drescher/KCI

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Proposed Modifications to Sampling Procedures
Church Creek/Parole Plaza NPDES Monitoring 2008
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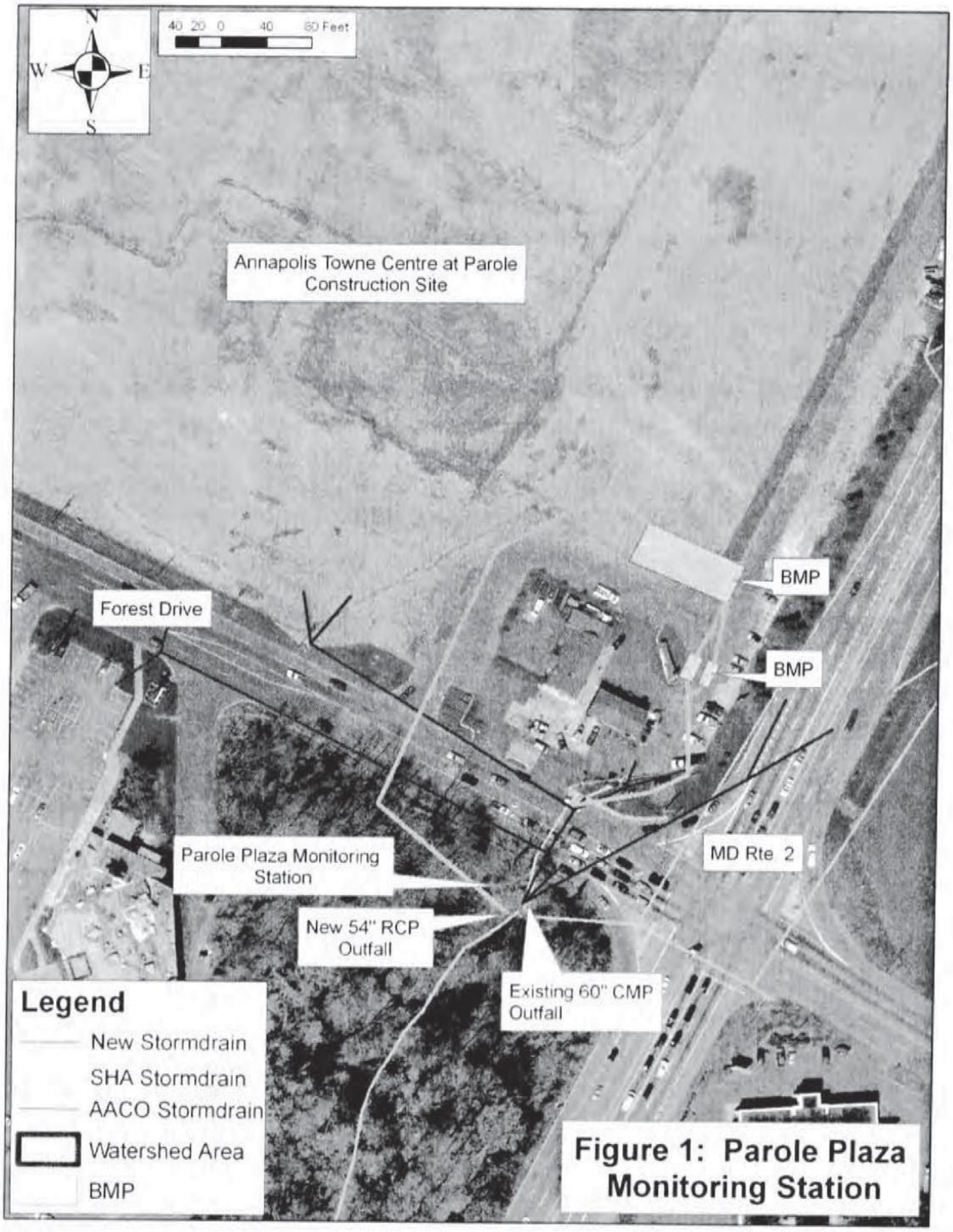

Figure 1: Parole Plaza Monitoring Station

Proposed Modifications to Sampling Procedures
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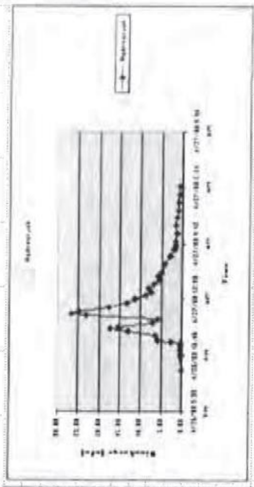
Figure 2

Parole Plaza Combined Hydrograph

Date	Time	CMP Level (ft)	RCP Level (ft)	CMP Q (cfs)	RCP Q (cfs)	RCP pH	RCP Temp Celsius	Combined Q (cfs)	RCP Prop. %	CMP Prop. %
4/26/08	4/26/08 10:20 PM	0.00	0.05	0.00	0.04	-	-	0.04	100	0
4/26/08	4/26/08 10:47 PM	0.00	0.15	0.00	0.19	6.70	15.40	0.19	100	0
4/26/08	4/26/08 10:50 PM	0.00	0.18	0.00	0.26	6.70	15.40	0.26	100	0
4/26/08	4/26/08 10:55 PM	0.00	0.16	0.00	0.21	6.60	15.80	0.21	100	0
4/26/08	4/26/08 11:00 PM	0.00	0.15	0.00	0.19	6.60	15.80	0.19	100	0
4/26/08	4/26/08 11:02 PM	0.10	0.15	0.15	0.19	6.00	16.00	[redacted]	56	44
4/26/08	4/26/08 11:06 PM	0.25	0.40	1.10	1.36	6.00	16.00	2.46	55	45
4/26/08	4/26/08 11:08 PM	0.43	0.52	3.36	2.37	5.80	16.10	5.74	41	59
4/26/08	4/26/08 11:15 PM	0.45	0.55	3.71	2.68	6.20	15.80	6.38	42	58
4/26/08	4/26/08 11:20 PM	0.65	0.75	7.95	5.06	6.10	15.50	13.01	39	61
4/26/08	4/26/08 11:22 PM	0.70	0.95	9.21	8.17	5.90	15.50	17.38	47	53
4/26/08	4/26/08 11:25 PM	0.65	0.90	7.95	7.31	5.90	15.60	15.26	48	52
4/26/08	4/26/08 11:30 PM	0.43	0.65	3.36	3.79	6.90	15.60	7.14	53	47
4/26/08	4/26/08 11:35 PM	0.40	0.58	2.85	2.98	7.00	15.60	5.83	51	49
4/26/08	4/26/08 11:40 PM	0.90	0.93	15.45	7.83	6.90	15.60	23.28	34	66
4/26/08	4/26/08 11:42 PM	0.85	1.20	13.73	12.96	7.00	15.60	[redacted]	48	52
4/26/08	4/26/08 11:45 PM	0.80	1.10	13.12	11.55	6.90	15.60	24.67	47	53
4/26/08	4/26/08 11:50 PM	0.72	0.90	9.79	7.83	7.10	15.80	17.62	44	56
4/26/08	4/26/08 11:55 PM	0.62	0.83	7.18	6.22	7.10	15.80	13.40	46	54
4/27/08	4/27/08 12:00 AM	0.57	0.77	6.04	5.34	7.20	15.30	11.38	47	53
4/27/08	4/27/08 12:05 AM	0.51	0.68	4.77	4.10	7.10	15.40	8.90	46	54
4/27/08	4/27/08 12:10 AM	0.46	0.64	3.88	3.66	7.40	15.30	7.53	49	51
4/27/08	4/27/08 12:15 AM	0.48	0.65	4.22	3.78	7.20	15.30	7.99	47	53
4/27/08	4/27/08 12:20 AM	0.42	0.65	3.19	3.78	8.00	15.30	6.97	54	46
4/27/08	4/27/08 12:25 AM	0.36	0.60	2.33	3.18	7.90	15.30	5.51	58	42
4/27/08	4/27/08 12:30 AM	0.38	0.60	2.59	3.18	7.80	15.30	5.77	55	45
4/27/08	4/27/08 12:35 AM	0.36	0.55	2.33	2.68	7.60	15.40	5.01	53	47
4/27/08	4/27/08 12:45 AM	0.30	0.55	1.55	2.68	7.30	15.30	4.23	63	37
4/27/08	4/27/08 12:55 AM	0.25	0.45	1.10	1.77	7.20	15.30	2.87	62	38
4/27/08	4/27/08 1:05 AM	0.18	0.40	0.55	1.36	7.30	15.30	1.91	71	29
4/27/08	4/27/08 1:10 AM	0.17	0.37	0.50	1.17	7.20	15.30	1.67	70	30
4/27/08	4/27/08 1:15 AM	0.16	0.35	0.45	1.05	7.40	15.30	[redacted]	70	30
4/27/08	4/27/08 1:25 AM	0.13	0.33	0.30	0.93	7.20	15.30	1.23	76	24
4/27/08	4/27/08 1:35 AM	0.13	0.40	0.30	1.36	7.30	15.30	1.66	82	18
4/27/08	4/27/08 1:45 AM	0.13	0.35	0.30	1.05	7.40	15.30	1.35	78	22
4/27/08	4/27/08 1:55 AM	0.13	0.30	0.30	0.74	7.20	15.30	1.04	71	29
4/27/08	4/27/08 2:05 AM	0.11	0.30	0.20	0.74	7.60	15.30	0.94	79	21
4/27/08	4/27/08 2:15 AM	0.10	0.25	0.15	0.53	7.30	15.30	0.68	78	22
4/27/08	4/27/08 2:25 AM	0.09	0.25	0.14	0.53	7.40	15.30	0.66	80	20



RCP - Velocity Probe

Depth	Velocity	SNR	Notes

CMP - Velocity Probe

Depth	Velocity	SNR	Notes

Comments

Pipe	Time	Comment
---	3:22 PM	CMP dry, RCP with small baseflow (0.05), Church normal
---	10:19 PM	Started to rain
	10:35 PM	Steady Light Rain/Thunder
	10:47 PM	RCP: Turbid flow
CMP	11:03 PM	smells bad, trash
CMP	11:50 PM	Muddy Water

Storm Event Narratives

- July 28, 2016 - At Church Creek, only four of the parameter EMCs were greater than the average concentrations of the storms captured since December 12, 2012. The EMC of BOD exceeded its long-term historical average by 142%, which included a peak limb concentration of 20 mg/L. The other three parameter EMCs (total Kjeldahl nitrogen, nitrate-nitrite, and lead) exceeded their historical average values for storm runoff by smaller percentages. Zinc had high concentrations during the rising limb (217 µg/L) and peak limb (122 µg/L) of this storm, however neither concentration exceeded the threshold to trigger reanalysis by the laboratory. Three of the parameter EMCs at Parole Plaza during the storm were greater than the corresponding average concentrations of the storms captured since December 12, 2012. The EMCs of BOD total Kjeldahl nitrogen, and zinc exceeded their historical averages by 46%, 29.8%, and 3.3%, respectively. The rising limb concentrations of BOD (25 mg/L) and total Kjeldahl nitrogen (2.7 mg/L) were the cause of above-average EMCs for this storm. Individual zinc concentrations were higher than the long-term average during the rising and peak limbs; however, the EMC was generally comparable to the historical average value.

- September 19, 2016 Storm - At Church Creek, field staff inadvertently transferred sample water into the incorrect set of bottles. Field staff went back to the site, and poured the remaining volume into the correct sample bottles, but there was insufficient volume to analyze for hardness. At Church Creek, three parameter EMCs were greater than the average concentrations of the storms captured since December 12, 2012: TSS (41.9%), lead (61.7%), and *E. coli* (132.9%). The higher than average EMCs for TSS and *E.coli* resulted from the higher than average sample concentrations during the rising and peak, and all three limbs, respectively. For lead, the concentrations during each limb were comparable to each other, but were all above the long-term average. At Parole Plaza, field staff noted an oily odor coming from the CMP during the event. The EMCs of only two parameters, TSS (9.0%) and total phosphorus (30.4%), were greater than the corresponding average concentrations of the storms captured since December 12, 2012. Total phosphorus and TSS concentrations during the rising and peak limbs were higher than the applicable long-term averages and contributed to the overall higher EMC values. No concentrations of these analytes triggered reanalysis by the laboratory.

- September 27, 2016 Storm - Total Kjeldahl nitrogen, TSS, lead, and *E. coli* EMCs were greater than the average concentrations of the storms captured since December 12, 2012 at Church Creek. The EMC for *E.coli* was greater than the corresponding historical average by 194%. During the rising limb, the *E. coli* concentration was 91,000 MPN, which was the highest concentration recorded during the last four years of sampling at Church Creek. The total phosphorus EMC was similar to the historical average value. Similar to Church Creek, the *E. coli* EMC at Parole Plaza was higher than the average concentration of storms captured since December 12, 2012. However, individual limb concentrations did not include record concentrations as was the case at Church Creek. The total Kjeldahl nitrogen EMC was similar to (i.e., 4.5% higher than) the historical average value.

- November 9, 2017 - Six of the parameter EMCs were greater than the long-term average concentrations of the storms captured since December 12, 2012, at Church Creek. The EMCs for total Kjeldahl nitrogen (TKN), nitrate-nitrite, total phosphorus, and hardness exceeded their long-term historical averages by over 100%. The rising limb concentrations for these parameters were possibly the main factor in the above-average EMCs for this storm. At Parole Plaza, five of the parameter EMCs during the storm were greater than the corresponding average concentrations of the storms captured since December 12, 2012. The EMCs of BOD, TKN, total phosphorus, and zinc exceeded their historical averages by a small percentage. The unusual high concentrations of lead during all three limbs at Parole Plaza and the blank samples caused doubt in the results therefore they have been removed from the EMC spreadsheet for both sites. Also during this storm event, field staff noticed the smell of cooking oil coming from the RCP.

- November 29, 2016 Storm **-** Because October and November were very dry months with a total rainfall of only 2.8 inches, this storm was accepted by Anne Arundel County even though it did not meet the 0.1" minimum rainfall requirement. At Church Creek, only two parameter EMCs were greater than the average concentrations of the storms captured since December 12, 2012: nitrate-nitrite (56.3%), and total phosphorus (108.6%). The higher than average EMC for total phosphorus resulted from the higher than average sample concentration during the peak limb. The individual concentration of 2.60 mg/L for total phosphorus during the peak limb was the highest since December 12, 2012. During this storm event, at Parole Plaza a large amount of leaves flowed through the RCP, and affected the measured level and the EMCs calculations; therefore no EMC calculations were completed for this storm at Parole Plaza. During the storm, field staff continually cleared the leaves from the RCP to maintain accurate flow measurements. Concentrations of TPH, zinc and BOD during the rising and peak limbs were higher than the detection limit. The *E. coli* concentration was very high during the peak limb.

- December 6, 2016 Storm **-** None of the parameter EMCs were greater than the average concentrations of the storms captured since December 12, 2012 at both stations. At Church Creek, most concentrations were higher during the peak limb than the rising and falling limbs, but were not high enough to cause EMCs to exceed long-term averages. At Parole Plaza, the rising limb concentrations of most parameters were higher than the peak and falling limbs. None of the individual concentrations during this event were identified as a concern.

- January 23, 2017 Storm – At Church Creek, five of the parameter EMCs were greater than the long-term average concentrations of the storms captured since December 12, 2012. The EMCs for total metals (copper, lead, and zinc) exceeded their long-term historical averages by over 100%. The highest concentrations of metals during this event occurred during the peak limb. The TSS EMC exceeded its long-term historical average (by less than 25%), which may have contributed to the higher than average concentrations of the metals. At Parole Plaza, EMCs for the same five parameters as Church Creek, plus phosphorus, were greater than the corresponding average concentrations of the storms captured since December 12, 2012. The TSS and lead EMCs exceeded their historical averages by over 100%. Maximum concentrations for both parameters occurred during the peak limb. During this storm event, field staff noticed that the water discharging from the pipes was gray and smelled like gasoline and oil; however, TPH results were below detection limits.

- February 28, 2017 Storm - At Church Creek, all parameter EMCs were less than the average concentrations of the storms captured since December 12, 2012. During this event, duplicate samples were collected at Church Creek during the falling limb. All of the results were within 20% of each other. At Parole Plaza, the EMC of only one parameter (TPH) was greater (69.8%) than the corresponding average concentration of the storms captured since December 12, 2012. Specifically, concentrations of TPH during the rising and peak limbs were higher than the detection limit. During this storm, the field crew inadvertently failed to program the In-situ sonde to record pH from the CMP; therefore, the pH readings on the EMC spreadsheet are only from the RCP for this event.

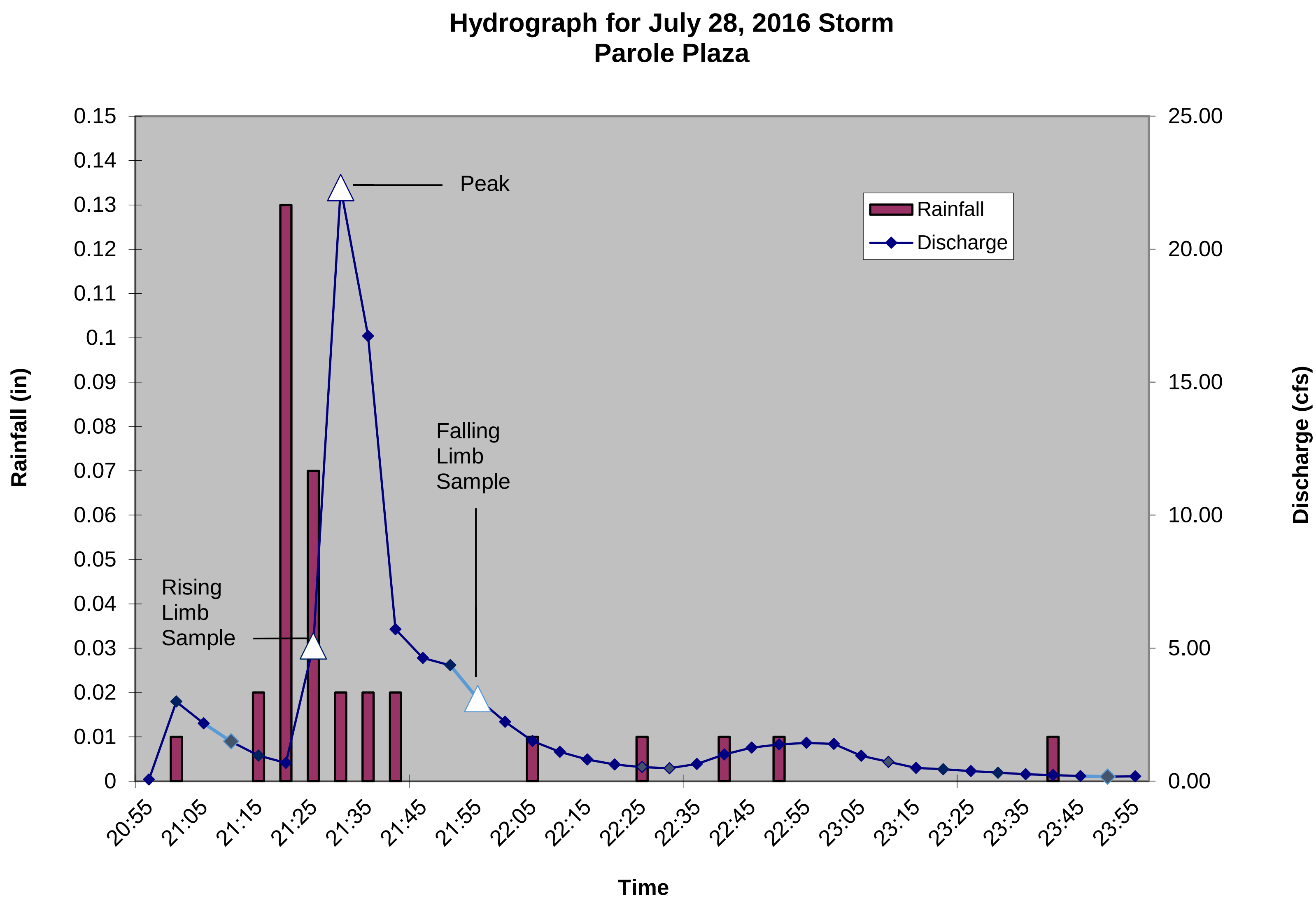
- March 31, 2017 Storm - During the March 31, 2017 event, the copper EMC was greater than the average concentration of the storms captured since December 12, 2012 at Church Creek, but only by 7.5%. Concentrations of copper were higher than the detection limit during all three limbs which contributed to the overall higher EMC value, but none exceeded concentrations that would be considered a concern. During this storm, at Parole Plaza, the same parameters from the January 23, 2017 storm had greater EMCs than the corresponding average concentrations of the storms captured since December 12, 2012. Total phosphorus, TSS, copper, lead, zinc, and hardness exceeded their historical averages by 6.3% to 34.1%.

- April 25, 2017 - During this storm event, *E. coli* samples were now being analyzed by new laboratory (Water Testing Labs of Maryland). Since it was the first time analyzing the *E. coli* samples they were not aware that the samples needed to be diluted; therefore, none of the samples were diluted and none of results were included in the EMC calculations. At Church Creek, the only parameter EMC that was greater than the average concentrations of storms captured since December 12, 2012 was copper. The EMC of copper was greater than the corresponding historical averages by 32.8%. At Parole Plaza, five parameter EMCs (TKN, total phosphorus, copper, zinc, and TPH were greater than the average concentrations of the storms captured since December 12, 2012. The parameters greater than the corresponding historical averages ranged between 12.85 to 52.7%. The TPH concentration was 7 mg/L during the rising and peak limb of the storm event causing the EMC to increase.

- May 12, 2017 - None of parameter EMCs were greater than the average concentrations of the storms captured since December 12, 2012 at both stations. None of the parameter concentrations were unusually high or stood out as a problem at either station.

- June 19, 2017 - At Church Creek, six parameter EMCs were greater than the average concentrations of the storms captured since December 12, 2012. EMCs for BOD, TSS, copper, lead, zinc and E. coli were greater than the corresponding historical averages by 18.5% to 226.2%. The concentration of metals were elevated during the rising limb which contributed to the higher EMCs; have been requested to be reanalyzed by the

Martel along with TPH because they are over their parameter threshold for the laboratory. Copper, zinc, and TPH EMCs were also greater than the average concentrations of the storms captured since December 12, 2012 at Parole Plaza which can be explained by high concentrations during the rising limb. The EMC for TPH was greater than the corresponding historical averages by 420.7%. All of these parameters have been requested to be reanalyzed as well.


Hydrograph for July 28, 2016 Storm
Parole Plaza
Rainfall (in)
Discharge (cfs)
Time
Peak
Falling Limb Sample
Rising Limb Sample
Rainfall
Discharge
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
25.00
20.00
15.00
10.00
5.00
0.00
20:55
21:05
21:15
21:25
21:35
21:45
21:55
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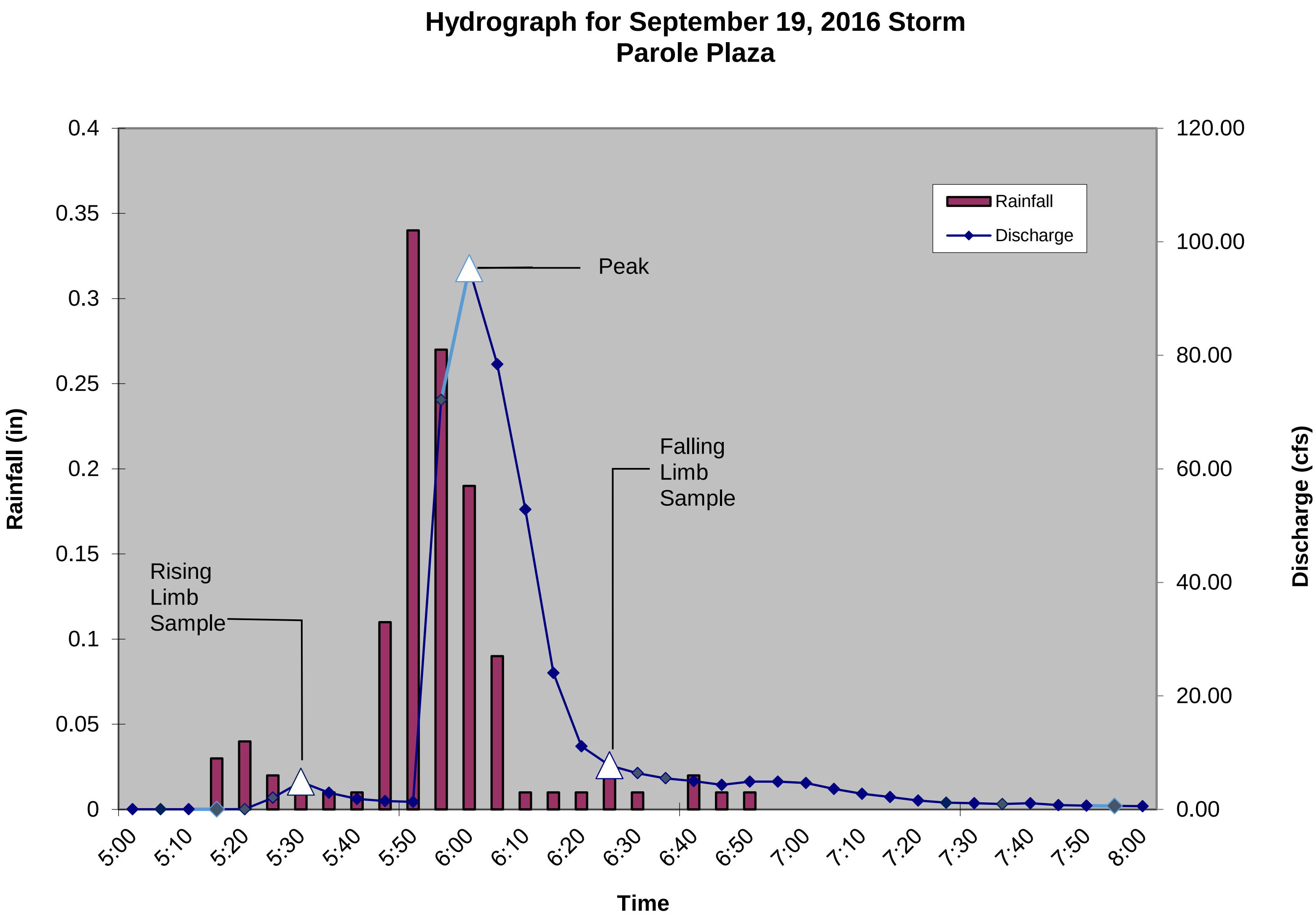
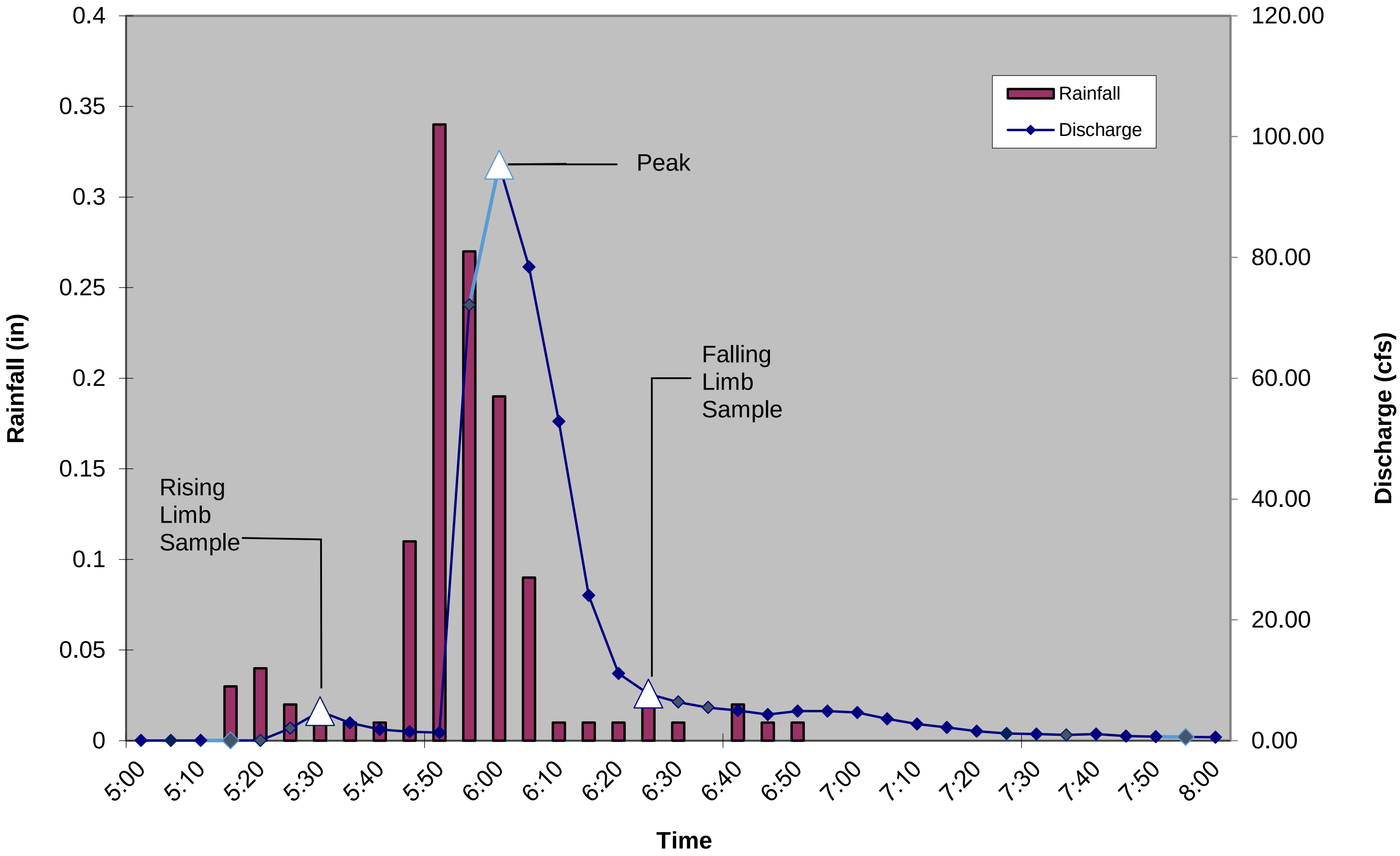
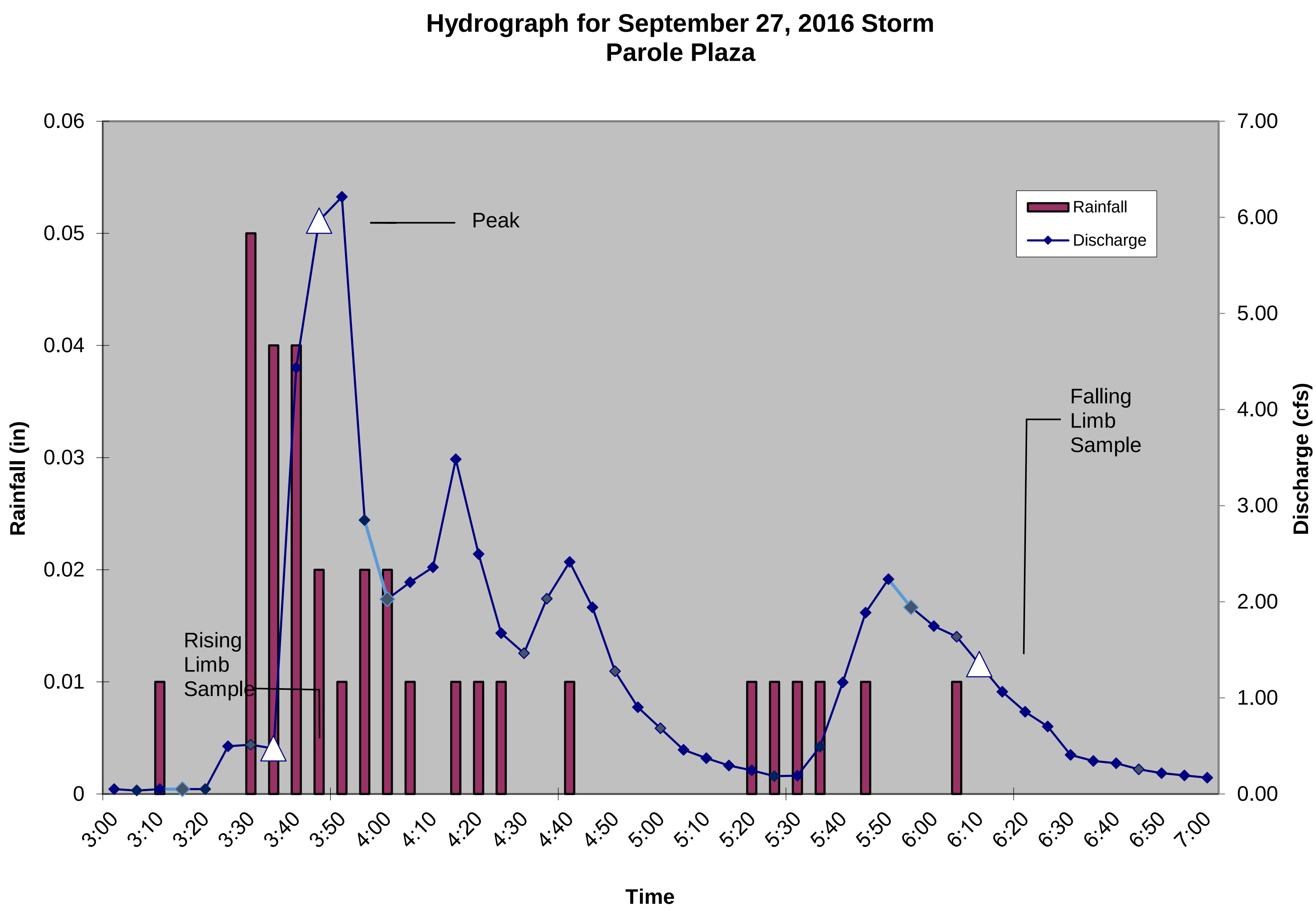
23:35
23:45
23:55



