CHEMICAL, BIOLOGICAL, AND PHYSICAL CHARACTERIZATION OF THE CHURCH CREEK AND PAROLE PLAZA NPDES MONITORING STATIONS: 2014 - 2015

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 2014 through June 2015.

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.

2 METHODS

2.1 CHEMICAL MONITORING

During the 2015 sampling period, July 2014 through June 2015, eight storm events were sampled and four 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). Currently, 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 2014 through June 2015. 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 Sediments	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 9223B
Hardness	1.0	SM 2340 C

During the sampling period, eight storm samples and four baseflow samples were collected. Baseflow samples were taken in lieu of storm samples for the following reasons:

- September 16, 2014 - Baseflow samples were collected on September 16 at both sites due to the approaching end of the quarter and inability to monitor the September 6 storm event. At time of arrival (early afternoon), both Church Creek and Parole Plaza were exhibiting baseflow conditions. For this event, samples were collected 70 hours after the most recent rainfall.

- September 30, 2014 - Total rainfall for the month of September was 1.69", which was below average. Rainfall in September primarily occurred on weekends when no staff from Versar and the lab were available to capture the event. On the last day of September, field staff obtained a baseflow sample to represent the September event.

- February 25, 2015 - The total rainfall amount for January and February, which included rain, snow, and wintry mix was 4.53". Beginning January 12 and continuing until the end of February, a runoff event (either rain, snow, or snow melt) took place every other day, which limited sampling opportunities. Monitoring attempts on February 9 and February 22, which were predicted to be rain, were not successful due to snowfall instead. Because of storm sampling false starts and persistence of runoff events inside the 72-hour window, baseflow samples were collected on February 25.

- March 26, 2015 - The start of rainfall on March 26 was predicted for three different times, all with uncertain probability. A Versar field crew prepared to sample the event, but the storm surprisingly arrived before the predicted time in the afternoon and the field team could not sample. Since the end of the month was near, Versar waited 72 hours for the dry weather criterion to be satisfied and then collected a baseflow sample.

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 12, 2014 - The total rainfall for this event was 3.32" and lasted approximately 12 hours, based on data from the Church Creek rain gauge.

- October 15, 2014 - The total rainfall for this event was 0.84" and lasted approximately 6 hours, based on data from the Church Creek rain gauge.

- November 6, 2014 - The total rainfall for this event was 0.30" and lasted approximately 12 hours, based on data from the Church Creek rain gauge.

- December 22, 2014 - The total rainfall for this event was 0.12" and lasted approximately 8 hours, based on data from the Church Creek rain gauge.

- March 4, 2015 - The total rainfall for this event was 0.23" and lasted approximately 8.5 hours, based on data from the Church Creek rain gauge.

- April 14, 2015 - The total rainfall for this event was 0.53" and lasted approximately 13.5 hours, based on data from the Church Creek rain gauge.

- June 8, 2015 - The total rainfall for this event was 0.23" and lasted approximately 8.5 hours, based on data from the Church Creek rain gauge.

- June 27, 2015 - The total rainfall for this event was 1.24" and lasted approximately 21 hours, based on data from the Church Creek rain gauge.

A total of 40.52 inches of precipitation was recorded at the Church Creek station during the 2015 reporting period. Rainfall was measured using a tipping bucket rain gage located at the Church Creek station.

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)
8 August 2014	3.32
18 September 2014	0.00 (Baseflow)
30 September 2014	0.00 (Baseflow)
15 October 2014	0.84
6 November 2014	0.30
22 December 2014	0.12
25 February 2015	0.00 (Baseflow)
4 March 2015	0.23
31 March 2015	0.00 (Baseflow)
14 April 2015	0.53
8 June 2015	0.23
27 June 2015	1.24

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 samples should be equivalent in concentrations. When personnel leave the site during an event, the sampler is programmed to collect discrete, four-bottle (four-liter) samples at fixed time intervals. These intervals are based upon observations of the unique storm response characteristics of each watershed and the anticipated event duration to ensure that samples are distributed to characterize the typical storm as accurately as possible. The only 2015 event that the ISCO was programmed to collect samples was on June 27, 2015. The ISCO sampler collected samples at 45 minute intervals for 18 hours during this event. For this event, TPH and *E. coli* samples were not submitted to the labs since field personnel were not available to collect manual samples for TPH, and submit the samples to the lab within the 6 hour holding time for *E. coli*.

When the 54" RCP came online 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 flow depth at 5-minute intervals, and stored data for up to three months. Data were downloaded bi-weekly. Stage/discharge relationships were prepared for each pipe, to determine the discharge from the pipes based on field-measured depths. The relationships were based on a combination of field measurements and modeled values. The model was necessary in order to characterize major storm events where measured values were 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. As was the case at the Church Creek station, the only 2015 event that ISCO samplers were programmed to collect samples was on June 27, 2015. Field personnel temporarily installed an ISCO sampler at each pipe to collect samples at 45 minute intervals for 18 hours. For this event, TPH and *E. coli* samples were not submitted to the labs since field personnel were not available to collect manual samples for TPH, and submit the samples to the lab within the 6 hour holding time for *E. coli*.

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

2.1.3 Monitoring Station Maintenance

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

- On August 5 at 12:20, staff unscrewed the cap on the Global Water logger for the RCP at Parole Plaza to download data. While unscrewing the cap, the wire attached to the battery assembly disconnected. Staff sent the Global Water logger to the manufacturer for repairs. The logger was reinstalled on August 27; however, the unit had been reset to write data at the factory default rate of once every 15 days. Since there were almost no data recorded until September 24, data were estimated by applying a correction curve. The correction curve was prepared by plotting CMP level versus RCP level from storm events where both data sets were known to be correct. The corrected RCP data were obtained by using the correction curve equation, which was determined using a SAS curve-fitting program. Resulting RCP levels that were 0 or less were replaced with an assumed baseflow value of 0.02 ft.

- During the early October storm event, continuous level data were accidently erased from the logger for the CMP at Parole Plaza; therefore, data are missing from September 30 until October 14 at 8:52. The inverse of the correction curve equation used to estimate missing RCP levels was used to estimate CMP levels for the missing data. Corrected CMP data values were set to 0 when RCP levels fell below 0.02 ft. since the CMP typically does not exhibit baseflow when RCP levels are below 0.02 ft. During the 10/24/14 maintenance visit, the field team noticed the mounting plate for the RCP logger had become distorted in shape due to sand, gravel, and debris buildup under the plate. The field team was able to straighten the plate at the time but eventually a screw is needed in the plate to keep it from happening again. Fixing the plate caused an inaccurate reading at 15:00.

- During routine maintenance on February 6, the Versar field crew discovered the battery had died for the RCP logger at Parole Plaza; therefore, continuous level data are missing from January 30 until February 6 at 13:20. Missing data was estimated using the RCP correction curve that was prepared for the missing September 2014 data.

- During the February 25 maintenance visit, the field team noticed the mounting plate for the RCP logger had become distorted in shape due to sand, gravel, and debris buildup under the plate. The field team was able to straighten the plate at the time and is looking into the type of screws needed in the plate to keep it from happening again.

- During routine maintenance on March 18, 2015, the Versar field crew accidently deleted the data (March 4 – March 18) while collecting the data from the CMP logger. During a subsequent visit, while checking on the batteries in the CMP logger, Versar noticed that the wire leading from the power supply was stripped. Since the logger had no power, data are missing from March 31 until the logger was replaced in April. Missing data were estimated using the CMP correction curve that was prepared for the missing October 2014 data.

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 2015 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.

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 (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

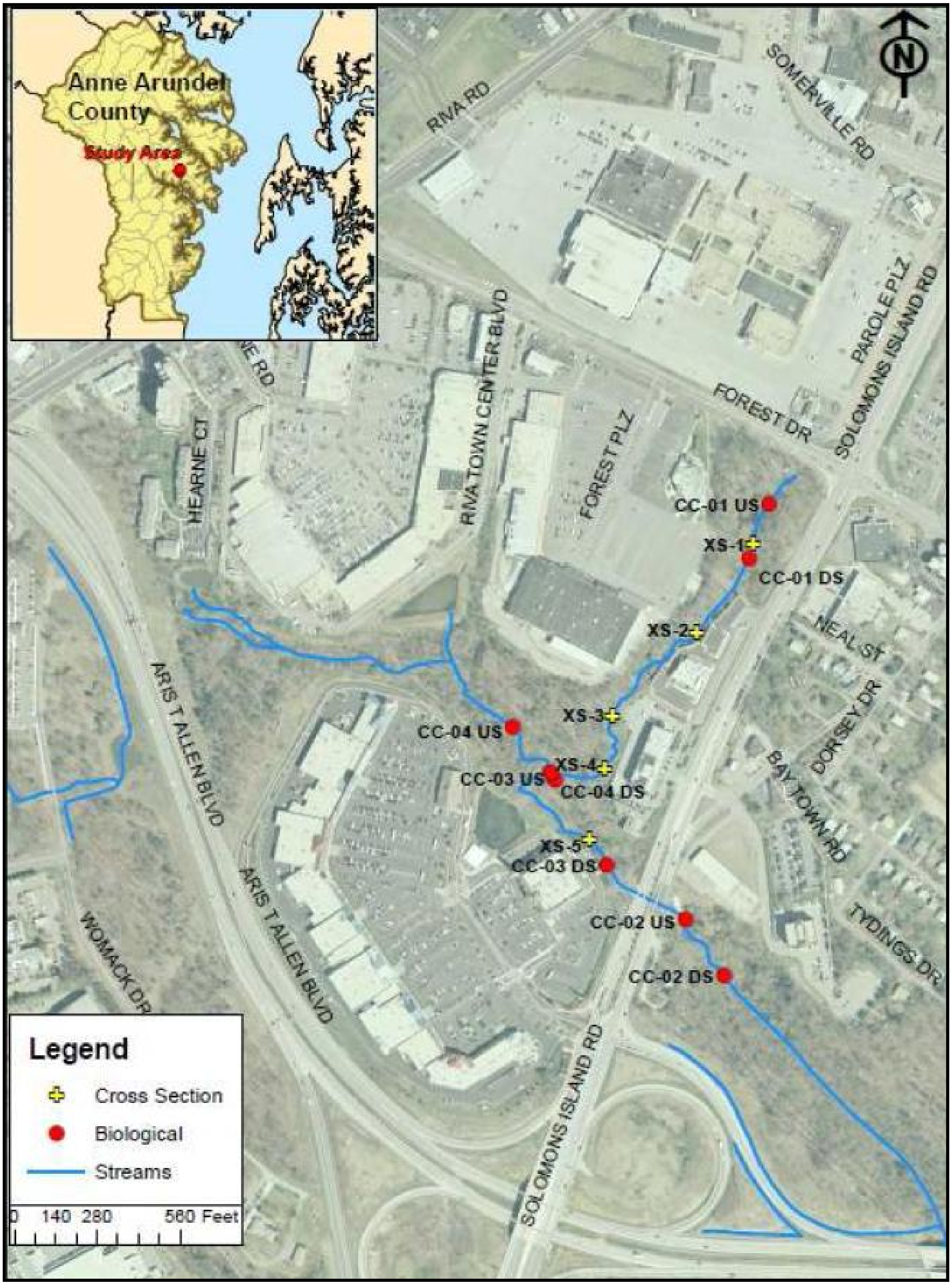


Figure 2-1. Church Creek study area and stream monitoring locations

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). Overall habitat quality typically increases as the total score for each site 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 2015 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 rootwads, rootmats and woody debris and associated snag habitat; leaf packs; submerged macrophytes and associated substrate; and undercut banks. Other less preferred habitats include gravel, broken peat, clay lumps and detrital or sand areas in runs; however, of the aforementioned habitat types, those that are located within moving water are preferred over those in still water.

2.2.5 Biological Sample Processing and Identification

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

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

2.2.6 Biological Data Analysis

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

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

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

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

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

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

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

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

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

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

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

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

Table 2-9. Maryland Biological Stream Survey BIBI scoring

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

2.3 PHYSICAL MONITORING

2.3.1 Monitoring Sites

Five cross sections (XS), four of which were established in 2003 and one which was established in 2007, have been measured annually through 2015. 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 2015 were used to prepare this annual summary report.

2.3.2 Physical Data Collection and Analysis

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

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

Table 2-10. Rosgen stream classification types

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

Source: Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado

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

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

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

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

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

D50 was visually estimated. However, if the channel did have variation in bed material size from feature to feature, a full pebble count was performed.

2.4 LAND USE AND STORMWATER MANAGEMENT ASSESSMENT

2.4.1 Church Creek Watershed Land Use

A previous report (Versar 2013) provided information on land use, based on field reconnaissance conducted during 2013. As seen in an aerial photograph and stormwater best management practice (BMP) facilities map (Figure 2-2), the watershed is predominantly commercial with open space area adjacent to the stream channels. There is little available area for further development in the watershed except for areas that are being redeveloped. Anecdotal information indicates there has been no change in land use in this watershed since the 2013 land use evaluation. Changes in land use characteristics were not field evaluated during the 2014 or 2015 reporting period.

2.4.2 Church Creek Watershed Stormwater BMPs

Based on record review and field reconnaissance conducted during December 2015 - January 2016, the Church Creek watershed contains 29 BMPs, as shown in Figure 2-2. BMP details are provided in Table 2-11. Starting in the summer of 2014 and continuing through the 2015, inspections were performed at BMPs under the County's jurisdiction. Inspection and maintenance information is currently being updated in the County's BMP database. Inspection reports are maintained at the County's offices.

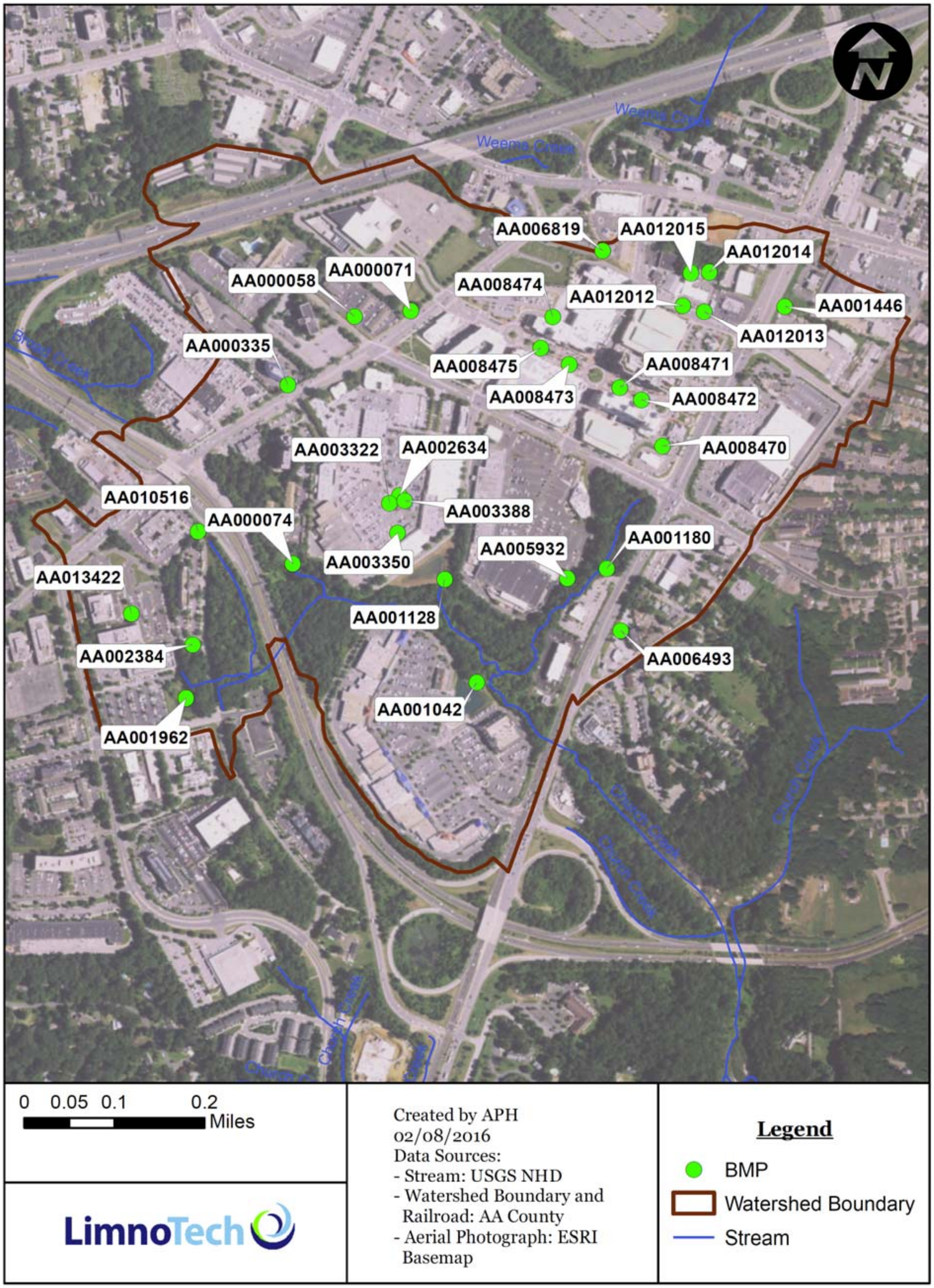


Figure 2-2. Church Creek BMPs

VERSAR

Table 2-11. Church Creek BMP overview

AA County Urban BMP Database ID	BMP Type[(a)]	Drainage Area (acres)	Location	Address	Last Inspection[(b)]	Rank[(c)]
AA001128	PWED	22.94	Festival at Riva	Riva Rd. & Forest Dr.	8/18/2014	1
AA001042	PWED	18.79	Annapolis Harbour Center	Old Solomons Island Rd.	10/30/2014	2
AA000335	ITRN	9.16	Sovran Building	-	5/6/2003	3
AA005932	ITRN	6.73	South Annapolis Forest Drive Home Depot	Forest Dr.	8/25/2014	4
AA008474	XOGS	5.63	Annapolis Town Center at Parole Infrastructure	Forest Dr.	8/13/2014	5
AA008470	FSND	4.78	Annapolis Town Center at Parole Infrastructure	Forest Dr.	8/13/2014	6
AA000074	XDPD	4.47	Forest Garden Apartments	130 Hearne Ct.	2/11/2015	7
AA000071	XDED	3.71	Nationwide Insurance	2500 Riva Rd.	11/13/2001	8
AA002384	ITRN	2.23	Hampton Inn & Suites	124 Womack Dr.	11/18/2014	9
AA000058	XDPD	2.07	Parole Professional Building	132 Holiday Ct.	1/7/2004	10
AA012015	MSGW	1.94	AAA Mid Atlantic Car Care	2054 Summerfield Rd.	-	11
AA008473	XOGS	1.88	Annapolis Town Center at Parole Infrastructure	Forest Dr.	8/13/2014	12
AA001962	XDPD	1.15	Hemlsman Property/ Womack Ave.	-	-	13
AA001446	PWED	1.13	Second National Federal Savings Bank	2045 West St.	11/15/2001	14
AA006493	ITRN	1.00	Annapolis Harbour Center	2431 Solomons Island Rd.	8/8/2014	15
AA001180	ITRN	0.53	Two Restaurant Sites	2436 Solomons Island Rd.	12/3/2014	16
AA008472	XOGS	0.53	Annapolis Town Center at Parole Infrastructure	Forest Dr.	8/13/2014	17
AA002634	ITRN	0.50	Festival at Riva	Riva Rd. & Forest Dr.	8/24/1995	18
AA003322	ITRN	0.50	Festival at Riva	Riva Rd. & Forest Dr.	8/24/1995	18
AA003350	ITRN	0.50	Festival at Riva	Riva Rd. & Forest Dr.	8/24/1995	18
AA003388	ITRN	0.50	Festival at Riva	Riva Rd. & Forest Dr.	8/24/1995	18
AA008475	FBIO	0.40	Annapolis Town Center at Parole Infrastructure	Forest Dr.	8/13/2014	22
AA008471	FSND	0.30	Annapolis Town Center at Parole Infrastructure	Forest Dr.	8/13/2014	23
AA013422	SPSC	0.30	ARINC	2551 Riva Rd.	2/18/2014	23
AA012013	SPSC	0.26	AAA Mid Atlantic Car Care	2054 Summerfield Rd.	-	25
AA012012	SPSC	0.21	AAA Mid Atlantic Car Care	2054 Summerfield Rd.	-	26
AA006819	NDRR	0.20	Days Inn/ Riva Road	2451 Riva Rd.	-	27
AA010516	ODSW	0.14	2525 Riva Road	2525 Riva Rd.	7/16/2014	28
AA012014	APRP	0.03	AAA Mid Atlantic Car Care	2054 Summerfield Rd.	-	29

(a) MDE BMP codes, see Appendix H
(b) Dates as recorded in the County's Urban BMP database (Attachment A, Table B of Anne Arundel County MS4 Report for FY2015, February 2016)
(c) Ranked in order by drainage area

3 RESULTS

3.1 POLLUTANT CONCENTRATIONS

During this sampling period, 56 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)	4.0	88	31
TKN (mg/L)	0.5	25	21
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	38	2
Total Lead (µg/L)	2.0	100	40
Total Zinc (µg/L)	20	0	0
TPH (mg/L)	5.0	100	77
E. coli (MPN/100 ml)	10.0	13	10
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. Table 3-4 shows the maximum value for each parameter during wet weather monitoring, the station of occurrence, and the storm date of the observation. Parole Plaza had the highest wet-weather value for ten of the thirteen parameters measured during wet weather sampling in 2015. A nitrate-nitrite concentration of 170 mg/L was observed at Parole Plaza during the August 2014 storm event. This concentration is more than 100 times higher than all of the other storm event nitrate-nitrite concentrations observed at this station during the 2015 monitoring period, and thus was flagged as an outlier and was not included in the EMC and loading calculations. During the same event, *E. coli* concentrations of 4,500 MPN/100 mL, 54,750 MPN/100 mL, and 241,960 MPN/100 mL were observed at the Parole Plaza station, while all *E. coli* concentrations fell below the detection limit at the Church Creek station. Consistently high *E. coli* concentrations at the upstream station paired with non-detectable *E. coli* concentrations at the downstream station is illogical and is likely the result of a lab or sampling anomaly; therefore, the *E. coli* data for the August 2014 storm event were not included in EMC and loading calculations. 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)	65.48	65.84
pH	6.9	7.1
BOD_5 (mg/L)	BDL	5
TKN (mg/L)	0.80	0.70
Nitrate + Nitrite (mg/L)	1.60	6.00
Total Phosphorus (mg/L)	0.08	0.09
TSS (mg/L)	22	18
Total Copper (µg/L)	2.80	8.60
Total Lead (µg/L)	BDL	BDL
Total Zinc (µg/L)	98	130
TPH (mg/L)	BDL	BDL
E. coli (MPN/100 ml)	171	246
Hardness (mg/L)	480	890
BDL: Below Detection Limit		

Table 3-3. Maximum wet weather values observed during sampling period		
Parameter	**Church Creek**	**Parole Plaza**
Water Temperature (°F)	75.56	77.20
pH	7.20	8.38
BOD_5 (mg/L)	20	39
TKN (mg/L)	1.60	1.80
Nitrate + Nitrite (mg/L)	1.70	170*
Total Phosphorus (mg/L)	0.56	0.26
TSS (mg/L)	180	230
Total Copper (µg/L)	30	38
Total Lead (µg/L)	14	13
Total Zinc (µg/L)	190	280
TPH (mg/L)	8	6
E. coli (MPN/100 ml)	24,196	241,960**
Hardness (mg/L)	180	410
BDL: Below Detection Limit * Flagged as an outlier. Was not included in EMC and Loading calculations **Was not included in EMC and Loading calculations due to large discrepancy between Church Creek and Parole Plaza *E. coli* values during August 12, 2014 storm event		

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

Parameter	Date of Storm	Site	Maximum Value
Water Temperature (°F)	8/12/14	Parole Plaza	77.20
pH	4/14/15	Parole Plaza	8.38
BOD_5 (mg/L)	12/22/14	Parole Plaza	39
TKN (mg/L)	12/22/14	Parole Plaza	1.80
Nitrate + Nitrite (mg/L)	8/12/14	Parole Plaza	170*
Total Phosphorus (mg/L)	11/6/14	Church Creek	0.56
TSS (mg/L)	6/8/15	Parole Plaza	230
Total Copper (µg/L)	3/4/15	Parole Plaza	38
Total Lead (µg/L)	8/12/14 and 10/15/14	Church Creek	14
Total Zinc (µg/L)	3/4/15	Parole Plaza	280
TPH (mg/L)	6/8/15	Church Creek	8
E. coli (MPN/100 ml)	8/12/14	Parole Plaza	241,960**
Hardness (mg/L)	3/4/15	Parole Plaza	410

* Flagged as an outlier. Was not included in EMC and Loading calculations
**Was not included in EMC and Loading calculations due to large discrepancy between Church Creek and Parole Plaza *E. coli* values during August 12, 2014 storm event

3.2 EVENT MEAN CONCENTRATIONS AND POLLUTANT LOADINGS

Flow-weighted stormflow event mean concentrations (EMCs) values are presented in Table 3-5. EMCs for every parameter except TKN, total lead, TPH and hardness were higher at Parole Plaza than EMCs at Church Creek.

Summed loads for the sampled events monitored during the July 2014 to June 2015 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 2014 to June 2015		
Parameter	**Church Creek**	**Parole Plaza**
Water Temperature (°F)	70.31	71.42
pH	6.87	7.66
BOD_5 (mg/L)	1.83	1.96
TKN (mg/L)	0.613	0.566
Nitrate + Nitrite (mg/L)	0.278	0.361
Total Phosphorus (mg/L)	0.126	0.128
TSS (mg/L)	42.06	42.95
Total Copper (µg/L)	10.96	12.63
Total Lead (µg/L)	4.44	3.36
Total Zinc (µg/L)	72.16	80.97
TPH (mg/L)	2.1	1.7
E. coli (MPN/100 ml)	2,100.13	3,332.62
Hardness (mg/L)	34.62	33.28

Table 3-6. Estimated pollutant loadings for observed events, in pounds, for the July 2014 to June 2015 sampling period				
Parameter	**Church Creek**		**Parole Plaza**	
	Total	**Per Acre**	**Total**	**Per Acre**
BOD_5	1,363.08	4.88	82.00	1.36
TKN	456.45	1.64	23.65	0.39
Nitrate + Nitrite	207.04	0.74	15.08	0.25
Total Phosphorus	93.43	0.33	5.34	0.09
TSS	31,302.12	112.16	1,795.00	29.71
Total Copper	8.16	0.03	0.53	0.01
Total Lead	3.307	0.01	0.140	<0.01
Total Zinc	53.695	0.19	3.384	0.06
TPH	1548.277	5.55	71.737	1.19
Hardness	25,762.729	92.31	1,390.646	23.02

3.3 BIOLOGICAL ASSESSMENT

Biological and physical habitat assessments were completed on March 12, 2015. 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.

Physical habitat quality was evaluated using the MBSS PHI, and rated “Degraded” for two sites and “Partially Degraded” for two site (Table 3-7). Index scores varied somewhat and ranged from a low of 52.9 at CC-02 to a high of 66.7 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 “Non-supporting” for one site (Table 3-7). The scores ranged from a low of 59 at CC-02 to a high of 67 at CC-01. Generally, epifaunal substrate/cover, embeddedness, velocity/depth regime, and vegetative protection scored low for all the sites. Overall, RBP scores throughout the study area indicate habitat conditions that are limiting the potential for healthy biological communities, similar to what was found using the PHI.

Table 3-7. PHI and RBP physical habitat assessment results - 2015

Site	PHI Score	PHI Narrative Rating	RBP Score	RBP Narrative Rating
CC-01	66.4	Partially Degraded	67	Partially Supporting
CC-02	52.9	Degraded	59	Non- supporting
CC-03	66.7	Partially Degraded	66	Partially Supporting
CC-04	62.7	Degraded	66	Partially Supporting

For biological conditions, three stations received a rating of “Very Poor” and one station rated “Poor”, indicating a highly impaired benthic macroinvertebrate community. Only six total taxa were observed at station CC-01, which is extremely low. Number of EPT taxa, Number of Ephemeroptera and Percent Ephemeroptera metrics scored low for all sites. The Percent Climbers metric received high scores for all sites while the Percent Intolerant to Urban received median scores at stations CC-03 and CC-04. The lower than average temperature during March 2015 combined with the high conductivity values from salt treatment of roads found at the sites likely contributed to the metrics being scored lower this year than in the past. BIBI scores and ratings are summarized in Table 3-8.

Table 3-8. Benthic macroinvertebrate assessment results - 2015

Site	BIBI Score	Narrative Rating
CC-01	1.57	Very Poor
CC-02	1.57	Very Poor
CC-03	2.14	Poor
CC-04	1.86	Very Poor

To supplement the biological assessment data, *in situ* water quality parameters were measured at each biological monitoring site prior to sample collection. Table 3-9 shows the water quality data for each site. All parameters measured were within Maryland's water quality standards for Use I streams. Conductivity values were very elevated compared to most coastal plain streams, and far 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). Conductivity values were relatively high compared to most coastal plain streams, 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, 2009a; 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 typically results from 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. Seasonal use of road salt has most likely caused conductivity values to be high.

Table 3-9. *In situ* water quality results - 2015

Site	pH	Temperature	Dissolved Oxygen	Turbidity	Conductivity
	SU	°C	mg/L	NTU	µS/cm
CC-01	7.07	8.62	10.50	25.6	3015
CC-02	7.07	5.90	12.00	29.9	1464
CC-03	7.05	6.21	10.82	28.0	1746
CC-04	6.97	7.75	11.07	30.8	1816

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 2015 data for Church Creek sites are in Appendix F.

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 2015 showing approximately a 0.3 feet difference. In 2015, geomorphic assessment parameters continue to support the classification of this reach as an F channel. The channel evolution is supported by a 36.3% increase in channel cross-sectional area since 2003 and considerable widening and mid-channel bar formation immediately downstream, which is indicative of a channel that it not stable and is undergoing a widening and degradation phase. Left bank widening was also apparent between 2013 and 2014 monitoring years and remained consistent during 2015. 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 G4 channel based on its low width/depth ratio, relatively low slope, and sandy substrate. Between 2014 and 2015 monitoring the substrate became slightly less coarse. 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 has become coarser resulting in a G4/3c classification. 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 channel due to an increase in width/depth ratio. It should also be noted that 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, is leading to aggradation and a reduction in the cross sectional area. Since 2003 cross-sectional area has decreased by 35.7%.

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 F4/3 channel due to a significantly decreased entrenchment ratio from 4.0 to 1.7 between 2012 and 2015. Although still categorized as moderate, the width/depth ratio has also decreased slightly. Between 2014 and 2015 this portion of the reach has become slightly coarser from a D50 of 34 mm to 61 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 2014-June 2015 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 concerns 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

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	2.80	8.60
Zinc (µg/L)	120	120	98	130*
Total P	0.0225		0.08*	0.09*
BOD_5	7		0	5
Nitrate + Nitrite	0.095		1.60*	6.00*
TSS	500		22	18
TKN	None		0.80	0.70
TPH	None		BDL	BDL
*E. coli*** (MPN/100ml)	235		171	246*
Hardness	None		480	890

* 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	14	13
Copper (µg/L)	13	30*	38*
Zinc (µg/L)	120	190*	280*
Total P	0.0225	0.56*	0.26*
BOD_5	7	20*	39*
Nitrate + Nitrite	0.095	1.70*	170*[(a)]
TSS	500	180	230
TKN	None	1.60	1.80
TPH	None	8	6
*E. coli*** (MPN/100ml)	235	24,196*	241,960*[(b)]
Hardness	None	180	410

* Criterion exceeded
** Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.
[(a)] Flagged as an outlier. Was not included in EMC and Loading calculations
[(b)] Was not included in EMC and Loading calculations due to large discrepancy between Church Creek and Parole Plaza *E. coli* values during August 12, 2014 storm event

parameters measured at the monitoring stations. In addition, a clear cause and effect relationship between water quality and ecological condition is difficult to determine. However, these comparisons can be used as general indicators of water quality impairment. Both State and Federal criteria are based on ambient stream conditions. Chronic criteria consider the maximum levels at which aquatic life can survive if continuously subjected to a pollutant concentration. Acute criteria reflect the maximum level at which an aquatic organism can survive if periodically subjected to a pollutant concentration. Since storm events represent a periodic condition, wet-weather samples are compared only to acute criteria.

