CHEMICAL, BIOLOGICAL, AND PHYSICAL CHARACTERIZATION OF THE CHURCH CREEK AND PAROLE PLAZA NPDES MONITORING STATIONS: 2015 - 2016

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 2015 through June 2016.

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 2016 sampling period, July 2015 through June 2016, ten storm events were sampled and two baseflow samples were collected 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, Inc., 2015a, 2015b, and 2015c) 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 2015 through June 2016. 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, ten storm samples and two baseflow samples were collected. Baseflow samples were taken in lieu of storm samples for the following reasons:

- **December 10, 2015 Baseflow -** During the first two months of the fall quarter, there were five storms with rain amounts greater than 0.1 inches; one of them was successfully monitored. The total rainfall recorded in October and November was 5.1”. Because of the low number of eligible rain events during this quarter, baseflow samples were collected on December 10.

- **March 24, 2016 Baseflow -** Snow, rain, and wintry mix throughout January, February, and March produced a runoff event at least once per week, on average, which limited sampling opportunities. Because of the limited storm runoff sampling opportunities during this quarter, baseflow samples were collected on March 24.

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.

- August 20, 2015 Storm - The total rainfall for this event was 0.10" and lasted approximately 2.0 hours, based on data from the Church Creek rain gauge.
- September 10, 2015 Storm - The total rainfall for this event was 1.92" and lasted approximately 5.0 hours, based on data from the Church Creek rain gauge.
- September 29, 2015 Storm - The total rainfall for this event was 1.79" and lasted approximately 4.5 hours, based on data from the Church Creek rain gauge.
- November 9, 2015 Storm - The total rainfall for this event was 0.64" and lasted approximately 8.0 hours, based on data from the Church Creek rain gauge.
- December 17, 2015 Storm - The total rainfall for this event was 0.31" and lasted 10.0 hours, based on data from the Church Creek rain gauge.
- February 16, 2016 Storm - The total rainfall for this event was 1.2" and lasted approximately 8.0 hours, based on data from the Church Creek rain gauge.
- March 14, 2016 Storm - The total rainfall for this event was 0.42" and lasted 8.0 hours, based on data from the Church Creek rain gauge.
- April 4, 2016 - The total rainfall for this event was 0.19" and lasted approximately 7.0 hours, based on data from the Church Creek rain gauge.
- May 17, 2016 - The total rainfall for this event was 0.27" and lasted approximately 10.0 hours, based on data from the Church Creek rain gauge.
- June 16, 2016 - The total rainfall for this event was 0.29" and lasted approximately 8.0 hours, based on data from the Church Creek rain gauge.

A total of 31.11 inches of precipitation was recorded at the Church Creek station during the 2016 reporting period. Rainfall was measured using a tipping bucket rain gage located at the Church Creek station. Note that due to a gauge clog occurring in July 2015, approximately 4.81 inches of rain may not have been recorded when compared to Anne Arundel County's Weems Creek gauge (C. Victoria, pers. comm. January 4, 2017).

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 and baseflow events

Date	Rainfall (inches)
20 August 2015	0.10
10 September 2015	1.92
29 September 2015	1.79
9 November 2015	0.64
10 December 2015	0.00 (Baseflow)
17 December 2015	0.31
16 February 2016	1.20
14 March 2016	0.42
24 March 2016	0.00 (Baseflow)
7 April 2016	0.19
17 May 2016	0.27
16 June 2016	0.29

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. A Technical Memorandum describing the 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., and Chesapeake Environmental Lab, Inc. All *E. coli* samples were delivered to the Chesapeake Environmental Lab for processing within six hours of being collected, and all other samples were delivered to Martel Laboratories JDS 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:

- During the August 31 maintenance visit, the suction line for the ISCO sampler was replaced. Also during this visit, the rain gauge was found clogged and full of water. The field crew unclogged the rain gauge and checked the tipping bucket mechanism for proper functioning; affected values are highlighted in the data spreadsheet. The Versar field crew discovered dead batteries on August 25 in the RCP logger at Parole Plaza; therefore, continuous level data are missing from August 12 until the routine maintenance on August 25 at 12:05 p.m. when the batteries were replaced. During the September 29 storm event, the field team accidently deleted the level data (September 22 – September 29) while downloading the data from the RCP logger for the storm to determine the flow rate. Level data during both of these time frames were estimated by applying a correction curve.

- While cleaning the pH probe during routine maintenance on October 12, a staff member accidentally broke the sensor ball on the pH probe; the probe was subsequently replaced later that day. Five water quality measurements in the Church Creek continuous data record are not accurate because data were recorded during calibration and repair of equipment (10/12/15 and 11/2/15). Additionally, there are unexplained, missing data from 10:25 a. m. to 11:25 a. m. on December 7; the anomalous data are highlighted in the raw data tab in the file.

- Due to the blizzard at the end of January, Versar skipped one of the biweekly visits for safety reasons. Though the team was able to travel to the site (February 1), the YSI could not be calibrated due to high flows caused by snow melt. The YSI was finally calibrated on February 29 during routine maintenance. After calibrating the pH probe during the routine maintenance visit on January 14, low pH values were noted when it was reinstalled into the stream. The field team performed an accuracy check on the pH probe after observing the low values; the pH values were found to be accurate. Prior to the arrival of the March 14 storm, during the routine maintenance, Versar adjusted the time for both loggers for Daylight Savings Time (DST).

- During the March 14 storm event at Parole Plaza, the field team accidentally deleted level data while copying and pasting the storm levels. Affected data include: February 29 at 11:35 a.m. until March 13 at 10:35 p.m. for the CMP, and from February 29 at 11:30 a.m. until March 13 at 10:30 p.m. for RCP. To prevent a recurrence of this problem, two copies of the downloaded data are made.

- On April 1 at 5:55 p.m., pH values began to decrease below neutral (7.0). Calibrations on March 24 (before) and April 19 (after) were equivalent to the calibration solution, therefor the readings are accurate. “Suds” that flowed through the site several times throughout winter and early spring may have impacted pH levels. During a maintenance trip before the May 17 storm, the field crew accepted an “out of range” pH reading during calibration, which calls into question the accuracy of pH recordings, especially those taken during the storm. Therefore, no pH data for Church Creek are compiled in the storm and EMC spreadsheets. Further investigation over the next several weeks identified a faulty pH probe. On June 30 at 10:20 a.m., the county’s YSI was replaced with Versar’s YSI 600 XL multiparameter sonde. All questionable pH values are highlighted in red. During the June 16 storm event, the field crew used a calibrated Pro DSS YSI to measure pH for accuracy. These values are listed in the EMC spreadsheet for this storm event.

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 2016 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.

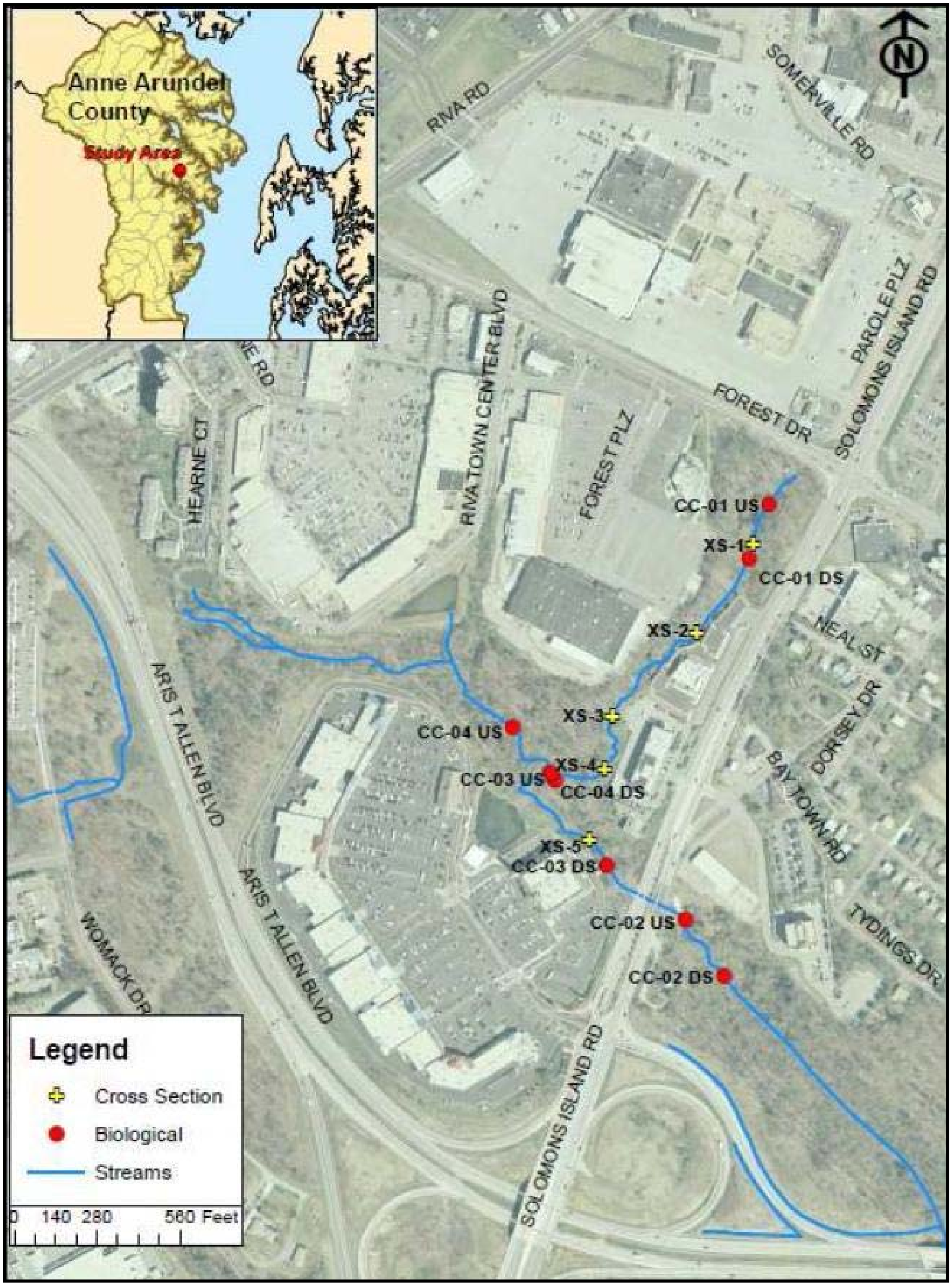

Figure 2-1. Church Creek study area and stream monitoring locations

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 March 2016 following the MBSS Spring index period protocols (DNR, 2010) 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 root-wads, 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 2016. 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 2016 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

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 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

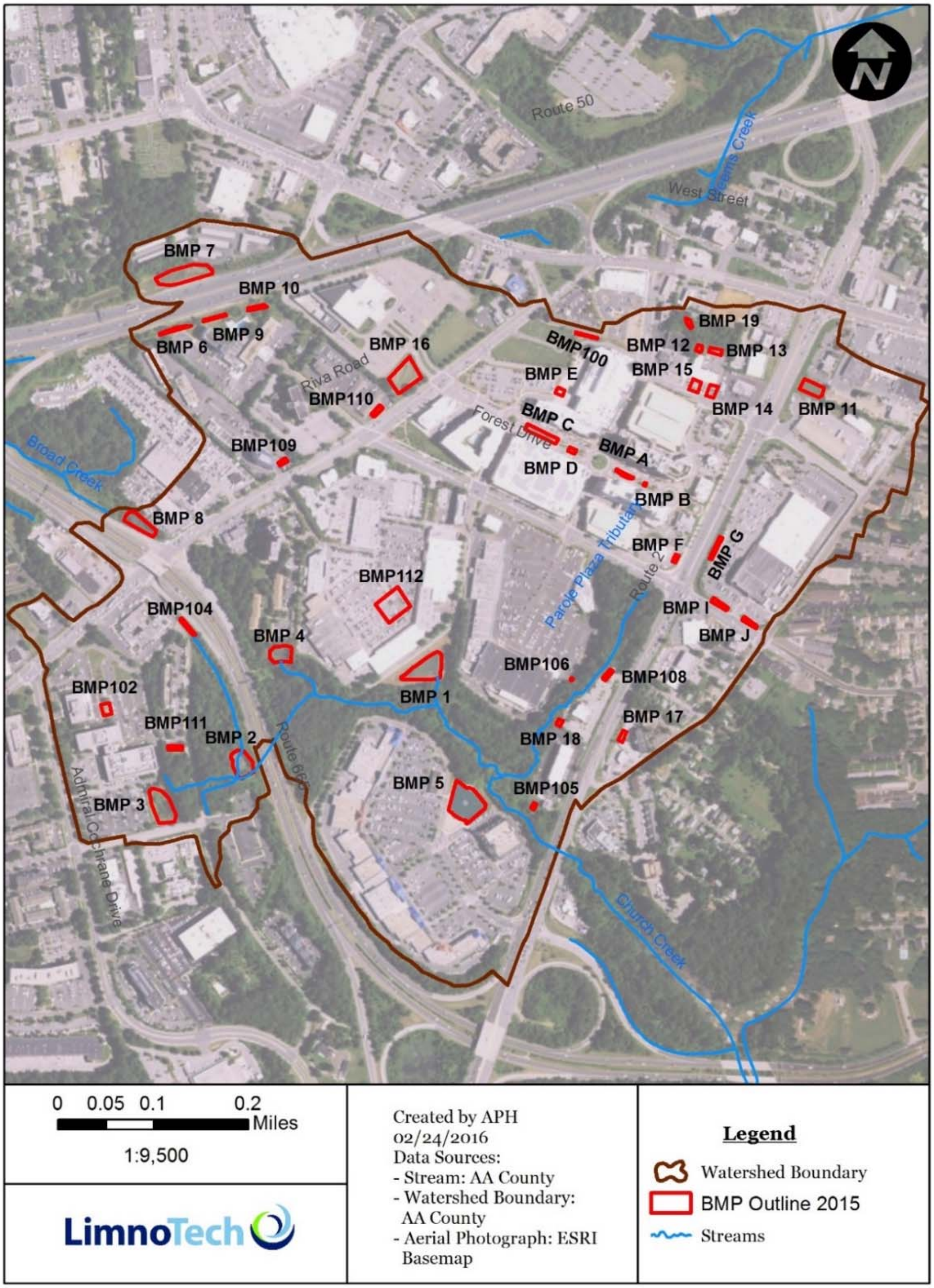

Figure 2-2. Church Creek BMPs

information indicates there has been no change in land use in this watershed since the 2013 land use evaluation.

2.4.1 Church Creek Watershed BMP Inspections

The Church Creek watershed contains 40 BMPs (29 of which are currently in the County's BMP inventory database), as shown in Figure 2-2 and Table 2-11. Inspections were conducted on December 9 and 12, 2015 and January 13, 2016. Inspections at BMPs under the County's jurisdiction are carried out regularly and records are maintained at the County office. Each BMP was inspected during dry weather conditions (defined as a minimum 48 hours of dry weather since the last rain event). A brief overview of actions recommended to address maintenance/performance issues at specific BMPs are in the following section. Further details, including the detailed inspection findings for each of the BMPs, inspection forms, and photographs, are included in Appendix I.

All of the stormwater BMPs identified during the last inspection in 2013 were inspected again during this effort. No new BMPs have been installed since the 2013 inspection (Versar 2013) and so no new BMPs were inspected; however, the most recent inspections did provide more precise data on the BMPs compared to the 2013 inspections. In addition, some BMPs that were inspected are not included in the County's BMP inventory database or have since been more precisely located outside of the Church Creek watershed. Inspected BMPs that are not in the County's database are a legacy of previous BMP inspections, and were inspected during this effort because they were inspected in 2013.

2.4.2 Summary of Recommended Priority Actions

This section summarizes the results of the inspection of each BMP for its physical condition. In addition, this report notes if there were any issues with the way that BMPs are characterized in the County's BMP inventory database. For 'Physical Issues,' the BMPs are grouped into three categories: those for which immediate attention is recommended; those that show early signs of stress but do not require corrective action at this point; and those that are in good condition. For 'Database Issues' the BMPs are grouped into two categories - those that have classification issues; and those that are missing from the database, are not located correctly, or require some other changes to be made.

Note that some of the BMPs identified for immediate action are owned by Maryland State Highway Administration (SHA) or private owners; in these cases, the County will need to coordinate with BMP owners to address maintenance issues.

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)©	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)©	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

2.4.2.1 Physical Issues

Immediate action recommended:

- BMP 19, located at 2200 Somerville Road, should be considered non-functional and failing. The inspection revealed standing water, significant amounts of trash, heavy vegetative debris, and a clogged orifice. Immediate action is recommended to restore this BMP to its original condition.
- The low flow orifice for BMP 1 appears to be clogged with trash. Trash should be removed for optimal BMP performance.BMP 6 shows evidence of erosion and is becoming choked with vegetation growth and roadside trash. Erosion and vegetation should be managed for better performance.
- BMP 9 is becoming choked with vegetation growth and roadside trash. Vegetation should be managed for better performance.
- BMP 10 is full of invasive vegetation and debris. Ponding is also present in the basin. A complete retrofit of this BMP is necessary.
- BMP 4 had an eroding hole in the southern embankment as well as ponding, suggesting it is either failing or has been misclassified. This BMP should be evaluated for either maintenance or to correct the information in the database
- BMPs 2 and 8 have standing water even though the BMPs are classified as a Dry Pond and an Infiltration Basin, respectively. These BMPs are either failing or are Extended Detention Structures, Wet (PWED that have been characterized incorrectly. These BMPs should be evaluated for either maintenance or to correct the information in the database.
- BMP 102 has standing water, debris buildup, and missing curb cuts for two flow-in points to the BMP. Removal of leaf debris and installation of curb cuts in east parking lot are recommended.
- BMP 104 has standing water, trash and vegetation debris, as well as heavy invasive plant coverage. Immediate remediation is necessary for this BMP to function properly.
- BMP 105 has standing water and heavy invasive plant coverage. Remediation is necessary for this BMP to function. This BMP was deleted from the 2015 database; however, it was included in the maps and database used during the inspection process.

Showing early signs of stress, but no immediate action recommended:

- BMP 3 contains some invasive vegetation and shows evidence of sedimentation.
- BMP 11 may require sediment removal from the flow-in points to the BMP. Sediment berms approximately the same elevation of the curb may be preventing storm runoff from entering the BMP.

- BMP 12 shows signs of nascent erosion.
- BMP 7 has vegetation covering the north fence line and a small amount of invasive vegetation. This structure is classified as a Detention Structure (Dry Pond) (XDPD); however, it has standing water inside the structure. The fence should be cleared and this BMP should be evaluated for either maintenance or to correct the information in the database.
- BMPs B, E, 17, and 106 have standing water inside the structure.

In good condition:

- BMPs 5, 13, 14, 15, 16, 100, 101, 108, 109, 110, and 111 are in good condition.
- BMPs 18, A, C, D, F, G, I, and J are in good condition except for a small amount of trash or debris.

2.4.2.2 Database Issues

BMP classification issues:

- BMP classifications have changed from 2013 to 2015 for BMPs 7, 11, 14, 15, A, 102, and 110 based on updated data from the 2015 database. However, field observations of these BMPs do not support the classification changes for these BMPs. It is recommended that these BMPs undergo further investigation to reconcile information in the database with field observations.
- BMP classifications have changed from 2013 to 2015 for BMPs 1, 3, 4, 5, 12, 13, 16, 17, 18, B, C, D, E, and F based on updated data from the 2015 database. These updates appear to be appropriate based on field observation of these BMPs and are noted here for completeness.

Recommended changes to individual BMPs in the BMP inventory database:

- BMPs 2, 6, 8, 9, 10, 18, 19, G, I, J, 101, 103, and 105 are not currently included in the Urban BMP database. LimnoTech recommends adding these BMPs to the database.
- The location of BMP 7 data point in the Database appears incorrect. It is currently situated on a building to the northeast of the actual pond.

3 RESULTS

3.1 POLLUTANT CONCENTRATIONS

During this sampling period, 64 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	Dry Weather	Wet Weather
BOD_5 (mg/L)	2.0	75	12
TKN (mg/L)	0.5	25	22
Nitrate + Nitrite (mg/L)	0.05	0	0
Total Phosphorus (mg/L)	0.01	0	0
TSS (mg/L)	1.0	0	0
Total Copper (µg/L)	2.0	25	0
Total Lead (µg/L)	2.0	100	27
Total Zinc (µg/L)	20	0	0
TPH (mg/L)	5.0	100	80
E. coli (MPN/100 ml)	10.0	25	0
Hardness (mg/L)	1.0	0	0

Tables 3-2 and 3-3 show the maximum values observed for dry and 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 3-4. Parole Plaza had the highest values for seven of the thirteen parameters measured during wet weather sampling in 2016. At Church Creek, maximum wet weather values for all metrics excluding zinc were measured during the September 10 storm event. The maximum zinc concentration at Church Creek was 712 µg/L and observed during the November 9 storm. Chemical monitoring summaries can be found in Appendix G.

Table 3-2. Maximum dry weather values observed during sampling period		
Parameter	**Church Creek**	**Parole Plaza**
Water Temperature (°F)	49.1	59.8
pH	6.80	7.26
BOD_5 (mg/L)	4	BDL
TKN (mg/L)	0.9	0.7
Nitrate + Nitrite (mg/L)	1.20	5.40
Total Phosphorus (mg/L)	0.07	0.03
TSS (mg/L)	15	9
Total Copper (µg/L)	2	9
Total Lead (µg/L)	BDL	BDL
Total Zinc (µg/L)	850	120
TPH (mg/L)	BDL	BDL
E. coli (MPN/100 ml)	243	73
Hardness (mg/L)	140	210
BDL: Below Detection Limit		

Table 3-3. Maximum wet weather values observed during sampling period		
Parameter	**Church Creek**	**Parole Plaza**
Water Temperature (°F)	79.9	81.0
pH	7.15	8.79
BOD_5 (mg/L)	40	46
TKN (mg/L)	4.1	2.6
Nitrate + Nitrite (mg/L)	1.80	1.30
Total Phosphorus (mg/L)	1.70	0.25
TSS (mg/L)	280	220
Total Copper (µg/L)	67	180
Total Lead (µg/L)	43	18
Total Zinc (µg/L)	712	430
TPH (mg/L)	10	11
E. coli (MPN/100 ml)	38,730	72,700
Hardness (mg/L)	410	750
BDL: Below Detection Limit		

Table 3-4. Storm dates for wet weather maximum values

Parameter	Date of Storm	Site	Maximum Value
Water Temperature (°F)	8/20/15	Parole Plaza	81.0
pH	4/7/16	Parole Plaza	8.79
BOD_5 (mg/L)	4/7/16	Parole Plaza	46
TKN (mg/L)	9/10/15	Church Creek	4.1
Nitrate + Nitrite (mg/L)	9/10/15	Church Creek	1.80
Total Phosphorus (mg/L)	9/10/15	Church Creek	1.70
TSS (mg/L)	9/10/15	Church Creek	280
Total Copper (µg/L)	5/17/16	Parole Plaza	180
Total Lead (µg/L)	9/10/15	Church Creek	43
Total Zinc (µg/L)	11/9/15	Church Creek	712
TPH (mg/L)	2/16/16	Parole Plaza	11
E. coli (MPN/100 ml)	9/10/15	Parole Plaza	72,700
Hardness (mg/L)	2/16/16	Parole Plaza	750

3.2 EVENT MEAN CONCENTRATIONS AND POLLUTANT LOADINGS

Flow-weighted stormflow event mean concentrations (EMCs) values are presented in Table 3-5. EMCs for BOD, TKN, combined nitrate and nitrite, total phosphorus, TSS, lead, zinc, and TPH were higher at Church Creek than at Parole Plaza.

Summed loads for the sampled events monitored during the July 2015 to June 2016 sampling period are shown in Table 3-6. Church Creek per-acre loading rates for monitored events were higher than Parole Plaza for all parameters.

Table 3-5. Average EMCs observed during July 2015 to June 2016

Parameter	Church Creek	Parole Plaza
Water Temperature (°F)	63.5	66.8
pH	6.38	7.51
BOD_5 (mg/L)	7	3
TKN (mg/L)	0.7	0.5
Nitrate + Nitrite (mg/L)	0.44	0.40
Total Phosphorus (mg/L)	0.14	0.12
TSS (mg/L)	55	43
Total Copper (µg/L)	12.2	20.9
Total Lead (µg/L)	6.8	2.7
Total Zinc (µg/L)	98	11
TPH (mg/L)	1.5	1.1
E. coli (MPN/100 ml)	8,049	18,268
Hardness (mg/L)	44	49

Table 3-6. Estimated pollutant loadings for observed events, in pounds, for the July 2015 to June 2016 sampling period

Parameter	Church Creek		Parole Plaza	
	Total	Per Acre	Total	Per Acre
BOD_5	4,023.04	14.41	123.88	2.05
TKN	451.24	1.62	19.61	0.32
Nitrate + Nitrite	240.82	0.86	12.83	0.21
Total Phosphorus	77.29	0.28	3.95	0.07
TSS	30,223.75	108.29	1,392.17	23.05
Total Copper	6.73	0.024	0.68	0.011
Total Lead	3.79	0.014	0.10	0.002
Total Zinc	54.16	0.194	3.58	0.059
TPH	1948.83	6.98	103.15	1.71
Hardness	24,464.06	87.66	1,588.75	26.30

3.3 BIOLOGICAL ASSESSMENT

Biological and physical habitat assessments were completed on March 23 and 24, 2016. 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 “Degraded” for three sites and “Partially Degraded” for one site (Table 3-7). Index scores ranged from a low of 58.5 at CC-02 to a high of 68.6 at CC-03. 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 that are 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 3-7). Scores ranged from 61 at CC-02 to 76 at CC-01. Generally, epifaunal substrate/cover, embeddedness, 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 3-7. PHI and RBP physical habitat assessment results - 2016				
Site	PHI Score	PHI Narrative Rating	RBP Score	RBP Narrative Rating
CC-01	64.8	Degraded	71	Partially Supporting
CC-02	58.5	Degraded	61	Partially Supporting
CC-03	68.6	Partially Degraded	62	Partially Supporting
CC-04	62.7	Degraded	76	Supporting

For biological conditions, two stations received a rating of "Very Poor" and two stations were rated as "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 and Percent Ephemeroptera. The Percent Climbers metric received high scores for all sites while the Percent Intolerant to Urban metric received a high score at station CC-04, and low scores at the other three stations. One site, CC-02, received a low score for Number of Scraper Taxa, while all other sites had median scores for the same metric. Two sites, sites CC-01 and CC-02, received low scores for the Number of Taxa while the other two sites received median scores for the Number of Taxa metric. 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 3-8.

Table 3-8. Benthic macroinvertebrate assessment results - 2016		
Site	BIBI Score	Narrative Rating
CC-01	1.86	Very Poor
CC-02	1.57	Very Poor
CC-03	2.14	Poor
CC-04	2.71	Poor

To supplement the biological assessment data, *in situ* water quality parameters were measured at each biological monitoring site prior to sample collection. Table 3-9 shows the water quality data for each site. Dissolved oxygen (mg/L) parameters for two sites were below 5 mg/L, Maryland's water quality standard for Use I streams. pH at one site, CC-01, was also slightly less than the minimum pH of 6.5 specified for Use class I streams. Conductivity values were elevated 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 (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). In 2014, a greater than average snow amount caused the roads to be treated with salt more frequently than during an average year. Although 2015 conductivity values, at three of the four stations, were reduced by approximately half as compared to 2014 values, levels were still twice the amount found in previous years. Conductivity measurements in 2016 were an order of magnitude lower than the previous two years, however, still relatively high compared to conductivities recorded in other urban streams. Seasonal use of road salt has most likely caused conductivity values to be high.

Table 3-9. *In situ* water quality results - 2016

Site	pH	Temperature	Dissolved Oxygen	Turbidity	Conductivity
	SU	°C	mg/L	NTU	µS/cm
CC-01	6.48	15.51	11.43	15.4	750
CC-02	6.92	9.15	8.57	23.1	736
CC-03	6.98	10.83	3.78	24.6	747
CC-04	6.85	15.04	3.66	27.5	876

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 2016 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 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 2016 showing approximately a 0.5 feet difference. In 2016, geomorphic assessment parameters continue to support the classification of this reach as an F channel. The channel evolution is supported by a 53.0% 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. Left bank widening was also apparent between 2013 and 2014 monitoring years and remained consistent during 2015 and 2016. 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 low width/depth ratio, low slope, and gravel substrate. Between 2015 and 2016 monitoring the substrate became slightly coarser. Since 2012 its entrenchment ratio was slightly higher than those typical of G streams, but to retain consistency with the 2011 classification, the G rating was retained. 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. 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.

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, in 2016, due to the 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. 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.

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 an F4 channel due to a significantly decreased entrenchment ratio from 4.0 to 1.5 between 2012 and 2016. Between 2015 and 2016 this portion of the reach has become slightly less coarse from a D50 of 61 mm to 24 mm. 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.

4 DISCUSSION

Results from the July 2015-June 2016 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.

Tables 4-2 and 4-3 compare baseflow and storm event results to the Federal and State acute and chronic 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

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

Parameter (mg/L, except as noted)	Chronic	Acute	Church Creek	Parole Plaza
Lead (µg/L)	2.5	65	BDL	BDL
Copper (µg/L)	9	13	1.6	8.7
Zinc (µg/L)	120	120	850*	120
Total P	0.0225		0.09*	0.03*
BOD_5	7		4	0
Nitrate + Nitrite	0.095		1.20*	5.40*
TSS	500		15	9
TKN	None		0.9	0.7
TPH	None		BDL	BDL
*E. coli*** (MPN/100ml)	235		243*	73
Hardness	None		140	210

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

Table 4-3. 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	43	18
Copper (µg/L)	13	67*	180*
Zinc (µg/L)	120	712*	430*
Total P	0.0225	1.70*	0.25*
BOD_5	7	40*	46*
Nitrate + Nitrite	0.095	1.80*	1.30*
TSS	500	280	220
TKN	None	4.1	2.6
TPH	None	10	11
*E. coli*** (MPN/100ml)	235	38,730*	72,700*
Hardness	None	410	750

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

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.

As in prior years, comparisons to water quality criteria continue to indicate elevated pollutant concentrations in the Church Creek watershed, primarily during wet weather conditions. In particular, copper, zinc, total phosphorous, BOD_5, nitrate-nitrite, and *E. coli* frequently exceeded criteria at both sampling stations. Table 4-3 (above) shows the maximum concentrations for each sampling site, and compares these to the criteria. Additionally, as shown in Table 4-2, the Federal water quality criteria were exceeded for total phosphorous and nitrate-nitrite during baseflow sampling at both the Church Creek and Parole Plaza stations, with zinc and *E. coli* also being exceeded at the Church Creek station.

Table 4-4 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 Church Creek monitoring station than at the Parole Plaza station for all contaminants except for copper and zinc. Throughout the 2016 monitoring period, *E. coli* concentrations exceeded 93% of the time at both stations. Prior to site stabilization, total suspended solids concentrations had been particularly high due to construction activity at Annapolis Towne Centre. Following site stabilization in Fall 2008, the event mean concentrations for total suspended solids have markedly dropped. During the last five reporting years, no wet weather samples exceeded the water quality criterion for total suspended solids at either station.

Table 4-5 shows the annual average event mean concentrations that exceeded water quality criteria. As can be seen from the table, some criteria were consistently exceeded at both stations. At Parole Plaza, 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 (USEPA, 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 (Table 4-6 and 4-7) 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 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, this likely caused pollutant loads to decrease.

Table 4-4. 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	0	0
Copper (µg/L)	13	33	67
Zinc (µg/L)	120	27	47
Total P	0.0225	100	93
BOD_5	7	40	30
Nitrate + Nitrite	0.095	100	93
TSS	500	0	0
TKN	None	NA	NA
TPH	None	NA	NA
*E. coli** (MPN/100ml)	235	93	93
Hardness	None	NA	NA

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

Table 4-5. 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	6.8[(a)]	2.7[(a)]
Copper (µg/L)	9	13	12.2[(a)]	21.0[(a,b)]
Zinc (µg/L)	120	120	98	110
Total P	0.0225		0.14[(a)]	0.12[(a)]
BOD_5	7		7	3
Nitrate + Nitrite	0.095		0.44[(a)]	0.40[(a)]
TSS	500		55	43
TKN	None		0.7	0.5
TPH	None		1.5	1.1
*E. coli** (MPN/100ml)	235		8,049[(a)]	18,268 [(a)]
Hardness	None		44	49

[(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 4-6. Total annual loading rates, in pounds, observed at the Parole Plaza Sampling Station from 2002 to 2016

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
2002-2006 Mean	8,544	59,548	535	974	438	104	23	11	NA	2,186,095
2009-2016 Mean	1,991	13,644	52	324	182	46	1	6	18,483	8,388
2002-2016 Mean	7,047	89,643	339	699	360	88	11	19	18,483	8,680

(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 4-7. Loading rates, in pounds, observed at the Church Creek Sampling Station from 2002 to 2016

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
2002-2006 Mean	22,329	131,034	1,178	2,143	963	228	52	25	NA	4,810,490
2009-2015 Mean	37,628	248,367	1,261	7,330	3,427	614	30	63	385,286	4,279
2002-2016 Mean	49,865	440,337	1,867	6,773	33,532	700	56	89	385,286	4,361**

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

During the 2016 reporting year, loading rates at the Parole Plaza station decreased for most parameters sampled except BOD, copper, and *E. coli* when compared to the 2015 reporting year. Church Creek 2016 reporting year loading rates decreased for all sampled parameters when compared to the 2015 reporting year except for BOD, TKN, zinc, *E. coli* and lead. At the Church Creek station, *E. coli* and BOD had a loading rate increase over 100% when compared to 2015, however, for each of the other parameters, there was less than a 30% increase in loading rates. The 2016 *E. coli* concentrations have increased at both stations, yet they are still not as high as the pre-construction years (2002-2006).

During the post-construction period (2009 to 2016), 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, most of the sampled parameters have exceeded average pre-construction (2002-2006) monitoring levels, and continued to do so in 2016.

Seasonal pollutant loads in 2016 are provided in Table 4-8. Again this year, hardness was much higher in the winter at both stations likely due to the use of salt to deice local roads. TSS was also highest in the winter at both stations, and lead was highest in winter at Church Creek. High TSS loads are probably a product of accelerated stream bank erosion occurring after several freeze-thaw cycles facilitated by the swings in temperature observed during the 2016 winter. The highest loads of,total phosphorus, nitrate–nitrite, and copper were recorded in the spring at both stations. Increases in copper, nitrate–nitrite and total phosphorus loads were likely associated with increases in TSS, greater volumes of water passing through the watershed, and escalations of organic matter. Some parameters, such as nitrate–nitrite, have high ambient concentrations which were observed at Parole Plaza during the winter baseflow sampling event (March 24).