Hydrograph for September 19, 2016 Storm
Parole Plaza
Rainfall (in)
Discharge (cfs)
Time
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
120.00
100.00
80.00
60.00
40.00
20.00
0.00
5:00
5:10
5:20
5:30
5:40
5:50
6:00
6:10
6:20
6:30
6:40
6:50
7:00
7:10
7:20
7:30
7:40
7:50
8:00
Rainfall
Discharge
Peak
Rising Limb Sample
Falling Limb Sample

Hydrograph for September 19, 2016 Storm
Parole Plaza




Hydrograph for September 27, 2016 Storm
Parole Plaza
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Peak
Rising Limb Sample
Falling Limb Sample
0.06
0.05
0.04
0.03
0.02
0.01
0
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
3:00
3:10
3:20
3:30
3:40
3:50
4:00
4:10
4:20
4:30
4:40
4:50
5:00
5:10
5:20
5:30
5:40
5:50
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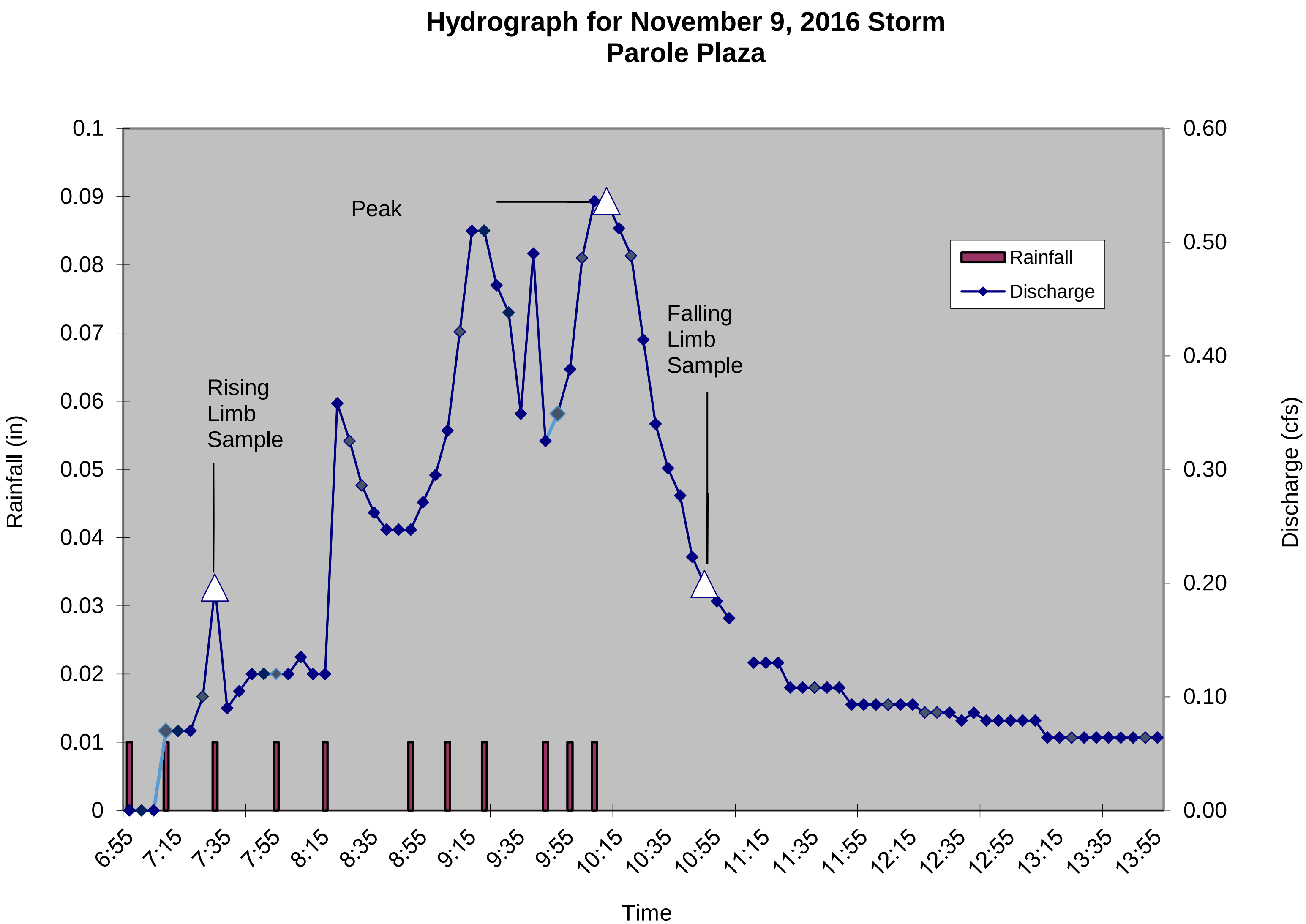
6:10
6:20
6:30
6:40
6:50
7:00



Hydrograph for November 9, 2016 Storm
Parole Plaza
Rainfall (in)
Discharge (cfs)
Time
Peak
Rising Limb Sample
Falling Limb Sample
Rainfall
Discharge
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.60
0.50
0.40
0.30
0.20
0.10
0.00
6:55
7:15
7:35
7:55
8:15
8:35
8:55
9:15
9:35
9:55
10:15
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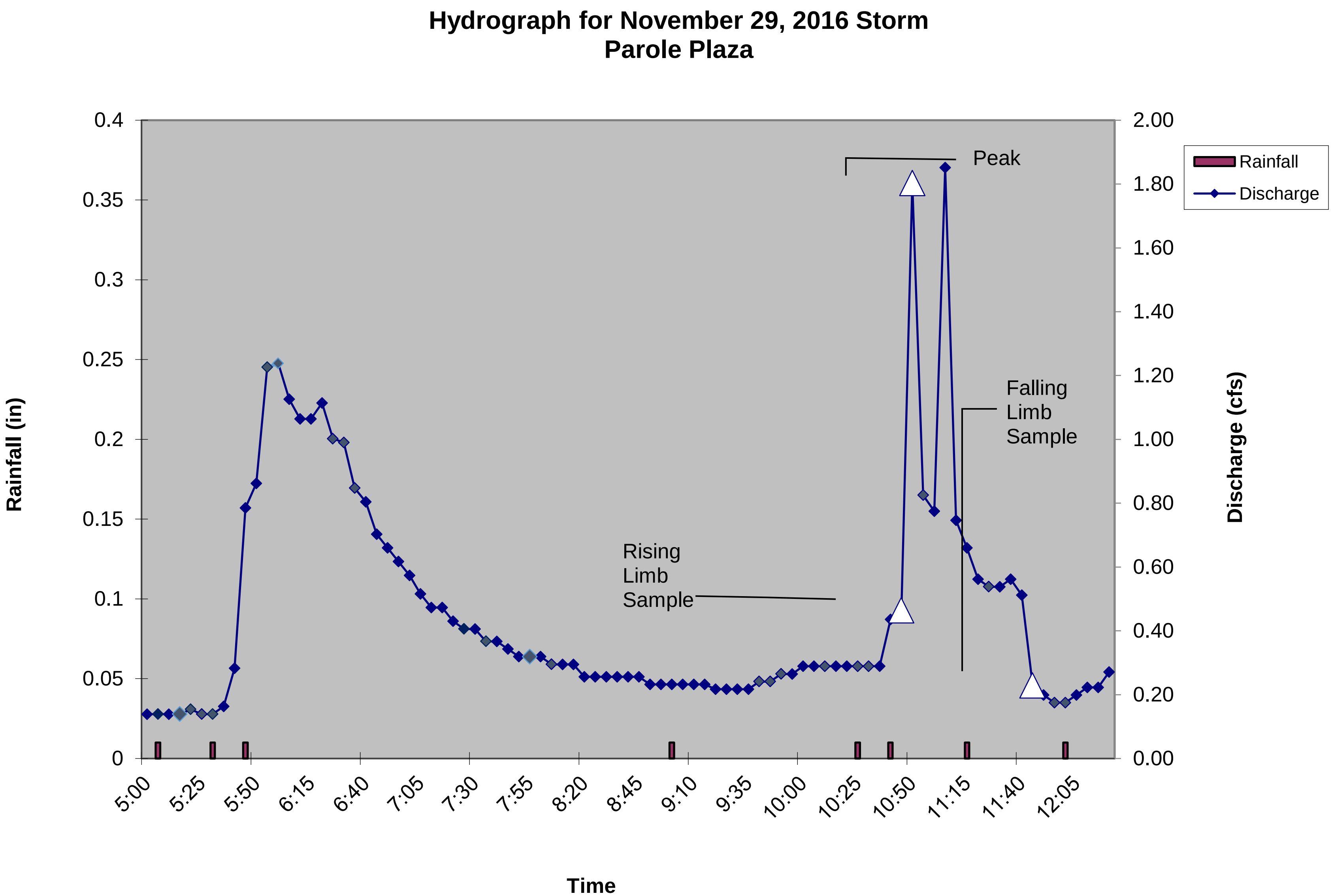
13:15
13:35
13:55


Hydrograph for November 29, 2016 Storm
Parole Plaza
Rainfall (in)
Discharge (cfs)
Time
Peak
Rising
Limb
Sample
Falling
Limb
Sample
Rainfall
Discharge
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
5:00
5:25
5:50
6:15
6:40
7:05
7:30
7:55
8:20
8:45
9:10
9:35
10:00
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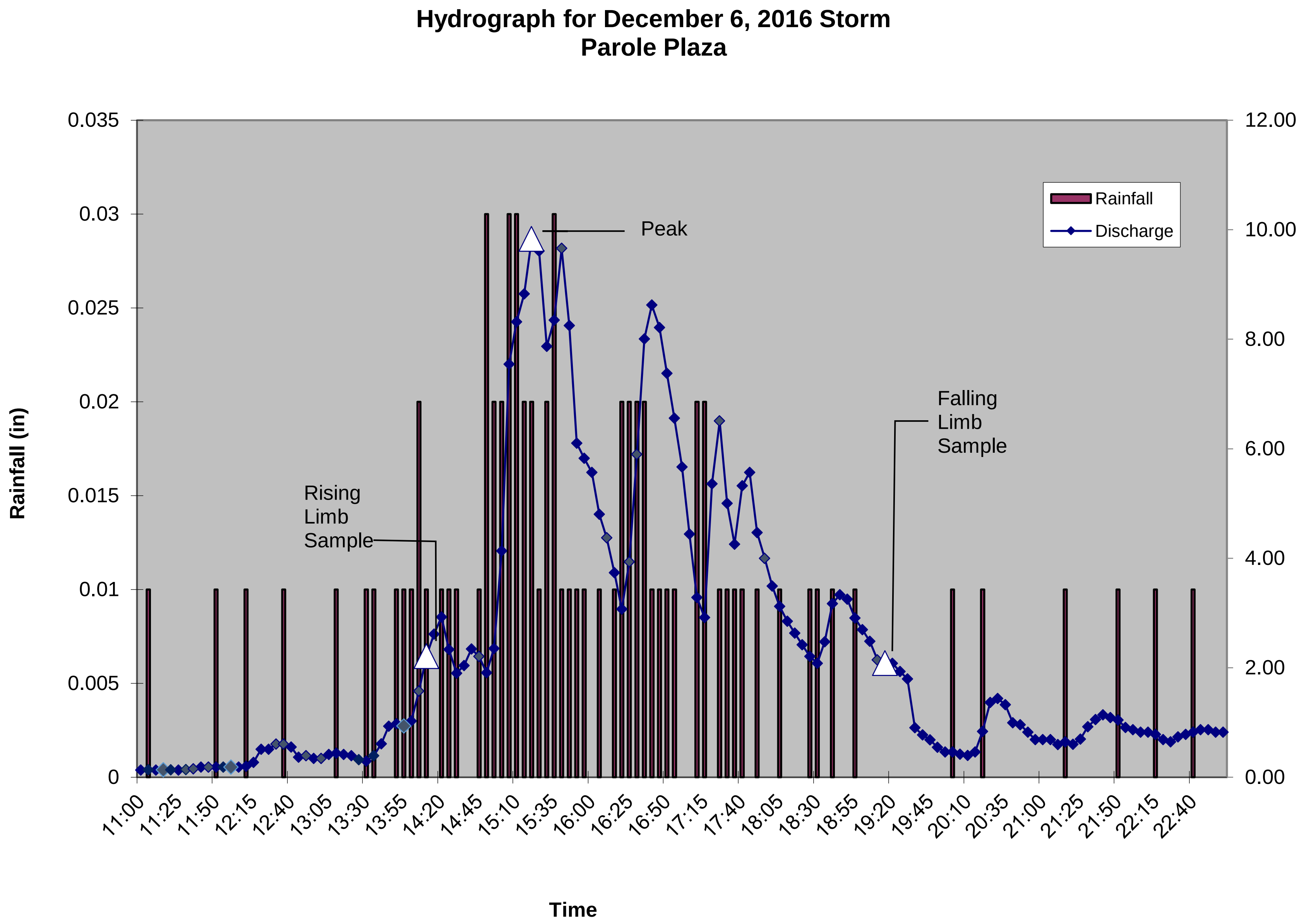
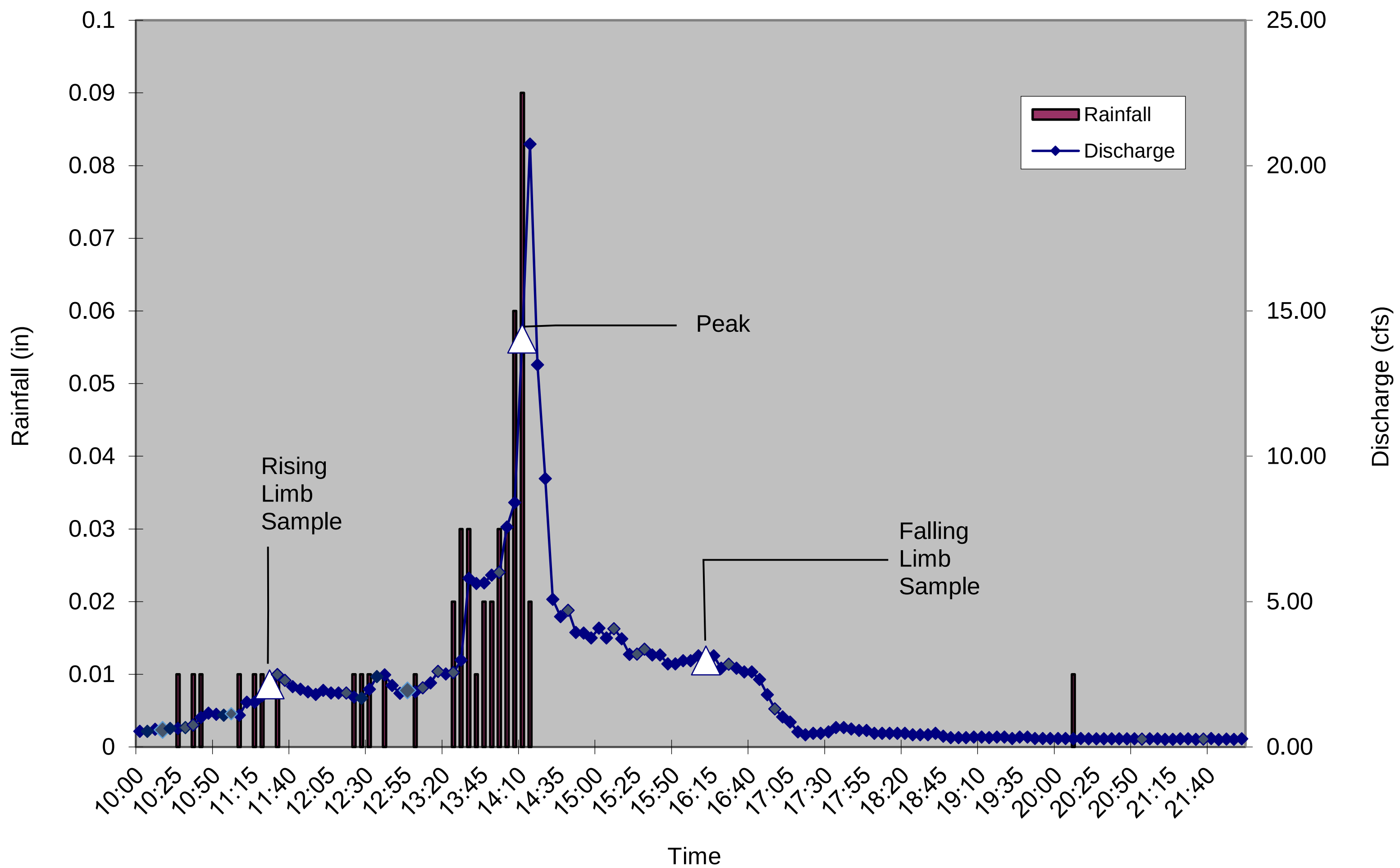
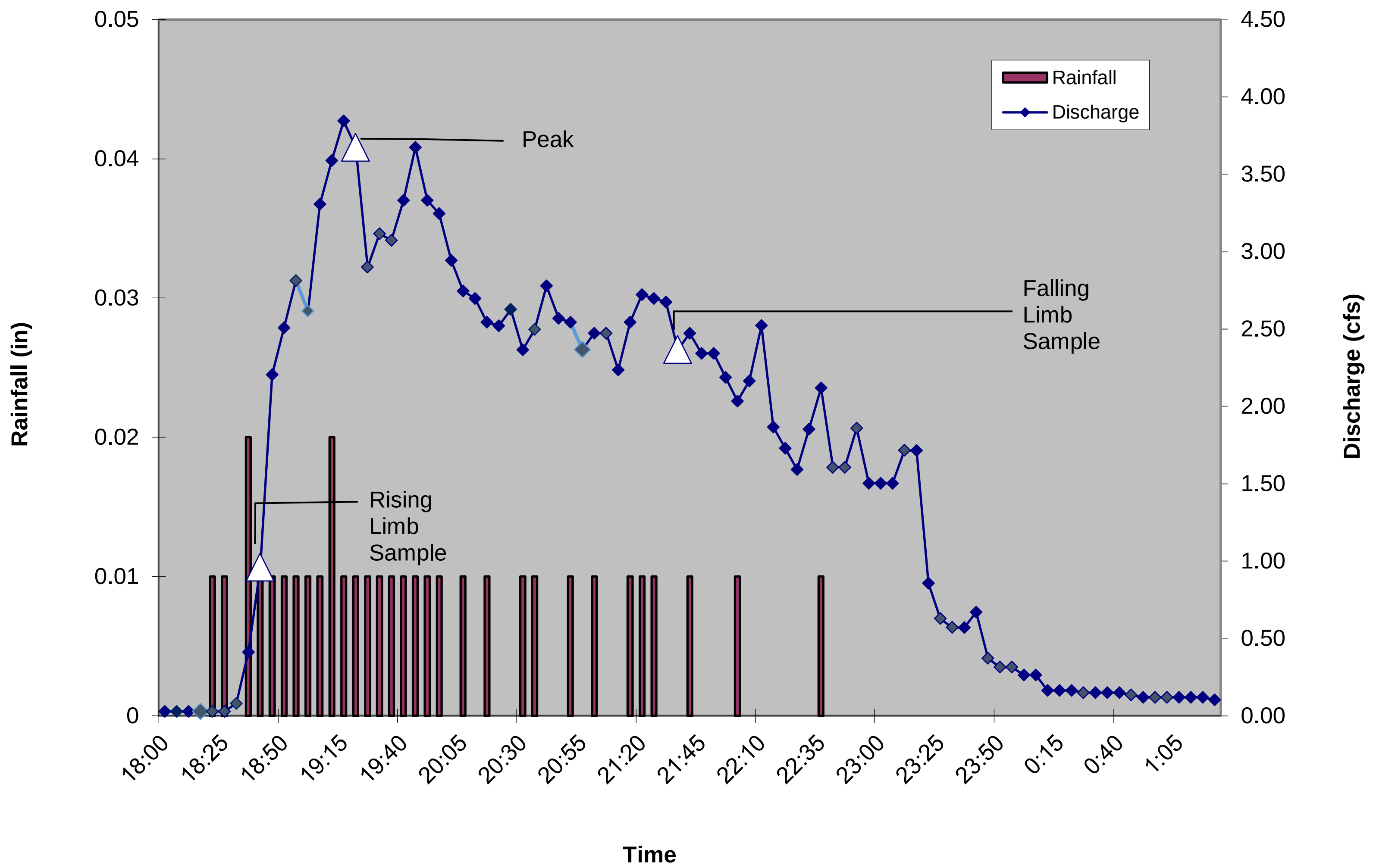
10:50
11:15
11:40
12:05

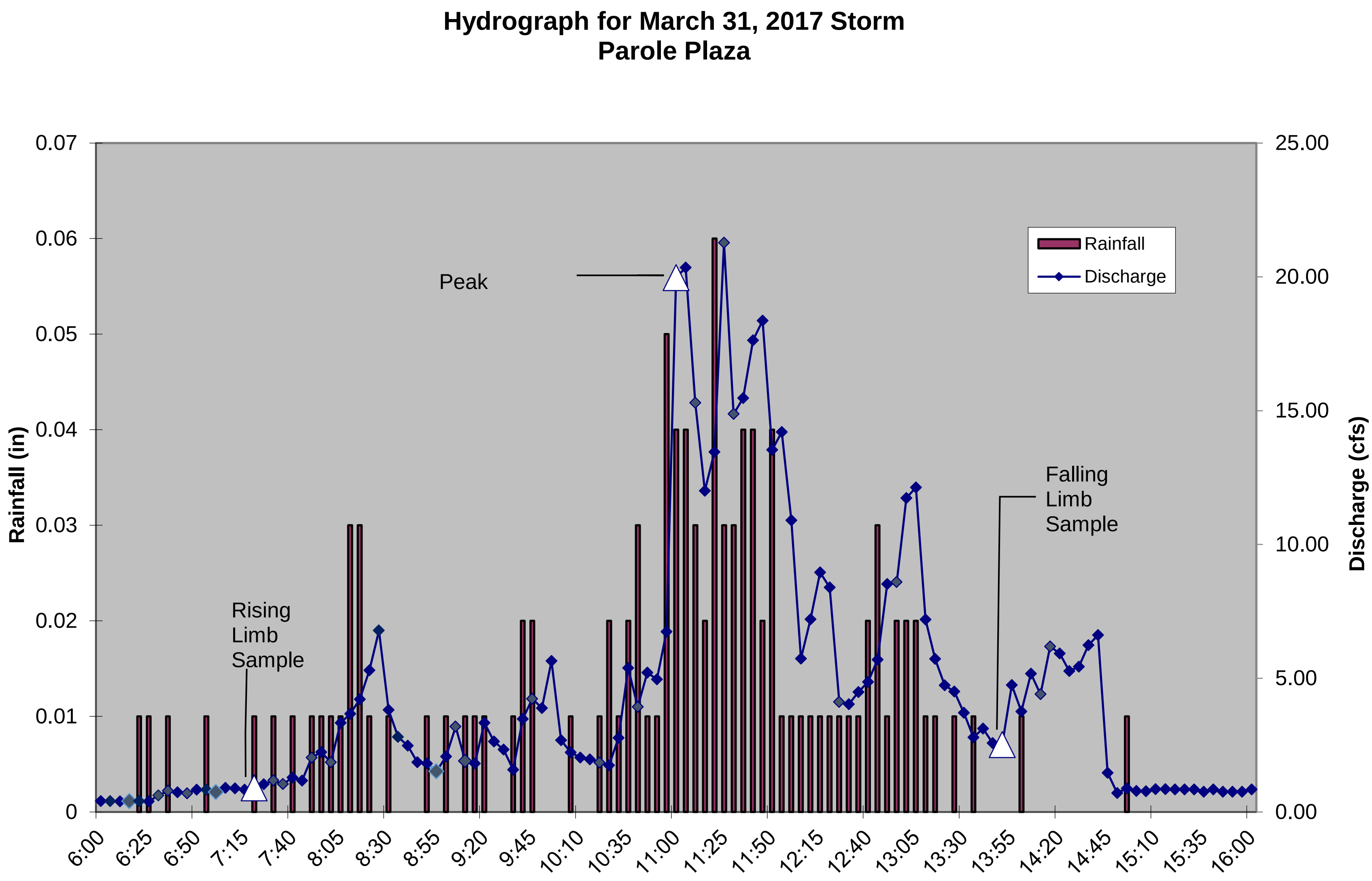

Hydrograph for December 6, 2016 Storm
Parole Plaza
Rainfall (in)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Rainfall
Discharge
Peak
Rising Limb Sample
Falling Limb Sample
11:00
11:25
11:50
12:15
12:40
13:05
13:30
13:55
14:20
14:45
15:10
15:35
16:00
16:25
16:50
17:15
17:40
18:05
18:30
18:55
19:20
19:45
20:10
20:35
21:00
21:25
21:50
22:15
22:40
Time