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 Parole Plaza 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 Parole Plaza monitoring station than at the Church Creek station for all contaminants except for total phosphorus and nitrate-nitrite, which were exceeded 100% of the time at both stations. *E. coli* concentrations also remained high at both stations throughout the 2015 monitoring period, exceeding water quality criteria 71% of the time at Church Creek, and 95% of the time at Parole Plaza. Note that prior to site stabilization, total suspended solids concentrations had been particularly high due to construction activity at Annapolis Towne Centre. Following stabilization of the site in Fall 2008, the event mean concentrations for total suspended solids have dropped significantly. During the last four 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.

The 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. For 2008, loading rates 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. The high levels in 2007 likely resulted from the 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 the 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	29	71
Zinc (µg/L)	120	25	50
Total P	0.0225	100	100
BOD_5	7	12.5	21
Nitrate + Nitrite	0.095	100	100
TSS	500	0	0
TKN	None	NA	NA
TPH	None	NA	NA
*E. coli** (MPN/100ml)	235	71	95
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	4[(a)]	3[(a)]
Copper (µg/L)	9	13	11[(a)]	13[(a)]
Zinc (µg/L)	120	120	72	81
Total P	0.0225		0.126[(a)]	0.128[(a)]
BOD_5	7		1.83	1.96
Nitrate + Nitrite	0.095		0.278[(a)]	0.361[(a)]
TSS	500		42.06	42.95
TKN	None		0.61	0.57
TPH	None		2.1	1.7
*E. coli** (MPN/100ml)	235		2,100.13[(a)]	3,332.62[(a)]
Hardness	None		34.62	33.28

[(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 2015

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
2002-2006 Mean	8,544	59,548	535	974	438	104	23	11	NA	2,186,095
2009-2015 Mean	2,088	14,038	55	340	193	48	1	6	19,224	6,977
2002-2015 Mean	**7,488**	**95,701**	**362**	**737**	**380**	**92**	**11**	**20**	**19,224**	**7,482**

[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 2015

Year	BOD	TSS	TP	TKN	NO_3+NO_2	Zinc	Lead	Copper	Hardness	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
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
2002-2015 Mean	**50,099**	**440,337**	**1,867**	**6,773**	**33,532**	**700**	**56**	**89**	**385,286**	**3,951****

* 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 2015 reporting year, loading rates decreased for all sampled parameters at the Parole Plaza station when compared to the 2014 reporting year. At the Church Creek station, 2015 reporting year loading rates decreased for all sampled parameters when compared to the 2014 reporting year except for TSS, zinc, lead, and copper. None of the parameters at the Church Creek station had a loading rate increase of more than 30% when compared to 2014. The 2015 *E. coli* concentrations at the Church Creek station were the lowest observed since 2007. The low *E. coli* concentrations observed at both stations is partly due to there being no *E. coli* storm event data from the summer quarter (which is typically the quarter with the highest *E. coli* concentrations) that was used to calculate the annual EMCs.

During the post-construction period (2009 to 2015), the loading rates at Parole Plaza have tended to be below 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 doing so in 2015.

Seasonal pollutant loads in 2015 are provided in Table 4-8. Hardness was much higher in the winter at both stations due to the large amount of road salt used to deice local roads during a winter that produced an abnormally large amount of snow and ice. In total, five of the parameters were highest in the winter, and four of the parameters were highest in the fall at the Church Creek station. All parameters, except TKN and *E. coli*, were highest in the winter at the Parole Plaza station. This may be due to a combination of some parameters having high natural background concentrations (e.g. nitrate-nitrite, which is often diluted during storm events) observed during the two winter baseflow sampling events, and other parameters having elevated concentrations during the sole storm event after consistent freeze/thaw cycles occurring during the first couple months of winter may have caused an increase in weathering of infrastructure, allowing more pollutants (e.g. dissolved metals and sediments) to be available for entrainment and transport during the late winter rain event. It should be noted, however, that the limited number of samples collected for each season ultimately makes it difficult to draw strong conclusions about seasonal pollutant loading rates. These interpretations should be viewed cautiously.

Annual average event mean concentrations 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 the event mean concentrations have changed from 2004 to 2015 at the Parole Monitoring Station. As can be seen from the graphs, nearly every concentration rose substantially between 2006 and 2007 when the majority of the site work was being conducted at the Towne Centre. These concentrations fell significantly in 2008, as the site was stabilized, and continued the downward trend 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 2015 decreased when compared to those from 2014, with the exception of a slight increase in lead. 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 event mean concentrations for many of the parameters, although this was not the case in 2015.

Table 4-8. Seasonal loading rates, in pounds, observed at the Church Creek and Parole Plaza sampling stations in 2015

Season	BOD	TSS	TP	TKN	NO_3+NO_2	Zinc	Lead	Copper	Hardness	*E. coli*[*]
Church Creek										
Summer	1,823	88,805	239	916	314	120	9.0	11.9	44,711	100
Fall	5,153	112,526	331	1,355	758	167	10.5	19.7	77,710	12,602
Winter	7,797	96,267	305	2,105	1,403	240	9.3	32.9	257,709	722
Spring	4,870	46,822	182	1,367	673	139	6.4	34.3	75,497	594
Parole Plaza										
Summer	59	3,310	10	30	24	3.8	0.3	0.6	1,336	11
Fall	233	3,373	11	74	37	9.5	0.2	1.2	2,977	15,045
Winter	347	4,573	15	67	71	15.0	0.4	2.0	21,367	2,009
Spring	301	3,351	10	61	31	9.7	0.2	1.6	3,343	3,264

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

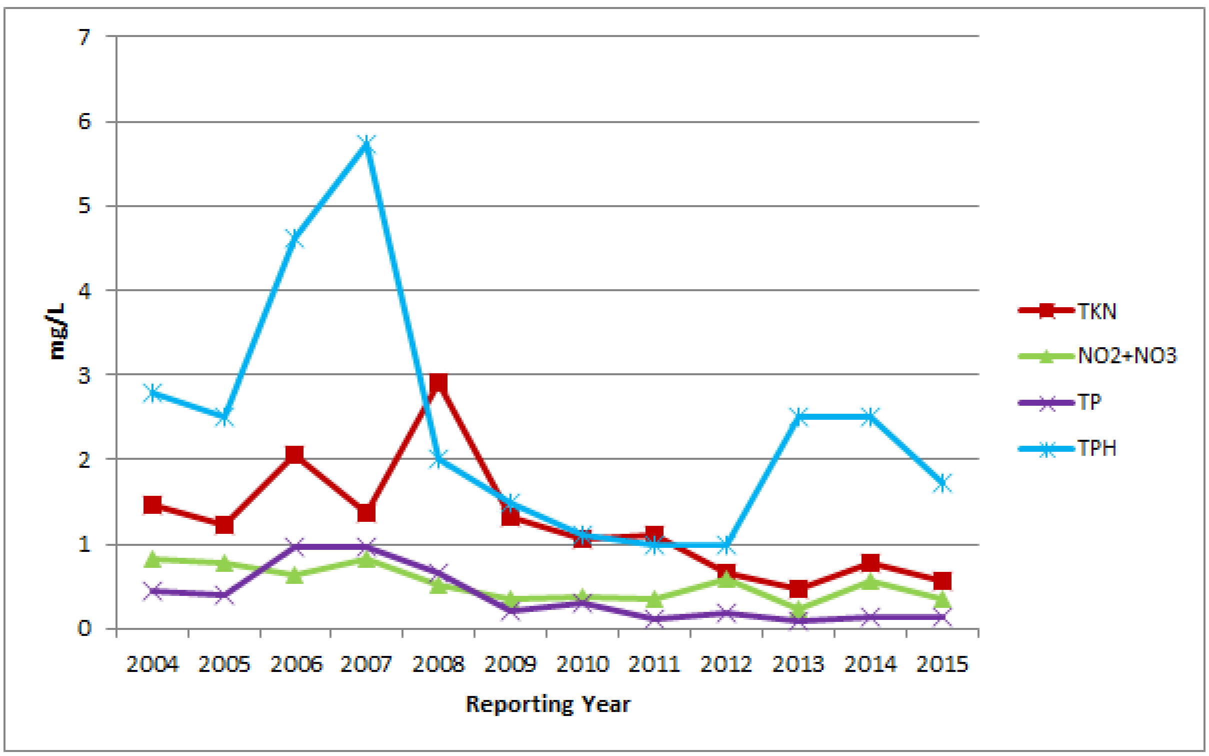


Figure 4-1. Parole station long-term monitoring: annual EMCs (TKN, NO_2+NO_3, TP, TPH; mg/L)

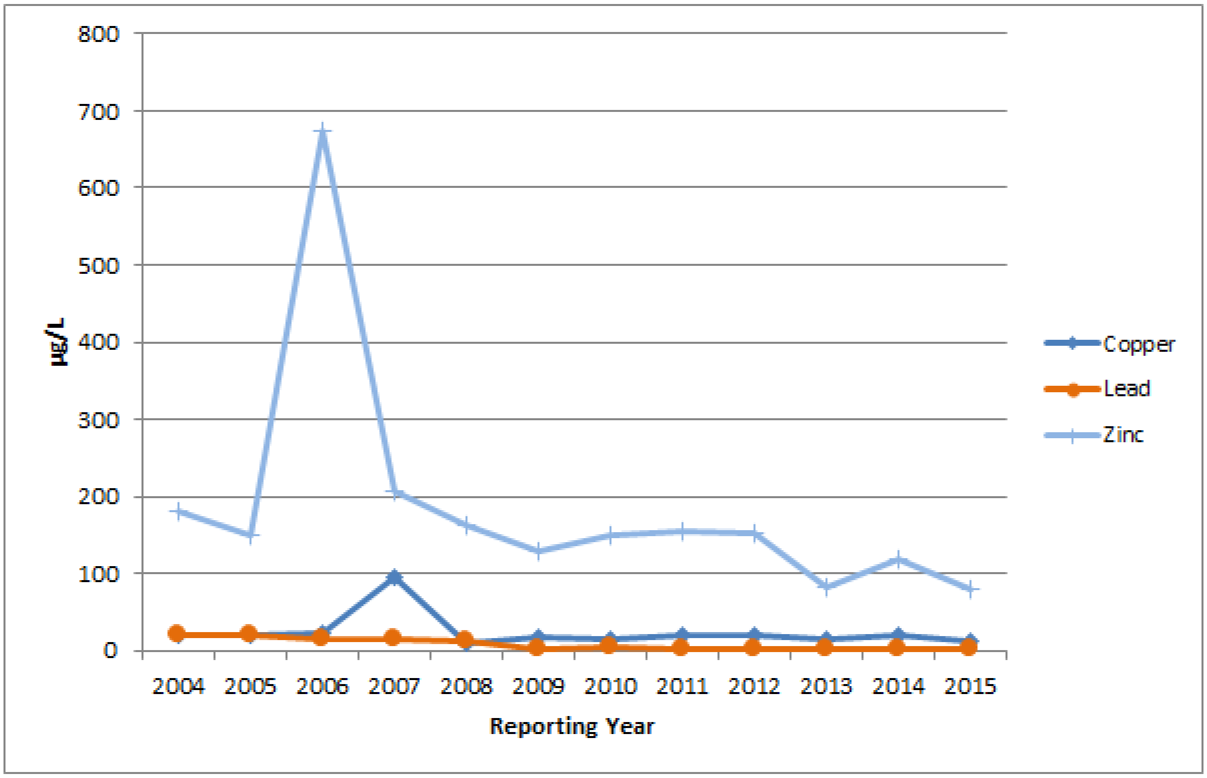


Figure 4-2. Parole station long-term monitoring: annual EMCs (Cu, Pb, Zn; mg/L)

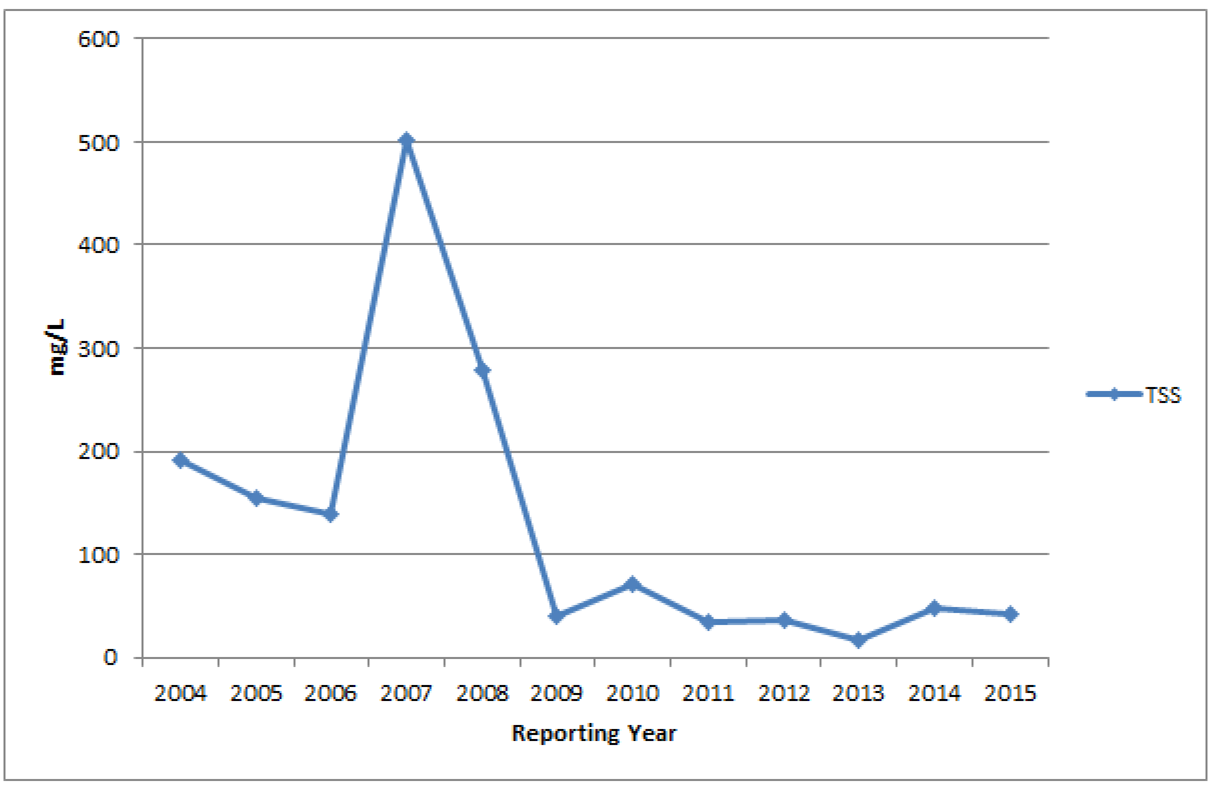


Figure 4-3. Parole station long-term monitoring: annual EMCs (TSS; mg/L)

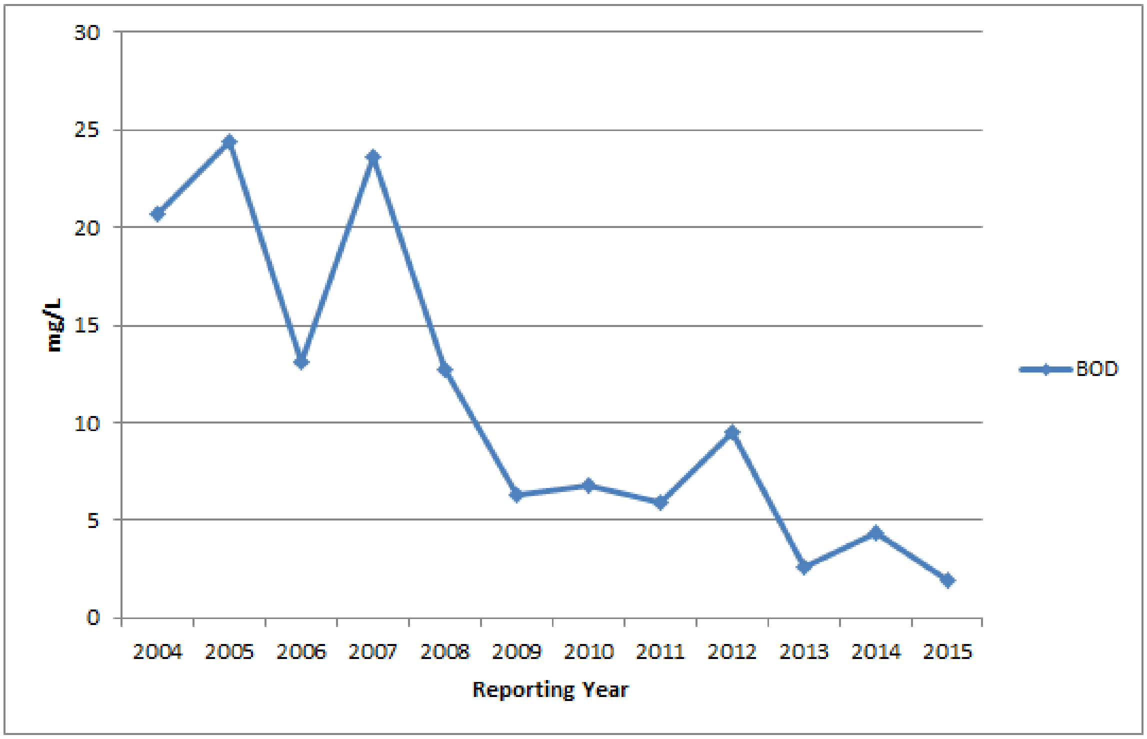


Figure 4-4. Parole station long-term monitoring: annual EMCs (BOD_5; mg/L)

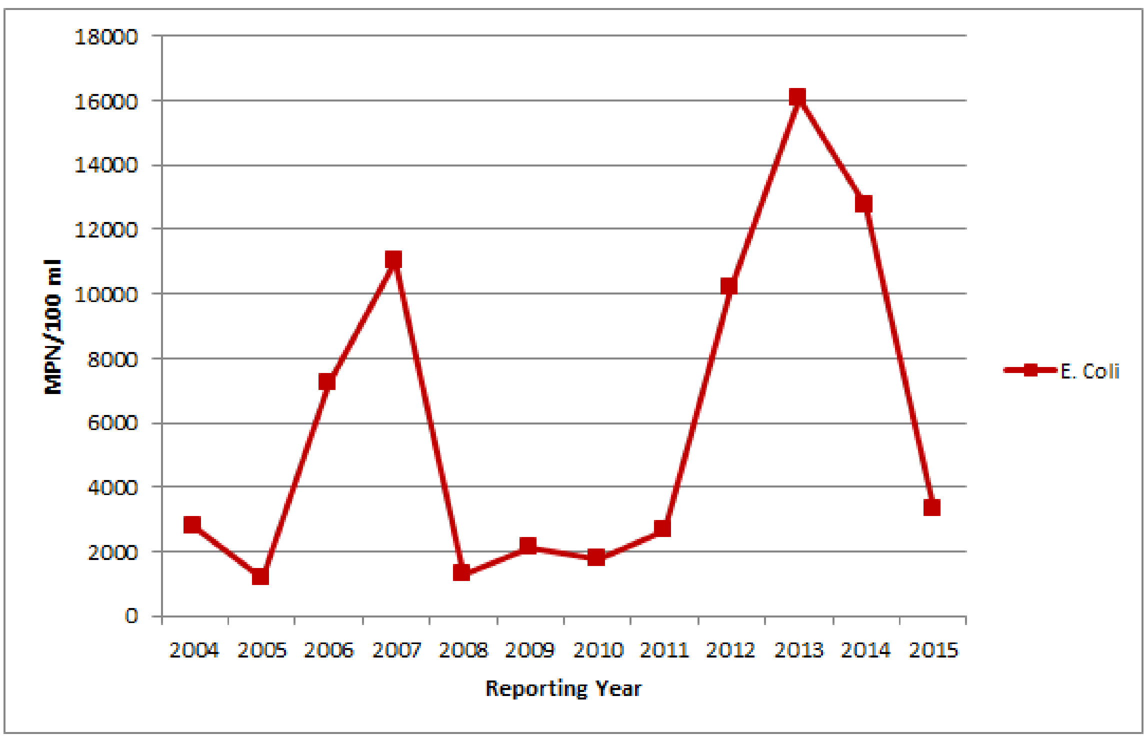


Figure 4-5. Parole station long-term monitoring: annual EMCs (*E. coli*; MPN/100 mL)

Figures 4-6 through 4-10 show a slightly different trend in EMCs for the Church Creek Monitoring Station. A slight rise in pollutant concentrations at Church Creek was observed in 2015 for TKN, nitrate-nitrite, TSS, zinc, and lead when compared to 2014 EMCs. 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.

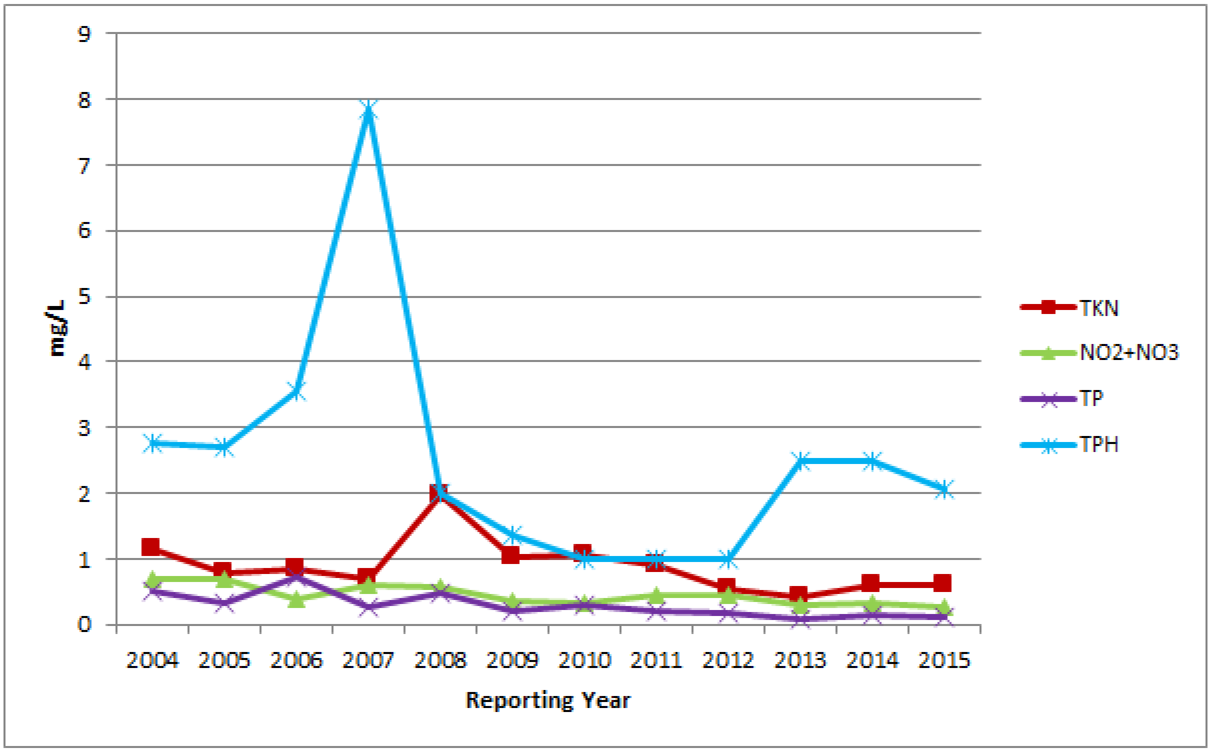


Figure 4-6. Church Creek station long-term monitoring: annual EMCs (TKN, NO_2+NO_3, TP, TPH; mg/L)

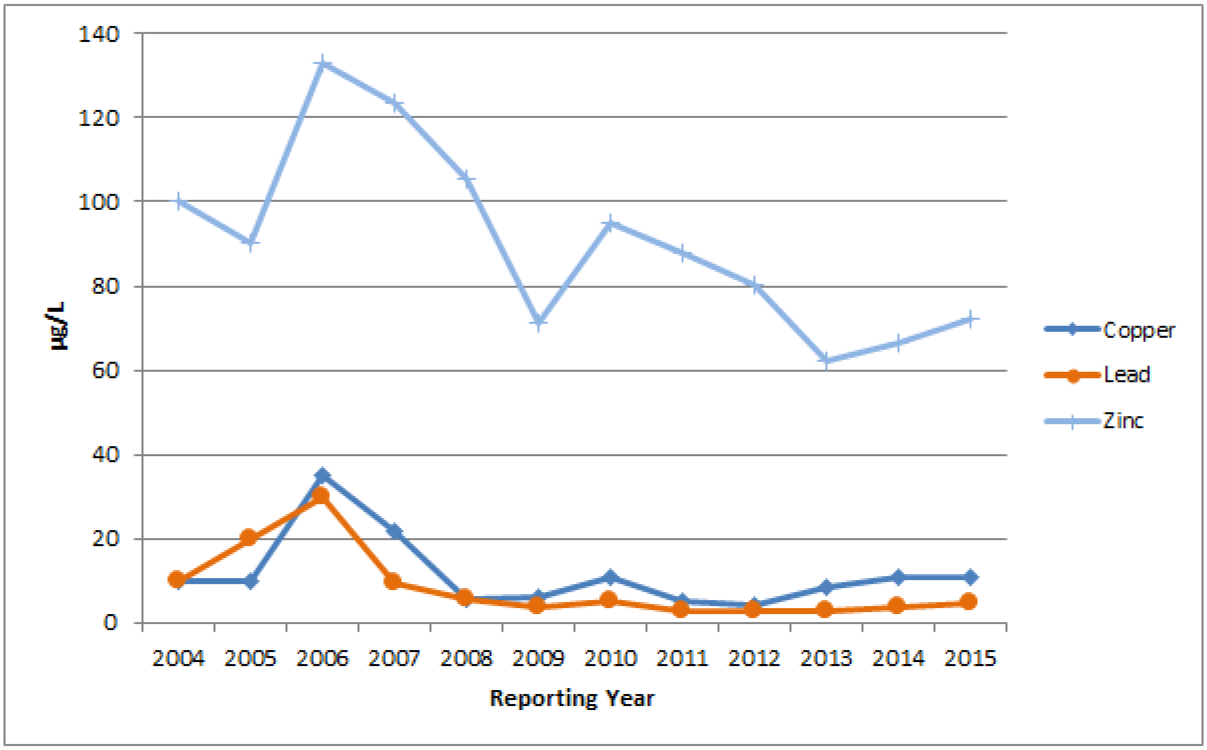


Figure 4-7. Church Creek station long-term monitoring: annual EMCs (Cu, Pb, Zn; mg/L)

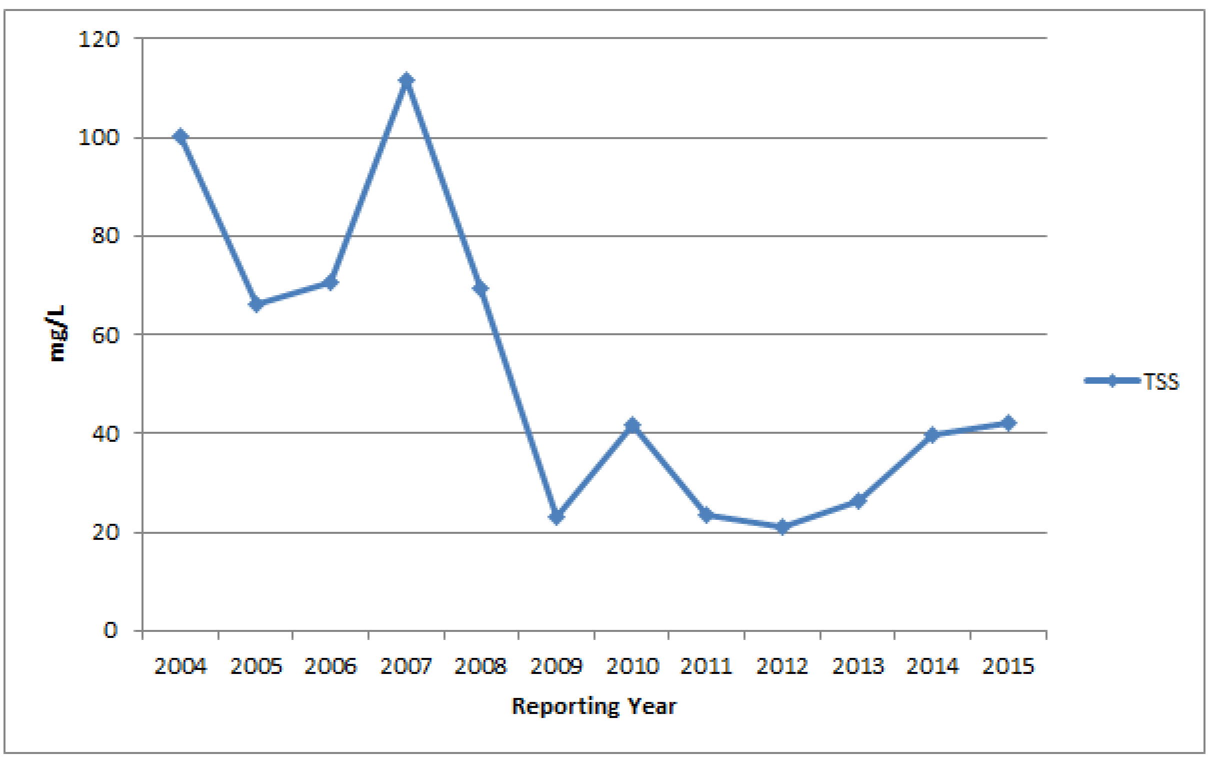


Figure 4-8. Church Creek station long-term monitoring: annual EMCs (TSS; mg/L)

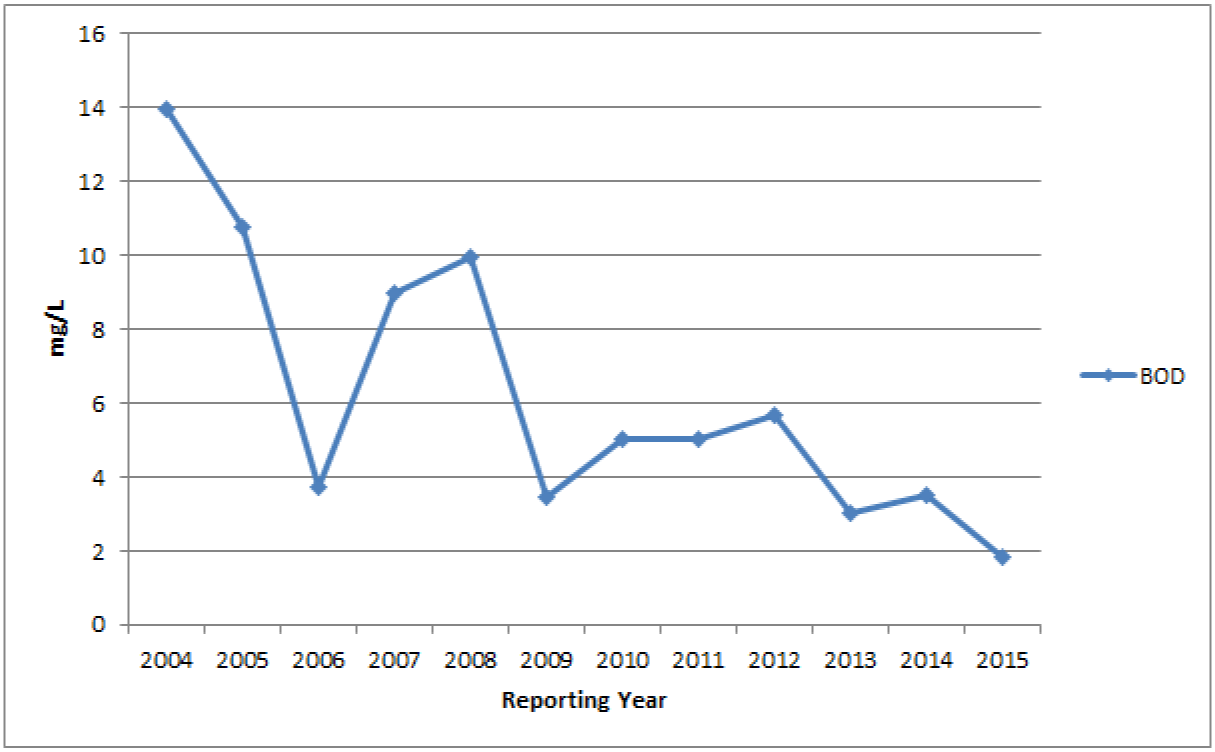


Figure 4-9. Church Creek station long-term monitoring: annual EMCs (BOD_5; mg/L)