Table 4-8. Seasonal loading rates, in pounds, observed at the Church Creek and Parole Plaza sampling stations in 2016

Season	BOD	TSS	TP	TKN	NO_3+NO_2	Zinc	Lead	Copper	Hardness	*E. coli**
Church Creek										
Summer	15,285	70,082	214	883	844	127	11	20	37,753	12,638
Fall	8,391	56,655	262	2,465	677	383	7	16	78,337	4,433
Winter	8,602	140,342	257	1,867	515	169	17	19	130,503	1,644
Spring	14,309	59,343	292	1,433	1,044	139	7	38	98,137	4,629
Parole Plaza										
Summer	170	1,908	7	19	24	5	0	1	848	26,836
Fall	161	1,105	4	82	22	8	0	2	1,703	10,289
Winter	231	4,458	8	52	16	8	0	1	8,896	430
Spring	746	3,415	10	65	42	15	0	5	3,331	8,109

* 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 2016 at the Parole Monitoring Station. Nearly every concentration rose

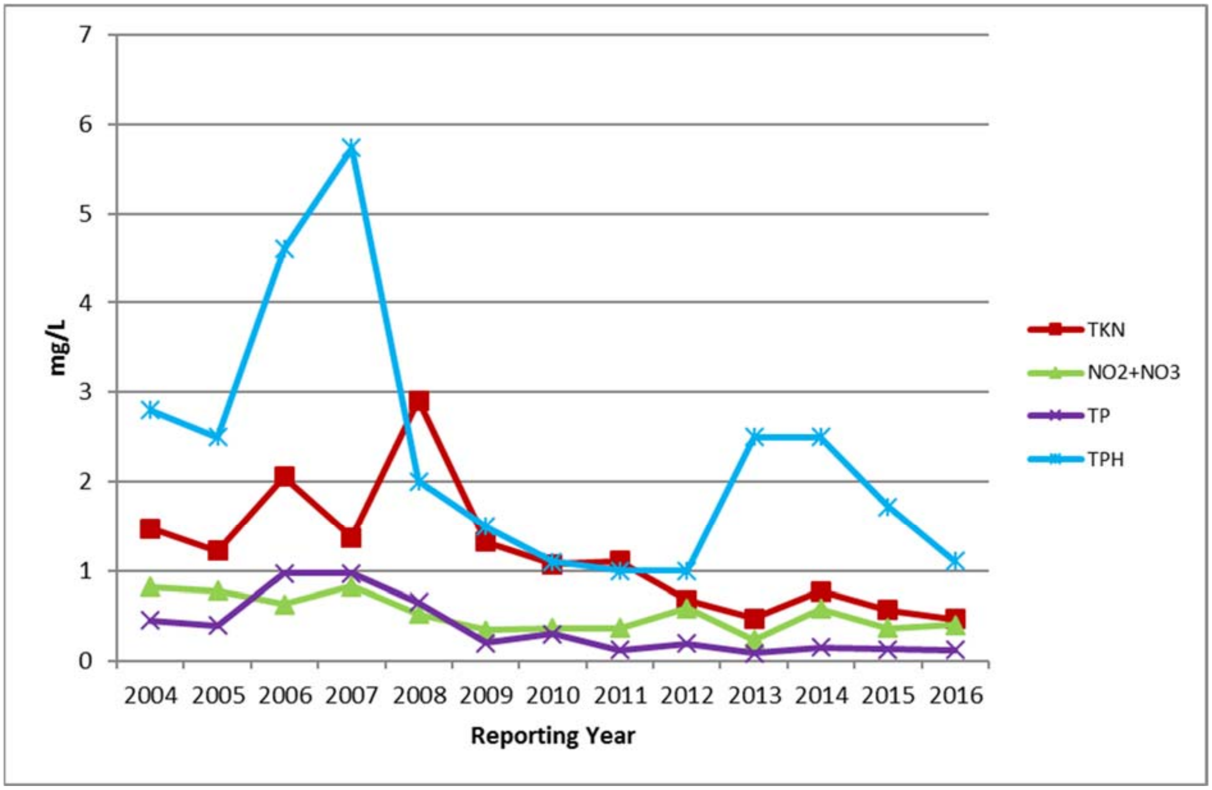

Figure 4-1. Parole station long-term monitoring: annual EMCs (TKN, NO_2+NO_3, TP, TPH; mg/L)

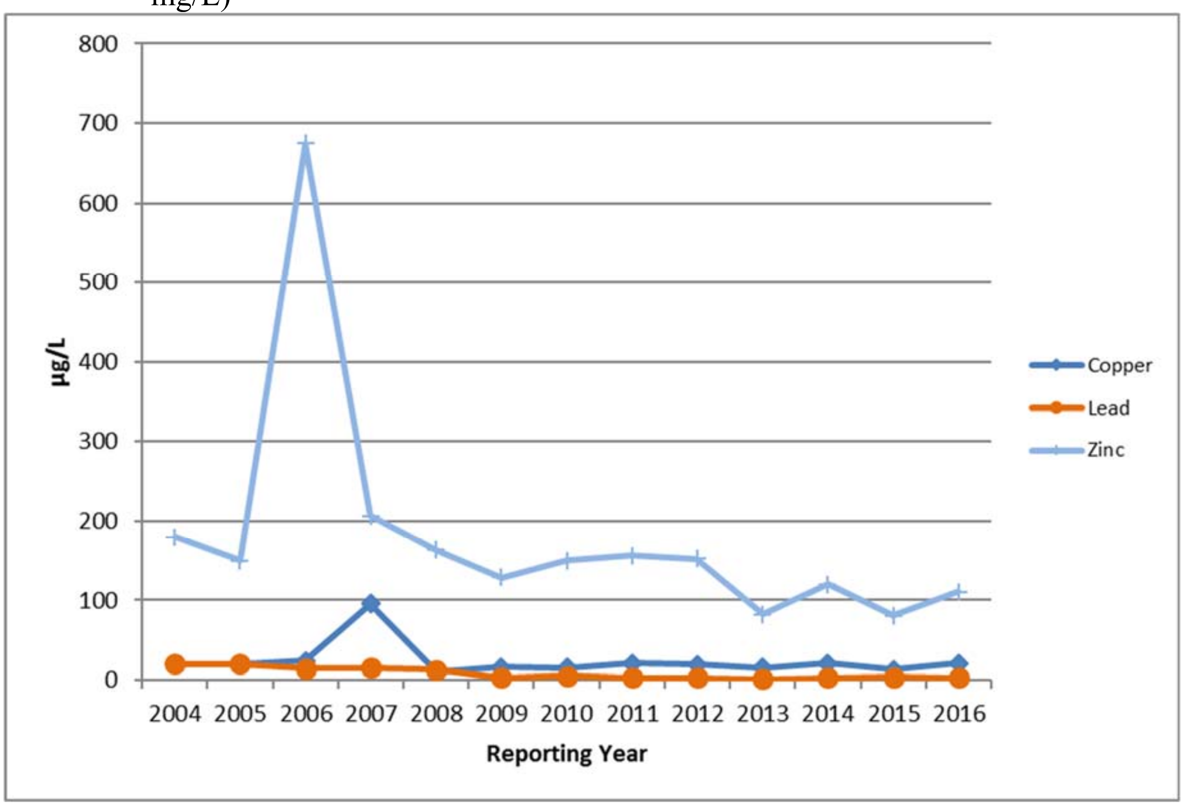

Figure 4-2. Parole station long-term monitoring: annual EMCs (Cu, Pb, Zn; mg/L)

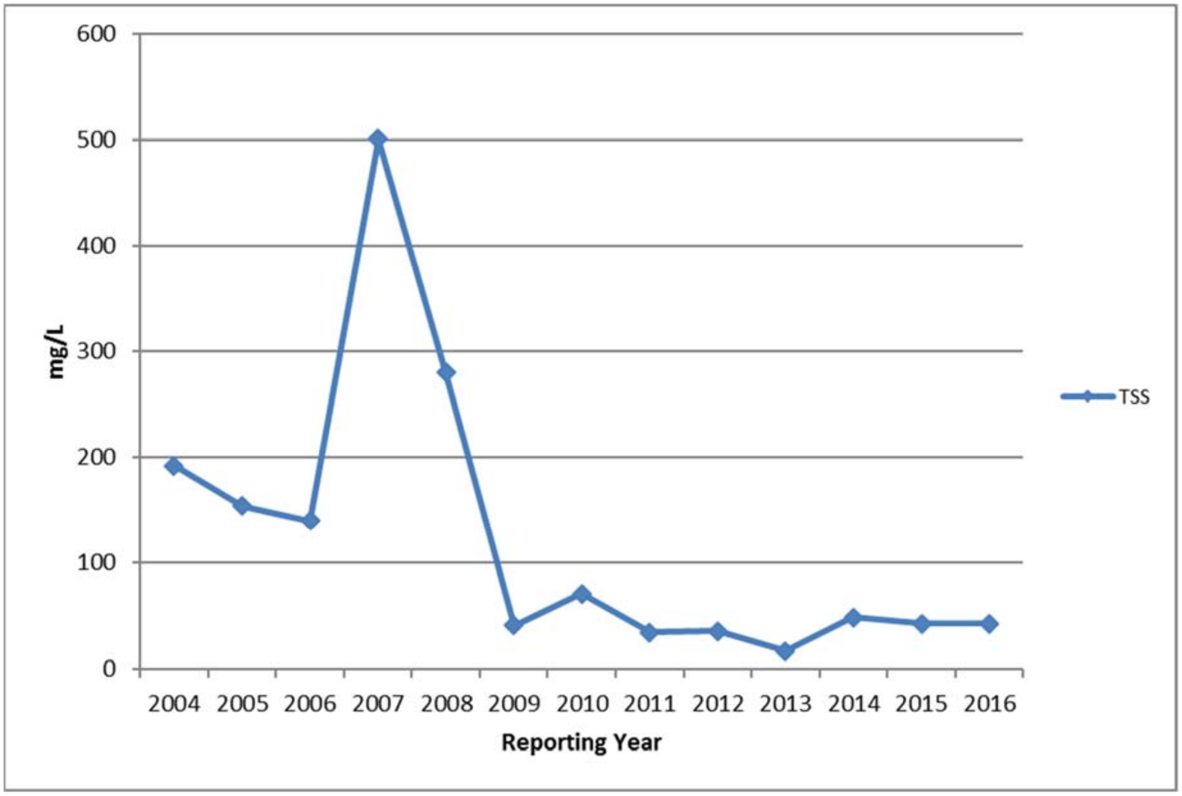

Figure 4-3. Parole station long-term monitoring: annual EMCs (TSS; mg/L)

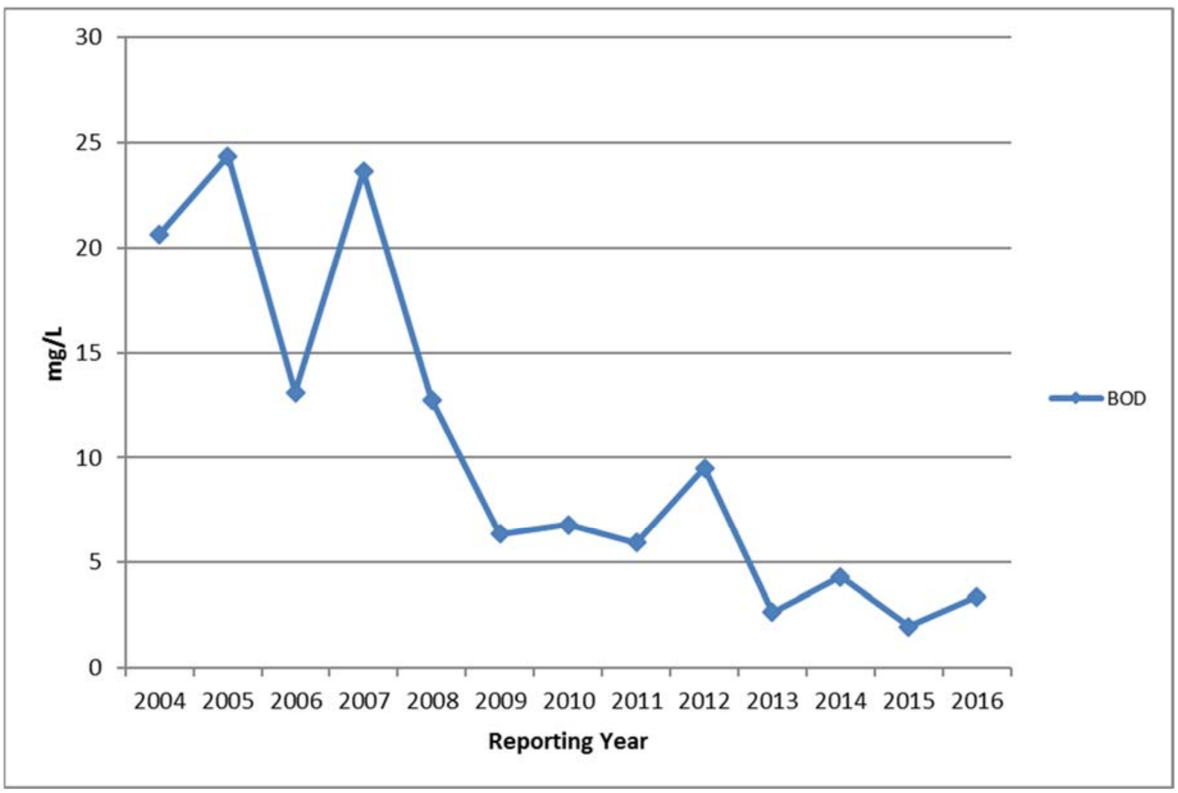

Figure 4-4. Parole station long-term monitoring: annual EMCs (BOD_5; mg/L)

substantially between 2006 and 2007 when the majority of the site work was being conducted at the Towne Centre. These concentrations notably fell 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. Pollutant concentrations in 2016 have slightly increased for most parameters when compared to those from 2015, with the exception of a slight decrease in TPH. 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, although this was not the case in 2016 except for *E.coli*.

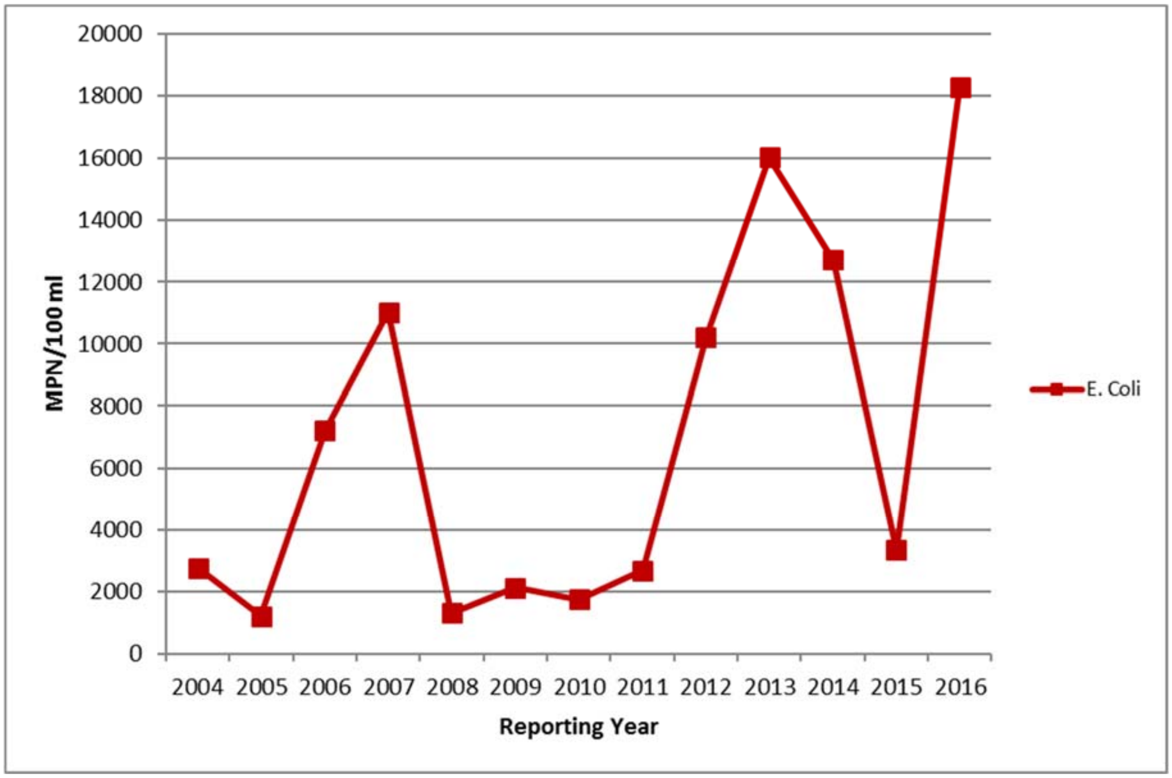

Figure 4-5. Parole station long-term monitoring: annual EMCs (*E. coli*; MPN/100 mL)

Figures 4-6 through 4-10 show almost the same trend in EMCs for the Church Creek Monitoring Station. A slight rise in pollutant concentrations at Church Creek was observed in 2016 for TKN, nitrate-nitrite, lead, and copper when compared to 2015 EMCs. However, TSS, zinc, BOD, and *E.coli* have increased substantially when compared to the last three years. Note that the apparent rise in TPH at Church Creek in 2013, like Parole Plaza, was due to an increase in the detection limit. Also like Parole Plaza, summer season concentrations were not included with the 2013 EMC data.

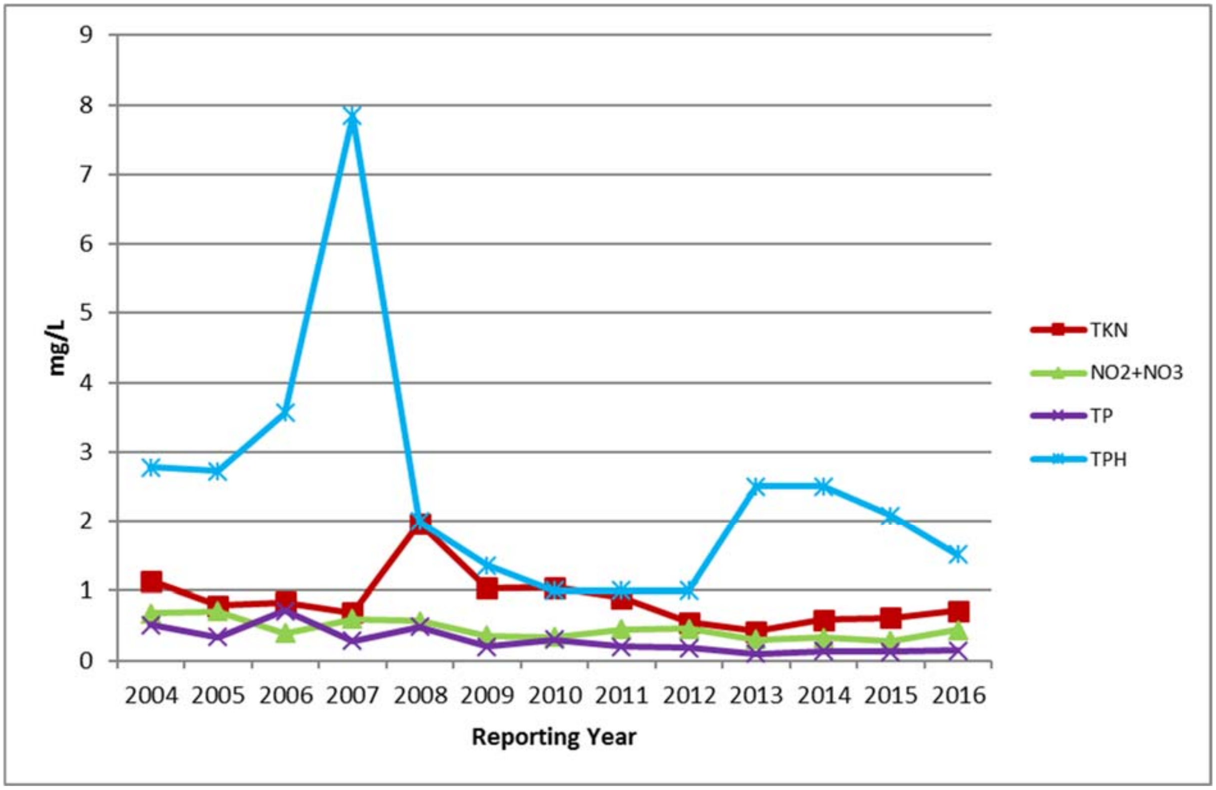

Figure 4-6. Church Creek station long-term monitoring: annual EMCs (TKN, NO_2+NO_3, TP, TPH; mg/L)

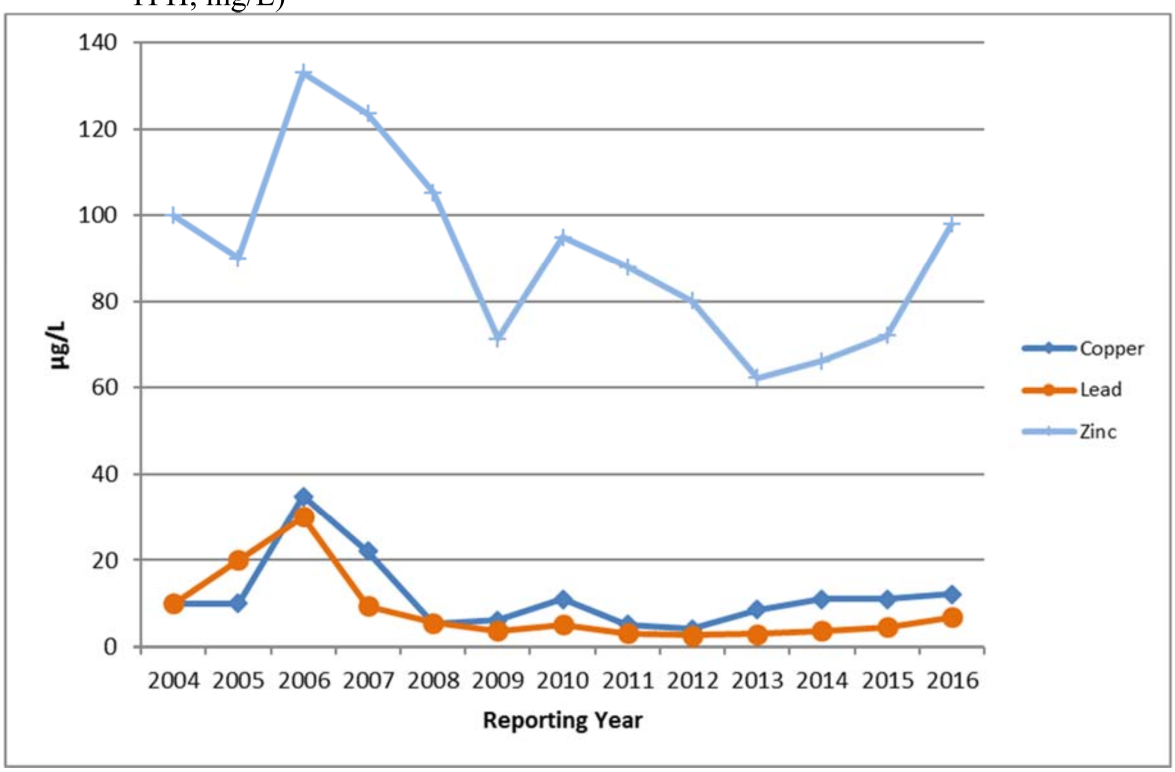

Figure 4-7. Church Creek station long-term monitoring: annual EMCs (Cu, Pb, Zn; mg/L)

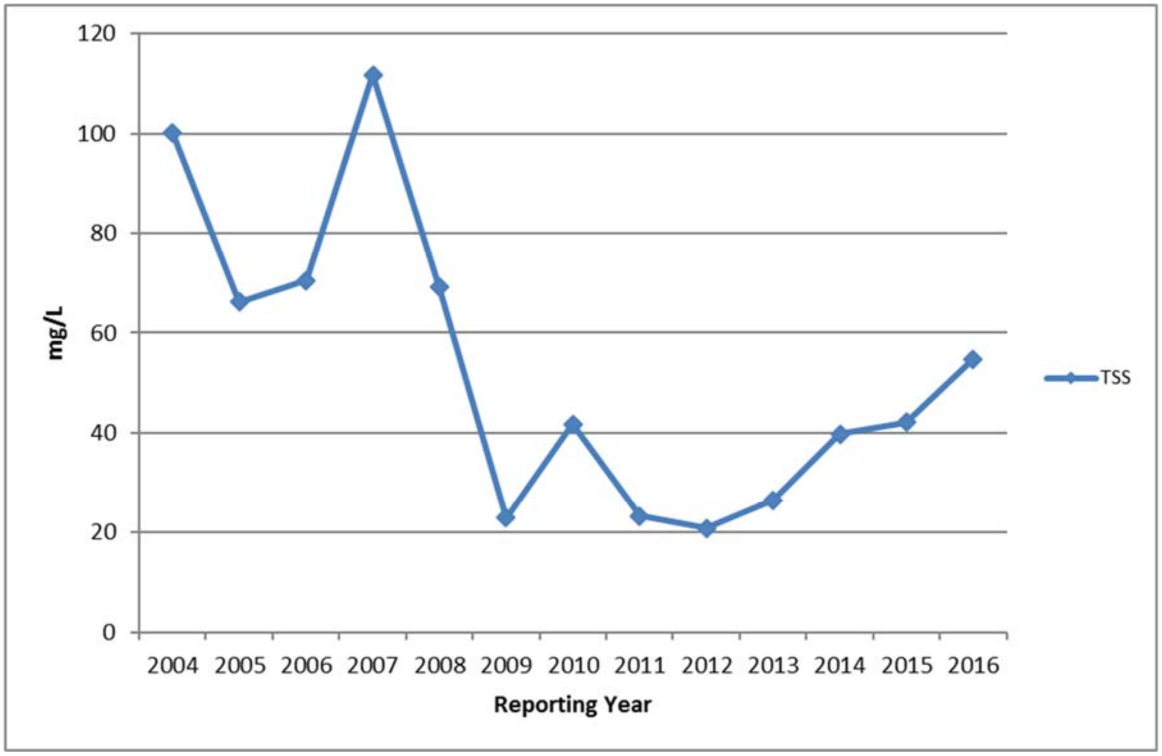

Figure 4-8. Church Creek station long-term monitoring: annual EMCs (TSS; mg/L)

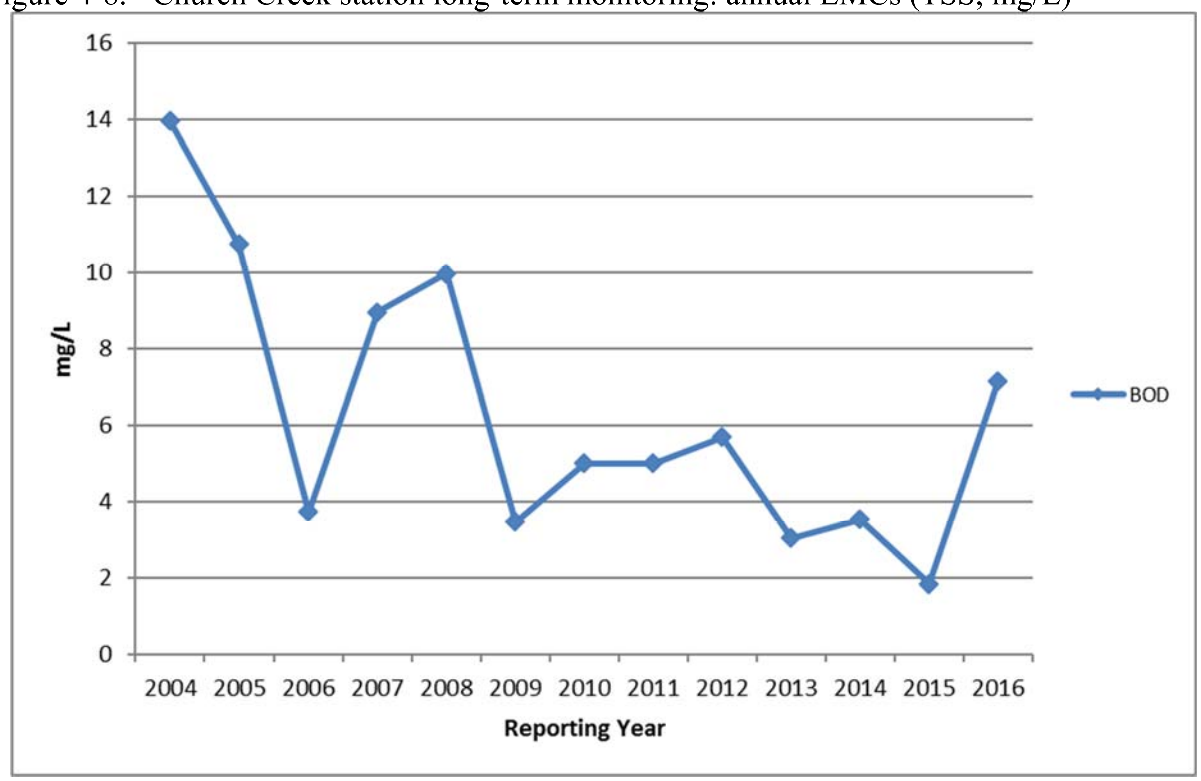

Figure 4-9. Church Creek station long-term monitoring: annual EMCs (BOD_5; mg/L)

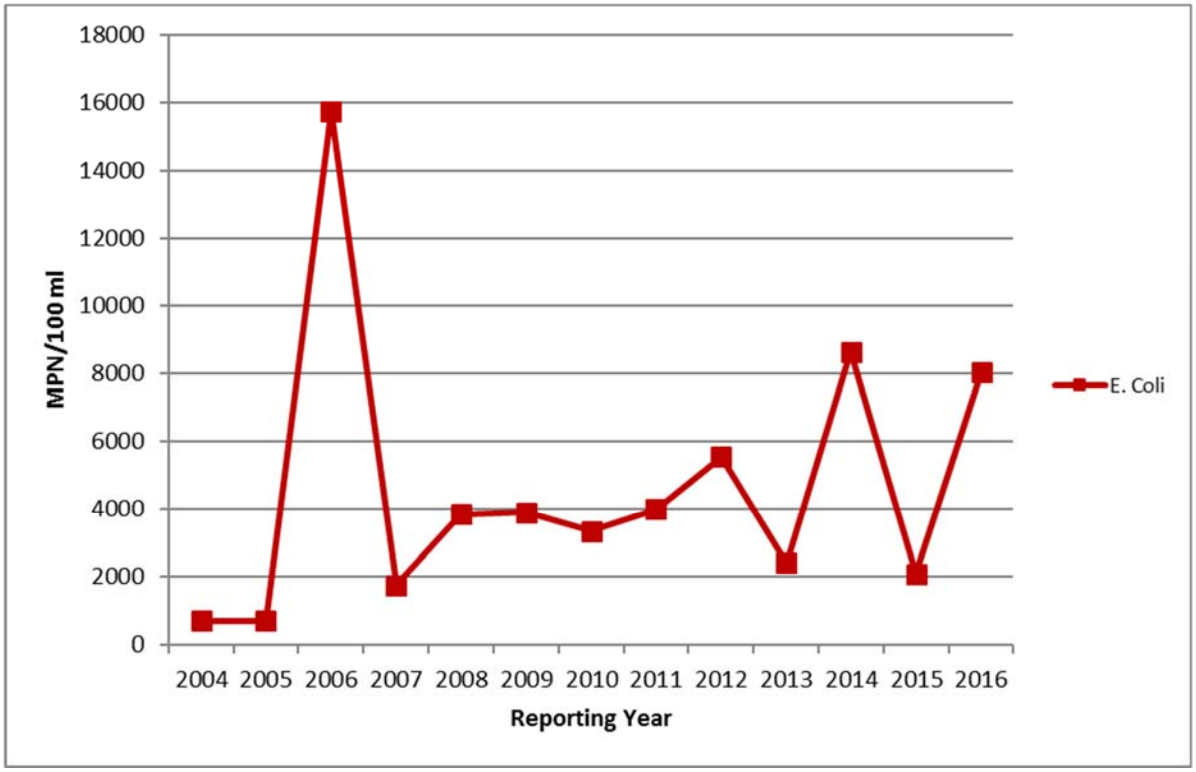

Figure 4-10. Church Creek station long-term monitoring: annual EMCs (*E. coli*; MPN/ 100 mL)

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 and appears to have changed very little from the previous year (Table 4-9, Figure 4-11). Three of the four sites were rated the same in 2016 as in 2015 indicating no change in habitat condition. One site (CC-01) was downgraded from a rating of Partially Degraded in 2015 to a rating of Degraded in 2016. 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 4-9. PHI scores from 2006 to 2016

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

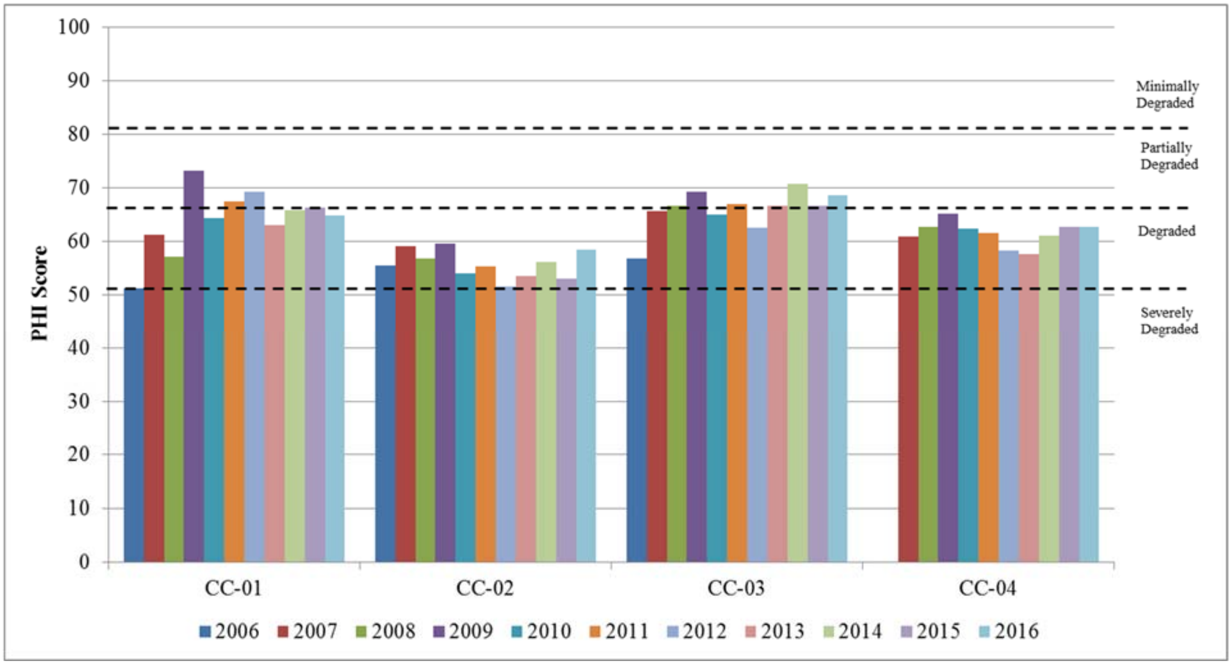

Figure 4-11. Comparison of PHI scores from 2006 to 2016

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 4-9 and Figure 4-11 were calculated using the original method, while scores for 2013-2016 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 2016 (Table 4-10) 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 4-10. BIBI scores from 2006 to 2016