Hydrograph for January 23, 2017 Storm
Parole Plaza



Hydrograph for February 28, 2017 Storm
Parole Plaza





Hydrograph for March 31, 2017 Storm
Parole Plaza
Rainfall (in)
Discharge (cfs)
Rainfall
Discharge
Peak
Rising
Limb
Sample
Falling
Limb
Sample
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
25.00
20.00
15.00
10.00
5.00
0.00
6:00
6:25
6:50
7:15
7:40
8:05
8:30
8:55
9:20
9:45
10:10
10:35
11:00
11:25
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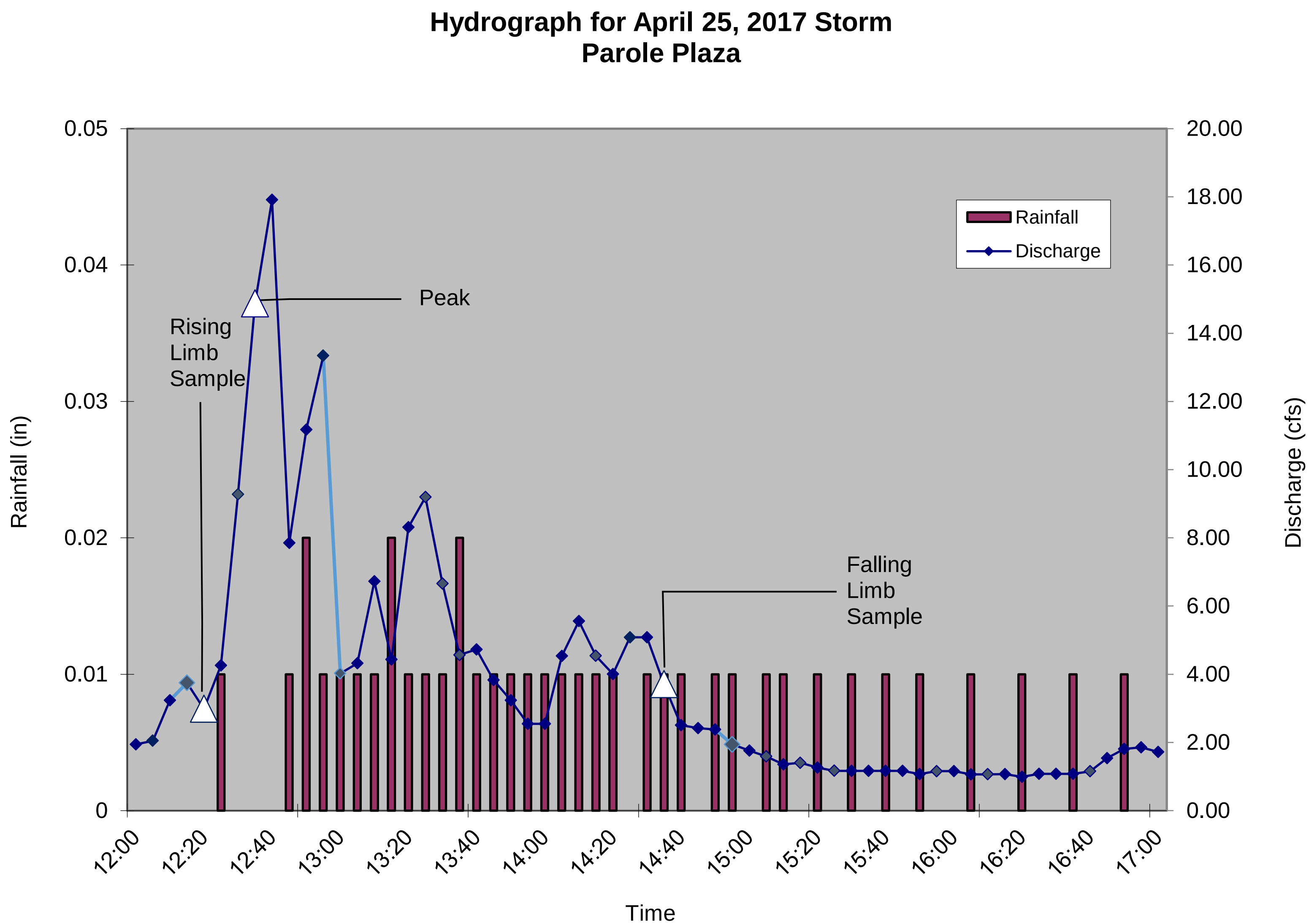
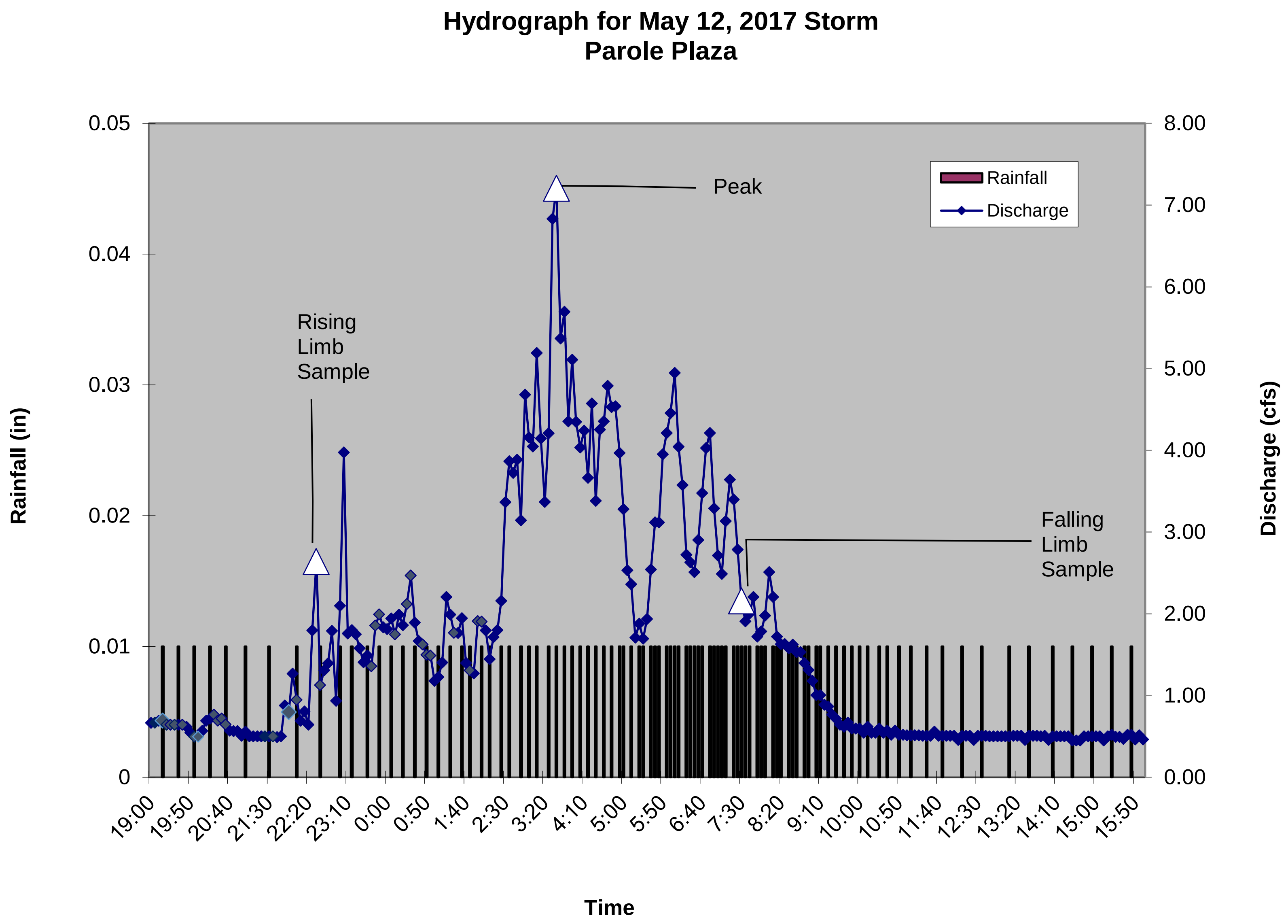
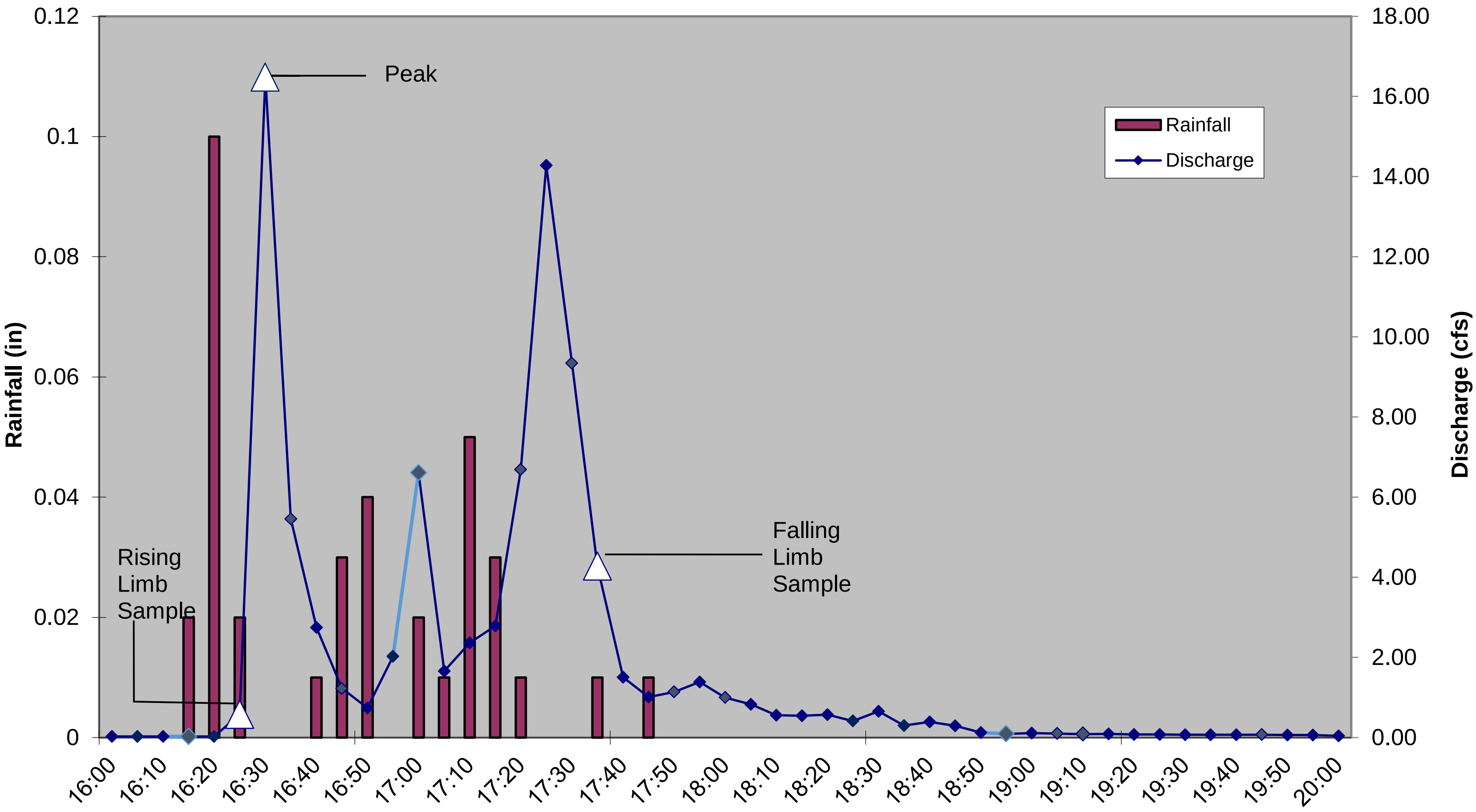
15:35
16:00

A-20


Hydrograph for April 25, 2017 Storm
Parole Plaza
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Peak
Rising
Limb
Sample
Falling
Limb
Sample
0.05
0.04
0.03
0.02
0.01
0
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
12:00
12:20
12:40
13:00
13:20
13:40
14:00
14:20
14:40
15:00
15:20
15:40
16:00
16:20
16:40
17:00

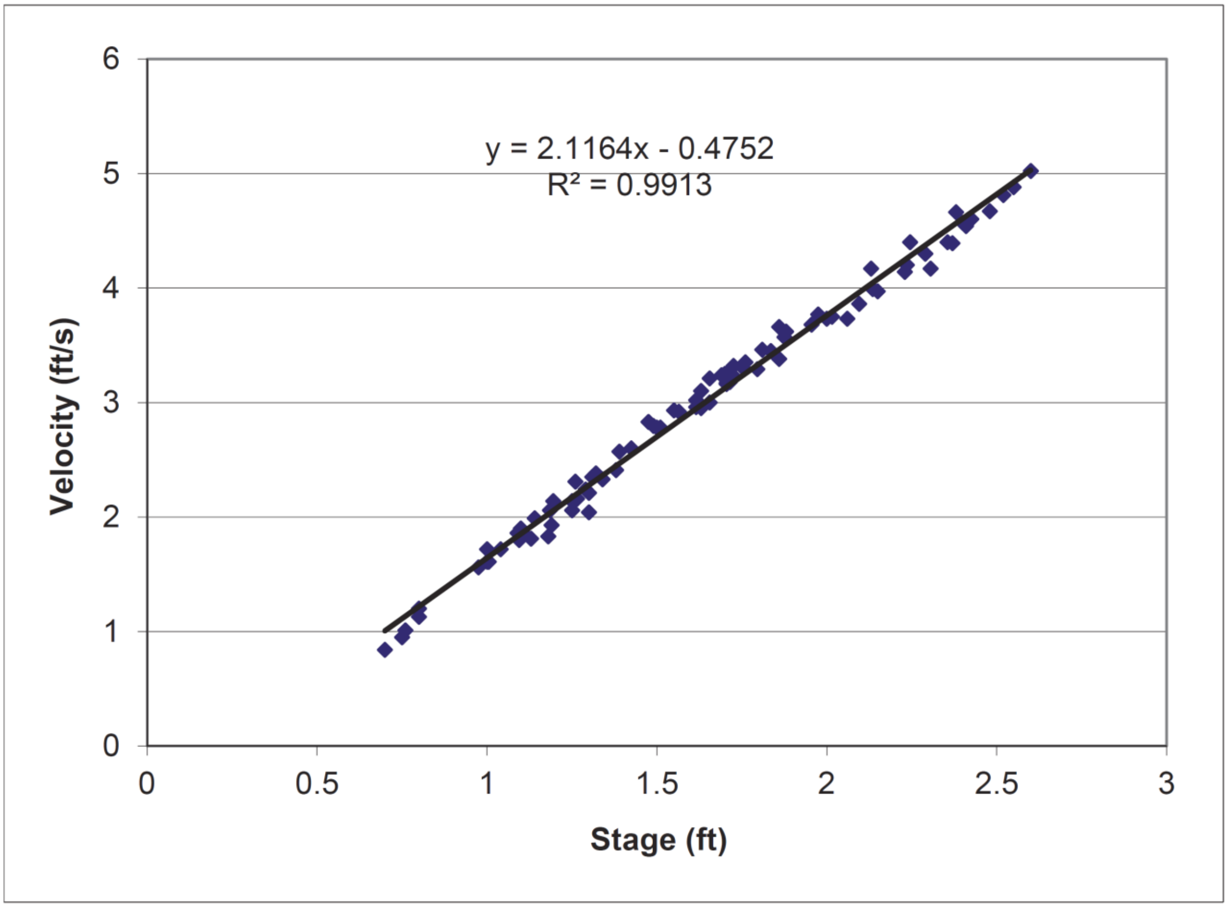

Hydrograph for May 12, 2017 Storm
Parole Plaza
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Peak
Rising Limb Sample
Falling Limb Sample
0.05
0.04
0.03
0.02
0.01
0
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
19:00
19:50
20:40
21:30
22:20
23:10
0:00
0:50
1:40
2:30
3:20
4:10
5:00
5:50
6:40
7:30
8:20
9:10
10:00
10:50
11:40
12:30
13:20
14:10
15:00
15:50

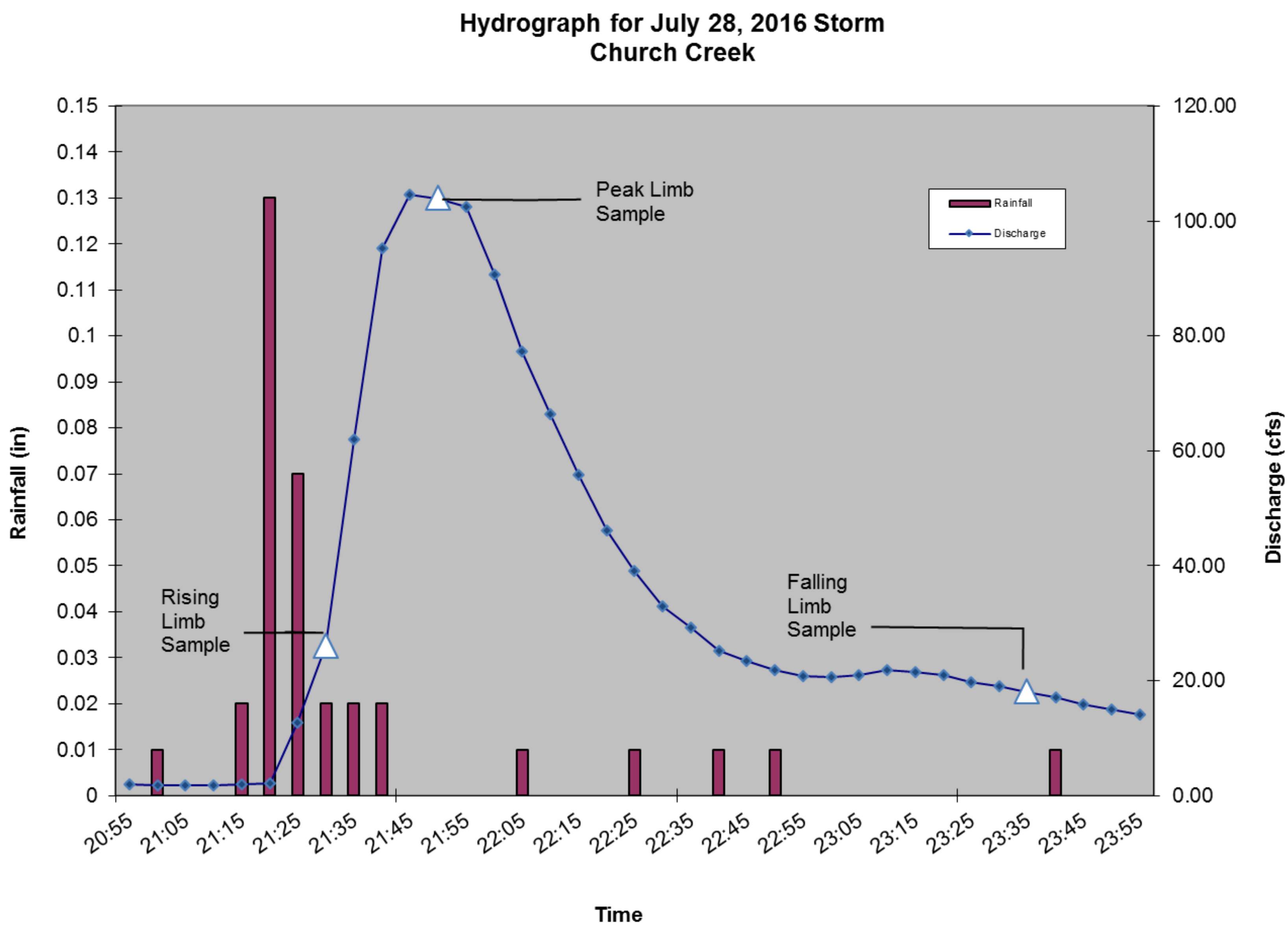
Hydrograph for June 19, 2017 Storm
Parole Plaza



Church Creek Discharge Rating Table

Stage (ft)	Flow Area (ft²)	Wetted Perimeter (ft)	Top Width (ft)	Velocity, (ft/s)	Discharge (cfs)
0.0	0	0	0	0.00	0.00
0.1	0.21	2.77	2.75	0.00	0.00
0.2	0.53	3.62	3.57	0.00	0.00
0.3	0.91	4.03	3.93	0.16	0.15
0.4	1.31	4.36	4.19	0.37	0.49
0.5	1.75	4.83	4.58	0.58	1.02
0.6	2.22	5.09	4.73	0.79	1.76
0.7	2.70	5.34	4.88	1.01	2.72
0.8	3.20	5.73	5.20	1.22	3.90
0.9	3.74	6.14	5.54	1.43	5.35
1.0	4.31	6.48	5.81	1.64	7.07
1.1	4.90	6.75	5.98	1.85	9.08
1.2	5.50	7.01	6.16	2.06	11.35
1.3	6.13	7.28	6.33	2.28	13.95
1.4	6.77	7.53	6.49	2.49	16.84
1.5	7.43	7.80	6.66	2.70	20.06
1.6	8.10	8.08	6.86	2.91	23.58
1.7	8.80	8.37	7.06	3.12	27.48
1.8	9.51	8.65	7.26	3.33	31.71
1.9	10.25	8.93	7.44	3.55	36.35
2.0	11.00	9.15	7.52	3.76	41.33
2.1	11.75	9.35	7.54	3.97	46.64
2.2	12.51	9.55	7.57	4.18	52.30
2.3	13.26	9.75	7.60	4.39	58.24
2.4	14.03	9.96	7.63	4.60	64.60
2.5	14.79	10.16	7.65	4.82	71.23
2.6	15.56	10.36	7.68	5.03	78.23
2.7	16.33	10.56	7.71	5.24	85.55
2.8	17.10	10.76	7.73	5.45	93.21
2.9	17.87	10.96	7.76	5.66	101.19
3.0	18.65	11.17	7.79	5.87	109.55
3.1	19.43	11.37	7.81	6.09	118.24
3.2	20.21	11.57	7.84	6.30	127.27
3.3	21.00	11.77	7.87	6.51	136.69
3.4	21.79	11.97	7.89	6.72	146.44
3.5	22.58	12.18	7.92	6.93	156.53
3.6	23.37	12.38	7.95	7.14	166.95
3.7	24.17	12.58	7.98	7.36	177.78


y = 2.1164x - 0.4752
R² = 0.9913
Velocity (ft/s)
Stage (ft)
0
1
2
3
4
5
6
0
0.5
1
1.5
2
2.5
3