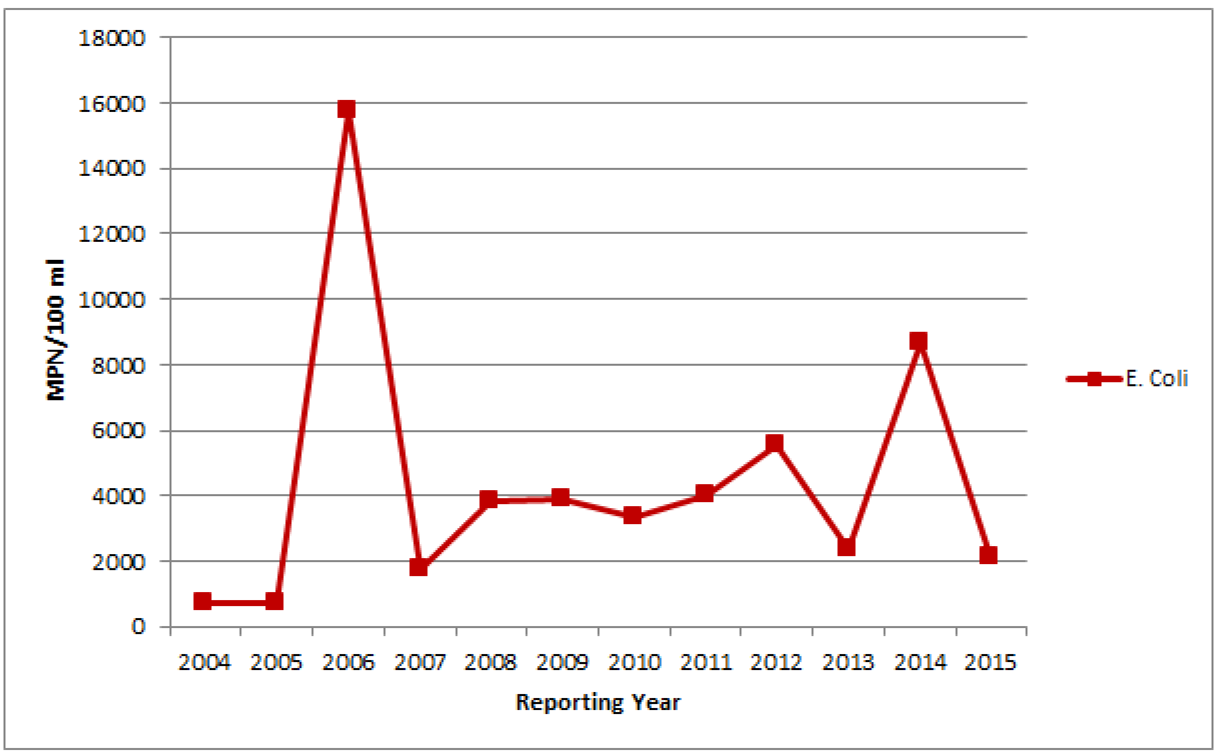


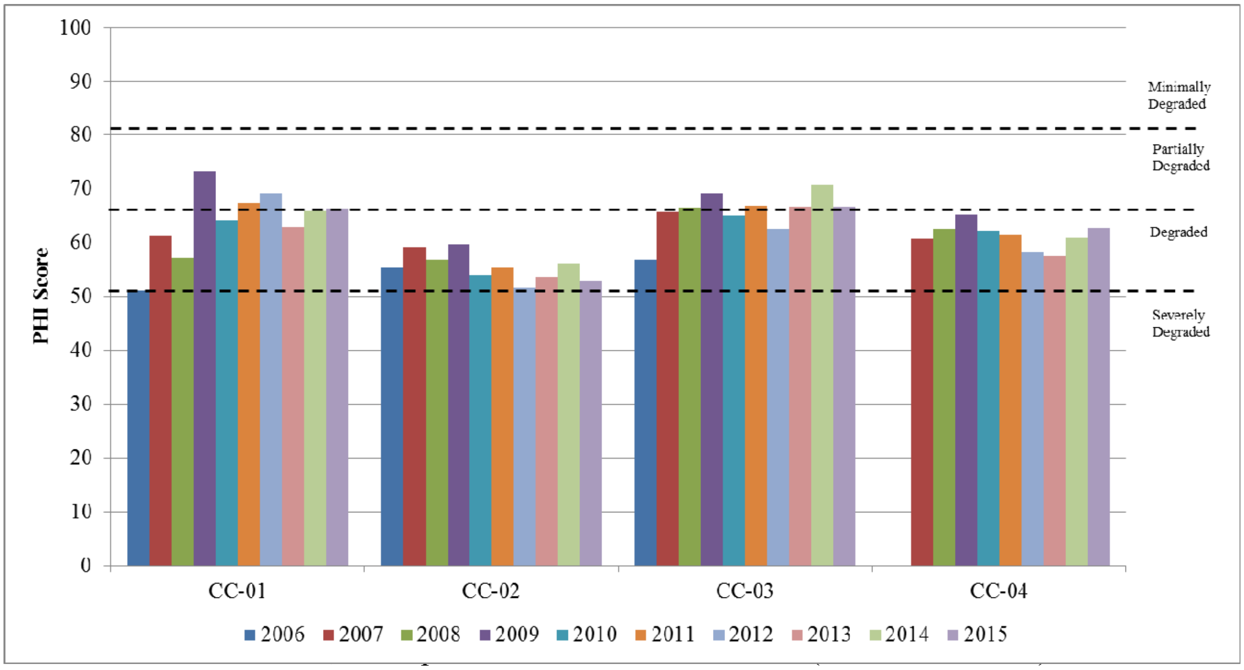
Figure 4-10. Church Creek station long-term monitoring: annual EMCs (*E. coli*; MPN/ 100 mL)

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 2015 as in 2014 indicating no change in habitat condition. One site (CC-01) was slightly upgraded from a rating of Degraded in 2014 to a rating of Partially Degraded in 2015. 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 2015

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



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, 2014, and 2015 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 2015 (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 the 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 2015

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

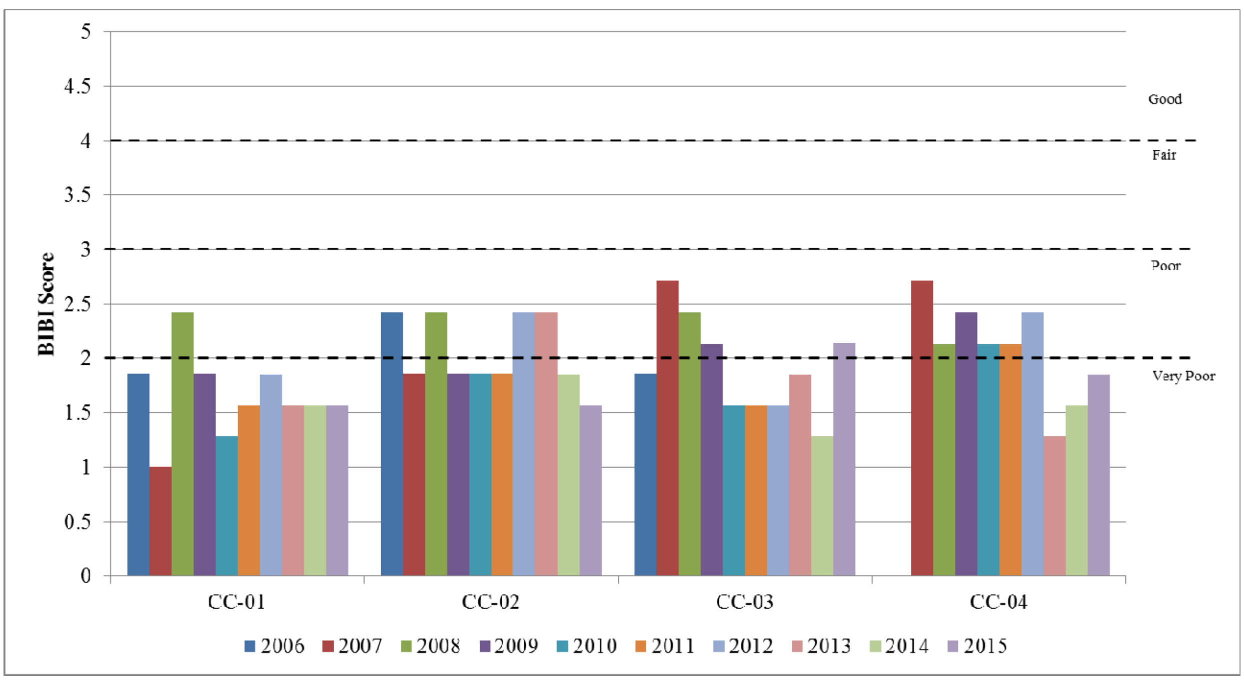


Figure 4-12. Comparison of BIBI scores from 2006 to 2015

4.3 GEOMORPHIC CONDITIONS

The Church Creek study area has a very high percentage of impervious surface cover (approximately 64 percent), and only one reach was classified as a C channel, which are generally considered stable stream types due to adequate floodplain connectivity. In contrast, the other four reaches were classified as either F or G channels, which are more entrenched and less stable. The Parole Plaza Tributary 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
XS-1	E5	C5	E4	E5 → C5	E5 → C4/5	C4/5 → F4/5	F5	F4	F5/4	F4
XS-2	E5	E5	E5	E5	E5	G5c	G5c	G5c	G4c	G4
XS-3	G5c	G5c	G5c	G5c	G5c	No Data	No Data	G4c	G4c	G4/3c
XS-4	E5	E5	E5	E5	E5	E5	E5	C5	C5	C5
XS-5	E5b	C5	C5	C5	C3/5	C3/5	C3/5	F4/3	F3	F3/4

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 2015 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.

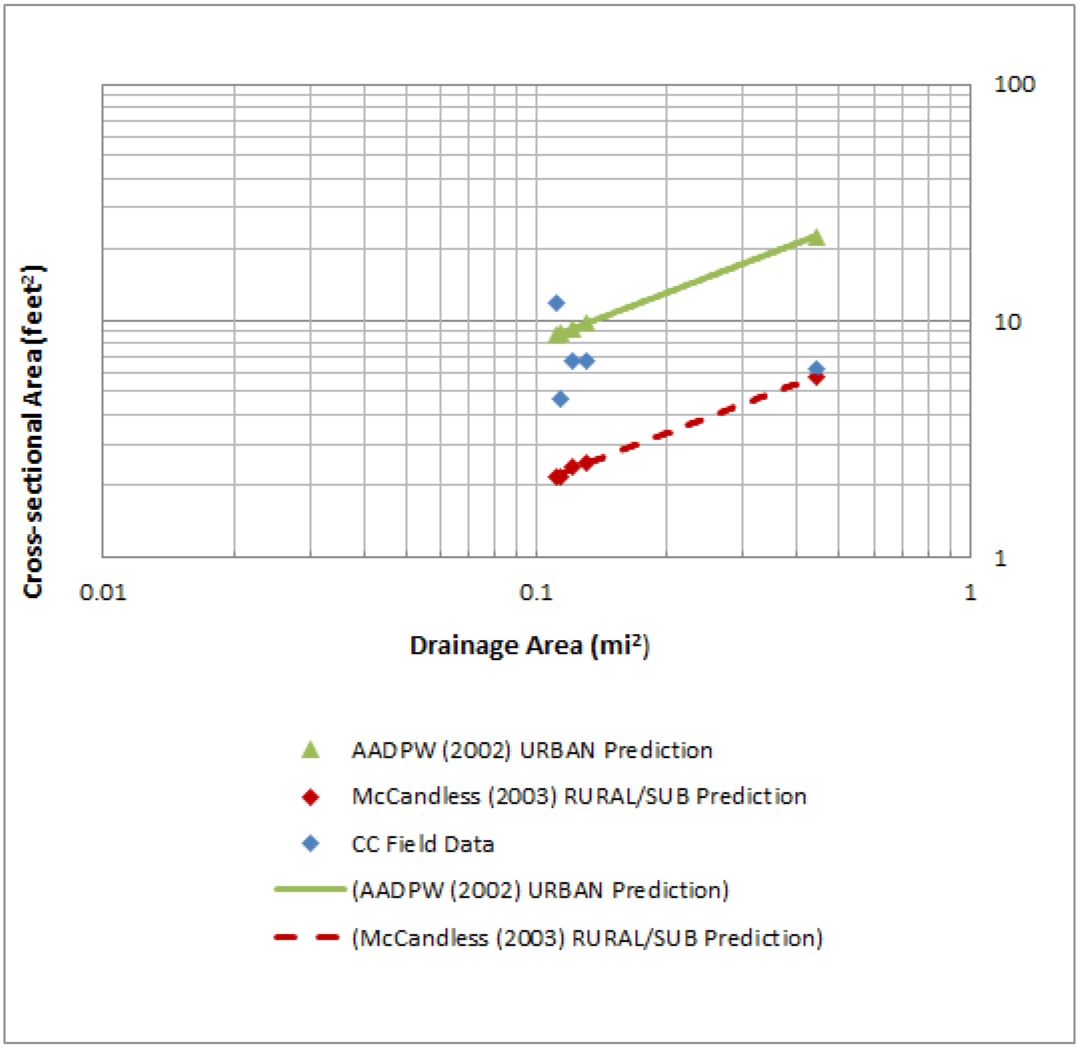


Figure 4-13. Comparison of bankfull channel cross sectional area to drainage area (CC = Church Creek, 2015 data)

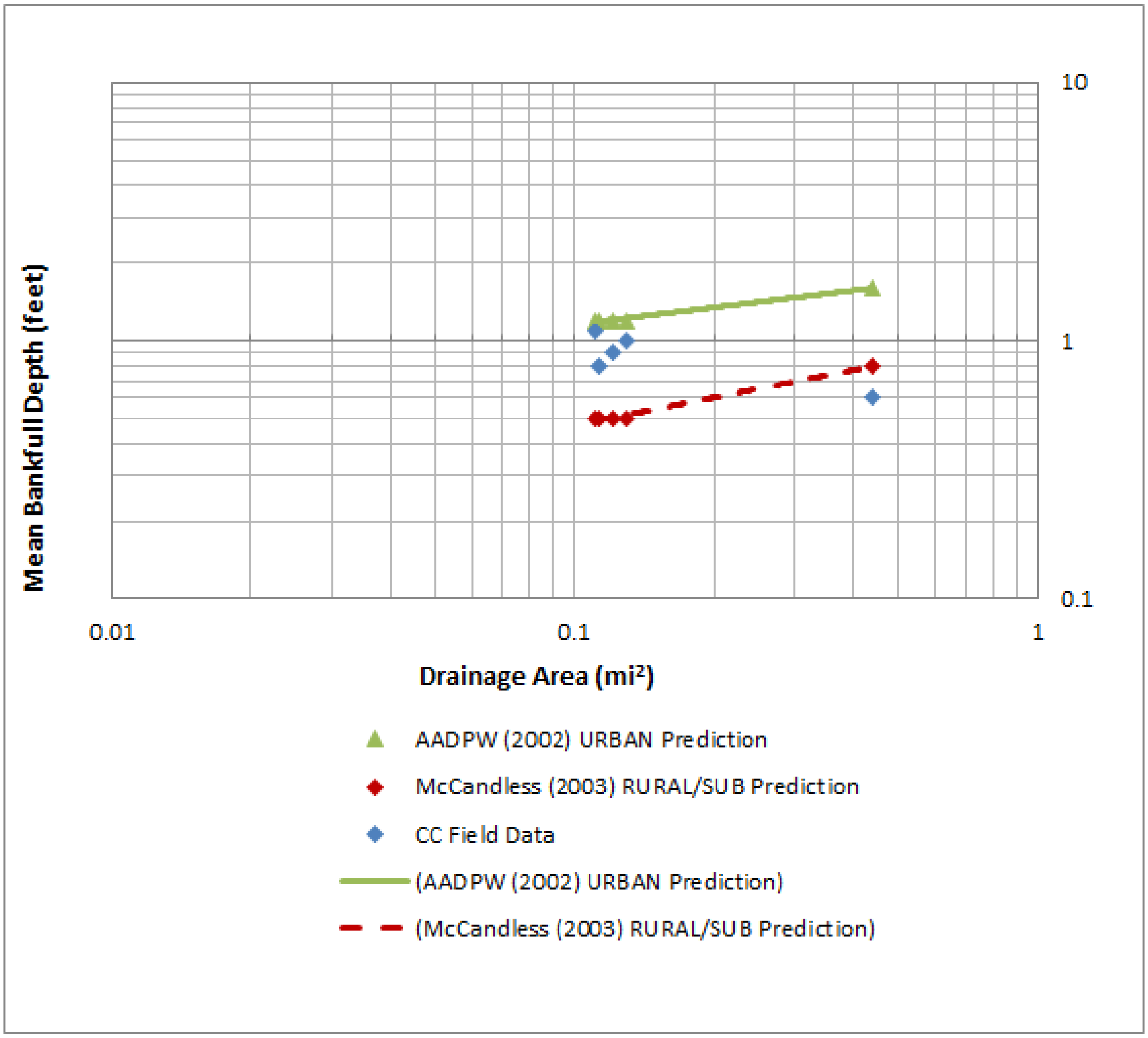


Figure 4-14. Comparison of mean bankfull depth to drainage area (CC = Church Creek, 2015 data)

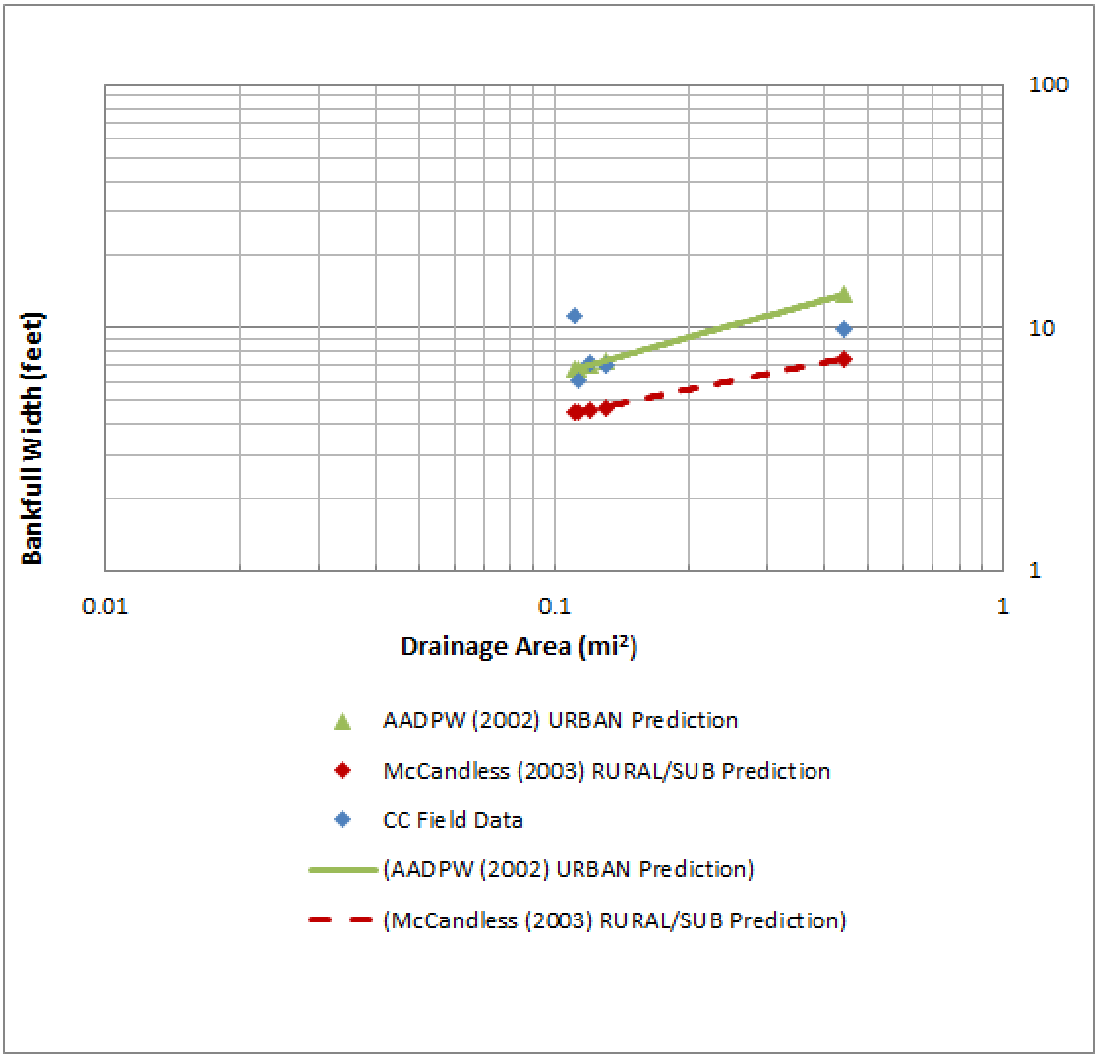


Figure 4-15. Comparison of bankfull width to drainage area (CC = Church Creek, 2015 data)

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 2015 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 2015. Comparison of baseline cross sectional area is however comparable to 2011 through 2015 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
% Change 2003-2014	36.3	84.3	-6.1[c]	-35.7	-30.9
% Change 2011-2014	7.5	3.1	-9.7	17.9	-36.2

[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 36.3%, and 84.3% respectively, since baseline measurements began in 2003. The bed elevation at XS-1 appears to have dropped more than half a foot since 2003, remaining relatively stable since last year, but with a noticeable amount of bed scour occurring between 2008 and 2009 (Appendix F). With the exception of minor scouring near the left bank, there has been very little overall change in bed elevation during 2013 to 2014. Over the last year however, there has been slightly more scour occurring mid channel which has resulted in a mean depth increase from 0.7 ft. in 2014 to 1.1 ft. in 2015. The channel at XS-2 has widened notably since 2003, with considerable erosion along the right bank and toe of slope on the right bank, although the left bank has not experienced further erosion during the last five years (Appendix F). Although cross section area comparisons between baseline and 2015 show a substantial increase, percent change occurring over the last four years only has been fairly minimal with 7.5% increase at XS-1 and 3.1% increase at XS-2.

Cross section XS-3 has had very minimal changes in cross-sectional area with just a 6% decrease since 2003 baseline measurements and -9.7% change between 2011 and 2015. 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 four years, the right bank has experienced some aggradation (Appendix F). Between 2012 and 2015 monitoring, there has been little change with the exception of slight aggradation across the stream bed. Cross section XS-3 continues to have yard waste (i.e., grass clippings, leaves, and branches) dumped along the left bank floodplain.

Conversely, the two most downstream cross sections (XS-4, and XS-5) showed varying degrees of aggradation, decreasing from baseline measurements in cross-sectional area 35.7%, and 30.9%, respectively. 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. In 2015, widening continued along the right bank as well as significant degradation of the stream bed by almost one foot. Another significant change at XS-4 first occurred between 2003 and 2006, where the average bed elevation dropped by more than one-half foot (Appendix F). The woody debris jam just downstream of XS-4 which formed between 2011 and 2012 is still present and contributing to debris and sediment accumulation in the channel and on the banks. Between 2011 and 2015 the cross-sectional area has increased by 17.9% but continues overall trend in aggradation at this location since 2003 (a net 35.7% decrease in cross-sectional area compared to the baseline study). 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. During the past two years, however, there has been little change in both stream bed elevation and bank stability (Appendix F).

4.4 GENERAL CONCLUSIONS

Based upon the data collected in 2015, stream water quality has 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.

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APPENDIX A

STORM EVENT HYDROGRAPHS, NARRATIVES AND COMPOSITE SAMPLING METHOD TECHNICAL MEMORANDUM

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
KCI Job Order No. 01-032333.38
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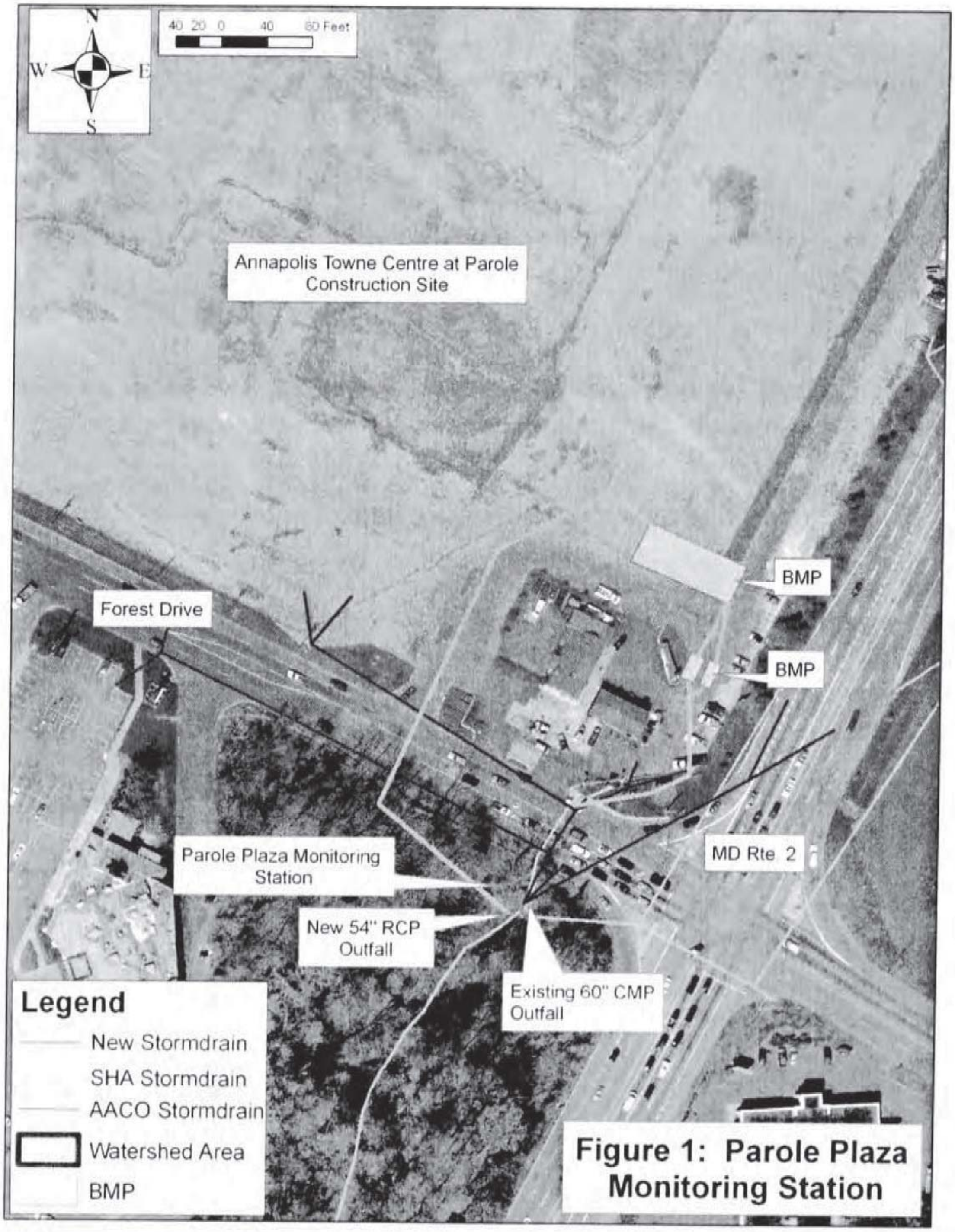

Figure 1: Parole Plaza Monitoring Station

VERSAR

Proposed Modifications to Sampling Procedures
Church Creek/Parole Plaza NPDES Monitoring 2008
KCI Job Order No. 01-032333.38
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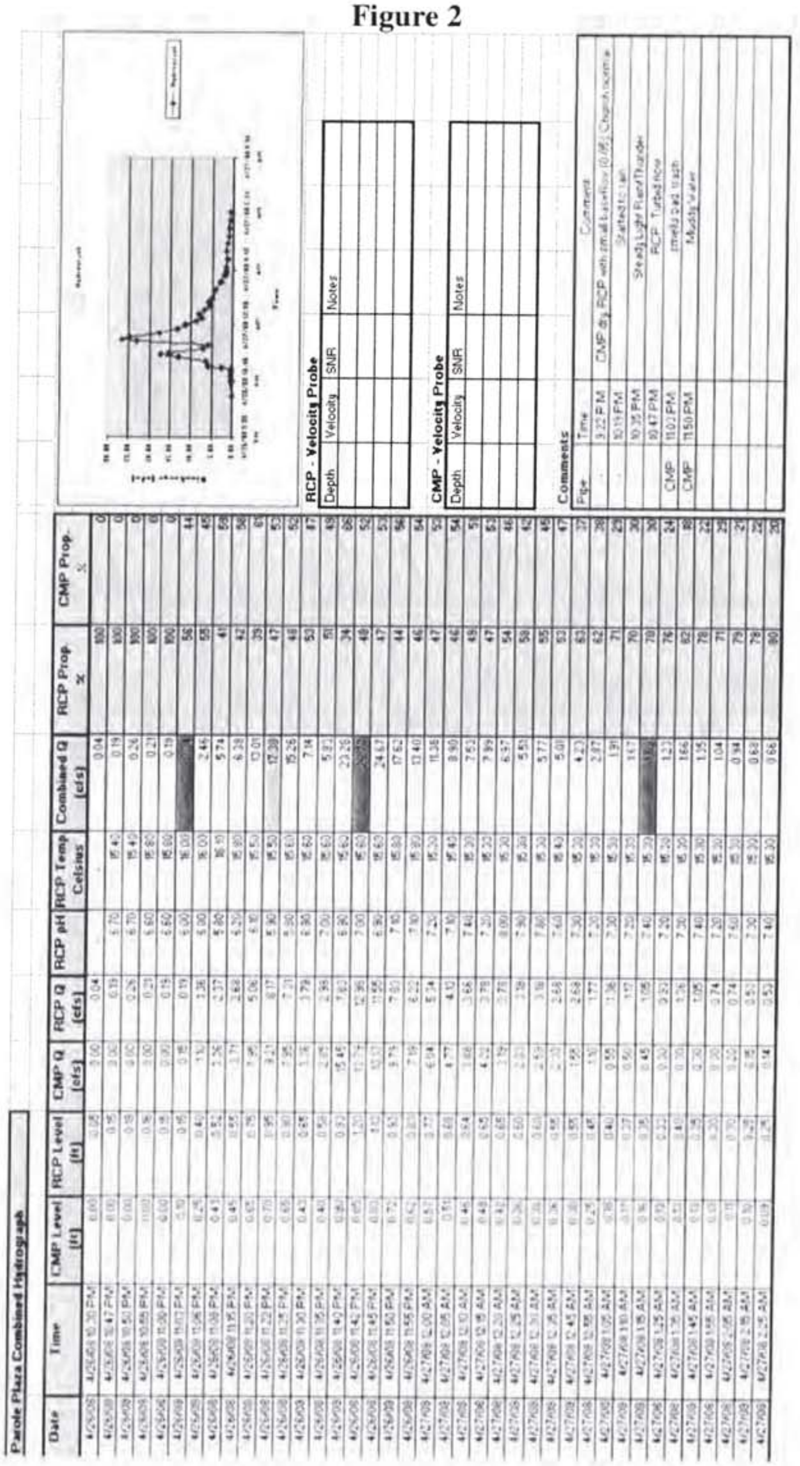
Figure 2



Storm Event Narratives

- August 12, 2014 – At Church Creek, the EMCs of most parameters during the August 12, 2014 storm were greater than the two baseflow values from the last month of the summer quarter, except for TKN, nitrate-nitrite, *E. coli,* and hardness. TPH and *E. coli* were not detected in any samples at Church Creek during the event. The anomalous results were investigated by project staff, including possibilities of sampling error and laboratory error, but no cause for the non-detectible results was found. At Parole Plaza, the EMCs of most parameters during the August 12, 2014 storm were greater than the two baseflow values from the last month of the summer quarter except nitrate-nitrite, zinc, and hardness. At Parole Plaza, TPH was the only parameter not detected in any samples. Unlike at Church Creek, *E. coli* was detected at high concentrations in samples during the event. During the August 12 storm event, level measurements were measured manually for the RCP pipe at Parole Plaza due to the unavailability of the Global Water logger. These records are highlighted in blue in the spreadsheet.

- October 15, 2014 - At Church Creek, the EMCs of most parameters during the October 15, 2014 storm were greater than the other two storm EMCs from the fall quarter, except for BOD, TKN, nitrate-nitrite, and total phosphorus. TPH was not detected in any samples at Church Creek during the event; therefore, the EMC is presented as 0. At Parole Plaza, the EMCs of total phosphorus, TSS, lead, and *E. coli* during the October 15, 2014 storm were greater than the two storm EMCs from the fall quarter. As was the case at Church Creek, TPH at Parole Plaza was not detectible in any samples.