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

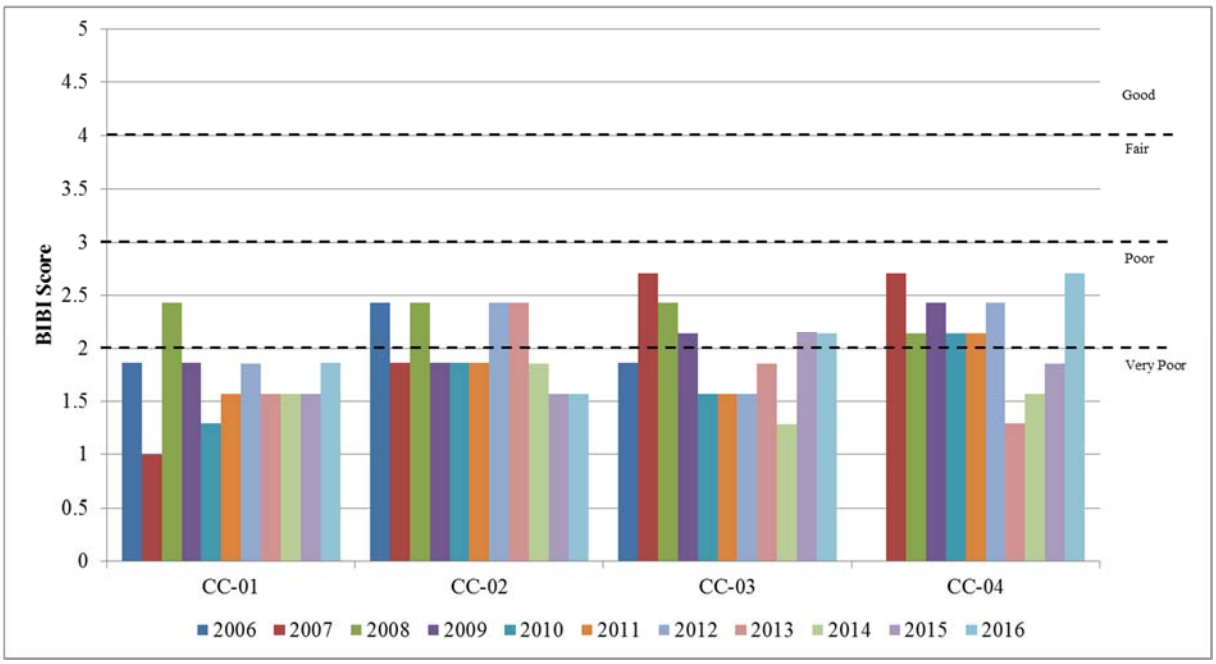

Figure 4-12. Comparison of BIBI scores from 2006 to 2016

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 Parole Plaza Tributary 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 4-11. 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 4-11. Past Rosgen classifications

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

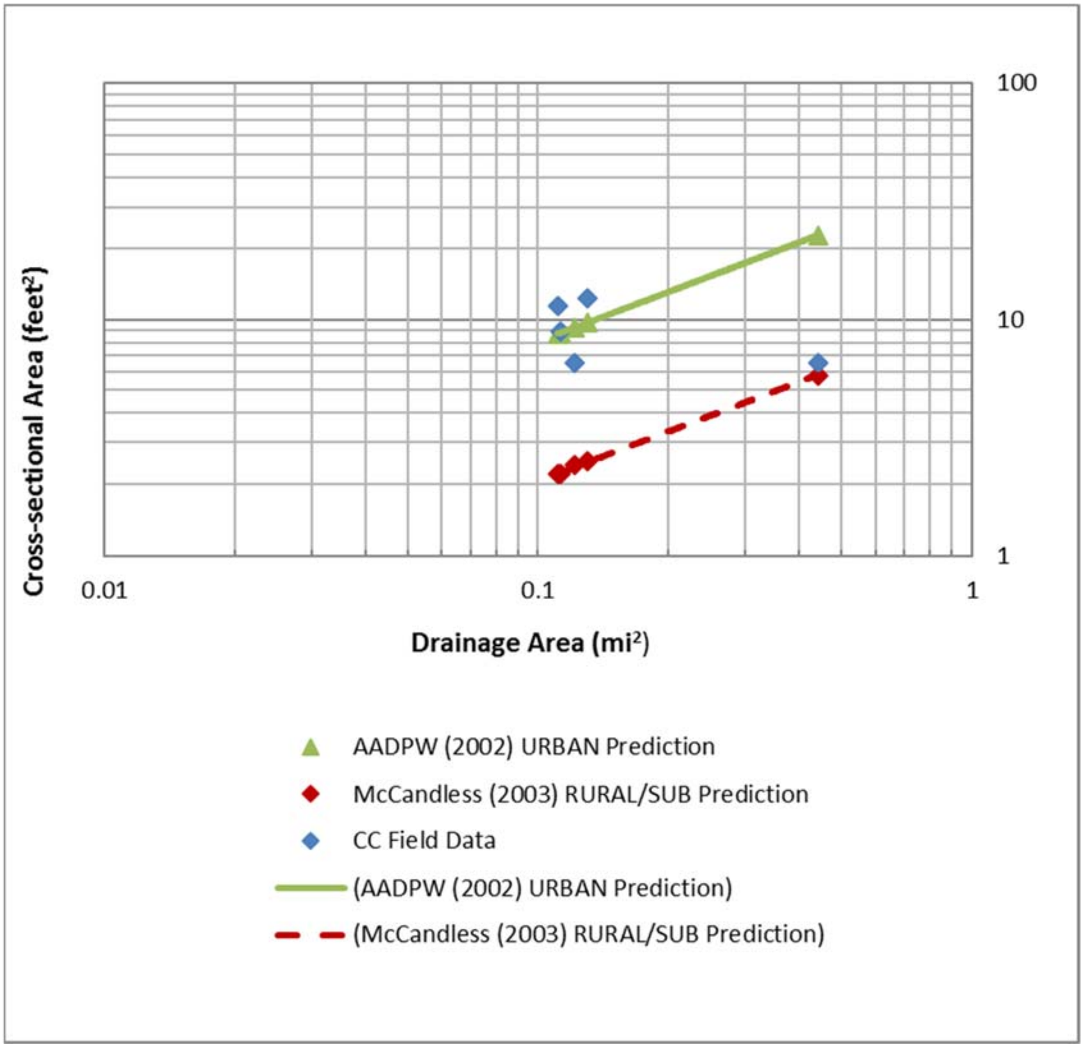

Figure 4-13. Comparison of bankfull channel cross sectional area to drainage area (CC = Church Creek, 2016 data)

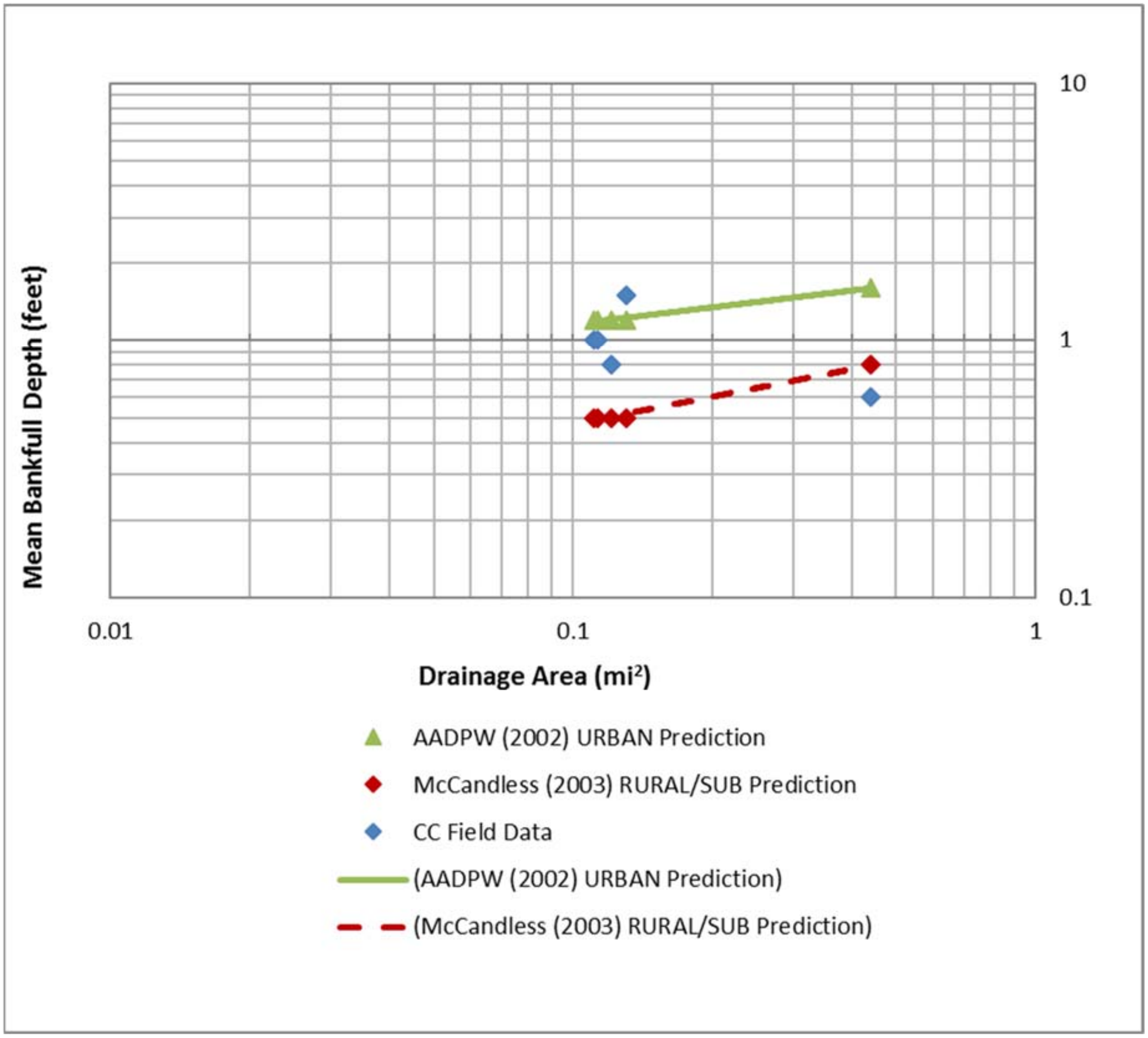

Figure 4-14. Comparison of mean bankfull depth to drainage area (CC = Church Creek, 2016 data)

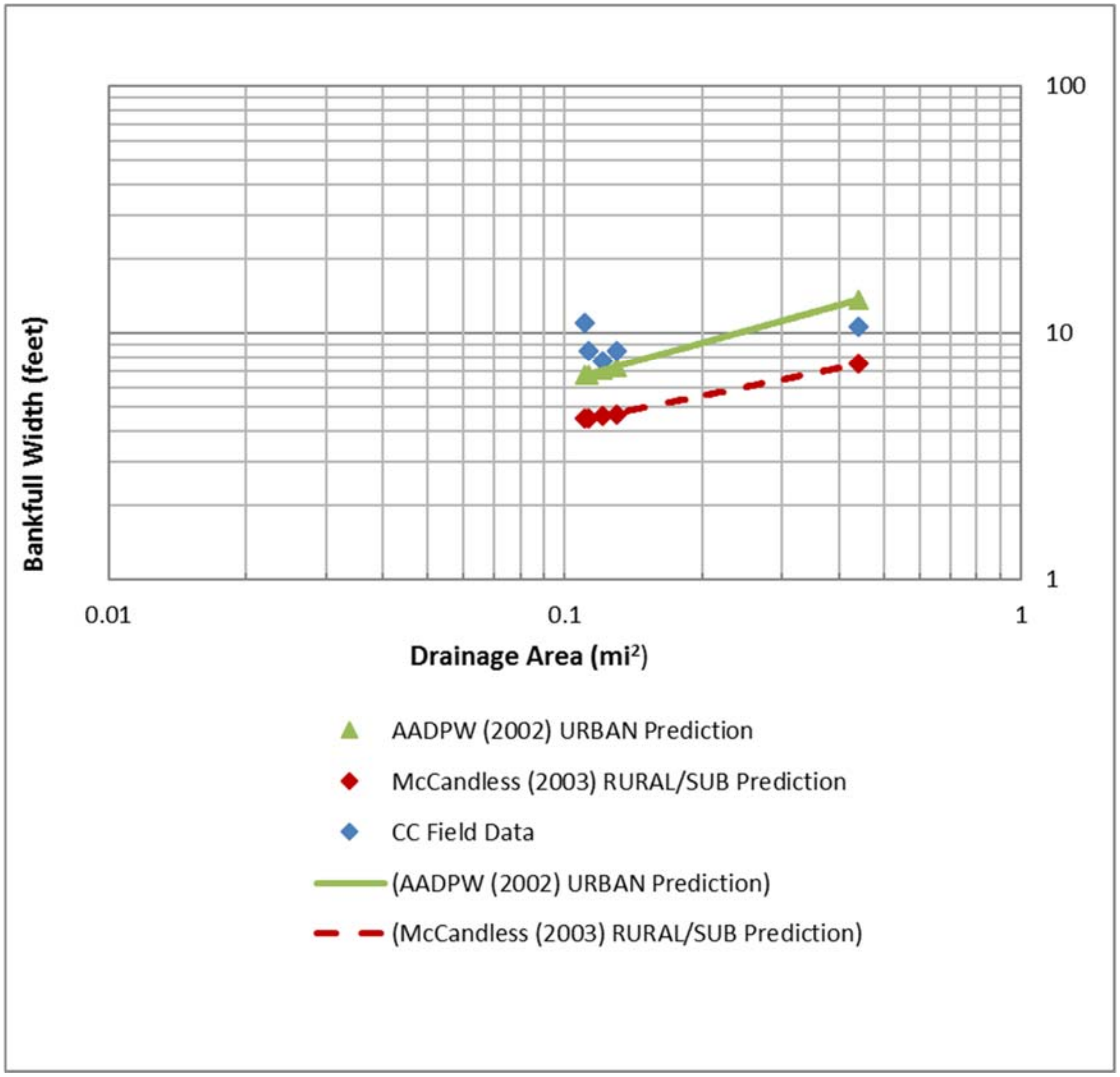

Figure 4-15. Comparison of bankfull width to drainage area (CC = Church Creek, 2016 data)

Three of the five cross sections showed enlargement from channel erosion while the other two showed aggradation as compared to baseline measurements (Table 4-12). 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 2016 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 2016. Comparison of baseline cross sectional area is however comparable to 2011 through 2016 since all calculations are made using the same top of bank elevation.

Table 4-12. 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
% Change 2003-2016	53.0	158.4	-5.6[c]	9.8	-32.0
% Change 2011-2016	20.7	44.7	-9.2	101.3	-37.1

[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, with increases of approximately 53.0%, and 158.4% 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 2016 (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. 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 has both widened along the left bank and deepened mid channel (Appendix F). Cross section area comparisons between baseline and 2016 show a substantial increase with a moderate percent change occurring over the last five years of 20.7% increase at XS-1 and 44.7% increase at XS-2.

Cross section XS-3 has had very minimal changes in cross-sectional area with just a 5.6% decrease since 2003 baseline measurements and -9.2% change between 2011 and 2016. 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 with the exception of slight aggradation across the stream bed and toe of the right bank. Cross section XS-3 continues to have yard waste (i.e., grass clippings, leaves, and branches) dumped along the left bank floodplain.

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 to grow by 59% in the past year alone, and 101.3% since 2011.

Cross section XS-5 has been armored with cobble-sized rip rap in its bed to protect the sewer line. Between 2012 and 2013, XS-5 appears to have eroded by several inches of sediment, most notably near the left bank. Cross-sectional area has decreased by 37.1% 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 exhibited very little change also, decreasing by only 1.5% since 2014.

4.4 GENERAL CONCLUSIONS

Based upon the data collected in 2016, 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. 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. 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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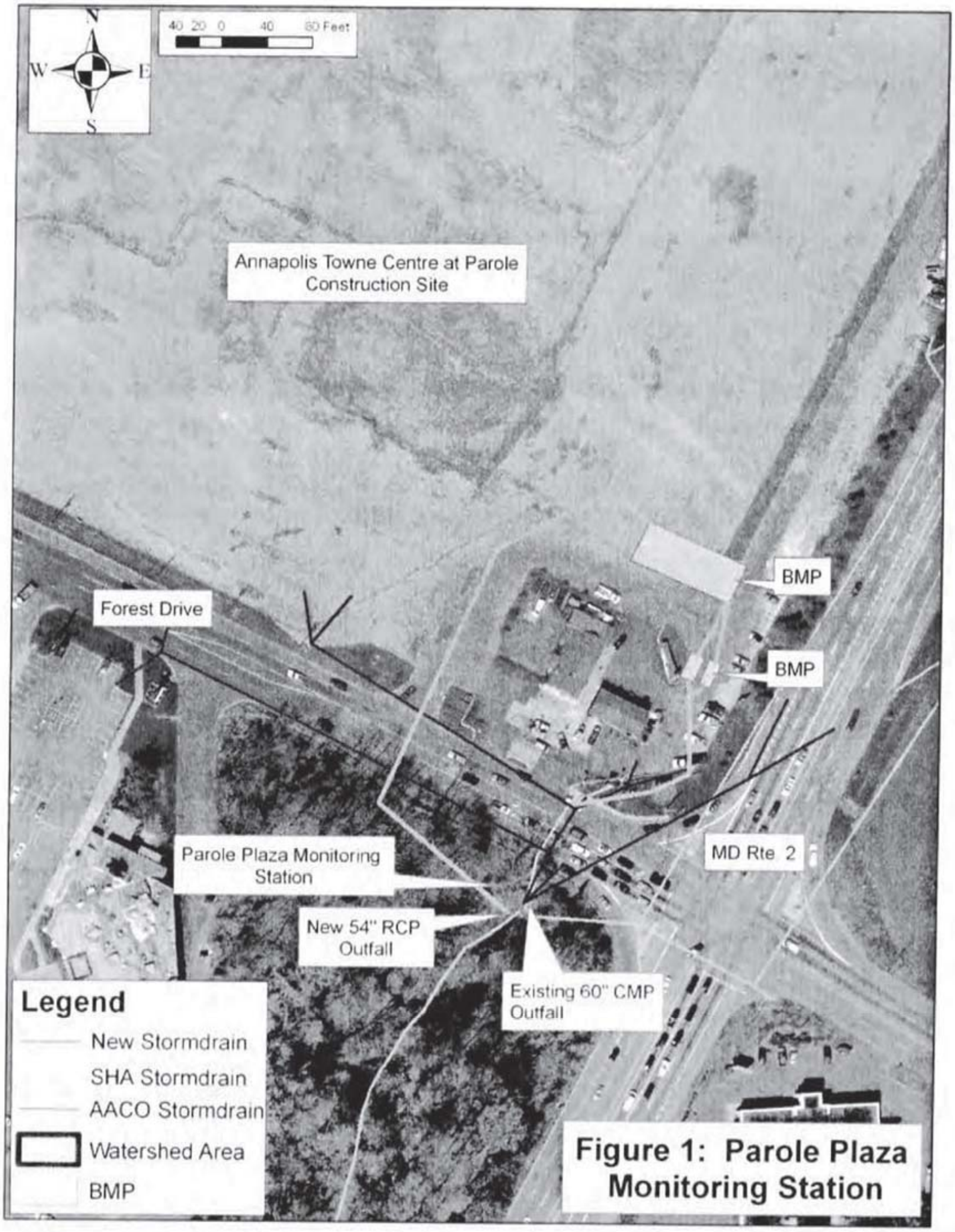


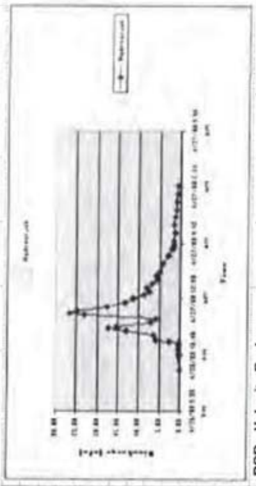
Figure 1: Parole Plaza Monitoring Station

VERSAR

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 10:30 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 11:03 PM	0.10	0.15	0.15	0.19	6.00	16.00	[illegible]	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	3.26	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	6.39	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	7.21	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	0.87	0.92	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	12.74	12.96	7.00	15.60	[illegible]	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	0.92	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	7.19	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	0.39	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	0.58	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	0.48	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	[illegible]	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
--	9:22 P M	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

- August 20, 2015 – At Church Creek, half of the parameter EMCs during the storm were greater than the average concentrations of the storms captured since December 12, 2012; nitrate-nitrite, total phosphorus, TSS, copper, TPH, and hardness were lower than the historical average. Nitrate-nitrite and total phosphorus EMCs were generally comparable to historical average values for storm runoff. EMCs for the remaining parameters exceeded historical averages by between 5.5% (zinc) and 228% (*E. coli*). At Parole Plaza, during the storm event, the logger batteries were found unexpectedly dead. Because of the rapid onset of the event, the field crew wasn't able to purchase new batteries or take manual measurements of level. The flashy event also caused the rising limb to be missed by the field team. The remaining CMP and RCP composite samples were prepared using a 50/50 ratio of samples from the individual pipes. The EMCs of all parameters during the storm were less than the corresponding average concentrations of the storms captured since December 12, 2012, except for BOD, TSS, and *E. coli*. The total phosphorus EMC was comparable to the historical average for storm events. The EMCs for TSS, BOD, and *E. coli* exceeded their historical averages by approximately 15% to 25%.

- September 10, 2015 **-** During the September 10, 2015 event at Church Creek, the EMCs of half of the parameters were once again greater than the average concentrations of the storms captured since December 12, 2012, except for TKN, total phosphorus, copper, zinc, TPH, and hardness. The other parameter EMCs exceeded their historical averages by between 2.3% (TSS) and 157% (*E. coli*). Total phosphorus and copper EMCs were generally comparable to historical average values for storm runoff. At Church Creek, *E. coli* results during the event were extremely high, especially during the rising limb (38,730 MPN/ 100 mL). In addition to *E. coli*, all other parameter concentrations except copper, TPH, and hardness were extremely high during the rising limb and were the highest recorded for the past four years of sampling. For example, zinc was 200% higher than the usual reported values. At Parole Plaza, during compositing of the rising limb, the bottle for the RCP sample broke. Since the rising limb would consist of only the CMP discharge, the rising limb was not calculated in the EMC spreadsheet. EMCs of all parameters, were lower than the average concentrations of the storms captured since December 12, 2012, except for TSS, lead, and *E. coli*. These parameters were greater than the historical average by between 7.2% (TSS) and 130% (lead). The EMC for total phosphorus was comparable to the historical average for storm events.

- September 29, 2015 **-** During the September 29, 2015 storm event, at Church Creek, most parameter EMCs were less than the average concentrations of the storms captured since December 12, 2012, except for lead and *E. coli*. These EMCs exceeded their historical averages by 35% (lead) and 69% (*E. coli*). The total phosphorus EMC was generally comparable to historical average values for storm runoff. At Parole Plaza, the EMCs of all parameters were less than the average concentrations of the storms captured since December 12, 2012 except for total phosphorus and *E. coli*. The total phosphorus EMC was comparable to the historical average for storm events while the *E. coli* EMC was 26% greater than the historical average.

- November 9, 2015 - At Church Creek, most of the parameter EMCs during the storm were less than the average concentrations of the storms captured since December 12, 2012. The total phosphorus EMC was generally comparable to historical average values for storm runoff. The EMCs for TKN and zinc exceeded their historical averages by 35% and 147%. Zinc's EMC was probably high due to the high concentration of 712 µg/L during the rising limb. The EMCs of most parameters during the storm at Parole Plaza were less than the corresponding average concentrations of the storms captured since December 12, 2012, except for TKN, copper, lead, and *E. coli*. EMCs for TKN, copper, lead, and *E. coli* exceeded their historical averages by approximately 9.0% to approximately 100%. During the falling limb, concentrations of *E. coli* (19,863 MPN/100 mL), copper (74.0 µg/L), lead (6.4 µg/L), and zinc (120 µg/L) were high.

- December 17, 2015 - During the December 17, 2015 event at Church Creek, only the TKN EMC was greater than (39%) the average concentrations of the storms captured since December 12, 2012. Total phosphorus, BOD, and nitrate-nitrite EMCs were similar to historical average values. At Parole Plaza, zinc concentrations stood out the most during the rising and peak limbs; with values of 270 µg/L (rising limb) and 330 µg/L (peak limb). The EMCs of all parameters were lower than the average concentrations of the storms captured since December 12, 2012, except for TKN and zinc. These parameters were greater than the corresponding historical averages by between 23.5% (TKN) and 47.5% (zinc).

- February 16, 2016 - During this event duplicate samples were taken at Church Creek during the peak limb. All of the results were close in range. Field scientists observed highly turbid discharge during the event which they attributed to cinders carried into the stream by runoff. At Church Creek, most of the parameter EMCs during the storm were greater than the average concentrations of the storms captured since December 12, 2012. Total phosphorus and BOD EMCs were generally comparable to historical average values for storm runoff. The EMC for TPH was 7.8 mg/L and therefore exceeded its historical average by 991%. The highest concentration of TPH (10 mg/L) occurred during the peak limb and likely contributed to the unusually high EMC. The lead EMC also exceeded its long-term historical average by 179%. During the rising limb, lead had a high concentration of 39 µg/L. Several other parameters had unusually high concentrations during the rising limb that contributed to overall high EMCs: hardness (410 mg/L), zinc (250 µg/L), lead (39 µg/L), copper (31 µg/L), and TSS (260 mg/L). Most of the EMCs at Parole Plaza during the storm were less than the corresponding average concentrations of the storms captured since December 12, 2012, except for TSS, TPH, lead, zinc, and hardness. The EMCs for four of parameters exceeded their historical averages significantly: TSS (147%), lead (201%), TPH (1,175%), and hardness (257%). The TPH concentration was higher than usual during both the rising (11 mg/L) and falling limb (10 mg/L). Hardness (750 mg/L) and lead (18 µg/L) were at their highest during the rising limb. Zinc, copper, and TSS were high, but not the maximum concentrations observed for past storms.

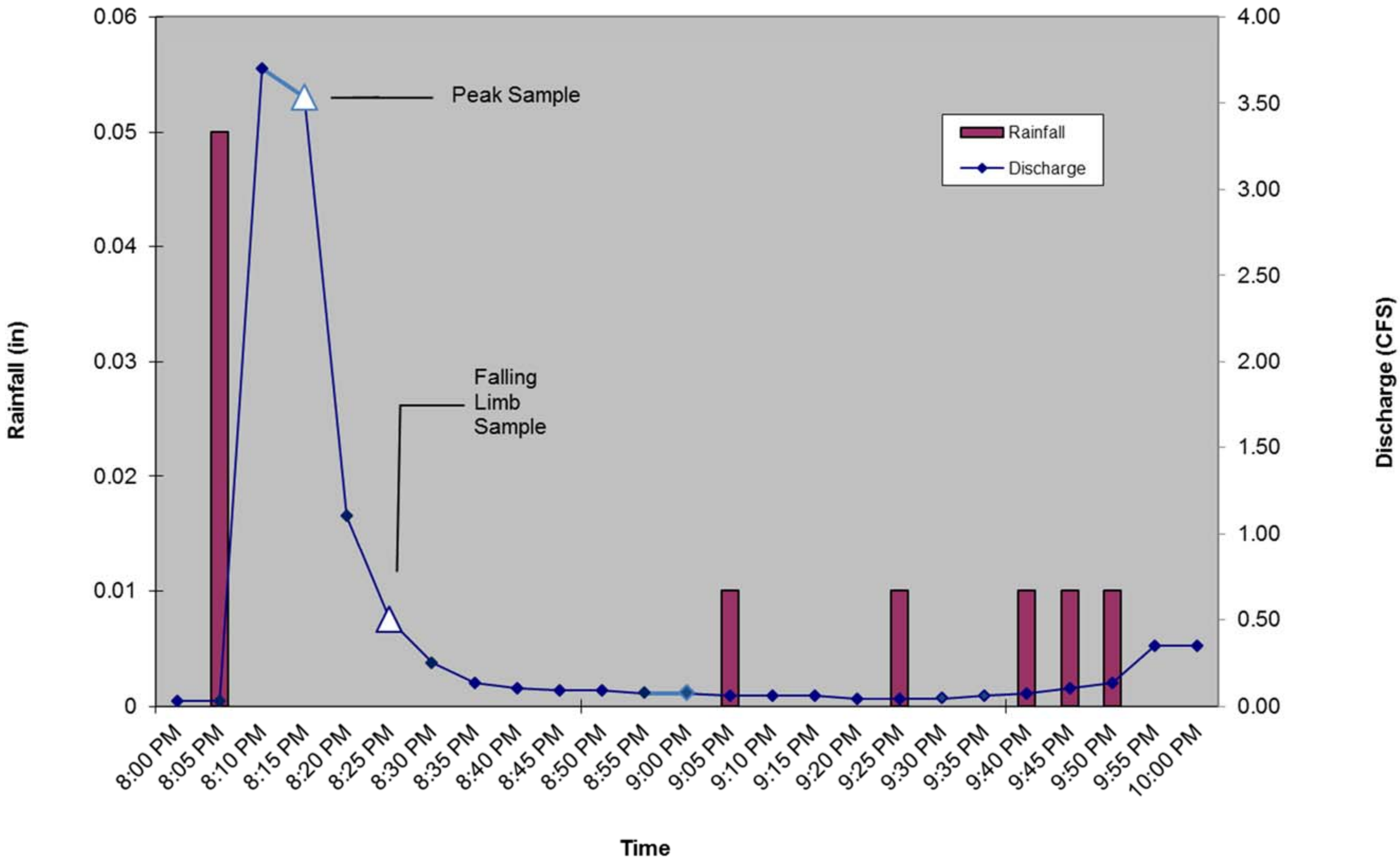
- March 14, 2016 - During the March 14, 2016 event at Church Creek, the parameter EMCs were mostly greater than the average concentrations of the storms captured since December 12, 2012. These parameter EMCs were greater than the corresponding historical averages by between 1.8% (TSS) and 56.8% (TKN). Even though the EMCs were higher than the historical averages, the concentrations were less than the February 16 storm event. During the event, field staff noted dark, opaque discharge in the channel and an oily odor coming from the CMP during the rising limb. Concentrations of many parameters at Parole Plaza, however, were lower compared to the February 16 storm. The EMCs of only three parameters (BOD, zinc, and TPH) were greater than the average concentrations of the storms captured since December 12, 2012. Zinc, BID, and TPH were 3.1%, 66.7%, and 71.5% greater than corresponding historical values respectively. The rising limb TPH concentration was 7 mg/L, contributing to the higher than usual EMC.

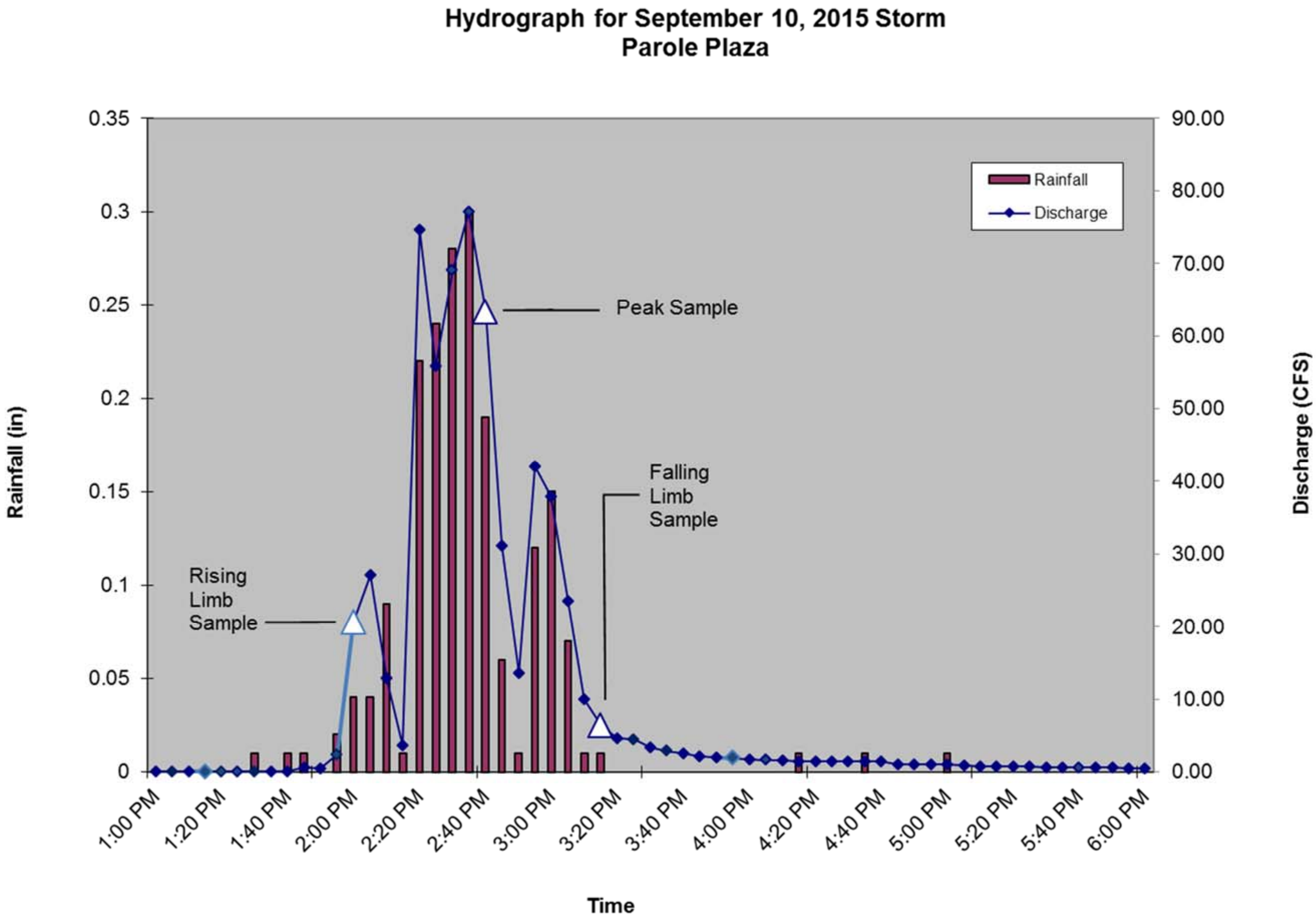
- April 7, 2016 - At Church Creek, there were five parameter EMCs (BOD, TKN, copper, TPH, and hardness) greater than the average concentrations of storms captured since December 12, 2012. These parameter EMCs were greater than the corresponding historical averages by between 3.4% (hardness) and 114% (copper). Also during this storm event, a pH value of 4.5 was measured. Low pH values may be due to the several occasions of “suds” flowing through the stream and still lingering in the watershed. During the event, field staff noted the “dirty “water discharge, but no “suds” were visible in the channel. At Parole Plaza, most parameter EMCs were greater than the average concentrations of the storms captured since December 12, 2012 except nitrate-nitrite, zinc, TPH, hardness, and *E. coli*. The parameters greater than the corresponding historical averages were: BOD (214.7%), TKN (115.4%), total phosphorus (68.6%), TSS (157.9%), copper (91.6%), and lead (117.9%). The TPH concentration was 0 mg/L during all three limbs of the storm event.