Hydrograph for July 28, 2016 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
120.00
100.00
80.00
60.00
40.00
20.00
0.00
20:55
21:05
21:15
21:25
21:35
21:45
21:55
22:05
22:15
22:25
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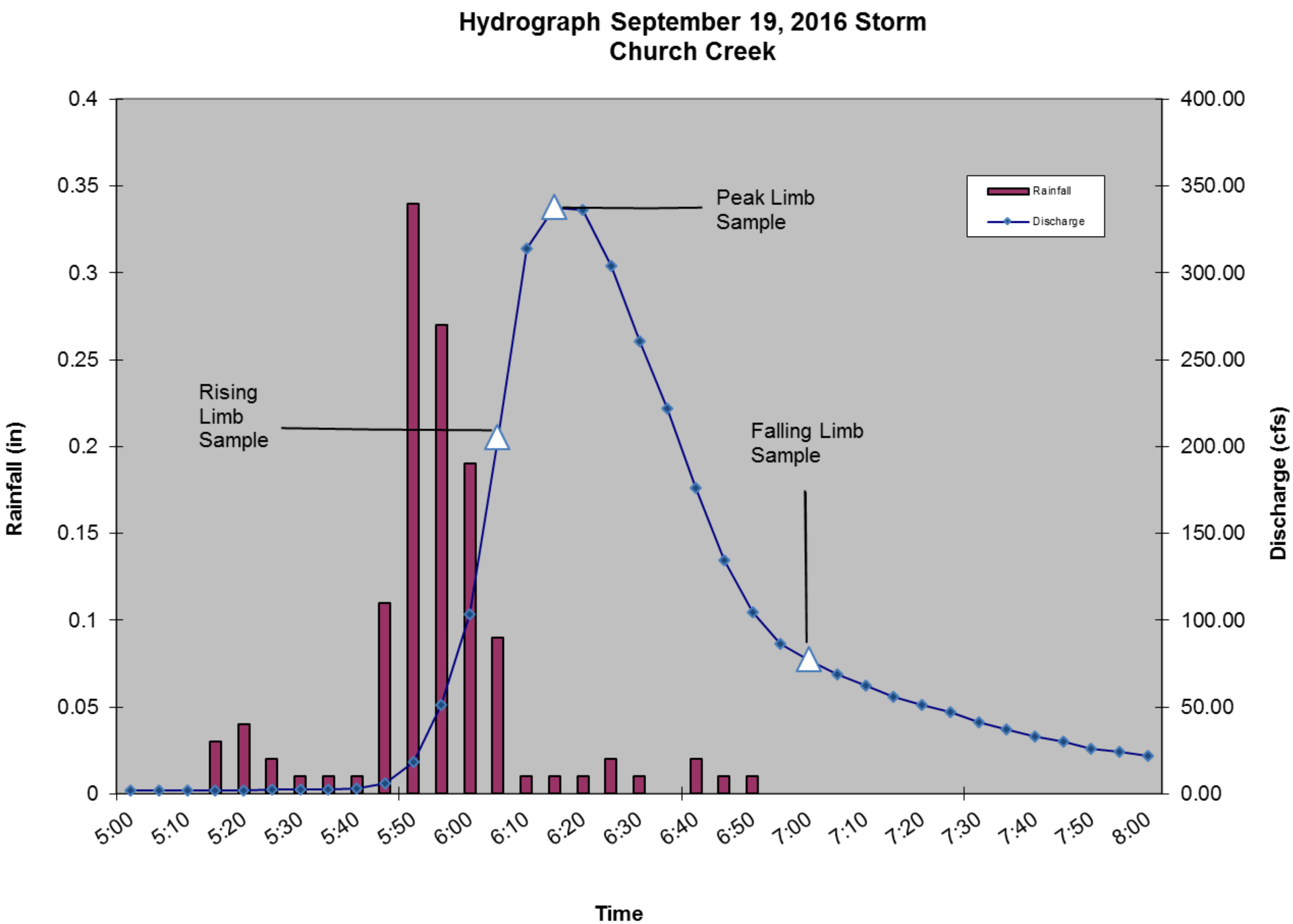
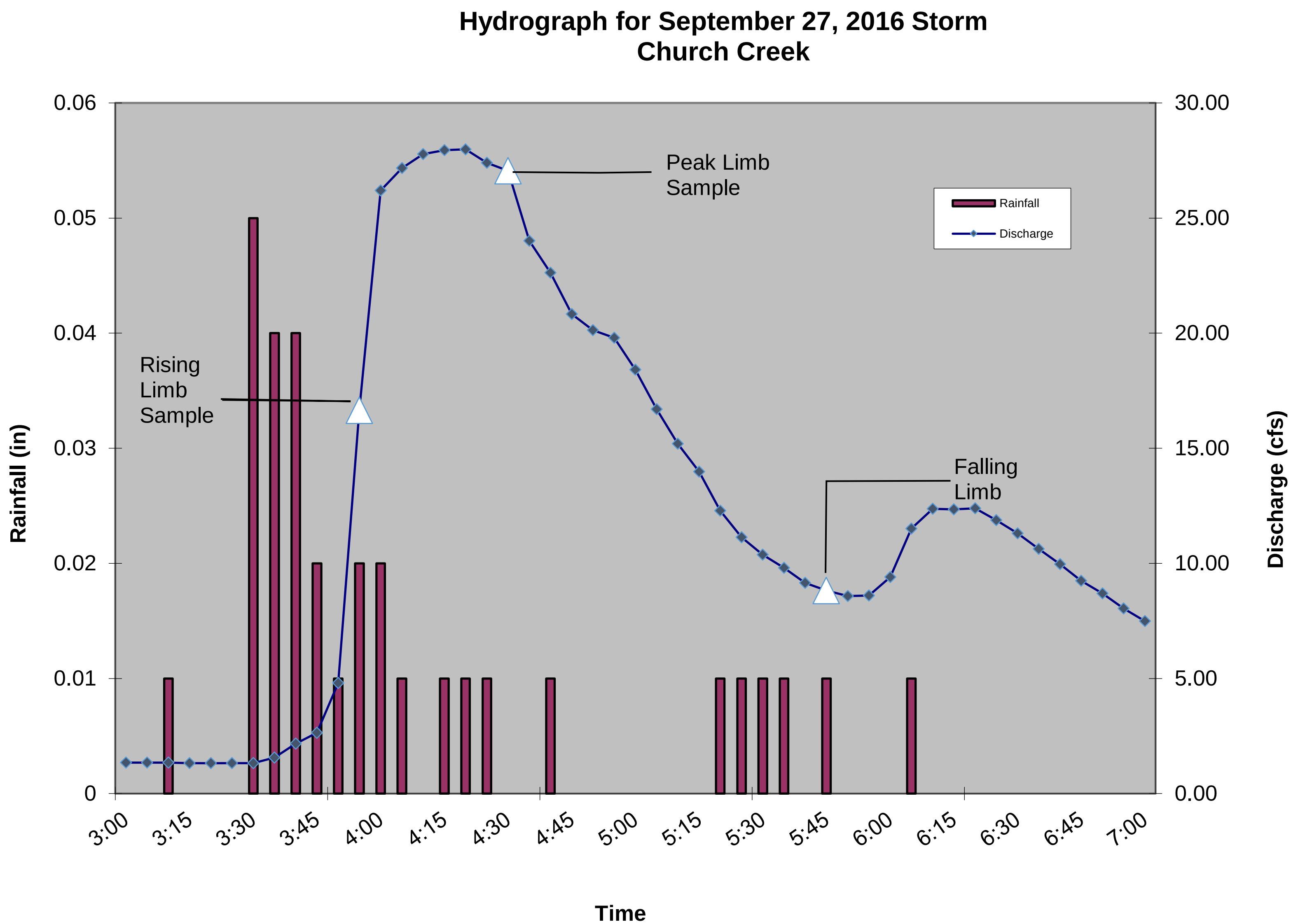
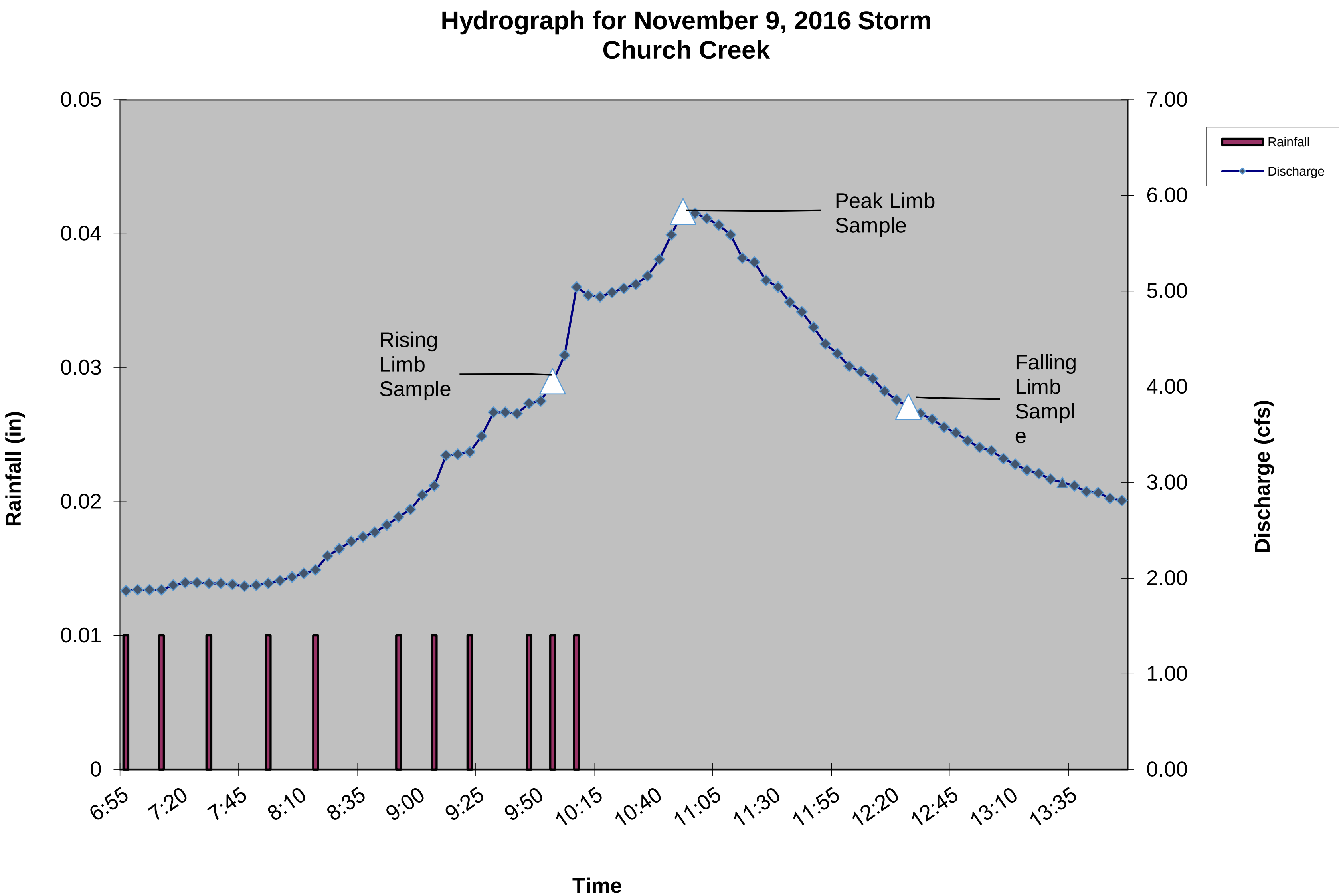
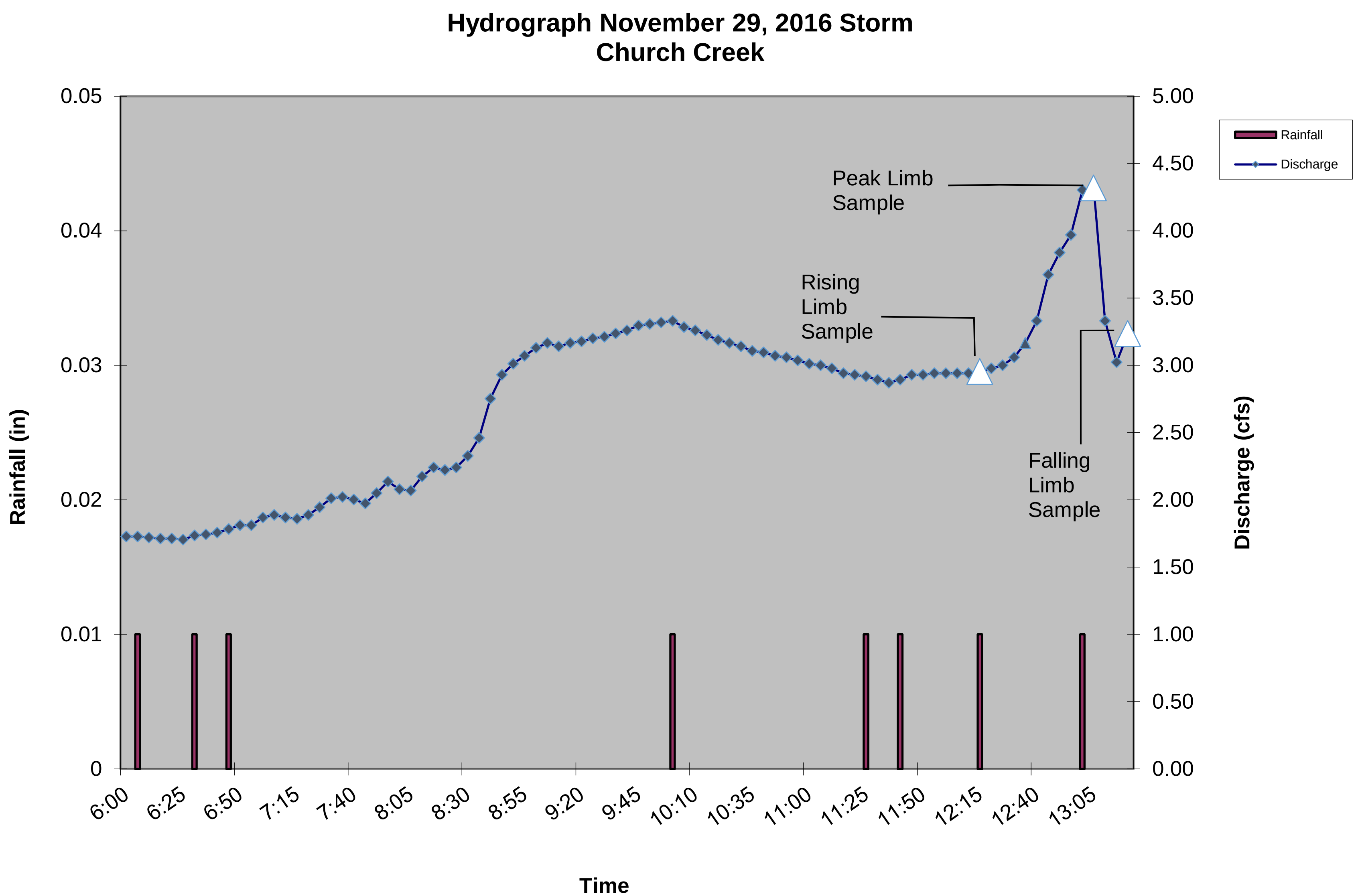
23:35
23:45
23:55



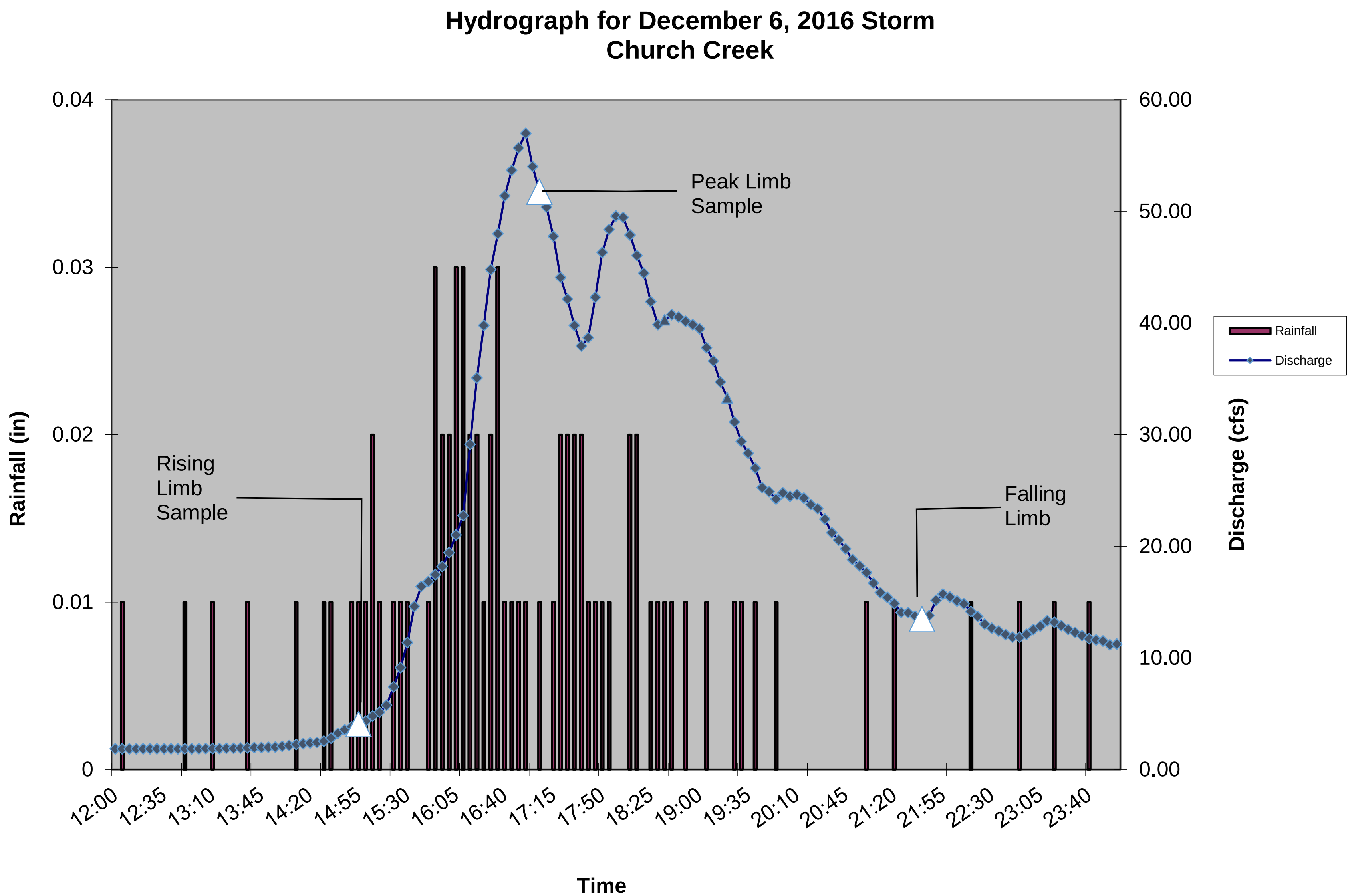
Hydrograph September 19, 2016 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
5:00
5:10
5:20
5:30
5:40
5:50
6:00
6:10
6:20
6:30
6:40
6:50
7:00
7:10
7:20
7:30
7:40
7:50
8:00
Rainfall
Discharge
Rising Limb Sample
Peak Limb Sample
Falling Limb Sample


Hydrograph for September 27, 2016 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
0.06
0.05
0.04
0.03
0.02
0.01
0
30.00
25.00
20.00
15.00
10.00
5.00
0.00
3:00
3:15
3:30
3:45
4:00
4:15
4:30
4:45
5:00
5:15
5:30
5:45
6:00
6:15
6:30
6:45
7:00
Rising Limb Sample
Peak Limb Sample
Falling Limb
Rainfall
Discharge

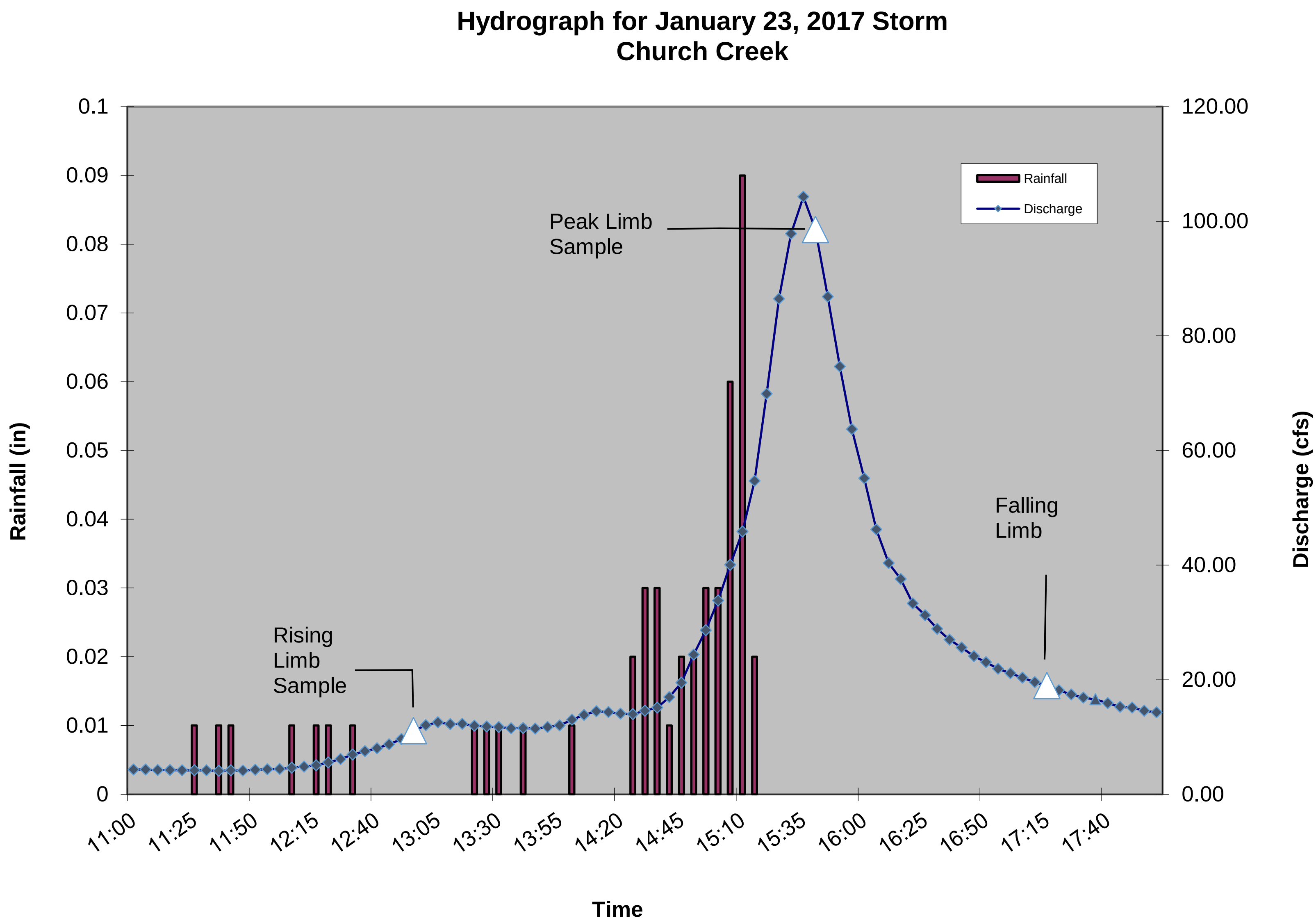

Hydrograph for November 9, 2016 Storm
Church Creek
Rainfall
Discharge
Rising Limb Sample
Peak Limb Sample
Falling Limb Sampl e
Rainfall (in)
Discharge (cfs)
Time
0.05
0.04
0.03
0.02
0.01
0
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
6:55
7:20
7:45
8:10
8:35
9:00
9:25
9:50
10:15
10:40
11:05
11:30
11:55
12:20
12:45
13:10
13:35

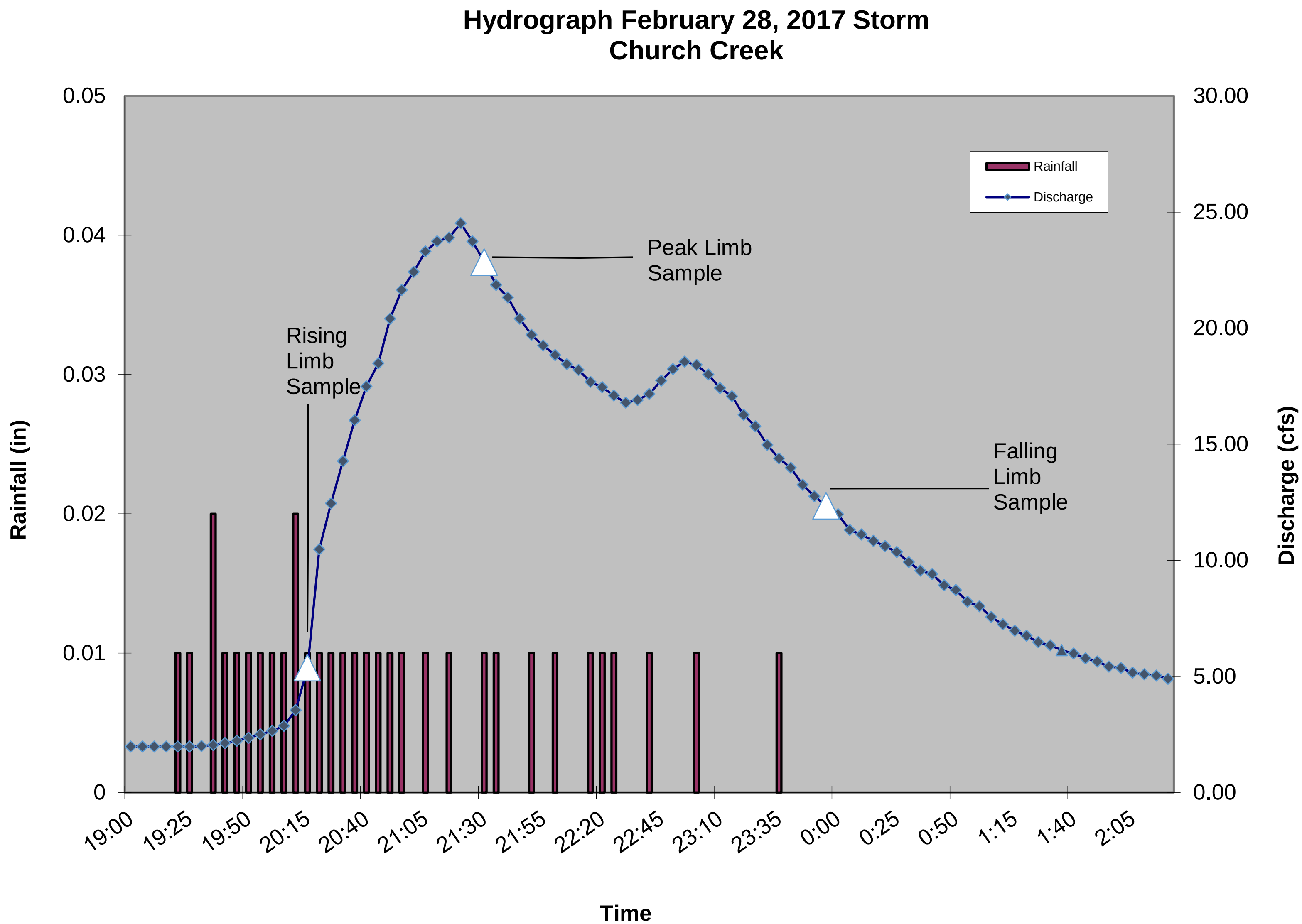


Hydrograph November 29, 2016 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
0.05
0.04
0.03
0.02
0.01
0
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
6:00
6:25
6:50
7:15
7:40
8:05
8:30
8:55
9:20
9:45
10:10
10:35
11:00
11:25
11:50
12:15
12:40
13:05

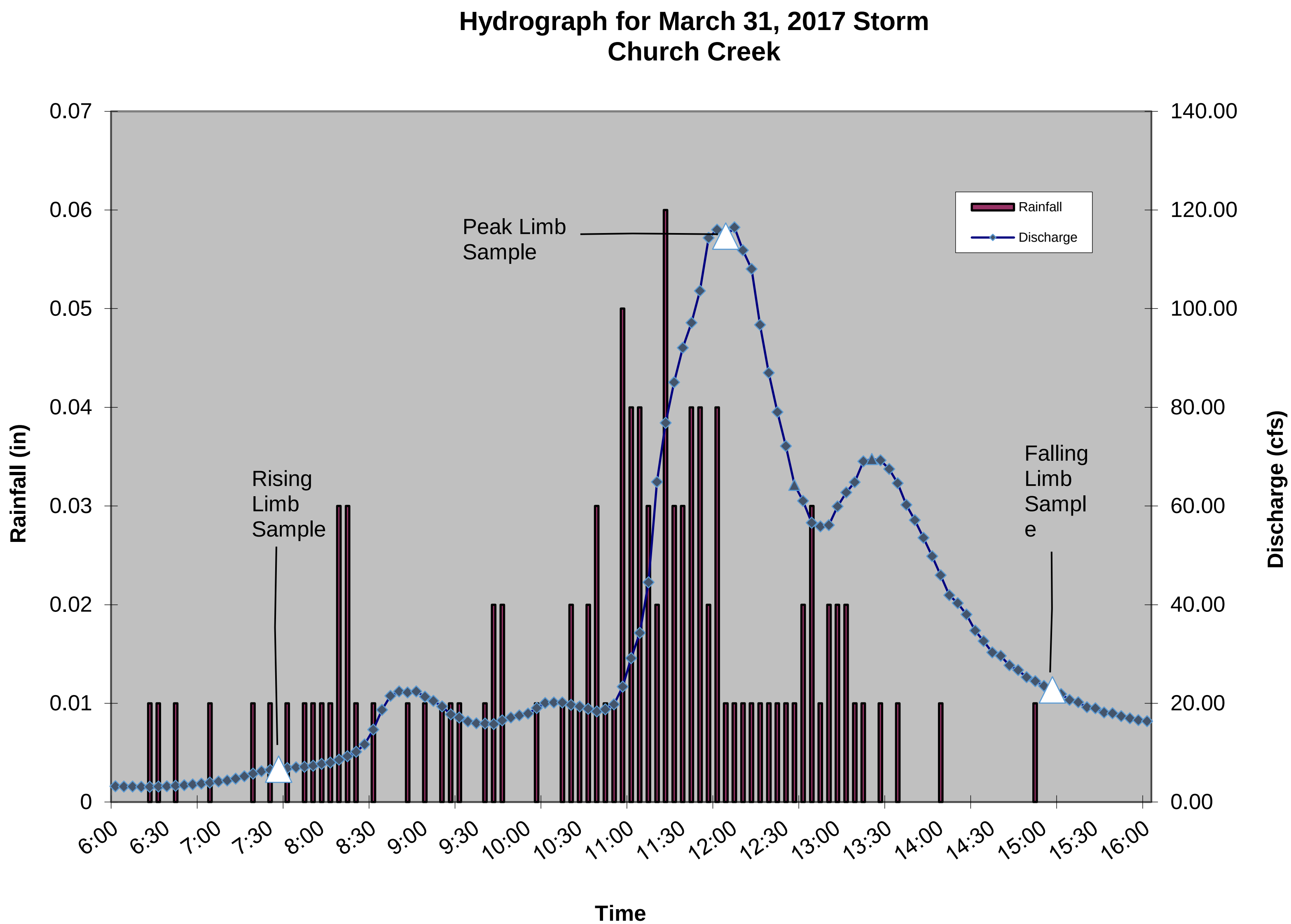


Hydrograph for December 6, 2016 Storm
Church Creek
0.04
0.03
0.02
0.01
0
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Rainfall (in)
Discharge (cfs)
Rising Limb Sample
Peak Limb Sample
Falling Limb
Rainfall
Discharge
12:00
12:35
13:10
13:45
14:20
14:55
15:30
16:05
16:40
17:15
17:50
18:25
19:00
19:35
20:10
20:45
21:20
21:55
22:30
23:05
23:40
Time

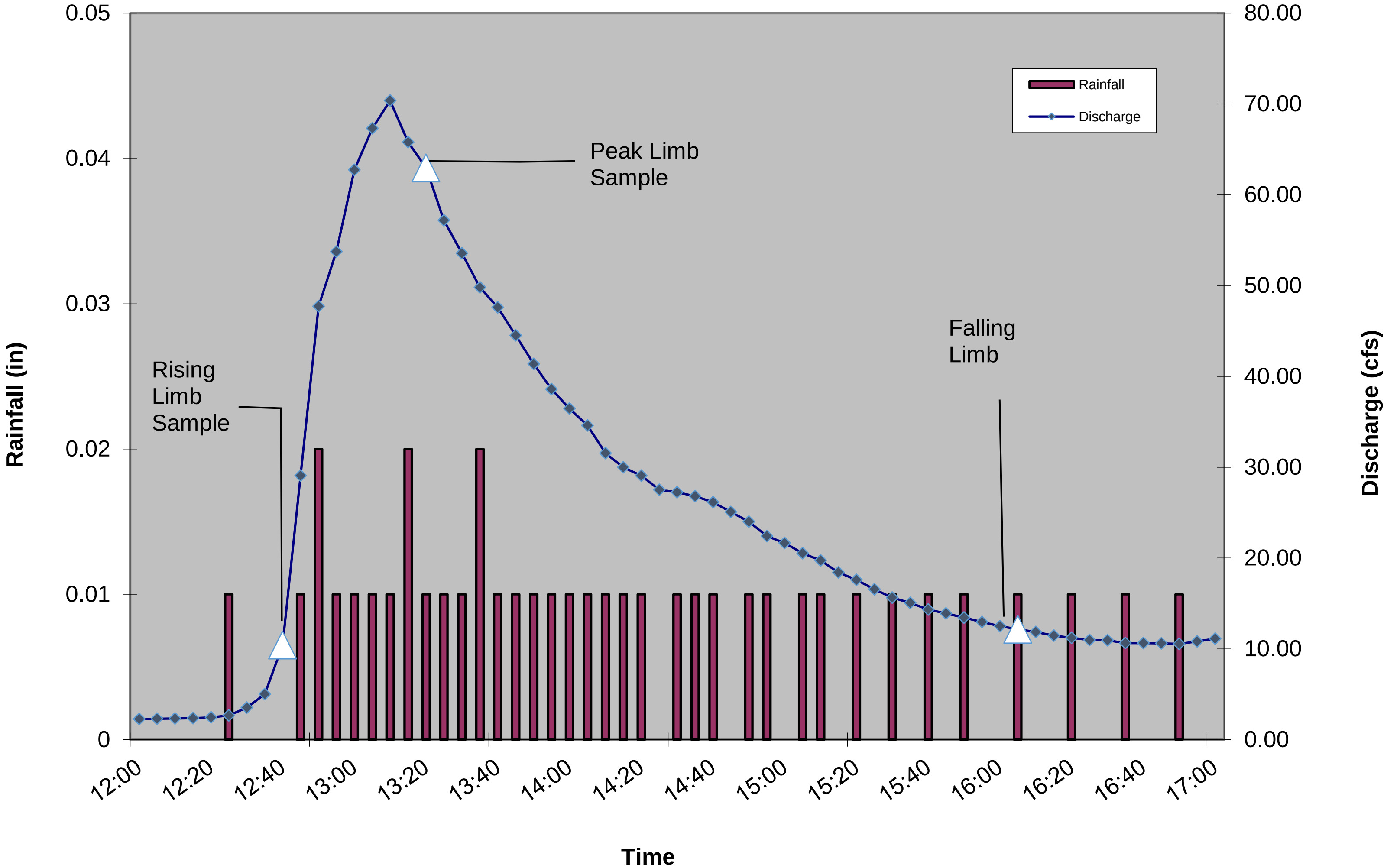

Hydrograph for January 23, 2017 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
120.00
100.00
80.00
60.00
40.00
20.00
0.00
11:00
11:25
11:50
12:15
12:40
13:05
13:30
13:55
14:20
14:45
15:10
15:35
16:00
16:25
16:50
17:15
17:40
Rainfall
Discharge
Peak Limb Sample
Rising Limb Sample
Falling Limb