- November 6, 2014 - At Church Creek, during the November 6, 2014 storm, the total phosphorus EMC was greater than the other two storm EMCs from the fall quarter. TPH was not detected in any samples at Church Creek during the event; therefore, the EMC is presented as 0. At Parole Plaza, the EMCs of most parameters during the November 6, 2014 storm were less than the other two storm EMCs s from the fall quarter except BOD, nitrate-nitrite, and zinc. As was the case at Church Creek, TPH at Parole Plaza was not detectible in any samples.

- December 22, 2014 – At Church Creek, during the December 22, 2014 storm, BOD, TKN, nitrate-nitrite, and total phosphorus EMCs were greater than the other two storm EMCs from the fall quarter. TPH was not detected in any samples at Church Creek during the event; therefore, the EMC is presented as 0. At Parole Plaza, the *E. coli* EMC during the December 22, 2014 storm was less than the other two storm EMCs from the fall quarter. The greatest EMCs for the quarter occurred during this storm for most parameters. TPH was not detectible in any samples during this event.

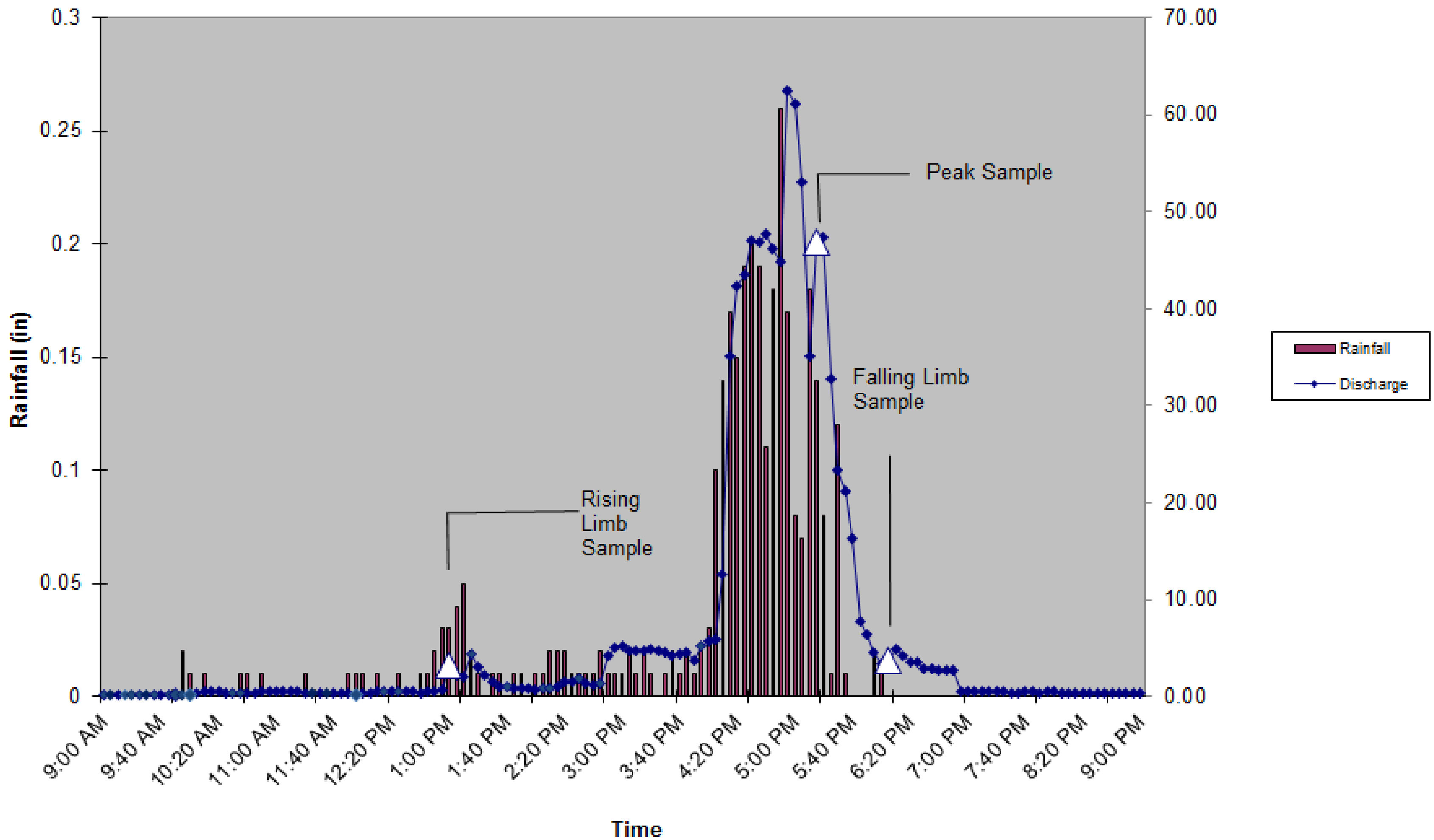
- March 4, 2015 - At Church Creek, the EMCs of all parameters during the storm were greater than the average concentrations of the storms captured since December 12, 2012, except for BOD and *E. coli*. EMCs for BOD and total phosphorus were generally comparable to historical average values for storm runoff. The EMCs for the remaining parameters exceeded their historical averages by between 34% (TSS) and 151% (hardness). During this event, TPH was detected for the first time since Versar began monitoring in December 2012, at 5.0 and 7.0 mg/L. At Parole Plaza, the EMCs of all parameters during the March 4, 2015 storm were greater than the average concentrations of the storms captured since December 12, 2012, except for BOD, nitrate-nitrite, and *E. coli*. The EMC for TKN was comparable to the historical average for storm events; other parameters were greater than the historical average by between 16% (TSS) and 98% (lead). The EMC for hardness was five times the historical average, which may have been caused by input of deicing compounds during the quarter. At Parole Plaza, TPH was detected for the first time since Versar began monitoring in December 2012, at 6.0 mg/L (during the rising limb only).

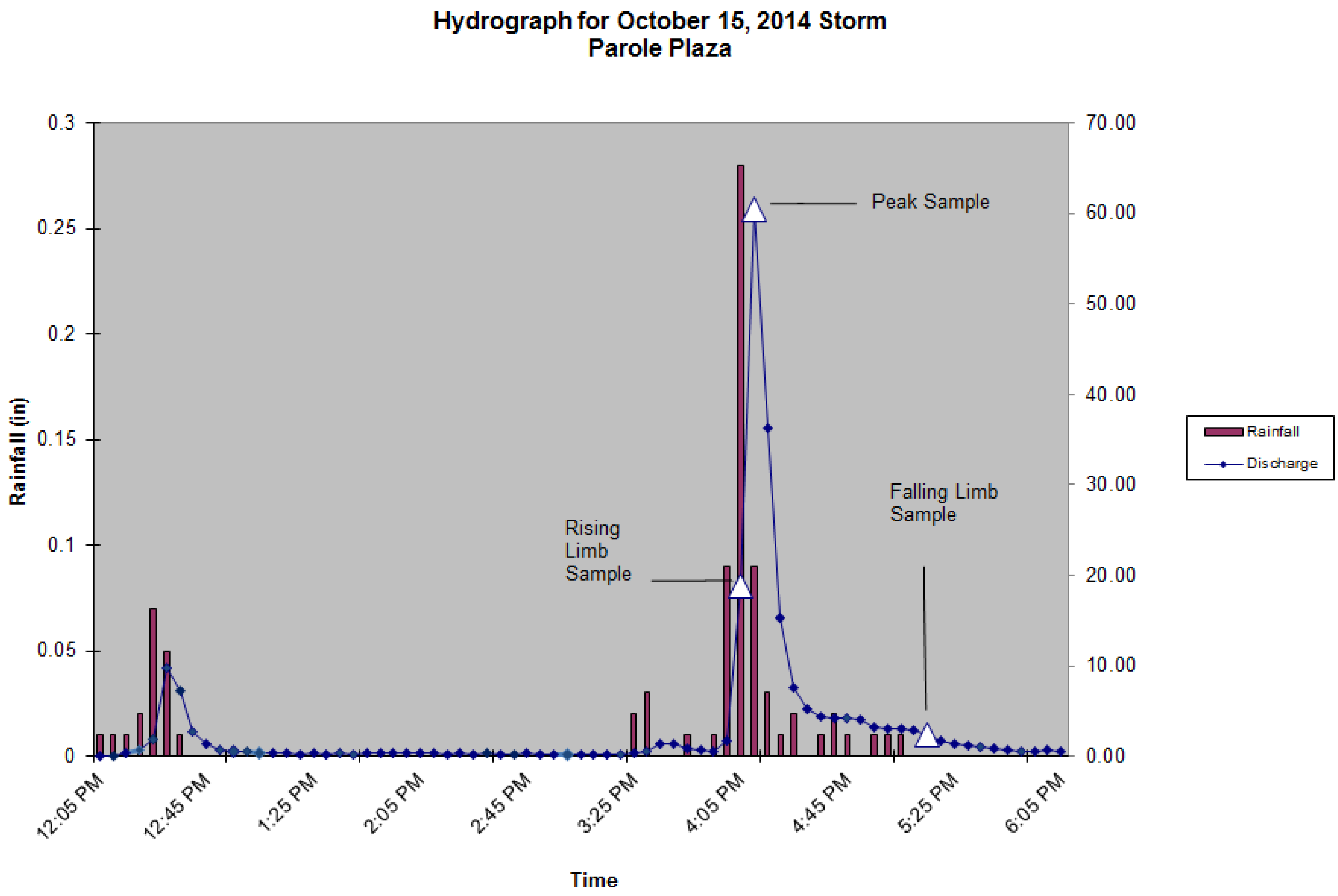
- April 14, 2015 - At the Church Creek station, the EMCs of all parameters during the April 14, 2015 storm were normal when compared to their historical concentrations. TPH and Lead were not detected in any samples at Church Creek during the event. At the Parole Plaza station, the EMCs of most parameters during the April 14, 2015 storm were comparable to EMC values for the other storms monitored during the quarter, except for BOD, which was more than twice the concentration of the other Spring storm events. As was the case at Church Creek, TPH was not detected in any samples.

- June 8, 2015 - At the Church Creek station, EMCs for BOD, TKN, nitrate-nitrite, Total Phosphorus, TSS, Lead, Zinc, TPH, and *E. coli* during the June 8, 2015 storm were higher than the EMC values for the other storms monitored during the quarter. At the Parole Plaza station, the EMCs of nitrate-nitrite and *E. coli* were higher than EMCs for other storms monitored during the quarter. TPH was the only parameter not detected in any of the Parole Plaza samples.

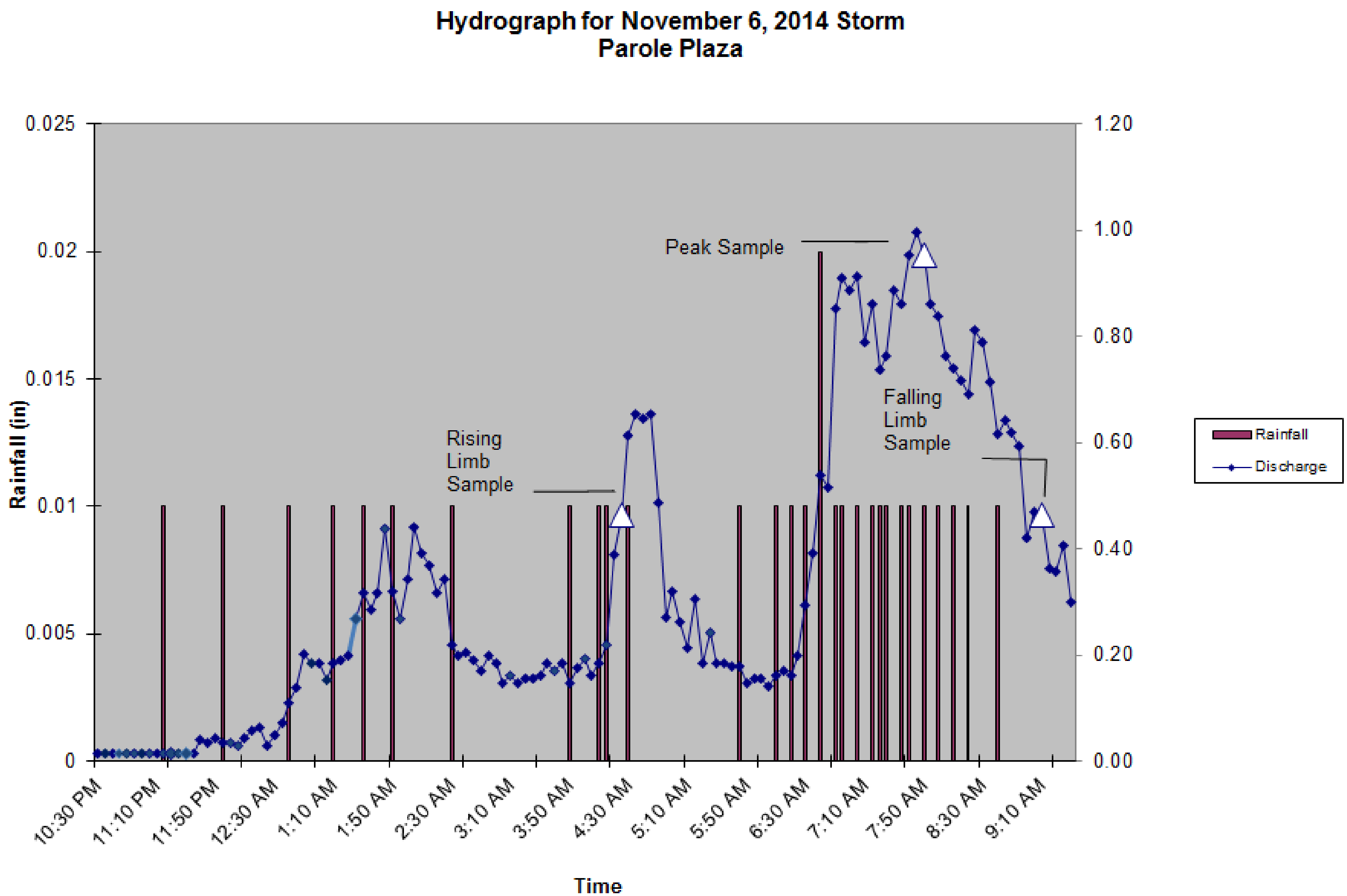
- June 27, 2015 - At the Church Creek station, the EMCs of many parameters, including BOD, nitrate-nitrite, total phosphorus, TSS, zinc, and hardness, were lower during the June 27, 2015 storm than the EMC values for the other storms monitored during the quarter. TPH and *E. coli* samples were not analyzed for this event. Samples were collected with ISCO samplers due to a lack of available staff that were needed at the stations during this event in order to collect manual TPH samples and transport *E. coli* samples to the lab within the hold time. At the Parole Plaza station, the EMCs of all parameters during the June 27, 2015 storm were lower than the EMC values for other storms monitored during the quarter, except for temperature and pH. Lead was the only parameter not detected in any Parole Plaza samples. As was the case with Church Creek, TPH and *E. coli* samples were not analyzed for this event.

Hydrograph for August 12, 2014 Storm
Parole Plaza



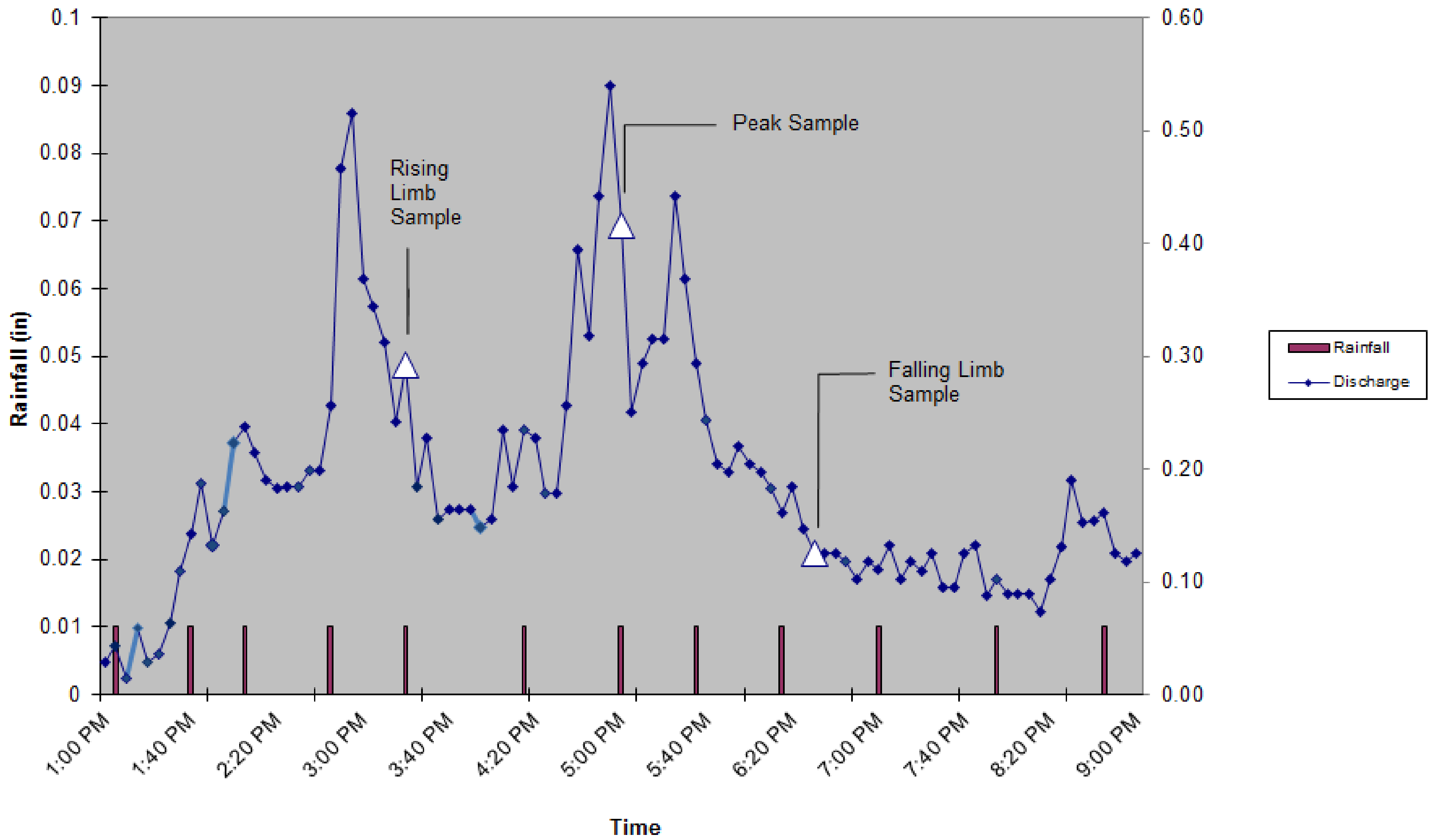


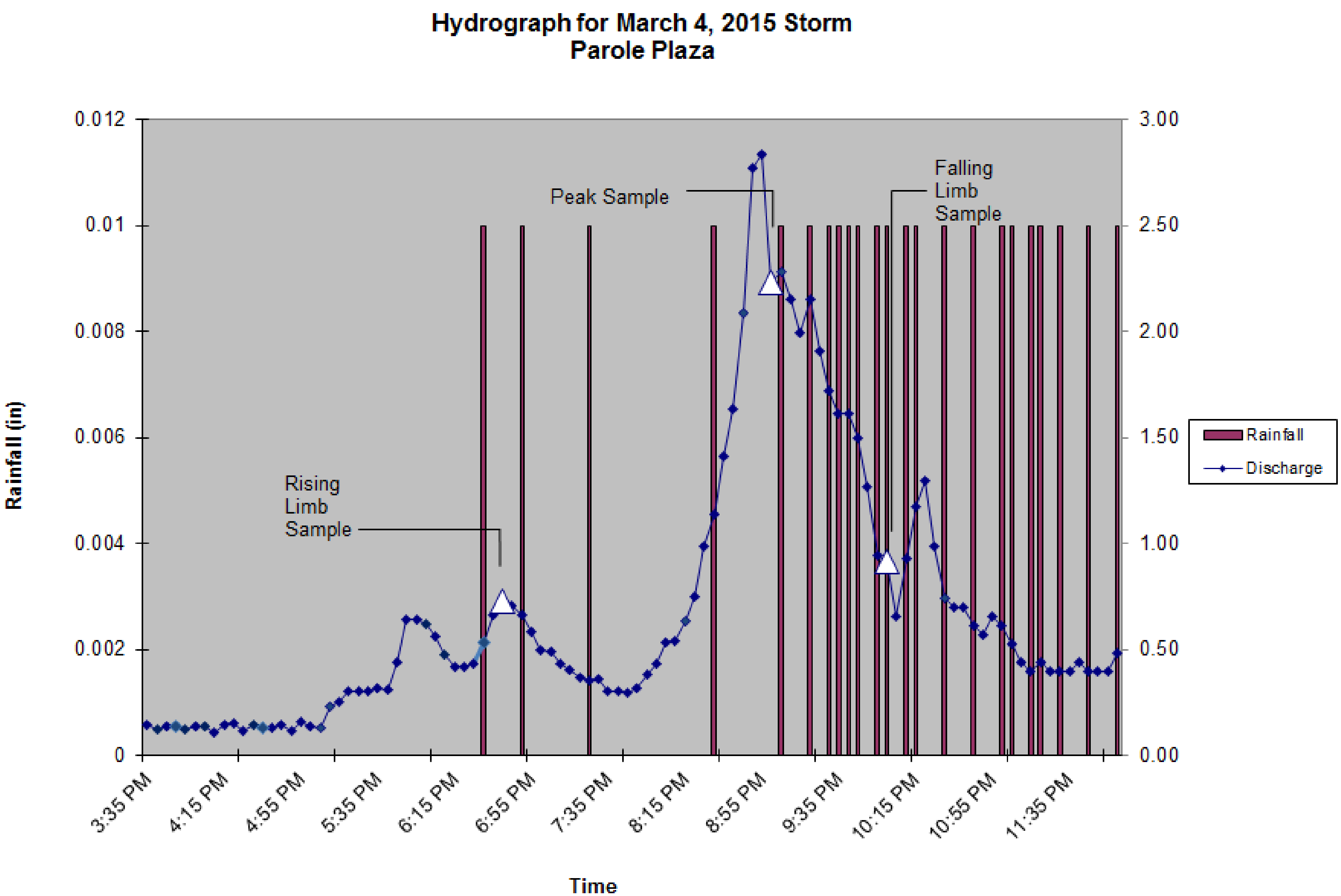
Hydrograph for October 15, 2014 Storm
Parole Plaza
Rainfall (in)
0.3
0.25
0.2
0.15
0.1
0.05
0
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Peak Sample
Rising Limb Sample
Falling Limb Sample
Rainfall
Discharge
12:05 PM
12:45 PM
1:25 PM
2:05 PM
2:45 PM
3:25 PM
4:05 PM
4:45 PM
5:25 PM
6:05 PM
Time



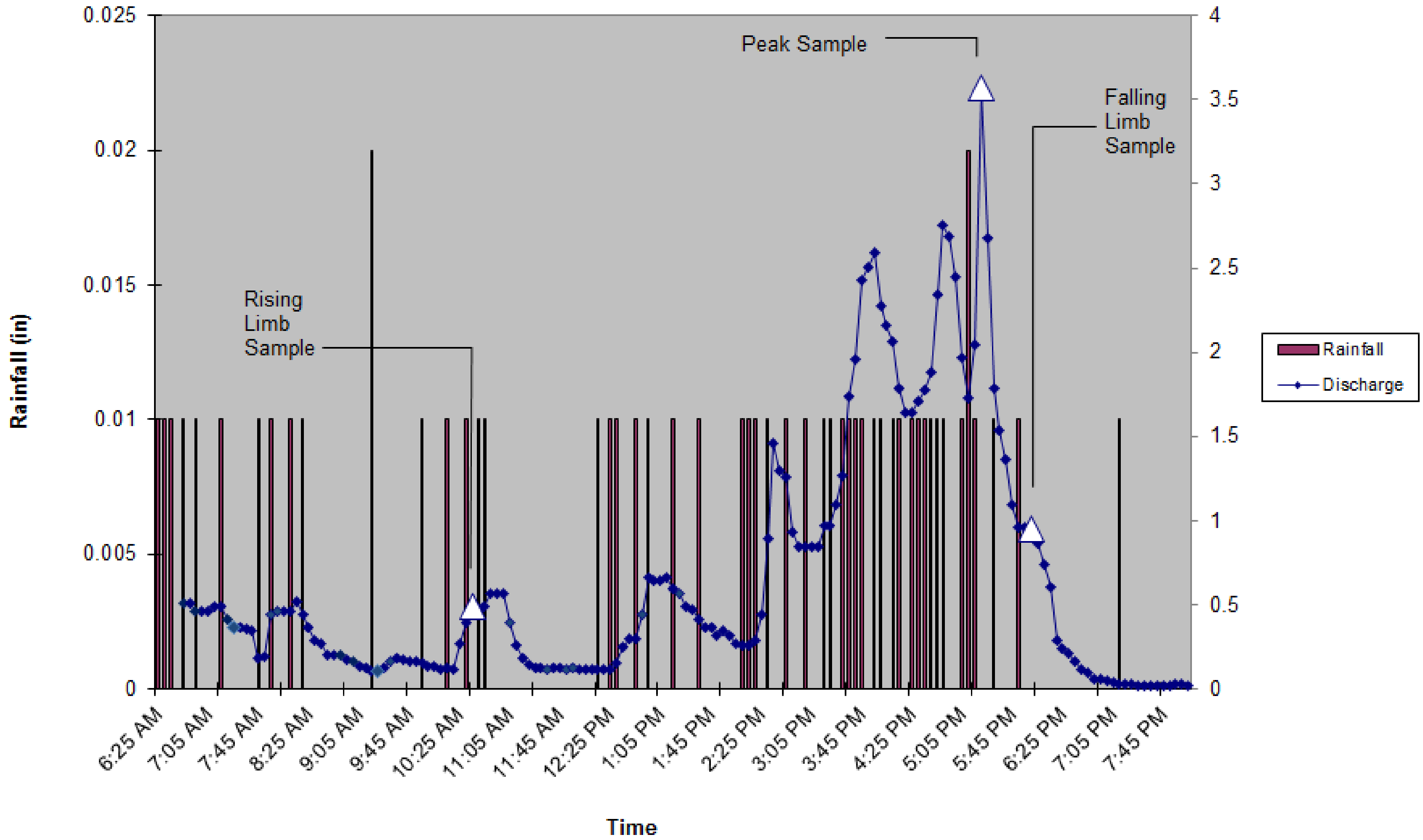
Hydrograph for November 6, 2014 Storm
Parole Plaza
Rainfall (in)
0.025
0.02
0.015
0.01
0.005
0
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Peak Sample
Rising Limb Sample
Falling Limb Sample
Rainfall
Discharge
10:30 PM
11:10 PM
11:50 PM
12:30 AM
1:10 AM
1:50 AM
2:30 AM
3:10 AM
3:50 AM
4:30 AM
5:10 AM
5:50 AM
6:30 AM
7:10 AM
7:50 AM
8:30 AM
9:10 AM
Time

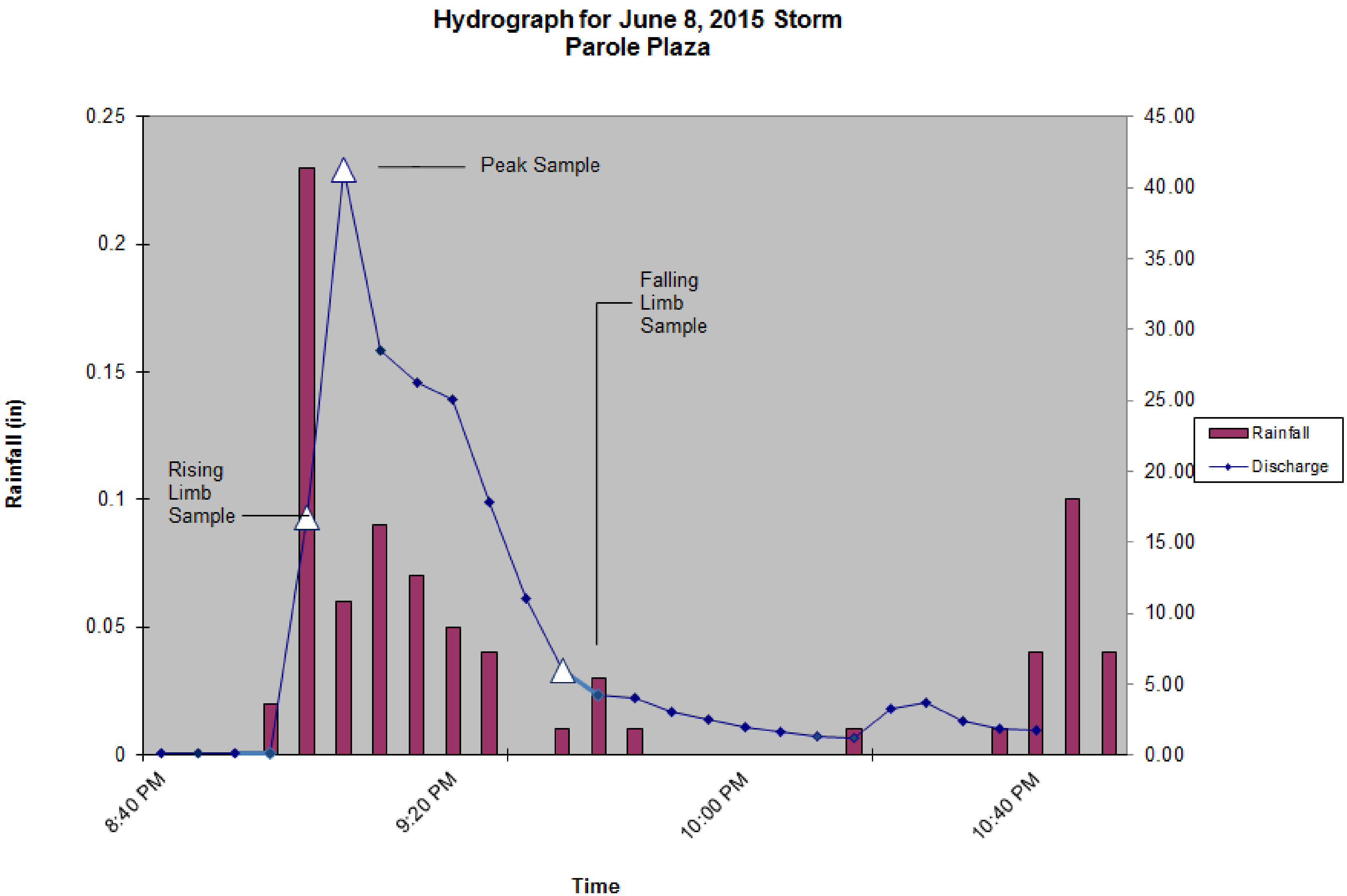
Hydrograph for December 22, 2014 Storm
Parole Plaza




Hydrograph for March 4, 2015 Storm
Parole Plaza
Rainfall (in)
Time
Rising Limb Sample
Peak Sample
Falling Limb Sample
Rainfall
Discharge
0.012
0.01
0.008
0.006
0.004
0.002
0
3.00
2.50
2.00
1.50
1.00
0.50
0.00
3:35 PM
4:15 PM
4:55 PM
5:35 PM
6:15 PM
6:55 PM
7:35 PM
8:15 PM
8:55 PM
9:35 PM
10:15 PM
10:55 PM
11:35 PM