- May 17, 2016 - At Church Creek, copper was the only EMC parameter greater than the average concentrations of the storms captured since December 12, 2012, by 138.4%. The falling limb copper concentration was 67 µg/L, contributing to a higher than usual EMC. Due to the malfunction of the pH probe, pH values were not recorded during this storm event at Church Creek, therefore, no pH EMC was calculated. All metals and BOD EMCs at Parole Plaza were greater than the average concentrations of the storms captured since December 12, 2012 by between 38% (zinc) and 346.9% (copper). Metal concentrations were higher than usual during this storm event, contributing to the higher than usual EMCs.

- June 16, 2016 - At Church Creek, four parameter EMCs were greater than the average concentrations of the storms captured since December 12, 2012. EMCs for BOD, TKN, nitrate-nitrite, and *E. coli* were greater than the corresponding historical averages by 10.4% to 49.7%. The concentration of BOD, TKN, and nitrate-nitrite were elevated during the rising limb which contributed to the higher EMCs. Because the pH probe was not reading properly, manual readings were recorded using a calibrated Pro DSS YSI. The *E. coli* EMC was 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 peak and falling limb. However, the *E. coli* EMC was only greater than the corresponding historical averages by 8%.

Hydrograph for August 20, 2015 Storm
Parole Plaza





Hydrograph for September 10, 2015 Storm
Parole Plaza
Rainfall
Discharge
Peak Sample
Rising Limb Sample
Falling Limb Sample
Rainfall (in)
Discharge (CFS)
Time
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1:00 PM
1:20 PM
1:40 PM
2:00 PM
2:20 PM
2:40 PM
3:00 PM
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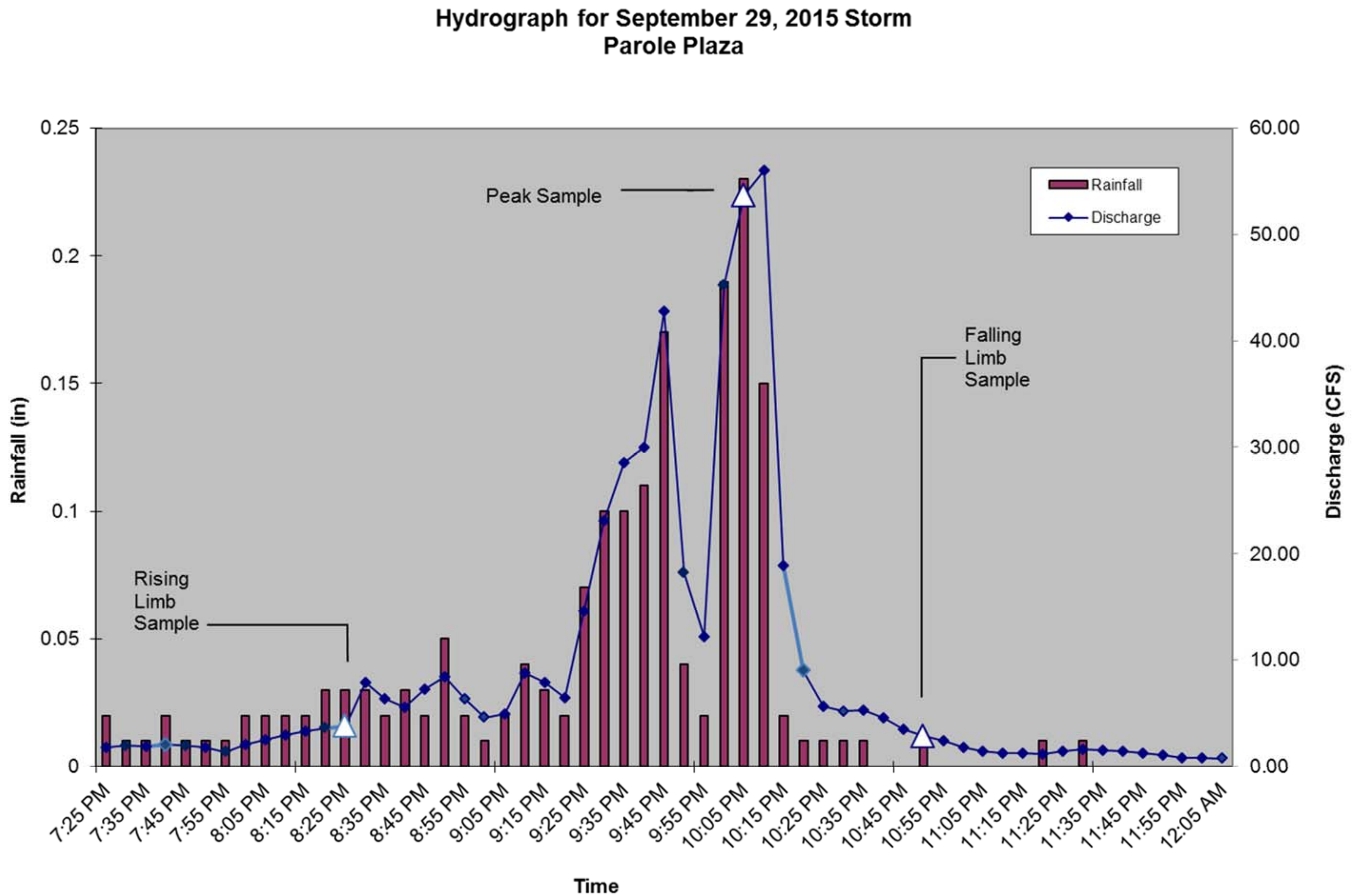
5:40 PM
6:00 PM


Hydrograph for September 29, 2015 Storm
Parole Plaza
Rainfall
Discharge
Peak Sample
Falling
Limb
Sample
Rising
Limb
Sample
Rainfall (in)
Discharge (CFS)
0.25
0.2
0.15
0.1
0.05
0
60.00
50.00
40.00
30.00
20.00
10.00
0.00
7:25 PM
7:35 PM
7:45 PM
7:55 PM
8:05 PM
8:15 PM
8:25 PM
8:35 PM
8:45 PM
8:55 PM
9:05 PM
9:15 PM
9:25 PM
9:35 PM
9:45 PM
9:55 PM
10:05 PM
10:15 PM
10:25 PM
10:35 PM
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11:25 PM
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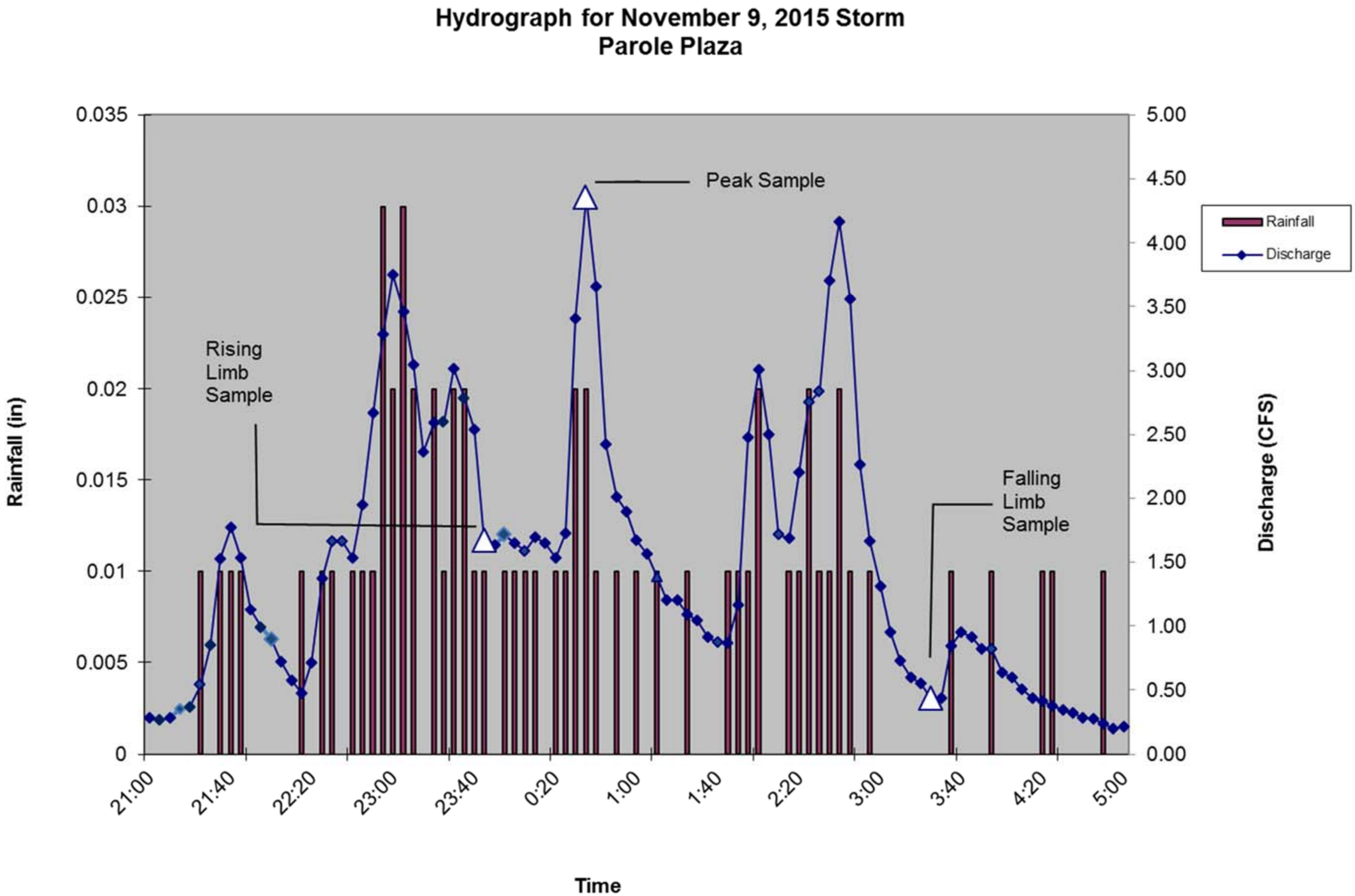
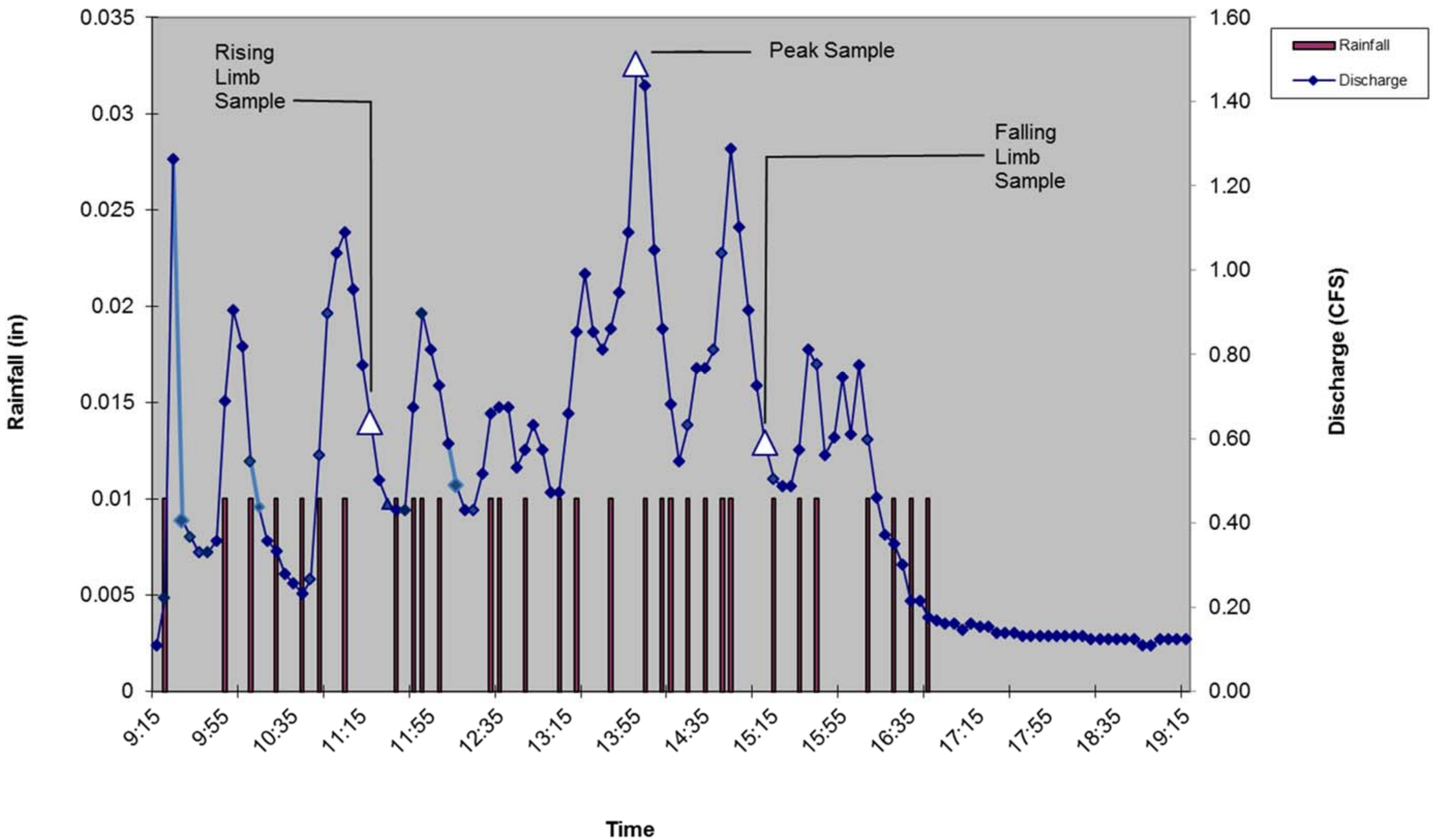
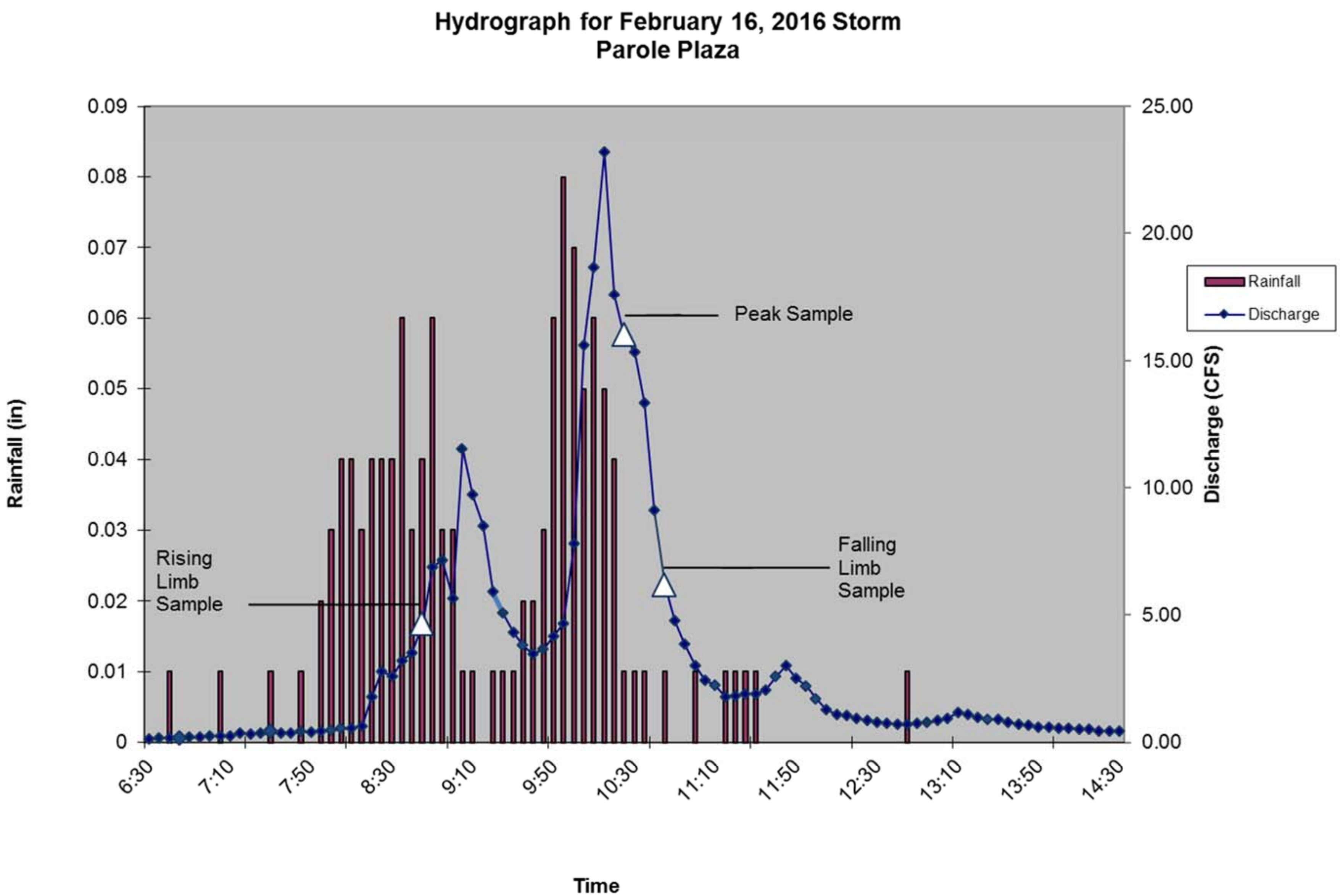
11:45 PM
11:55 PM
12:05 AM
Time


Hydrograph for November 9, 2015 Storm
Parole Plaza
Rainfall (in)
Discharge (CFS)
Time
Rainfall
Discharge
Peak Sample
Rising Limb Sample
Falling Limb Sample
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
21:00
21:40
22:20
23:00
23:40
0:20
1:00
1:40
2:20
3:00
3:40
4:20
5:00

Hydrograph for December 17, 2015 Storm
Parole Plaza





Hydrograph for February 16, 2016 Storm
Parole Plaza
Rainfall (in)
Discharge (CFS)
Time
Rainfall
Discharge
Peak Sample
Rising Limb Sample
Falling Limb Sample
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
6:30
7:10
7:50
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9:10
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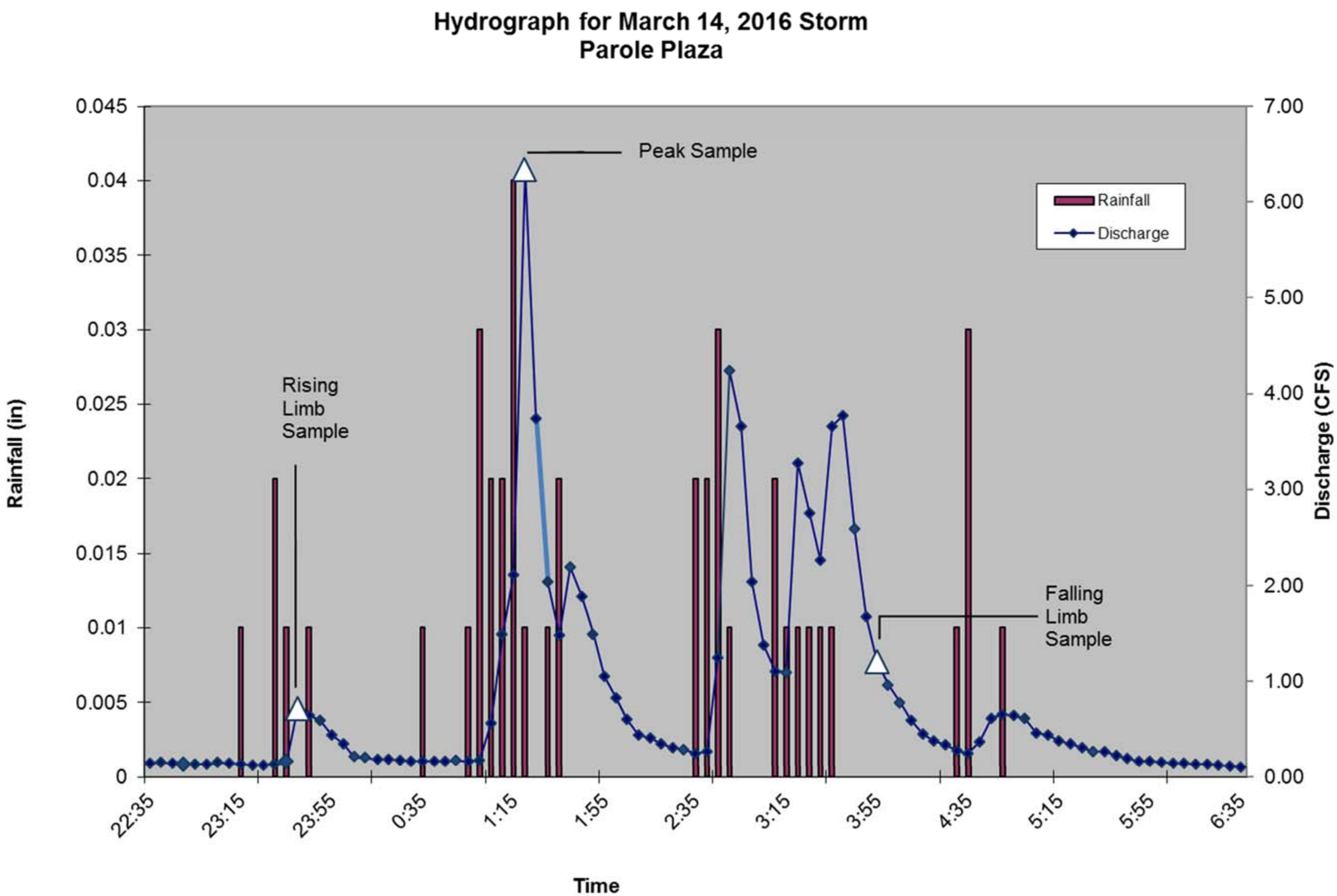
11:50
12:30
13:10
13:50
14:30


Hydrograph for March 14, 2016 Storm
Parole Plaza
Rainfall (in)
Discharge (CFS)
Time
Rainfall
Discharge
Peak Sample
Rising Limb Sample
Falling Limb Sample
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
22:35
23:15
23:55
0:35
1:15
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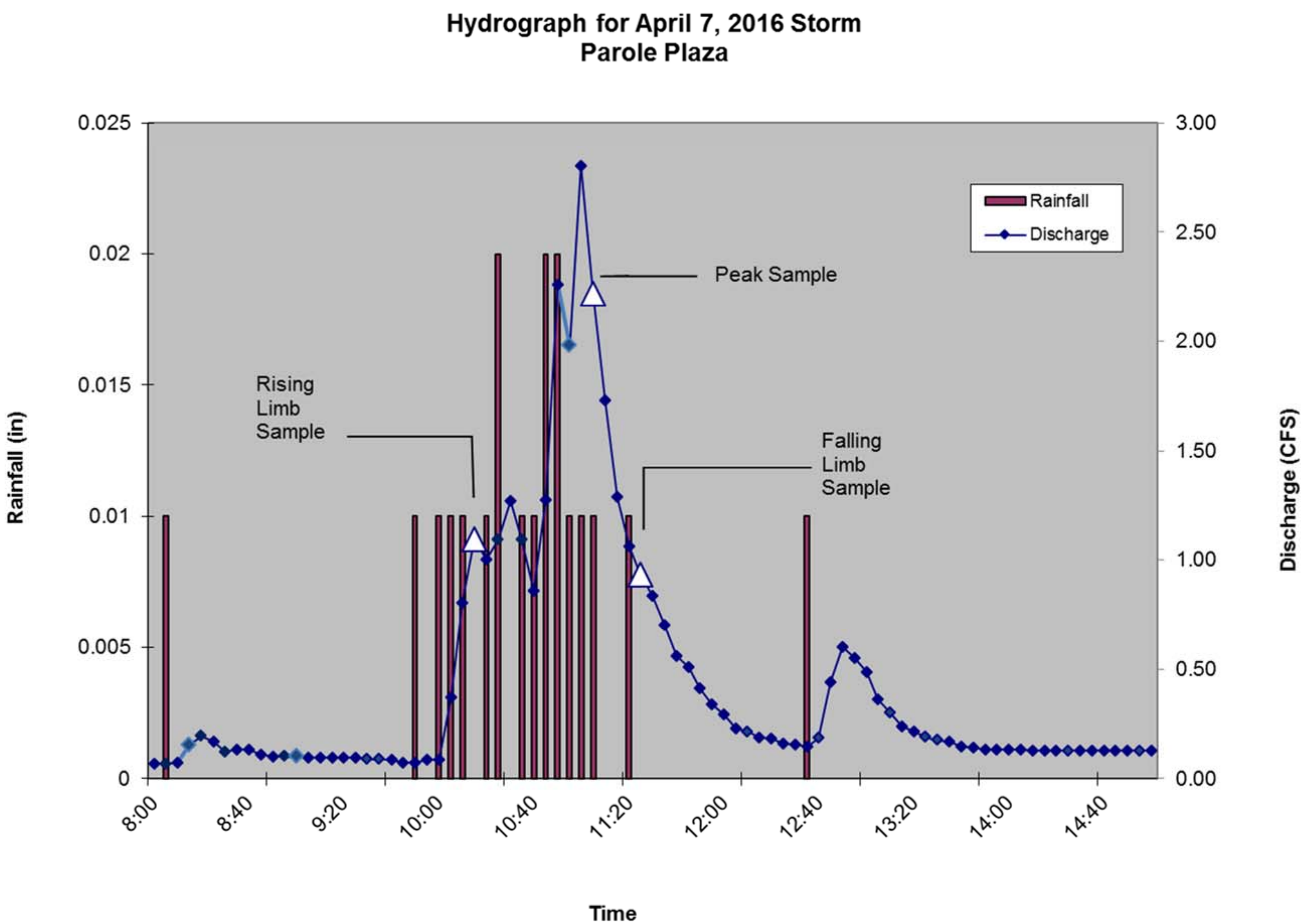
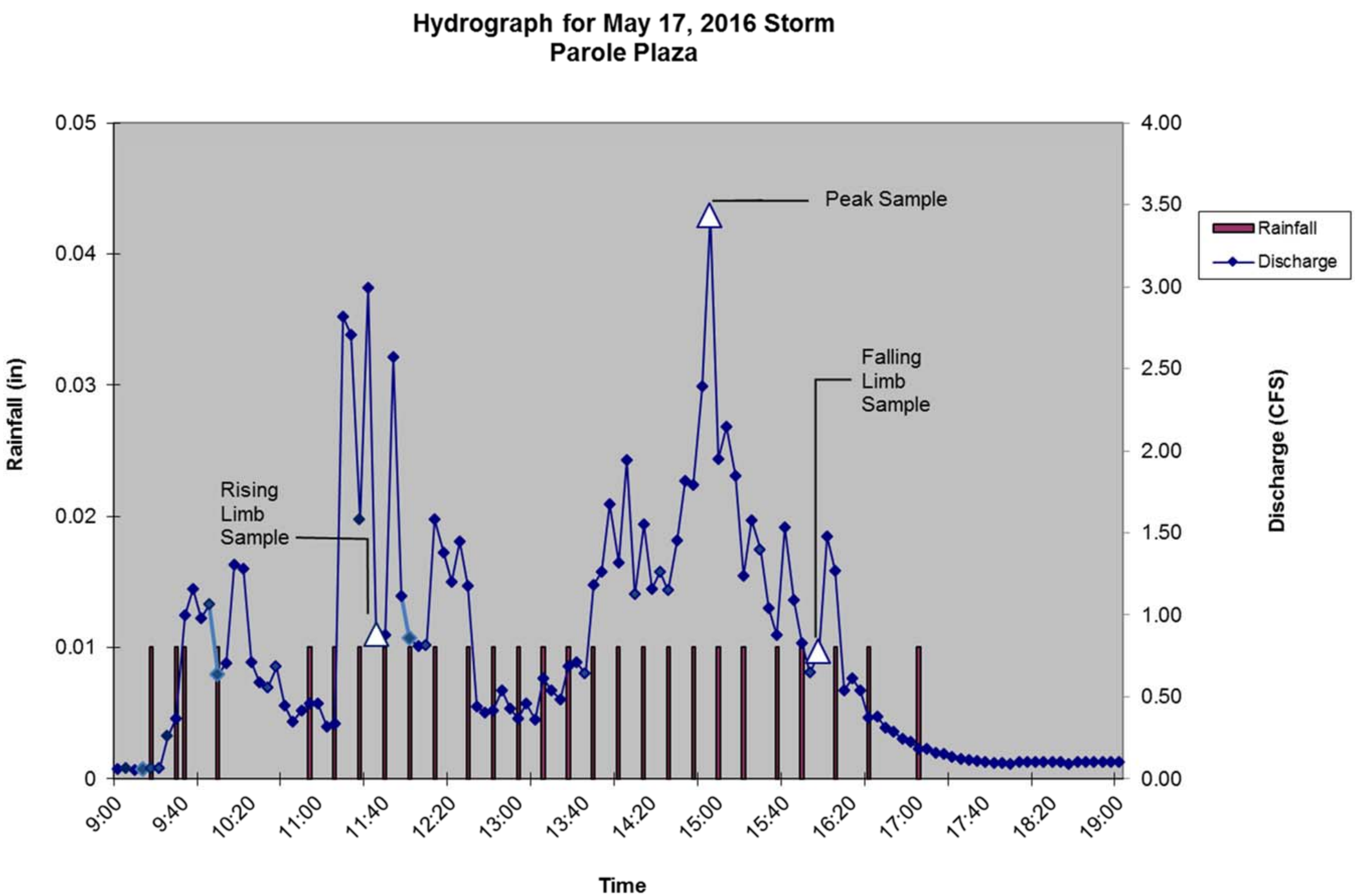
2:35
3:15
3:55
4:35
5:15
5:55
6:35

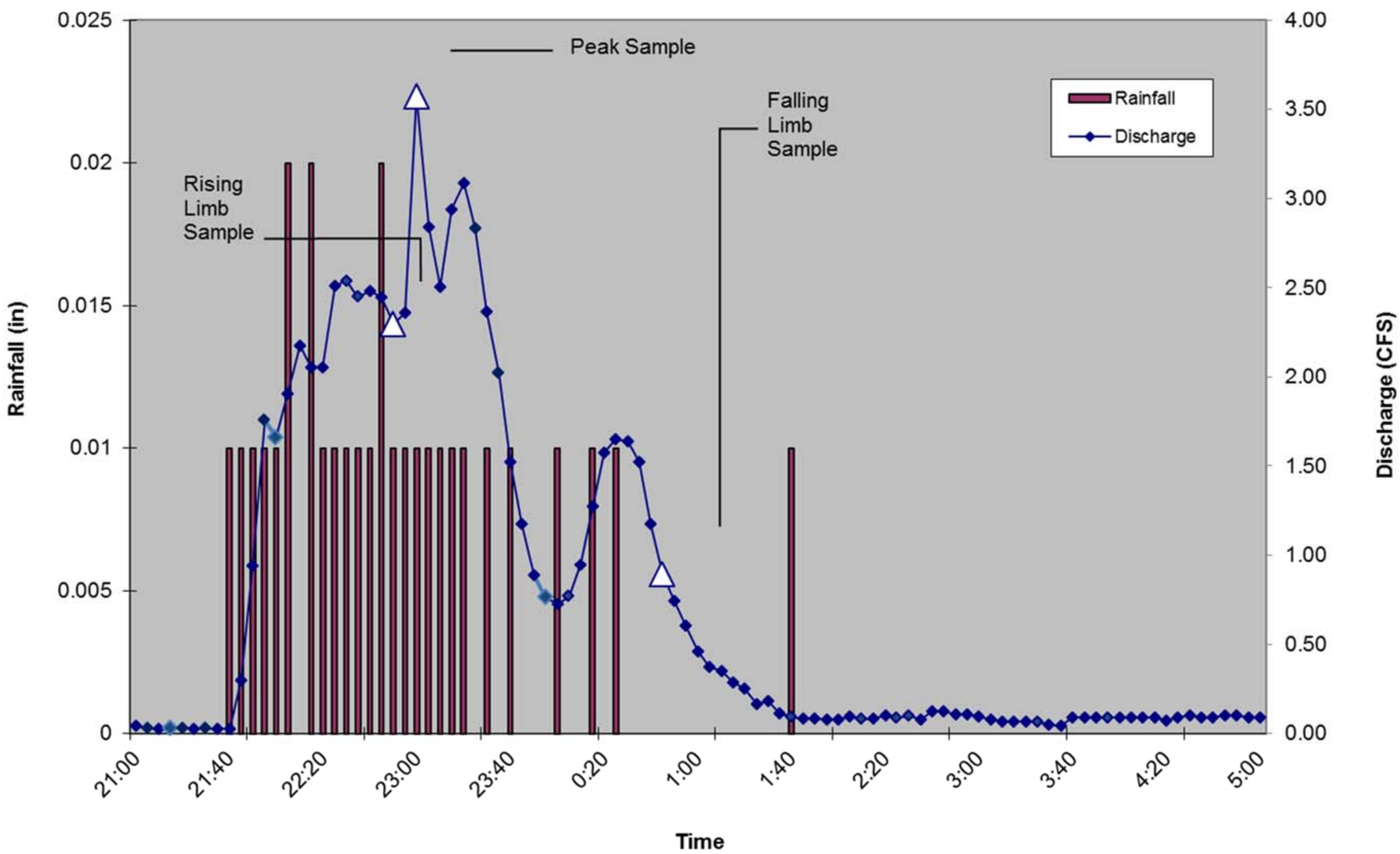


Hydrograph for April 7, 2016 Storm
Parole Plaza
Rainfall (in)
Discharge (CFS)
Time
0.025
0.02
0.015
0.01
0.005
0
3.00
2.50
2.00
1.50
1.00
0.50
0.00
8:00
8:40
9:20
10:00
10:40
11:20
12:00
12:40
13:20
14:00
14:40
Rainfall
Discharge
Peak Sample
Rising Limb Sample
Falling Limb Sample