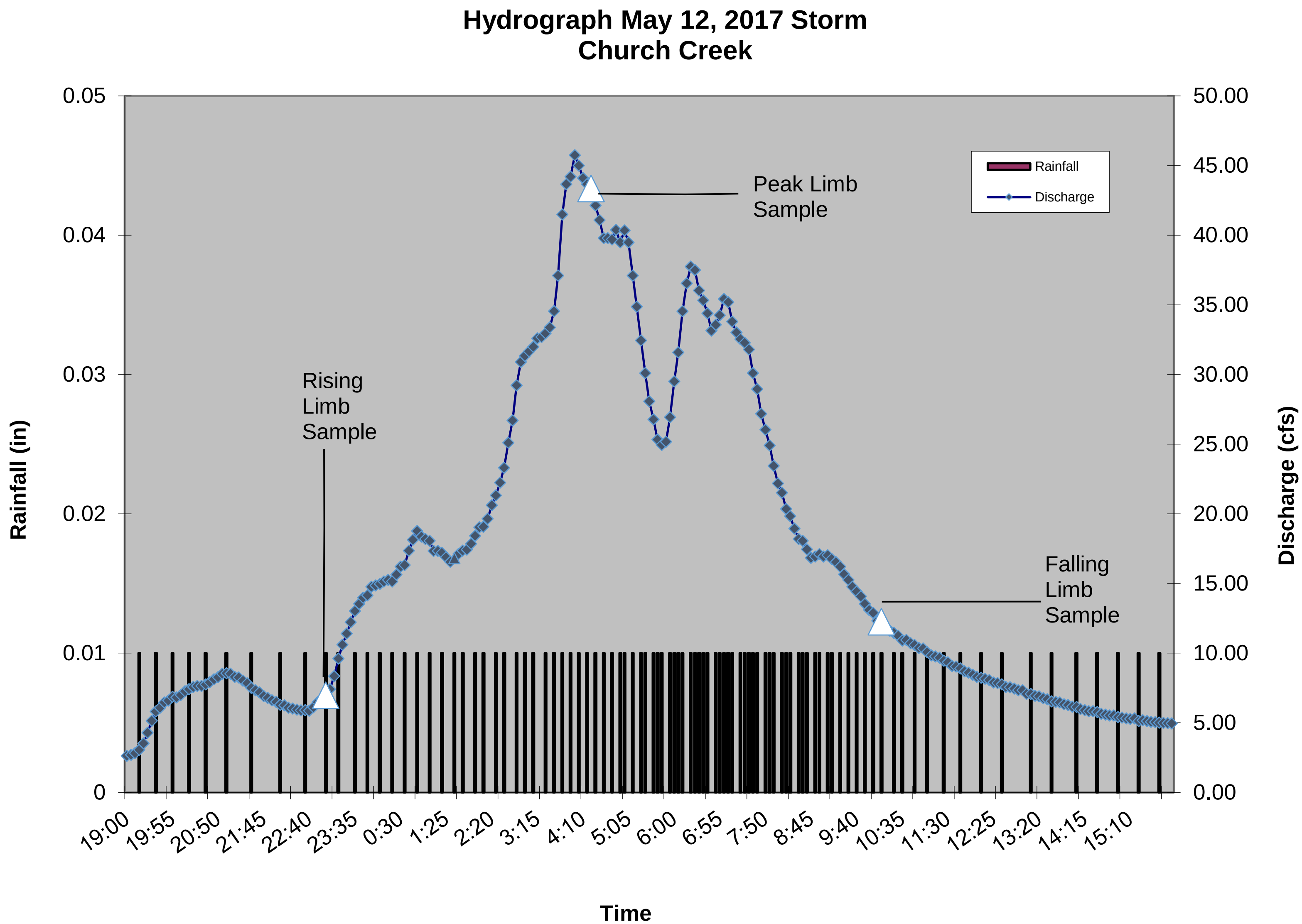


Hydrograph February 28, 2017 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
0.05
0.04
0.03
0.02
0.01
0
30.00
25.00
20.00
15.00
10.00
5.00
0.00
19:00
19:25
19:50
20:15
20:40
21:05
21:30
21:55
22:20
22:45
23:10
23:35
0:00
0:25
0:50
1:15
1:40
2:05

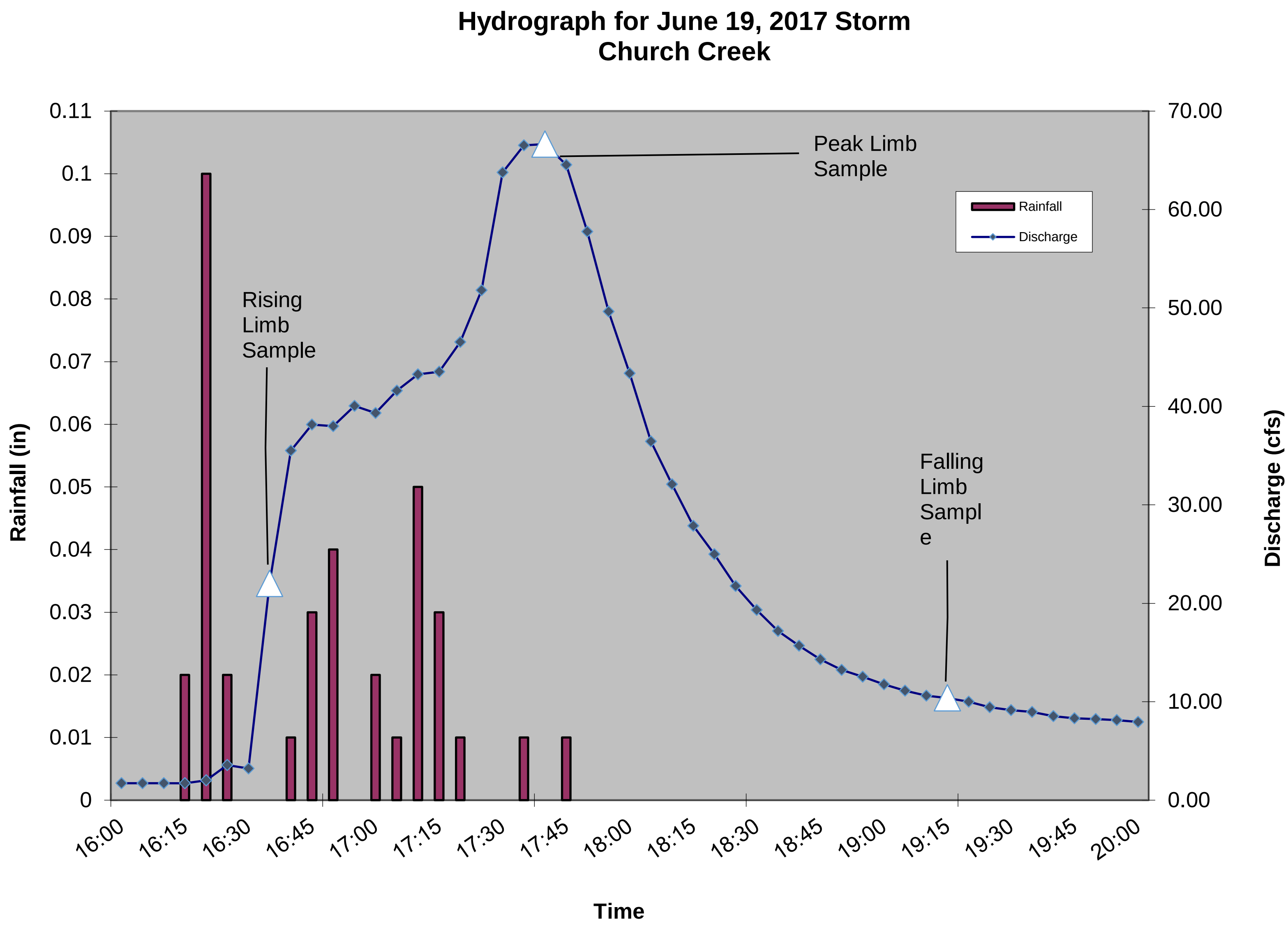

Hydrograph for March 31, 2017 Storm
Church Creek
Rainfall
Discharge
Peak Limb
Sample
Rising
Limb
Sample
Falling
Limb
Sampl
e
Rainfall (in)
Discharge (cfs)
Time
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
6:00
6:30
7:00
7:30
8:00
8:30
9:00
9:30
10:00
10:30
11:00
11:30
12:00
12:30
13:00
13:30
14:00
14:30
15:00
15:30
16:00

Hydrograph for April 25, 2017 Storm
Church Creek





Hydrograph May 12, 2017 Storm
Church Creek
Rainfall (in)
0.05
0.04
0.03
0.02
0.01
0
Discharge (cfs)
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Rainfall
Discharge
Peak Limb
Sample
Rising
Limb
Sample
Falling
Limb
Sample
19:00
19:55
20:50
21:45
22:40
23:35
0:30
1:25
2:20
3:15
4:10
5:05
6:00
6:55
7:50
8:45
9:40
10:35
11:30
12:25
13:20
14:15
15:10
Time


Hydrograph for June 19, 2017 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rising
Limb
Sample
Peak Limb
Sample
Falling
Limb
Sampl
e
Rainfall
Discharge
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
16:00
16:15
16:30
16:45
17:00
17:15
17:30
17:45
18:00
18:15
18:30
18:45
19:00
19:15
19:30
19:45
20:00

APPENDIX B

MASTER TAXA LIST

Order	Family	Genus	Taxon	FFG[(a)]	Habit[(b)]	Tolerance Value[(c)]
Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	Collector	sp	6.7
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7
Arhynchobdellida	Erpobdellidae		Erpobdellidae	Predator	sp	10
Basommatophora	Ancylidae	Ferrissia	Ferrissia	Scraper	cb	7
Basommatophora	Lymnaeidae	Fossaria	Fossaria	Scraper	cb	6.9
Basommatophora	Lymnaeidae	Pseudosuccinea	Pseudosuccinea	Collector	cb	6.3
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7
Diptera	Chironomidae	Chironomini	Chironomini			5.9
Diptera	Chironomidae	Chironomus	Chironomus	Collector	bu	4.6
Diptera	Chironomidae	Conchapelopia	Conchapelopia	Predator	sp	6.1
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6
Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	Collector	bu	9
Diptera	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3
Diptera	Chironomidae	Potthastia	Potthastia	Collector	sp	0
Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	Collector	sp	6.2
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9
Diptera	Psychodidae		Psychodidae			4
Diptera	Psychodidae	Psychoda	Psychoda	Collector	bu	4
Diptera	Sciomyzidae		Sciomyzidae	Predator	bu	6
Diptera	Simuliidae		Simuliidae	Filterer	cn	3.2
Diptera	Tipulidae	Tipula	Tipula	Shredder	bu	6.7
Haplotaxida	Enchytraeidae		Enchytraeidae	Collector	bu	9.1
Haplotaxida	Naididae		Naididae	Collector	bu	8.5
Hoplonemertea	Tetrastemmatidae	Prostoma	Prostoma	Predator		7.3
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6
Lumbricida	Lumbricidae		Lumbricidae	Collector		10
Lumbriculida	Lumbriculidae		Lumbriculidae	Collector	bu	6.6
Odonata	Aeshnidae	Boyeria	Boyeria	Predator	cb, sp	6.3
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3
Odonata	Coenagrionidae	Argia	Argia	Predator	cn, cb, sp	9.3
Odonata	Coenagrionidae	Ischnura	Ischnura	Predator	cb	9
Rhynchobdellida	Glossiphoniidae	Helobdella	Helobdella	Predator	sp	6
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5
Tricladida	Dugesiidae	Girardia	Girardia	Predator	sp	9.3
Tubificida	Tubificidae		Tubificidae	Collector	cn	8.4
Tubificida	Tubificidae	Limnodrilus	Limnodrilus	Collector	cn	8.6
Veneroida	Pisidiidae		Sphaeriidae	Filterer	bu	6.5
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7

[(a)] Functional Feeding Group
[(b)] Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer
Some information for the particular taxa was not available.
[(c)] Tolerance Values, based on Hilsenhoff, modified for Maryland

APPENDIX C

BIOLOGICAL ASSESSMENT RESULTS

Church Creek Site CC-01

Sampled: 4/12/2017

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Poor
BIBI Score	2.14

Metric	Value	Score
Total Taxa	10	1
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	0	1
% Ephemeroptera	0	1
Scraper Taxa	2	5
% Climbers	64.35	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	9
Boyeria	3
Enchytraeidae	3
Fossaria	1
Limnodrilus	2
Naididae	13
Physa	61
Prostoma	5
Psychodidae	1
Sciomyzidae	4
Tubificidae	13

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	67.41

Metric	Score
Drainage area (acres)	70.40
Remoteness	18.60
Percent Shading	68.32
Epifaunal Substrate	69.16
Instream Habitat	92.64
Instream Wood Debris	100.00
Bank Stability	55.74

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	74

Metric	Score
Epifaunal Substrate / Cover	11
Embeddedness	11
Velocity / Depth Regime	10
Sediment Deposition	13
Channel Flow Status	8
Channel Alteration	19
Frequency of Riffles	16
Bank Stability	5(Left)/4(Right)
Vegetative Protection	7(Left)/5(Right)
Riparian Veg Zone Width	9(Left)/6(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	13.86
pH	6.29
Specific Conductance (µS/cm)	2319
Temperature (°C)	17.6
Turbidity (NTUs)	17.5

Church Creek Site CC-02

Sampled: 4/12/2017

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Poor
BIBI Score	2.14

Metric	Value	Score
Total Taxa	21	3
EPT Taxa	1	1
Number Ephemeroptera	0	1
% Intolerant to Urban	1.63	1
% Ephemeroptera	0	1
Scraper Taxa	1	3
% Climbers	11.38	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	3
Caecidotea	1
Calopteryx	2
Cheumatopsyche	1
Chironomus	1
Conchapelopia	1
Crangonyx	1
Cricotopus	13
Cricotopus	5
Dicrotendipes	2
Gammarus	53
Girardia	1
Hemerodromia	1
Ischnura	1
Lumbriculidae	5
Naididae	10
Physa	1
Pisidium	3
Polypedilum	5
Polypedilum	2
Potthastia	1
Rheocricotopus	1
Sphaeriidae	1
Tubificidae	8

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Degraded
PHI Score	60.97

Metric	Score
Drainage area (acres)	282.24
Remoteness	23.05
Percent Shading	68.32
Epifaunal Substrate	48.50
Instream Habitat	78.42
Instream Wood Debris	87.41
Bank Stability	60.10

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	61

Metric	Score
Epifaunal Substrate / Cover	10
Embeddedness	8
Velocity / Depth Regime	9
Sediment Deposition	11
Channel Flow Status	11
Channel Alteration	13
Frequency of Riffles	10
Bank Stability	3(Left)/4(Right)
Vegetative Protection	5(Left)/4(Right)
Riparian Veg Zone Width	7(Left)/7(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	7.86
pH	7.04
Specific Conductance (µS/cm)	468
Temperature (°C)	15.4
Turbidity (NTUs)	16.2

Church Creek Site CC-03

Sampled: 4/17/2017

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Poor
BIBI Score	2.43

Metric	Value	Score
Total Taxa	18	3
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	0.78	1
% Ephemeroptera	0	1
Scraper Taxa	2	5
% Climbers	14.84	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	5
Caecidotea	1
Cricotopus	32
Cricotopus	9
Enchytraeidae	1
Erpobdellidae	4
Ferrissia	2
Gammarus	9
Helobdella	1
Hemerodromia	1
Ischnura	1
Limnodrilus	4
Naididae	29
Orthocladius	4
Orthocladius	2
Physa	8
Polypedilum	3
Prostoma	1
Psychoda	1
Simuliidae	1
Tubificidae	9

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	71.72

Metric	Score
Drainage area (acres)	282.24
Remoteness	20.96
Percent Shading	45.47
Epifaunal Substrate	100.00
Instream Habitat	100.00
Instream Wood Debris	93.33
Bank Stability	70.56

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	70

Metric	Score
Epifaunal Substrate / Cover	15
Embeddedness	11
Velocity / Depth Regime	12
Sediment Deposition	16
Channel Flow Status	15
Channel Alteration	12
Frequency of Riffles	6
Bank Stability	6(Left)/8(Right)
Vegetative Protection	5(Left)/4(Right)
Riparian Veg Zone Width	4(Left)/4(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	6.08
pH	6.67
Specific Conductance (µS/cm)	479
Temperature (°C)	17
Turbidity (NTUs)	15.7

Church Creek Site CC-04

Sampled: 4/12/2017

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.86

Metric	Value	Score
Total Taxa	16	3
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	5.04	1
% Ephemeroptera	0	1
Scraper Taxa	1	3
% Climbers	6.72	3

Benthic Macroinvertebrate Taxa List

Taxa	Count
Caecidotea	6
Chironomini	1
Chironomus	3
Conchapelopia	4
Conchapelopia	1
Cricotopus	4
Cricotopus	22
Erpobdellidae	2
Gammarus	3
Limnodrilus	5
Lumbricidae	1
Lumbriculidae	4
Naididae	30
Orthocladius	1
Physa	2
Pisidium	1
Polypedilum	4
Pseudosuccinea	2
Tipula	1
Tubificidae	22

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	67.92

Metric	Score
Drainage area (acres)	110.53
Remoteness	20.96
Percent Shading	40.96
Epifaunal Substrate	72.03
Instream Habitat	99.12
Instream Wood Debris	100.00
Bank Stability	74.42

Rapid Bioassessment Protocal

Narrative Rating	Supporting
RBP Score	78

Metric	Score
Epifaunal Substrate / Cover	13
Embeddedness	11
Velocity / Depth Regime	8
Sediment Deposition	8
Channel Flow Status	14
Channel Alteration	19
Frequency of Riffles	16
Bank Stability	8(Left)/7(Right)
Vegetative Protection	5(Left)/5(Right)
Riparian Veg Zone Width	8(Left)/9(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	5.58
pH	6.49
Specific Conductance (µS/cm)	392
Temperature (°C)	19.3
Turbidity (NTUs)	13.2

Select physical habitat parameters (raw scores) 2017			
Site	**Epifaunal Substrate (0 – 20)**	**Instream Habitat (0-20)**	**Embeddedness (0 – 100%)**
CC-01	7	10	80
CC-02	5	10	80
CC-03	15	16	35
CC-04	8	12	90

APPENDIX D

QA/QC INFORMATION

Quality Assurance/Quality Control Summary for NPDES Monitoring Activities

This section describes all Quality Assurance/Quality Control (QA/QC) procedures implemented for this project including field sampling, laboratory sorting and subsampling, data entry, metric calculation, final IBI calculation, geomorphic field sampling, and classification of stream types.

Field Sampling
Initial QA/QC procedures for benthic macroinvertebrate field sampling included formal training for field crew leaders in MBSS Sampling Protocols. All field crew members have attended at least one MBSS Spring Index Period Training. At least one crew member extensively trained and certified in MBSS sampling protocols was present for each field sampling day. Also during field sampling, each data sheet was double checked for completeness and sample bottle labels were double checked for accuracy. Geomorphic assessment field crews have more than one year of experience conducting similar assessment using the Rosgen Stream Classification Methodology, and the Geomorphic Field Leader has completed two or more levels of Rosgen training.

Geomorphic assessment survey equipment is calibrated annually and regularly inspected to ensure proper functioning. Cross-section and profile data were digitally plotted and analyzed in Ohio Department of Natural Resources (ODNR) Reference Reach Spreadsheet Version 4.3L for accuracy.

Water quality QA/QC procedures included calibration of the YSI multiprobe meter daily during the sampling season. Dissolved oxygen probe membranes were inspected regularly and replaced when dirty or damaged.

Laboratory Sorting and Subsampling
Sorting QA/QC was conducted on one sample since only seven samples were collected for this survey (The four samples from Church Creek are analyzed concurrently with three samples taken in Picture Spring Branch). This check consisted of entirely resorting the sorted grid cells of one randomly selected sample. This QC met the sorting efficiency criterion of 90%, so no further action was required. As a taxonomic QC, one sample was re-identified completely by another Versar SFS-certified taxonomist following the same identification methods stated above. The Percent Difference in Enumeration (PDE) and the Percent Taxonomic Disagreement (PTD) were calculated, and no further action was required since both the PDE and PTD met MBSS and County MQO requirements.

Data Entry
All data entered were double checked by someone other than the person who performed the initial data entry. Any errors found during QA/QC were corrected to ensure 100% accuracy of the data.

Metric and IBI Calculations
Ten percent of metric and IBI calculations were checked by hand using a calculator to ensure correct calculation by the Access database. Any discrepancies were addressed at that time.

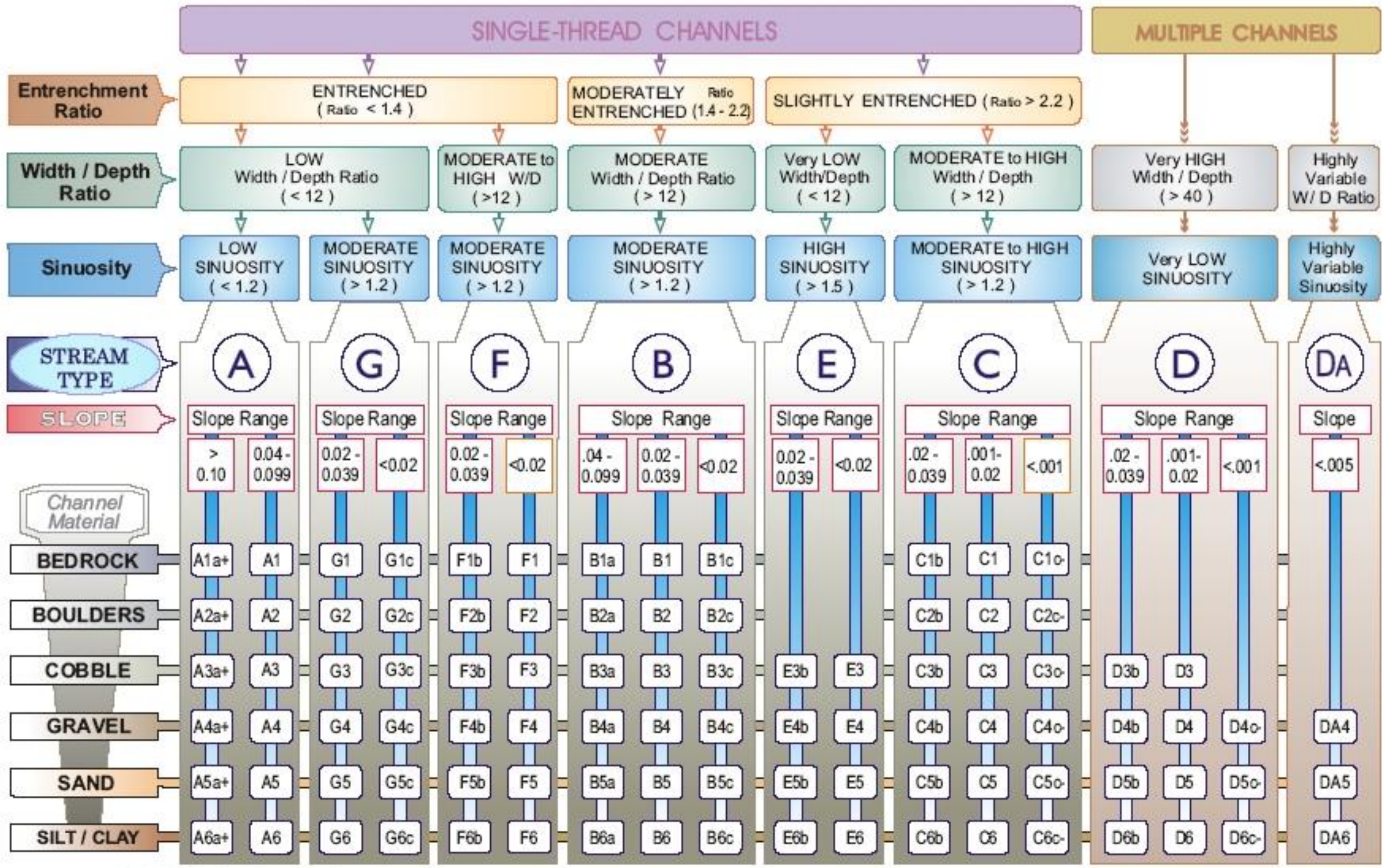
Identification of Stream Types

All stream types were determined by hand based on the methods of the Rosgen Stream Classification (Rosgen 1996). Due to the natural variability, or continuum, of streams, adjustments in the values of Width Depth Ratio (+/- 2.0) and Entrenchment Ratio (+/-0.2) are allowed, which may result in assigning a different stream type. Therefore, all stream types assigned were checked and any necessary adjustments were made.

APPENDIX E

ROSGEN CLASSIFICATION SCHEME

The Key to the Rosgen Classification of Natural Rivers



KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the *"continuum of physical variables"* within stream reaches, values of ***Entrenchment*** and ***Sinuosity*** ratios can vary by +/- 0.2 units; while values for ***Width / Depth*** ratios can vary by +/- 2.0 units.