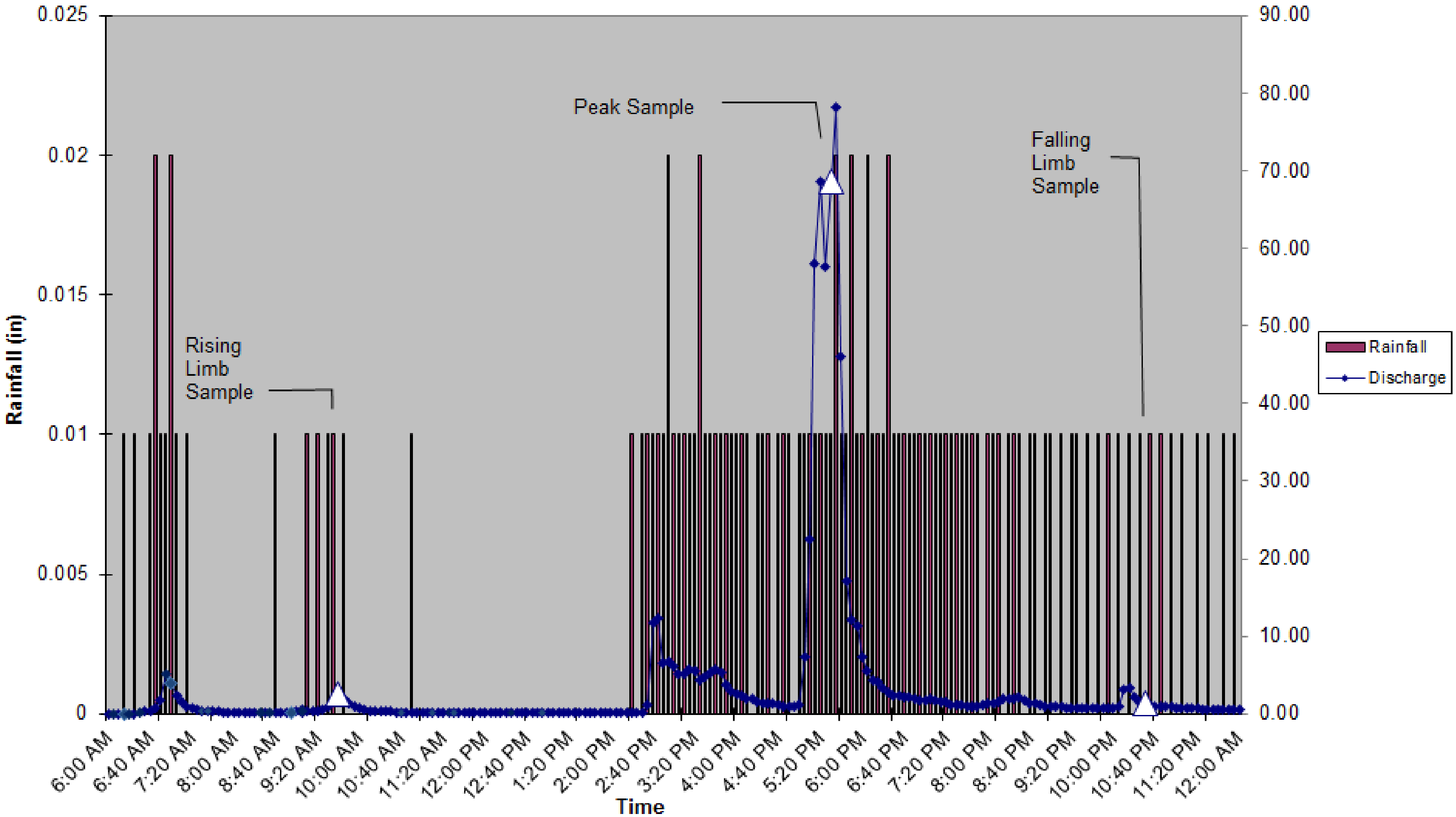
Hydrograph for April 14, 2015 Storm
Parole Plaza





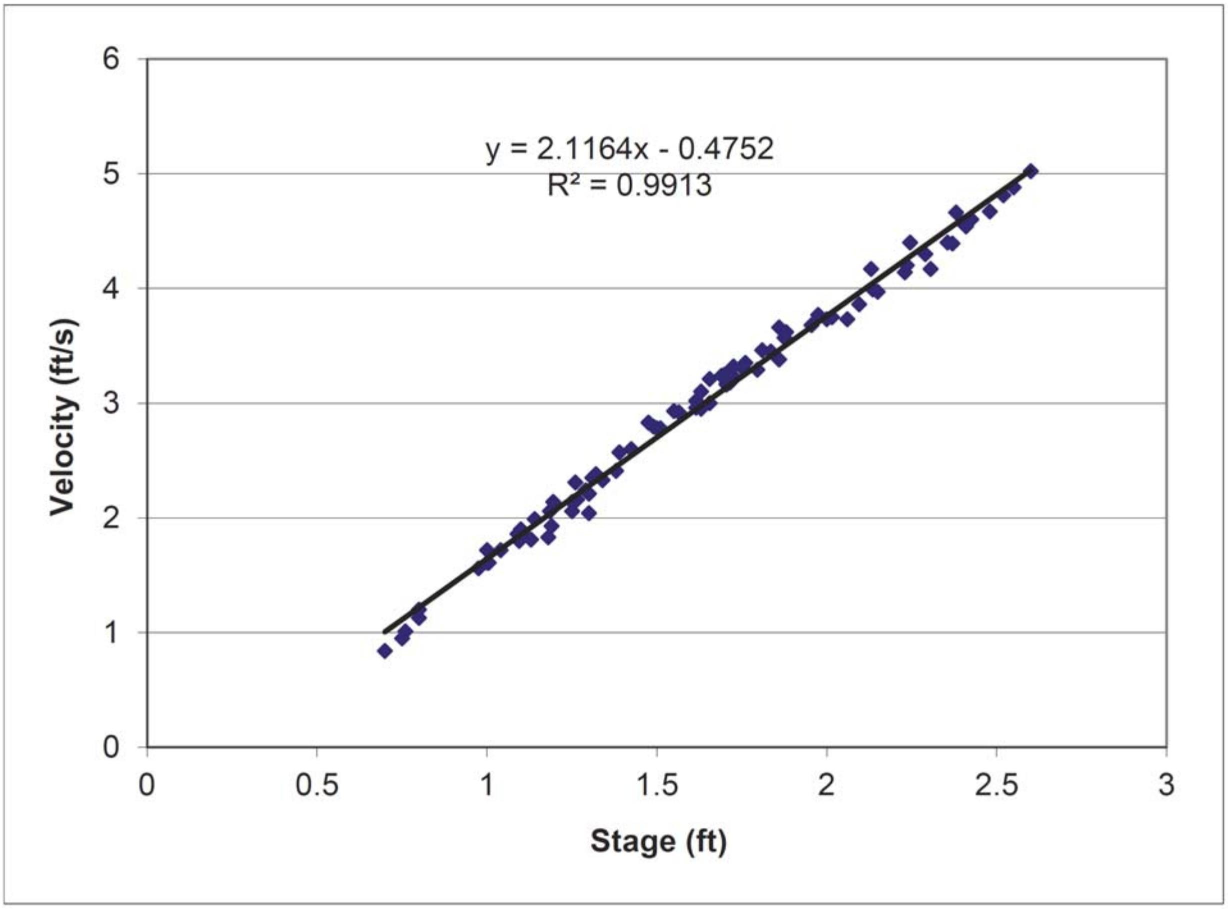
Hydrograph for June 8, 2015 Storm
Parole Plaza
Rainfall (in)
0.25
0.2
0.15
0.1
0.05
0
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Peak Sample
Falling Limb Sample
Rising Limb Sample
Rainfall
Discharge
8:40 PM
9:20 PM
10:00 PM
10:40 PM
Time

Hydrograph for June 27, 2015 Storm
Parole Plaza

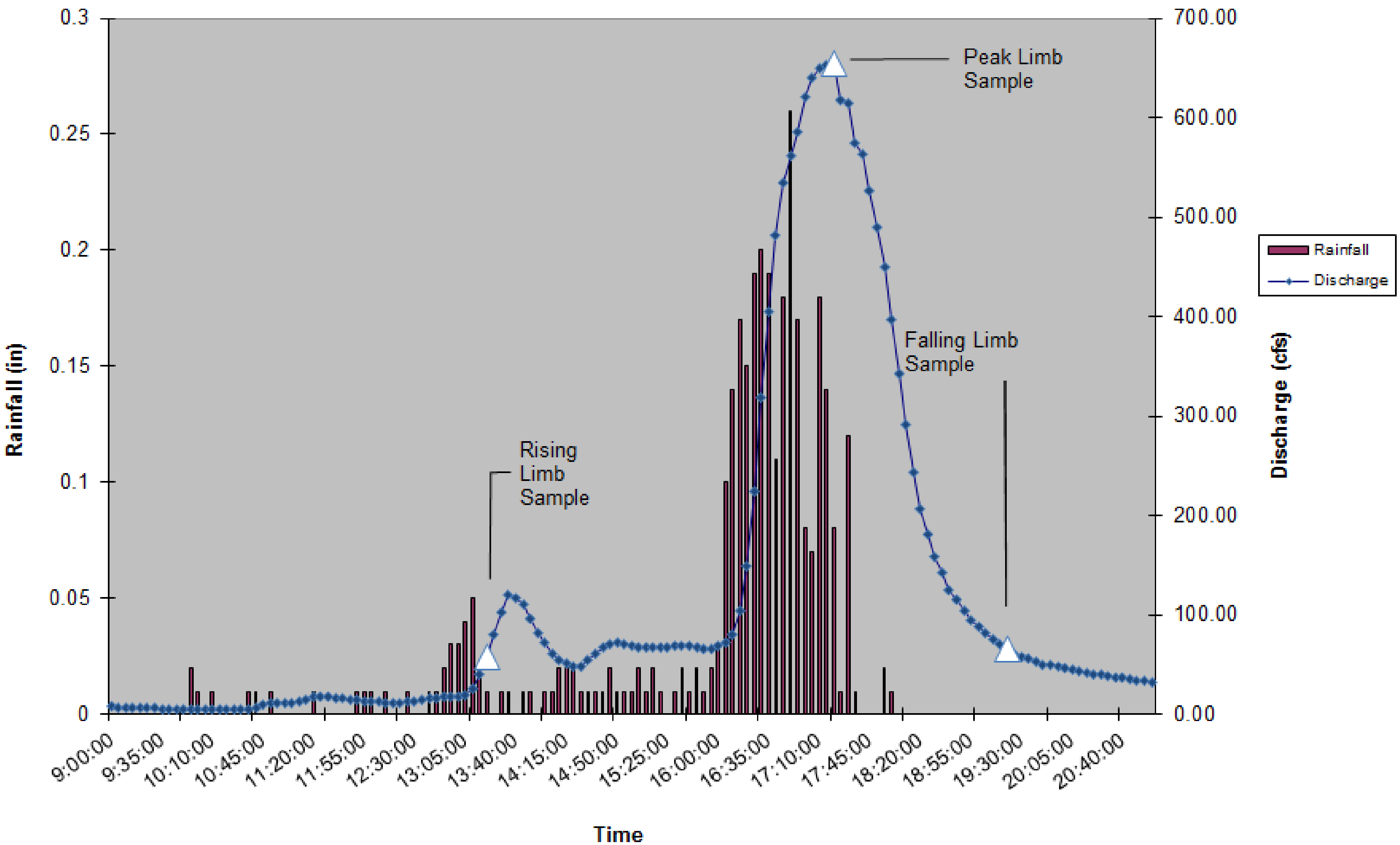


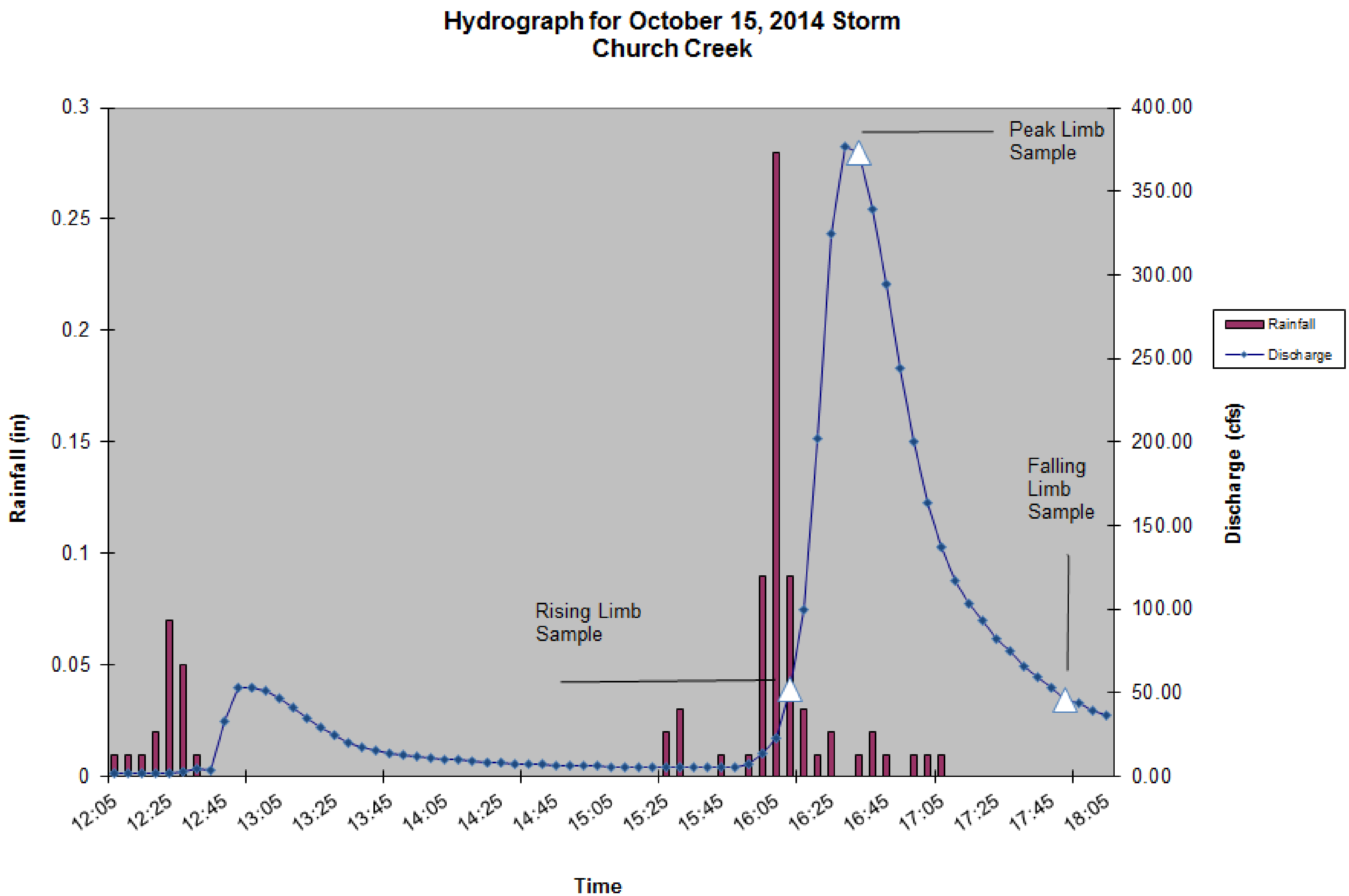
Church Creek Discharge Rating Table

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 12, 2014 Storm
Church Creek




Hydrograph for October 15, 2014 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
0.3
0.25
0.2
0.15
0.1
0.05
0
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
12:05
12:25
12:45
13:05
13:25
13:45
14:05
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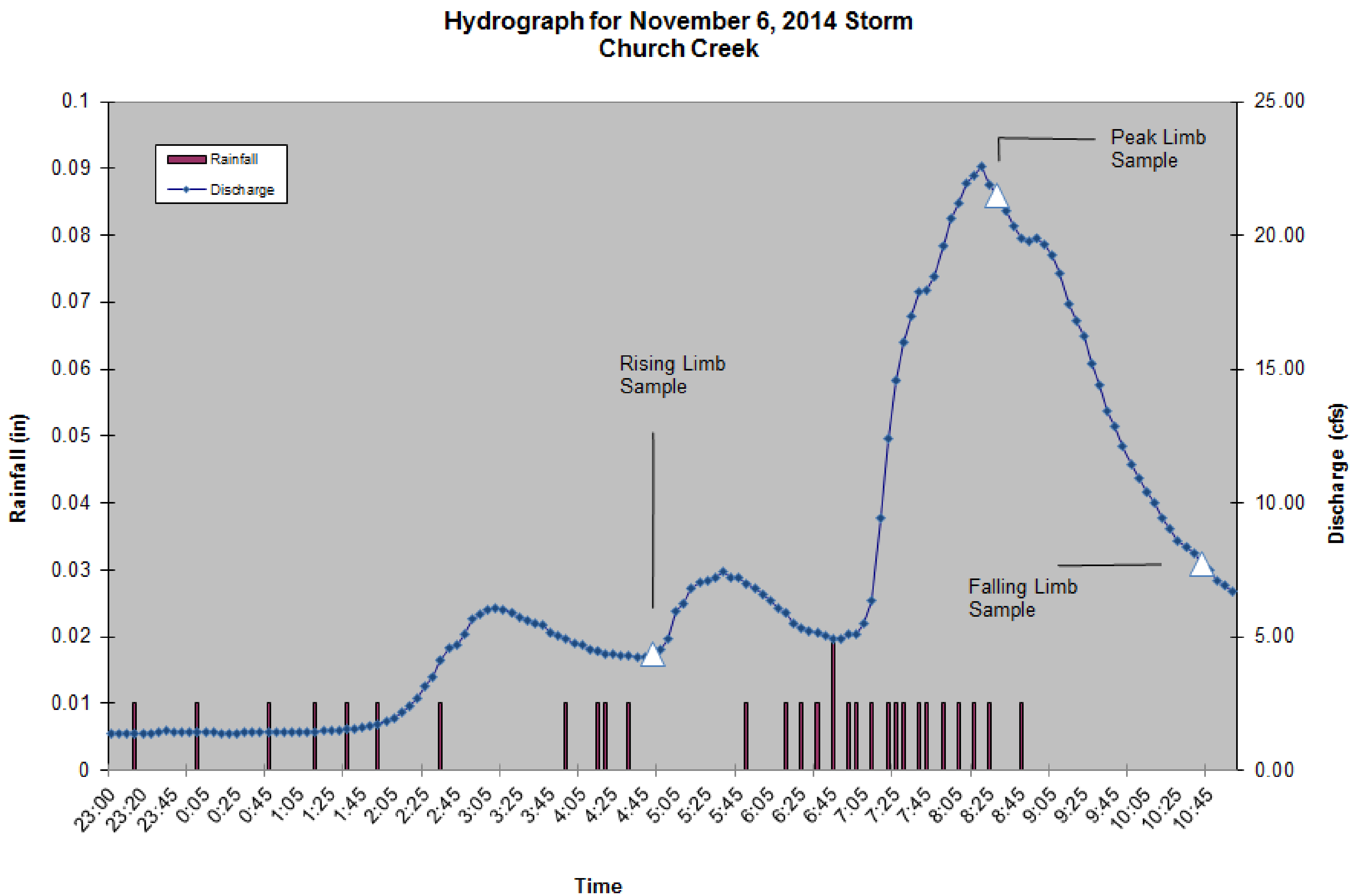
17:25
17:45
18:05



Hydrograph for November 6, 2014 Storm
Church Creek
Rainfall
Discharge
Rising Limb Sample
Peak Limb Sample
Falling Limb Sample
Rainfall (in)
Discharge (cfs)
Time
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
25.00
20.00
15.00
10.00
5.00
0.00
23:00
23:20
23:45
0:05
0:25
0:45
1:05
1:25
1:45
2:05
2:25
2:45
3:05
3:25
3:45
4:05
4:25
4:45
5:05
5:25
5:45
6:05
6:25
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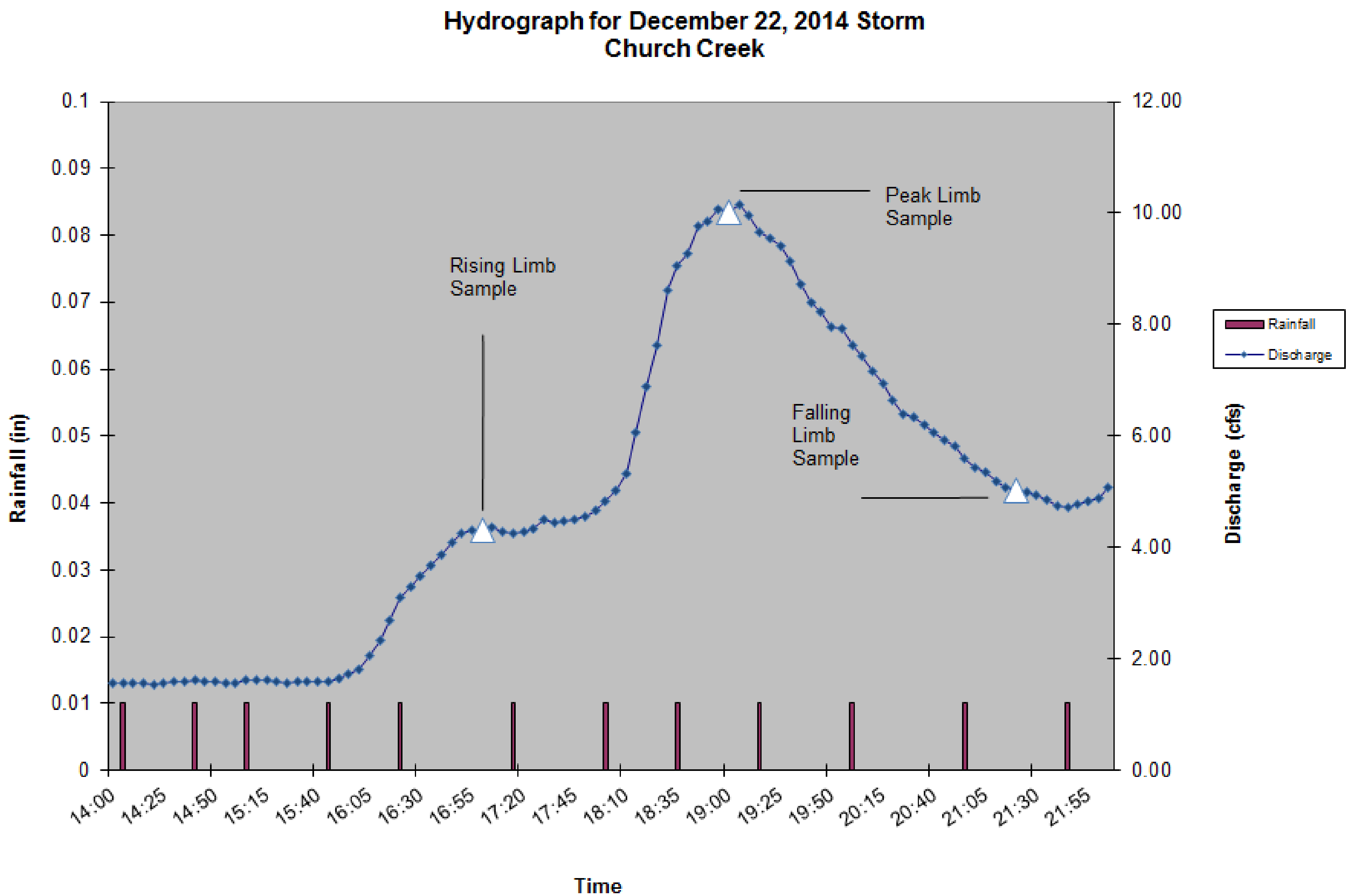
10:05
10:25
10:45


Hydrograph for December 22, 2014 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rising Limb Sample
Peak Limb Sample
Falling Limb Sample
Rainfall
Discharge
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
12.00
10.00
8.00
6.00
4.00
2.00
0.00
14:00
14:25
14:50
15:15
15:40
16:05
16:30
16:55
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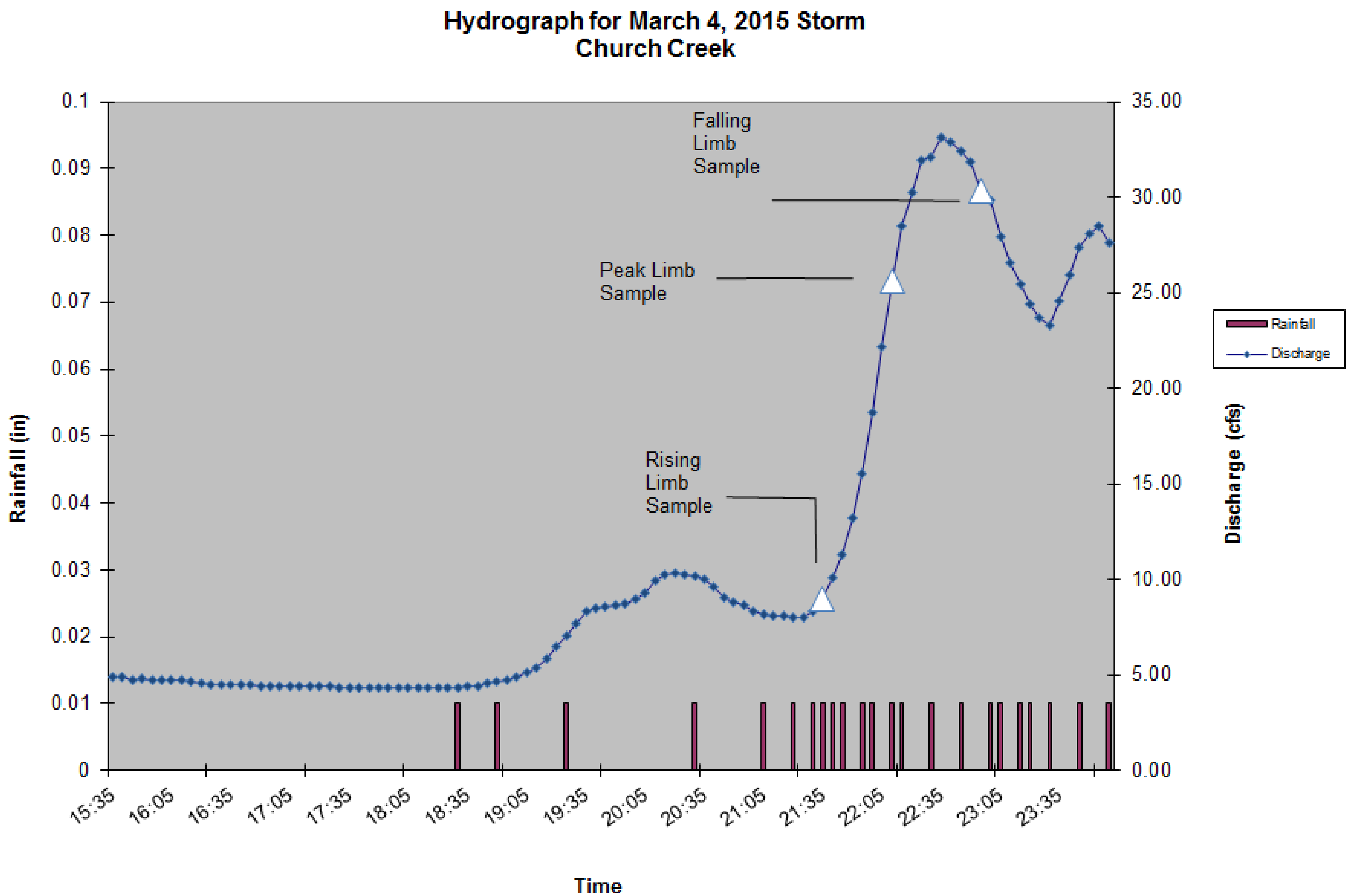
20:40
21:05
21:30
21:55



Hydrograph for March 4, 2015 Storm
Church Creek
Falling Limb Sample
Peak Limb Sample
Rising Limb Sample
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
15:35
16:05
16:35
17:05
17:35
18:05
18:35
19:05
19:35
20:05
20:35
21:05
21:35
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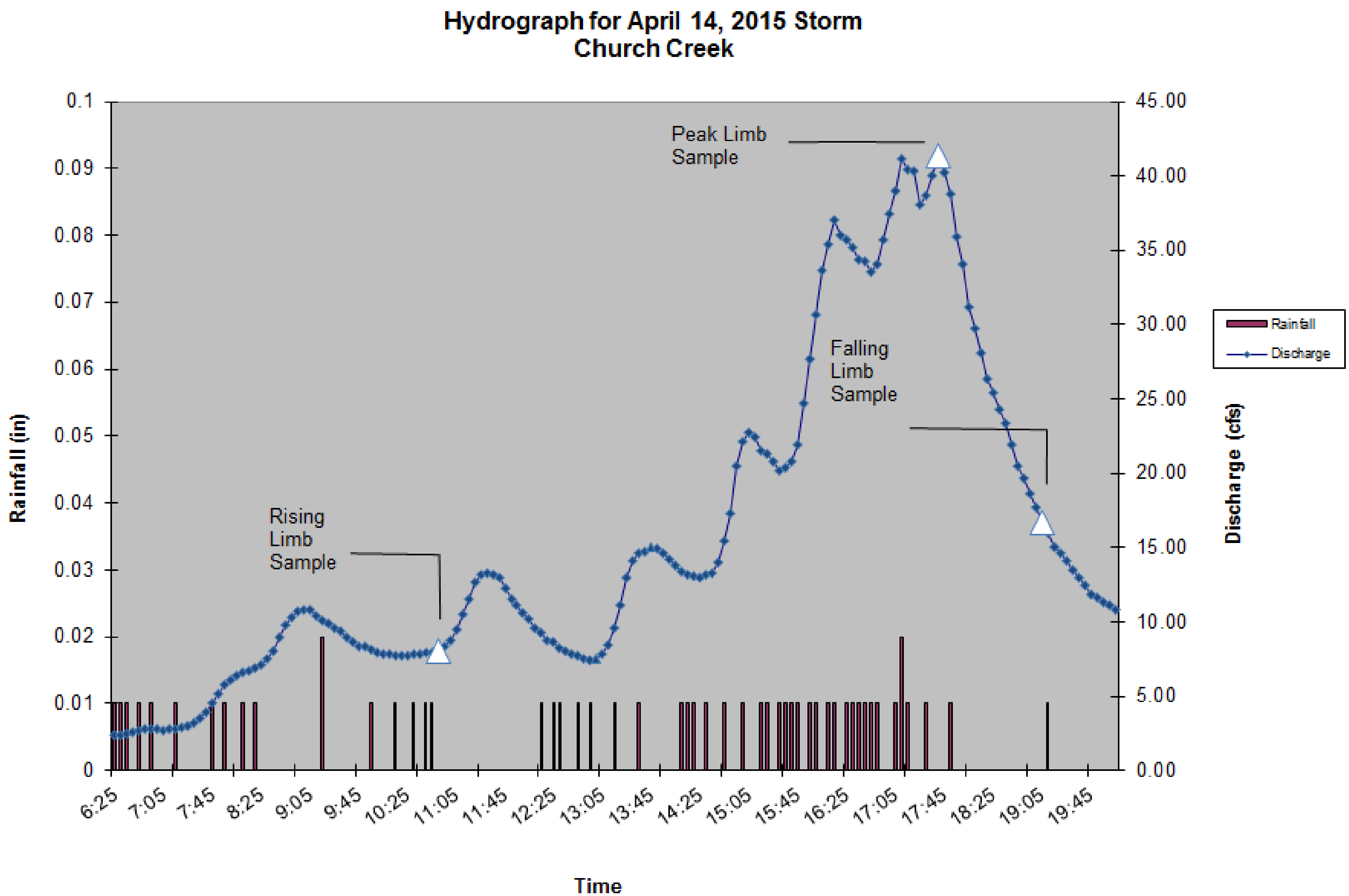
22:35
23:05
23:35