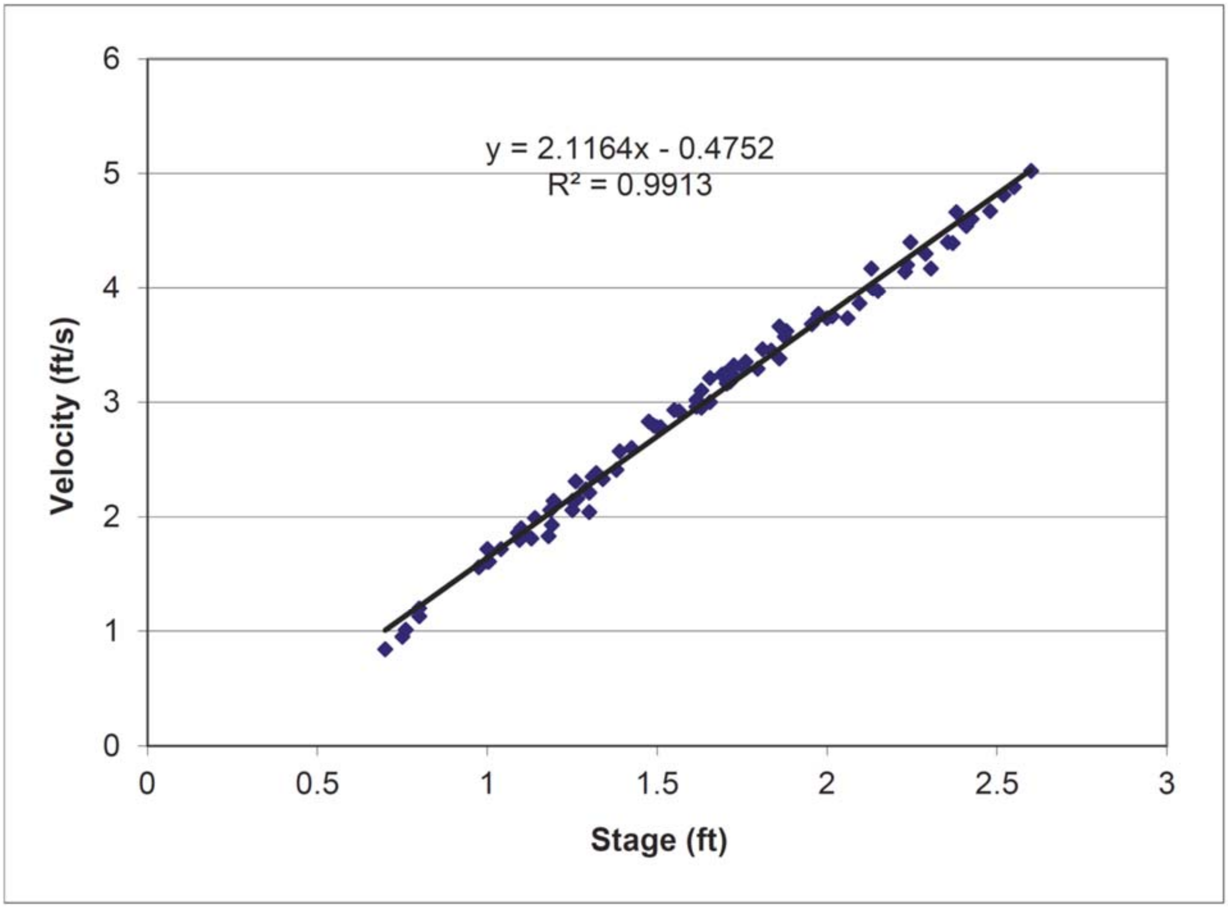


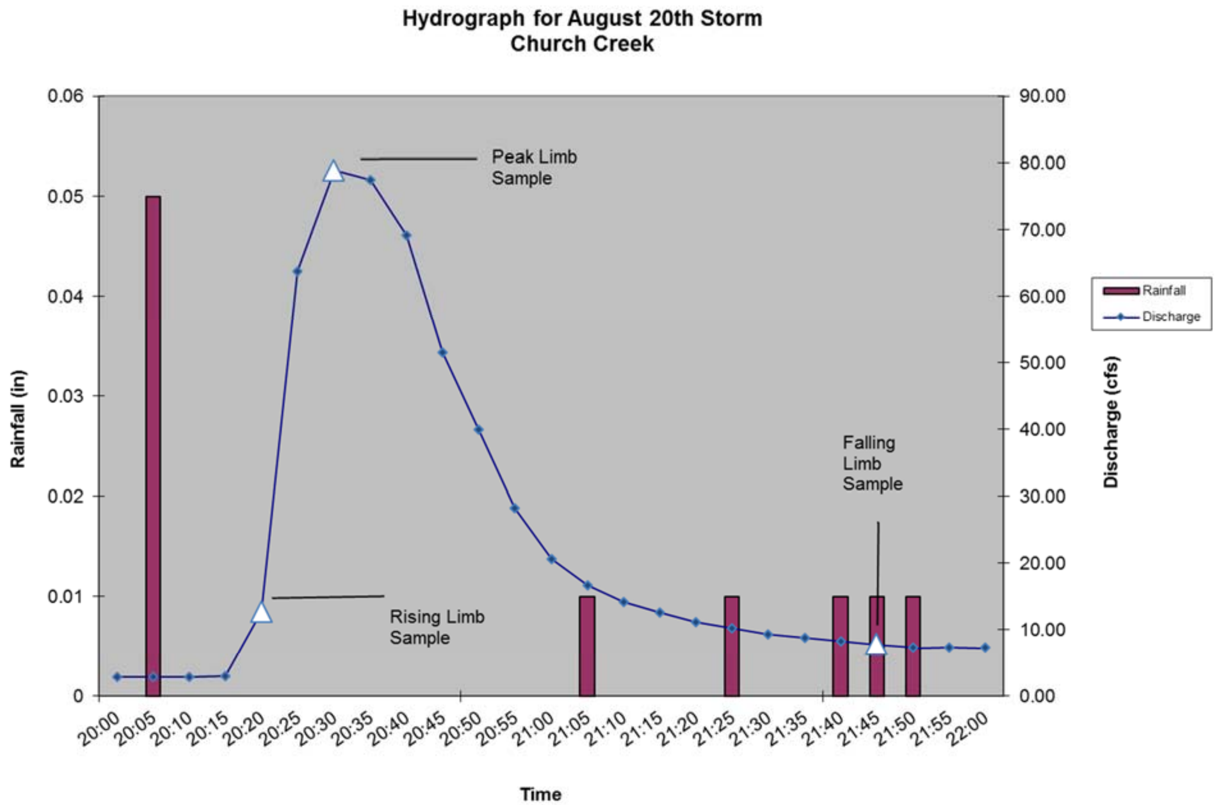
Hydrograph for May 17, 2016 Storm
Parole Plaza
Rainfall (in)
Discharge (CFS)
Time
Rainfall
Discharge
Peak Sample
Rising Limb Sample
Falling Limb Sample
0.05
0.04
0.03
0.02
0.01
0
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
9:00
9:40
10:20
11:00
11:40
12:20
13:00
13:40
14:20
15:00
15:40
16:20
17:00
17:40
18:20
19:00

Hydrograph for June 16, 2016 Storm
Parole Plaza

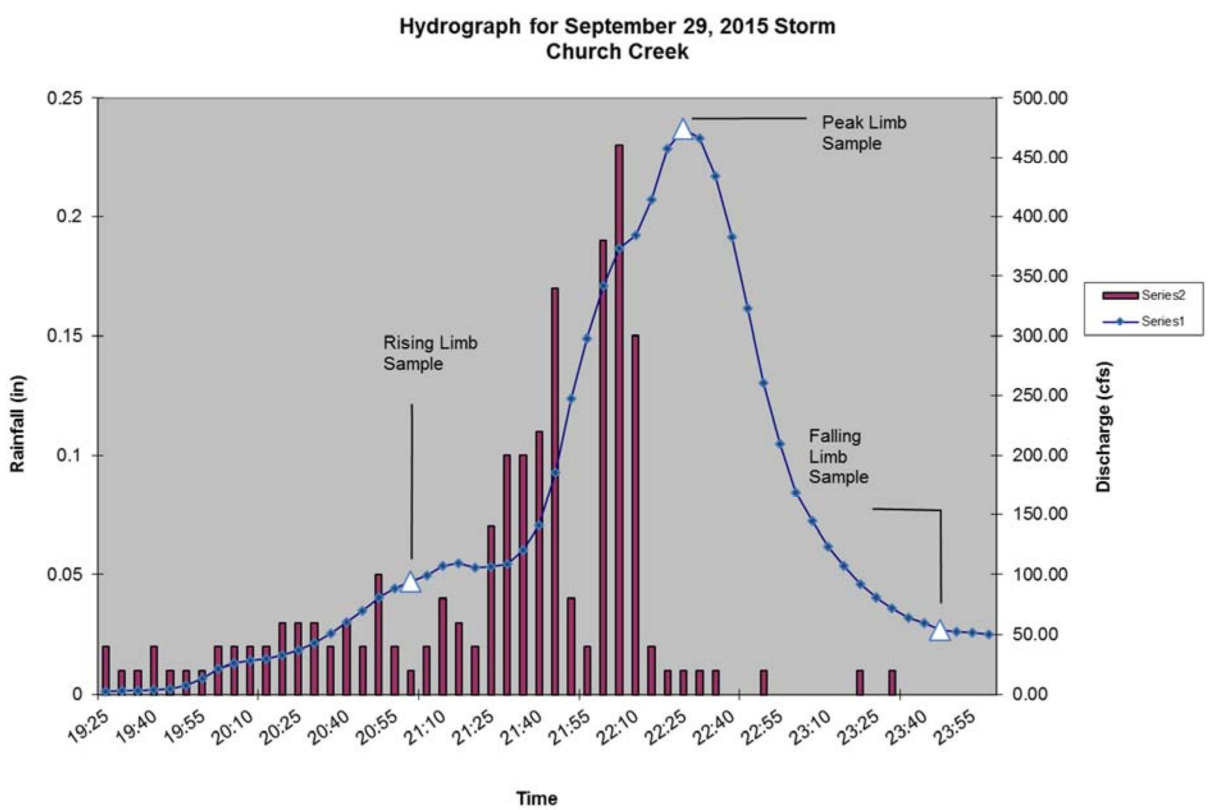


Church Creek Discharge Rating Table					
Stage (ft)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)	Velocity, (ft/s)	Discharge (cfs)
0.0	0	0	0	0.00	0.00
0.1	0.21	2.77	2.75	0.00	0.00
0.2	0.53	3.62	3.57	0.00	0.00
0.3	0.91	4.03	3.93	0.16	0.15
0.4	1.31	4.36	4.19	0.37	0.49
0.5	1.75	4.83	4.58	0.58	1.02
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

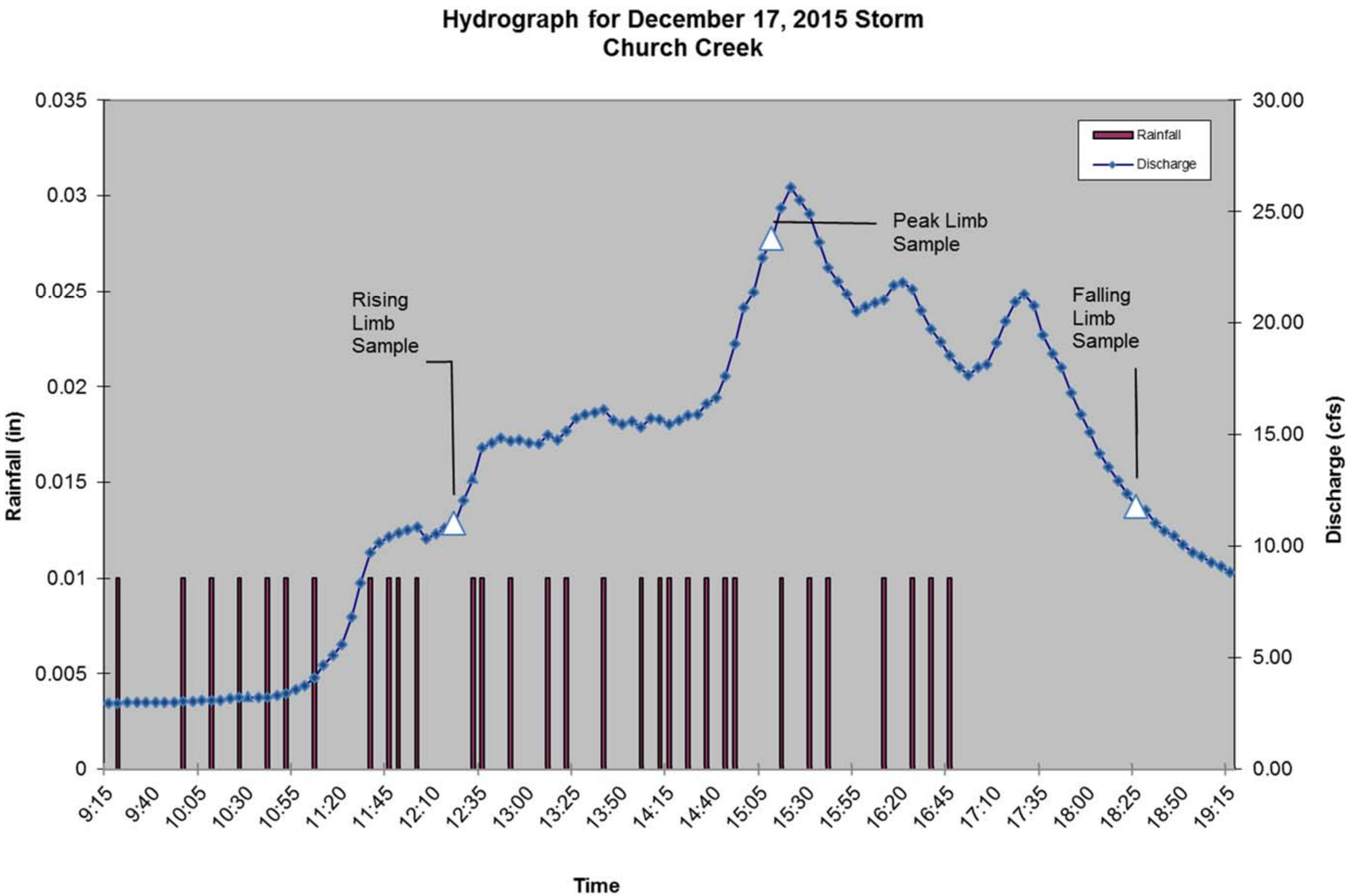

y = 2.1164x - 0.4752
R² = 0.9913
Velocity (ft/s)
Stage (ft)
0
1
2
3
4
5
6
0
0.5
1
1.5
2
2.5
3

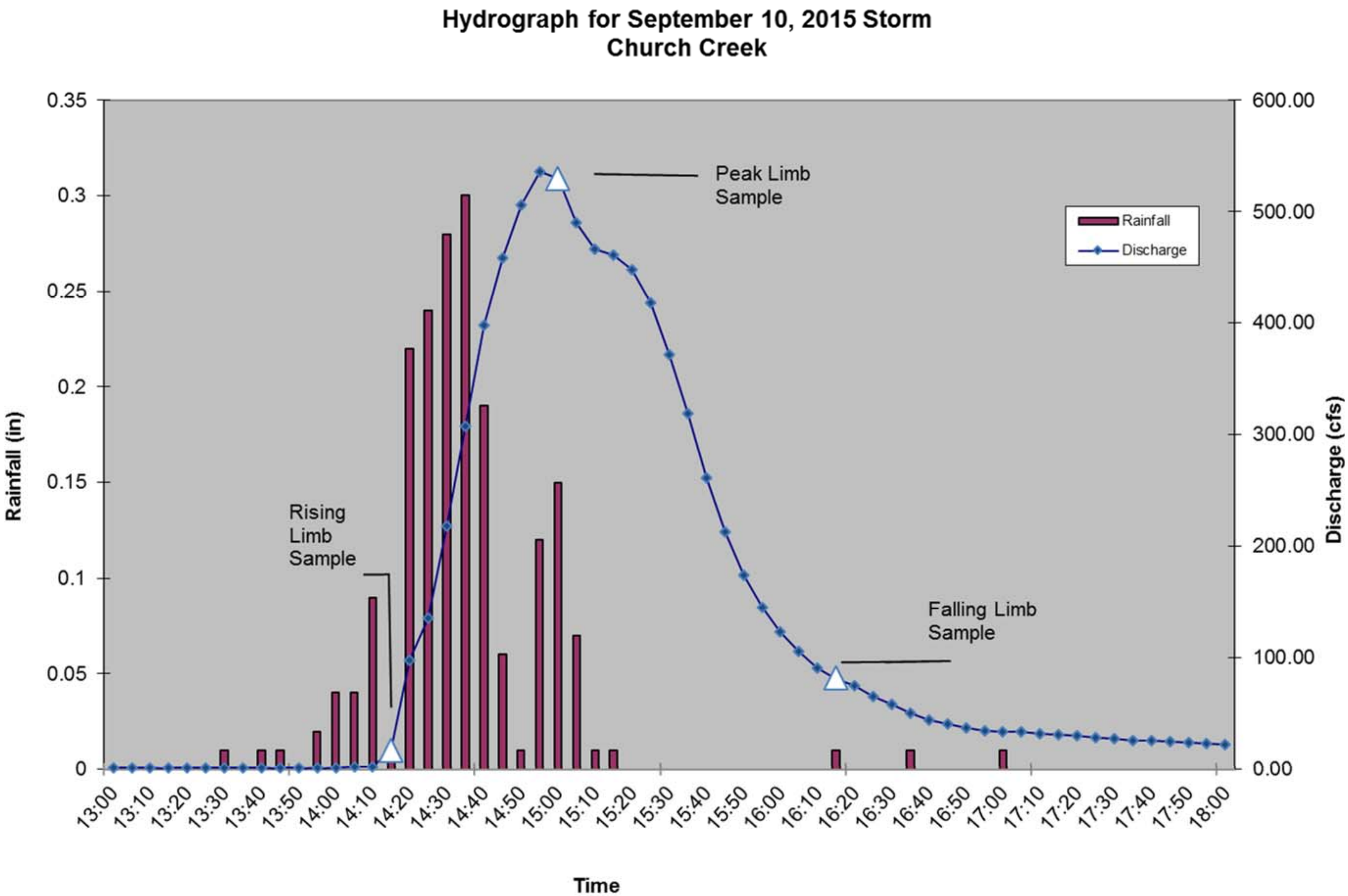


Hydrograph for August 20th Storm
Church Creek
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge

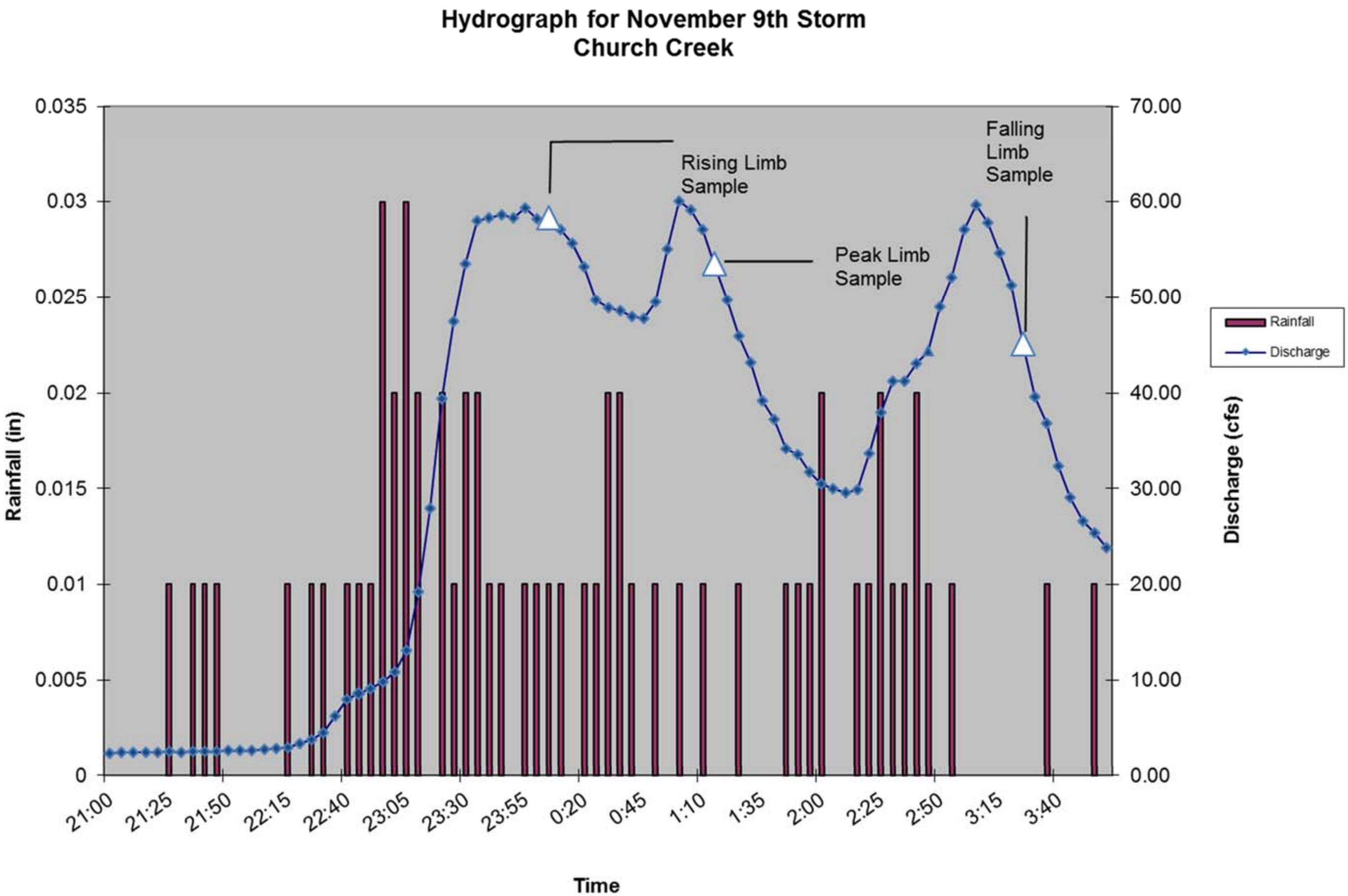


Hydrograph for September 29, 2015 Storm
Church Creek
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
Rainfall (in)
Discharge (cfs)
Time
Series2
Series1

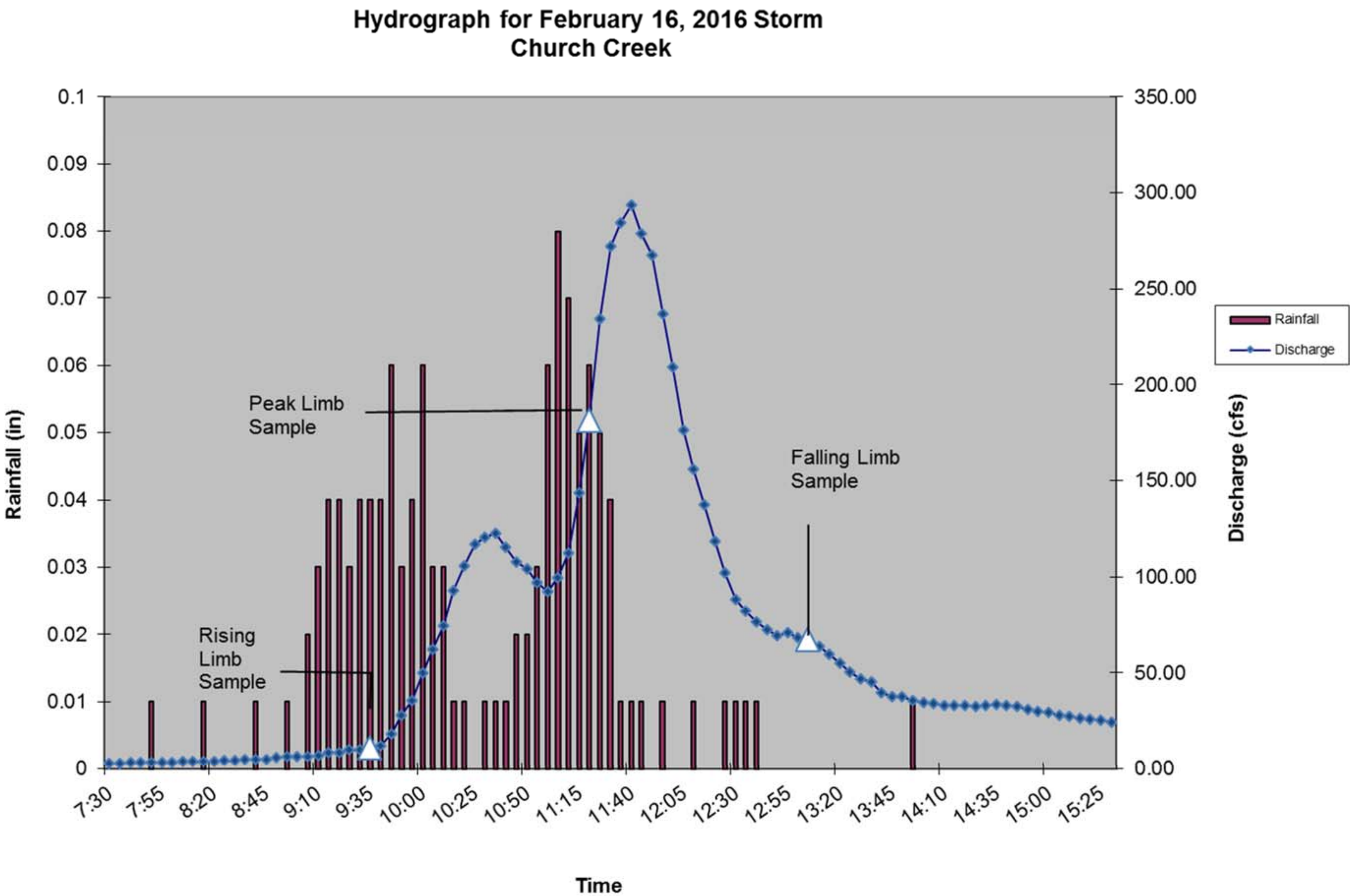

Hydrograph for December 17, 2015 Storm
Church Creek
Rainfall
Discharge
Rising Limb Sample
Peak Limb Sample
Falling Limb Sample
Rainfall (in)
Discharge (cfs)
Time
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
30.00
25.00
20.00
15.00
10.00
5.00
0.00
9:15
9:40
10:05
10:30
10:55
11:20
11:45
12:10
12:35
13:00
13:25
13:50
14:15
14:40
15:05
15:30
15:55
16:20
16:45
17:10
17:35
18:00
18:25
18:50
19:15



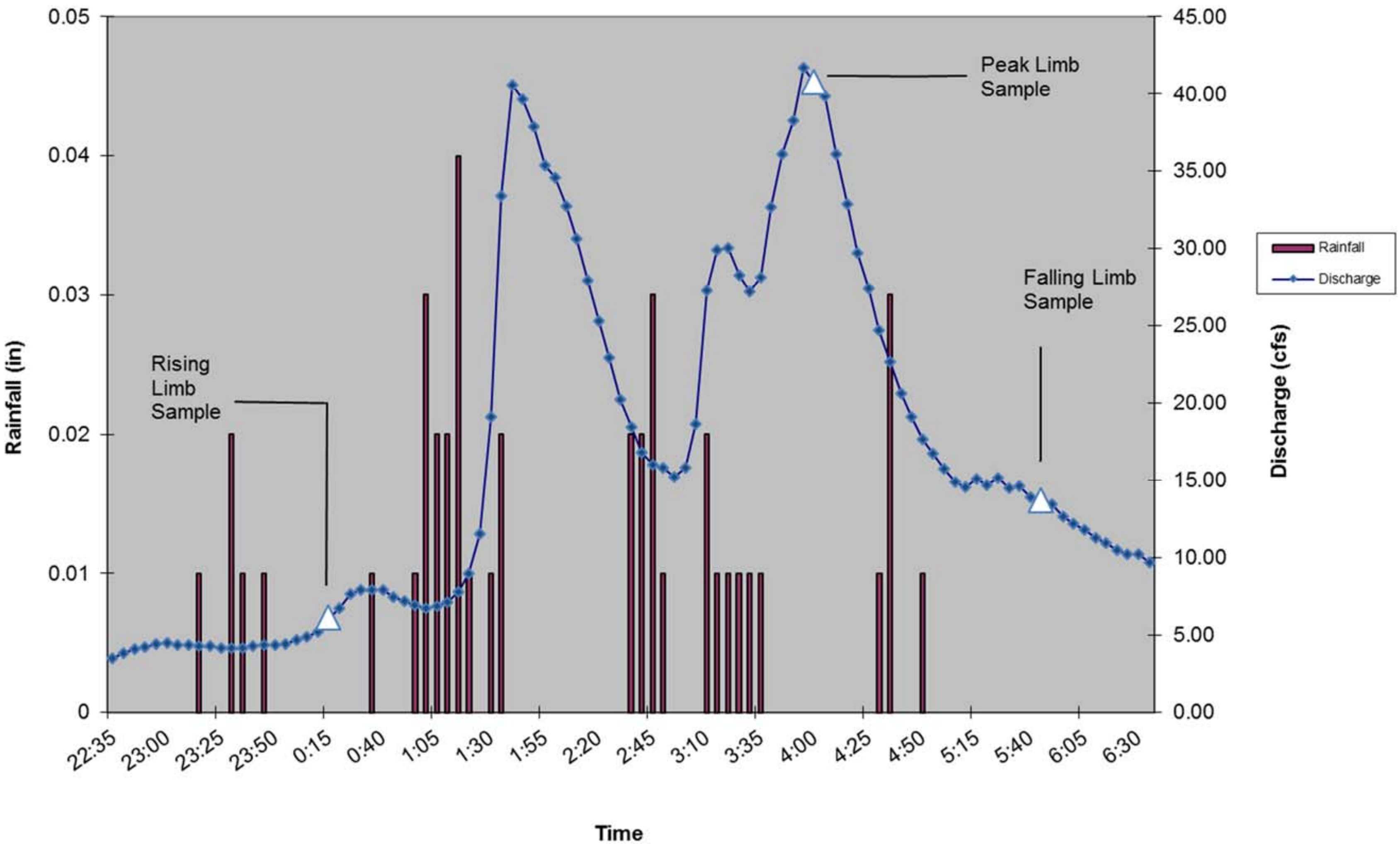
Hydrograph for September 10, 2015 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
600.00
500.00
400.00
300.00
200.00
100.00
0.00
13:00
13:10
13:20
13:30
13:40
13:50
14:00
14:10
14:20
14:30
14:40
14:50
15:00
15:10
15:20
15:30
15:40
15:50
16:00
16:10
16:20
16:30
16:40
16:50
17:00
17:10
17:20
17:30
17:40
17:50
18:00



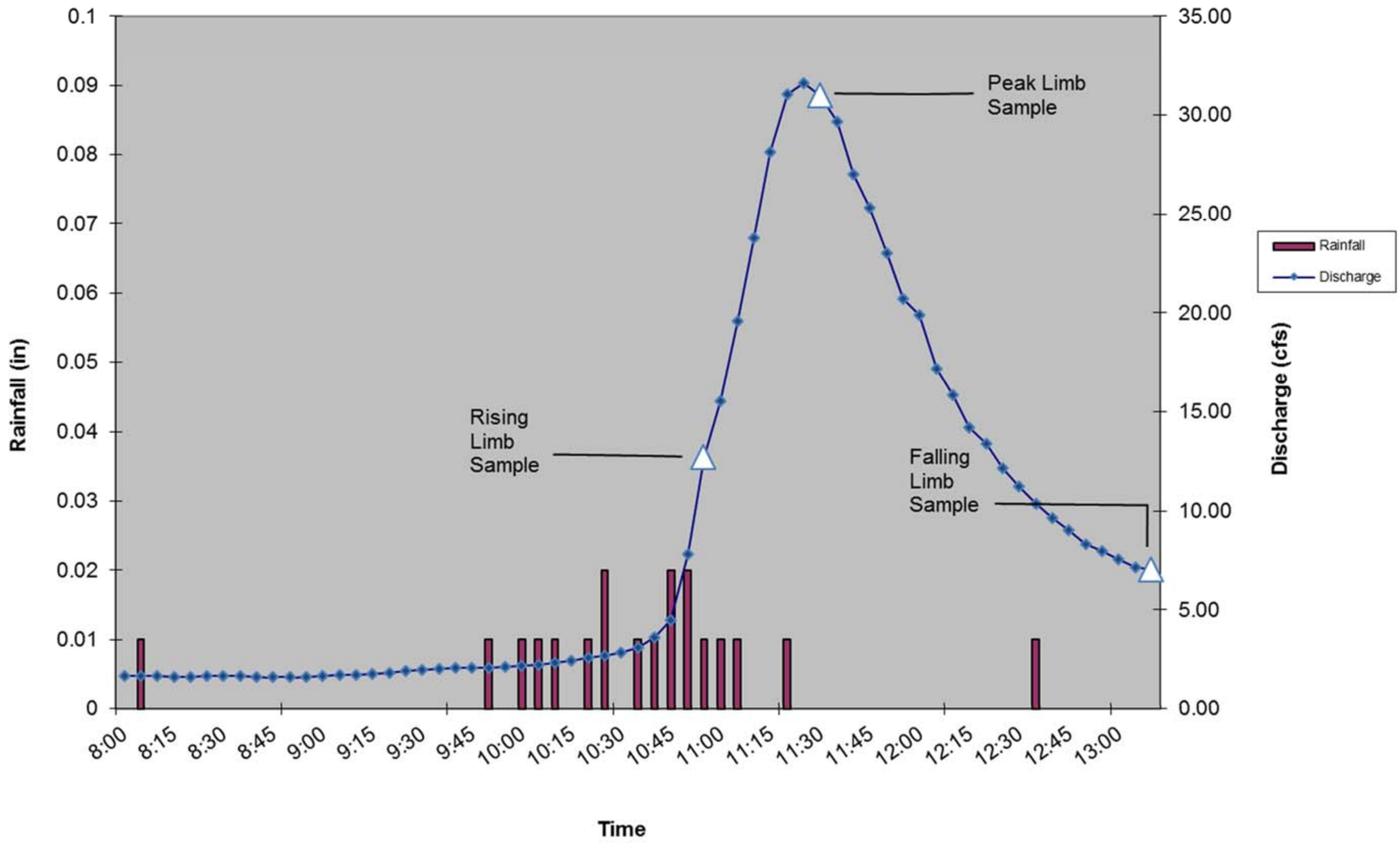
Hydrograph for November 9th Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rising Limb Sample
Peak Limb Sample
Falling Limb Sample
Rainfall
Discharge
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
21:00
21:25
21:50
22:15
22:40
23:05
23:30
23:55
0:20
0:45
1:10
1:35
2:00
2:25
2:50
3:15
3:40