Source: Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

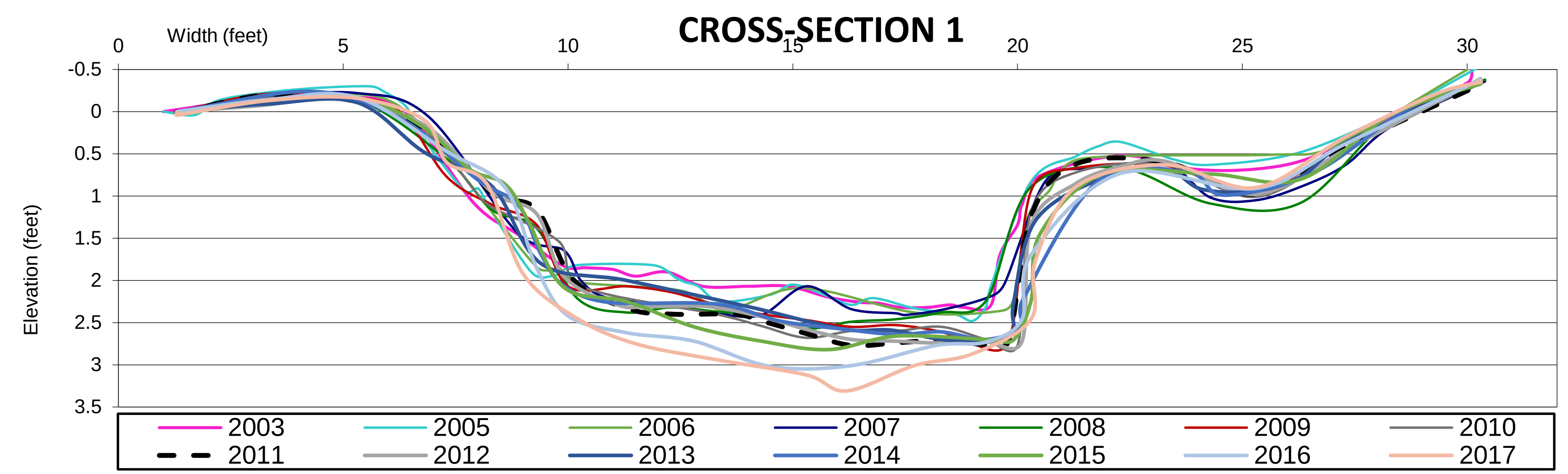
APPENDIX F

GEOMORPHOLOGICAL DATA

Church Creek
2017 Geomorphic Assessment Results Summary

Assessment Parameter	Cross-section				
	XS-1 Glide @ sta 3+70.5	XS-2 Glide @ sta 6+82	XS-3 Pool @ sta 11+00	XS-4 Pool @ sta 13+53	XS-5 Riffle @ sta 17+10
Classification	F4	G4c	G4c	E4/5	F4
Bankfull Width (ft)	13.8	9.0	9.9	8.8	11.2
Mean Depth (ft)	1.7	1.2	2.1	1.6	0.8
Bankfull X-Sec Area (sq ft)	23.4	11.0	21.2	14.4	9.4
Width:Depth Ratio	8.1	7.4	4.7	5.4	13.4
Flood-Prone Width (ft)	29.0	22.8	20.9	23.5	19.6
Entrenchment Ratio	2.1	2.5	2.1	2.7	1.7
D50(mm)	8	9.5	1.3	5.5	15
Water Surface Slope (ft/ft)	0.00097	0.028	0.01	0.0028	0.0079
Sinuosity	<1.2	<1.2	<1.2	<1.2	<1.2
Drainage Area (mi2)	0.111	0.113	0.121	0.130	0.441
Adjustments?	Sin ↑, ER ↓, W/D ↑	Sin ↑, ER ↓	Sin ↑, ER ↓	Sin ↑	Sin ↑, ER ↓

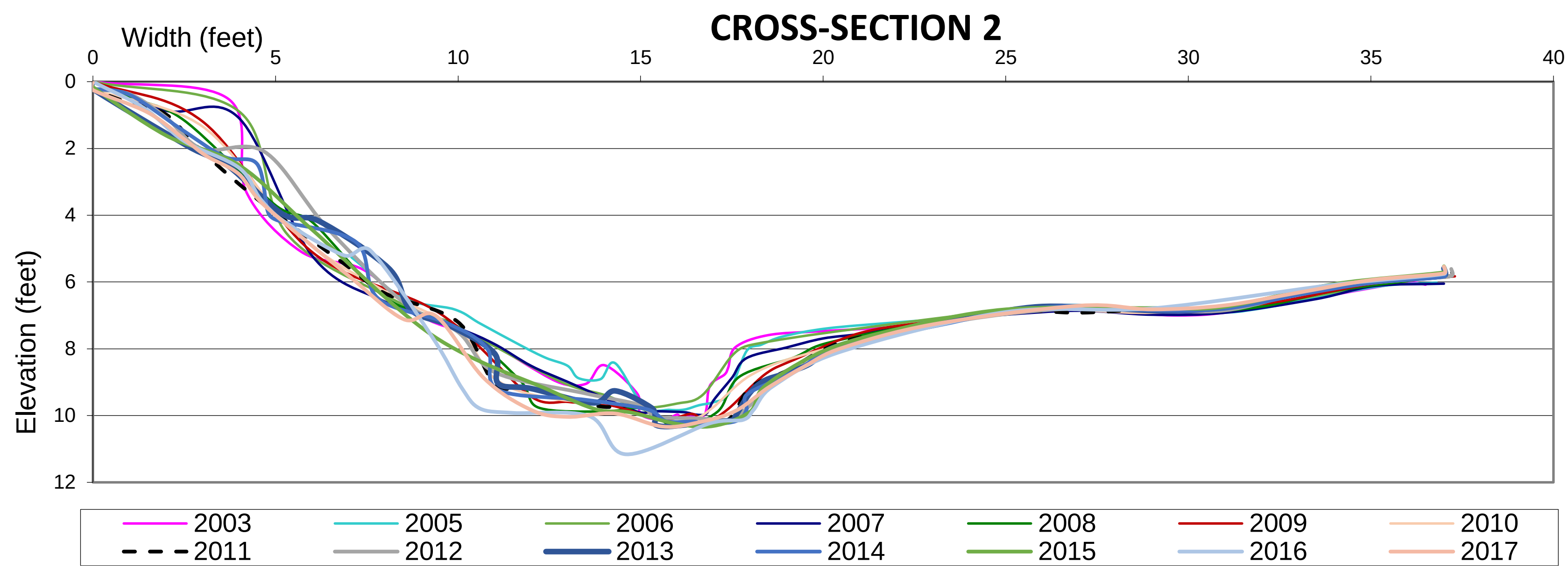
F-4



Upstream View	Downstream View

Left Bank View	Right Bank View

2017 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	13.8
Mean Depth (d_{bkf}) (feet)	1.7
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	23.4
Width/Depth Ratio (W_{bkf}/d_{bkf})	8.1
Width of Flood-prone Area (W_{fpa}) (feet)	29.0
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	2.1
Channel Materials D_{50} (millimeters)	8
Water Surface Slope (S)	0.00097
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, ER ↓, W/D ↑
STREAM TYPE	**F4**



Upstream View

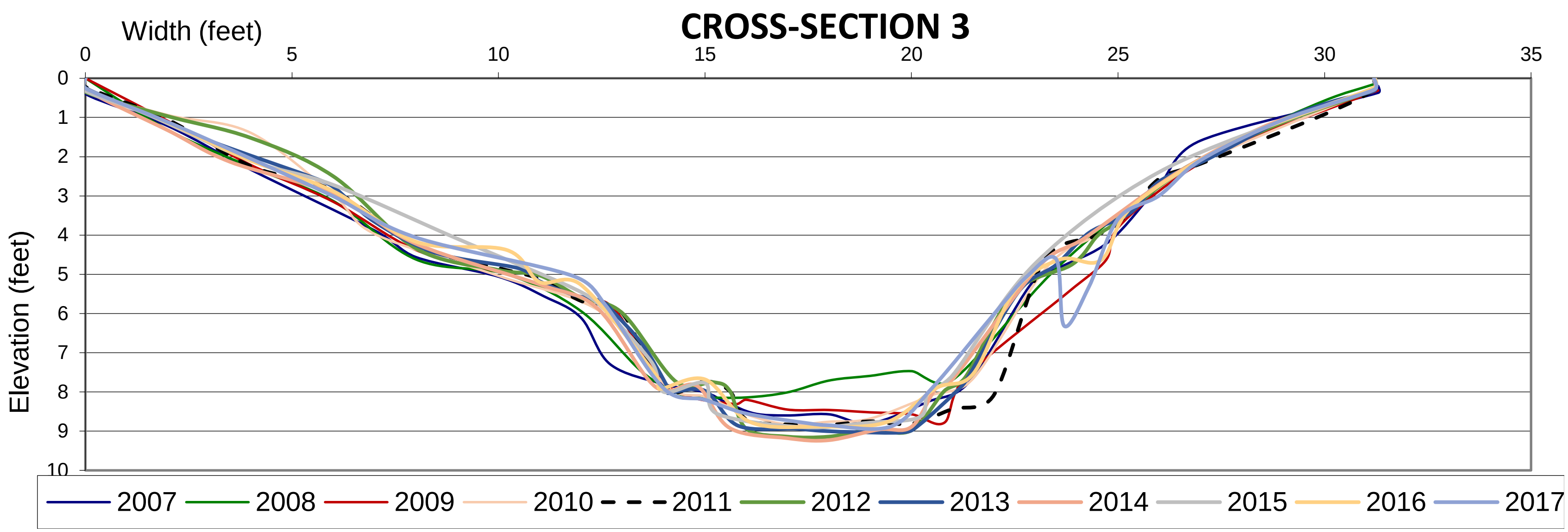
Downstream View

Left Bank View

Right Bank View

2017 Geomorphic Assessment Results

Bankfull Width (W_{bkf}) (feet)	9.0
Mean Depth (d_{bkf}) (feet)	1.2
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	11.0
Width/Depth Ratio (W_{bkf}/d_{bkf})	7.4
Width of Flood-prone Area (W_{fpa}) (feet)	22.8
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	2.5
Channel Materials D_{50} (millimeters)	9.5
Water Surface Slope (S)	0.028
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, ER ↓
STREAM TYPE	**G4c**



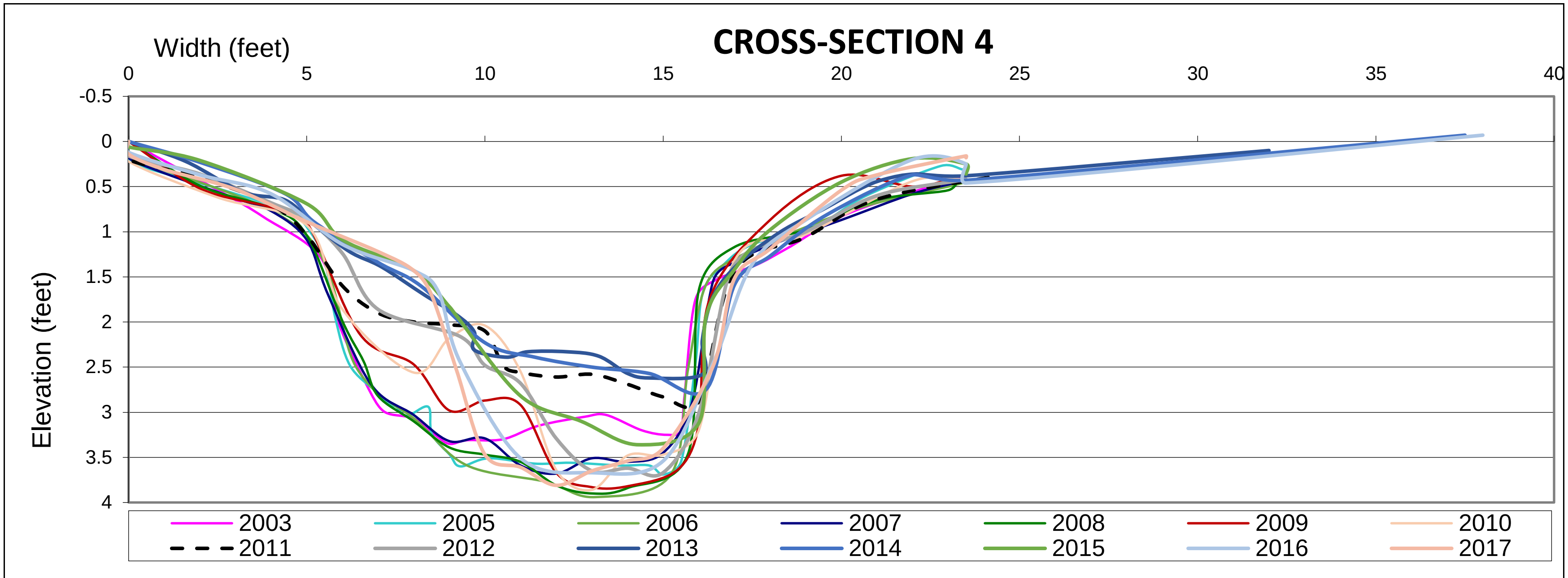
Upstream View

Downstream View

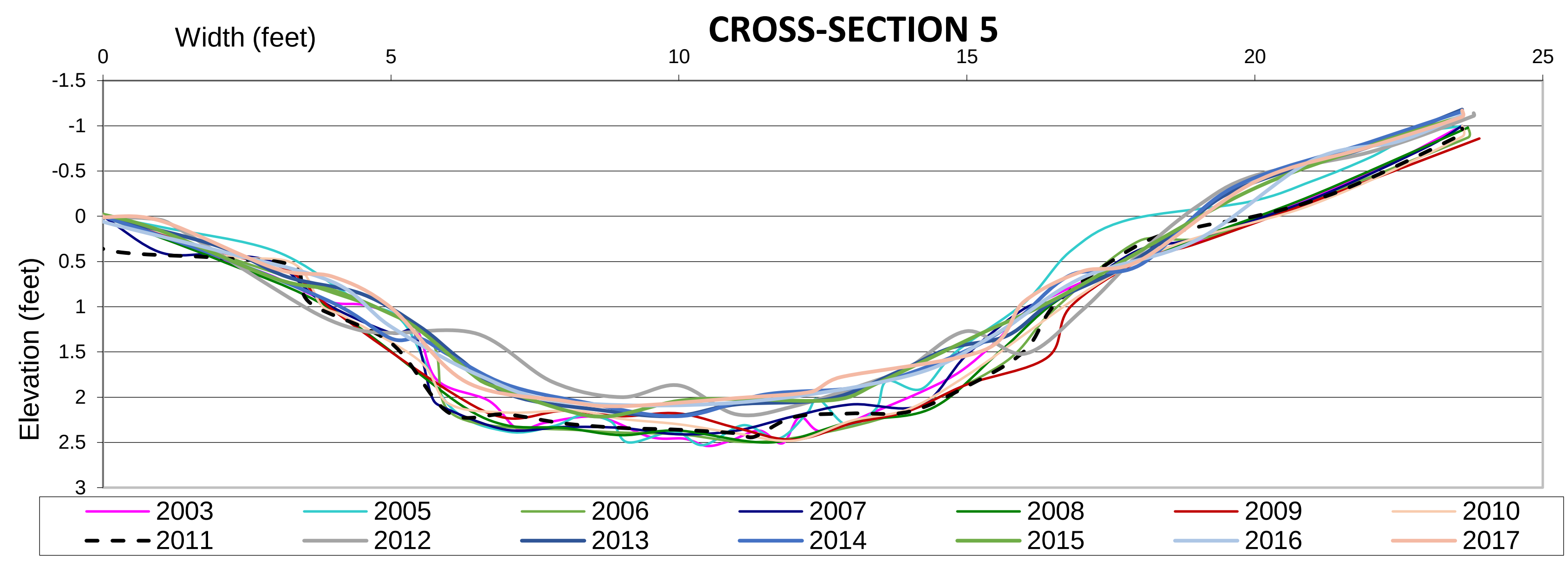
Left Bank View

Right Bank View

2017 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	9.9
Mean Depth (d_{bkf}) (feet)	2.1
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	21.2
Width/Depth Ratio (W_{bkf}/d_{bkf})	4.7
Width of Flood-prone Area (W_{fpa}) (feet)	20.9
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	2.1
Channel Materials D_{50} (millimeters)	1.3
Water Surface Slope (S)	0.01
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, ER ↓
STREAM TYPE	**G4c**



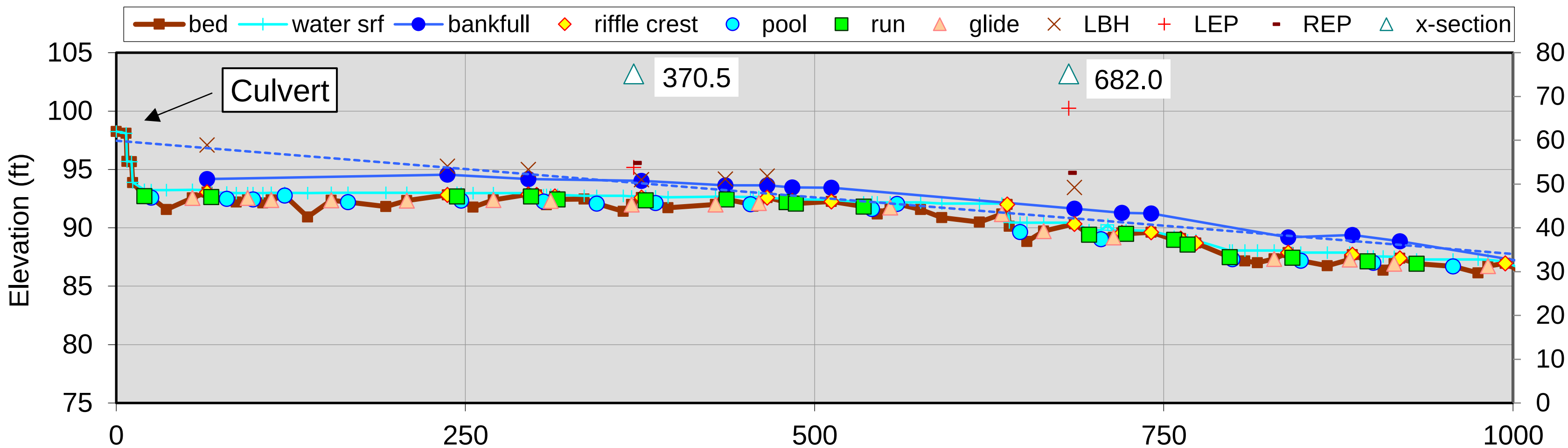
Photographs		2017 Geomorphic Assessment Results	
		Bankfull Width (W_{bkf}) (feet)	8.8
		Mean Depth (d_{bkf}) (feet)	1.6
		Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	14.4
		Width/Depth Ratio (W_{bkf}/d_{bkf})	5.4
Upstream View	Downstream View	Width of Flood-prone Area (W_{fpa}) (feet)	23.5
		Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	2.7
		Channel Materials D_{50} (millimeters)	5.5
		Water Surface Slope (S)	0.0028
		Sinuosity (K) = stream length/valley length	<1.2
		Adjustments?	Sin ↑
Left Bank View	Right Bank View	**STREAM TYPE**	**E4/5**

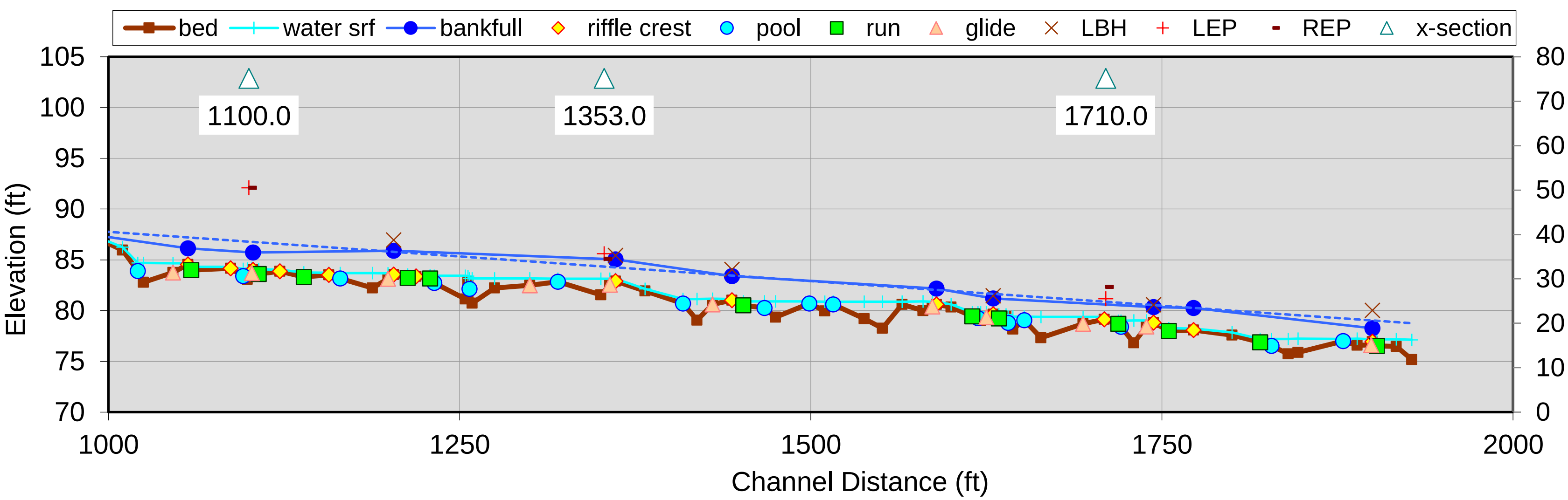


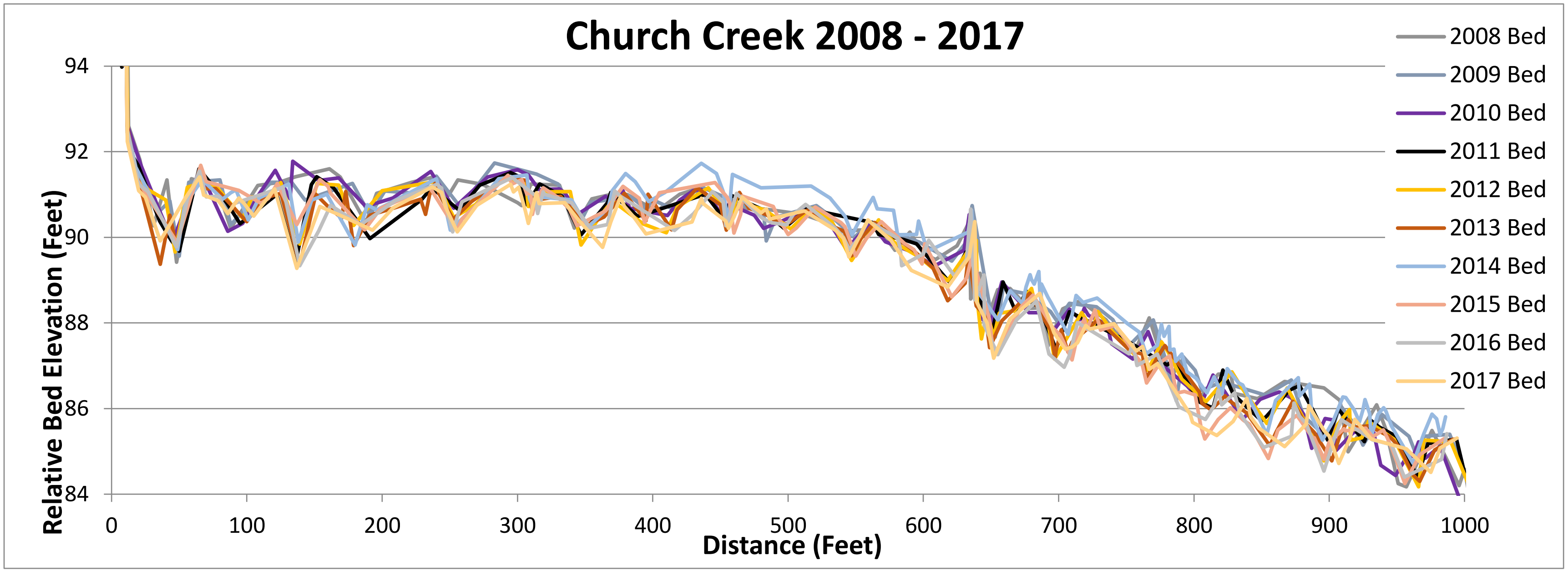
	
Upstream View	Downstream View
	
Left Bank View	Right Bank View

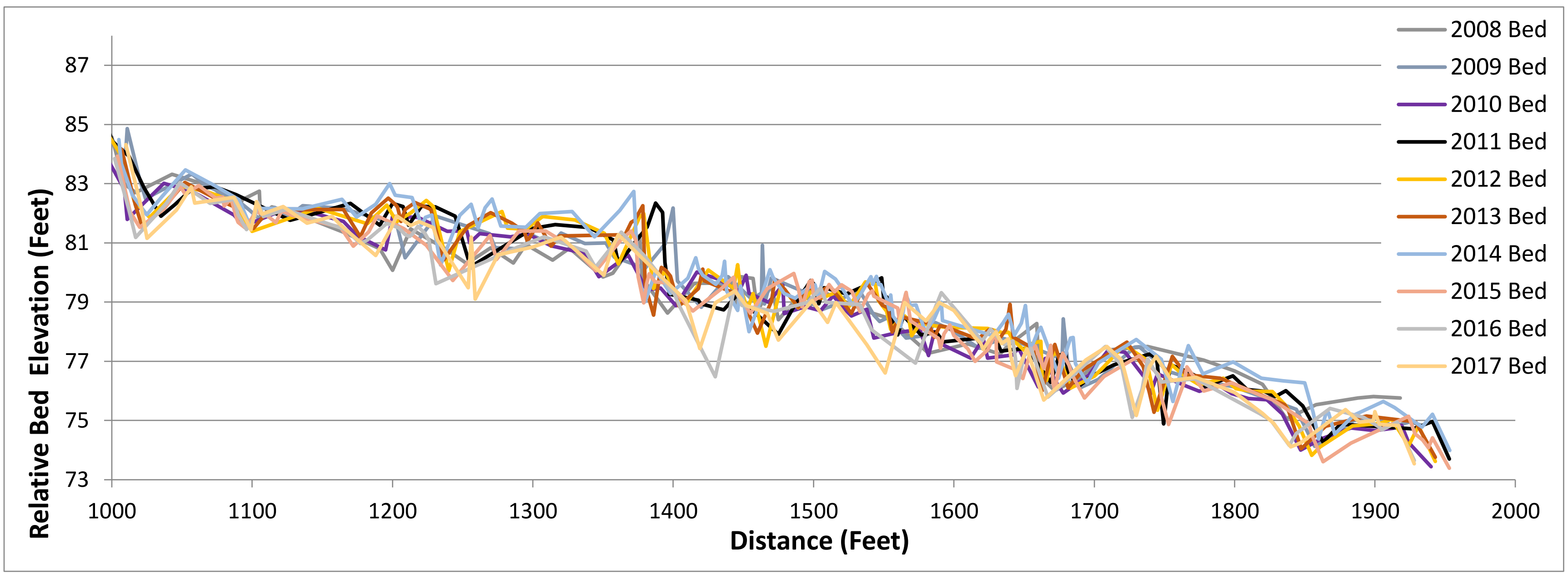
2017 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	11.2
Mean Depth (d_{bkf}) (feet)	0.8
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	9.4
Width/Depth Ratio (W_{bkf}/d_{bkf})	13.4
Width of Flood-prone Area (W_{fpa}) (feet)	19.6
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.7
Channel Materials D_{50} (millimeters)	15
Water Surface Slope (S)	0.0079
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, ER ↓
STREAM TYPE	**F4**

Church Creek Longitudinal Profile






Church Creek 2008 - 2017
Relative Bed Elevation (Feet)
Distance (Feet)
94
92
90
88
86
84
0
100
200
300
400
500
600
700
800
900
1000
2008 Bed
2009 Bed
2010 Bed
2011 Bed
2012 Bed
2013 Bed
2014 Bed
2015 Bed
2016 Bed
2017 Bed


Relative Bed Elevation (Feet)
Distance (Feet)
87
85
83
81
79
77
75
73
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2008 Bed
2009 Bed
2010 Bed
2011 Bed
2012 Bed
2013 Bed
2014 Bed
2015 Bed
2016 Bed
2017 Bed