Hydrograph for April 14, 2015 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
Rising Limb Sample
Peak 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
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
6:25
7:05
7:45
8:25
9:05
9:45
10:25
11:05
11:45
12:25
13:05
13:45
14:25
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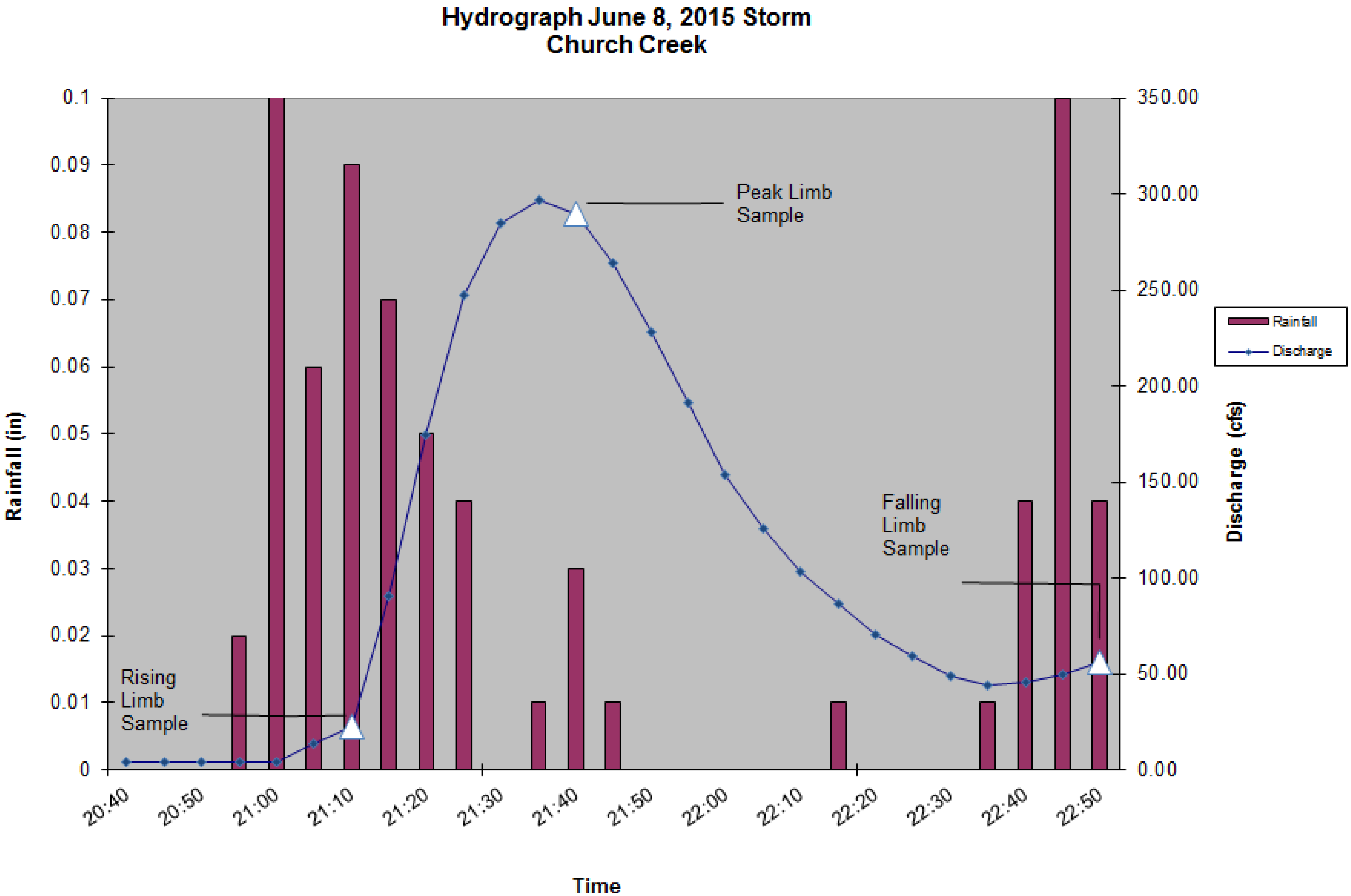
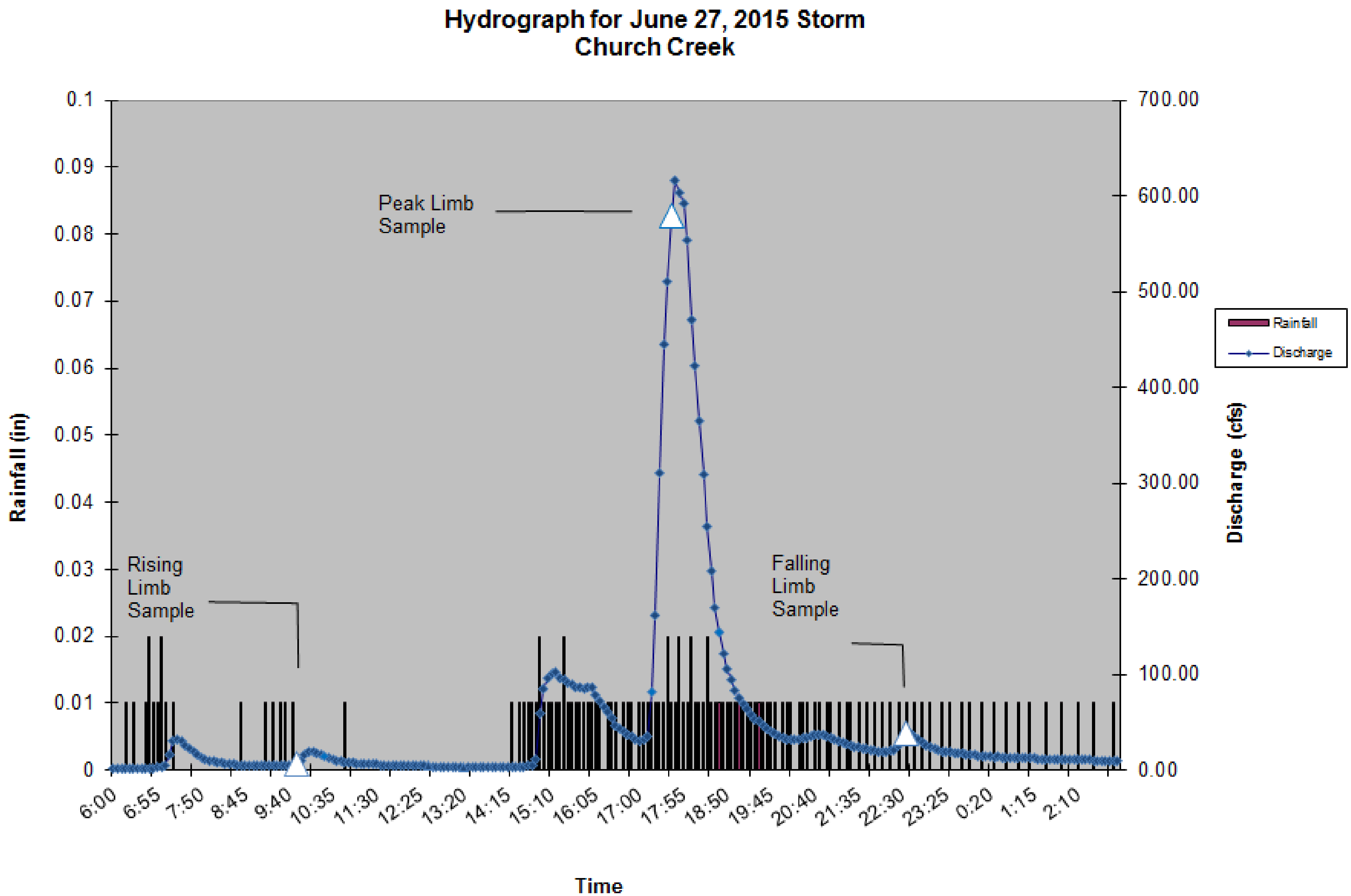
18:25
19:05
19:45


Hydrograph June 8, 2015 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
20:40
20:50
21:00
21:10
21:20
21:30
21:40
21:50
22:00
22:10
22:20
22:30
22:40
22:50
Rainfall
Discharge
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample


Hydrograph for June 27, 2015 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
Rainfall
Discharge
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
6:00
6:55
7:50
8:45
9:40
10:35
11:30
12:25
13:20
14:15
15:10
16:05
17:00
17:55
18:50
19:45
20:40
21:35
22:30
23:25
0:20
1:15
2:10

APPENDIX B

MASTER TAXA LIST

Order	Family	Genus	Final ID	FFG[1]	Habit[2]	Tolerance Value[3]
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7
Arhynchobdellida	Erpobdellidae		Erpobdellidae	Predator	sp	10
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7
Coleoptera	Dytiscidae	Neoporus	Neoporus	Predator		
Diptera			Diptera			6
Diptera	Chironomidae	Conchapelopia	Conchapelopia	Predator	sp	6.1
Diptera	Chironomidae	Cryptochironomus	Cryptochironomus	Predator	sp, bu	7.6
Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	Collector	bu	9
Diptera	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2
Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	Collector	cn	8.7
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9
Diptera	Ptychopteridae	Bittacomorpha	Bittacomorpha	Collector	bu	4
Diptera	Tipulidae	Limonia	Limonia	Shredder	bu, sp	4.8
Diptera	Tipulidae	Tipula	Tipula	Shredder	bu	6.7
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6
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	Pachydiplax	Pachydiplax	Predator		8
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5
Tubificida	Tubificidae		Tubificidae	Collector	cn	8.4
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7

1 Functional Feeding Group
2 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer information for the particular taxa was not available.
3 Tolerance Values, based on Hilsenhoff, modified for Maryland; na indicates information for the particular taxa was not available.

APPENDIX C

BIOLOGICAL ASSESSMENT RESULTS

Church Creek Site CC-01

Sampled: 3/12/2015

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.57

Metric	Value	Score
Total Taxa	6	1
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	0	1
% Ephemeroptera	0	1
Scraper Taxa	0	1
% Climbers	29.79	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	12
Calopteryx	2
Erpobdellidae	2
Pisidium	6
Tipula	1
Tubificidae	24

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	66.35

Metric	Score
Drainage area (acres)	70.40
Remoteness	24.93
Percent Shading	63.55
Epifaunal Substrate	57.54
Instream Habitat	92.64
Instream Wood Debris	94.26
Bank Stability	65.20

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	67

Metric	Score
Epifaunal Substrate / Cover	6
Embeddedness	10
Velocity / Depth Regime	8
Sediment Deposition	12
Channel Flow Status	15
Channel Alteration	18
Frequency of Riffles	8
Bank Stability	6(Left)/6(Right)
Vegetative Protection	6(Left)/5(Right)
Riparian Veg Zone Width	8(Left)/4(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	10.5
pH	7.07
Specific Conductance (µS/cm)	3015
Temperature (°C)	8.62
Turbidity (NTUs)	25.6

Church Creek Site CC-02

Sampled: 3/12/2015

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.57

Metric	Value	Score
Total Taxa	14	3
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	3.70	1
% Ephemeroptera	0	1
Scraper Taxa	0	1
% Climbers	7.34	3

Benthic Macroinvertebrate Taxa List

Taxa	Count
Boyeria	2
Caecidotea	4
Coenagrionidae	5
Conchapelopia	3
Dicrotendipes	1
Gammarus	59
Neoporus	1
Orthocladius	1
Pachydiplax	1
Phaenopsectra	2
Pisidium	10
Polypedilum	1
Tubificidae	18
Zavrelimyia	1

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Degraded
PHI Score	52.93

Metric	Score
Drainage area (acres)	282.24
Remoteness	31.22
Percent Shading	54.42
Epifaunal Substrate	48.50
Instream Habitat	72.88
Instream Wood Debris	69.66
Bank Stability	40.89

Rapid Bioassessment Protocal

Narrative Rating	Non-supporting
RBP Score	59

Metric	Score
Epifaunal Substrate / Cover	7
Embeddedness	8
Velocity / Depth Regime	9
Sediment Deposition	10
Channel Flow Status	15
Channel Alteration	15
Frequency of Riffles	7
Bank Stability	3(Left)/4(Right)
Vegetative Protection	6(Left)/7(Right)
Riparian Veg Zone Width	4(Left)/4(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	12
pH	7.07
Specific Conductance (µS/cm)	1464
Temperature (°C)	5.9
Turbidity (NTUs)	29.9

Church Creek Site CC-03

Sampled: 3/12/2015

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Poor
BIBI Score	2.14

Metric	Value	Score
Total Taxa	14	3
EPT Taxa	1	1
Number Ephemeroptera	0	1
% Intolerant to Urban	13.68	3
% Ephemeroptera	0	1
Scraper Taxa	0	1
% Climbers	9.47	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	6
Caecidotea	13
Calopteryx	2
Cheumatopsyche	17
Conchapelopia	1
Cryptochironomus	2
Erpobdellidae	1
Gammarus	7
Limonia	1
Orthocladius	33
Pisidium	9
Polypedilum	1
Rheotanytarsus	1
Zavrelimyia	1

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	66.68

Metric	Score
Drainage area (acres)	282.24
Remoteness	31.22
Percent Shading	40.96
Epifaunal Substrate	94.97
Instream Habitat	100.00
Instream Wood Debris	72.62
Bank Stability	60.31

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	66

Metric	Score
Epifaunal Substrate / Cover	12
Embeddedness	11
Velocity / Depth Regime	9
Sediment Deposition	12
Channel Flow Status	16
Channel Alteration	16
Frequency of Riffles	7
Bank Stability	6(Left)/6(Right)
Vegetative Protection	5(Left)/5(Right)
Riparian Veg Zone Width	3(Left)/3(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	10.82
pH	7.05
Specific Conductance (µS/cm)	1746
Temperature (°C)	6.21
Turbidity (NTUs)	28

Church Creek Site CC-04

Sampled: 3/12/2015

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.86

Metric	Value	Score
Total Taxa	13	1
EPT Taxa	1	1
Number Ephemeroptera	0	1
% Intolerant to Urban	21.19	3
% Ephemeroptera	0	1
Scraper Taxa	1	3
% Climbers	3.39	3

Benthic Macroinvertebrate Taxa List

Taxa	Count
Bittacomorpha	1
Caecidotea	25
Calopteryx	1
Cheumatopsyche	28
Conchapelopia	6
Diptera	3
Gammarus	14
Hemerodromia	1
Lumbriculidae	1
Phaenopsectra	1
Physa	2
Pisidium	12
Polypedilum	1
Tubificidae	22

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Degraded
PHI Score	62.70

Metric	Score
Drainage area (acres)	110.53
Remoteness	31.22
Percent Shading	40.96
Epifaunal Substrate	54.61
Instream Habitat	76.92
Instream Wood Debris	100.00
Bank Stability	72.51

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	66

Metric	Score
Epifaunal Substrate / Cover	5
Embeddedness	8
Velocity / Depth Regime	7
Sediment Deposition	6
Channel Flow Status	15
Channel Alteration	18
Frequency of Riffles	13
Bank Stability	8(Left)/8(Right)
Vegetative Protection	6(Left)/3(Right)
Riparian Veg Zone Width	9(Left)/5(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	11.07
pH	6.97
Specific Conductance (µS/cm)	1816
Temperature (°C)	7.75
Turbidity (NTUs)	30.8

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. This check consisted of entirely resorting one randomly selected sample to a sorting consistency above ninety percent efficiency. This QC resulted in a sorting efficiency above 95%, 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.

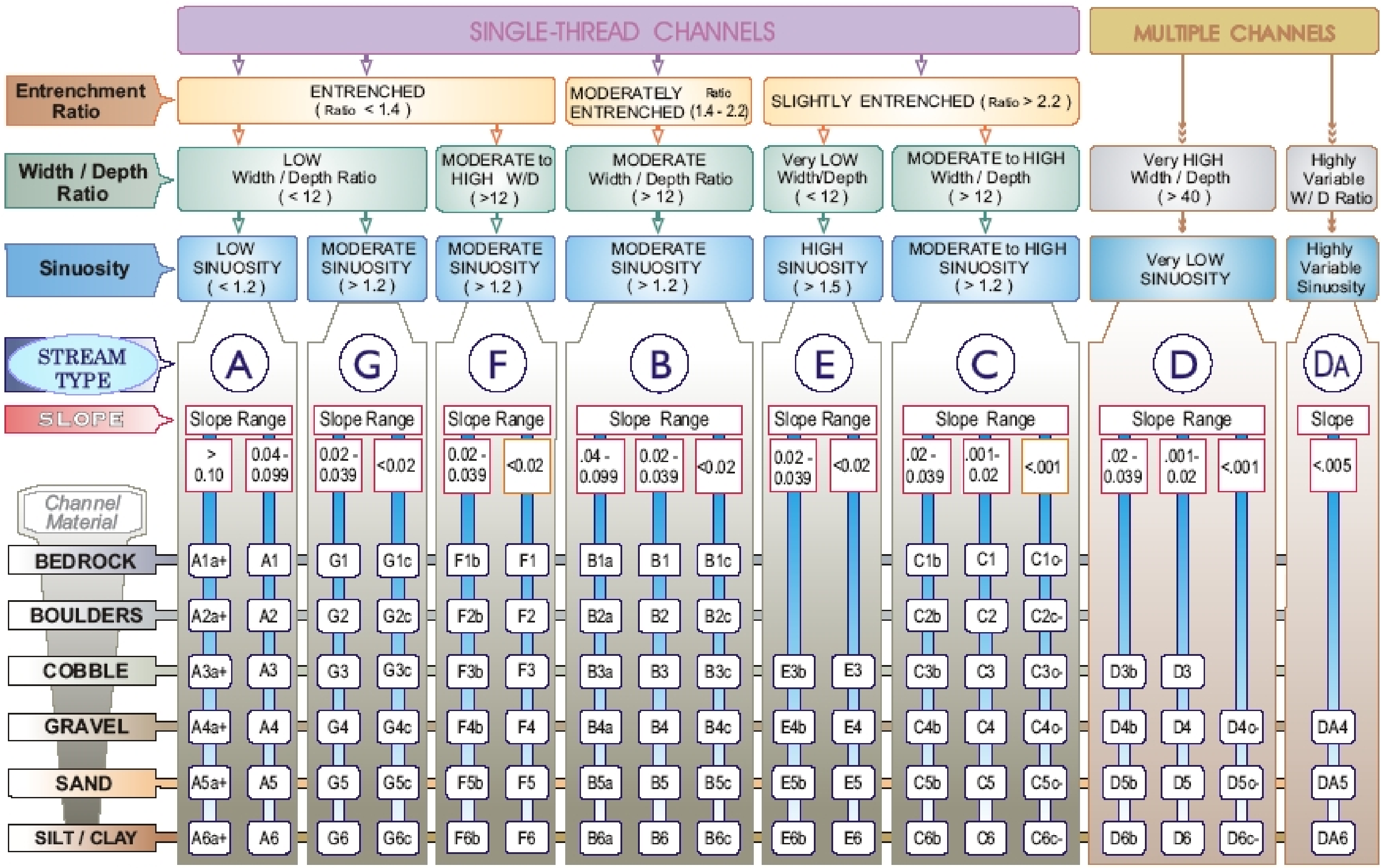
Identification of Stream Types

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.

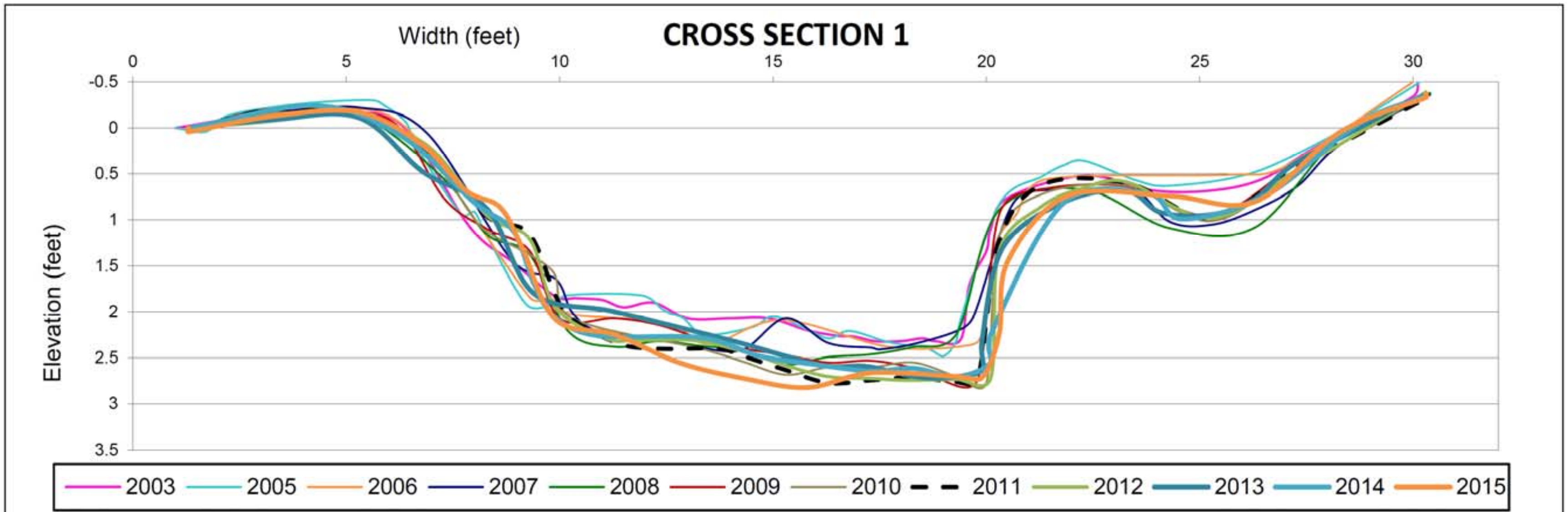
Source: Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

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+36
Classification	F4	G4	G4/3c	C5	F3/4
Bankfull Width (ft)	11.2	6.1	7.2	7.0	9.9
Mean Depth (ft)	1.1	0.8	0.9	1.0	0.6
Bankfull X-Sec Area (sq ft)	12.0	4.7	6.7	6.8	6.2
Width:Depth Ratio	10.5	7.9	7.7	7.1	15.6
Flood-Prone Width (ft)	21.9	10.5	9.1	15.6	16.7
Entrenchment Ratio	1.9	1.7	1.3	2.2	1.7
D50(mm)	15	10	16	1.3	61
Water Surface Slope (ft/ft)	0.003	0.022	0.005	0.002	0.014
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 ↑, W/D ↑	Sin ↑, ER ↓



Upstream View

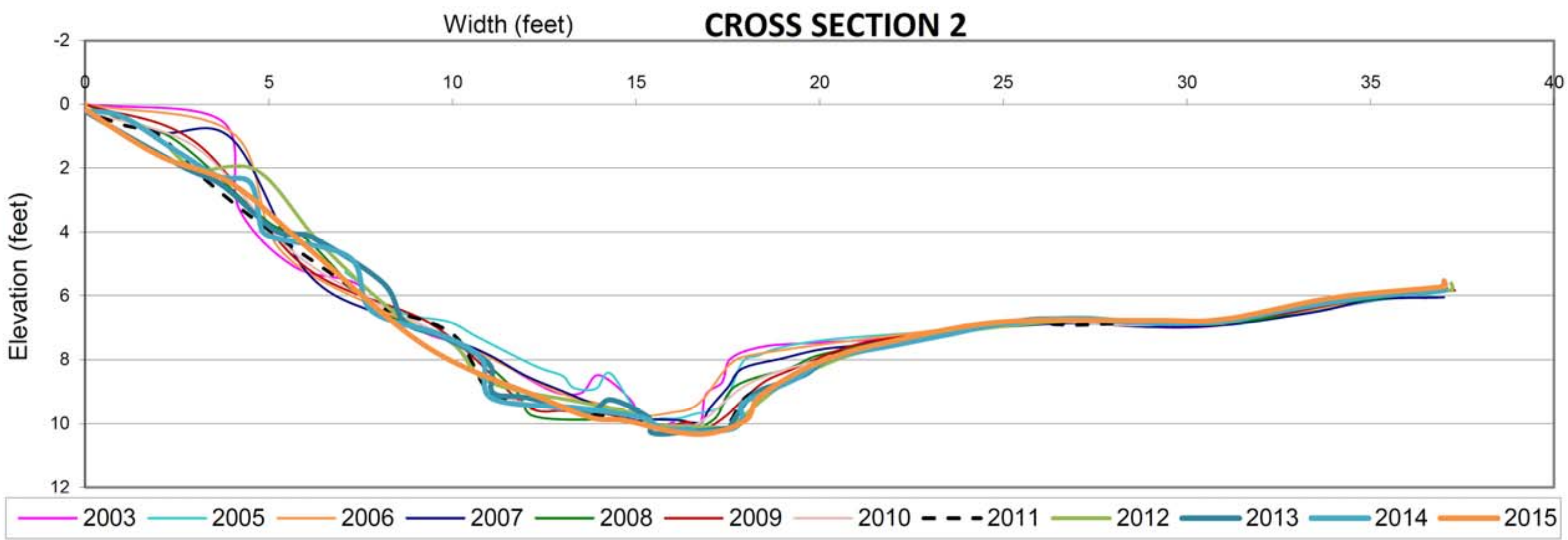
Downstream View

Left Bank View

Right Bank View

2015 Geomorphic Assessment Results

Bankfull Width (W_{bkf}) (feet)	11.2
Mean Depth (d_{bkf}) (feet)	1.1
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	12.0
Width/Depth Ratio (W_{bkf}/d_{bkf})	10.5
Width of Flood-prone Area (W_{fpa}) (feet)	21.9
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.9
Channel Materials D_{50} (millimeters)	15
Water Surface Slope (S)	0.003
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, ER ↓, W/D ↑
STREAM TYPE	**F4**



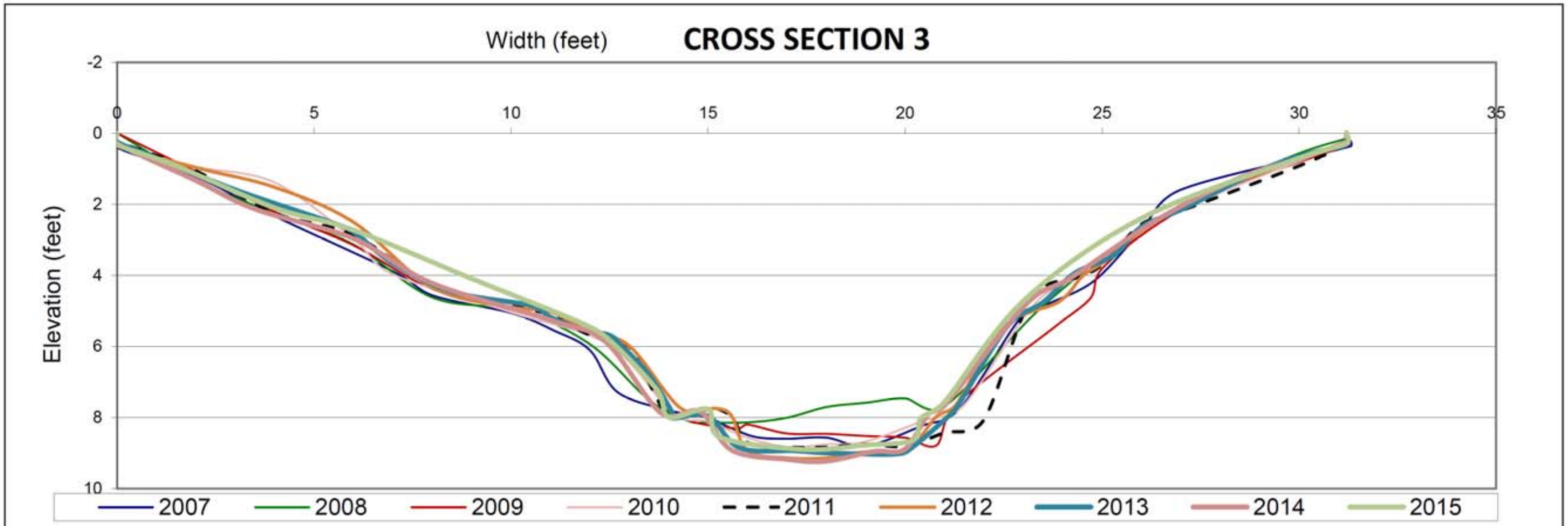

Upstream View


Downstream View


Left Bank View

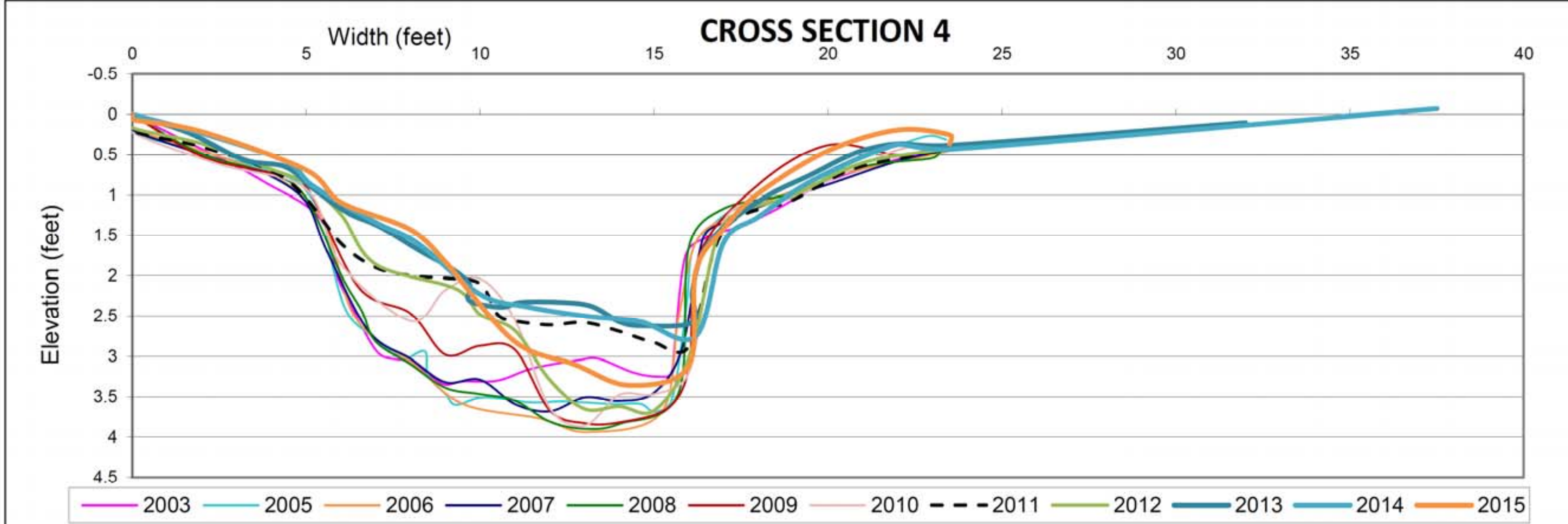

Right Bank View

2015 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	6.1
Mean Depth (d_{bkf}) (feet)	0.8
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	4.7
Width/Depth Ratio (W_{bkf}/d_{bkf})	7.9
Width of Flood-prone Area (W_{fpa}) (feet)	10.5
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.7
Channel Materials D_{50} (millimeters)	10
Water Surface Slope (S)	0.022
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑ ER ↓
STREAM TYPE	**G4**



	
Upstream View	Downstream View
	
Left Bank View	Right Bank View

2015 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	7.2
Mean Depth (d_{bkf}) (feet)	0.9
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	6.7
Width/Depth Ratio (W_{bkf}/d_{bkf})	7.7
Width of Flood-prone Area (W_{fpa}) (feet)	9.1
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.3
Channel Materials D_{50} (millimeters)	16
Water Surface Slope (S)	0.005
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	**G4/3c**



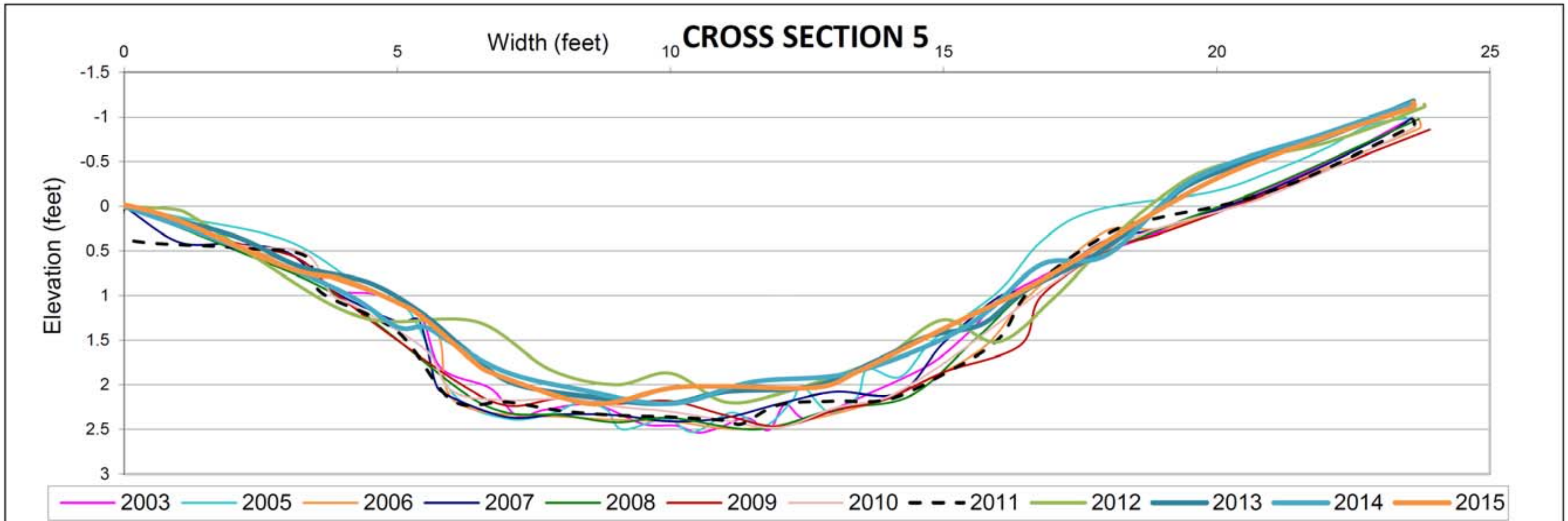
Upstream View

Downstream View

Left Bank View

Right Bank View

2015 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	7.0
Mean Depth (d_{bkf}) (feet)	1.0
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	6.8
Width/Depth Ratio (W_{bkf}/d_{bkf})	7.1
Width of Flood-prone Area (W_{fpa}) (feet)	15.6
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	2.2
Channel Materials D_{50} (millimeters)	1.3
Water Surface Slope (S)	0.002
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, W/D ↑
STREAM TYPE	**C5**