Hydrograph for February 16, 2016 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
7:30
7:55
8:20
8:45
9:10
9:35
10:00
10:25
10:50
11:15
11:40
12:05
12:30
12:55
13:20
13:45
14:10
14:35
15:00
15:25

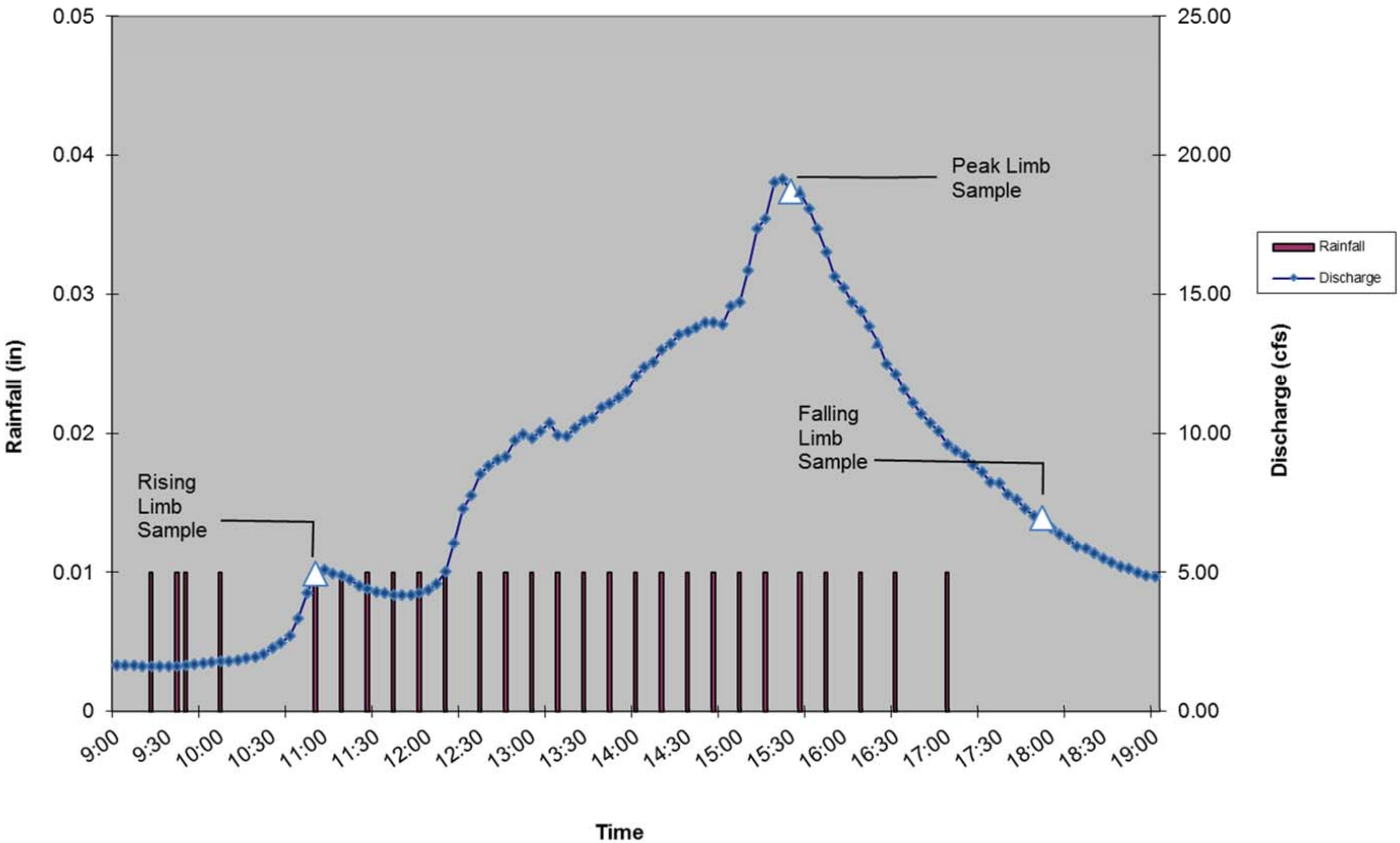
Hydrograph for March 14, 2016 Storm
Church Creek

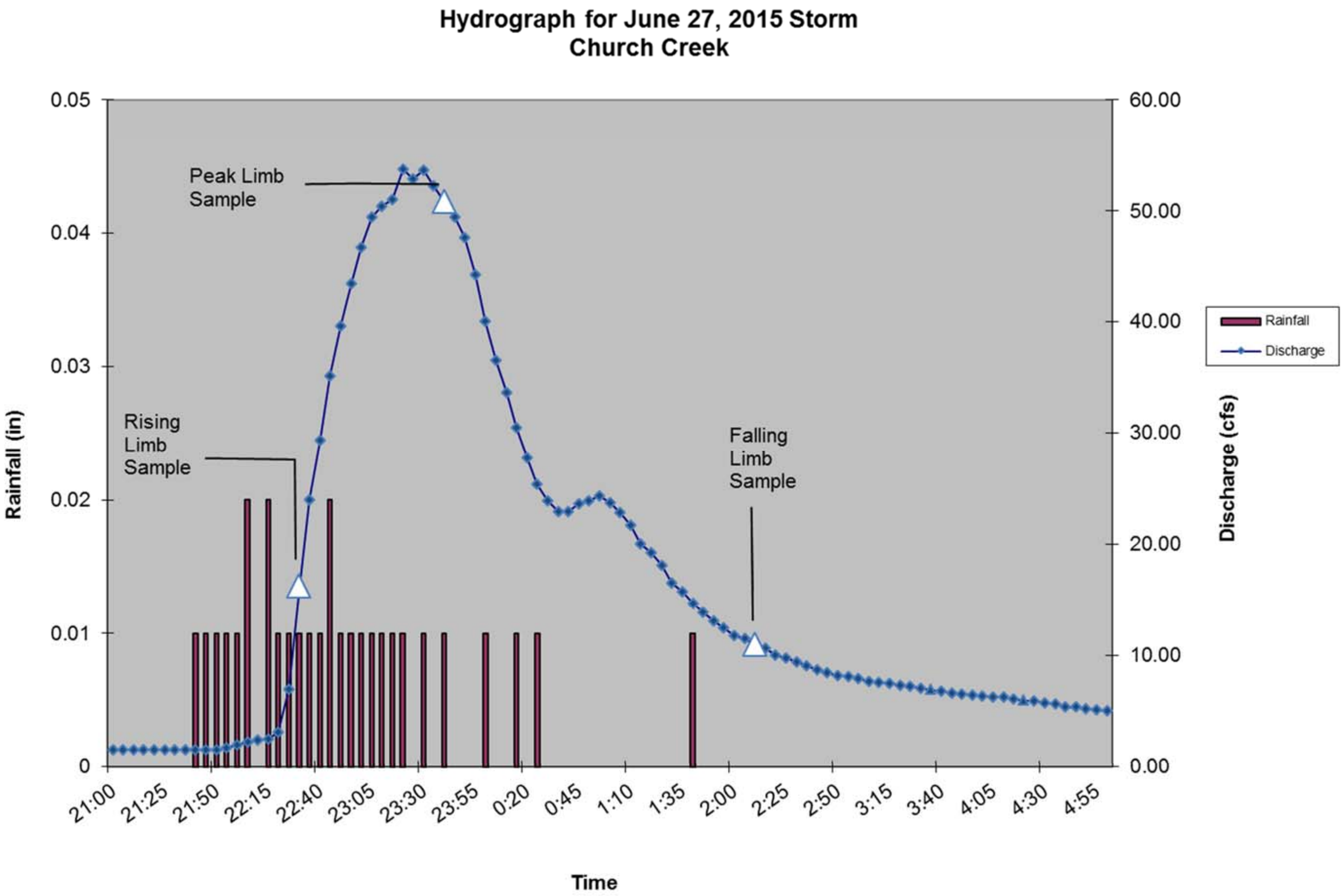


Hydrograph for April 7, 2016 Storm
Church Creek



Hydrograph May 17, 2016 Storm
Church Creek





Hydrograph for June 27, 2015 Storm
Church Creek
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
0.05
0.04
0.03
0.02
0.01
0
60.00
50.00
40.00
30.00
20.00
10.00
0.00
21:00
21:25
21:50
22:15
22:40
23:05
23:30
23:55
0:20
0:45
1:10
1:35
2:00
2:25
2:50
3:15
3:40
4:05
4:30
4:55

APPENDIX B

MASTER TAXA LIST

Order	Family	Genus	Taxon	FFG[a]	Habit[b]	Tolerance Value[c]
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7
Arhynchobdellida	Erpobdellidae		Erpobdellidae	Predator	sp	10
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7
Diptera	Chironomidae	Conchapelopia	Conchapelopia	Predator	sp	6.1
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6
Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	Predator	sp, bu	7.6
Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	Collector	bu	9
Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	Collector	sp	6.1
Diptera	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3
Diptera	Empididae		Odontomyia/hedriodiscus	Collector		7
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9
Diptera	Tipulidae	Limonia	Limonia	Shredder	bu, sp	4.8
Diptera	Tipulidae	Molophilus	Molophilus		bu	4.8
Haplotaxida	Enchytraeidae		Enchytraeidae	Collector	bu	9.1
Hoplonemertea	Tetrastemmatidae	Prostoma	Prostoma	Predator		7.3
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6
Lepidoptera			Lepidoptera			6.7
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		Coenagrionidae	Predator	cb	9
Odonata	Coenagrionidae	Argia	Argia	Predator	cn, cb, sp	9.3
Odonata	Libellulidae		Libellulidae	Predator		9
Odonata	Libellulidae	Pachydiplax	Pachydiplax	Predator		8
Rhynchobdellida	Glossiphoniidae	Placobdella	Placobdella	Predator		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	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: 3/23/2016

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.86

Metric	Value	Score
Total Taxa	11	1
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	0	1
% Ephemeroptera	0	1
Scraper Taxa	1	3
% Climbers	73.77	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	15
Calopteryx	2
Erpobdellidae	1
Lepidoptera	7
Limnodrilus	9
Lumbriculidae	3
Molophilus	1
Physa	73
Pisidium	1
Prostoma	1
Tubificidae	8

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Degraded
PHI Score	64.80

Metric	Score
Drainage area (acres)	70.40
Remoteness	18.60
Percent Shading	68.32
Epifaunal Substrate	63.35
Instream Habitat	81.54
Instream Wood Debris	100.00
Bank Stability	57.01

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	71

Metric	Score
Epifaunal Substrate / Cover	10
Embeddedness	9
Velocity / Depth Regime	9
Sediment Deposition	10
Channel Flow Status	12
Channel Alteration	19
Frequency of Riffles	16
Bank Stability	4(Left)/5(Right)
Vegetative Protection	5(Left)/6(Right)
Riparian Veg Zone Width	6(Left)/9(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	11.43
pH	6.48
Specific Conductance (µS/cm)	750
Temperature (°C)	15.51
Turbidity (NTUs)	15.4

Church Creek Site CC-02

Sampled: 3/23/2016

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.57

Metric	Value	Score
Total Taxa	12	1
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	1.63	1
% Ephemeroptera	0	1
Scraper Taxa	0	1
% Climbers	13.01	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	5
Caecidotea	2
Calopteryx	2
Coenagrionidae	1
Conchapelopia	12
Cryptochironomus	4
Dicrotendipes	1
Gammarus	73
Lepidoptera	2
Limnodrilus	9
Pisidium	4
Polypedilum	8

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Degraded
PHI Score	58.47

Metric	Score
Drainage area (acres)	282.24
Remoteness	23.05
Percent Shading	68.32
Epifaunal Substrate	48.50
Instream Habitat	67.33
Instream Wood Debris	84.45
Bank Stability	59.19

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	61

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

Water Chemistry

Dissolved Oxygen (mg/L)	8.57
pH	6.92
Specific Conductance (µS/cm)	736
Temperature (°C)	9.15
Turbidity (NTUs)	23.1

Church Creek Site CC-03

Sampled: 3/24/2016

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Poor
BIBI Score	2.14

Metric	Value	Score
Total Taxa	19	3
EPT Taxa	1	1
Number Ephemeroptera	0	1
% Intolerant to Urban	4.84	1
% Ephemeroptera	0	1
Scraper Taxa	1	3
% Climbers	16.94	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	3
Boyeria	1
Caecidotea	6
Calopteryx	3
Cheumatopsyche	3
Conchapelopia	12
Cricotopus	2
Enchytraeidae	1
Eukiefferiella	5
Gammarus	15
Hemerodromia	1
Lepidoptera	8
Limonia	1
Lumbriculidae	1
Orthocladius	35
Physa	1
Pisidium	2
Polypedilum	13
Tubificidae	11

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	68.64

Metric	Score
Drainage area (acres)	282.24
Remoteness	20.96
Percent Shading	45.47
Epifaunal Substrate	94.97
Instream Habitat	89.52
Instream Wood Debris	90.37
Bank Stability	70.56

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	62

Metric	Score
Epifaunal Substrate / Cover	12
Embeddedness	12
Velocity / Depth Regime	10
Sediment Deposition	11
Channel Flow Status	13
Channel Alteration	11
Frequency of Riffles	6
Bank Stability	8(Left)/6(Right)
Vegetative Protection	4(Left)/3(Right)
Riparian Veg Zone Width	4(Left)/4(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	3.78
pH	6.98
Specific Conductance (µS/cm)	747
Temperature (°C)	10.83
Turbidity (NTUs)	24.6

Church Creek Site CC-04

Sampled: 3/23/2016

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Poor
BIBI Score	2.71

Metric	Value	Score
Total Taxa	17	3
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	47.66	5
% Ephemeroptera	0	1
Scraper Taxa	1	3
% Climbers	13.28	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Caecidotea	61
Calopteryx	5
Coenagrionidae	9
Conchapelopia	3
Erpobdellidae	1
Gammarus	17
Girardia	2
Lepidoptera	6
Libellulidae	2
Odontomyia/hedriodiscus	1
Orthocladius	3
Pachydiplax	1
Physa	1
Pisidium	10
Placobdella	1
Polypedilum	2
Tubificidae	3

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Degraded
PHI Score	62.70

Metric	Score
Drainage area (acres)	110.53
Remoteness	20.96
Percent Shading	40.96
Epifaunal Substrate	54.61
Instream Habitat	88.02
Instream Wood Debris	100.00
Bank Stability	71.63

Rapid Bioassessment Protocal

Narrative Rating	Supporting
RBP Score	76

Metric	Score
Epifaunal Substrate / Cover	11
Embeddedness	10
Velocity / Depth Regime	8
Sediment Deposition	9
Channel Flow Status	15
Channel Alteration	19
Frequency of Riffles	16
Bank Stability	6(Left)/7(Right)
Vegetative Protection	5(Left)/4(Right)
Riparian Veg Zone Width	9(Left)/8(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	3.66
pH	6.85
Specific Conductance (µS/cm)	876
Temperature (°C)	15.04
Turbidity (NTUs)	27.5

Select physical habitat parameters (raw scores) 2016			
Site	Epifaunal Substrate (0 – 20)	Instream Habitat (0-20)	Embeddedness (0 – 100%)
CC-01	6	8	70
CC-02	5	8	70
CC-03	13	12	40
CC-04	5	10	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.

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 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.

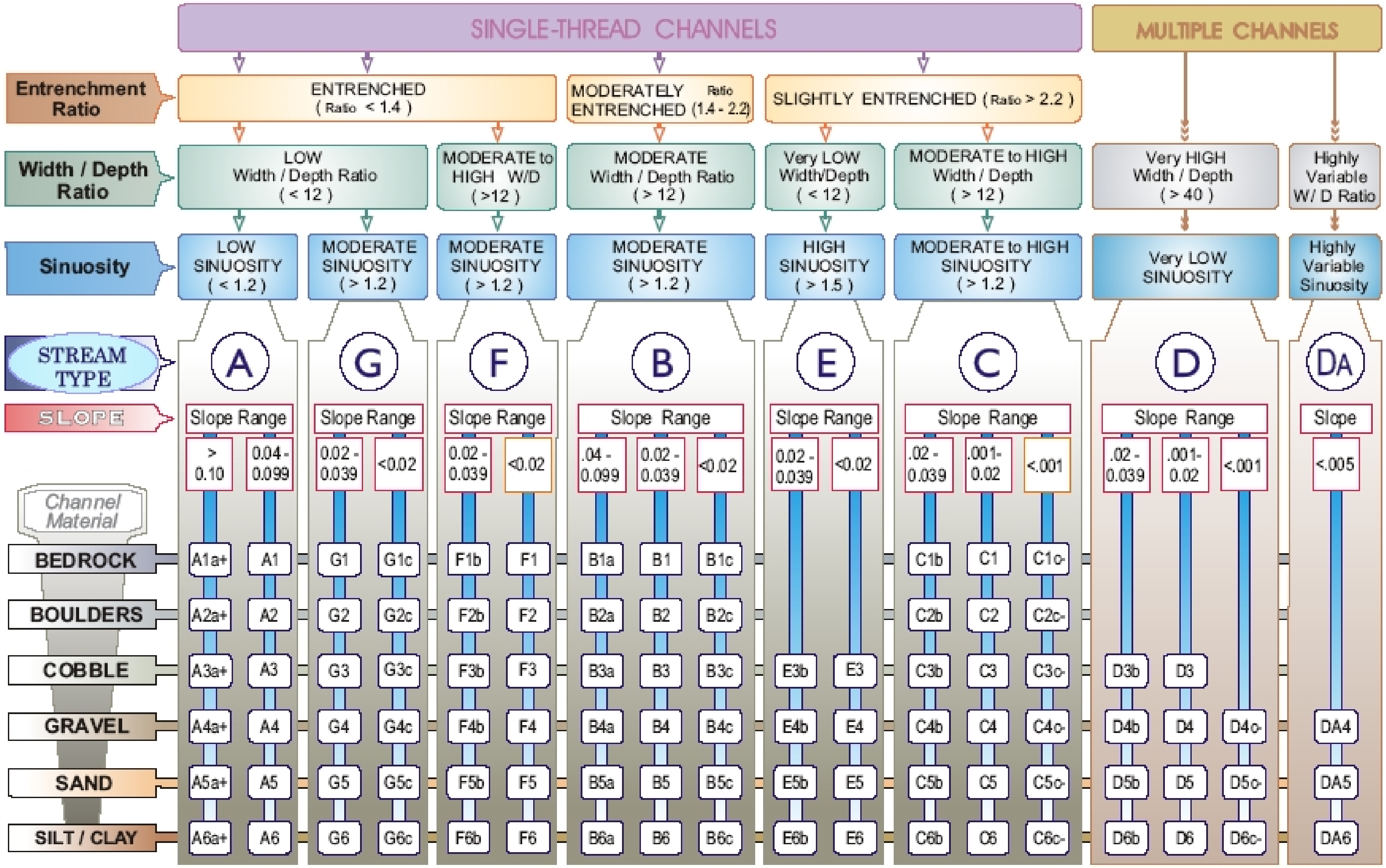
Identification of Stream Types

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.

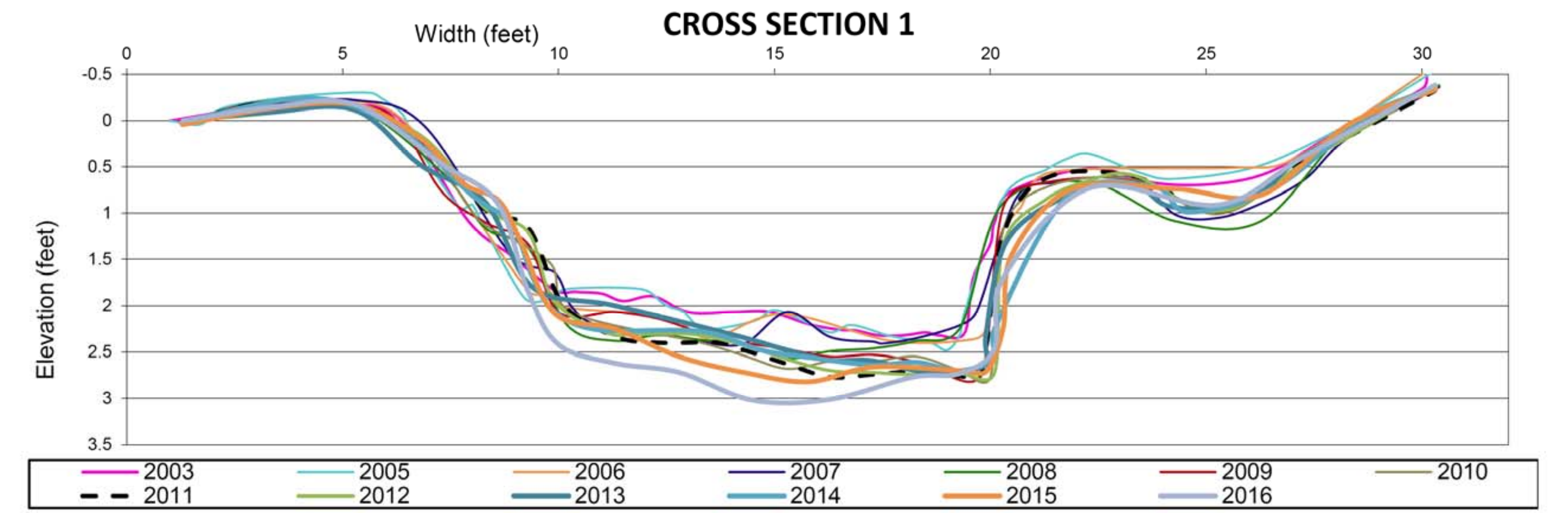
Source: Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

APPENDIX F

GEOMORPHOLOGICAL DATA

Church Creek
2015 Geomorphic Assessment Results Summary

Assessment Parameter	Cross Section				
	XS-1 Pool @ sta 3+70.5	XS-2 Pool @ 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	E5/4	F4
Bankfull Width (ft)	11.1	8.5	7.7	8.5	10.7
Mean Depth (ft)	1.0	1.0	0.8	1.5	0.6
Bankfull X-Sec Area (sq ft)	11.4	8.9	6.5	12.3	6.5
Width:Depth Ratio	10.8	8.1	9.2	5.8	17.7
Flood-Prone Width (ft)	20.3	15.2	9.4	37.6	16.4
Entrenchment Ratio	1.8	1.8	1.2	4.4	1.5
D50(mm)	2	8.5	9.3	1.2	24
Water Surface Slope (ft/ft)	0.003	0.014	0.007	0.001	0.015
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 ↑	Sin ↑	Sin ↑, ER ↓



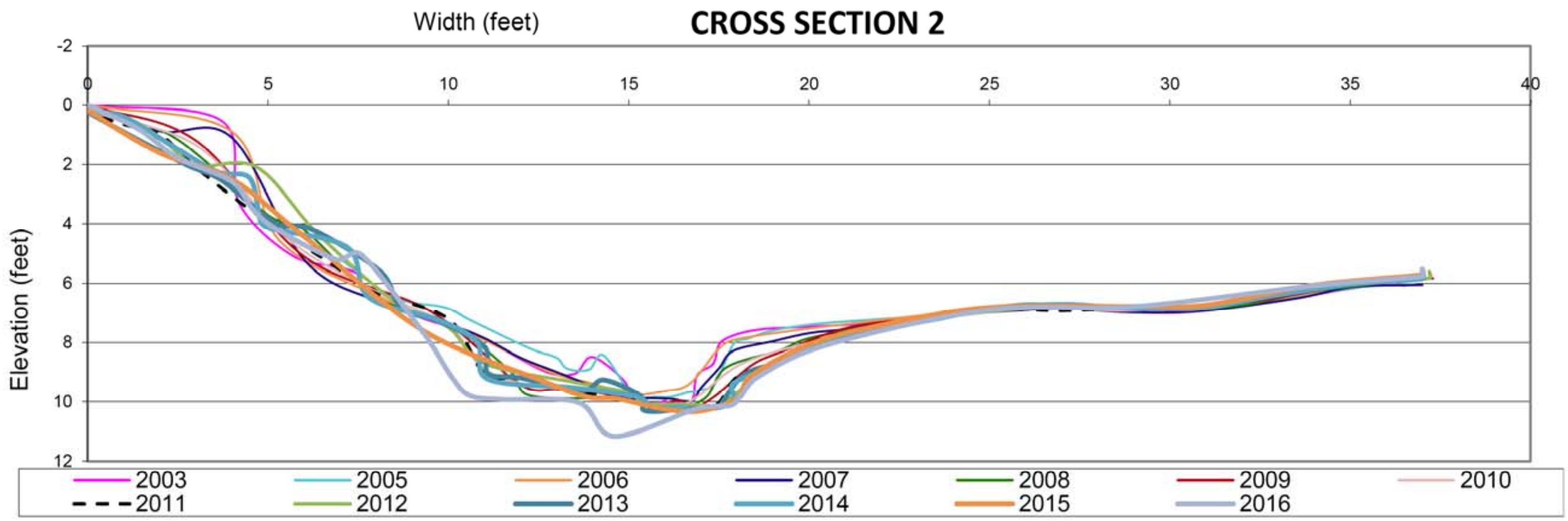
Upstream View

Downstream View

Left Bank View

Right Bank View

2016 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	11.1
Mean Depth (d_{bkf}) (feet)	1.0
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	11.4
Width/Depth Ratio (W_{bkf}/d_{bkf})	10.8
Width of Flood-prone Area (W_{fpa}) (feet)	20.3
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.8
Channel Materials D_{50} (millimeters)	2
Water Surface Slope (S)	0.003
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, ER ↓, W/D ↑
STREAM TYPE	**F4**



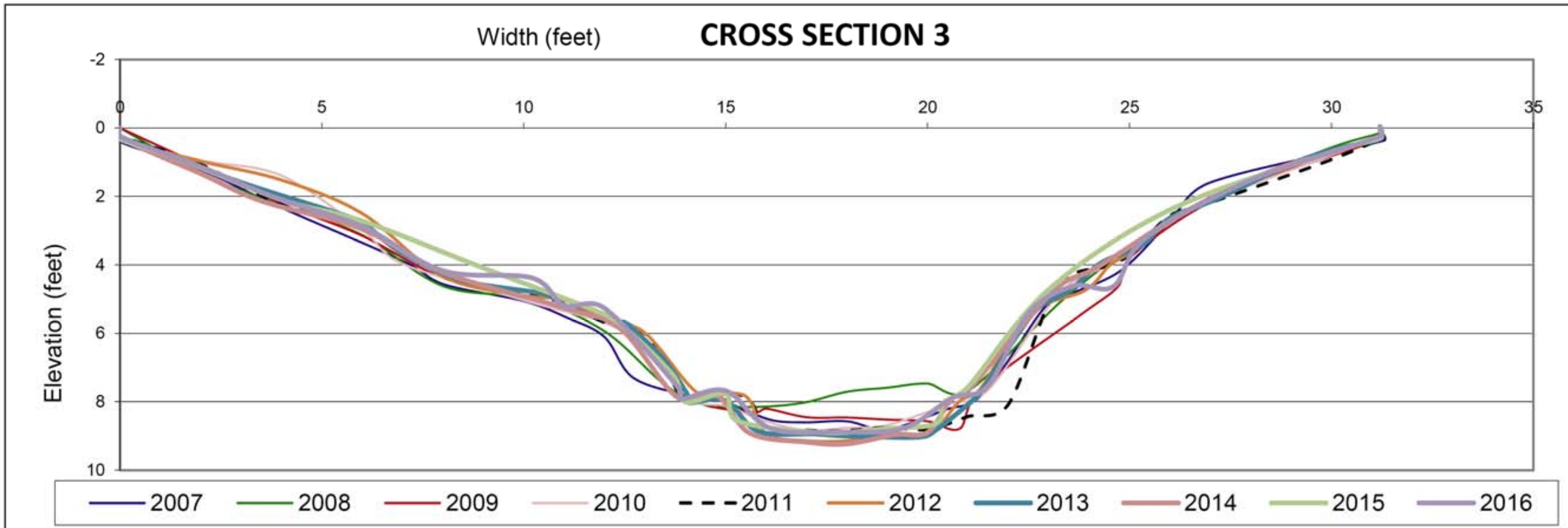

Upstream View


Downstream View


Left Bank View


Right Bank View

2016 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	8.5
Mean Depth (d_{bkf}) (feet)	1.0
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	8.9
Width/Depth Ratio (W_{bkf}/d_{bkf})	8.1
Width of Flood-prone Area (W_{fpa}) (feet)	15.2
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.8
Channel Materials D_{50} (millimeters)	8.5
Water Surface Slope (S)	0.014
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, ER ↓
STREAM TYPE	**G4c**



Upstream View

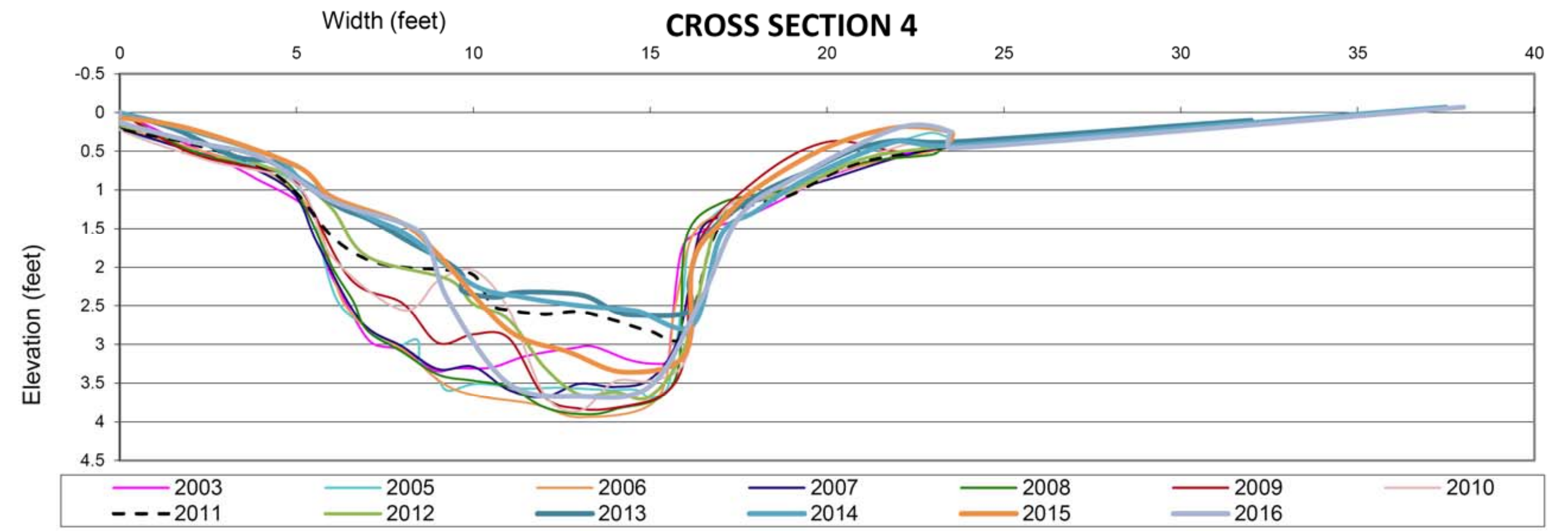
Downstream View

Left Bank View

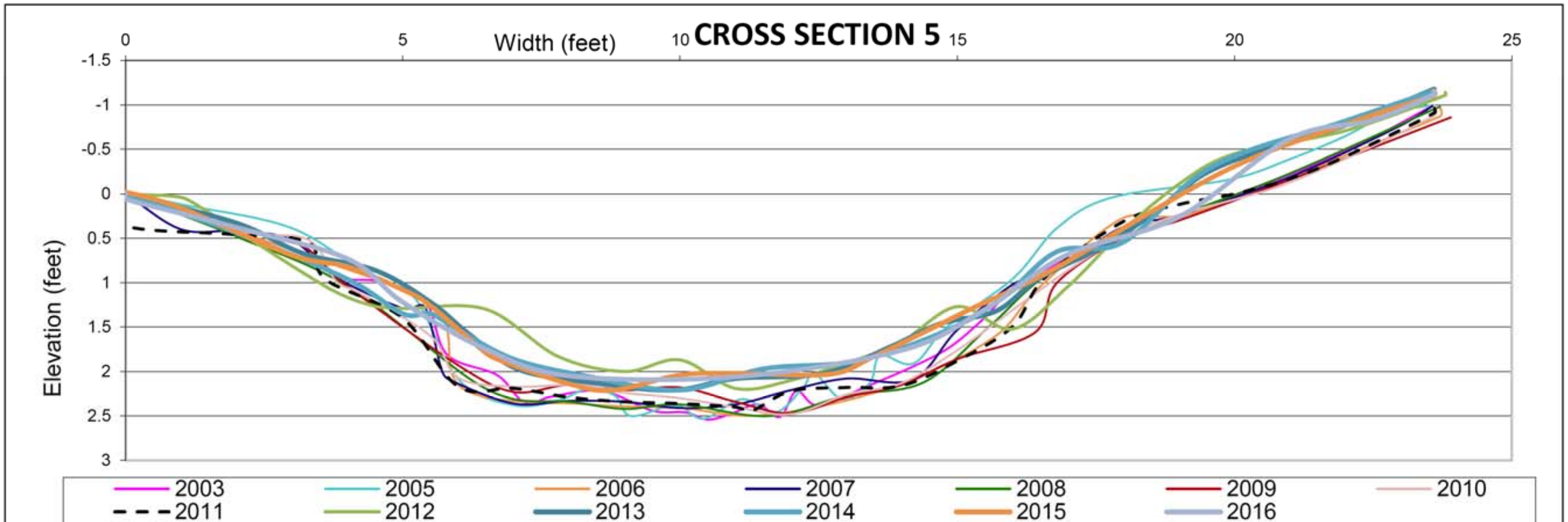
Right Bank View

2016 Geomorphic Assessment Results

Bankfull Width (W_{bkf}) (feet)	7.7
Mean Depth (d_{bkf}) (feet)	0.8
Bankfull Cross-sectional Area (A_{bkf}) ($feet_2$)	6.5
Width/Depth Ratio (W_{bkf}/d_{bkf})	9.2
Width of Flood-prone Area (W_{fpa}) (feet)	9.4
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.2
Channel Materials D_{50} (millimeters)	9.3
Water Surface Slope (S)	0.007
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	**G4c**