APPENDIX G

CHEMICAL MONITORING RESULTS

Anne Arundel County NPDES
Sampling and EMC Data – 2017 Reporting Year
Parole Plaza Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Duration (Hours)	Intensity (In/Hr)	Temperature - field (oF)	Flow (CF)	pH - field (pH)	dt for BOD (mg/L)	BOD ((0) mg/L)	BOD ((dt) mg/L)	dt for Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	Total Kjeldahl Nitrogen ((dt) mg/L)	dt for Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	Nitrate+ Nitrite - N ((dt) mg/L)	dt for Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)	Total Phosphorus ((dt) mg/L)	dt for TSS (mg/L)	TSS ((0) mg/L)	TSS ((dt) mg/L)	dt for Copper (µg/L)	Copper ((0) µg/L)	Copper ((dt) µg/L)	dt for Lead (µg/L)	Lead ((0) µg/L)	Lead ((dt) µg/L)	dt for Zinc (µg/L)	Zinc ((0) µg/L)	Zinc ((dt) µg/L)	dt for TPH (mg/L)	TPH ((0) mg/L)	TPH ((dt) mg/L)	dt for E-COLI (MPN)	E-COLI ((0) MPN)	E-COLI ((dt) MPN)	dt for HARDNESS (mg/L)	HARDNESS ((0) mg/L)	HARDNESS ((dt) mg/L)
Versar	1	AP	7/28/2016	2125	101	O	S	0.34	3.0	0.11	80.38	3262	7.28	2	25	25	0.5	2.7	2.7	0.05	0.61	0.61	0.01	0.14	0.14	1	97	97	2.0	24.1	24.1	2.0	6.2	6.2	20	214	214	5.0	0.0	5.0	10	959	959	1	45	45
Versar	2	AP	7/28/2016	2130	101	O	S				80.22	4109	7.41	2	16	16	0.5	1.3	1.3	0.05	0.58	0.58	0.01	0.07	0.07	1	32	32	2.0	18.4	18.4	2.0	2.7	2.7	20	221	221	5.0	0.0	5.0	10	0	10	1	25	25
Versar	3	AP	7/28/2016	2155	101	O	S				79.76	13243	7.46	2	4	4	0.5	0.7	0.7	0.05	0.54	0.54	0.01	0.05	0.05	1	4	4	2.0	16.3	16.3	2.0	0.0	2.0	20	115	115	5.0	0.0	5.0	10	0	10	1	20	20
										Event Mean Concentration:	**79.95**		**7.42**	**2**	**10**	**10**	**0.5**	**1.1**	**1.1**	**0.05**	**0.56**	**0.56**	**0.01**	**0.07**	**0.07**	**1**	**24**	**24**	**2.0**	**18.0**	**18.0**	**2.0**	**1.5**	**2.8**	**20**	**152**	**152**	**5.0**	**0.0**	**5.0**	**10**	**152**	**160**	**1**	**25**	**25**
Versar	1	AP	9/19/2016	530	101	O	S	1.22	3.0	0.41	76.41	1389	8.02	4	24	24	0.5	2.2	2.2	0.05	0.84	0.84	0.01	0.25	0.25	1	80	80	2.0	34.8	34.8	2.0	4.6	4.6	20	404	404	5.0	0.0	5.0	100	0	100	1	50	50
Versar	2	AP	9/19/2016	600	101	O	S				73.85	38968	7.99	4	0	4	0.5	0.8	0.8	0.05	0.19	0.19	0.01	0.17	0.17	1	97	97	2.0	24.1	24.1	2.0	4.7	4.7	20	239	239	5.0	0.0	5.0	100	3550	3550	1	29	29
Versar	3	AP	9/19/2016	625	101	O	S				73.78	65408	7.69	4	0	4	0.5	0.8	0.8	0.05	0.66	0.66	0.01	0.16	0.16	1	21	21	2.0	13.0	13.0	2.0	0.0	2.0	20	86	86	5.0	0.0	5.0	100	0	100	1	21	21
										Event Mean Concentration:	**73.84**		**7.80**	**4**	**0**	**4**	**0.5**	**0.8**	**0.8**	**0.05**	**0.49**	**0.49**	**0.01**	**0.16**	**0.16**	**1**	**50**	**50**	**2.0**	**17.4**	**17.4**	**2.0**	**1.8**	**3.0**	**20**	**147**	**147**	**5.0**	**0.0**	**5.0**	**100**	**1308**	**1371**	**1**	**24**	**24**
Versar	1	AP	9/27/2016	335	101	O	S	0.32	4.5	0.07	67.74	437	7.89	4	10	10	0.5	3.0	3.0	0.05	0.74	0.74	0.01	0.30	0.30	1	83	83	2.0	14.6	14.6	2.0	0.0	2.0	20	262	262	5.0	0.0	5.0	100	410	410	1	34	34
Versar	2	AP	9/27/2016	340	101	O	S				68.02	2297	7.98	4	8	8	0.5	1.6	1.6	0.05	0.43	0.43	0.01	0.15	0.15	1	70	70	2.0	14.9	14.9	2.0	3.4	3.4	20	171	171	5.0	0.0	5.0	100	980	980	1	28	28
Versar	3	AP	9/27/2016	610	101	O	S				73.37	15156	8.58	4	0	4	0.5	0.8	0.8	0.02	0.40	0.40	0.01	0.06	0.06	1	2	2	2.0	11.8	11.8	2.0	0.0	2.0	20	116	116	5.0	0.0	5.0	100	46110	46110	1	26	26
										Event Mean Concentration:	**72.55**		**8.49**	**4**	**1**	**5**	**0.5**	**1.0**	**1.0**	**0.02**	**0.41**	**0.41**	**0.01**	**0.08**	**0.08**	**1**	**13**	**13**	**2.0**	**12.3**	**12.3**	**2.0**	**0.4**	**2.2**	**20**	**127**	**127**	**5.0**	**0.0**	**5.0**	**100**	**39201**	**39201**	**1**	**26**	**26**
Versar	1	AP	11/9/2016	630	101	O	S	0.11	7.0	0.02	56.99	122	8.07	4	11	11	0.5	1.8	1.8	0.05	1.40	1.40	0.01	0.15	0.15	1	10	10	2.0	18.1	18.1	***	***	***	20	233	233	5.0	0.0	5.0	10	341	341	1	41	41
Versar	2	AP	11/9/2016	910	101	O	S				59.75	3436	7.45	4	8	8	0.5	1.2	1.2	0.05	0.61	0.61	0.01	0.16	0.16	1	20	20	2.0	22.0	22.0	***	***	***	20	183	183	5.0	0.0	5.0	10	63	63	1	41	41
Versar	3	AP	11/9/2016	950	101	O	S				58.92	877	7.46	4	6	6	0.5	1.2	1.2	0.05	0.92	0.92	0.01	0.12	0.12	1	12	12	2.0	18.1	18.1	***	***	***	20	166	166	5.0	0.0	5.0	10	645	645	1	59	59
										Event Mean Concentration:	**59.51**		**7.47**	**4**	**8**	**8**	**0.5**	**1.2**	**1.2**	**0.05**	**0.69**	**0.69**	**0.01**	**0.15**	**0.15**	**1**	**18**	**18**	**2.0**	**21.1**	**21.1**	*******	*******	*******	**20**	**181**	**181**	**5.0**	**0.0**	**5.0**	**10**	**186**	**186**	**1**	**45**	**45**
Versar	1	AP	11/29/2016	1045	101	O	S	0.08	8.0	0.01	58.01	8836	7.35	4	18	18	0.5	2.5	2.5	0.05	3.00	3.00	0.01	0.36	0.36	1	38	38	2.0	39.2	39.2	2.0	4.7	4.7	20	303	303	5.0	6.0	6.0	10	1314	1314	1	140	140
Versar	2	AP	11/29/2016	1050	101	O	S				56.65	340	7.87	4	18	18	0.5	2.5	2.5	0.05	1.40	1.40	0.01	0.49	0.49	1	89	89	2.0	38.3	38.3	2.0	5.5	5.5	20	663	663	5.0	7.0	7.0	10	24196	24196	1	50	50
Versar	3	AP	11/29/2016	1145	101	O	S				57.15	2576	7.80	4	12	12	0.5	1.9	1.9	0.05	1.40	1.40	0.01	0.30	0.30	1	35	35	2.0	40.5	40.5	2.0	3.1	3.1	20	249	249	5.0	10.0	10.0	10	4611	4611	1	76	76
										Event Mean Concentration:	**No EMCs were calculated for this storm – leaf litter in RCP affected flow record**																																			
Versar	1	AP	12/6/2016	1410	101	O	S	0.78	12.0	0.07	47.24	4990	8.65	4	6	6	0.5	1.2	1.2	0.05	0.44	0.44	0.01	0.15	0.15	1	62	62	2.0	27.1	27.1	2.0	4.0	4.0	20	228	228	5.0	6.0	6.0	100	850	850	1	60	60
Versar	2	AP	12/6/2016	1520	101	O	S				45.88	16642	8.92	4	0	4	0.5	0.8	0.8	0.05	0.22	0.22	0.01	0.10	0.10	1	36	36	2.0	17.0	17.0	2.0	2.4	2.4	20	133	133	5.0	0.0	5.0	100	4960	4960	1	30	30
Versar	3	AP	12/6/2016	1915	101	O	S				48.31	68958	8.59	4	0	4	0.5	0.7	0.7	0.05	0.36	0.36	0.01	0.09	0.09	1	10	10	2.0	10.7	10.7	2.0	0.0	2.0	20	80	80	5.0	0.0	5.0	100	2180	2180	1	30	30
										Event Mean Concentration:	**47.80**		**8.65**	**4**	**0**	**4**	**0.5**	**0.7**	**0.7**	**0.05**	**0.34**	**0.34**	**0.01**	**0.10**	**0.10**	**1**	**18**	**18**	**2.0**	**12.8**	**12.8**	**2.0**	**0.7**	**2.2**	**20**	**98**	**98**	**5.0**	**0.3**	**5.1**	**100**	**2617**	**2617**	**1**	**32**	**32**
Versar	1	AP	1/23/2017	1125	101	O	S	0.49	12.0	0.04	47.25	5161	7.70	2	5	5	0.5	1.0	1.0	0.05	0.29	0.29	0.01	0.08	0.08	1	94	94	2.0	32.3	32.3	2.0	5.1	5.1	20	300	300	5.0	0.0	5.0	10	3255	3255	1	79	79
Versar	2	AP	1/23/2017	1410	101	O	S				43.73	31808	7.46	2	6	6	0.5	1.9	1.9	0.05	0.17	0.17	0.01	0.29	0.29	1	340	340	2.0	62.5	62.5	2.0	14.8	14.8	20	341	341	5.0	0.0	5.0	10	3448	3448	1	140	140
Versar	3	AP	1/23/2017	1610	101	O	S				44.97	37197	6.65	2	0	2	0.5	0.0	0.5	0.05	0.40	0.40	0.01	0.13	0.13	1	58	58	2.0	15.2	15.2	2.0	2.0	2.0	20	120	120	5.0	0.0	5.0	10	9804	9804	1	83	83
										Event Mean Concentration:	**44.59**		**7.07**	**2**	**3**	**4**	**0.5**	**0.9**	**1.1**	**0.05**	**0.29**	**0.29**	**0.01**	**0.20**	**0.20**	**1**	**181**	**181**	**2.0**	**36.7**	**36.7**	**2.0**	**7.7**	**7.7**	**20**	**227**	**227**	**5.0**	**0.0**	**5.0**	**10**	**6622**	**6622**	**1**	**107**	**107**
Versar	1	AP	2/28/2017	1840	101	O	S	0.33	9.0	0.04	56.46	338	7.35*	2	21	21	0.5	2.1	2.1	0.05	1.40	1.40	0.01	0.18	0.18	1	140	140	2.0	56.7	56.7	2.0	6.6	6.6	20	392	392	5.0	9.0	9.0	1	66	66	1	96	96
Versar	2	AP	2/28/2017	1920	101	O	S				56.94	6960	7.49*	2	5	5	0.5	1.0	1.0	0.05	0.56	0.56	0.01	0.15	0.15	1	52	52	2.0	31.1	31.1	2.0	2.6	2.6	20	169	169	5.0	5.0	5.0	1	2620	2620	1	42	42
Versar	3	AP	2/28/2017	2135	101	O	S				56.55	22412	7.46*	2	2	2	0.5	0.0	0.5	0.05	0.32	0.32	0.01	0.09	0.09	1	10	10	2.0	15.7	15.7	2.0	0.0	2.0	20	100	100	5.0	0.0	5.0	1	8420	8420	1	27	27
										Event Mean Concentration:	**56.64**		**7.47**	**2**	**3**	**3**	**0.5**	**0.3**	**0.6**	**0.05**	**0.39**	**0.39**	**0.01**	**0.11**	**0.11**	**1**	**21**	**21**	**2.0**	**19.8**	**19.8**	**2.0**	**0.7**	**2.2**	**20**	**119**	**119**	**5.0**	**1.3**	**5.0**	**1**	**6966**	**6966**	**1**	**31**	**31**
Versar	1	AP	3/31/2017	0720	101	O	S	1.12	10.0	0.11	49.12	3157	7.79	2	6	6	0.5	1.5	1.5	0.05	1.30	1.30	0.01	0.18	0.18	1	18	18	2.0	24.0	24.0	2.0	0.0	2.0	20	175	175	5.0	0.0	5.0	1	188	188	1	44	44
Versar	2	AP	3/31/2017	1100	101	O	S				49.91	41236	7.85	2	6	6	0.5	1.5	1.5	0.05	0.37	0.37	0.01	0.20	0.20	1	190	190	2.0	52.8	52.8	2.0	12.8	12.8	20	352	352	5.0	0.0	5.0	1	649	649	1	140	140
Versar	3	AP	3/31/2017	1350	101	O	S				51.28	98216	7.26	2	0	2	0.5	0.7	0.7	0.05	0.50	0.50	0.01	0.12	0.12	1	15	15	2.0	17.6	17.6	2.0	0.0	2.0	20	109	109	5.0	0.0	5.0	1	2580	2580	1	37	37
										Event Mean Concentration:	**50.84**		**7.44**	**2**	**2**	**3**	**0.5**	**0.9**	**0.9**	**0.05**	**0.48**	**0.48**	**0.01**	**0.14**	**0.14**	**1**	**66**	**66**	**2.0**	**27.9**	**27.9**	**2.0**	**3.7**	**5.1**	**20**	**181**	**181**	**5.0**	**0.0**	**5.0**	**1**	**1969**	**1969**	**1**	**67**	**67**

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Duration (Hours)	Intensity (In/Hr)	Temperature - field (oF)	Flow (CF)	pH - field (pH)	dt for BOD (mg/L)	BOD ((0) mg/L)	BOD ((dt) mg/L)	dt for Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	Total Kjeldahl Nitrogen ((dt) mg/L)	dt for Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	Nitrate+ Nitrite - N ((dt) mg/L)	dt for Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)	Total Phosphorus ((dt) mg/L)	dt for TSS (mg/L)	TSS ((0) mg/L)	TSS ((dt) mg/L)	dt for Copper (µg/L)	Copper ((0) µg/L)	Copper ((dt) µg/L)	dt for Lead (µg/L)	Lead ((0) µg/L)	Lead ((dt) µg/L)	dt for Zinc (µg/L)	Zinc ((0) µg/L)	Zinc ((dt) µg/L)	dt for TPH (mg/L)	TPH ((0) mg/L)	TPH ((dt) mg/L)	dt for E-COLI (MPN)	E-COLI ((0) MPN)	E-COLI ((dt) MPN)	dt for HARDNESS (mg/L)	HARDNESS ((0) mg/L)	HARDNESS ((dt) mg/L)
Versar	1	AP	4/25/2017	1220	101	O	S	0.39	5.0	0.08	58.31	3449	7.75	2	10	10	0.5	2.0	2.0	0.05	0.49	0.49	0.01	0.28	0.28	1	64	64	2.0	40.0	40.0	2.0	3.5	3.5	20	223	223	5.0	7.0	7.0	1	1482	1482	1	64	64
Versar	2	AP	4/25/2017	1235	101	O	S				60.36	6738	8.00	2	25	25	0.5	2.9	2.9	0.05	0.15	0.15	0.01	0.46	0.46	1	230	230	2.0	135.0	135.0	2.0	22.3	22.3	20	1150	1150	5.0	7.0	7.0	1	2292	2292	1	170	170
Versar	3	AP	4/25/2017	1435	101	O	S				59.79	46059	7.81	2	3	3	0.5	0.8	0.8	0.05	0.29	0.29	0.01	0.12	0.12	1	10	10	2.0	11.8	11.8	2.0	0.0	2.0	20	70	70	5.0	0.0	5.0	1	2420	2420	1	27	27
										Event Mean Concentration:	**59.76**		**7.83**	**2**	**6**	**6**	**0.5**	**1.1**	**1.1**	**0.05**	**0.29**	**0.29**	**0.01**	**0.17**	**0.17**	**1**	**40**	**40**	**2.0**	**28.3**	**28.3**	**2.0**	**2.9**	**4.5**	**20**	**209**	**209**	**5.0**	**1.3**	**5.4**		******	******	**1**	**46**	**46**
Versar	1	AP	5/12/2017	2230	101	O	S	0.98	21.0	0.05	56.87	8676	7.81	2	0	2	0.5	0.0	0.5	0.05	0.40	0.40	0.01	0.06	0.06	1	10	10	2.0	12.9	12.9	2.0	2.8	2.8	20	97	97	5.0	6.0	6.0	1	3637	3637	1	32	32
Versar	2	AP	5/13/2017	335	101	O	S				54.09	42377	7.85	2	0	2	0.5	0.0	0.5	0.05	0.15	0.15	0.01	0.05	0.05	1	10	10	2.0	6.7	6.7	2.0	0.0	2.0	20	67	67	5.0	0.0	5.0	1	7600	7600	1	18	18
Versar	3	AP	5/13/2017	730	101	O	S				52.93	50746	7.64	2	0	2	0.5	0.0	0.5	0.05	0.24	0.24	0.01	0.06	0.06	1	3	3	2.0	6.4	6.4	2.0	0.0	2.0	20	63	63	5.0	0.0	5.0	1	7811	7811	1	26	26
										Event Mean Concentration:	**53.75**		**7.74**	**2**	**0**	**2**	**0.5**	**0.0**	**0.5**	**0.05**	**0.22**	**0.22**	**0.01**	**0.06**	**0.06**	**1**	**7**	**7**	**2.0**	**7.1**	**7.1**	**2.0**	**0.2**	**2.1**	**20**	**68**	**68**	**5.0**	**0.5**	**5.1**	**1**	**7367**	**7367**	**1**	**23**	**23**
Versar	1	AP	6/19/2017	1625	101	O	S	0.36	4.0	0.09	81.37	125	7.39	2	10	10	0.5	2.4	2.4	0.05	0.65	0.65	0.01	0.31	0.31	1	530	530	2.0	200.0	200.0	2.0	55.0	55.0	20	1810	1810	5.0	9.0	9.0	1	1247	1247	1	400	400
Versar	2	AP	6/19/2017	1630	101	O	S				78.62	2559	7.35	2	10	10	0.5	2.2	2.2	0.05	0.51	0.51	0.01	0.30	0.30	1	200	200	2.0	144.0	144.0	2.0	12.0	12.0	20	993	993	5.0	7.0	7.0	1	4553	4553	1	68	68
Versar	3	AP	6/19/2017	1735	101	O	S				77.66	19896	7.40	2	3	3	0.5	0.8	0.8	0.05	0.53	0.53	0.01	0.11	0.11	1	22	22	2.0	23.0	23.0	2.0	0.0	2.0	20	163	163	5.0	5.0	5.0	1	65044	65044	1	28	28
										Event Mean Concentration:	**77.79**		**7.40**	**2**	**4**	**4**	**0.5**	**1.0**	**1.0**	**0.05**	**0.53**	**0.53**	**0.01**	**0.13**	**0.13**	**1**	**45**	**45**	**2.0**	**37.7**	**37.7**	**2.0**	**1.7**	**3.4**	**20**	**266**	**266**	**5.0**	**5.2**	**5.2**	**1**	**57837**	**57837**	**1**	**35**	**35**

* No pH readings taken from CMP so volume-weighted pH composite could not be calculated. Values are for RCP only.

** Samples were not diluted - the data has been discarded and not included in subsequent flow weighted EMC and loading calculations

*** Error in results - the data has been discarded and not included in subsequent flow weighted EMC and loading calculations

Anne Arundel County NPDES
Sampling and EMC Data – 2017 Reporting Year
Parole Plaza Station

	oF Temperature - field	pH pH - field	(0) mg/L BOD	(dt) mg/L BOD	(0) mg/L Total Kjeldahl Nitrogen	(dt) mg/L Total Kjeldahl Nitrogen	(0) mg/L Nitrate+ Nitrite - N	(dt) mg/L Nitrate+ Nitrite - N	(0) mg/L Total Phosphorus	(dt) mg/L Total Phosphorus	(0) mg/L TSS	(dt) mg/L TSS	(0) µg/L Copper	(dt) µg/L Copper	(0) µg/L Lead	(dt) µg/L Lead	(0) µg/L Zinc	(dt) µg/L Zinc	(0) mg/L TPH	(dt) mg/L TPH	(0) MPN E-COLI	(dt) MPN E-COLI	(0) mg/L HARDNESS	(dt) mg/L HARDNESS
Summer Quarter Flow-Weighted EMC (7/28/16, 9/19/16, 9/27/16):	74.56	7.83	1.78	5.09	0.88	0.88	0.49	0.49	0.14	0.14	41.54	41.54	16.82	16.82	1.89	2.89	145.01	145.01	0.00	5.00	5841.28	5888.78	24.68	24.68
Average:			3.43	mg/l	0.88	mg/l	0.49	mg/l	0.14	mg/l	41.54	mg/l	16.82	µg/l	2.24	µg/l	145.01	µg/l	2.5	mg/l	5865.03	MPN/100mL	24.68	mg/l
			0.0002143	lb/cf	0.0000550	lb/cf	0.0000306	lb/cf	0.0000088	lb/cf	0.0025927	lb/cf	0.0000011	lb/cf	0.0000001	lb/cf	0.0000091	lb/cf	0.0001560	lb/cf			0.0015405	lb/cf
Total Volume (Quarter Events):			144,269	cf																				
Pollutant Load (Quarter Events):			30.9	lbs	7.9	lbs	4.4	lbs	1.3	lbs	374.0	lbs	0.2	lbs	0.02	lbs	1.31	lbs	22.51	lbs			222.2	lbs
Total Volume (Quarter):			1,602,889	cf																				
Pollutant Load (Quarter):			343.6	lbs	88.1	lbs	49.0	lbs	14.0	lbs	4,155.8	lbs	1.7	lbs	0.2	lbs	14.5	lbs	250.1	lbs			2,469.2	lbs
Fall Quarter Flow-Weighted EMC (11/9/16, 11/29/16, 12/6/17):	48.35	8.60	0.67	4.28	0.77	0.77	0.36	0.36	0.10	0.10	17.66	17.66	13.15	13.15	0.65	2.18	101.84	101.84	0.32	5.05	2503.94	2503.94	32.25	32.25
Average:			2.48	mg/l	0.77	mg/l	0.36	mg/l	0.10	mg/l	17.66	mg/l	13.15	µg/l	1.41	µg/l	101.84	µg/l	2.68	mg/l	2503.94	MPN/100mL	32.25	mg/l
			0.0001545	lb/cf	0.0000479	lb/cf	0.0000222	lb/cf	0.0000061	lb/cf	0.0011025	lb/cf	0.0000008	lb/cf	0.0000001	lb/cf	0.0000064	lb/cf	0.0001675	lb/cf			0.0020132	lb/cf
Total Volume (Quarter Events):			95,025	cf																				
Pollutant Load (Quarter Events):			14.7	lbs	4.6	lbs	2.1	lbs	0.6	lbs	104.8	lbs	0.1	lbs	0.0	lbs	0.6	lbs	15.9	lbs			191.3	lbs
Total Volume (Quarter):			1,235,323	cf																				
Pollutant Load (Quarter):			190.9	lbs	59.2	lbs	27.4	lbs	7.5	lbs	1,362.0	lbs	1.0	lbs	0.1	lbs	7.9	lbs	206.9	lbs			2,487.0	lbs
Winter Quarter Flow-Weighted EMC (1/23/17, 2/28/17, 3/31/17):	49.66	7.33	2.31	3.41	0.85	0.97	0.41	0.41	0.15	0.15	95.16	95.16	29.57	29.57	4.55	5.55	187.34	187.34	0.15	5.01	3971.33	3971.33	74.75	74.75
Average:			2.86	mg/l	0.91	mg/l	0.41	mg/l	0.15	mg/l	95.16	mg/l	29.57	µg/l	5.05	µg/l	187.34	µg/l	2.58	mg/l	3971.33	MPN/100mL	74.75	mg/l
			0.0001786	lb/cf	0.0000566	lb/cf	0.0000258	lb/cf	0.0000097	lb/cf	0.0059395	lb/cf	0.0000018	lb/cf	0.0000003	lb/cf	0.0000117	lb/cf	0.0001610	lb/cf			0.0046654	lb/cf
Total Volume (Quarter Events):			246,485	cf																				
Pollutant Load (Quarter Events):			44.0	lbs	14.0	lbs	6.4	lbs	2.4	lbs	1,464.0	lbs	0.5	lbs	0.1	lbs	2.9	lbs	39.7	lbs			1,149.9	lbs
Total Volume (Quarter):			2,585,072	cf																				
Pollutant Load (Quarter):			461.6	lbs	146.3	lbs	66.6	lbs	25.0	lbs	15,354.1	lbs	4.8	lbs	0.8	lbs	30.2	lbs	416.2	lbs			12,060.4	lbs
Spring Quarter Flow-Weighted EMC (4/25/17, 5/12/17, 6/19/17):	58.63	7.73	2.37	3.49	0.47	0.75	0.28	0.28	0.10	0.10	21.64	21.64	17.51	17.51	1.24	3.00	136.33	136.33	1.31	5.16	16529.53	16529.53	31.84	31.84
Average:			2.93	mg/l	0.61	mg/l	0.28	mg/l	0.10	mg/l	21.64	mg/l	17.51	µg/l	2.12	µg/l	136.33	µg/l	3.23	mg/l	16529.53	MPN/100mL	31.84	mg/l
			0.0001829	lb/cf	0.0000382	lb/cf	0.0000173	lb/cf	0.0000063	lb/cf	0.0013509	lb/cf	0.0000011	lb/cf	0.0000001	lb/cf	0.0000085	lb/cf	0.0002019	lb/cf			0.0019871	lb/cf
Total Volume (Quarter Events):			180,624	cf																				
Pollutant Load (Quarter Events):			33.0	lbs	6.9	lbs	3.1	lbs	1.1	lbs	244.0	lbs	0.2	lbs	0.0	lbs	1.5	lbs	36.5	lbs			358.9	lbs
Total Volume (Quarter):			1,369,592	cf																				
Pollutant Load (Quarter):			250.6	lbs	52.3	lbs	23.7	lbs	8.6	lbs	1,850.2	lbs	1.5	lbs	0.2	lbs	11.7	lbs	276.5	lbs			2,721.5	lbs
AVERAGE ANNUAL EMCs:	57.29	7.73	1.98	mg/l	0.74	mg/l	0.38	mg/l	0.13	mg/l	52.58	mg/l	21.20	µg/l	2.45	µg/l	152.16	µg/l	0.46	mg/l	7570.73	mg/l	46.22	mg/l
TOTAL ANNUAL POLLUTANT LOAD (EVENTS):			**122.66**	**lbs**	**33.34**	**lbs**	**15.99**	**lbs**	**5.37**	**lbs**	**2,186.81**	**lbs**	**0.88**	**lbs**	**0.13**	**lbs**	**6.33**	**lbs**	**114.58**	**lbs**			**1,922.42**	**lbs**
Per Acre:			**2.03**		**0.55**		**0.26**		**0.09**		**36.20**		**0.014**		**0.002**		**0.105**		**1.90**				**31.82**	
TOTAL 2017 POLLUTANT LOAD:			**1,246.59**	**lbs**	**345.98**	**lbs**	**166.67**	**lbs**	**55.22**	**lbs**	**22,722.01**	**lbs**	**8.97**	**lbs**	**1.33**	**lbs**	**64.24**	**lbs**	**1,149.74**	**lbs**			**19,738.13**	**lbs**