Upstream View

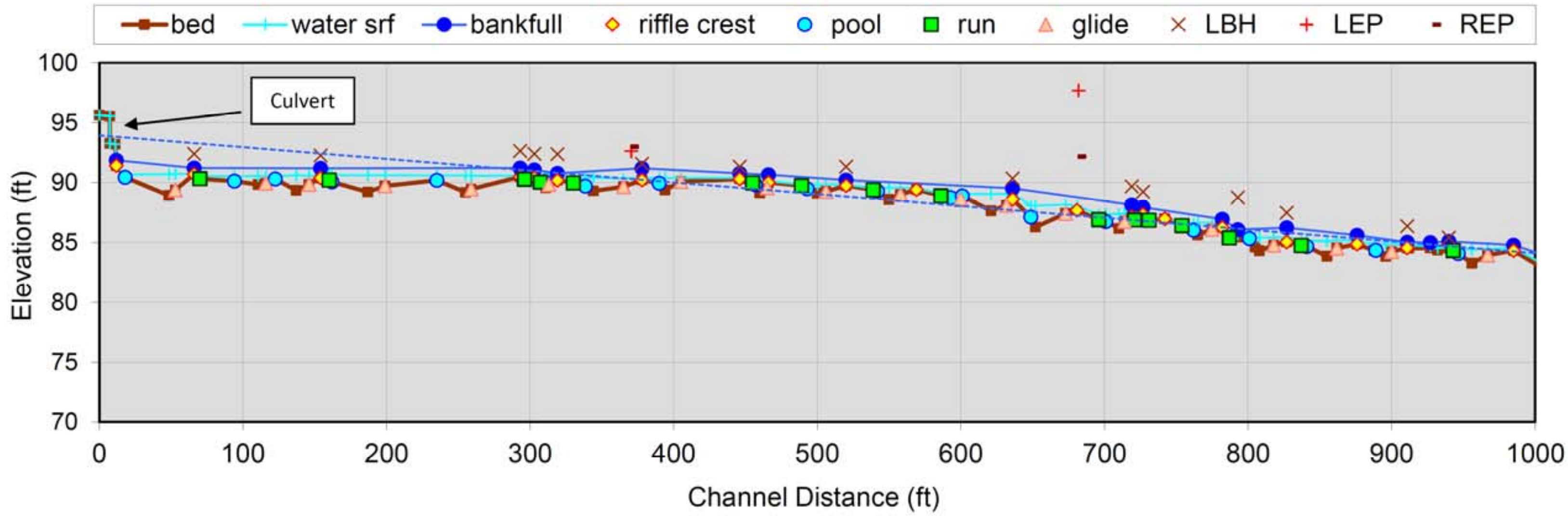
Downstream View

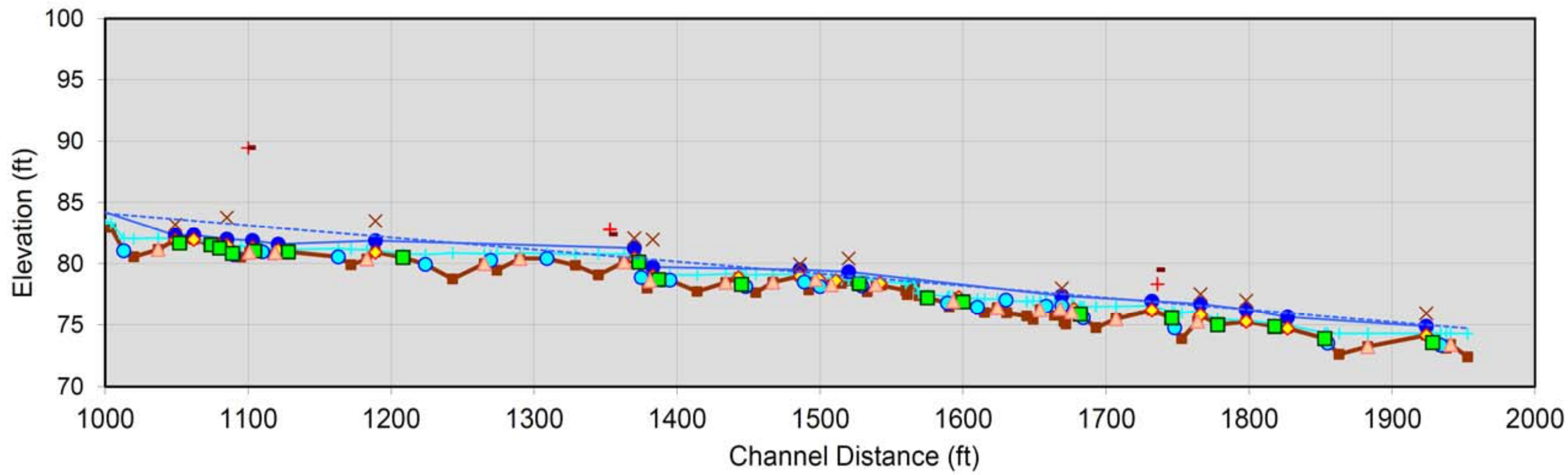
Left Bank View

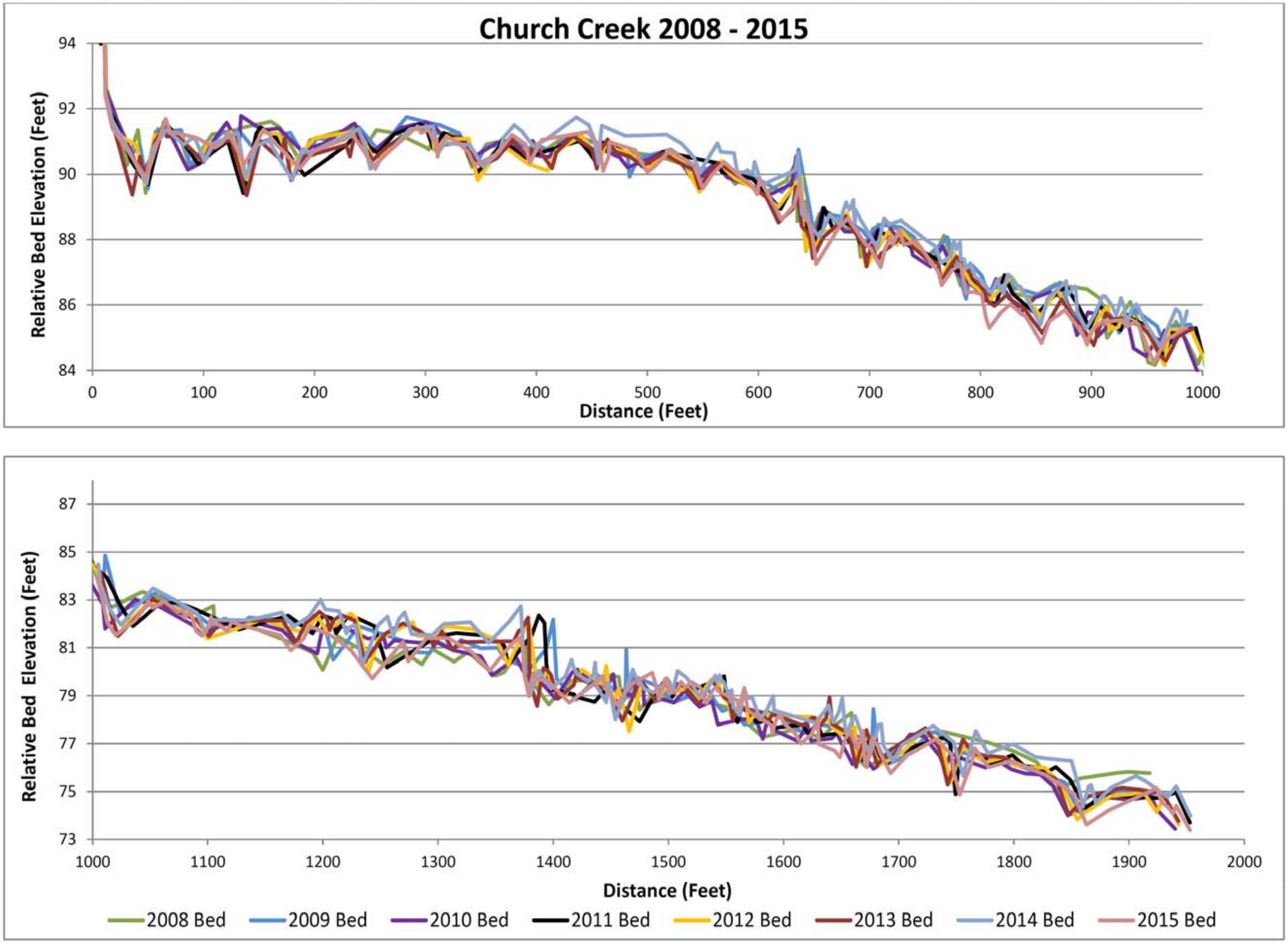
Right Bank View

2015 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	9.9
Mean Depth (d_{bkf}) (feet)	0.6
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	6.2
Width/Depth Ratio (W_{bkf}/d_{bkf})	15.6
Width of Flood-prone Area (W_{fpa}) (feet)	16.7
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.7
Channel Materials D_{50} (millimeters)	61
Water Surface Slope (S)	0.003
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑, ER ↓
STREAM TYPE	**F4/3**

Church Creek Longitudinal Profile







Church Creek 2008 - 2015
Relative Bed Elevation (Feet)
94
92
90
88
86
84
0
100
200
300
400
500
600
700
800
900
1000
Distance (Feet)
Relative Bed Elevation (Feet)
87
85
83
81
79
77
75
73
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Distance (Feet)
2008 Bed
2009 Bed
2010 Bed
2011 Bed
2012 Bed
2013 Bed
2014 Bed
2015 Bed

APPENDIX G

CHEMICAL MONITORING RESULTS

Anne Arundel County NPDES
Sampling and EMC Data – 2015 Reporting Year
Parole Plaza Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Duration (Hours)	Intensity (In/Hr)	Temperature - field (oF)	Flow (cf)	pH - field (pH)	dt for BOD ((dt) mg/L)	BOD (mg/L)	BOD ((0) mg/L)	dt for Total Kjeldahl Nitrogen ((dt) mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	dt for Nitrate+ Nitrite - N ((dt) mg/L)	Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	dt for Total Phosphorus ((dt) mg/L)	Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)
Versar	1	AP	8/12/2014	1300	101	O	S	3.32	12.0	0.28	77.20	5669	7.53	2.00	4.00	4.00	0.50	1.60	1.60	0.05	170.0	170.0	0.01	0.13	0.13
Versar	2	AP	8/12/2014	1715	101	O	S				74.14	213561	7.14	2.00	0.00	2.00	0.50	0.00	0.50	0.05	0.140	0.140	0.01	0.17	0.17
Versar	3	AP	8/12/2014	1800	101	O	S				74.97	56436	7.07	2.00	0.00	2.00	0.50	1.50	1.50	0.05	1.500	1.500	0.01	0.20	0.20
COMBINED 8/12/2014										Event Mean Concentration:	74.37		7.14	2.00	0.08	2.04	0.50	0.340	0.73	0.05	0.424	0.424	0.01	0.175	0.175
Versar	1	AP	9/16/2014	1320	101	O	B				65.34	80	6.09	2.00	0.00	2.00	0.50	0.00	0.50	0.05	6.00	6.00	0.01	0.02	0.02
										Event Mean Concentration:	65.34		6.09	2.00	0.00	2.00	0.50	0.00	0.50	0.05	6.00	6.00	0.01	0.02	0.02
Versar	1	AP	9/30/2014	1130	101	O	B				65.84	2	7.06	2.00	0.00	2.00	0.50	0.70	0.70	0.05	4.80	4.80	0.01	0.02	0.02
										Event Mean Concentration:	65.84		7.06	2.00	0.00	2.00	0.50	0.70	0.70	0.05	4.80	4.80	0.01	0.02	0.02
Versar	1	AP	10/15/2014	1605	101	O	S	0.84	6.0	0.14	71.55	15385	7.99	2.00	2.00	2.00	0.50	0.90	0.90	0.05	0.24	0.24	0.01	0.08	0.08
Versar	2	AP	10/15/2014	1610	101	O	S				71.44	11899	7.74	2.00	0.00	2.00	0.50	0.00	0.50	0.05	0.17	0.17	0.01	0.15	0.15
Versar	3	AP	10/15/2014	1715	101	O	S				70.20	37477	8.04	2.00	0.00	2.00	0.50	1.00	1.00	0.05	0.34	0.34	0.01	0.16	0.16
COMBINED 10/15/2014										Event Mean Concentration:	70.74		7.98	2.00	0.48	2.00	0.50	0.793	0.88	0.05	0.285	0.285	0.01	0.139	0.139
Versar	1	AP	11/6/2014	325	101	O	S	0.30	12.0	0.03	59.31	3367	7.14	2.00	3.00	3.00	0.50	1.30	1.30	0.05	1.40	1.40	0.01	0.07	0.07
Versar	2	AP	11/6/2014	650	101	O	S				54.88	5917	7.13	2.00	3.00	3.00	0.50	0.80	0.80	0.05	0.65	0.65	0.01	0.06	0.06
Versar	3	AP	11/6/2014	810	101	O	S				56.95	3298	7.63	2.00	5.00	5.00	0.50	0.00	0.50	0.05	1.10	1.10	0.01	0.07	0.07
COMBINED 11/06/2014										Event Mean Concentration:	56.61		7.27	2.00	3.52	3.52	0.50	0.724	0.86	0.05	0.969	0.969	0.01	0.065	0.065
Versar	1	AP	12/22/2014	1520	101	O	S	0.12	8.0	0.02	44.96	1638	7.70	2.00	39.00	39.00	0.50	1.80	1.80	0.05	1.20	1.20	0.01	0.18	0.18
Versar	2	AP	12/22/2014	1700	101	O	S				42.31	1473	8.28	2.00	11.00	11.00	0.50	1.70	1.70	0.05	0.78	0.78	0.01	0.12	0.12
Versar	3	AP	12/22/2014	1830	101	O	S				44.53	1349	8.20	2.00	14.00	14.00	0.50	1.30	1.30	0.05	1.10	1.10	0.01	0.09	0.09
COMBINED 12/22/2014										Event Mean Concentration:	43.96		8.04	2.00	22.19	22.19	0.50	1.616	1.62	0.05	1.031	1.031	0.01	0.133	0.133
Versar	1	AP	2/25/2015	1050	101	O	B				40.07	10	6.26	2.00	5.00	5.00	0.50	0.60	0.60	0.05	3.50	3.50	0.01	0.06	0.06
										Event Mean Concentration:	40.07		6.26	2.00	5.00	5.00	0.50	0.60	0.60	0.05	3.50	3.50	0.01	0.06	0.06
Versar	1	AP	3/4/2015	1840	101	O	S	0.23	8.5	0.03	42.69	3221	8.20	4.00	7.00	7.00	0.50	1.30	1.30	0.05	1.30	1.30	0.01	0.26	0.26
Versar	2	AP	3/4/2015	2100	101	O	S				42.39	7107	8.26	4.00	6.00	6.00	0.50	0.90	0.90	0.05	0.79	0.79	0.01	0.24	0.24
Versar	3	AP	3/4/2015	22:00	101	O	S				41.82	6218	8.12	4.00	0.00	4.00	0.50	0.70	0.70	0.05	0.98	0.98	0.01	0.12	0.12
										Event Mean Concentration:	42.23		8.20	4.00	3.94	5.44	0.50	0.90	0.90	0.05	0.961	0.96	0.01	0.199	0.20
Versar	1	AP	3/31/2015	1230	101	O	B				52.34	6	6.96	2.00	0.00	2.00	0.50	0.70	0.70	0.05	3.20	3.20	0.01	0.09	0.09
										Event Mean Concentration:	52.34		6.96	2.00	0.00	2.00	0.50	0.70	0.70	0.05	3.20	3.20	0.01	0.09	0.09
Versar	1	AP	4/14/2015	1035	101	O	S	0.53	13.5	0.04	59.33	3962	7.81	4.00	16.00	16.00	0.50	1.50	1.50	0.05	0.45	0.45	0.01	0.18	0.18
Versar	2	AP	4/14/2015	1720	101	O	S				56.74	22420	8.37	4.00	9.00	9.00	0.50	0.70	0.70	0.05	0.20	0.20	0.01	0.14	0.14
Versar	3	AP	4/14/2015	1800	101	O	S				55.15	3794	8.27	4.00	6.00	6.00	0.50	0.90	0.90	0.05	0.28	0.28	0.01	0.17	0.17
										Event Mean Concentration:	56.88		8.29	4.00	9.54	9.54	0.50	0.83	0.83	0.05	0.243	0.24	0.01	0.149	0.15
Versar	1	AP	6/8/2015	2100	101	O	S	0.23	8.5	0.03	69.73	2582	7.14	2.00	6.00	6.00	0.50	1.00	1.00	0.05	0.30	0.30	0.01	0.11	0.11
Versar	2	AP	6/8/2015	2105	101	O	S				73.58	8698	8.06	2.00	5.00	5.00	0.50	1.30	1.30	0.05	0.25	0.25	0.01	0.19	0.19
Versar	3	AP	6/8/2015	2135	101	O	S				73.71	39659	7.72	2.00	4.00	4.00	0.50	0.70	0.70	0.05	0.44	0.44	0.01	0.10	0.10
										Event Mean Concentration:	73.48		7.75	2.00	4.27	4.27	0.50	0.82	0.82	0.05	0.400	0.40	0.01	0.116	0.12
Versar	1	AP	6/27/2015	945	101	O	S	1.24	21.0	0.06	71.66	11072	7.85	2.00	0.00	2.00	0.50	0.70	0.70	0.05	0.43	0.43	0.01	0.04	0.04
Versar	2	AP	6/27/2015	1715	101	O	S				73.28	172393	8.14	2.00	0.00	2.00	0.50	0.00	0.50	0.05	0.19	0.19	0.01	0.05	0.05
Versar	3	AP	6/27/2015	2230	101	O	S				72.42	30863	7.95	2.00	0.00	2.00	0.50	0.90	0.90	0.05	0.25	0.25	0.01	0.13	0.13
										Event Mean Concentration:	73.07		8.10	2.00	0.00	2.00	0.50	0.17	0.57	0.05	0.211	0.21	0.01	0.061	0.06

Sampler	ID	Date	dt for TSS ((dt) mg/L)	TSS (mg/L)	TSS ((0) mg/L)	dt for Copper ((dt) µg/L)	Copper (µg/L)	Copper ((0) µg/L)	dt for Lead ((dt) µg/L)	Lead (µg/L)	Lead ((0) µg/L)	dt for Zinc ((dt) µg/L)	Zinc (µg/L)	Zinc ((0) µg/L)	dt for TPH ((dt) mg/L)	TPH ((0) mg/L)	TPH ((0) mg/L)	dt for E-COLI ((dt) MPN)	E-COLI (MPN)	E-COLI ((0) MPN)	dt for HARDNESS ((dt) mg/L)	HARDNESS ((0) mg/L)	HARDNESS ((0) mg/L)
Versar	1	8/12/2014	1.0	98.0	98.0	2.00	29.00	29.00	2.00	5.50	5.50	20.00	240.00	240.00	5.0	0.0	5.0	100.0	4500.0	4500.0	1.0	52.0	52.0
Versar	2	8/12/2014	1.0	63.0	63.0	2.00	11.00	11.00	2.00	5.70	5.70	20.00	64.00	64.00	5.0	0.0	5.0	100.0	54750.0	54750.0	1.0	21.0	21.0
Versar	3	8/12/2014	1.0	44.0	44.0	2.00	11.00	11.00	2.00	4.00	4.00	20.00	65.00	65.00	5.0	0.0	5.0	100.0	241960.0	241960.0	1.0	33.0	33.0
COMBINED 8/12/2014			1.0	59.8	59.8	2.00	11.37	11.37	2.00	5.348	5.348	20.00	67.824	67.824	5.0	0.0	5.0	100.0	92043.5	92043.5	1.0	24.1	24.1
Versar	1	9/16/2014	1.0	6.0	6.0	2.00	4.10	4.10	2.00	0.00	2.00	20.00	81.00	81.00	5.0	0.0	5.0	10.0	10.0	10.0	1.0	200.0	200.0
			1.0	6.0	6.0	2.00	4.10	4.10	2.00	0.00	2.00	20.00	81.00	81.00	5.0	0.0	5.0	10.0	10.0	10.0	1.0	200.0	200.0
Versar	1	9/30/2014	1.0	1.0	1.0	2.00	0.00	2.00	2.00	0.00	2.00	20.00	57.00	57.00	5.0	0.0	5.0	10.0	41.0	41.0	1.0	190.0	190.0
			1.0	1.0	1.0	2.00	0.00	2.00	2.00	0.00	2.00	20.00	57.00	57.00	5.0	0.0	5.0	10.0	41.0	41.0	1.0	190.0	190.0
Versar	1	10/15/2014	1.0	40.0	40.0	2.00	12.00	12.00	2.00	3.40	3.40	20.00	110.000	110.000	5.0	0.0	5.0	10.0	0.0	10.0	1.0	28.0	28.0
Versar	2	10/15/2014	1.0	95.0	95.0	2.00	19.00	19.00	2.00	5.90	5.90	20.0	120.000	120.000	5.0	0.0	5.0	10.0	24196.0	24196.0	1.0	34.0	34.0
Versar	3	10/15/2014	1.0	33.0	33.0	2.00	12.00	12.00	2.00	0.00	2.00	20.0	84.000	84.000	5.0	0.0	5.0	10.0	24196.0	24196.0	1.0	37.0	37.0
COMBINED 10/15/2014			1.0	46.1	46.1	2.00	13.29	13.29	2.00	1.892	3.049	20.0	96.791	96.791	5.0	0.0	5.0	10.0	18447.9	18450.3	1.0	34.3	34.3
Versar	1	11/6/2014	1.0	16.0	16.0	2.00	15.00	15.00	2.00	0.00	2.00	20.0	200.0	200.0	5.0	0.0	5.0	10.0	780.0	780.0	1.0	44.0	44.0
Versar	2	11/6/2014	1.0	11.0	11.0	2.00	8.20	8.20	2.00	0.00	2.00	20.0	130.0	130.0	5.0	0.0	5.0	10.0	1333.0	1333.0	1.0	25.0	25.0
Versar	3	11/6/2014	1.0	7.0	7.0	2.00	12.00	12.00	2.00	0.00	2.00	20.0	120.0	120.0	5.0	0.0	5.0	10.0	7270.0	7270.0	1.0	36.0	36.0
COMBINED 11/06/2014			1.0	11.3	11.3	2.00	11.02	11.02	2.00	0.00	2.00	20.0	146.11	146.11	5.0	0.0	5.0	10.0	2741.3	2741.3	1.0	33.0	33.0
Versar	1	12/22/2014	1.0	32.0	32.0	2.00	36.00	36.00	2.00	2.50	2.50	20.0	250.0	250.0	5.0	0.0	5.0	10.0	309.0	309.0	1.0	55.0	55.0
Versar	2	12/22/2014	1.0	27.0	27.0	2.00	25.00	25.00	2.00	2.60	2.60	20.0	230.0	230.0	5.0	0.0	5.0	10.0	384.0	384.0	1.0	43.0	43.0
Versar	3	12/22/2014	1.0	14.0	14.0	2.00	18.00	18.00	2.00	0.00	2.00	20.0	170.0	170.0	5.0	0.0	5.0	10.0	272.0	272.0	1.0	49.0	49.0
COMBINED 12/22/2014			1.0	24.9	24.9	2.00	26.92	26.92	2.00	1.777	2.382	20.0	219.20	219.20	5.0	0.0	5.0	10.0	322.6	322.6	1.0	49.2	49.2
Versar	1	2/25/2015	1.0	18.0	18.0	2.00	8.60	8.60	2.00	0.00	2.00	20.0	130.0	130.0	5.0	0.0	5.0	10.0	246.0	246.0	1.0	890.0	890.0
			1.0	18.0	18.0	2.00	8.60	8.60	2.00	0.00	2.00	20.0	130.0	130.0	5.0	0.0	5.0	10.0	246.0	246.0	1.0	890.0	890.0
Versar	1	3/4/2015	1.0	81.0	81.0	2.00	38.0	38.0	2.00	5.20	5.20	20.0	280.0	280.0	5.0	6.0	6.0	10.0	2046.0	2046.0	1.0	410.0	410.0
Versar	2	3/4/2015	1.0	87.0	87.0	2.00	31.0	31.0	2.00	6.70	6.70	20.0	240.0	240.0	5.0	0.0	5.0	10.0	2014.0	2014.0	1.0	240.0	240.0
Versar	3	3/4/2015	1.0	23.0	23.0	2.00	15.0	15.0	2.00	2.40	2.40	20.0	120.0	120.0	5.0	0.0	5.0	10.0	1989.0	1989.0	1.0	280.0	280.0
			1.0	61.8	61.78	2.00	26.35	26.35	2.00	4.79	4.79	20.0	202.69	202.69	5.0	1.2	5.2	10.0	2010.8	2010.8	1.0	288.1	288.1
Versar	1	3/31/2015	1.0	7.00	7.0	2.00	7.20	7.20	2.00	0.00	2.00	20.0	75.0	75.0	5.0	0.0	5.0	10.0	20.0	20.0	1.0	250.0	250.0
			1.0	7.00	7.0	2.00	7.20	7.20	2.00	0.00	2.00	20.0	75.0	75.0	5.0	0.0	5.0	10.0	20.0	20.0	1.0	250.0	250.0
Versar	1	4/14/2015	1.0	52.0	52.0	2.00	29.0	29.0	2.00	3.20	3.20	20.0	220.0	220.0	5.0	0.0	5.0	10.0	414.0	414.0	1.0	58.0	58.0
Versar	2	4/14/2015	1.0	80.0	80.0	2.00	25.0	25.0	2.00	4.40	4.40	20.0	170.0	170.0	5.0	0.0	5.0	10.0	5794.0	5794.0	1.0	52.0	52.0
Versar	3	4/14/2015	1.0	19.0	19.0	2.00	14.0	14.0	2.00	0.00	2.00	20.0	95.0	95.0	5.0	0.0	5.0	10.0	4884.0	4884.0	1.0	44.0	44.0
			1.0	68.7	68.65	2.00	24.14	24.14	2.00	3.69	3.94	20.0	167.13	167.13	5.0	0.0	5.0	10.0	4973.3	4973.3	1.0	51.8	51.8
Versar	1	6/8/2015	1.0	230.0	230.0	2.00	31.4	31.4	2.00	13.00	13.00	20.0	239.0	239.0	5.0	0.0	5.0	10.0	388.0	388.0	1.0	70.0	70.0
Versar	2	6/8/2015	1.0	160.0	160.0	2.00	37.0	37.0	2.00	8.30	8.30	20.0	230.0	230.0	5.0	0.0	5.0	10.0	2014.0	3873.0	1.0	62.0	62.0
Versar	3	6/8/2015	1.0	29.0	29.0	2.00	15.0	15.0	2.00	2.00	2.00	20.0	100.0	100.0	5.0	0.0	5.0	10.0	19863.0	19863.0	1.0	25.0	25.0
			1.0	61.6	61.56	2.00	19.59	19.59	2.00	3.63	3.63	20.0	129.24	129.24	5.0	0.0	5.0	10.0	15828.0	16145.5	1.0	33.6	33.6
Versar	1	6/27/2015	1.0	7.0	7.0	2.00	15.0	15.0	2.00	0.00	2.00	20.0	110.0	110.0	N/A	N/A	N/A	N/A	N/A	N/A	1.0	34.0	34.0
Versar	2	6/27/2015	1.0	14.0	14.0	2.00	8.2	8.2	2.00	0.00	2.00	20.0	45.0	45.0	N/A	N/A	N/A	N/A	N/A	N/A	1.0	18.0	18.0
Versar	3	6/27/2015	1.0	10.0	10.0	2.00	15.0	15.0	2.00	0.00	2.00	20.0	80.0	80.0	N/A	N/A	N/A	N/A	N/A	N/A	1.0	40.0	40.0
			1.0	13.1	13.06	2.00	9.53	9.53	2.00	0.00	2.00	20.0	53.40	53.40							1.0	22.0	22.0