		**2016 Geomorphic Assessment Results**	
		Bankfull Width (W_{bkf}) (feet)	8.5
		Mean Depth (d_{bkf}) (feet)	1.5
		Bankfull Cross-sectional Area (A_{bkf}) (feet2)	12.3
		Width/Depth Ratio (W_{bkf}/d_{bkf})	5.8
Upstream View	Downstream View	Width of Flood-prone Area (W_{fpa}) (feet)	37.6
		Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	4.4
		Channel Materials D_{50} (millimeters)	1.2
		Water Surface Slope (S)	.001
		Sinuosity (K) = stream length/valley length	<1.2
		Adjustments?	Sin ↑
Left Bank View	Right Bank View	**STREAM TYPE**	**E5/4**



Upstream View

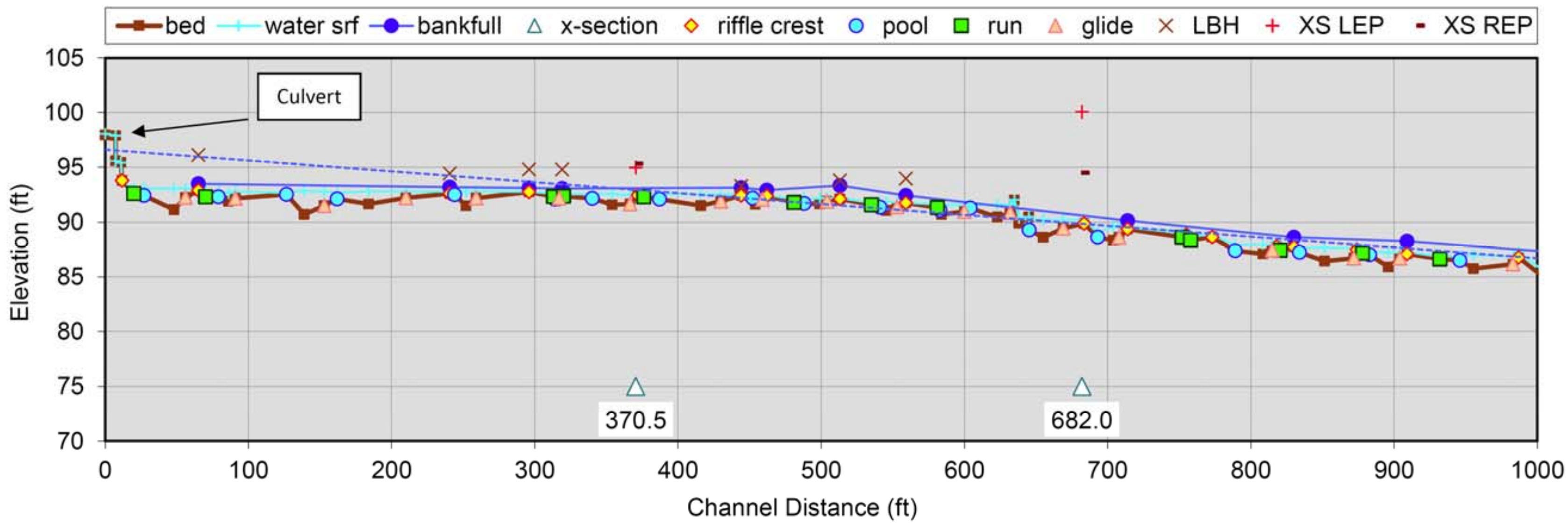
Downstream View

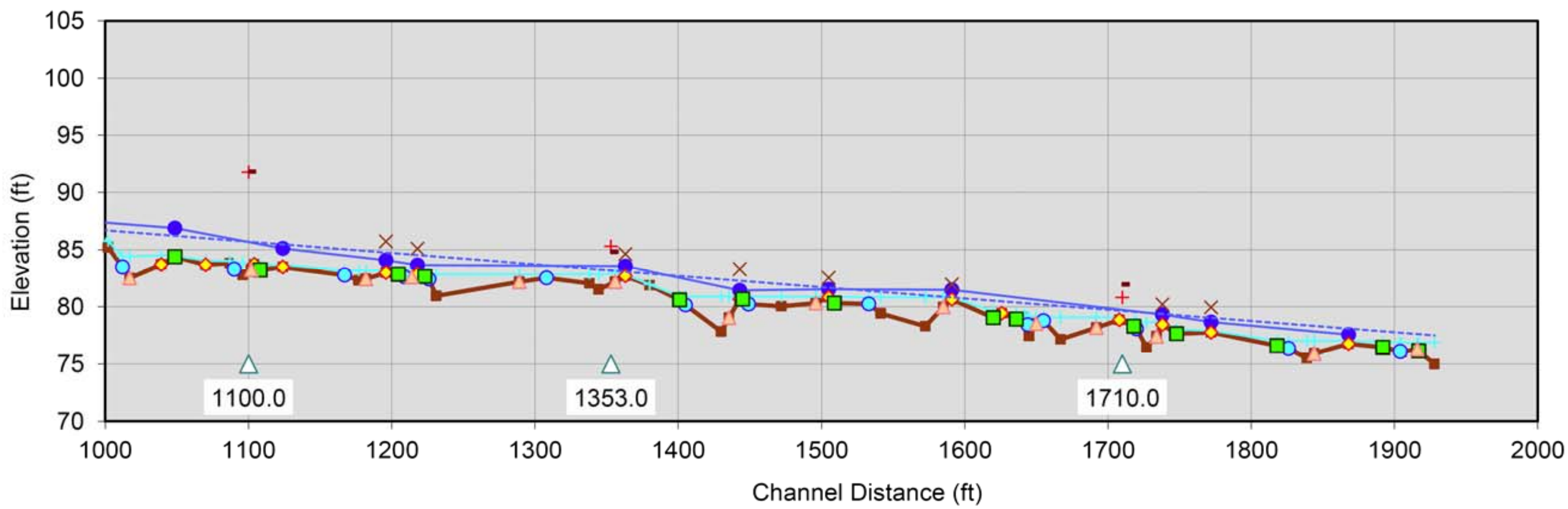
Left Bank View

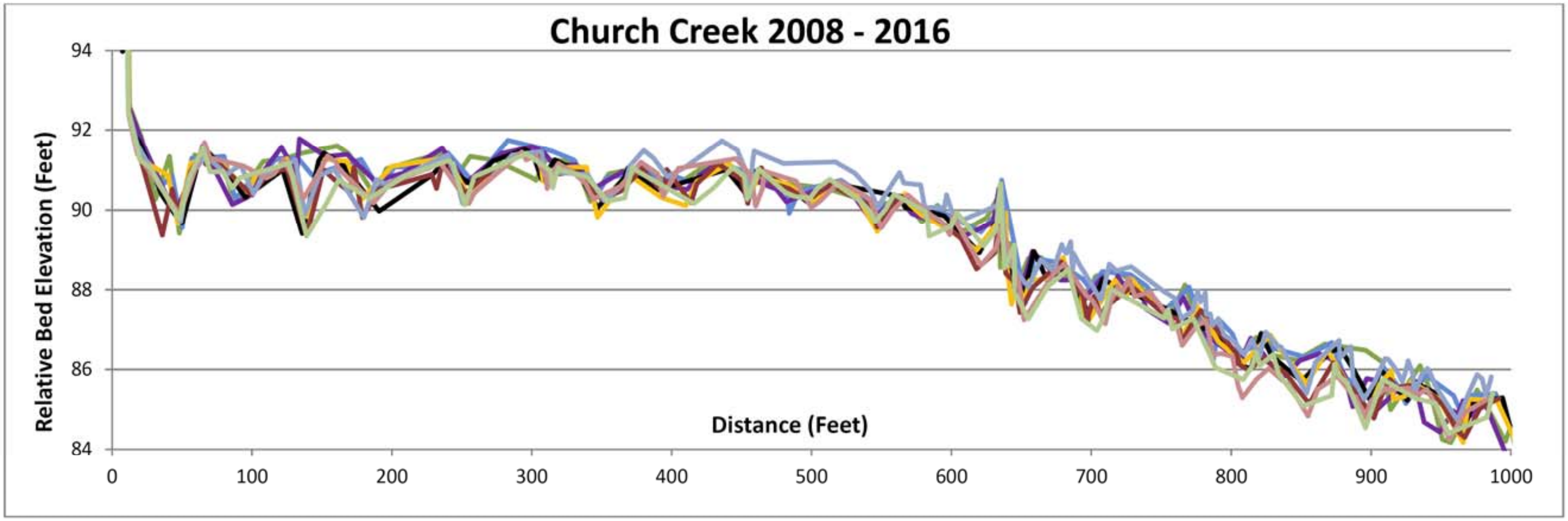
Right Bank View

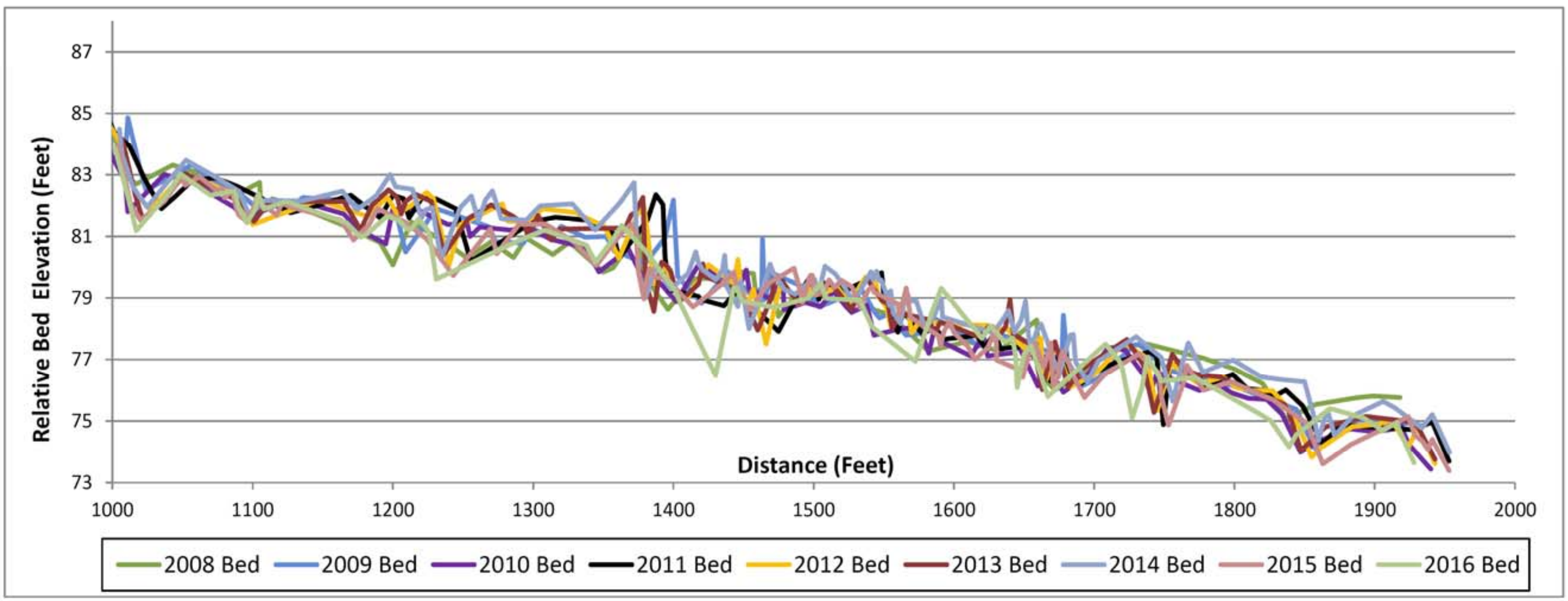
2016 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	10.7
Mean Depth (d_{bkf}) (feet)	0.6
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	6.5
Width/Depth Ratio (W_{bkf}/d_{bkf})	17.7
Width of Flood-prone Area (W_{fpa}) (feet)	16.4
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.5
Channel Materials D_{50} (millimeters)	24
Water Surface Slope (S)	0.015
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, ER ↓
STREAM TYPE	**F4**

Church Creek Longitudinal Profile






Church Creek 2008 - 2016
Relative Bed Elevation (Feet)
94
92
90
88
86
84
Distance (Feet)
0
100
200
300
400
500
600
700
800
900
1000


Relative Bed Elevation (Feet)
87
85
83
81
79
77
75
73
Distance (Feet)
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

APPENDIX G

CHEMICAL MONITORING RESULTS

Anne Arundel County NPDES
Sampling and EMC Data – 2016 Reporting Year
Parole Plaza Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Inches Depth	Hours Duration	In/Hr Intensity	oF Temperature - field	CF Flow	pH pH - field	mg/L dt for BOD	(0) mg/L BOD	(dt) mg/L BOD	mg/L dt for Total Kjeldahl Nitrogen	(0) mg/L Total Kjeldahl Nitrogen	(dt) mg/L Total Kjeldahl Nitrogen	mg/L dt for Nitrate+ Nitrite - N	(0) mg/L Nitrate+ Nitrite - N	(dt) mg/L Nitrate+ Nitrite - N	mg/L dt for Total Phosphorus	(0) mg/L Total Phosphorus	(dt) mg/L Total Phosphorus	mg/L dt for TSS	(0) mg/L TSS	(dt) mg/L TSS	µg/L dt for Copper	(0) µg/L Copper	(dt) µg/L Copper	µg/L dt for Lead	(0) µg/L Lead	(dt) µg/L Lead	µg/L dt for Zinc	(0) µg/L Zinc	(dt) µg/L Zinc	mg/L dt for TPH	(0) mg/L TPH	(dt) mg/L TPH	MPN dt for E-COLI	(0) MPN E-COLI	(dt) MPN E-COLI	mg/L dt for HARDNESS	(0) mg/L HARDNESS	(dt) mg/L HARDNESS
Versar	1	AP	8/20/2015		101	O	S	0.10	2.0	0.05	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Versar	2	AP	8/20/2015	2015	101	O	S				80.98	1655	7.34	2	13	13	0.5	0.9	0.9	0.05	0.36	0.36	0.01	0.06	0.06	1	75	75	2.0	26.1	26.1	2.0	4.1	4.1	20	144	144	5.0	0.0	5.0	10	2247	2247	1	38	38
Versar	3	AP	8/20/2015	2025	101	O	S				80.15	935	7.35	2	4	4	0.5	0.0	0.5	0.02	0.33	0.33	0.01	0.07	0.07	1	33	33	2.0	15.2	15.2	2.0	0.0	2.0	20	97	97	5.0	0.0	5.0	10	24196	24196	1	17	17
Versar	1	AP	9/10/2015	1400	101	O	S	1.92	5.0	0.38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Versar	2	AP	9/10/2015	1440	101	O	S				76.95	108750	6.98	2	3	3	0.5	0.0	0.5	0.05	0.54	0.54	0.01	0.10	0.10	1	36	36	2.0	13.9	13.9	2.0	2.6	2.6	20	93	93	5.0	0.0	5.0	100	20460	20460	1	11	11
Versar	3	AP	9/10/2015	1615	101	O	S				77.03	57977	6.93	2	3	3	0.5	0.0	0.5	0.05	0.62	0.62	0.01	0.15	0.15	1	38	38	2.0	14.1	14.1	2.0	0.0	2.0	20	76	76	5.0	0.0	5.0	100	72700	72700	1	19	19
Versar	1	AP	9/29/2015	2025	101	O	S	1.79	4.5	0.40	74.92	8561	7.51	2	5	5	0.5	0.0	0.5	0.05	0.27	0.27	0.01	0.08	0.08	1	39	39	2.0	16.7	16.7	2.0	2.7	2.7	20	178	178	5.0	7.0	7.0	10	988	988	1	24	24
Versar	2	AP	9/29/2015	2205	101	O	S				74.13	95440	7.36	2	0	2	0.5	0.0	0.5	0.05	0.15	0.15	0.01	0.10	0.10	1	33	33	2.0	8.1	8.1	2.0	2.1	2.1	20	65	65	5.0	0.0	5.0	10	12003	12003	1	11	11
Versar	3	AP	9/29/2015	2250	101	O	S				74.50	40943	7.20	2	7	7	0.5	0.9	0.9	0.02	0.47	0.47	0.01	0.21	0.21	1	22	22	2.0	10.8	10.8	2.0	0.0	2.0	20	75	75	5.0	0.0	5.0	10	19863	19863	1	27	27
Versar	1	AP	11/9/2015	2245	101	O	S	0.64	8.0	0.08	56.16	16275	7.77	2	2	2	0.5	1.0	1.0	0.05	0.13	0.13	0.01	0.07	0.07	1	19	19	2.0	11.0	11.0	2.0	0.0	2.0	20	13	13	5.0	0.0	5.0	10	7701	7701	1	19	19
Versar	2	AP	11/9/2015	2335	101	O	S				56.12	5885	7.84	2	0	2	0.5	0.6	0.6	0.05	0.10	0.10	0.01	0.06	0.06	1	11	11	2.0	9.2	9.2	2.0	0.0	2.0	20	90	90	5.0	0.0	5.0	10	10462	10462	1	15	15
Versar	3	AP	11/9/2015	225	101	O	S				59.13	19217	7.14	2	0	2	0.5	1.6	1.6	0.05	0.34	0.34	0.01	0.05	0.05	1	3	3	2.0	74.0	74.0	2.0	6.4	6.4	20	120	120	5.0	0.0	5.0	10	19863	19863	1	26	26
Versar	1	AP	12/17/2015	1120	101	O	S	0.31	10.0	0.03	54.34	4223	8.05	2	5	5	0.5	1.6	1.6	0.05	1.30	1.30	0.01	0.05	0.05	1	20	20	2.0	13.0	13.0	2.0	0.0	2.0	20	270	270	5.0	0.0	5.0	10	528	528	1	42	42
Versar	2	AP	12/17/2015	1355	101	O	S				54.30	6230	8.35	2	7	7	0.5	1.1	1.1	0.05	0.45	0.45	0.01	0.12	0.12	1	60	60	2.0	24.0	24.0	2.0	3.8	3.8	20	330	330	5.0	0.0	5.0	10	496	496	1	36	36
Versar	3	AP	12/17/2015	1510	101	O	S				55.25	4095	8.11	2	3	3	0.5	1.0	1.0	0.05	0.27	0.27	0.01	0.04	0.04	1	8	8	2.0	9.3	9.3	2.0	0.0	2.0	20	150	150	5.0	0.0	5.0	10	364	364	1	30	30
Versar	1	AP	2/16/2016	845	101	O	S	1.20	8.0	0.15	37.13	7106	8.41	4	11	11	0.5	2.1	2.1	0.05	1.00	1.00	0.01	0.19	0.19	1	220	220	2.0	63.0	63.0	2.0	18.0	18.0	20	430	430	5.0	11.0	11.0	10	613	613	1	750	750
Versar	2	AP	2/16/2016	1025	101	O	S				44.50	53319	8.77	4	0	4	0.5	1.0	1.0	0.05	0.13	0.13	0.01	0.19	0.19	1	110	110	2.0	20.0	20.0	2.0	7.1	7.1	20	160	160	5.0	5.0	5.0	10	341	341	1	140	140
Versar	3	AP	2/16/2016	1055	101	O	S				44.91	14674	8.59	4	5	5	0.5	1.1	1.1	0.05	0.51	0.51	0.01	0.17	0.17	1	52	52	2.0	12.0	12.0	2.0	3.6	3.6	20	99	99	5.0	10.0	10.0	10	602	602	1	260	260
Versar	1	AP	3/14/2016	2340	101	O	S	0.42	8.0	0.05	50.95	620	7.74	2	8	8	0.5	1.7	1.7	0.05	1.30	1.30	0.01	0.19	0.19	1	64	64	1.0	26.0	26.0	1.0	3.6	3.6	20	250	250	5.0	7.0	7.0	10	384	384	1	46	46
Versar	2	AP	3/14/2016	120	101	O	S				51.00	3541	7.74	2	8	8	0.5	1.5	1.5	0.05	0.37	0.37	0.01	0.14	0.14	1	99	99	1.0	23.0	23.0	1.0	4.6	4.6	20	300	300	5.0	5.0	5.0	10	908	908	1	39	39
Versar	3	AP	3/14/2016	355	101	O	S				51.32	15757	7.70	2	10	10	0.5	0.6	0.6	0.05	0.41	0.41	0.01	0.04	0.04	1	5	5	1.0	9.9	9.9	1.0	0.6	0.6	20	110	110	5.0	0.0	5.0	10	384	384	1	32	32
Versar	1	AP	4/7/2016	1015	101	O	S	0.42	8.0	0.05	54.40	1281	8.08	2	46	46	0.5	2.6	2.6	0.05	0.89	0.89	0.01	0.21	0.21	1	63	63	2.0	36.0	36.0	2.0	3.4	3.4	20	340	340	5.0	0.0	5.0	10	2359	2359	1	56	56
Versar	2	AP	4/7/2016	1105	101	O	S				55.59	4588	8.23	2	17	17	0.5	2.1	2.1	0.05	0.18	0.18	0.01	0.25	0.25	1	160	160	2.0	44.0	44.0	2.0	6.9	6.9	20	32	32	5.0	0.0	5.0	10	12033	12033	1	56	56
Versar	3	AP	4/7/2016	1125	101	O	S				55.09	1696	8.79	2	9	9	0.5	0.8	0.8	0.05	0.26	0.26	0.01	0.12	0.12	1	51	51	2.0	32.0	32.0	2.0	3.7	3.7	20	190	190	5.0	0.0	5.0	10	9208	9208	1	36	36
Versar	1	AP	5/17/2016	1135	101	O	S	0.42	8.0	0.05	58.83	7481	7.30	2	10	10	0.5	1.1	1.1	0.05	0.73	0.73	0.01	0.12	0.12	1	33	33	2.0	24.0	24.0	2.0	2.2	2.2	20	210	210	5.0	0.0	5.0	10	1500	1500	1	44	44
Versar	2	AP	5/17/2016	1455	101	O	S				60.28	13244	7.71	2	7	7	0.5	0.6	0.6	0.05	0.32	0.32	0.01	0.08	0.08	1	36	36	2.0	180.0	180.0	2.0	9.0	9.0	20	240	240	5.0	0.0	5.0	10	4884	4884	1	37	37
Versar	3	AP	5/17/2016	1600	101	O	S				58.56	5481	7.91	2	6	6	0.5	0.6	0.6	0.05	0.41	0.41	0.01	0.06	0.06	1	10	10	2.0	16.0	16.0	2.0	0.0	2.0	20	100	100	5.0	0.0	5.0	10	4884	4884	1	40	40
Versar	1	AP	6/16/2016	2250	101	O	S	0.42	8.0	0.05	71.67	7999	7.79	2	6	6	0.5	0.0	0.5	0.05	0.30	0.30	0.01	0.09	0.09	1	40	40	2.0	14.0	14.0	2.0	0.0	2.0	20	120	120	5.0	0.0	5.0	10	1019	1019	1	27	27
Versar	2	AP	6/16/2016	2300	101	O	S				70.90	1588	7.81	2	4	4	0.5	0.6	0.6	0.05	0.45	0.45	0.01	0.09	0.09	1	13	13	2.0	15.0	15.0	2.0	0.0	2.0	20	120	120	5.0	0.0	5.0	10	24196	24196	1	19	19
Versar	3	AP	6/16/2016	0:45	101	O	S				69.09	10933	7.93	2	4	4	0.5	0.0	0.5	0.05	0.72	0.72	0.01	0.11	0.11	1	4	4	2.0	16.0	16.0	2.0	0.0	2.0	20	140	140	5.0	0.0	5.0	10	19863	19863	1	31	31
															9						28			28			0			20			0			14						28				
															30						93			93			0			67			0			47						93				
nondetects															4			7			0			0			0			0			11			0			22			0			0	
															13			23			0			0			0			0			37			0			73			0			0	
PP Max											80.98		8.79		46			2.6			1.3			0.250			220			180			18			430			11			72700			750	
CC+PP nondetects															7.0			13.0			0.0			0.0			0.0			0.0			16.0			0.0			48.0			0.0			0.0	
															12			22			0			0			0			0			27			0			80			0			0	

Anne Arundel County NPDES
Sampling and EMC Data – 2016 Reporting Year
Church Creek Station

								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	(dt) mg/L	mg/L	(0) mg/L
Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth	Durartion	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
Versar	1	AC	8/20/2015	2020	102	I	S	0.10	2.0	0.05	79.88	4960	6.90	2	20	20	0.5	1.0	1.0	0.05	0.52	0.52	0.01	0.19	0.19	1	59	59	2.0	24.1	24.1	2.0	18.9	18.9	20	201	201	5.0	0.0	5.0	10	12997	12997	1	64	64
Versar	2	AC	8/20/2015	2030	102	I	S				79.52	32889	7.00	2	15	15	0.5	2.5	2.5	0.05	0.37	0.37	0.01	0.17	0.17	1	92	92	2.0	20.3	20.3	2.0	10.3	10.3	20	146	146	5.0	0.0	5.0	10	12997	12997	1	36	36
Versar	3	AC	8/20/2015	2145	102	I	S				79.34	126613	6.90	2	10	10	0.5	0.7	0.7	0.05	0.35	0.35	0.01	0.07	0.07	1	23	23	2.0	9.6	9.6	2.0	3.0	3.0	20	64	64	5.0	0.0	5.0	10	17329	17329	1	34	34
										Event Mean Concentration:	**79.39**		**6.92**	**2**	**11**	**11**	**0.5**	**1.1**	**1.1**	**0.05**	**0.36**	**0.36**	**0.01**	**0.09**	**0.09**	**1**	**38**	**38**	**2.0**	**12.2**	**12.2**	**2.0**	**4.9**	**4.9**	**20**	**85**	**85**	**5.0**	**0.0**	**5.0**	**10**	**16332**	**16332**	**1**	**35**	**35**
Versar	1	AC	9/10/2015	1415	102	I	S	1.92	5.0	0.38	76.10	9795	6.70	2	40	40	0.5	4.1	4.1	0.05	1.80	1.80	0.01	1.70	1.70	1	280	280	2.0	54.4	54.4	2.0	43.3	43.3	20	570	570	5.0	0.0	5.0	100	38730	38730	1	98	98
Versar	2	AC	9/10/2015	1500	102	I	S				77.36	879520	6.50	2	29	29	0.5	1.2	1.2	0.05	0.79	0.79	0.01	0.14	0.14	1	31	31	2.0	10.0	10.0	2.0	6.5	6.5	20	67	67	5.0	0.0	5.0	100	12740	12740	1	29	29
Versar	3	AC	9/10/2015	1615	102	I	S				77.90	1317897	6.50	2	5	5	0.5	0.0	0.5	0.05	0.68	0.68	0.01	0.09	0.09	1	54	54	2.0	12.7	12.7	2.0	6.6	6.6	20	79	79	5.0	0.0	5.0	100	16070	16070	1	15	15
										Event Mean Concentration:	**77.68**		**6.50**	**2**	**15**	**15**	**0.5**	**0.5**	**0.8**	**0.05**	**0.73**	**0.73**	**0.01**	**0.12**	**0.12**	**1**	**46**	**46**	**2.0**	**11.8**	**11.8**	**2.0**	**6.7**	**6.7**	**20**	**76**	**76**	**5.0**	**0.0**	**5.0**	**100**	**14844**	**14844**	**1**	**21**	**21**
Versar	1	AC	9/29/2015	2100	102	I	S	1.79	4.5	0.40	74.12	196033	6.60	2	6	6	0.5	0.9	0.9	0.05	0.36	0.36	0.01	0.23	0.23	1	70	70	2.0	16.9	16.9	2.0	6.7	6.7	20	90	90	5.0	0.0	5.0	10	15531	15531	1	31	31
Versar	2	AC	9/29/2015	2220	102	I	S				73.94	1025130	6.50	2	0	2	0.5	0.0	0.5	0.05	0.17	0.17	0.01	0.12	0.12	1	54	54	2.0	10.5	10.5	2.0	6.5	6.5	20	64	64	5.0	0.0	5.0	10	12033	12033	1	16	16
Versar	3	AC	9/29/2015	2320	102	I	S				73.76	1010298	6.40	2	3	3	0.5	0.0	0.5	0.02	0.27	0.27	0.01	0.11	0.11	1	28	28	2.0	9.4	9.4	2.0	4.1	4.1	20	64	64	5.0	0.0	5.0	10	7270	7270	1	23	23
										Event Mean Concentration:	**73.87**		**6.46**	**2**	**2**	**3**	**0.5**	**0.1**	**0.5**	**0.04**	**0.23**	**0.23**	**0.01**	**0.13**	**0.13**	**1**	**44**	**44**	**2.0**	**10.6**	**10.6**	**2.0**	**5.4**	**5.4**	**20**	**66**	**66**	**5.0**	**0.0**	**5.0**	**10**	**10184**	**10184**	**1**	**20**	**20**
Versar	1	AC	11/9/2015	2305	102	I	S	0.64	8.0	0.08	54.32	205441	6.70	2	6	6	0.5	1.1	1.1	0.05	0.19	0.19	0.01	0.15	0.15	1	49	49	2.0	8.4	8.4	2.0	5.1	5.1	20	712	712	5.0	0.0	5.0	10	8164	8164	1	29	29
Versar	2	AC	11/9/2015	2415	102	I	S				54.32	223703	6.80	2	3	3	0.5	1.0	1.0	0.05	0.22	0.22	0.01	0.12	0.12	1	27	27	2.0	6.7	6.7	2.0	3.9	3.9	20	61	61	5.0	0.0	5.0	10	4352	4352	1	23	23
Versar	3	AC	11/9/2015	225	102	I	S				55.22	332164	6.70	2	0	2	0.5	1.1	1.1	0.05	0.18	0.18	0.01	0.09	0.09	1	14	14	2.0	5.1	5.1	2.0	2.6	2.6	20	43	43	5.0	0.0	5.0	10	4352	4352	1	25	25
										Event Mean Concentration:	**54.71**		**6.73**	**2**	**3**	**3**	**0.5**	**1.1**	**1.1**	**0.05**	**0.19**	**0.19**	**0.01**	**0.12**	**0.12**	**1**	**27**	**27**	**2.0**	**6.5**	**6.5**	**2.0**	**3.7**	**3.7**	**20**	**229**	**229**	**5.0**	**0.0**	**5.0**	**10**	**5381**	**5381**	**1**	**25**	**25**
Versar	1	AC	12/10/2015	1050	102	I	B				46.94	639	6.50	2	0	2	0.5	0.6	0.6	0.05	1.20	1.20	0.01	0.06	0.06	1	10	10	2.0	0.0	2.0	2.0	0.0	2.0	20	850	850	5.0	0.0	5.0	10	243	243	1	140	140
										Event Mean Concentration:	**46.94**		**6.50**	**2**	**0**	**2**	**0.5**	**0.6**	**0.6**	**0.05**	**1.20**	**1.20**	**0.01**	**0.06**	**0.06**	**1**	**10**	**10**	**2.0**	**0.0**	**2.0**	**2.0**	**0.0**	**2.0**	**20**	**850**	**850**	**5.0**	**0.0**	**5.0**	**10**	**243**	**243**	**1**	**140**	**140**
Versar	1	AC	12/17/2015	1120	102	I	S	0.31	10.0	0.03	50.90	60719	6.40	2	6	6	0.5	1.6	1.6	0.05	1.30	1.30	0.01	0.19	0.19	1	41	41	2.0	6.2	6.2	2.0	2.5	2.5	20	88	88	5.0	0.0	5.0	10	2142	2142	1	120	120
Versar	2	AC	12/17/2015	1410	102	I	S				53.42	163473	6.70	2	6	6	0.5	1.1	1.1	0.05	0.45	0.45	0.01	0.17	0.17	1	31	31	2.0	11.0	11.0	2.0	3.7	3.7	20	86	86	5.0	0.0	5.0	10	3448	3448	1	44	44
Versar	3	AC	12/17/2015	1725	102	I	S				53.60	229774	6.60	2	4	4	0.5	1.0	1.0	0.05	0.27	0.27	0.01	0.06	0.06	1	9	9	2.0	6.5	6.5	2.0	0.0	2.0	20	50	50	5.0	0.0	5.0	10	2613	2613	1	35	35
										Event Mean Concentration:	**53.17**		**6.61**	**2**	**5**	**5**	**0.5**	**1.1**	**1.1**	**0.05**	**0.47**	**0.47**	**0.01**	**0.12**	**0.12**	**1**	**21**	**21**	**2.0**	**8.1**	**8.1**	**2.0**	**1.7**	**2.7**	**20**	**68**	**68**	**5.0**	**0.0**	**5.0**	**10**	**2851**	**2851**	**1**	**50**	**50**
Versar	1	AC	2/16/2016	900	102	I	S	1.20	8.0	0.15	35.60	77721	6.60	2	12	12	0.5	2.8	2.8	0.05	0.78	0.78	0.01	0.39	0.39	1	260	260	2.0	31.0	31.0	2.0	39.0	39.0	20	250	250	5.0	9.0	9.0	10	4611	4611	1	410	410
Versar	2	AC	2/16/2016	1045	102	I	S				39.56	899378	6.90	2	5	5	0.5	1.3	1.3	0.05	0.19	0.19	0.01	0.19	0.19	1	150	150	2.0	16.0	16.0	2.0	16.0	16.0	20	130	130	5.0	10.0	10.0	10	1860	1860	1	82	82
Versar	3	AC	2/16/2016	1230	102	I	S				40.28	716888	6.80	2	5	5	0.5	1.3	1.3	0.05	0.32	0.32	0.01	0.20	0.20	1	61	61	2.0	11.0	11.0	2.0	7.4	7.4	20	110	110	5.0	5.0	5.0	10	801	801	1	110	110
										Event Mean Concentration:	**39.68**		**6.84**	**2**	**5**	**5**	**0.5**	**1.4**	**1.4**	**0.05**	**0.27**	**0.27**	**0.01**	**0.20**	**0.20**	**1**	**117**	**117**	**2.0**	**14.6**	**14.6**	**2.0**	**13.4**	**13.4**	**20**	**127**	**127**	**5.0**	**7.8**	**7.8**	**10**	**1538**	**1538**	**1**	**109**	**109**
Versar	1	AC	3/14/2016	2415	102	I	S	0.42	8.0	0.05	52.16	26514	6.80	2	8	8	0.5	1.7	1.7	0.05	1.30	1.30	0.01	0.11	0.11	1	13	13	1.0	11.0	11.0	1.0	1.7	1.7	20	96	96	5.0	0.0	5.0	10	1483	1483	1	85	85
Versar	2	AC	3/14/2016	400	102	I	S				51.08	290825	6.60	2	12	12	0.5	1.5	1.5	0.05	0.76	0.76	0.01	0.15	0.15	1	65	65	1.0	13.0	13.0	1.0	10.0	10.0	20	120	120	5.0	0.0	5.0	10	1616	1616	1	42	42
Versar	3	AC	3/14/2016	545	102	I	S				51.26	134421	6.50	2	6	6	0.5	1.0	1.0	0.05	0.69	0.69	0.01	0.10	0.10	1	19	19	1.0	6.6	6.6	1.0	2.6	2.6	20	99	99	5.0	0.0	5.0	10	3076	3076	1	46	46
										Event Mean Concentration:	**51.20**		**6.58**	**2**	**10**	**10**	**0.5**	**1.4**	**1.4**	**0.05**	**0.77**	**0.77**	**0.01**	**0.13**	**0.13**	**1**	**48**	**48**	**1.0**	**11.0**	**11.0**	**1.0**	**7.3**	**7.3**	**20**	**112**	**112**	**5.0**	**0.0**	**5.0**	**10**	**2043**	**2043**	**1**	**46**	**46**
Versar	1	AC	3/24/2016	1020	102	I	B				49.10	456	6.8	4	4	4	0.5	0.9	0.9	0.05	0.73	0.73	0.01	0.07	0.07	1	15	15	1.0	1.6	1.6	1.0	0.0	1.0	20	55	55	5.0	0.0	5.0	10	110	110	1	130	130
										Event Mean Concentration:	**49.10**		**6.80**	**4**	**4**	**4**	**0.5**	**0.9**	**0.9**	**0.05**	**0.73**	**0.73**	**0.01**	**0.07**	**0.07**	**1**	**15**	**15**	**1.0**	**1.6**	**1.6**	**1.0**	**0.0**	**1.0**	**20**	**55**	**55**	**5.0**	**0.0**	**5.0**	**10**	**110**	**110**	**1**	**130**	**130**