Anne Arundel County NPDES
Sampling and EMC Data – 2017 Reporting Year
Church Creek Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Duration (Hours)	Intensity (In/Hr)	Temperature - field (oF)	Flow (CF)	pH - field (pH)	dt for BOD (mg/L)	BOD ((0) mg/L)	BOD ((dt) mg/L)	dt for Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	Total Kjeldahl Nitrogen ((dt) mg/L)	dt for Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	Nitrate+ Nitrite - N ((dt) mg/L)	dt for Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)	Total Phosphorus ((dt) mg/L)	dt for TSS (mg/L)	TSS ((0) mg/L)	TSS ((dt) mg/L)	dt for Copper (µg/L)	Copper ((0) µg/L)	Copper ((dt) µg/L)	dt for Lead (µg/L)	Lead ((0) µg/L)	Lead ((dt) µg/L)	dt for Zinc (µg/L)	Zinc ((0) µg/L)	Zinc ((dt) µg/L)	dt for TPH (mg/L)	TPH ((0) mg/L)	TPH ((dt) mg/L)	dt for E-COLI (MPN)	E-COLI ((0) MPN)	E-COLI ((dt) MPN)	dt for HARDNESS (mg/L)	HARDNESS ((0) mg/L)	HARDNESS ((dt) mg/L)
Versar	1	AC	7/28/2016	2130	102	I	S	0.34	3.0	0.11	78.98	10952	6.9	2	9	9	0.5	1.8	1.8	0.05	0.81	0.81	0.01	0.25	0.25	1	29	29	2.0	27.4	27.4	2.0	15.3	15.3	20	217	217	5.0	0.0	5.0	10	1396	1396	1	85	85
Versar	2	AC	7/28/2016	2155	102	I	S				79.52	129017	6.9	2	20	20	0.5	1.1	1.1	0.05	0.67	0.67	0.01	0.19	0.19	1	72	72	2.0	17.2	17.2	2.0	13.0	13.0	20	122	122	5.0	0.0	5.0	10	73	73	1	36	36
Versar	3	AC	7/28/2016	2340	102	I	S				80.42	225359	6.6	2	12	12	0.5	0.9	0.9	0.05	0.59	0.59	0.01	0.06	0.06	1	10	10	2.0	5.9	5.9	2.0	0.0	13.0	20	37	37	5.0	0.0	5.0	10	0	10	1	41	41
										Event Mean Concentration:	**80.06**		**6.71**	**2**	**15**	**15**	**0.5**	**1.0**	**1.0**	**0.05**	**0.62**	**0.62**	**0.01**	**0.11**	**0.11**	**1**	**32**	**32**	**2.0**	**10.5**	**10.5**	**2.0**	**5.0**	**13.1**	**20**	**72**	**72**	**5.0**	**0.0**	**5.0**	**10**	**68**	**74**	**1**	**41**	**41**
Versar	1	AC	9/19/2016	605	102	I	S	1.22	3.0	0.41	74.12	89836	6.7	4	9	9	0.5	1.8	1.8	0.05	0.24	0.24	0.01	0.33	0.33	1	190	190	2.0	8.2	8.2	2.0	7.3	7.3	20	74	74	5.0	0.0	5.0	100	15530	15530	1	NA	NA
Versar	2	AC	9/19/2016	615	102	I	S				73.76	175729	6.4	4	0	4	0.5	0.9	0.9	0.05	0.21	0.21	0.01	0.20	0.20	1	90	90	2.0	9.7	9.7	2.0	7.9	7.9	20	77	77	5.0	0.0	5.0	100	11260	11260	1	NA	NA
Versar	3	AC	9/19/2016	705	102	I	S				73.76	571547	6.6	4	0	4	0.5	0.6	0.6	0.05	0.35	0.35	0.01	0.15	0.15	1	42	42	2.0	8.1	8.1	2.0	8.1	8.1	20	72	72	5.0	0.0	5.0	100	12910	12910	1	NA	NA
										Event Mean Concentration:	**73.80**		**6.57**	**4**	**1**	**5**	**0.5**	**0.8**	**0.8**	**0.05**	**0.31**	**0.31**	**0.01**	**0.18**	**0.18**	**1**	**68**	**68**	**2.0**	**8.5**	**8.5**	**2.0**	**8.0**	**8.0**	**20**	**73**	**73**	**5.0**	**0.0**	**5.0**	**100**	**12845**	**12845**	**1**	NA	NA
Versar	1	AC	9/27/2016	355	102	I	S	1.79	4.5	0.40	66.02	8439	6.7	4	13	13	0.5	4.4	4.4	0.05	0.30	0.30	0.01	1.00	1.00	1	400	400	2.0	36.0	36.0	2.0	20.4	20.4	20	320	320	5.0	0.0	5.0	100	91000	91000	1	72	72
Versar	2	AC	9/27/2016	430	102	I	S				67.28	55894	6.6	4	4	4	0.5	1.7	1.7	0.05	0.20	0.20	0.01	0.24	0.24	1	70	70	2.0	12.8	12.8	2.0	8.9	8.9	20	104	104	5.0	0.0	5.0	100	17850	17850	1	51	51
Versar	3	AC	9/27/2016	545	102	I	S				67.64	72710	6.7	4	0	4	0.5	1.0	1.0	0.05	0.25	0.25	0.01	0.11	0.11	1	23	23	2.0	6.3	6.3	2.0	2.2	2.2	20	45	45	5.0	0.0	5.0	100	12110	12110	1	44	44
										Event Mean Concentration:	**67.39**		**6.66**	**4**	**2**	**5**	**0.5**	**1.5**	**1.5**	**0.05**	**0.23**	**0.23**	**0.01**	**0.22**	**0.22**	**1**	**65**	**65**	**2.0**	**10.8**	**10.8**	**2.0**	**6.0**	**6.0**	**20**	**86**	**86**	**5.0**	**0.0**	**5.0**	**100**	**19309**	**19309**	**1**	**49**	**49**
Versar	1	AC	11/9/2016	855	102	I	S	0.11	7.0	0.02	52.70	27598	6.3	4	7	7	0.5	3.6	3.6	0.05	1.70	1.70	0.01	0.89	0.89	1	52	52	2.0	4.6	4.6	***	***	***	20	70	70	5.0	0.0	5.0	10	1081	1081	1	140	140
Versar	2	AC	11/9/2016	950	102	I	S				53.60	16613	6.3	4	12	12	0.5	1.3	1.3	0.05	1.40	1.40	0.01	0.35	0.35	1	160	160	2.0	11.1	11.1	***	***	***	20	154	154	5.0	0.0	5.0	10	10462	10462	1	150	150
Versar	3	AC	11/9/2016	1125	102	I	S				55.58	27549	6.3	4	12	12	0.5	1.7	1.7	0.05	1.40	1.40	0.01	0.12	0.12	1	11	11	2.0	8.4	8.4	***	***	***	20	70	70	5.0	0.0	5.0	10	209	209	1	100	100
										Event Mean Concentration:	**54.01**		**6.30**	**4**	**10**	**10**	**0.5**	**2.3**	**2.3**	**0.05**	**1.52**	**1.52**	**0.01**	**0.47**	**0.47**	**1**	**61**	**61**	**2.0**	**7.6**	**7.6**	*******	*******	*******	**20**	**89**	**89**	**5.0**	**0.0**	**5.0**	**10**	**2918**	**2918**	**1**	**127**	**127**
Versar	1	AC	11/29/2016	1115	102	I	S	0.08	8.0	0.01	48.74	58583	6.8	4	0	4	0.5	0.0	0.5	0.05	0.91	0.91	0.01	0.09	0.09	1	14	14	2.0	5.8	5.8	2.0	0.0	2.0	20	61	61	5.0	0.0	5.0	10	52	52	1	150	150
Versar	2	AC	11/29/2016	1205	102	I	S				49.46	10486	6.8	4	4	4	0.5	0.9	0.9	0.05	0.96	0.96	0.01	2.60	2.60	1	24	24	2.0	3.5	3.5	2.0	0.0	2.0	20	52	52	5.0	0.0	5.0	10	146	146	1	140	140
Versar	3	AC	11/29/2016	1220	102	I	S				49.46	3039	6.8	4	7	7	0.5	1.0	1.0	0.05	0.96	0.96	0.01	0.23	0.23	1	28	28	2.0	3.6	3.6	2.0	0.0	2.0	20	45	45	5.0	0.0	5.0	10	364	364	1	140	140
										Event Mean Concentration:	**48.88**		**6.80**	**4**	**1**	**4**	**0.5**	**0.2**	**0.6**	**0.05**	**0.92**	**0.92**	**0.01**	**0.46**	**0.46**	**1**	**16**	**16**	**2.0**	**5.4**	**5.4**	**2.0**	**0.0**	**2.0**	**20**	**59**	**59**	**5.0**	**0.0**	**5.0**	**10**	**79**	**79**	**1**	**148**	**148**
Versar	1	AC	12/6/2016	1355	102	I	S	0.78	12.0	0.07	46.40	22690	6.9	4	0	4	0.5	0.0	0.5	0.05	0.76	0.76	0.01	0.08	0.08	1	12	12	2.0	5.9	5.9	2.0	0.0	2.0	20	49	49	5.0	0.0	5.0	100	0	100	1	86	86
Versar	2	AC	12/6/2016	1605	102	I	S				45.68	207310	7.0	4	8	8	0.5	0.6	0.6	0.05	0.26	0.26	0.01	0.14	0.14	1	34	34	2.0	10.1	10.1	2.0	3.9	3.9	20	65	65	5.0	0.0	5.0	100	4650	4650	1	33	33
Versar	3	AC	12/6/2016	2040	102	I	S				45.68	525576	7.0	4	0	4	0.5	1.0	1.0	0.05	0.26	0.26	0.01	0.07	0.07	1	11	11	2.0	5.3	5.3	2.0	0.0	2.0	20	43	43	5.0	0.0	5.0	100	1560	1560	1	33	33
										Event Mean Concentration:	**45.70**		**7.00**	**4**	**2**	**5**	**0.5**	**0.9**	**0.9**	**0.05**	**0.28**	**0.28**	**0.01**	**0.09**	**0.09**	**1**	**17**	**17**	**2.0**	**6.6**	**6.6**	**2.0**	**1.1**	**2.5**	**20**	**49**	**49**	**5.0**	**0.0**	**5.0**	**100**	**2361**	**2364**	**1**	**35**	**35**
Versar	1	AC	1/23/2017	1155	102	I	S	0.49	12.0	0.04	NA	37702	7	2	3	3	0.5	1.3	1.3	0.05	0.56	0.56	0.01	0.12	0.12	1	34	34	2.0	13.0	13.0	2.0	2.9	2.9	20	104	104	5.0	0.0	5.0	10	3448	3448	1	94	94
Versar	2	AC	1/23/2017	1440	102	I	S				NA	280072	7.1	2	3	3	0.5	0.9	0.9	0.05	0.18	0.18	0.01	0.28	0.28	1	88	88	2.0	58.4	58.4	2.0	27.8	27.8	20	361	361	5.0	0.0	5.0	10	4352	4352	1	100	100
Versar	3	AC	1/23/2017	1615	102	I	S				NA	221801	7.1	2	0	2	0.5	0.9	0.9	0.05	0.20	0.20	0.01	0.12	0.12	1	33	33	2.0	7.4	7.4	2.0	2.5	13.0	20	63	63	5.0	0.0	5.0	10	5172	5172	1	48	48
										Event Mean Concentration:	**NA**		**7.09**	**2**	**2**	**3**	**0.5**	**0.9**	**0.9**	**0.05**	**0.21**	**0.21**	**0.01**	**0.20**	**0.20**	**1**	**62**	**62**	**2.0**	**34.3**	**34.3**	**2.0**	**15.7**	**15.7**	**20**	**221**	**221**	**5.0**	**0.0**	**5.0**	**10**	**4626**	**4626**	**1**	**78**	**78**
Versar	1	AC	2/28/2017	1915	102	I	S	0.33	9.0	0.04	54.5	10747.60	7.1	6	0	6	0.5	0.9	0.9	0.05	0.78	0.78	0.01	0.14	0.14	1	43	43	2.0	22.9	22.9	2.0	2.5	2.5	20	117	117	5.0	6.0	6.0	1	121	121	1	91	91
Versar	2	AC	2/28/2017	2030	102	I	S				55.76	86078.26	7.2	2	5	5	0.5	1.0	1.0	0.05	0.44	0.44	0.01	0.14	0.14	1	41	41	2.0	16.8	16.8	2.0	3.8	3.8	20	91	91	5.0	0.0	5.0	1	3130	3130	1	47	47
Versar	3	AC	2/28/2017	2255	102	I	S				55.58	151646.57	7.3	2	3	3	0.5	0.0	0.5	0.05	0.32	0.32	0.01	0.08	0.08	1	13	13	2.0	7.5	7.5	2.0	0.0	2.0	20	49	49	5.0	0.0	5.0	1	2160	2160	1	38	38
										Event Mean Concentration:	**55.60**		**7.26**	**2**	**4**	**4**	**0.5**	**0.4**	**0.7**	**0.05**	**0.38**	**0.38**	**0.01**	**0.10**	**0.10**	**1**	**24**	**24**	**2.0**	**11.4**	**11.4**	**2.0**	**1.4**	**2.6**	**20**	**67**	**67**	**5.0**	**0.3**	**5.0**	**1**	**2408**	**2408**	**1**	**43**	**43**
Versar	1	AC	3/31/2017	735	102	I	S	1.12	10.0	0.11	49.82	23443	7.2	2	23	23	0.5	2.1	2.1	0.05	1.60	1.60	0.01	0.20	0.20	1	23	23	2.0	20.3	20.3	2.0	0.0	2.0	20	82	82	5.0	0.0	5.0	1	2920	2920	1	98	98
Versar	2	AC	3/31/2017	1155	102	I	S				50.00	471171	7.5	2	2	2	0.5	0.8	0.8	0.05	0.32	0.32	0.01	0.17	0.17	1	54	54	2.0	19.0	19.0	2.0	7.1	7.1	20	77	77	5.0	0.0	5.0	1	1410	1410	1	26	26
Versar	3	AC	3/31/2017	1505	102	I	S				51.62	660875	7.3	2	2	2	0.5	0.9	0.9	0.05	0.33	0.33	0.01	0.10	0.10	1	18	18	2.0	11.2	11.2	2.0	2.1	2.1	20	85	85	5.0	0.0	5.0	1	921	921	1	31	31
										Event Mean Concentration:	**50.92**		**7.38**	**2**	**2**	**2**	**0.5**	**0.9**	**0.9**	**0.05**	**0.35**	**0.35**	**0.01**	**0.13**	**0.13**	**1**	**33**	**33**	**2.0**	**14.6**	**14.6**	**2.0**	**4.1**	**4.1**	**20**	**82**	**82**	**5.0**	**0.0**	**5.0**	**1**	**1161**	**1161**	**1**	**30**	**30**

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth	Duration	Intensity	Temperature - field	Flow	pH - field	dt for BOD	BOD	BOD	dt for Total Kjeldahl Nitrogen	Total Kjeldahl Nitrogen	Total Kjeldahl Nitrogen	dt for Nitrate+ Nitrite - N	Nitrate+ Nitrite - N	Nitrate+ Nitrite - N	dt for Total Phosphorus	Total Phosphorus	Total Phosphorus	dt for TSS	TSS	TSS	dt for Copper	Copper	Copper	dt for Lead	Lead	Lead	dt for Zinc	Zinc	Zinc	dt for TPH	TPH	TPH	dt for E-COLI	E-COLI	E-COLI	dt for HARDNESS	HARDNESS	HARDNESS
								Inches	Hours	In/Hr	oF	CF	pH	mg/L	(0) mg/L	(dt) mg/L	mg/L	(0) mg/L	(dt) mg/L	mg/L	(0) mg/L	(dt) mg/L	mg/L	(0) mg/L	(dt) mg/L	mg/L	(0) mg/L	(dt) mg/L	µg/L	(0) µg/L	(dt) µg/L	µg/L	(0) µg/L	(dt) µg/L	µg/L	(0) µg/L	(dt) µg/L	mg/L	(0) mg/L	(dt) mg/L	MPN	(0) MPN	(dt) MPN	mg/L	(0) mg/L	(dt) mg/L
Versar	1	AC	4/25/2017	1240	102	I	S	0.39	5.0	0.08	58.46	8086	7	2	15	15	0.5	2.6	2.6	0.05	0.37	0.37	0.01	0.48	0.48	1	210	210	2.0	45.8	45.8	2.0	11.1	11.1	20	243	243	5.0	5.0	5.0	1	1553	1553	1	79	79
Versar	2	AC	4/25/2017	1320	102	I	S				59.36	130027	7	2	5	5	0.5	1.3	1.3	0.05	0.19	0.19	0.01	0.24	0.24	1	88	88	2.0	21.0	21.0	2.0	6.4	6.4	20	84	84	5.0	0.0	5.0	1	2420	2420	1	35	35
Versar	3	AC	4/25/2017	1605	102	I	S				60.08	276979	7.2	2	0	2	0.5	0.0	0.5	0.05	0.22	0.22	0.01	0.09	0.09	1	15	15	2.0	16.4	16.4	2.0	0.0	2.0	20	38	38	5.0	0.0	5.0	1	2420	2420	1	36	36
										Event Mean Concentration:	**59.82**		**7.13**	**2**	**2**	**3**	**0.5**	**0.5**	**0.8**	**0.05**	**0.21**	**0.21**	**0.01**	**0.14**	**0.14**	**1**	**42**	**42**	**2.0**	**18.4**	**18.4**	**2.0**	**2.2**	**3.6**	**20**	**56**	**56**	**5.0**	**0.1**	**5.0**		**	**	**1**	**37**	**37**
Versar	1	AC	5/12/2017	2255	102	I	S	0.98	21.0	0.05	57.38	92661	7.1	2	0	2	0.5	0.7	0.7	0.05	0.29	0.29	0.01	0.05	0.05	1	11	11	2.0	7.0	7.0	2.0	0.0	2.0	20	40	40	5.0	7.0	7.0	1	909	909	1	24	24
Versar	2	AC	5/13/2017	415	102	I	S				54.68	420994	7.2	2	0	2	0.5	0.0	0.5	0.05	0.14	0.14	0.01	0.09	0.09	1	24	24	2.0	6.8	6.8	2.0	2.6	2.6	20	44	44	5.0	0.0	5.0	1	2613	2613	1	42	42
Versar	3	AC	5/13/2017	1010	102	I	S				55.40	585240	7.2	2	0	2	0.5	0.0	0.5	0.05	0.16	0.16	0.01	0.07	0.07	1	9	9	2.0	5.1	5.1	2.0	0.0	2.0	20	35	35	5.0	0.0	5.0	1	4352	4352	1	27	27
										Event Mean Concentration:	**55.29**		**7.19**	**2**	**0**	**2**	**0.5**	**0.1**	**0.5**	**0.05**	**0.16**	**0.16**	**0.01**	**0.08**	**0.08**	**1**	**15**	**15**	**2.0**	**5.9**	**5.9**	**2.0**	**1.0**	**2.2**	**20**	**39**	**39**	**5.0**	**0.6**	**5.2**	**1**	**3395**	**3395**	**1**	**32**	**32**
Versar	1	AC	6/19/2017	1635	102	I	S	0.36	4.0	0.09	79.16	7734	6.9	2	7	7	0.5	0.6	0.6	0.05	0.91	0.91	0.01	0.27	0.27	1	43	43	2.0	408.0	408.0	2.0	401.0	401.0	20	3600	3600	5.0	12.0	12.0	1	22470	22470	1	230	230
Versar	2	AC	6/19/2017	1740	102	I	S				79.34	177693	7.1	2	12	12	0.5	1.3	1.3	0.05	0.59	0.59	0.01	0.22	0.22	1	94	94	2.0	23.0	23.0	2.0	9.0	9.0	20	125	125	5.0	0.0	5.0	1	26130	26130	1	42	42
Versar	3	AC	6/19/2017	1915	102	I	S				79.16	176785	6.9	2	4	4	0.5	0.0	0.5	0.05	0.50	0.50	0.01	0.12	0.12	1	25	25	2.0	9.0	9.0	2.0	2.0	2.0	20	51	51	5.0	0.0	5.0	1	13540	13540	1	39	39
										Event Mean Concentration:	**79.25**		**7.00**	**2**	**8**	**8**	**0.5**	**0.7**	**0.9**	**0.05**	**0.55**	**0.55**	**0.01**	**0.17**	**0.17**	**1**	**59**	**59**	**2.0**	**24.4**	**24.4**	**2.0**	**14.0**	**14.0**	**20**	**163**	**163**	**5.0**	**0.3**	**5.1**	**1**	**19907**	**19907**	**1**	**45**	**45**

** Samples were not diluted - the data has been discarded and not included in subsequent flow weighted EMC and loading calculations

*** Error in results - the data has been discarded and not included in subsequent flow weighted EMC and loading calculations

Anne Arundel County NPDES
Sampling and EMC Data – 2017 Reporting Year
Church Creek Station

	oF	pH	(0) mg/L	(dt) mg/L	(0) mg/L	(dt) mg/L	(0) mg/L	(dt) mg/L	(0) mg/L	(dt) mg/L	(0) mg/L	(dt) mg/L	(0) µg/L	(dt) µg/L	(0) µg/L	(dt) µg/L	(0) µg/L	(dt) µg/L	(0) mg/L	(dt) mg/L	(0) MPN	(dt) MPN	(0) mg/L	(dt) mg/L
	Temperature - field	pH - field	BOD	BOD	Total Kjeldahl Nitrogen	Total Kjeldahl Nitrogen	Nitrate+ Nitrite - N	Nitrate+ Nitrite - N	Total Phosphorus	Total Phosphorus	TSS	TSS	Copper	Copper	Lead	Lead	Zinc	Zinc	TPH	TPH	E-COLI	E-COLI	HARDNESS	HARDNESS
Summer Quarter Flow-Weighted EMC (7/28/16, 9/19/16, 9/27/16):	74.85	6.62	4.87	7.32	0.92	0.92	0.39	0.39	0.17	0.17	58.02	58.02	9.27	9.27	7.00	9.19	74.15	74.15	0.00	5.00	10021.38	10023.06	42.74	42.74
Average:			6.10	mg/l	0.92	mg/l	0.39	mg/l	0.17	mg/l	58.02	mg/l	9.27	µg/l	8.09	µg/l	74.15	µg/l	2.50	mg/l	10022.22	MPN/100mL	42.74	mg/l
			0.0003805	lb/cf	0.0000574	lb/cf	0.0000242	lb/cf	0.0000103	lb/cf	0.0036211	lb/cf	0.0000006	lb/cf	0.0000005	lb/cf	0.0000046	lb/cf	0.0001560	lb/cf			0.0026678	lb/cf
Total Volume (Quarter Events):			1,339,485	cf																				
Pollutant Load (Quarter Events):			509.6	lbs	76.9	lbs	32.4	lbs	13.8	lbs	4,850.4	lbs	0.8	lbs	0.7	lbs	6.2	lbs	209.0	lbs			3,573.5	lbs
Total Volume (Quarter):			28,590,186	cf																				
Pollutant Load (Quarter):			10,877.5	lbs	1,641.4	lbs	691.0	lbs	294.6	lbs	103,527.3	lbs	16.5	lbs	14.4	lbs	132.3	lbs	4,461.2	lbs			76,273.6	lbs
Fall Quarter Flow-Weighted EMC (11/9/16, 11/29/16, 12/6/17):	46.62	6.93	2.72	5.42	0.92	0.97	0.43	0.43	0.15	0.15	20.74	20.74	6.60	6.60	0.97	2.47	53.37	53.37	0.00	5.00	2222.45	2224.97	51.06	51.06
Average:			4.07	mg/l	0.95	mg/l	0.43	mg/l	0.15	mg/l	20.74	mg/l	6.60	µg/l	1.72	µg/l	53.37	µg/l	2.50	mg/l	2223.71	MPN/100mL	51.06	mg/l
			0.0002539	lb/cf	0.0000590	lb/cf	0.0000266	lb/cf	0.0000093	lb/cf	0.0012946	lb/cf	0.0000004	lb/cf	0.0000001	lb/cf	0.0000033	lb/cf	0.0001560	lb/cf			0.0031871	lb/cf
Total Volume (Quarter Events):			899,444	cf																				
Pollutant Load (Quarter Events):			228.3	lbs	53.1	lbs	23.9	lbs	8.4	lbs	1,164.4	lbs	0.4	lbs	0.1	lbs	3.0	lbs	140.3	lbs			2,866.6	lbs
Total Volume (Quarter):			19,349,299	cf																				
Pollutant Load (Quarter):			4,912.4	lbs	1,142.0	lbs	514.0	lbs	180.7	lbs	25,048.8	lbs	8.0	lbs	2.1	lbs	64.5	lbs	3,019.3	lbs			61,668.6	lbs
Winter Quarter Flow-Weighted EMC (1/23/17, 2/28/17, 3/31/17):	37.38	7.28	2.39	2.65	0.83	0.87	0.32	0.32	0.15	0.15	39.66	39.66	19.63	19.63	6.97	8.34	118.27	118.27	0.03	5.01	2282.32	2282.32	45.29	45.29
Average:			2.52	mg/l	0.85	mg/l	0.32	mg/l	0.15	mg/l	39.66	mg/l	19.63	µg/l	7.66	µg/l	118.27	µg/l	2.52	mg/l	2282.32	MPN/100mL	45.29	mg/l
			0.0001572	lb/cf	0.0000532	lb/cf	0.0000198	lb/cf	0.0000092	lb/cf	0.0024757	lb/cf	0.0000012	lb/cf	0.0000005	lb/cf	0.0000074	lb/cf	0.0001572	lb/cf			0.0028267	lb/cf
Total Volume (Quarter Events):			1,943,537	cf																				
Pollutant Load (Quarter Events):			305.6	lbs	103.3	lbs	38.5	lbs	17.9	lbs	4,811.6	lbs	2.4	lbs	0.9	lbs	14.3	lbs	305.6	lbs			5,493.8	lbs
Total Volume (Quarter):			22,568,474	cf																				
Pollutant Load (Quarter):			3,548.5	lbs	1,199.7	lbs	447.2	lbs	207.4	lbs	55,872.1	lbs	27.7	lbs	10.8	lbs	166.6	lbs	3,548.8	lbs			63,794.1	lbs
Spring Quarter Flow-Weighted EMC (4/25/17, 5/12/17, 6/19/17):	60.92	7.14	1.95	3.42	0.26	0.65	0.25	0.25	0.11	0.11	29.39	29.39	12.23	12.23	3.76	4.78	66.70	66.70	0.42	5.13	7488.72	7488.72	35.71	35.71
Average:			2.69	mg/l	0.46	mg/l	0.25	mg/l	0.11	mg/l	29.39	mg/l	12.23	µg/l	4.27	µg/l	66.70	µg/l	2.77	mg/l	7488.72	MPN/100mL	35.71	mg/l
			0.0001677	lb/cf	0.0000285	lb/cf	0.0000156	lb/cf	0.0000068	lb/cf	0.0018344	lb/cf	0.0000008	lb/cf	0.0000003	lb/cf	0.0000042	lb/cf	0.0001730	lb/cf			0.0022291	lb/cf
Total Volume (Quarter Events):			1,876,198	cf																				
Pollutant Load (Quarter Events):			314.6	lbs	53.4	lbs	29.2	lbs	12.9	lbs	3,441.7	lbs	1.4	lbs	0.5	lbs	7.8	lbs	324.6	lbs			4,182.1	lbs
Total Volume (Quarter):			25,158,577.5	cf																				
Pollutant Load (Quarter):			4,219.0	lbs	716.1	lbs	392.0	lbs	172.3	lbs	46,150.4	lbs	19.2	lbs	6.7	lbs	104.7	lbs	4,353.1	lbs			56,079.8	lbs
AVERAGE ANNUAL EMCs:	54.33	7.04	2.85	mg/l	0.69	mg/l	0.33	mg/l	0.14	mg/l	37.73	mg/l	13.12	µg/l	5.09	µg/l	82.91	µg/l	0.14	mg/l	5596.70	mg/l	42.62	mg/l
TOTAL ANNUAL POLLUTANT LOAD (EVENTS):			1,358.19	lbs	286.71	lbs	124.01	lbs	52.91	lbs	14,267.97	lbs	4.96	lbs	2.20	lbs	31.35	lbs	979.61	lbs			16,116.07	lbs
Per Acre:			4.87		1.03		0.44		0.19		51.12		0.02		0.01		0.11		3.51				57.75	
TOTAL 2017 POLLUTANT LOAD:			23,557.41	lbs	4,699.28	lbs	2,044.22	lbs	854.98	lbs	230,598.58	lbs	71.38	lbs	34.01	lbs	468.11	lbs	15,382.44	lbs			257,816.15	lbs

APPENDIX H

BMP CODES

MDE Approved BMP Classifications

ESD BMPs		
Category	Code	Code Description
Alternative Surfaces (A)		
E	AGRE	Green Roof - Extensive
E	AGRI	Green Roof - Intensive
E	APRP	Permeable Pavements
E	ARTF	Reinforced Turf
Nonstructural Techniques (N)		
E	NDRR	Disconnection of Rooftop Runoff
E	NDNR	Disconnection of Non-Rooftop Runoff
E	NSCA	Sheetflow to Conservation Areas
Micro-Scale Practices (M)		
E	MRWH	Rainwater Harvesting
E	MSGW	Submerged Gravel Wetlands
E	MILS	Lanscape Infiltration
E	MIBR	Infiltration Berms
E	MIDW	Dry Wells
E	MMBR	Micro-Bioretention
E	MRNG	Rain Gardens
E	MSWG	Grass Swale
E	MSWW	Wet Swale
E	MSWB	Bio-Swale
E	MENF	Enhanced Filters
Structural BMPs		
Ponds (P)		
S	PWED	Extended Detention Structure, Wet
S	PWET	Retention Pond (Wet Pond)
S	PMPS	Mutliple Pond System
S	PPKT	Pocket Pond
S	PMED	Micropool Extended Detention Pond
Wetlands (W)		
S	WSHW	Shallow Marsh
S	WEDW	ED - Wetland
S	WPWS	Wet Pond - Wetland
S	WPKT	Pocket Wetland
Infiltration (I)		
S	IBAS	Infiltration Basin
S	ITRN	Infiltration Trench

Filtering Systems (F)		
S	FBIO	Bioretention
S	FSND	Sand Filter
S	FUND	Underground Filter
S	FPER	Perimeter (Sand) Filter
S	FORG	Organic Filter (Peat Filter)
S	FBIO	Bioretention
Open Channels (O)		
S	ODSW	Dry Swale
S	OWSW	Wet Swale
Other Practices (X)		
S	XDPD	Detention Structure (Dry Pond)
S	XDED	Extended Detention Structure, Dry
S	XFLD	Flood Management Area
S	XOGS	Oil Grit Separator
S	XOTH	Other

MDE Approved Alternative BMP Classifications

Alt. BMPs (A)	Code	Code Description
A	MSS	Mechanical Street Sweeping
A	VSS	Regenerative/Vacuum Street Sweeping
A	IMPP	Impervious Surface Elimination (to pervious)
A	IMPF	Impervious Surface Elimination (to forest)
A	FPU	Planting Trees or Forestation on Pervious Urban
A	CBC	Catch Basin Cleaning
A	SDV	Storm Drain Vacuuming
A	STRE	Stream Restoration
A	OUT	Outfall Stabilization
A	SPSC	Regenerative Step Pool Storm Conveyance
A	SHST	Shoreline Management
A	SEPP	Septic Pumping
A	SEPD	Septic Denitrification
A	SEPC	Septic Connections to WWTP

APPENDIX I

BMP ACRONYMS

MDE-APPROVED BMP TYPE ACRONYMS

BMP—Best Management Practice

APRP—Permeable Pavements

FBIO—Bioretention

FSND—Sand Filter

IBAS—Infiltration Basin

IMPP—Impervious Surface Elimination (to pervious)

ITRN—Infiltration Trench

MMBR—Micro-Bioretention

MSGW—Submerged Gravel Wetlands

MSWG—Grass Swale

MSWW—Wet Swale

NDRR—Disconnection of Rooftop Runoff

ODSW—Dry Swale

OWSW—Wet Swale

PWED—Extended Detention Structure, Wet

XDED—Extended Detention Structure, Dry

XDPD—Detention Structure (Dry Pond)

XOGS—Oil Grit Separator