VERSAR

Anne Arundel County NPDES
Sampling and EMC Data – 2015 Reporting Year
Parole Plaza Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Duration (Hours)	Intensity (In/Hr)	Temperature - field (oF)	Flow (cf)	pH - field (pH)	dt for BOD ((dt) mg/L)	BOD (mg/L)	BOD ((0) mg/L)	dt for Total Kjeldahl Nitrogen ((dt) mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	dt for Nitrate+ Nitrite - N ((dt) mg/L)	Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	dt for Total Phosphorus ((dt) mg/L)	Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)	dt for TSS ((dt) mg/L)	TSS (mg/L)	TSS ((0) mg/L)	dt for Copper ((dt) µg/L)	Copper (µg/L)	Copper ((0) µg/L)	dt for Lead ((dt) µg/L)	Lead (µg/L)	Lead ((0) µg/L)	dt for Zinc ((dt) µg/L)	Zinc (µg/L)	Zinc ((0) µg/L)	dt for TPH ((dt) mg/L)	TPH ((0) mg/L)	TPH ((0) mg/L)	dt for E-COLI ((dt) MPN)	E-COLI (MPN)	E-COLI ((0) MPN)	dt for HARDNESS ((dt) mg/L)	HARDNESS ((0) mg/L)	HARDNESS ((0) mg/L)
SUMMER QUARTER (JULY, AUGUST, SEPTEMBER)																																														
Summer Quarter Flow-Weighted EMC (8/12/14, 9/16/14, 9/30/14):											74.37		7.14		0.08	2.04		0.34	0.73		0.43	0.43		0.18	0.18		59.81	59.81		11.37	11.37		5.35	5.35		67.83	67.83		0.00	5.00		10.76	10.76		24.15	24.15
Average:															1.06	mg/l		0.53	mg/l		0.43	mg/l		0.18	mg/l		59.81	mg/l		11.368	µg/l		5.347	µg/l		67.828	µg/l		2.50	mg/l		10.76	MPN/100mL		24.15	mg/l
															0.0000663	lb/cf		0.0000333	lb/cf		0.0000266	lb/cf		0.0000109	lb/cf		0.0037333	lb/cf		0.0000007	lb/cf		0.0000003	lb/cf		0.0000042	lb/cf		0.0001560	lb/cf					0.0015071	lb/cf
Total Volume (Quarter Events):															275,748	cf																														
Pollutant Load (Quarter Events):															18.3	lbs		9.18	lbs		7.33	lbs		3.02	lbs		1,029.46	lbs		0.20	lbs		0.09	lbs		1.17	lbs		43.03	lbs					415.59	
Total Volume (Quarter):															886,593	cf																														
Pollutant Load (Quarter):															59	lbs		30	lbs		24	lbs		10	lbs		3,310	lbs		0.6	lbs		0.3	lbs		4	lbs		138	lbs					1,336	
FALL QUARTER (OCTOBER, NOVEMBER, DECEMBER)																																														
Fall Quarter Flow-Weighted EMC(10/15/14, 11/6/14, 12/22/14):											67.11		7.87		2.13	3.34		0.83	0.92		0.431	0.431		0.127	0.127		39.55	39.55		13.680	13.680		1.595	2.851		111.050	111.050		0.0	5.0		15043.95	15045.83		34.92	34.92
Average:															2.73	mg/l		0.87	mg/l		0.43	mg/l		0.13	mg/l		39.55	mg/l		13.680	µg/l		2.223	µg/l		111.050	µg/l		2.50	mg/l		15044.89	MPN/100mL		34.92	mg/l
															0.0001705	lb/cf		0.0000545	lb/cf		0.0000269	lb/cf		0.0000080	lb/cf		0.0024688	lb/cf		0.0000009	lb/cf		0.0000001	lb/cf		0.0000069	lb/cf		0.0001560	lb/cf					0.0021794	lb/cf
Total Volume (Quarter Events):															81,802	cf																														
Pollutant Load (Quarter Events):															13.9	lbs		4.46	lbs		2.20	lbs		0.65	lbs		201.96	lbs		0.07	lbs		0.01	lbs		0.57	lbs		12.76	lbs					178.28	
Total Volume (Quarter):															1,366,102	cf																														
Pollutant Load (Quarter):															233	lbs		74.46	lbs		36.735	lbs		10.9	lbs		3372.7	lbs		1.166	lbs		0.190	lbs		9.469	lbs		213.2	lbs					2977.25	
WINTER QUARTER (JANUARY, FEBRUARY, MARCH)																																														
Fall Quarter Flow-Weighted EMC (2/25/15, 3/4/15, 3/31/15):											42.23		8.2		3.9	5.4		0.90	0.90		0.963	0.963		0.20	0.20		61.7	61.7		26.332	26.332		4.787	4.789		202.599	202.599		1	5.19		2009.0	2009.0		288.47	288.47
Average:															4.69	mg/l		0.90	mg/l		0.96	mg/l		0.20	mg/l		61.73	mg/l		26.33	µg/l		4.79	µg/l		202.60	µg/l		3.18	mg/l		2009.05	MPN/100mL		288.47	mg/l
															0.00	lb/cf		0.00	lb/cf		0.00	lb/cf		0.00	lb/cf		0.00	lb/cf		0.000	lb/cf		0.000	lb/cf		0.000	lb/cf		0.00	lb/cf					0.02	lb/cf
Total Volume (Quarter Events):															16561.71	cf																														
Pollutant Load (Quarter Events):															5	lbs		1	lbs		1	lbs		0	lbs		64	lbs		0	lbs		0	lbs		0	lbs		3	lbs					298.20	
Total Volume (Quarter):															1,186,701.000	cf																														
Pollutant Load (Quarter):															347	lbs		66.84	lbs		71.330	lbs		14.7	lbs		4572.6	lbs		1.950	lbs		0.355	lbs		15.006	lbs		235.6	lbs					21366.93	
SPRING QUARTER (APRIL, MAY, JUNE)																																														
Fall Quarter Flow-Weighted EMC (4/14/15), (6/8/15), (6/27/15):											71.5		8.1		1.7	3.2		0.35	0.64		0.25	0.25		0.08	0.08		27.1	27.1		12.757	12.757		1.003	2.480		78.092	78.092		0.0	1.4		3237	3292		27.04	27.04
Average:															2.4	mg/l		0.49	mg/l		0.247	mg/l		0.08	mg/l		27.1	mg/l		12.757	µg/l		1.742	µg/l		78.092	µg/l		1	mg/l		3264.3	MPN/100mL		27.04	mg/l
															0.00	lb/cf		0.000	lb/cf		0.000	lb/cf		0.000	lb/cf		0.00	lb/cf		0.00	lb/cf		0.000	lb/cf		0.000	lb/cf		0.00	lb/cf					0.00	lb/cf
Total Volume (Quarter Events):															295442.70	cf																														
Pollutant Load (Quarter Events):															44.9317016	lbs		9.0707229	lbs		4.5538323	lbs		1.4651592	lbs		499.7645975	lbs		0.2352417	lbs		0.0321146	lbs		1.4400340	lbs		12.6571187	lbs					498.5837437	
Total Volume (Quarter):															1,980,895	cf																														
Pollutant Load (Quarter):															301.3	lbs		60.82	lbs		30.53	lbs		9.82	lbs		3,350.84	lbs		1.58	lbs		0.22	lbs		9.66	lbs		84.86	lbs					3,342.92	
AVERAGE ANNUAL EMCs:											71.4		7.7		2.0	mg/l		0.57	mg/l		0.36	mg/l		0.13	mg/l		43.0	mg/l		12.634	µg/l		3.360	µg/l		80.971	µg/l		1.7	mg/l		3333	mg/l		33.28	mg/l
TOTAL ANNUAL POLLUTANT LOAD (EVENTS):															82.00	lbs		23.646	lbs		15.080	lbs		5.338	lbs		1795.00	lbs		0.528	lbs		0.140	lbs		3.384	lbs		71.74	lbs					1390.65	lbs
Per Acre:															1.36			0.39			0.25			0.09			29.7			0.009			0.002			0.06			1.2						23.0	
TOTAL 2015 POLLUTANT LOAD:															940.33	lbs		231.65	lbs		162.17	lbs		45.11	lbs		14,606.04	lbs		5.32	lbs		1.06	lbs		37.88	lbs		671.96	lbs					29,023.31	lbs
TOTAL 2014 POLLUTANT LOAD:															2,039.81	lbs		536.08	lbs		497.02	lbs		53.58	lbs		18,953.49	lbs		8.12	lbs		0.95	lbs		50.40	lbs		1,155.52	lbs					36,945.03	lbs

Anne Arundel County NPDES
Sampling and EMC Data – 2015 Reporting Year
Church Creek Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Durartion (Hours)	Intensity (In/Hr)	Temperature - field (oF)	Flow (cf)	pH - field (pH)	dt for BOD ((dt) mg/L)	BOD (mg/L)	BOD ((0) mg/L)	dt for Total Kjeldahl Nitrogen ((dt) mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	dt for Nitrate+ Nitrite - N ((dt) mg/L)	Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	dt for Total Phosphorus ((dt) mg/L)	Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)	dt for TSS ((dt) mg/L)	TSS (mg/L)	TSS ((0) mg/L)	dt for Copper ((dt) µg/L)	Copper (µg/L)	Copper ((0) µg/L)	dt for Lead ((dt) µg/L)	Lead (µg/L)	Lead ((0) µg/L)	dt for Zinc ((dt) µg/L)	Zinc (µg/L)	Zinc ((0) µg/L)	dt for TPH ((dt) mg/L)	TPH ((0) mg/L)	TPH ((0) mg/L)	dt for E-COLI ((dt) MPN)	E-COLI (MPN)	E-COLI ((0) MPN)	dt for HARDNESS ((dt) mg/L)	HARDNESS ((0) mg/L)	HARDNESS ((0) mg/L)
Versar	1	AC	8/12/2014	1320	102	I	S	3.32	12.0	0.28	75.56	188549	7.1	2.00	6.00	6.00	0.50	1.60	1.60	0.05	0.66	0.660	0.01	0.40	0.40	1.0	180.0	180.0	2.00	23.00	23.00	2.00	14.00	14.00	20.00	160.0	160.0	5.0	0.0	5.0	100.0	0.0	100.0	1.0	120.0	120.0
Versar	2	AC	8/12/2014	1720	102	I	S				73.58	2627549	6.9	2.00	0.00	2.00	0.50	0.80	0.80	0.05	0.17	0.170	0.01	0.16	0.16	1.0	62.0	62.0	2.00	8.20	8.20	2.00	6.50	6.50	20.00	73.0	73.0	5.0	0.0	5.0	100.0	0.0	100.0	1.0	23.0	23.0
Versar	3	AC	8/12/2014	1910	102	I	S				74.66	2031467	6.9	2.00	0.00	2.00	0.50	0.00	0.50	0.02	0.21	0.210	0.01	0.13	0.13	1.0	42.0	42.0	2.00	5.80	5.80	2.00	4.30	4.30	20.00	78.0	78.0	5.0	0.0	5.0	100.0	0.0	100.0	1.0	29.0	29.0
										Event Mean Concentration:	**74.11**		**6.9**	**2.00**	**0.23**	**2.16**	**0.50**	**0.50**	**0.71**	**0.04**	**0.206**	**0.206**	**0.01**	**0.157**	**0.157**	**1.0**	**58.2**	**58.2**	**2.00**	**7.770**	**7.770**	**2.000**	**5.87**	**5.87**	**20.00**	**78.48**	**78.48**	**5.0**	**0.0**	**5.0**	**100.0**	**0.0**	**100.0**	**1.0**	**29.3**	**29.3**
Versar	1	AC	9/18/2014	1330	102	I	B				65.48	591	6.9	2.00	0.00	2.00	0.50	0.00	0.50	0.05	0.80	0.800	0.01	0.08	0.080	1.0	22.00	22.0	2.00	2.00	2.00	2.00	0.000	2.00	20.00	38.0	38.0	5.0	0.0	5.0	10.0	171.0	171.0	1.0	100.0	100.0
										Event Mean Concentration:	**65.48**		**6.9**	**2.00**	**0.00**	**2.00**	**0.50**	**0.00**	**0.50**	**0.05**	**0.80**	**0.800**	**0.01**	**0.08**	**0.080**	**1.0**	**22.00**	**22.0**	**2.00**	**2.00**	**2.00**	**2.00**	**0.000**	**2.00**	**20.00**	**38.0**	**38.0**	**5.0**	**0.0**	**5.0**	**10.0**	**171.0**	**171.0**	**1.0**	**100.0**	**100.0**
Versar	1	AC	9/30/2014	1055	102	I	B				65.30	440	6.5	2.00	0.00	2.00	0.50	0.70	0.70	0.05	0.55	0.550	0.01	0.03	0.03	1.0	4.00	4.0	2.00	0.000	2.00	2.00	0.000	2.00	20.00	24.0	24.0	5.0	0.0	5.0	10.0	0.0	10.0	1.0	94.0	94.0
										Event Mean Concentration:	**65.30**		**6.5**	**2.00**	**0.00**	**2.00**	**0.50**	**0.70**	**0.70**	**0.05**	**0.55**	**0.550**	**0.01**	**0.030**	**0.030**	**1.0**	**4.00**	**4.0**	**2.00**	**0.000**	**2.00**	**2.00**	**0.000**	**2.00**	**20.00**	**24.0**	**24.0**	**5.0**	**0.0**	**5.0**	**10.0**	**0.0**	**10.0**	**1.0**	**94.0**	**94.0**
Versar	1	AC	10/15/2014	1610	102	I	S	0.84	6.0	0.14	70.16	214278	7	2.00	3.00	3.00	0.50	0.70	0.70	0.05	0.26	0.26	0.01	0.21	0.21	1.0	100.0	100.0	2.00	19.00	19.00	2.00	9.50	9.50	20.00	150.0	150.0	5.0	0.0	5.0	10.0	7701.0	7701.00	1.0	64.0	64.0
Versar	2	AC	10/15/2014	1635	102	I	S				70.70	364468	7.2	2.00	3.00	3.00	0.50	1.20	1.20	0.05	0.22	0.22	0.01	0.28	0.28	1.0	130.0	130.0	2.00	20.00	20.00	2.00	14.00	14.00	20.00	170.0	170.0	5.0	0.0	5.0	10.0	24196.0	24196.00	1.0	33.0	33.0
Versar	3	AC	10/15/2014	1750	102	I	S				69.62	671522	7	2.00	0.00	2.00	0.50	0.60	0.60	0.05	0.24	0.24	0.01	0.11	0.11	1.0	50.0	50.0	2.00	7.80	7.80	2.00	3.50	3.50	20.00	60.0	60.0	5.0	0.0	5.0	10.0	15531.0	15531.00	1.0	33.0	33.0
										Event Mean Concentration:	**70.03**		**7.1**	**2.00**	**1.39**	**2.46**	**0.50**	**0.79**	**0.79**	**0.05**	**0.238**	**0.238**	**0.01**	**0.177**	**0.177**	**1.0**	**81.9**	**81.9**	**2.00**	**13.276**	**13.276**	**2.00**	**7.589**	**7.589**	**20.00**	**107.49**	**107.49**	**5.0**	**0.0**	**5.0**	**10.0**	**16715.0**	**16715.0**	**1.0**	**38.3**	**38.3**
Versar	1	AC	11/6/2014	350	102	I	S	0.30	12.0	0.03	55.94	61762	6.6	2.00	3.00	3.00	0.50	0.80	0.80	0.05	1.50	1.50	0.01	0.11	0.11	1.0	13.0	13.0	2.00	4.80	4.80	2.00	0.000	2.00	20.00	59.0	59.0	5.0	0.0	5.0	10.0	420.0	420.00	1.0	90.0	90.0
Versar	2	AC	11/6/2014	730	102	I	S				55.40	136524	6.8	2.00	3.00	3.00	0.50	0.00	0.50	0.05	0.94	0.94	0.01	0.14	0.14	1.0	29.0	29.0	2.00	7.40	7.40	2.00	3.00	3.00	20.00	66.0	66.0	5.0	0.0	5.0	10.0	1670.0	1670.00	1.0	50.0	50.0
Versar	3	AC	11/6/2014	940	102	I	S				54.86	113283	6.7	2.00	2.00	2.00	0.50	0.90	0.90	0.05	0.56	0.56	0.01	0.56	0.56	1.0	6.0	6.0	2.00	4.80	4.80	2.00	0.000	2.00	20.00	48.0	48.0	5.0	0.0	5.0	10.0	1198.0	1198.00	1.0	43.0	43.0
										Event Mean Concentration:	**55.31**		**6.7**	**2.00**	**2.64**	**2.64**	**0.50**	**0.49**	**0.70**	**0.05**	**0.913**	**0.913**	**0.01**	**0.287**	**0.287**	**1.0**	**17.5**	**17.5**	**2.00**	**5.939**	**5.939**	**2.00**	**1.315**	**2.438**	**20.00**	**58.07**	**58.07**	**5.0**	**0.0**	**5.0**	**10.0**	**1250.6**	**1250.6**	**1.0**	**55.4**	**55.4**
Versar	1	AC	12/22/2014	1600	102	I	S	0.12	8.0	0.02	40.82	23588	6.6	2.00	4.00	4.00	0.50	0.00	0.50	0.05	1.50	1.50	0.01	0.04	0.04	1.0	11.0	11.0	2.00	0.00	2.00	2.00	0.000	2.00	20.00	73.0	73.0	5.0	0.0	5.0	10.0	63.0	63.00	1.0	120.0	120.0
Versar	2	AC	12/22/2014	1800	102	I	S				41.90	44458	6.6	2.00	20.00	20.00	0.50	1.00	1.00	0.05	1.70	1.70	0.01	0.16	0.16	1.0	17.0	17.0	2.00	6.60	6.60	2.00	0.000	2.00	20.00	100.0	100.0	5.0	0.0	5.0	10.0	262.0	262.00	1.0	97.0	97.0
Versar	3	AC	12/22/2014	2020	102	I	S				42.08	61746	6.7	2.00	13.00	13.00	0.50	1.50	1.50	0.05	0.73	0.73	0.01	0.06	0.06	1.0	11.0	11.0	2.00	6.20	6.20	2.00	0.000	2.00	20.00	67.0	67.0	5.0	0.0	5.0	10.0	279.0	279.00	1.0	54.0	54.0
										Event Mean Concentration:	**41.79**		**6.6**	**2.00**	**13.76**	**13.76**	**0.50**	**1.06**	**1.15**	**0.05**	**1.202**	**1.202**	**0.01**	**0.091**	**0.091**	**1.0**	**13.1**	**13.1**	**2.00**	**5.210**	**5.574**	**2.00**	**0.000**	**2.000**	**20.00**	**79.39**	**79.39**	**5.0**	**0.0**	**5.0**	**10.0**	**233.9**	**233.9**	**1.0**	**80.7**	**80.7**
Versar	1	AC	2/25/2015	930	102	I	B				32.1	245	6.9	2.00	0.00	2.00	0.50	0.80	0.80	0.05	1.60	1.60	0.01	0.04	0.04	1.0	9.0	9.0	2.00	2.80	2.80	2.00	0.000	2.00	20.00	98.0	98.0	5.0	0.0	5.0	10.0	41.0	41.0	1.0	480.0	480.0
										Event Mean Concentration:	**32.10**		**6.9**	**2.00**	**0.00**	**2.00**	**0.50**	**0.80**	**0.80**	**0.05**	**1.60**	**1.60**	**0.01**	**0.04**	**0.04**	**1.0**	**9.0**	**9.0**	**2.00**	**2.80**	**2.80**	**2.00**	**0.000**	**2.00**	**20.00**	**98.0**	**98.0**	**5.0**	**0.0**	**5.0**	**10.0**	**41.0**	**41.0**	**1.0**	**480.0**	**480.0**
Versar	1	AC	3/4/2015	2100	102	I	S	0.23	8.5	0.03	39.92	152328	6.9	4.00	6.00	6.00	0.50	1.50	1.50	0.05	1.00	1.00	0.01	0.18	0.18	1.0	55.0	55.0	2.00	21.00	21.00	2.00	5.20	5.20	20.00	150.0	150.0	5.0	5.0	5.00	10.0	327.0	327.0	1.0	180.0	180.0
Versar	2	AC	3/4/2015	2135	102	I	S				39.56	58952	6.9	4.00	5.00	5.00	0.50	1.30	1.30	0.05	0.79	0.79	0.01	0.24	0.24	1.0	85.0	85.0	2.00	26.00	26.00	2.00	8.70	8.70	20.00	190.0	190.0	5.0	7.0	7.00	10.0	1058.0	1058.0	1.0	150.0	150.0
Versar	3	AC	3/4/2015	2220	102	I	S				39.20	79804	6.9	4.00	0.00	4.00	0.50	0.80	0.80	0.05	0.58	0.58	0.01	0.15	0.15	1.0	44.0	44.0	2.00	13.00	13.00	2.00	4.00	4.00	20.00	100.0	100.0	5.0	7.0	7.00	10.0	1236.0	1236.0	1.0	110.0	110.0
										Event Mean Concentration:	**39.65**		**6.9**	**4.00**	**4.15**	**5.25**	**0.50**	**1.27**	**1.27**	**0.05**	**0.842**	**0.84**	**0.01**	**0.184**	**0.18**	**1.0**	**58.1**	**58.1**	**2.00**	**19.82**	**19.82**	**2.00**	**5.58**	**5.58**	**20.00**	**144.39**	**144.39**	**5.0**	**6.0**	**5.95**	**10.0**	**724.3**	**724.3**	**1.0**	**154.7**	**154.73**
Versar	1	AC	3/31/2015	1135	102	I	B				46.4	794	6.3	2.00	0.00	2.00	0.50	0.60	0.60	0.05	1.00	1.00	0.01	0.06	0.06	1.0	6.0	6.0	2.00	0.000	2.00	2.00	0.000	2.00	20.00	49.0	49.0	5.0	0.0	5.00	10.0	41.0	41.0	1.0	130.0	130.0
										Event Mean Concentration:	**46.40**		**6.3**	**2.00**	**0.00**	**2.00**	**0.50**	**0.60**	**0.60**	**0.05**	**1.00**	**1.00**	**0.01**	**0.06**	**0.06**	**1.0**	**6.0**	**6.0**	**2.00**	**0.000**	**2.00**	**2.00**	**0.000**	**2.00**	**20.00**	**49.0**	**49.0**	**5.0**	**0.0**	**5.00**	**10.0**	**41.0**	**41.0**	**1.0**	**130.0**	**130.0**
Versar	1	AP	4/14/2015	1045	102	I	S	0.53	13.5	0.04	57.20	102835	6.4	4.00	9.00	9.00	0.50	0.90	0.90	0.05	0.76	0.76	0.01	0.09	0.09	1.0	11.0	11.0	2.00	12.0	12.0	2.00	0.00	2.00	20.0	62.0	62.0	5.0	0.0	5.0	10.0	1354.0	1354.0	1.0	83.0	83.0
Versar	2	AP	4/14/2015	1740	102	I	S				57.38	480582	6.5	4.00	0.00	4.00	0.50	0.00	0.50	0.05	0.31	0.31	0.01	0.08	0.08	1.0	19.0	19.0	2.00	8.0	8.0	2.00	0.00	2.00	20.0	53.0	53.0	5.0	0.0	5.0	10.0	1043.0	1043.0	1.0	37.0	37.0
Versar	3	AP	4/14/2015	1905	102	I	S				56.84	139436	6.5	4.00	7.00	7.00	0.50	0.60	0.60	0.05	0.33	0.33	0.01	0.07	0.07	1.0	14.0	14.0	2.00	7.0	7.0	2.00	0.00	2.00	20.0	49.0	49.0	5.0	0.0	5.0	10.0	1126.0	1126.0	1.0	43.0	43.0
										Event Mean Concentration:	**57.25**		**6.49**	**4.00**	**2.63**	**5.29**	**0.50**	**0.24**	**0.58**	**0.05**	**0.378**	**0.38**	**0.01**	**0.079**	**0.08**	**1.0**	**16.9**	**16.90**	**2.00**	**8.38**	**8.38**	**2.00**	**0.00**	**2.00**	**20.0**	**53.51**	**53.51**	**5.0**	**0.0**	**5.0**	**10.0**	**1103.3**	**1103.3**	**1.0**	**44.7**	**44.7**
Versar	1	AP	6/8/2015	2110	102	I	S	0.23	8.5	0.03	73.4	13178	6.8	2.00	5.00	5.00	0.50	1.10	1.10	0.05	0.46	0.46	0.01	0.09	0.09	1.0	57.0	57.0	2.00	19.0	19.0	2.00	4.90	4.90	20.0	130.0	130.0	5.0	0.0	5.0	10.0	0.0	10.0	1.0	54.0	54.0
Versar	2	AP	6/8/2015	2140	102	I	S				73.4	375092	6.8	2.00	3.00	3.00	0.50	1.00	1.00	0.05	0.31	0.31	0.01	0.19	0.19	1.0	59.0	59.0	2.00	9.6	9.6	2.00	7.20	7.20	20.0	76.0	76.0	5.0	0.0	5.0	10.0	2014.0	9804.0	1.0	19.0	19.0
Versar	3	AP	6/8/2015	2250	102	I	S				72.86	492739	6.9	2.00	4.00	4.00	0.50	0.60	0.60	0.05	0.46	0.46	0.01	0.08	0.08	1.0	38.0	38.0	2.00	8.4	8.4	2.00	4.40	4.40	20.0	63.0	63.0	5.0	8.0	8.0	10.0	20.0	20.0	1.0	35.0	35.0
										Event Mean Concentration:	**73.10**		**6.86**	**2.00**	**3.59**	**3.59**	**0.50**	**0.78**	**0.78**	**0.05**	**0.396**	**0.40**	**0.01**	**0.127**	**0.13**	**1.0**	**47.2**	**47.22**	**2.00**	**9.07**	**9.07**	**2.00**	**5.60**	**5.60**	**20.0**	**69.54**	**69.54**	**5.0**	**4.5**	**6.7**	**10.0**	**868.7**	**4185.4**	**1.0**	**28.5**	**28.5**
Versar	1	AP	6/27/2015	945	102	I	S	1.24	21.0	0.06	70.61	151618	6.75	2.00	2.00	2.00	0.50	0.00	0.50	0.05	0.43	0.43	0.01	0.04	0.04	1.0	3.0	3.0	2.00	4.1	4.1	2.00	0.00	2.00	20.0	40.0	40.0	N/A	N/A	N/A	N/A	N/A	N/A	1.0	38.0	38.0
Versar	2	AP	6/27/2015	1715	102	I	S				72.50	1910098	6.85	2.00	0.00	2.00	0.50	0.70	0.70	0.05	0.16	0.16	0.01	0.06	0.06	1.0	15.0	15.0	2.00	5.6	5.6	2.00	0.00	2.00	20.0	34.0	34.0	N/A	N/A	N/A	N/A	N/A	N/A	1.0	20.0	20.0
Versar	3	AP	6/27/2015	2230	102	I	S				71.69	1424433	6.85	2.00	0.00	2.00	0.50	0.00	0.50	0.05	0.24	0.24	0.01	0.05	0.05	1.0	7.0	7.0	2.00	30.0	30.0	2.00	3.50	3.50	20.0	73.0	73.0	N/A	N/A	N/A	N/A	N/A	N/A	1.0	34.0	34.0
										Event Mean Concentration:	**72.09**		**6.85**	**2.00**	**0.09**	**2.00**	**0.50**	**0.38**	**0.61**	**0.05**	**0.204**	**0.20**	**0.01**	**0.055**	**0.06**	**1.0**	**11.2**	**11.21**	**2.00**	**15.50**	**15.50**	**2.00**	**1.43**	**2.61**	**20.0**	**50.20**	**50.20**							**1.0**	**26.5**	**26.5**

Anne Arundel County NPDES
Sampling and EMC Data – 2015 Reporting Year
Church Creek Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Durartion (Hours)	Intensity (In/Hr)	Temperature - field (oF)	Flow (cf)	pH - field (pH)	dt for BOD ((dt) mg/L)	BOD (mg/L)	BOD ((0) mg/L)	dt for Total Kjeldahl Nitrogen ((dt) mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	dt for Nitrate+ Nitrite - N ((dt) mg/L)	Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	dt for Total Phosphorus ((dt) mg/L)	Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)	dt for TSS ((dt) mg/L)	TSS (mg/L)	TSS ((0) mg/L)	dt for Copper ((dt) µg/L)	Copper (µg/L)	Copper ((0) µg/L)	dt for Lead ((dt) µg/L)	Lead (µg/L)	Lead ((0) µg/L)	dt for Zinc ((dt) µg/L)	Zinc (µg/L)	Zinc ((0) µg/L)	dt for TPH ((dt) mg/L)	TPH ((0) mg/L)	TPH ((0) mg/L)	dt for E-COLI ((dt) MPN)	E-COLI (MPN)	E-COLI ((0) MPN)	dt for HARDNESS ((dt) mg/L)	HARDNESS ((0) mg/L)	HARDNESS ((0) mg/L)
SUMMER QUARTER (JULY, AUGUST, SEPTEMBER)																																														
Summer Quarter Flow-Weighted EMC (9/12/13):											74.11		6.91		0.23	2.16		0.50	0.71		0.21	0.21		0.16	0.16		58.20	58.20		7.77	7.77		5.87	5.87		78.47	78.47		0.00	5.00		98.00	102.27		29.30	29.30
Average:															1.19	mg/l		0.60	mg/l		0.21	mg/l		0.16	mg/l		58.20	mg/l		7.769	µg/l		5.869	µg/l		78.469	µg/l		2.50	mg/l		100.14	MPN/100mL		29.30	mg/l
															0.0000746	lb/cf		0.0000375	lb/cf		0.0000129	lb/cf		0.0000098	lb/cf		0.0036325	lb/cf		0.0000005	lb/cf		0.0000004	lb/cf		0.0000049	lb/cf		0.0001560	lb/cf					0.0018289	lb/cf
Total Volume (Quarter Events):															4,848,595	cf																														
Pollutant Load (Quarter Events):															361.47	lbs		181.76	lbs		62.32	lbs		47.43	lbs		17,612.71	lbs		2.35	lbs		1.78	lbs		23.75	lbs		756.57	lbs					8,867.58	
Total Volume (Quarter):															24,447,042	cf																														
Pollutant Load (Quarter):															1,823	lbs		916	lbs		314	lbs		239	lbs		88,805	lbs		11.9	lbs		9.0	lbs		120	lbs		3,815	lbs					44,711	
FALL QUARTER (OCTOBER, NOVEMBER, DECEMBER)																																														
Fall Quarter Flow-Weighted EMC (10/7/13), (12/6/13), (12/23/13):											65.15		6.97		2.57	3.36		0.76	0.80		0.436	0.436		0.190	0.190		64.74	64.74		11.306	11.334		5.851	6.212		96.232	96.232		0.0	5.0		12602.20	12602.20		44.71	44.71
Average:															2.96	mg/l		0.78	mg/l		0.44	mg/l		0.19	mg/l		64.74	mg/l		11.320	µg/l		6.031	µg/l		96.232	µg/l		2.50	mg/l		12602.20	MPN/100mL		44.71	mg/l
															0.0001851	lb/cf		0.0000487	lb/cf		0.0000272	lb/cf		0.0000119	lb/cf		0.0040410	lb/cf		0.0000007	lb/cf		0.0000004	lb/cf		0.0000060	lb/cf		0.0001560	lb/cf					0.0027907	lb/cf
Total Volume (Quarter Events):															1,691,628	cf																														
Pollutant Load (Quarter Events):															313.04	lbs		82.31	lbs		46.03	lbs		20.10	lbs		6,835.85	lbs		1.20	lbs		0.64	lbs		10.16	lbs		263.96	lbs					4,720.80	
Total Volume (Quarter):															27,846,027	cf																														
Pollutant Load (Quarter):															5,153	lbs		1,355	lbs		758	lbs		331	lbs		112,526	lbs		19.7	lbs		10.5	lbs		167	lbs		4,345	lbs					77,710	
WINTER QUARTER (JANUARY, FEBRUARY, MARCH)																																														
Fall Quarter Flow-Weighted EMC:											39.66		6.90		4.14	5.24		1.27	1.27		0.84	0.84		0.18	0.18		57.88	57.88		19.75	19.76		5.56	5.57		144.09	144.09		5.93	5.95		721.83	721.83		154.94	154.94
Average:															4.69	mg/l		1.27	mg/l		0.84	mg/l		0.18	mg/l		57.88	mg/l		19.754	µg/l		5.564	µg/l		144.095	µg/l		5.94	mg/l		721.83	MPN/100mL		154.94	mg/l
															0.0002926	lb/cf		0.0000790	lb/cf		0.0000526	lb/cf		0.0000115	lb/cf		0.0036125	lb/cf		0.0000012	lb/cf		0.0000003	lb/cf		0.0000090	lb/cf		0.0003708	lb/cf					0.0096706	lb/cf
Total Volume (Quarter Events):															292,123	cf																														
Pollutant Load (Quarter Events):															85.47	lbs		23.07	lbs		15.38	lbs		3.35	lbs		1,055.29	lbs		0.36	lbs		0.10	lbs		2.63	lbs		108.32	lbs					2,825.02	
Total Volume (Quarter):															26,648,542	cf																														
Pollutant Load (Quarter):															7,797	lbs		2,105	lbs		1,403	lbs		305	lbs		96,267	lbs		32.9	lbs		9.3	lbs		240	lbs		9,882	lbs					257,709	
SPRING QUARTER (APRIL, MAY, JUNE)																																														
Fall Quarter Flow-Weighted EMC (4/7/14, 5/27/14, 6/19/14):											70.15		6.80		1.05	2.74		0.43	0.63		0.26	0.26		0.07	0.07		18.25	18.25		13.38	13.38		1.95	3.04		54.01	54.01		0.77	1.87		307.03	881.11		29.43	29.43
Average:															1.90	mg/l		0.53	mg/l		0.26	mg/l		0.07	mg/l		18.25	mg/l		13.378	µg/l		2.496	µg/l		54.014	µg/l		1.32	mg/l		594.07	MPN/100mL		29.43	mg/l
															0.0001185	lb/cf		0.0000333	lb/cf		0.0000164	lb/cf		0.0000044	lb/cf		0.0011391	lb/cf		0.0000008	lb/cf		0.0000002	lb/cf		0.0000034	lb/cf		0.0000824	lb/cf					0.0018368	lb/cf
Total Volume (Quarter Events):															5,090,010	cf																														
Pollutant Load (Quarter Events):															603.10	lbs		169.31	lbs		83.31	lbs		22.55	lbs		5,798.27	lbs		4.25	lbs		0.79	lbs		17.16	lbs		419.42	lbs					9,349.34	
Total Volume (Quarter):															41,102,669	cf																														
Pollutant Load (Quarter):															4,870	lbs		1367.24	lbs		672.776	lbs		182.1	lbs		46822.0	lbs		34.322	lbs		6.403	lbs		138.571	lbs		3386.9	lbs					75497.42	
AVERAGE ANNUAL EMCs:											70.3		6.9		1.83	mg/l		0.61	mg/l		0.28	mg/l		0.13	mg/l		42.1	mg/l		10.961	µg/l		4.444	µg/l		72.16	µg/l		2.1	mg/l		2100.1	mg/l		34.6	mg/l
TOTAL ANNUAL POLLUTANT LOAD (EVENTS):															1363.08	lbs		456.45	lbs		207.04	lbs		93.43	lbs		31302.1	lbs		8.157	lbs		3.307	lbs		53.70	lbs		1548.3	lbs					25762.7	lbs
Per Acre:															4.88			1.64			0.74			0.33			112.16			0.03			0.012			0.192			5.548						92.310	
TOTAL 2015 POLLUTANT LOAD:															19642.7	lbs		5743.28	lbs		3147.533	lbs		1057.26	lbs		344419.4	lbs		98.706	lbs		35.094	lbs		665.234	lbs		21428	lbs					455626.57	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