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								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	(dt) mg/L	mg/L	(0) mg/L
Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth	Durartion	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
Versar	1	AC	4/7/2016	1055	102	I	S	0.19	7.0	0.03	52.7	25351	4.40	2	7	7	0.5	1.8	1.8	0.05	0.94	0.94	0.01	0.18	0.18	1	34	34	2.0	9.4	9.4	2.0	0.0	2.0	20	79	79	5.0	6.0	6.0	10	141	141	1	100	100
Versar	2	AC	4/7/2016	1130	102	I	S				54.5	51463	4.50	2	13	13	0.5	1.6	1.6	0.05	0.47	0.47	0.01	0.34	0.34	1	77	77	2.0	26.0	26.0	2.0	9.7	9.7	20	150	150	5.0	0.0	5.0	10	3873	3873	1	72	72
Versar	3	AC	4/7/2016	1310	102	I	S				54.5	92584	4.40	2	13	13	0.5	0.9	0.9	0.05	0.31	0.31	0.01	0.12	0.12	1	23	23	2.0	34.0	34.0	2.0	0.0	2.0	20	61	61	5.0	0.0	5.0	10	717	717	1	48	48
										Event Mean Concentration:	**54.23**		**4.43**	**2**	**12**	**12**	**0.5**	**1.2**	**1.2**	**0.05**	**0.45**	**0.45**	**0.01**	**0.20**	**0.20**	**1**	**41**	**41**	**2.0**	**27.9**	**27.9**	**2.0**	**2.9**	**4.3**	**20**	**91**	**91**	**5.0**	**0.9**	**5.1**	**10**	**1590**	**1590**	**1**	**63**	**63**
Versar	1	AC	5/17/2016	1055	102	I	S	0.27	10.0	0.03	56.12	14471	NA	2	0	2	0.5	0.0	0.5	0.05	0.78	0.78	0.01	0.08	0.08	1	18	18	2.0	3.6	3.6	2.0	0.0	2.0	20	36	36	5.0	0.0	5.0	10	161	161	1	100	100
Versar	2	AC	5/17/2016	1530	102	I	S				59.36	164029	NA	2	6	6	0.5	0.0	0.5	0.05	0.48	0.48	0.01	0.17	0.17	1	42	42	2.0	13.0	13.0	2.0	4.7	4.7	20	80	80	5.0	0.0	5.0	10	3873	3873	1	53	53
Versar	3	AC	5/17/2016	1755	102	I	S				59.36	102223	NA	2	4	4	0.5	0.0	0.5	0.05	0.39	0.39	0.01	0.06	0.06	1	10	10	2.0	67.0	67.0	2.0	3.0	3.0	20	65	65	5.0	0.0	5.0	10	2046	2046	1	47	47
										Event Mean Concentration:	**59.19**			**2**	**5**	**5**	**0.5**	**0.0**	**0.5**	**0.05**	**0.46**	**0.46**	**0.01**	**0.13**	**0.13**	**1**	**29**	**29**	**2.0**	**32.2**	**32.2**	**2.0**	**3.8**	**3.9**	**20**	**72**	**72**	**5.0**	**0.0**	**5.0**	**10**	**3016**	**3016**	**1**	**53**	**53**
Versar	1	AC	6/16/2016	2230	102	I	S	0.29	8.0	0.04	70.7	13653	7.03	2	10	10	0.5	1.7	1.7	0.05	1.20	1.20	0.01	0.53	0.53	1	58	58	2.0	21.0	21.0	2.0	12.0	12.0	20	190	190	5.0	0.0	5.0	10	8664	8664	1	110	110
Versar	2	AC	6/16/2016	2340	102	I	S				71.06	184592	7.13	2	12	10	0.5	1.1	1.1	0.05	0.74	0.74	0.01	0.24	0.24	1	52	52	2.0	12.0	12.0	2.0	6.1	6.1	20	87	87	5.0	0.0	5.0	10	6867	6867	1	52	52
Versar	3	AC	6/16/2016	210	102	I	S				70.52	223142	7.15	2	6	5	0.5	0.8	0.8	0.05	0.63	0.63	0.01	0.09	0.09	1	13	13	2.0	7.8	7.8	2.0	0.0	2.0	20	54	54	5.0	0.0	5.0	10	6867	6867	1	46	46
										Event Mean Concentration:	**70.76**		**7.14**	**2**	**9**	**7**	**0.5**	**1.0**	**1.0**	**0.05**	**0.70**	**0.70**	**0.01**	**0.17**	**0.17**	**1**	**32**	**32**	**2.0**	**10.1**	**10.1**	**2.0**	**3.1**	**4.1**	**20**	**73**	**73**	**5.0**	**0.0**	**5.0**	**10**	**6925**	**6925**	**1**	**51**	**51**

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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 ((dt) mg/L)	HARDNESS (mg/L)	HARDNESS ((0) mg/L)
SUMMER QUARTER (JULY, AUGUST, SEPTEMBER)																																				
Summer Quarter Flow-Weighted EMC (8/20/15, 9/10/15, 9/29/15):	75.89		6.50		8.38	8.82		0.31	0.68		0.47	0.47		0.12	0.12		44.49	44.49		11.22	11.22		6.02	6.02		71.63	71.63		0.00	5.00		12637.89	12637.89		21.24	21.24
Average:					8.60	mg/l		0.50	mg/l		0.47	mg/l		0.12	mg/l		44.49	mg/l		0.011	mg/l		0.006	mg/l		0.072	mg/l		2.50	mg/l		12637.89	MPN/100mL		21.24	mg/l
					0.0005367	lb/cf		0.0000310	lb/cf		0.0000296	lb/cf		0.0000075	lb/cf		0.0027766	lb/cf		0.0000007	lb/cf		0.0000004	lb/cf		0.0000045	lb/cf		0.0001560	lb/cf					0.0013255	lb/cf
Total Volume (Quarter Events):					4,603,136	cf																														
Pollutant Load (Quarter Events):					2,470.3	lbs		142.69	lbs		136.398	lbs		34.5	lbs		12,781.1	lbs		3.224	lbs		1.729	lbs		20.580	lbs		718.3	lbs					6,101.6	lbs
Total Volume (Quarter):					28,481,712	cf																														
Table 4-8=== >>> Pollutant Load (Quarter):					15,285	lbs		883	lbs		844	lbs		214	lbs		79,082	lbs		20	lbs		11	lbs		127	lbs		4,444	lbs					37,753	lbs
FALL QUARTER (OCTOBER, NOVEMBER, DECEMBER)																																				
Fall Quarter Flow-Weighted EMC (11/9/15, 12/17/15):	54.13		6.68		3.43	3.98		1.09	1.09		0.30	0.30		0.12	0.12		24.99	24.99		7.06	7.06		2.91	3.29		169.12	169.12		0.00	5.00		4433.39	4433.39		34.56	34.56
Average:					3.70	mg/l		1.1	mg/l		0.30	mg/l		0.12	mg/l		24.99	mg/l		0.007	mg/l		0.003	mg/l		0.169	mg/l		2.50	mg/l		4433.39	MPN/100mL		34.56	mg/l
					0.0002310	lb/cf		0.0	lb/cf		0.0000187	lb/cf		0.0000072	lb/cf		0.0015599	lb/cf		0.0000004	lb/cf		0.0000002	lb/cf		0.0000106	lb/cf		0.0001560	lb/cf					0.0021569	lb/cf
Total Volume (Quarter Events):					1,215,915	cf																														
Pollutant Load (Quarter Events):					280.9	lbs		82.53	lbs		22.678	lbs		8.8	lbs		1,896.7	lbs		0.536	lbs		0.235	lbs		12.835	lbs		189.7	lbs					2,622.6	lbs
Total Volume (Quarter):					36,319,515	cf																														
Pollutant Load (Quarter):					8,391	lbs		2,465	lbs		677	lbs		262	lbs		56,655	lbs		16	lbs		7	lbs		383	lbs		5,667	lbs					78,337	lbs
WINTER QUARTER (JANUARY, FEBRUARY, MARCH)																																				
Winter Quarter Flow-Weighted EMC (2/16/16, 3/14/16):	42.11		6.79		6.30	6.30		1.37	1.37		0.38	0.38		0.19	0.19		102.81	102.81		13.81	13.81		12.13	12.13		123.93	123.93		6.19	7.24		1643.96	1643.96		95.60	95.60
Average:					6.30	mg/l		1.4	mg/l		0.38	mg/l		0.19	mg/l		102.81	mg/l		0.014	mg/l		0.012	mg/l		0.124	mg/l		6.71	mg/l		1643.96	MPN/100mL		95.60	mg/l
					0.0003933	lb/cf		0.0	lb/cf		0.0000235	lb/cf		0.0000118	lb/cf		0.0064170	lb/cf		0.0000009	lb/cf		0.0000008	lb/cf		0.0000077	lb/cf		0.0004190	lb/cf					0.0059671	lb/cf
Total Volume (Quarter Events):					2,146,202	cf																														
Pollutant Load (Quarter Events):					844.1	lbs		183.18	lbs		50.525	lbs		25.3	lbs		13,772.3	lbs		1.850	lbs		1.625	lbs		16.602	lbs		899.3	lbs					12,806.7	lbs
Total Volume (Quarter):					21,870,215	cf																														
Pollutant Load (Quarter):					8,602	lbs		1,867	lbs		515	lbs		257	lbs		140,342	lbs		19	lbs		17	lbs		169	lbs		9,164	lbs					130,503	lbs
SPRING QUARTER (APRIL, MAY, JUNE)																																				
Winter Quarter Flow-Weighted EMC (4/7/16), (5/17/16), (6/16/16):	63.82		4.31		8.19	7.54		0.71	0.87		0.57	0.57		0.16	0.16		32.61	32.61		20.65	20.65		3.29	4.11		76.14	76.14		0.17	5.03		4629.03	4629.03		53.92	53.92
Average:					7.86	mg/l		0.8	mg/l		0.57	mg/l		0.16	mg/l		32.61	mg/l		0.021	mg/l		0.004	mg/l		0.076	mg/l		2.60	mg/l		4629.03	MPN/100mL		53.92	mg/l
					0.0004907	lb/cf		0.0	lb/cf		0.0000358	lb/cf		0.0000100	lb/cf		0.0020352	lb/cf		0.0000013	lb/cf		0.0000002	lb/cf		0.0000048	lb/cf		0.0001624	lb/cf					0.0033657	lb/cf
Total Volume (Quarter Events):					871,508	cf																														
Pollutant Load (Quarter Events):					427.7	lbs		42.83	lbs		31.218	lbs		8.7	lbs		1,773.7	lbs		1.123	lbs		0.201	lbs		4.142	lbs		141.5	lbs					2,933.2	lbs
Total Volume (Quarter):					29,158,084	cf																														
Pollutant Load (Quarter):					14,309	lbs		1,433	lbs		1,044	lbs		292	lbs		59,343	lbs		38	lbs		7	lbs		139	lbs		4,735	lbs					98,137	lbs
AVERAGE ANNUAL EMCs:	63.50		6.38		7.17	mg/l		0.72	mg/l		0.437	mg/l		0.140	mg/l		54.80	mg/l		12.21	µg/l		6.81	µg/l		98.19	µg/l		1.52	mg/l		8048.99	mg/l		44.35	mg/l
TOTAL ANNUAL POLLUTANT LOAD (EVENTS):					4,023.04	lbs		451.24	lbs		240.82	lbs		77.29	lbs		30,223.75	lbs		6.73	lbs		3.79	lbs		54.16	lbs		1,948.83	lbs					24,464.06	lbs
Per Acre:					14.41			1.62			0.86			0.28			108.29			0.024			0.014			0.194			6.98						87.66	
TOTAL 2016 POLLUTANT LOAD:					46,586.55	lbs		6,647.73	lbs		3,080.70	lbs		1,025.52	lbs		335,422.40	lbs		92.40	lbs		41.01	lbs		818.48	lbs		24,010.75	lbs					344,729.48	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 INSPECTIONS

(see accompanying Adobe PDF file for complete contents of Appendix I, including datasheets and photographs)

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

BMP 1 (AA County Urban BMP Database ID AA001128)

This BMP is located in the wooded area between the Festival at Riva Shopping Center, Forest Plaza Shopping Center, and Annapolis Harbour Center. This BMP's classification was updated from an Extended Detention Structure, Wet (EDSW) in the 2013 database to an Extended Detention Structure, Wet (PWED) in the 2015 database, and LimnoTech agrees with this change based on the inspection. It receives flow from the Festival at Riva Shopping Center as well as from portions of Riva Road, Forest Drive, and Crosswinds Apartment. This BMP requires immediate maintenance. Trash was present in the detention structure and should be removed. The low flow riser orifice should be cleared as it appears to be clogged with trash.

BMP 2 (no AA County Urban BMP Database ID)

This BMP is located along Aris T. Allen Boulevard near the Hampton Inn & Suites. It is owned by MD SHA and primarily receives roadway stormwater. The structure is not included in the BMP database but was classified as a Dry Pond (DP) by inspectors. The dry pond has a significant amount of standing water, which was also observed during the 2012 and 2013 inspections. This suggests that the pond is not functioning as intended. If ponding water is a permanent feature of this BMP, it should be relabeled as an Extended Detention Structure, Wet (PWED). The pond is in overall good condition. The fence around the pond has a lot of vegetation growth and should be cut back. The inlet to the pond was half clogged with debris and sediment and should be cleared. This BMP requires immediate maintenance to return it to its original dry pond status.

BMP 3 (AA County Urban BMP Database ID AA001962)

The structure is located at the corner of Spruill Road and Admiral Cochrane Drive. It collects stormwater from the nearby ARINC parking lot. This BMP's classification was updated from a Dry Pond (DP) in the 2013 database to a Detention Structure (Dry Pond) (XDPD) in the 2015 database, and LimnoTech agrees with this change based on the inspection. Invasive vegetation was present in the detention pond, and there was evidence of sedimentation around the inlet. The BMP outfall could not be located. This BMP is generally in good condition. No immediate action is necessary, but this BMP is showing early signs of stress.

BMP 4 (AA County Urban BMP Database ID AA000074)

The BMP is located west of the Forest Garden Apartments at the end of Hearne Court. It collects stormwater from the apartment complex. This BMP's classification was updated from a Dry Pond (DP) in the 2013 database to an Extended Detention, Dry Pond (XDPD) in the 2015 database, and LimnoTech agrees with this change based on the inspection. The inspection revealed trash buildup from the nearby shopping center. A large hole was also noted on the southern embankment outside the fence, and this should be addressed in case of failing structural integrity. The BMP also had ponding water, suggesting that it is not functioning properly. The ponding water was also observed during the 2012 and 2013 inspections. If ponding water is a permanent feature of this BMP, it should be relabeled as an Extended Detention Structure, Wet (PWED). This BMP requires immediate maintenance to clear debris and vegetation as well as to address the embankment issue.

BMP 5 (AA County Urban BMP Database ID AA001042)

This structure is classified as an Extended Detention Structure, Wet (PWED) in the 2015 database and was updated from the EDSW classification. Based on the inspection, LimnoTech agrees with the change to PWED. The BMP is located west of the Annapolis Harbour Center parking lot. It collects stormwater from the shopping center parking lot. The large pond with its boardwalk is generally in good condition and does not require maintenance.

BMP 6 (no AA County Urban BMP Database ID)

This structure is an Infiltration Basin (IBAS) and is owned and maintained by MD SHA. It is located off of Route 50 near the parking lot of the "Double Tree by Hilton" hotel. The inspection revealed a narrow vegetated roadside feature which is filled with organic debris, and appears to be more like a swale than an infiltration basin. There is evidence of erosion along the bottom of the basin which should be addressed to prevent further damage to the structure. Invasive vegetation was present in this area but the main issue appears to be large trees growing in the infiltration basin. This BMP requires immediate maintenance to remove trees, shrubs, and debris for optimal infiltration basin function.

BMP 7 (AA County Urban BMP Database ID AA001069)

This BMP structure is classified as an Extended Detention (Dry Pond) (XDPD) in the 2015 database and was updated from a Dry Pond (DP) classification in the 2013 database. It is located north of Route 50 near E Classic Ct. and is owned and maintained by MD SHA. The inspection revealed heavy presence of invasive species on the fence and approximately 20% coverage in the pond. This vegetation should be removed. Moreover, stagnant water was present in the pond. It should be noted that MD SHA calls this BMP a Wet Pond (WP), which appears to be a more accurate description than the current description as a XDPD. This BMP corresponds to BMP AA001069 in the database. The location of the BMP in the database appears incorrect, pointing to the property building rather than the BMP proper. Immediate maintenance is not required for this BMP but it is showing early signs of stress.

BMP 8 (no AA County Urban BMP Database ID)

This structure is an Infiltration Basin (IBAS) located at the intersection of Aris T. Allen Blvd. and Riva Road. It is owned and maintained by MD SHA, and is surrounded by a fence. The inspection revealed some invasive vegetation in the structure and on the fence surrounding it, which should be removed. Additionally, the riser structure could not be fully inspected from behind the fence but appeared to be clear of debris. Ponding water was seen in this area, a feature that was also observed during the 2012 and 2013 inspections. This suggests that the BMP is not functioning as designed or should be designated as an Extended Detention Structure, Wet (PWED) rather than an infiltration basin. This BMP requires immediate maintenance to remove invasive vegetation and address the ponding.

BMP 9 (no AA County Urban BMP Database ID)

This structure is an Infiltration Basin (IBAS) located on the south side of Route 50, north of the hotel parking lot, and west of the hotel pool. It is owned and maintained by MD SHA. The inspection revealed a narrow vegetated roadside feature containing organic debris and invasive vegetation, which appears to be more like a swale than an infiltration basin. Immediate action should be taken to remove the invasive vegetation and cut back larger trees.

BMP 10 (no AA County Urban BMP Database ID)

This structure is also an Infiltration Basin (IBAS), and is located on the south side of Route 50, north of the hotel parking lot, and east of the hotel pool. It is owned and maintained by MD SHA. The inspection revealed a fence going through the structure that separates the hotel property from the right of way. There is evidence that slight ponding occurs during rain events. This area looks like an unkempt swale and would benefit from a retrofit or extensive restoration. Immediate maintenance is needed to remove vegetation and address the ponding.

BMP 11 (AA County Urban BMP Database ID AA001446)

This BMP is classified as an Extended Detention Structure, Wet (PWED) in the 2015 database, updated from an Extended Detention Structure, Dry (EDSD) classification in the 2013 database. The structure is located at 2310-2309 Solomons Island Road. This structure belongs to the City of Annapolis. The inspection revealed that the BMP was well-maintained and in good condition. However, the flow-in points from the parking area have sediment berms nearly the same height as the curb, potentially preventing runoff from entering the BMP. This may be a retrofit attempt to create a "forebay" to remove sediment from runoff before it enters the BMP. Based on settled sediment at the flow-in point, this retrofit has been successful. The BMP should be checked to ensure that runoff from the parking area actually enters the BMP. In addition, some minor trash was present that should be removed during the next scheduled maintenance. This BMP is also incorrectly listed as an Extended Detention Structure, Wet (PWED) in the BMP database. The BMP should be classified as a Detention Structure (Dry Pond) XDPD since it appears to be dry the majority of the time. While this BMP does not require immediate maintenance, the flow-in points should be checked during a rain event to ensure proper functionality.

BMP 12 (AA County Urban BMP Database ID AA012015)

This BMP is classified as a Submerged Gravel Wetland (MSGW) in the 2015 database and was updated from a Submerged Gravel Wetland (SGW) classification in the 2013 database. LimnoTech agrees on this change based on the inspection. The structure is located at 2054 Somerville Road behind the AAA building. It was found in fairly good condition; however, the inflow is causing erosion and sediment needs to be removed from the forebay. The erosion was also documented in the 2012 and 2013 BMP inspection reports. The area around the inflow should be stabilized to prevent further erosion. This BMP does not require any immediate maintenance but it is showing early signs of stress.

BMP 13 (AA County Urban BMP Database ID AA012014)

This is an area of Permeable Pavements (APRP). The BMP classification was updated from Permeable Pavements (PERMP) in 2013 to APRP in 2015. LimnoTech agrees on this change based on the inspection. The BMP is located at 2054 Somerville Road. It was found to be well-maintained, and in good condition. The paver gaps are beginning to fill with debris and fines based on small plant growth between the pavers but do not require maintenance at this time.

BMP 14 (AA County Urban BMP Database ID AA012013)

This BMP is located at 2054 Somerville Road. The BMP is classified as a Regenerative Step Pool Storm Conveyance (SPSC) in the 2015 database. It was originally classified as a Micro-Bioretention (MB) area in the 2013 database and this is a more appropriate description of the BMP. Therefore, the classification of this BMP should be changed to MMBR, which is the correct 'MDE

Approved BMP Classification' acronym for this BMP. This is a new installation and is in good condition. This BMP does not require any immediate maintenance.

BMP 15 (AA County Urban BMP Database ID AA012012)

This BMP is located at 2054 Somerville Road. The structure is classified as a Regenerative Step Pool Storm Conveyance (SPSC) in the 2015 database. It was originally classified as a Micro-Bioretention (MB) area in the 2013 database and this is a more appropriate description of the BMP. Therefore, the classification of this BMP should be changed to MMBR, which is the correct 'MDE Approved BMP Classification' acronym for this BMP. This is a new installation and is in good condition and does not require any immediate maintenance.

BMP 16 (AA County Urban BMP Database ID AA000071)

The BMP is located at 2453-2499 Riva Road near the south corner of the parking lot. The structure is classified as an Extended Detention Structure, Dry (XDED) in the 2015 database. It was updated from EDSD classification in the 2013 database. LimnoTech agrees on this change based on the inspection. This appears to be an older pond, but the inspection revealed it to be in good condition, with some minor sedimentation. No maintenance is required for this BMP.

BMP 17 (AA County Urban BMP Database ID AA006493)

This structure is located at 2431 Solomons Island Road and is classified as an Infiltration Trench (ITRN) in the 2015 database. This BMP was originally classified as an Infiltration Trench, Partial Exfiltration (ITPE) in the 2013 database. LimnoTech agrees on this change based on the inspection. The BMP is located inside a manhole in a parking lot, and at the time of inspection there was standing water inside the structure. The inspection team was unable to view the entire BMP because of the restricted access to the structure. This BMP is showing early signs of stress but no immediate action is necessary.

BMP 18 (AA County Urban BMP Database ID AA001872)

This BMP consists of an Infiltration Trench (ITRN) at 2436 Solomons Island Road, in the southwest corner of the parking lot. This BMP was inspected in 2015. It was found to be generally in good condition and no immediate maintenance is required; however, the catch basin leading to the ITRN is filled with debris which should be removed. This BMP was inspected in 2013 and was originally classified as an Infiltration Trench, Partial Exfiltration (ITPE).

This BMP was deleted from the 2015 database between the time of inspection and the writing of this report. The database ID associated with this BMP (as identified from the 2013 BMP inspection report) is AA001872, but this ID does not exist in the most recent version of the database. If this BMP is to be included in the BMP inventory, it should be placed back in the database.

BMP 19 (no AA County Urban BMP Database ID)

This structure is a dry pond (DP) located at 2200 Somerville Road and is not associated with a database ID. The inspection revealed standing water, significant amounts of trash, heavy vegetative debris, and a clogged orifice. This BMP should be considered non-functional and failing. It needs significant restoration, including landscaping, clearing of debris and trash, removal of trees, and clearing of the clogged orifice. This has been noted in both the 2012 and 2013 BMP inspection reports.

BMP A (AA County Urban BMP Database ID AA008471)

This structure is classified as a Sand Filter (FSND) in the 2015 database. Inspectors originally classified it as a Bioretention BMP during the 2013 inspection and in the 2013 Inspection Report. It is also a very similar structure to BMP C below (ID AA008475) which is classified as Bioretention (FBIO). Therefore this BMP classification should be checked for accuracy by the County. The BMP is in good condition and is healthily vegetated. No maintenance is required for this BMP.

BMP B (AA County Urban BMP Database ID AA008472)

This structure is a BaySaver hydrodynamic structure, located at the Annapolis Towne Centre at Parole. The 2015 database characterizes this BMP as an XOGS (Oil Grit Separator). It was classified as a Sand Filter (SF/FSND) in previous versions of the database. Field inspections support the updated 2015 classification. The BMP and inlet are in good condition; however, there is some debris buildup and ponding in the structure. In summary, this BMP is showing early signs of stress but no immediate action is necessary.

BMP C (AA County Urban BMP Database ID AA008475)

This structure is classified as a Bioretention (FBIO) BMP in the 2015 database but was originally classified as a Sand Filter (SF) in the 2013 database. Field inspections support the updated 2015 classification. This BMP is located at the Annapolis Towne Centre at Parole. This is a newly constructed area and the BMP is in good condition. Some debris was found in the riser which should be removed and the stones covering the filter fabric have started to settle into the basin and should be maintained. No immediate maintenance is required for this BMP.

BMP D (AA County Urban BMP Database ID AA008473)

This structure is a BaySaver (BS) hydrodynamic structure, located at the Annapolis Towne Centre at Parole. The 2015 database characterizes this BMP as an XOGS (Oil Grit Separator). It was classified as a Sand Filter (SF/FSND) in previous versions of the database. Field inspections support the updated 2015 classification. The BMP is generally in good condition. Minor debris was found inside the structure which should be removed. No immediate maintenance is required for this BMP.

BMP E (AA County Urban BMP Database ID AA008474)

This structure is a BaySaver hydrodynamic structure, located at the Annapolis Towne Centre at Parole. The 2015 database characterizes this BMP as an XOGS (Oil Grit Separator). It was classified as a Sand Filter (SF/FSND) in previous versions of the database. Field inspections support the updated 2015 classification. The BMP is generally in good condition; however, standing water was present. Thus, this BMP is showing early signs of stress but no immediate action is necessary.

BMP F (AA County Urban BMP Database ID AA008470)

This structure is classified as a Sand Filter (FSND) in the 2015 database, updated from the SF classification in the 2013 database. The BMP is located at the Annapolis Towne Centre at Parole. It contained a moderate amount of trash which should be removed. Because this BMP is located underground and had standing water, the inspection team could not fully assess the BMP. No immediate maintenance is required for this BMP.

BMP G (no AA County Urban BMP Database ID)

This structure was classified as a Bioretention (FBIO) BMP by the inspectors since no database ID is associated with it. The BMP is located at the Shoppers Food Warehouse at 2371 Solomons Island Road. There was some debris associated with the shopping center that was found in the Bioretention area. No immediate maintenance is required for this BMP.

Note: there is no BMP H

BMP I (no AA County Urban BMP Database ID)

This structure was classified as a Bioretention (FBIO) BMP by the inspectors since no database ID is associated with it. The BMP is located on the southwest side of the Shoppers Food Warehouse, at the approximate address of 2104-3098 Forest Drive. The inspection revealed some debris associated with the shopping center that should be cleared but no immediate maintenance is required for this BMP.

BMP J (no AA County Urban BMP Database ID)

This structure was classified as a Bioretention (FBIO) BMP by the inspectors since no Database ID is associated with it. The BMP is located on the southwest side of the Shoppers Food Warehouse, at the approximate address of 2100-2102 Forest Drive. The inspection revealed some debris associated with the shopping center that should be cleared, but no immediate maintenance is required for this BMP.

BMP 100 (AA County Urban BMP Database ID AA006819)

This BMP is composed of multiple rain barrels and is classified as Disconnection of Rooftop Runoff (NDRR) in the 2015 database. The rain barrels collect roof runoff from the Holiday Inn and Suites at 2451 Riva Road. Inspectors did not have access to the roof drains to check for clogs but the rain barrels appeared to be in good condition. No immediate maintenance is required for this BMP.

BMP 101 (AA County Urban BMP Database ID AA008115)

This BMP was initially characterized as an Impervious Surface Elimination (IMPP) associated with the Database ID AA008115. This BMP was moved outside of the Church Creek watershed between the inspection date and when a new version of the database was provided. The inspection showed some planted areas along the side of a new building. No immediate maintenance is required for this BMP.

BMP 102 (AA County Urban BMP Database ID AA013422)

This BMP is currently classified as a Regenerative Step Pool Storm Conveyance (SPSC). However, inspectors do not agree with this characterization and would recommend changing to Bioretention (FBIO). Previous versions of the database also considered this a Bioretention BMP and the as-built plans specify this as Bioretention. It was also unclear what impervious areas are supposed to drain to this BMP. One inflow pipe may be draining the northwest ARINC parking area but the pipe was submerged in standing water and difficult to assess. The flow-in points from the east parking lot still have intact curbs, so this area is not being treated. Immediate action should be taken to remediate the ponding at the low point in the BMP and to put in curb cuts at the flow in points from the east parking lot if this area is supposed to be treated.

BMP 103 (no AA County Urban BMP Database ID)

This BMP was moved outside of the Church Creek watershed between the time of inspection and the writing of this report. The version of the report used during the 2015 inspection classified this BMP as an Infiltration Trench (ITRN) and it was in good condition other than some leaf debris buildup. No immediate maintenance is required for this BMP if it is put back in the database.

BMP 104 (AA County Urban BMP Database ID AA004339)

This BMP is classified as a Dry Swale (ODSW). It is located along an on-ramp to Highway 665 and appears to collect runoff from the ramp. At the time of inspection there was standing water, trash and vegetation debris, as well as 80% coverage by invasive vegetation, including bulrush and cattails. Ponding suggests that this BMP is not functioning properly as a Dry Swale and should either be reclassified as a Wet Swale (OWSW) or remediated. This BMP requires immediate maintenance.

BMP 105 (no AA County Urban BMP Database ID)

This BMP is listed as an Infiltration Trench (ITRN) and is located just upstream of where Church Creek crosses underneath Solomons Island Road. The BMP was included in the dataset provided for field inspection purposes but has since been moved to a location outside of the Church Creek watershed. Inspection revealed that this location is either an abandoned BMP in the floodplain of Church Creek that is overgrown with invasive vegetation or a stormwater outfall in disrepair. Ponding also appears to be an issue in this BMP since the outfall of the storm drain was submerged. Immediate maintenance should be performed to remove invasive vegetation and to address the ponding if this is indeed a BMP.

BMP 106 (AA County Urban BMP Database ID AA005932)

This BMP is listed as an Infiltration Trench (ITRN) and is located in the southern corner of the Home Depot parking lot. Inspection of the manhole at this location showed standing water on the upstream side of the dam inside. This suggests that infiltration rates have decreased and that this BMP should be remediated. No immediate action is necessary but the BMP is showing early signs of stress.

Note: There is no BMP 107

BMP 108 (AA County Urban BMP Database ID AA001180)

This BMP is classified as an Infiltration Trench (ITRN) and is located in the northern corner of the Two Restaurant site. Actual inspection of the BMP was not possible due to immovable manhole lids. Observation wells were opened and there were no signs of debris at the flow-in points. No immediate maintenance is required at this BMP.

BMP 109 (AA County Urban BMP Database ID AA000335)

This BMP is listed as an Infiltration Trench (ITRN) and is located near the entrance to the parking lot of the Sovran Building on Riva Road. Actual inspection of the BMP was not possible due to parked cars and no access points. There were no signs of debris at the flow-in points. No immediate maintenance is required at this BMP.

BMP 110 (AA County Urban BMP Database ID AA000058)

The BMP is located in the southeast parking lot of the Parole Professional Plaza. It is classified as an Extended Detention, Dry Pond (XDPD) in the 2015 database. It was originally classified as an Underground Storage (UGS) BMP in the 2013 database. Since this BMP is located under the parking area, the Extended Detention Structure, Dry (XDED) is a more appropriate classification for this BMP, and it is recommended that this change be made to the BMP database. All inflow points and inspection points showed the BMP clear of trash and debris. No immediate maintenance is required at this BMP.

BMP 111 (AA County Urban BMP Database ID AA002384)

This BMP is listed as an Infiltration Trench (ITRN) and is located at the southern end of the Hampton Inn & Suites parking lot. The infiltration trench could not be inspected but the inflow points were clear of trash and debris. No field inspection form was completed for this BMP because the location was not known until after inspection dates. No immediate maintenance is required at this BMP.

BMP 112 (AA County Urban BMP Database ID AA002634, AA003322, AA003350, and AA003388)

These BMPs were originally all placed in the same location as a place holder for four separate Infiltration Trenches (ITRN). They have since been placed in their correct locations in the most recent 2015 database. These BMPs were not inspected because their locations were unknown and are located under paved parking areas.